U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

ASSESSMENT OF UNDISCOVERED MINERAL RESOURCES IN THE PACIFIC NORTHWEST: A CONTRIBUTION TO THE INTERIOR COLUMBIA BASIN ECOSYSTEM MANAGEMENT PROJECT

Edited by

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Executive Summary

This report is one in a series of digital maps, data files, and reports generated by the U.S. Geological Survey to provide geologic process and mineral resource information to a U.S. Forest Service and Bureau of Land Management interagency project, the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

Short term predictions of future mineral-economic activity can be extrapolated from the existing resource base in discovered deposits (*see* Bookstrom and others, 1996). However, long term forecasts must also account for the future discovery of extensions of known mineral deposits (within a km of a known mineral deposit), as well as for the future discovery of presently undiscovered mineral deposits. In this report we provide quantitative estimates of the presently undiscovered mineral resources in the ICBEMP area.

Quantitative estimates of undiscovered metallic mineral resources in the ICBEMP area involved delineating 124 tracts or areas that are permissive for the occurrence of 30 different metallic mineral deposit types, delineating areas that are favorable for undiscovered mineralization (some indication that mineralization is present or mineralizing processes have occurred) within these permissive tracts, estimating probability distributions of the number of undiscovered deposits that may be present within each permissive tract for 25 of the mineral deposit types, and numerically simulating the amount of undiscovered in-situ metals. A mean of 87 undiscovered deposits of the 25 deposit types considered in this analysis are estimated to be present in the ICBEMP area. Results of the numerical estimation of the in-situ amount of undiscovered metallic mineral resources that lie within the ICBEMP area are given in Summary Table below. Results of the numerical simulation for individual tracts are summarized in Appendix A.

This analysis provides some constraints on the amount of in-situ resources that remain within the study area but does not address the economic potential of these deposits. The information in this report constitutes some of the information necessary to forecast the likelihood and general location of the potential supply of metals from undiscovered mineral resources in the ICBEMP study area.

Summary Table: Summary statistics of the probabilistic estimate of undiscovered, in-situ resources of precious and base metals (metric tonnes of metal) in ICBEMP study area. Summary includes all deposit types and tracts that occur within the study area.

	Au	Ag	Cu	Pb	Zn	Mo
0.95 quantile	1,094	24,866	5,260,400	91,457	331,960	22,703
0.90 quantile	1,248	31,590	6,697,700	195,080	645,390	51,977
0.50 quantile	2,082	70,776	14,589,000	1,951,800	4,005,100	363,880
0.10 quantile	3,261	150,640	31,743,000	11,657,000	18,560,000	1,427,800
0.05 quantile	3,741	183,590	39,579,000	17,022,000	26,485,000	1,953,800
Mean	2,198	83,717	17,433,900	4,259,720	7,497,460	590,080

Some generalizations can be made about the likely areal distribution of undiscovered deposits in the ICBEMP area, and these are illustrated in the following summary figures (figs. A to F). For each of the economic elements in the Summary Table, more than 50% of the estimated mean undiscovered resource in the ICBEMP study area is estimated to occur in a limited contiguous area. 58% of the estimated mean undiscovered Au resources are estimated to occur in a contiguous area of southeastern Oregon, southwestern Idaho, and northeastern Nevada, predominantly in shallowly deposited vein and hot springs deposits (fig. A). 54% of the estimated mean undiscovered Ag resources are estimated to occur in the Belt Basin of northwestern Montana, northern Idaho, and easternmost Washington (fig. B). A nearly identical area in Montana, Idaho and Washington accounts for 72% of the estimated mean undiscovered resource (fig. C). A broadly overlapping but slightly different area in northwestern Montana, northern Idaho and northeastern Washington accounts for 93% of the estimated mean undiscovered Pb resource (fig. D) and 87% of the estimated mean undiscovered Zn resource (fig. E). Finally an arcuate area extending from southwestern Idaho to northwestern Montana is estimated to contain 59% of the estimated mean undiscovered molybdenum resource (fig. F).

Comparison can be made (fig. G) between the past production, known but unmined resources (both from Bookstrom and others, 1996), and estimated undiscovered resources (from this report) for the entire ICBEMP study area. For Au, Ag, Cu, Pb, Zn, and Mo, the estimated undiscovered resources account for 54%, 46%, 29%, 34%, 45%, and 16%, respectively, of the total resources (past production + known resources + estimated undiscovered resources) for the ICBEMP study area. For the same elements, the estimated undiscovered resources account for the following percentages of the total unmined resources (known resources + estimated undiscovered resources): 67%, 70%, 36%, 91%, 80%, and 16%, respectively. By implication, the specific sites which account for most of the resource of unmined copper and molybdenum are known. However, the specific sites of most of the unmined resources of gold, silver, lead, and zinc are not known, although the general regions in which they are most likely to occur are known.

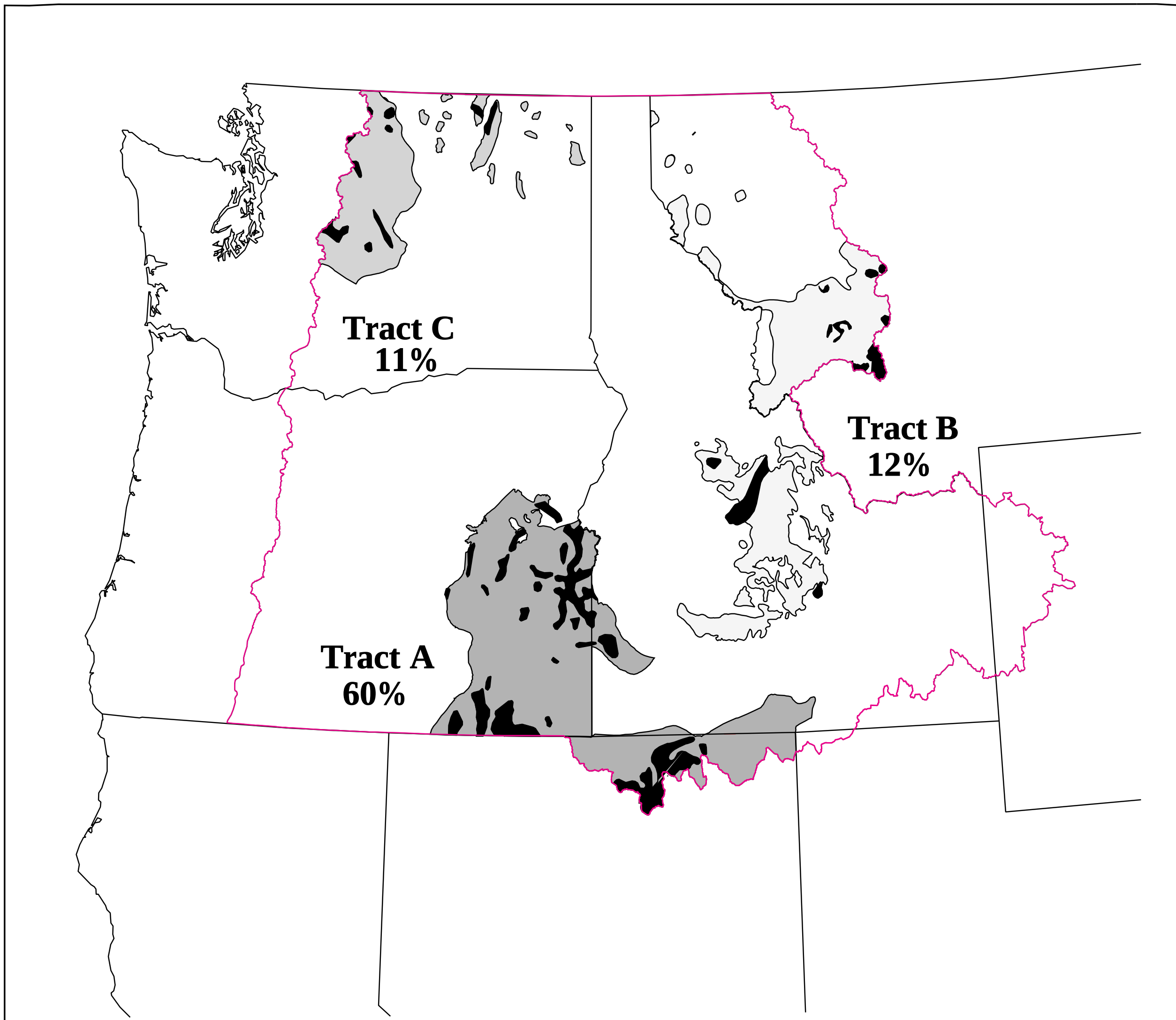


Figure A: Location of 83% of estimated undiscovered Au resources in ICBEMP

Undiscovered Au Resources

Explanation

Tract A — Composite Permissive Tract

Favorable Area

ICBEMP Study Area Boundary

12% Percent of total undiscovered Au resources in ICBEMP

Tract A Includes tracts:

W107 - Hot spring Au
W108 - Hot spring Au
W109 - Hot spring Au
W21 - Hot spring Au
W27 - Carlin sed-hosted Au
W101 - Comstock Au-Ag
W102 - Comstock Au-Ag
W17- Comstock Au-Ag

Tract B Includes tracts:

W129 - Hot spring Au
C05 - Hot spring Au
C02 - Au skarn
C13 - Comstock Au-Ag
C100 - Porphyry Cu

Tract C Includes tracts:

PC26 - Porphyry Cu
PC 101 - Comstock Au-Ag
W02 - Comstock Au-Ag

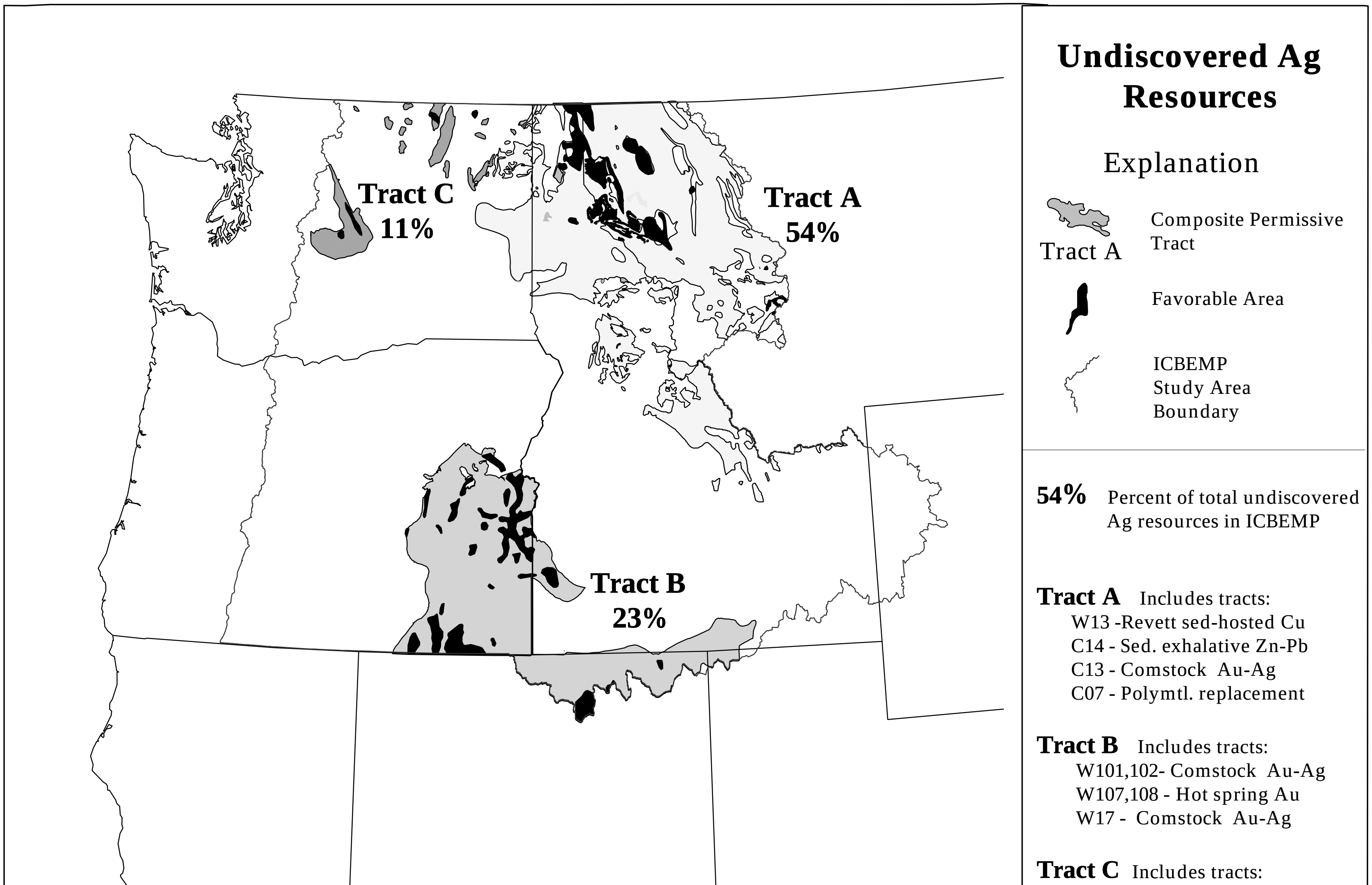


Figure B: Location of 88% of estimated undiscovered Ag resources in the ICBEMP

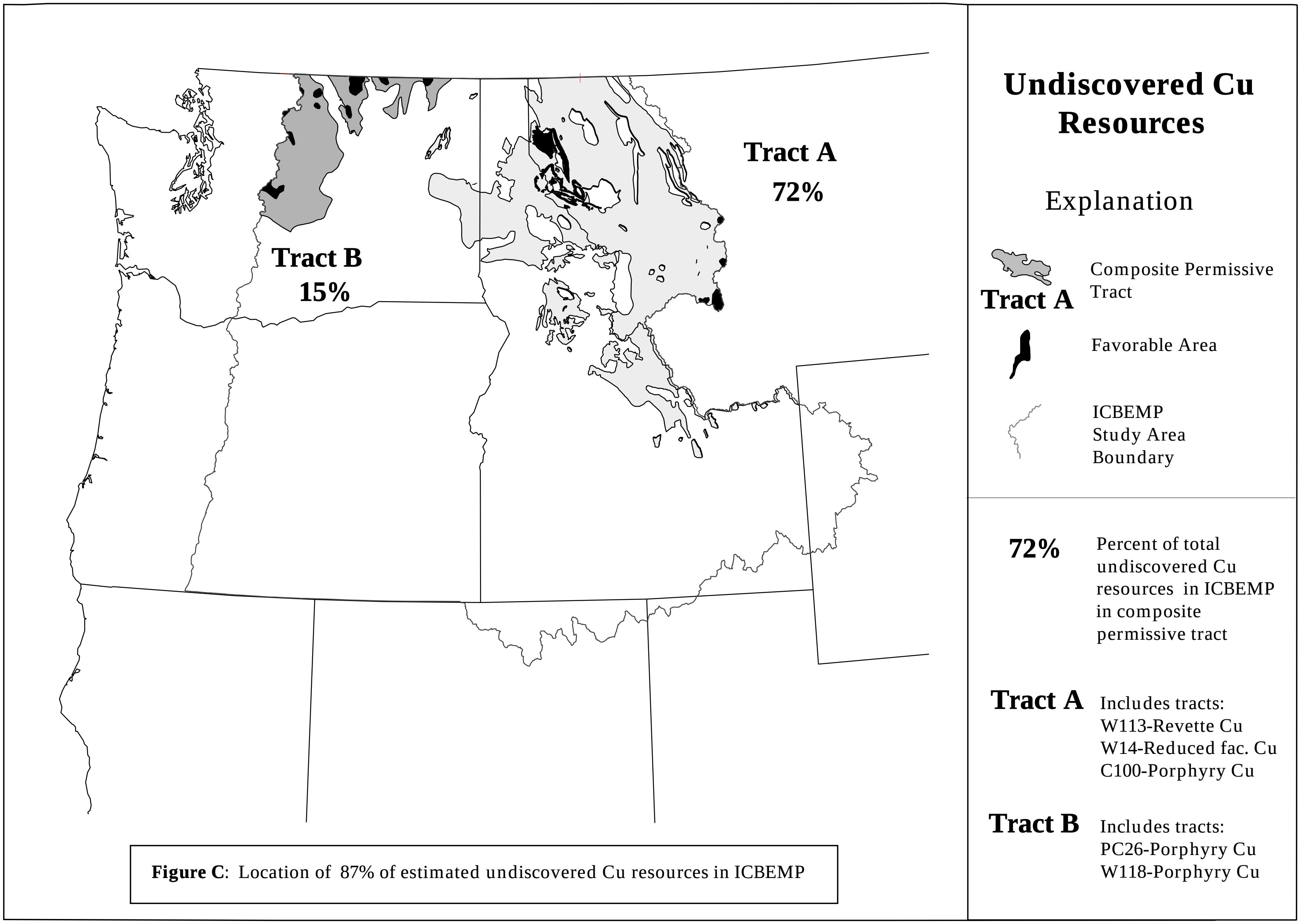


Figure C: Location of 87% of estimated undiscovered Cu resources in ICBEMP

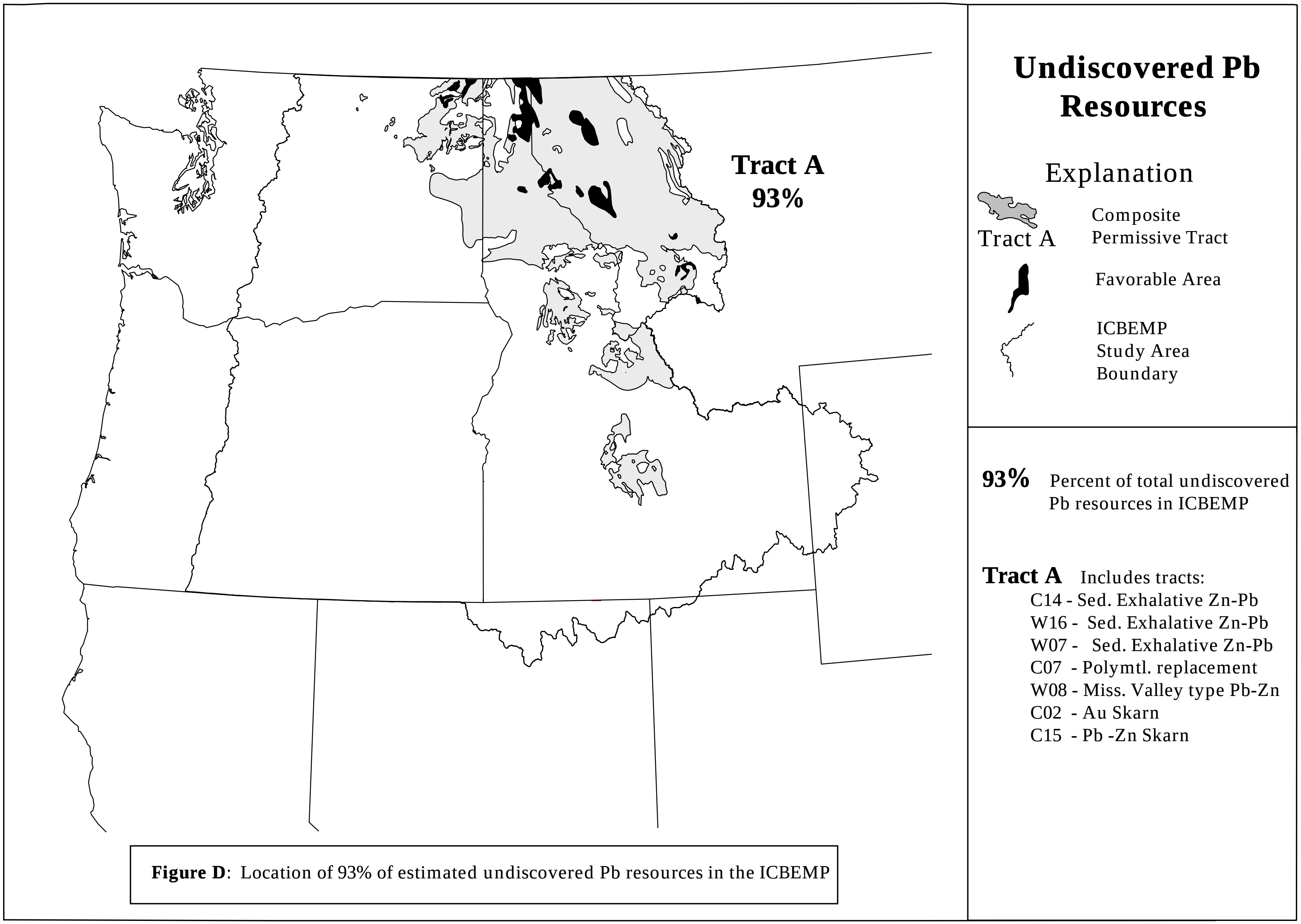
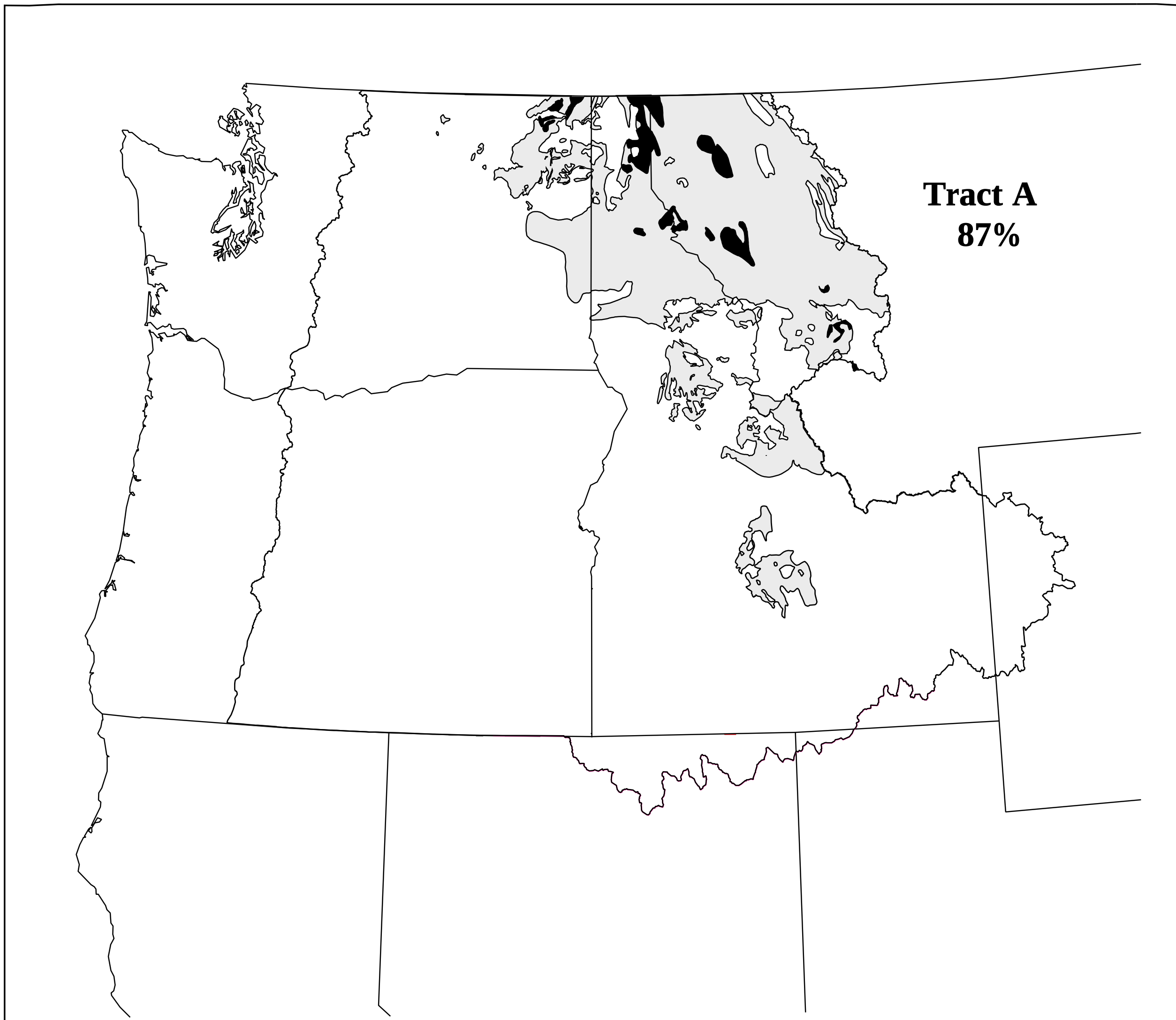


Figure D: Location of 93% of estimated undiscovered Pb resources in the ICBEMP



Undiscovered Zn Resources

Explanation

Tract A — Composite Permissive Tract

Favorable Area

ICBEMP Study Area Boundary

87% Percent of total undiscovered Zn resources in ICBEMP

Tract A Includes tracts:

C14 - Sed. Exhalative Zn-Pb
W16 - Sed. Exhalative Zn-Pb
W07 - Sed. Exhalative Zn-Pb
C07 - Polymtl. replacement
W08 - Miss. Valley type Pb-Zn
C02 - Au Skarn
C15 - Pb -Zn Skarn

Figure E: Location of 87% of estimated undiscovered Zn resources in the ICBEMP

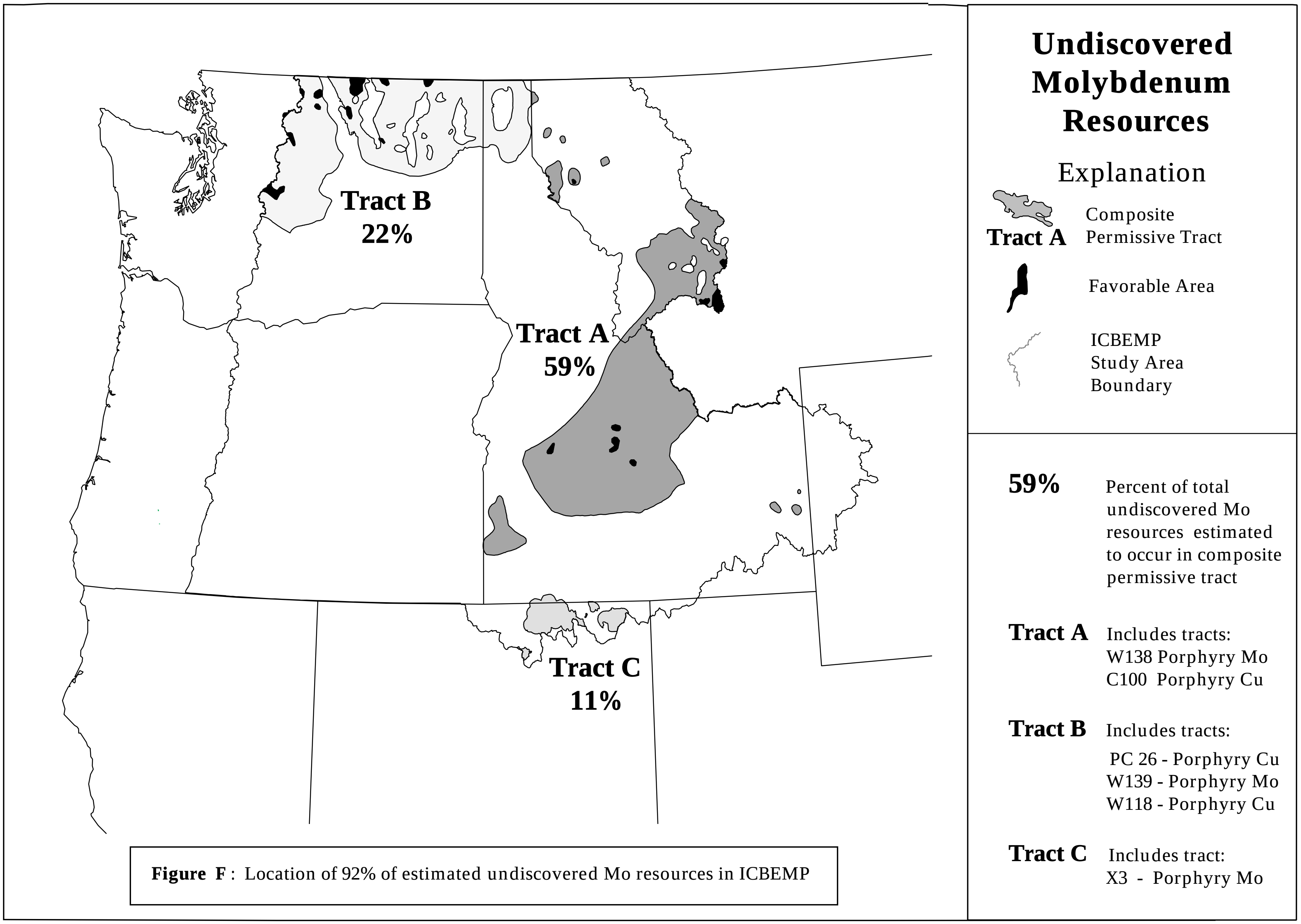
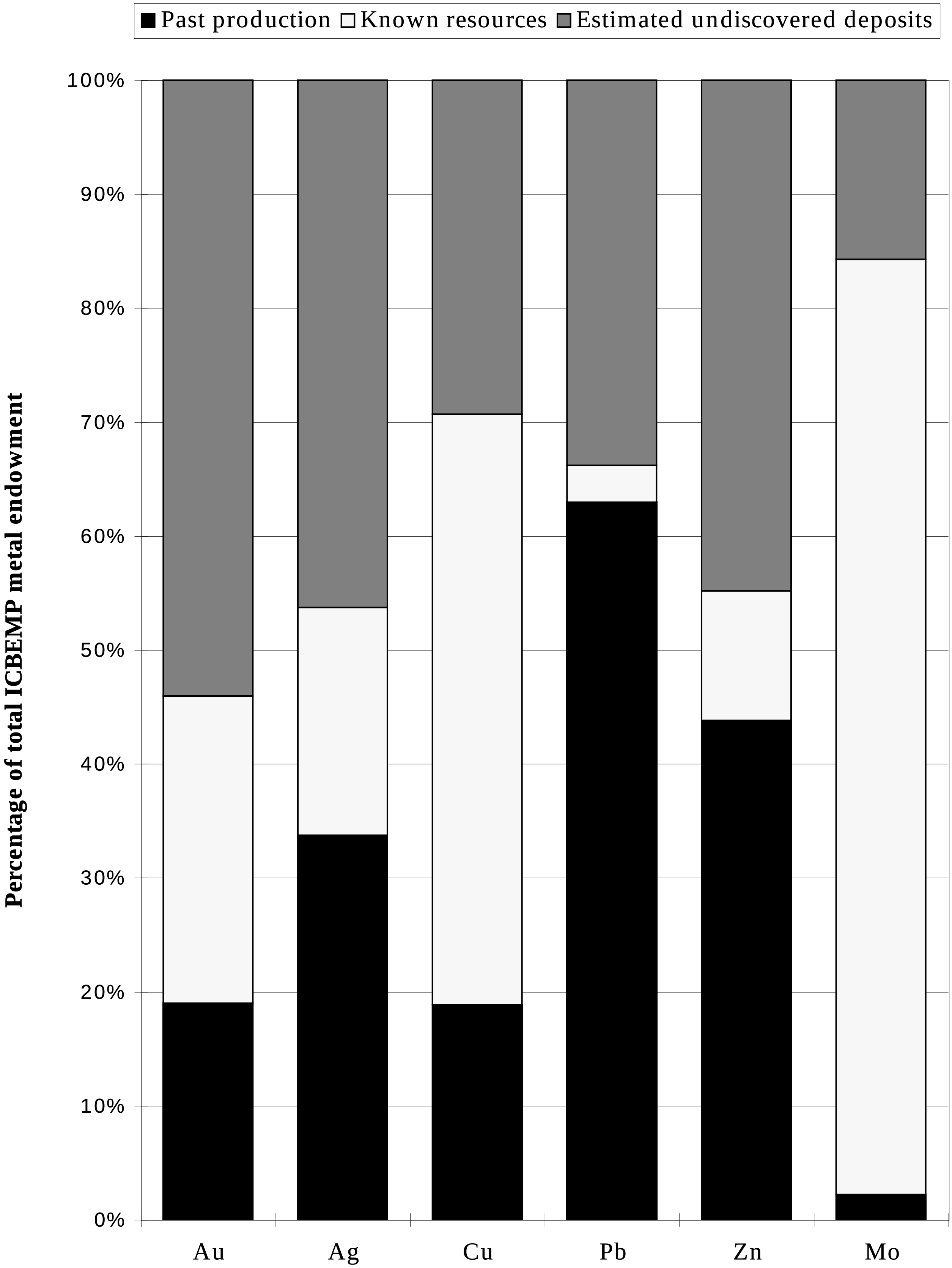


Figure F: Location of 92% of estimated undiscovered Mo resources in ICBEMP

Figure G: Relative apportionment of total metal endowments of the Interior Columbia Basin between past production, known but unmined resources, and estimated undiscovered deposits.



Introduction

This report is one in a series of digital maps, data files, and reports generated by the U.S. Geological Survey to provide geologic process and mineral resource information to a U.S. Forest Service and Bureau of Land Management interagency project, the Interior Columbia Basin Ecosystem Management Project (ICBEMP). The ICBEMP was initiated in early 1994 to develop an ecosystem management framework and assessment for land administered by the Forest Service and the Bureau of Land Management on those lands east of the Cascade crest within the interior Columbia River Basin. The project area includes all of the Columbia River drainage basin in the United States, east of the Cascade Mountain divide plus the remainder of southeastern Oregon which is not within the drainage basin (boundary shown on figure 1a). The project objectives are to:

- Conduct a <u>broad scientific assessment of the resources</u> within the interior Columbia River basin to characterize and assess landscape, ecosystem, social, and economic processes and functions and describe probable outcomes of various management practices and trends.
- Develop an <u>ecosystem management framework</u> that includes principles and processes which may be used in a National Environmental Protection Act (NEPA) process to develop management direction for federal agencies at all levels with the basin.
- Write an <u>Eastside Environmental Impact Statement</u> (EIS) proposing a broad array of alternative strategies for an area that encompasses ten national forests and portions of four BLM districts in eastern Washington and Oregon (western half of the ICBEMP study area; fig. 1a).
- Write an <u>Upper Columbia River Basin EIS</u> with a similar array of alternative strategies for an area that encompasses lands administered by the BLM and USFS in Idaho, western Montana, Wyoming, Utah, and Nevada within the Columbia River Basin (eastern half of the ICBEMP study area; fig. 1a).
- Conduct a <u>scientific evaluation of issues and alternatives</u> identified through the NEPA scoping process for the Eastside EIS.

The scope and extent of the project area varies depending on the objective. The broad scientific assessment considers all lands, not just those that are federally managed. It is focused on the Columbia River Basin but is not strictly limited to the actual drainage basin boundaries. Some scientific assessment staff from the USFS and BLM have extended their work beyond the formal project area because factors such as wildfires and wildlife migration are not limited to drainage divides or political boundaries. Most of the staff study groups use the Landscape Characterization boundary developed by the Landscape Ecology group (boundary shown on figure 1b). The broad assessment uses information suitable for compilation at a scale of 1:1,000,000.

In June, 1994, the USGS was asked by staff of the ICBEMP to provide economic data about undiscovered mineral resources for the basin. Accurate, objective information that allows comparison of mineral resources with other natural, economic and cultural resources is essential to the development of sound land-management plans. Mineral resource information is further enhanced as a land-planning tool when expanded to include predictions of the location and types of environmental impacts that could result from mineral-resource development. Information on mineral resources and their possible environmental effects allows land managers to consider both the economic benefits that result from mining and the environmental consequences of past, present, and future mineral production. For this report we present information on known and undiscovered mineral deposits in the area bounded by 39º N latitude and the Canadian border and by 107.5º W longitude and the Pacific coast, encompassing the entire states of Washington, Oregon, and Idaho, the northern parts of California, Nevada, and Utah, and the western parts of Montana and Wyoming (see figure 1a). Quantitative estimates of the number of undiscovered deposits were made for all tracts (or portions of tracts) that lie within the ICBEMP study boundary (shown on fig. 1a) and for which a grade and tonnage model is available. In some cases estimates were made both for the portion of a tract that lies with the ICBEMP study boundary and for the entire tract both inside and outside the boundary.

Procedures used in the Mineral-Resource Assessment

Mineral-resource assessments provide inventories of the past production and remaining resources of known mineral deposits (Bookstrom and others, 1996), indicate areas where the geology permits various deposit types, and gives estimates (at various confidence intervals) of the numbers of undiscovered deposits of each type (this report). The estimates of undiscovered deposits, in conjunction with the appropriate grade and tonnage information, provide the basis for forecasts of metal endowments of the areas under consideration. These quantitative estimates can be directly incorporated into economic assessment modeling done by the US Bureau of Mines and land-management agencies to evaluate various management scenarios.

The basis of the US Geological Survey approach to mineral assessment is the development of *mineral deposit models* (Cox and Singer, 1986). Mineral deposits sharing a relatively wide variety and large number of attributes are characterized together as a "type", and a model representing that type is developed. The model summarizes the geological environment of the deposit and the identifying characteristics of the mineral deposits themselves. If production and reserve information are available from enough known deposits of a given type, statistical models of the tonnage and grade (amount of a commodity expressed as a percentage by weight of the host rock) of these deposits are developed. Using the grade and tonnage models, the probable size and grade of undiscovered deposits can be statistically inferred.

The USGS has developed a 3-step method to assess the mineral-resource potential of an area (Root and others, 1992). The process begins with evaluation of relevant regional geological, geochemical, and geophysical data, and site-specific data on the known mineral deposits and prospects from the area. Known deposits are classified into types based on mineral deposit models. In the first step of the method, this information and available mineral deposit models are used to outline areas whose geologic characteristics allow the possibility of the presence of specific mineral deposit types. A "permissive tract" for a specific mineral deposit type does not necessarily outline an area that is favorable for the occurrence of that deposit type, but simply outlines the area where the occurrence of a given deposit type cannot be excluded using regional geologic considerations. The possibility of the occurrence of this mineral deposit type outside the permissive tract is negligible. For this study some permissive tracts are divided along arbitrary boundaries (i.e. state lines, study area boundaries) to facilitate their use in assessments within those boundaries.

In the second step in the assessment procedure, a team of experts makes an estimate of the number of undiscovered mineral deposits of each type expected in a tract permissive for that deposit type. The estimate is made for a number of confidence intervals (90% chance of *X* or more deposits with a grade and tonnage distribution similar to that in a given grade and tonnage model, and similarly at 50%, 10%, 5%, and 1%). To subjectively estimate the number of undiscovered deposits present within given tracts, several factors must be considered (Root and others, 1992). First, the estimate must be consistent with the grade and tonnage models for the deposit type. That is, the median undiscovered deposit is assumed to have grade and tonnage characteristics like that of the median deposit from the grade and tonnage models. Second, the methodology used to make the estimate is dependent on the type, amount, and nature of available geologic data. If the level of information is low, the number of deposits will be estimated by analogy to geologically similar areas. This method implicitly or explicitly assumes a frequency distribution of deposits within geologically similar tracts (expected number of deposits per unit area). If the level of information is sufficiently high, the number of undiscovered deposits can be estimated by using identified exploration targets such as mineralized systems or geological features closely associated with mineralized systems. In such cases, the probability that a particular target represents one or more deposits is estimated from the specific geological features of that target. In most cases, a combination of the two methods is used. The third factor that affects the estimates of undiscovered deposits is knowledge of the spatial distribution and effectiveness of previous mineral exploration in the region. Where exploration has been thorough, estimates of undiscovered deposits may be zero. It is more typical that exploration has been areally limited and of uncertain effectiveness.

The third step of the assessment procedure is to combine the estimates of the types and numbers of deposits with the grade and tonnage models in a numerical simulation ("MARK3 simulation") to produce a probability distribution of the quantities of contained metal in undiscovered deposits (Root and others, 1992). In this way, the geologist's knowledge is made available to the economist or decisionmaker in a form readily adaptable to further analysis. An economic analysis of future mineral development, based on the numerical simulation developed here, has been completed by the US Bureau of Mines (L. Blackman, USBM, written communication, 1995).

In addition to the permissive areas for the occurrence of undiscovered deposits of each type, favorable areas for the occurrence of undiscovered deposits were also delineated for the Interior Columbia Basin assessment. Factors that influenced the delineation of favorable tracts include: the presence and clustering of prospects of the appropriate deposit type, their association with favorable geologic features, the presence and clustering of stream sediment geochemical anomalies for appropriate elements, clustering of active (as of September, 1994) mining claims (using contoured maps of BLM registered mining claims, provided by Paul Hyndman, US Bureau of Mines), and known exploration activity. These favorable areas represent our best estimate of where mineral exploration and development are most likely to occur in the next ten to twenty years.

Presentation of the Mineral Resource Assessment

The assessment of undiscovered mineral deposits in the Pacific Northwest considers the potential for undiscovered deposits of 30 different mineral deposit types. These deposit types contain most of the known and undiscovered resources of gold, silver, copper, lead, zinc, molybdenum, cobalt, and platinum group elements in the Pacific Northwest.

The assessment for each deposit type is presented in a separate chapter. Each chapter begins with a general description of the deposit type. The general description of each deposit type includes its geologic setting, its genesis, the deposit shape, the median size and grade, and some key references.

The general deposit description is followed by two maps: the first map shows the permissive tracts and favorable areas for the deposit type in the Pacific Northwest, along with the outline of the ICBEMP study area. The second map shows the location of significant known deposits of that type in the map area along with the outline of the Landscape Characterization study area for the ICBEMP. The maps are followed by a table of past production, known resources, and development status of significant known deposits. Significant deposits are defined here as those whose contained metal (production plus remaining resource) exceeds one of the following criteria: gold - 2 metric tonnes, silver - 85 metric tonnes, copper - 50,000 metric tonnes, lead - 30,000 metric tonnes, and zinc - 50,000 metric tonnes. According to Singer (1995), deposits of this size range may represent close to 99 percent of the metal that has been discovered. Singer (1995) did not include molybdenum in his analysis; for this study deposits at least 14,000 metric tons of molybdenum were included in the compilation. For an area bounded by 39° N latitude and the Canadian border and by 107.5°W longitude and the Pacific coast, 410 deposits were located that met these criteria. More extensive information and source references on these significant deposits are presented in Bookstrom and others (1996).

After the maps and table, tracts are described individually (in alphabetical order). Individual tract descriptions (and the tract boundaries) were provided by regional experts and are individually authored. The title bar for each tract gives the tract number, the deposit type, the deposit model number from Cox and Singer (1986) or from the specified reference, the mean number of undiscovered deposits, and the state(s) in which the tract lies. The mean number of undiscovered deposits is derived from the Mark3 simulation of the estimated number of undiscovered deposits (Root and others, 1992).

In the text of the individual tract descriptions, the rationale for delineation of each permissive tract is described, and the references used to define the tract boundary are given. Information on the rationale for delineating the favorable areas within the permissive tract is also presented. Important examples of this deposit type in the permissive tract are briefly described. Estimates of the number of undiscovered deposits are given for each of the tracts that falls within the ICBEMP study area and that has available grade and tonnage models. For tracts that overlap the ICBEMP study area boundary, an estimate is given for that part of the tract within the boundary, and, in some cases, for the entire overlapping tract as well. The rationale for the estimate of the number of undiscovered deposits (or the rationale for not making an estimate) are briefly discussed.

Several appendices are included at the end of the report and are described in more detail on the first page of each appendix. Appendix A graphically presents the results of a Mark3 numerical simulation (Root and others, 1992) of the probability distribution of the quantities of contained metal in undiscovered deposits for each tract within the ICBEMP (listed alphabetically). Appendix B lists all the permissive tracts discussed in this report (arranged by deposit type in the order of presentation in the text) with some relevant information in tabular form. Appendix C1 consists of a table that lists the percentages of each permissive tract that occurs within each listed Ecological Reporting Unit (ERU) of the ICBEMP. Appendix C2 presents a table that lists the percentages of favorable area within each permissive tract that occurs within each listed ERU. Appendix D gives information on the digital coverages of the 30 maps of permissive terranes and favorable areas and how these can be obtained from the Internet.

Acknowledgements

We were greatly helped by numerous geologists familiar with specific areas, mineral deposits, or mineral deposit-types throughout the Interior Columbia Basin, and we thank them for all the help we were given. However we would also like to apologize and accept the blame for any misinterpretations of their data or explanations that we present in this report. We thank Tom Frost (USGS) for his encouragement throughout the project and for helping us to understand the kinds of data that were needed by the ICBEMP project members. Steve Ludington (USGS) repeatedly provided scientific guidance to our efforts and we are grateful for his commitment. Bill Scott (USGS) graciously provided the Mark3 simulator output through several iterations. Barry Moring and Kathy Conners (both USGS) provided digital files to help us complete our coverage of the area. Dave Frank (USGS) helped us locate USGS records of mines and prospects throughout the ICBEMP area. Paul Hyndman (formerly with the US Bureau of Mines) was extremely helpful in working with us to generate density maps of active and inactive mining claims from his database of BLM mining claim locations. Theresa McKay (Eastern Washington University) developed all the page-size illustrations for this report in Adobe Illustrator from Arc-info coverages, and we thank her for her care and dedication in performing that task. We thank Bob Kamilli (USGS) for taking on the

unhappy task of reviewing this massive document; his careful editing and technical comments greatly improved the final product.

Mineral Resource Assessment by Mineral Deposit type

Alkaline Au-Te Deposits

<u>General Deposit Description</u>

Alkaline Au-Te deposits consist of veins, stockworks, breccias, and disseminations of gold telluride minerals and lesser associated sulfide minerals in a gangue of quartz, calcite, fluorite, barite, and vanadium mica (Cox and Bagby, 1986). These deposits are spatially, and presumably genetically, associated with hypabyssal or extrusive potassic, silica-undersaturated alkalic rocks (Mutschler and Mooney, 1995). Host rocks and ore controls can be quite varied. Some of the well-studied examples (Cripple Creek and Boulder County, Colorado and Vatukoula, Fiji) are characterized by the occurrence of precious-metal tellurides and the presence of vanadium-bearing mica (roscoelite) in the alteration assemblage. The median tonnage and grade of this deposit type (Bliss and others, 1992) are, respectively, 2 million metric tonnes with 6.6 g Au/tonne and 3.4 g Ag/tonne.

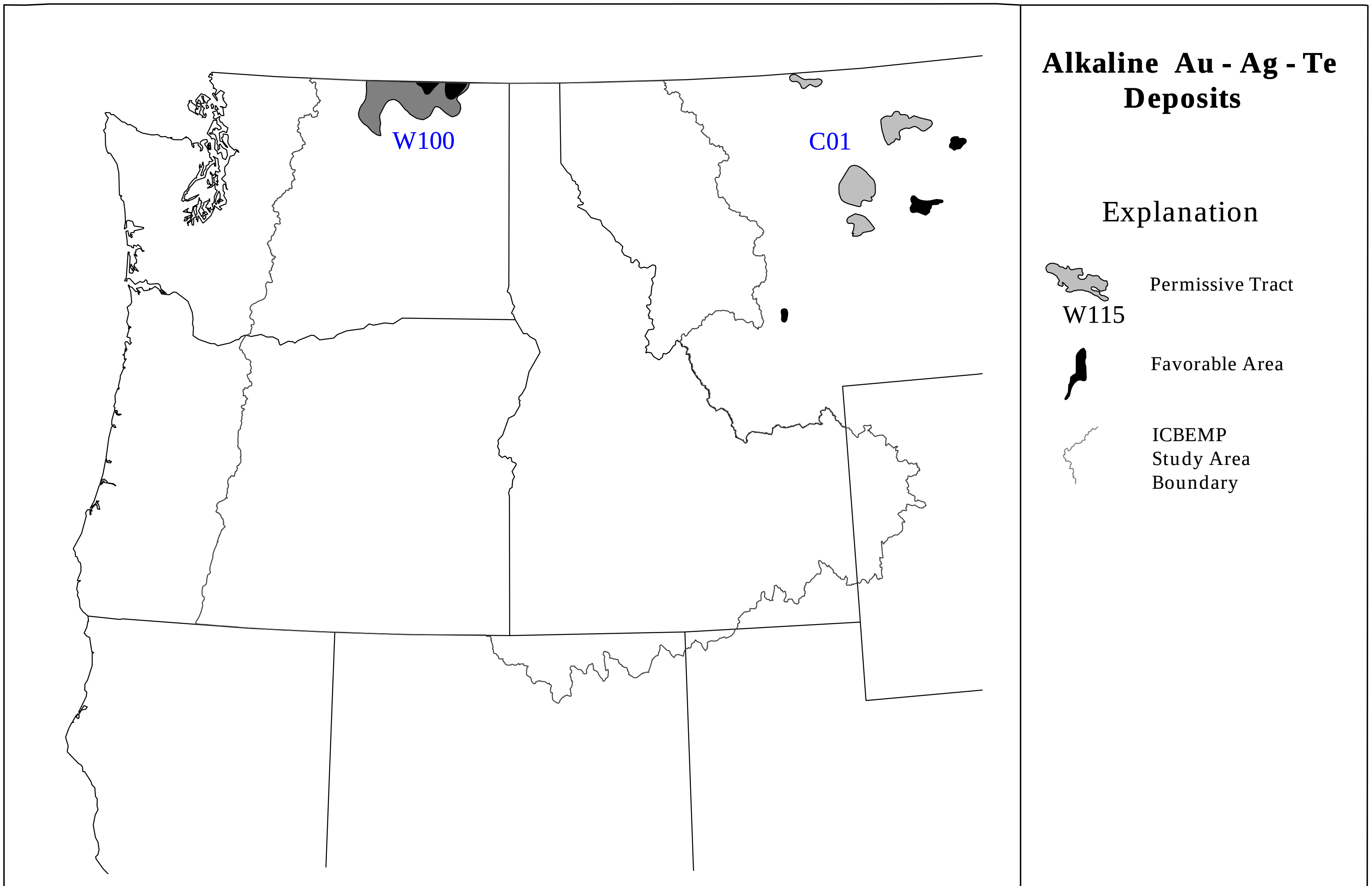


Figure 1a: Permissive and favorable tracts for Alkaline Au-Ag-Te deposits.

Alkaline Au - Ag - Te Deposits

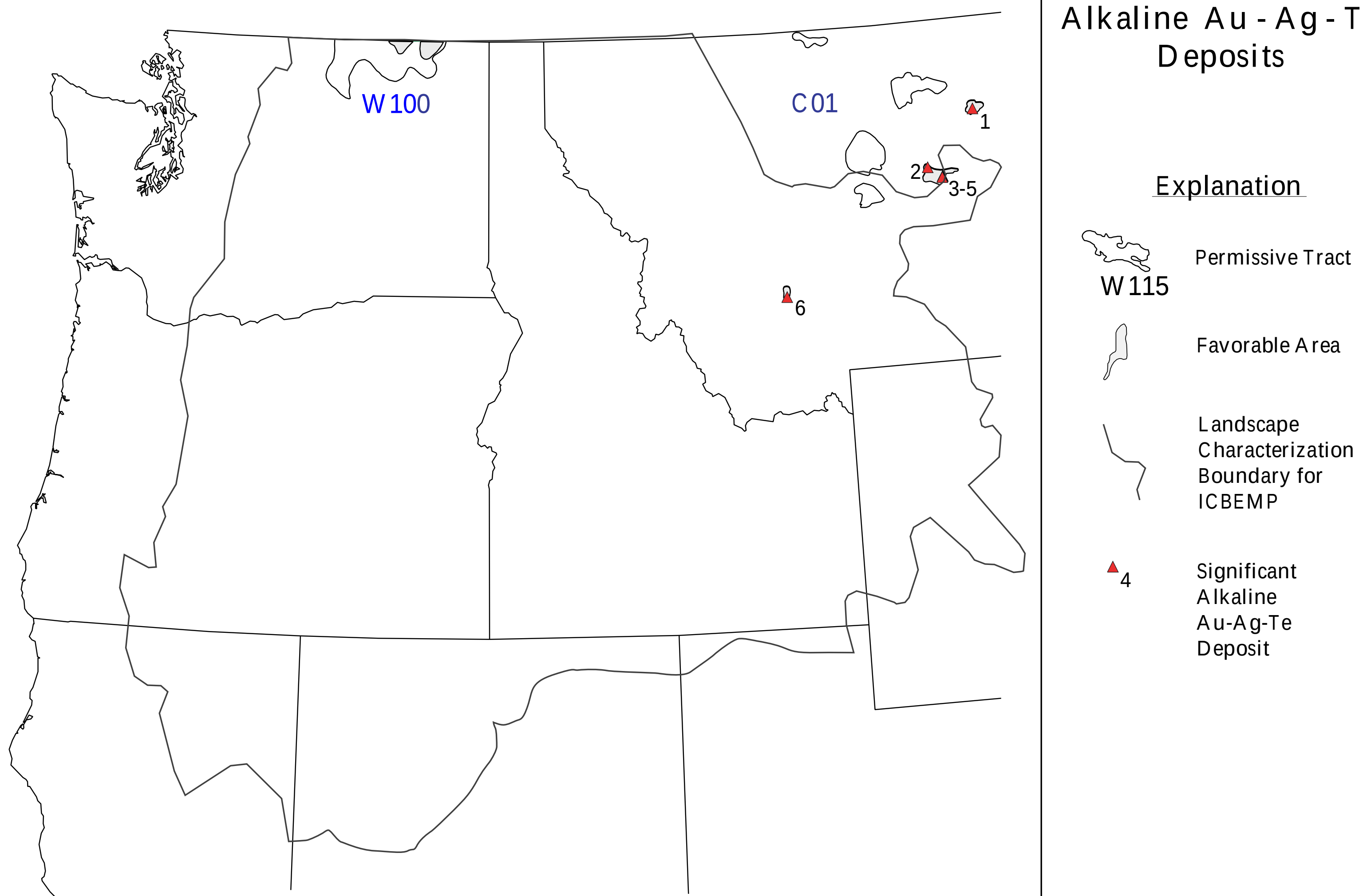


Figure 1b: Location of significant Alkaline Au-Ag-Te deposits in the map area.

Table 1: Significant alkaline Au-Ag-Te deposits in the map area

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status (*)
01	C01	Zortman - Landusky	Little Rocky Mountains	Phillips	MT	47.929	-108.586	P
02	C01	Canyon Resources	Kendall	Fergus	MT	47.294	-109.459	P
03	C01	Spotted Horse	Warm Springs (Maiden)	Fergus	MT	47.176	-109.210	I M
04	C01	Maginnis	Warm Springs (Maiden)	Fergus	MT	47.176	-109.219	I M
05	C01	Gilt Edge	Warm Springs (Gilt Edge)	Fergus	MT	47.144	-109.226	S
06	C01	Golden Sunlight	Whitehall	Jefferson	MT	45.906	-112.014	P

(*) - Explanation of status symbols

P = presently producing mine

S = recently producing mine that is being maintained for possible return to production

FM = Inactive mining property with announced reserves that is undergoing feasibility studies

FD = Unmined deposit with announced resources that is undergoing feasibility studies

IM = inactive mine

ID = inactive deposit with known resources

exr = suffix to IM and ID; "e" = recent exploration activity; "x" = depleted resources; "r" = undergoing reclamation

Table 1: Significant alkaline Au-Ag-Te deposits in the map area

Map No	Tract No	Deposit Name	Au production (tonnes)	Ag production (tonnes)	Cu production (tonnes)	Au resources (tonnes)	Ag resources (tonnes)
01	C01	Zortman - Landusky	87.53	373	unk (#)	35	315
02	C01	Canyon Resources	28.77	11	unk	10	unk
03	C01	Spotted Horse	5.45	0.46	0.91	neg	neg
04	C01	Maginnis	2.92	0.75	unk	neg	neg
05	C01	Gilt Edge	2.18	0.10	unk	neg	neg
06	C01	Golden Sunlight	65.46	40	25	55	25

(#) - Explanation for production and resource abbreviations

unk = production or resources suspected, but unknown amount

neg = known production or resources, but negligible amount

sig = significant known production or resources, but cannot be quantified

none = known to be zero

blank entry = no reported production or resources

Tract Descriptions

C01 — Alkaline Au-Te Deposits — Montana

Descriptive Model 22B

• 6.2 mean undiscovered deposits

by David Frishman

Rationale for Tract Delineation

The permissive tract was defined primarily by the location of Cretaceous and Tertiary alkaline intrusive centers that are part of what has been called the Central Montana Alkalic Province (CMAP, Baker and Berg, 1991). This province is characterized by alkaline (dominantly potassic) rocks that occur with subalkaline rocks. Tracts were identified based on lithologic information presented on the state map compiled by Ross and others (1955) supplemented by the personal knowledge of the assessors. Geophysical evidence was used to extend some tracts into covered areas where alkaline plutons may occur in the subsurface. In general, however, the country between known igneous centers, that lacks specific evidence for the existence of concealed intrusions, was excluded. If it were included, the area of this tract would be several times larger, and the apparent density of undiscovered deposits commensurately lower. The intrusive centers identified include those in productive districts (the Judith, North Moccasin, and Little Rocky Mountains, as well as the area around Whitehall), as well as other areas where alkaline rocks of late Cretaceous to early Tertiary age are present. These areas include the South Moccasin Mountains, the Sweet Grass Hills-Gold Butte area near the Canadian border, the Bearpaw Mountains-Rocky Boy area, the Highwood Mountains, and the northern portion of the Little Belt Mountains. The favorable tracts are based on personal knowledge of prospective occurrences and exploration activity, as well as that of another regional expert (James Elliot, USGS).

Important Examples of Deposit Type

The Golden Sunlight mine near Whitehall (#6 on Figure 1b), the Zortman and Landusky mining areas in the Little Rocky Mountains(#1, figure 1b), and the Canyon Resources mine (#2, figure 1b; formerly the Barnes-King, Muleshoe, Horseshoe, and other underground mines) in the Kendall mining district, North Moccasin Mountains are all large producing mines (Foster and Childs, 1993). The Gies mine (Cone Butte district) and the Spotted Horse mine (#3 on Figure 1b), both in the Judith Mountains, were minor producers in the late 1980s or early 1990s, and the Spotted Horse, Gilt Edge (#5 on Figure 1b), and Maginnis mines (#4 on Figure 1b), the Barnes-King, Horseshoe, Muleshoe and other mines (Kendall district), and numerous mines in the Zortman and Landusky areas in the Little Rocky Mountains were important producers in first half of this century. Numerous gold and fluorite prospects occur in the Bearpaw Mountains and the Sweet Grass Hills; mining companies have explored both of these areas for gold in recent years.

In the Kendall mining district, most ore is disseminated but stratabound in brecciated Mississippian Madison Limestone, whereas in the Little Rocky Mountains mining area, the vast majority of the tonnage has been produced from epithermal crackle-breccias developed in the intrusive rocks themselves. In the Judith Mountains, most production has come from the contact zone between the intrusive rocks and enclosing limestones, whereas at the Golden Sunlight mine in the Whitehall district, ore is associated with potassic alteration and molybdenum mineralization and is localized in a breccia pipe.

Rationale for Numerical Estimate

As defined by Bliss and others (1992), alkaline Au-Te deposits are small, exhibiting a median of 1.78 million metric tonnes of ore with a median Au grade of nearly 10 g/t. Most of the producing mines in Montana are larger and lower in grade (Zortman-Landusky contains more than 100 million metric tonnes of ore at 0.6 g/t Au; Golden Sunlight contains 70 million metric tonnes of ore at 1.8 g/t Au), but the assessment was made using the low tonnage and high grade specified in the deposit model. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 1, 6, 11, 12, and 20 or more deposits consistent with the grade and tonnage model of Bliss and others (1992).

W100 — Alkaline Au-Te Deposits — Washington

Descriptive Model 22B

• 0.1 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was defined primarily by the location of Mesozic and Paleozoic rock units of the Quesnellia island arc terrane (Stoffel and others, 1991), which hosts Late Triassic to Early Jurassic alkalic intrusive bodies in a late-stage shoshonitic volcanic-intrusive setting (Mortimer, 1986). Eocene alkalic rocks occur sporadically within the Quesnellia terrane near the Canadian border, and have some associated Au prospects. The tract includes several known alkalic intrusive centers (Fox, 1973), with several known telluride-bearing gold deposits. Favorable areas outlines are based on knowledge of occurrences, exploration activity, and US Bureau of Mines plots of mining claim densities.

Important Examples of Deposit Type

The Rossland camp near Rossland, British Columbia (40 km north of the Canada-U.S. border) is considered by some to be a deposit of this type (Fyles, 1984). This deposit is associated with Early Jurassic alkalic volcanic rocks and shallow intrusive bodies. Its tonnage is greater than over 90 percent of deposits of this type. The Comstock and Gold Dike deposits in the Shasket Creek district (western favorable tract in figure 1b) occur in syenitic dikes cutting older Quesnellia terrane rocks (Herdrick and Bunning, 1984; Tschauder, 1989). The grade and tonnage of these deposits are slightly less than the median for this deposit type, and are too small for inclusion with the significant deposits in Table 1.

Rationale for Numerical Estimate

As defined by Bliss and others (1992), alkaline Au-Te deposits are small, exhibiting a median of 1.78 million metric tonnes of ore with a median Au grade of nearly 10 g/t. The Rossland deposit is much larger than the median size and Shasket Creek is slightly smaller than the median. Favorable areas for undiscovered deposits are located south of Rossland in the U.S., near the Shasket Creek intrusive bodies, and near the Similkameen alkalic pluton to the west. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 2, 4 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model for Au-Ag-Te deposits associated with alkaline rocks (Bliss and others, 1992).

Massive sulfide, Besshi-type deposits

General Deposit Description

Besshi massive sulfide deposits are thin, sheetlike bodies of massive to well-laminated pyrite, pyrrhotite, and chalcopyrite within marine clastic sediments and mafic tuffs associated with submarine mafic volcanic and subvolcanic rocks (Fox, 1984; Cox, 1986a). The general exploration criteria for these deposits include: (1) host rocks--clastic sedimentary rocks and interbedded mafic volcanic tuffs and breccia host rocks; (2) local association with black shale, oxide-facies iron formation and red chert; (3) formation from submarine hot springs related to basaltic magmatism in rifted basins in island-arc or back-arc tectonic settings. The genesis of this deposit type is uncertain due to the amount of regional deformation and metamorphism of the deposits in the type locality in Japan.

Besshi-type volcanic-hosted massive sulfide ore deposits produce copper and zinc, with gold and silver as common byproducts. Relatively high grades of polymetallic ores, simple metallurgy, and potential for large deposits make these deposits an attractive exploration target. Besshi deposits have a median tonnage of 220,000 metric tonnes with a median Cu grade of 0.64% (Singer, 1986c).

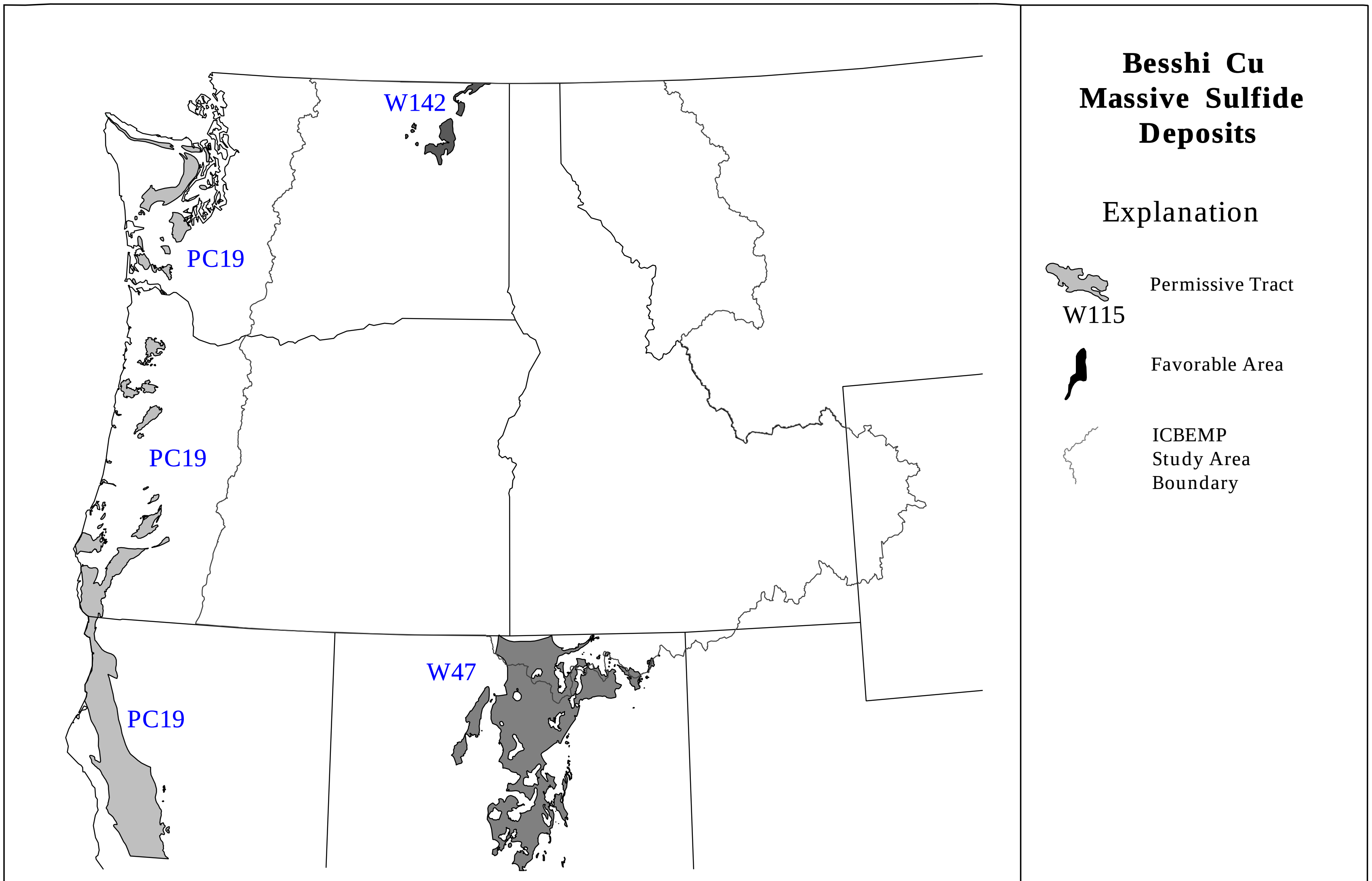


Figure 2a: Permissive and favorable tracts for Besshi Cu massive sulfide deposits.

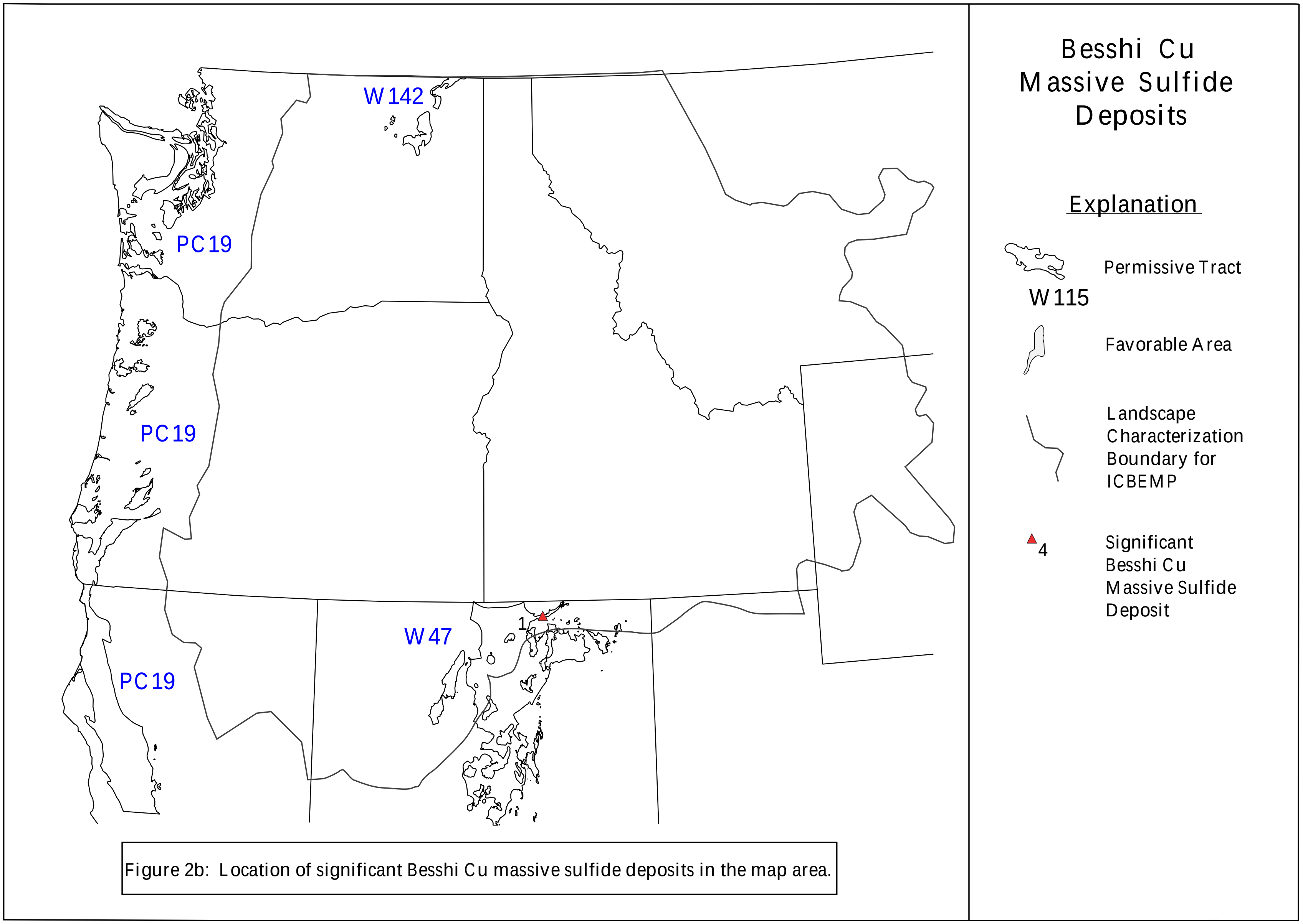


Figure 2b: Location of significant Besshi Cu massive sulfide deposits in the map area.

Table 2: Significant Besshi massive sulfide deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W47	Rio Tinto	Mountain City	Elko	NV	41.810	-115.980	I M

Table 2: Significant Besshi massive sulfide deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	**Tract No**	**Deposit Name**		**Au production (tonnes)**	**Ag production (tonnes)**	**Cu production (tonnes)**		**Cu resource (tonnes)**
01	W47	Rio Tinto		0.20	9.4	98,116		103,900

Tract Descriptions

PC19 | **Besshi massive sulfide deposits** | **Washington Oregon California**

Descriptive Model 24b
• 0.01 mean undiscovered deposits
(OR-WA portion only)

by Dennis Cox and Steve Ludington

Rationale for Tract Delineation

One massive sulfide deposit, Island Mountain, occurs in the Cretaceous Franciscan complex in California and Oregon. Island Mountain is difficult to classify as to massive sulfide type but, as it is in a sedimentary rather than volcanic environment, it most resembles a Besshi-type deposit. We have, therefore, included all of the Franciscan complex in a permissive tract for Besshi deposits even though only one example is known and only a small amount of this map unit is probably favorable for the occurrence of volcanogenic massive sulfide deposits. The Franciscan complex is composed chiefly of graywacke, siltstone, chert, and greenstone (Dickinson and others, 1982). In western Oregon and Washington, the submarine basalt and minor intercalated sedimentary rocks of the Tertiary Crescent Formation and its equivalent units are considered permissive for Besshi deposits although no occurrences are known.

Important Examples of Deposit Type

The Island Mountain massive-sulfide deposit (in California south of study area), which has produced 120,000 metric tonnes of pyrrhotite-rich ore averaging 3.3 percent Cu, 33 g/t Ag, and 2 g/t Au, was classified as a Besshi-type deposit by Koski and others (1993). Host rocks are a mélange of sandstone, siltstone, and minor chert and greenstone.

Rationale for Numerical Estimate (Oregon and Washington portion only)

Since the area lies entirely outside the ICBEMP study area, the team did not make an estimate of undiscovered deposits for the entire tract. Because of the proximity of the Oregon and Washington portion of the tract to the ICBEMP study area, the team made an estimate for that portion of the tract. Because the one Besshi type deposit in the tract occurs well south of the Oregon-California border, the team made a low estimate for the number of undiscovered deposits in Oregon and Washington. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered deposits (with a 99% chance of no deposits) consistent with the Besshi grade and tonnage model of Singer (1986c).

W47 | **Besshi massive sulfide deposits** | **Nevada**

Descriptive Model 24b
• 0.1 mean undiscovered deposits
(portion in ICBEMP area only)

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

Besshi deposits are stratabound, tabular bodies of massive iron, copper, and minor zinc sulfides found in sedimentary rocks in volcanic environments (Fox, 1984). The permissive tract is based on the distribution of rocks of the Ordovician Roberts Mountains assemblage, which include seafloor basalts, and represent a deep-water assemblage.

Important Examples of Deposit Type

The Rio Tinto copper deposit at Mountain City (#1, figure 2b) occurs in graphitic shale of the Valmy formation in the Roberts Mountains allochthon and has some similarity to Besshi deposits worldwide. It lacks a close association with mafic flow rocks, which are present in the best examples of the Besshi model in Japan, the eastern United States, and Norway.

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W47 that lies within the ICBEMP study area (figure 2a). An estimate of the number of undiscovered Besshi massive sulfide deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W47 lies within two counties. To arrive at the numerical estimate of undiscovered Besshi massive sulfide deposits in the ICBEMP portion of tract W47, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 0.14 mean undiscovered Besshi massive sulfide deposits for the part of the ICBEMP study that extends into tract W47. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 1, 2, and 3 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Singer (1986c) is equivalent to the estimated number of mean undiscovered deposits derived above.

W142 — Besshi massive sulfide deposits — Washington

Descriptive Model 24b

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The Kootenay terrane or Covada Group consists of a Paleozoic continental slope and rise sequence west of the North American Paleozoic continental shelf sequence (Smith and Gehrels, 1992). Sporadic occurrences of ferruginous chert associated with volcanic rocks indicate synvolcanic hot-spring activity, which is believed to be conducive to the formation of Besshi-type massive sulfide deposits. The permissive tract was drawn to include all of the Covada Group in the U.S. (Stoffel and others, 1991).

Important Examples of Deposit Type

Two important deposits of this type are known from this belt of rocks in British Columbia over 100 km north of the Canada-US border. The Goldstream deposit has reserves of 3.2 million metric tonnes containing 4.5 percent copper, 3.1 percent zinc, and 20 grams per metric ton of silver (Hoy, 1991). The True Blue deposit further south is another deposit of this type in British Columbia. In Washington, prospects and small deposits of this type are known but none have been major producers.

Rationale for Numerical Estimate

The lack of known major deposits in Washington or immediately across the border in British Columbia, along with the long history of exploration in northern Washington, cause us to consider this tract to have low potential for undiscovered deposits of this type. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model described by Singer (1986c).

Blackbird Co-Cu Deposits

General Deposit Description

Blackbird sedimentary exhalative copper-cobalt deposits in Idaho and Montana typically contain massive to disseminated pyrite ± cobaltiferous pyrite ± pyrrhotite ± magnetite ± arsenopyrite ± chalcopyrite ± cobaltite ± gold, in association with quartz ± tourmaline ± siderite ± barite, in stratabound layers, lenses, and stringers; and in concordant and discordant breccias (Earhart, 1986). Stratiform deposits are interpreted as submarine accumulations from seafloor hot-springs ("sedimentary-exhalative"). Cross-cutting veins and breccias beneath the stratiform deposits are interpreted to indicate fracture control of hydrothermal feeders and vents. Some selective replacement of subseafloor stratigraphic horizons during hydrothermal activity may also be responsible for stratabound ore horizons. Host rocks generally are fine-grained clastic metasedimentary rocks (argillite, siltite, and quartzite), which may have a basaltic pyroclastic component, and may contain mafic-alkalic intrusions that were emplaced before lithification of the sediments . Ore lenses may occur at multiple stratigraphic horizons, separated by barren metasedimentary rocks. They tend to be localized near basin-bounding fault zones that were active during sedimentation, as evidenced by growth faults, soft-sediment folds, dewatering structures, and(or) intraformational conglomerates (Modreski, 1985; Nash and Hahn, 1989; Nisbet and others, 1994; and Himes and Petersen, 1990). The median tonnage and grade of a deposit of this type (for the three deposits shown in Table 3) is 4.5 million metric tonnes of ore with 0.1% Co and 1.75% Cu.

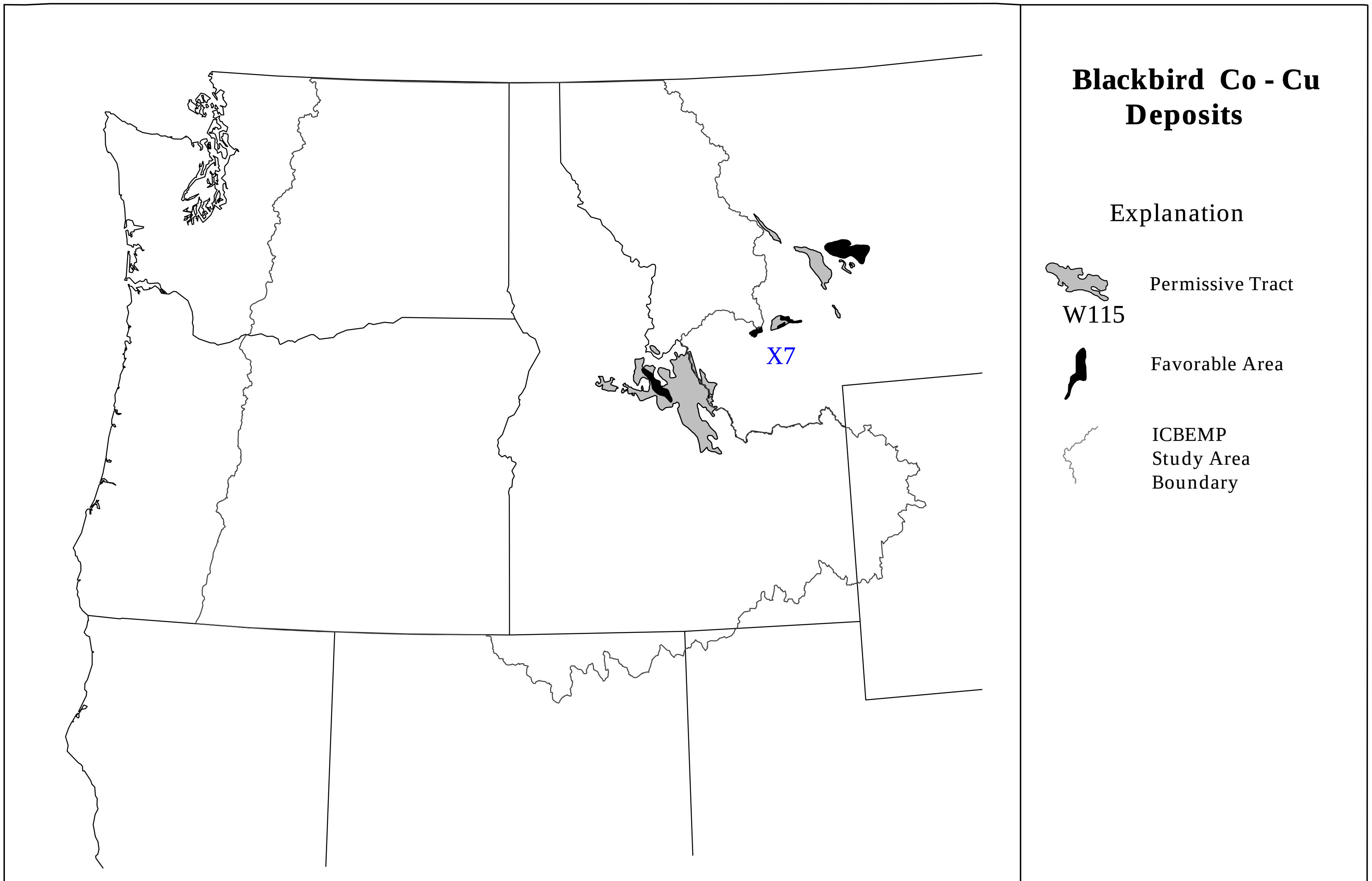


Figure 3a: Permissive and favorable tracts for Blackbird Co-Cu deposits.

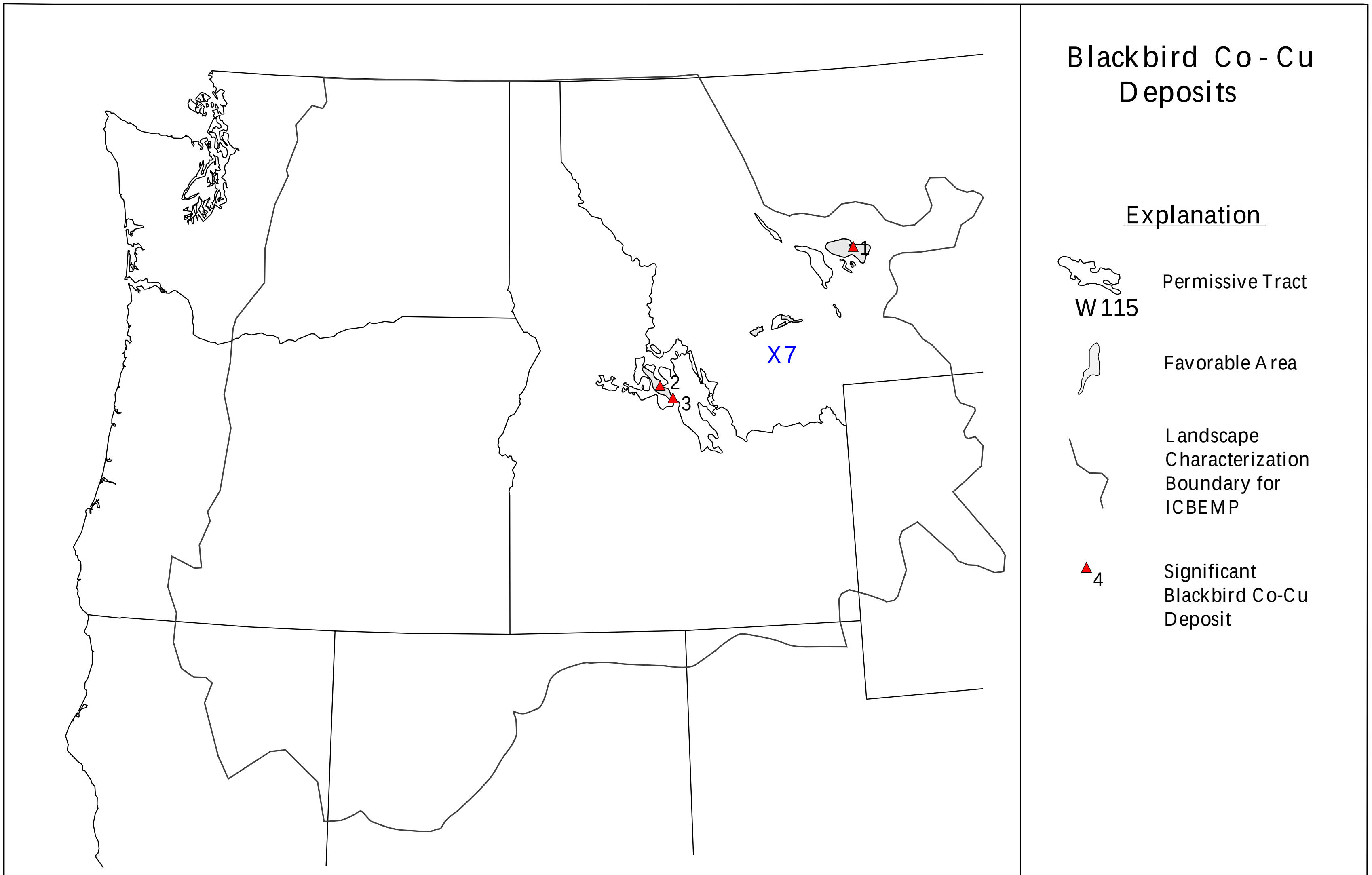


Figure 3b: Location of significant Blackbird Co-Cu deposits in the map area.

Table 3: Significant Blackbird Cu-Co deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	X7	Sheep Creek		Meagher	MT	46.750	-110.680	F D
02	X7	Blackbird	Blackbird	Lemhi	ID	45.121	-114.339	I M
03	X7	Iron Creek	Blackbird	Lemhi	ID	44.962	-114.115	I D

Table 3: Significant Blackbird Cu-Co deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name		Au production (tonnes)	Cu production (tonnes)	Co production (tonnes)		Cu resources (tonnes)	Co resources (tonnes)
01	X7	Sheep Creek		none	none	none		274,428	4,500
02	X7	Blackbird		0.43	91	14		226,800	113,400
03	X7	Iron Creek		none	none			150,956	17,418

Tract Descriptions

X7 **Blackbird Co-Cu Deposits** **Idaho Montana**

Descriptive Model 24d

No estimate of undiscovered deposits

by A.A. Bookstrom, M.L. Zientek, and S.E. Box

Rationale for Tract Delineation

Sedimentary exhalative, Blackbird-type copper-cobalt deposits of Idaho and Montana are hosted in fine-grained clastic metasedimentary rocks of Middle Proterozoic age. Deposits of the Idaho cobalt belt are hosted in the Yellowjacket Formation, which was deposited in the Yellowjacket basin. Deposits of western Montana are hosted in the Newland formation, which was deposited in the Helena embayment of the Belt basin. Metasedimentary rocks of the Yellowjacket Formation (in eastern Idaho), and of the Newland Formation (in western Montana) are considered permissive for the occurrence of sediment-hosted copper-cobalt deposits. The favorable tracts were outlined based on knowledge of occurrences, exploration activity, and a US Bureau of Mines plot of mining claim density.

Important Examples of Deposit Type

The Idaho cobalt belt is located in east-central Idaho. The belt extends northwesterly for about 55 km, along the strike of the Middle Proterozoic Yellowjacket Formation, which contains at least eleven sediment-hosted copper-cobalt occurrences, including the Blackbird (#2, figure 3b), Iron Creek (#3, figure 3b), Blackpine, and Salmon Canyon deposits. Lateral zonation within the Idaho Cobalt belt shows gradations from iron-bearing sulfides, to oxides, to carbonates, to silicates, as in banded iron-formation terranes (Nisbet and others, 1994). Rocks and ores of the Idaho cobalt belt are progressively metamorphosed toward the northwest, and some discordant ore textures are attributed to metamorphic remobilization (Nold, 1990).

The Blackbird deposit has known production and resources of about 226,891 tonnes of copper and 113,414 tonnes of cobalt, in ores that contain about 1.0 % copper, 0.5% cobalt, and 0.5 g Au/tonne (#2, Table 3). The Blackbird mine area contains at least 17 copper-cobalt-gold lodes, which are localized along eight stratigraphic horizons (Nash and others, 1987). The ore-bearing strata are characterized by biotitite (interpreted as mafic-alkalic metatuff) and metachert (interpreted as siliceous exhalite). The stratigraphically lower deposits consist of sub-massive to disseminated ore and gangue minerals--pyrite, pyrrhotite, chalcopyrite, cobaltite, quartz, and siderite--that fill syn-sedimentary disruption structures and veins. The stratigraphically higher deposits consist of metachert layers and lenses that contain finely laminated ore minerals--cobaltite, chalcopyrite, pyrite, native bismuth, and native gold (Nash and others, 1987).

The Blackpine deposit is located about two km southeast of the Blackbird deposit. Nisbet and others (1994) reported 14 mineralized zones that consist of semi-massive chalcopyrite horizons ranging from 7 cm to 1.7 m thick, with grades of 1.0 to 16.4 % copper and 1 g Au/tonne; and disseminated chalcopyrite zones ranging from 15 to 100 m thick, with grades of 0.1 to 1.2 % copper, 30 to 4,000 ppm cobalt.

The Salmon Canyon deposit is located about 27 km northwest of the Blackbird mine. Its ore grades are comparable to those of the Blackbird and Blackpine deposits, but it apparently is smaller and more strongly metamorphosed.

The Iron Creek deposit is located about 30 km southeast of the Blackbird mine (#3, Table 3). It is a large, low-grade deposit that consists of several lenses of abundant cobaltiferous pyrite and scattered chalcopyrite, in a zone as much as 250 m wide and 1,500 m long (Nash, 1989).

The Sheep Creek deposit (#1, Table 3) is located in west-central Montana, near the northeast margin of the Helena embayment of the Proterozoic Belt basin. Two zones of stratabound sulfide ore are separated by the Volcano Valley Fault zone (Himes and Petersen, 1990). The lower sulfide zone consists of stratabound silicified shale with disseminated clots and stringers of fine-grained pyrite, chalcopyrite, and dolomite. The lower zone contains a possible resource of 160,000 tonnes of copper in 4 million tonnes of ore with an average grade of 4% copper (Zieg and Leitch, 1993). The upper sulfide zone is a nearly continuous blanket of bedded, disseminated to massive pyrite that reaches over 90 m thick and extends over a strike length of 25 km. A stratabound copper horizon near the base of the upper sulfide zone reaches 12 m thick and contains disseminated chalcopyrite. It also contains barite-chalcopyrite veins and masses, tennantite, marcasite, and various cobalt minerals. In both zones significant amounts of cobalt, nickel, arsenic and copper are incorporated in pyrite rims (Himes and Petersen, 1990). The upper sulfide zone contains a possible resource of 112,500 tonnes of copper and 4,500 tonnes of cobalt in 4.5 million tonnes of ore with an average grade of 2.5% copper and 0.1% cobalt (Zieg and Leitch, 1993).

Rationale for Lack of Numerical Estimate

No estimates were made of undiscovered resources, because no grade-tonnage model is available, and grade-tonnage information is not available for enough deposits of this type to permit construction of a reliable grade-tonnage model for them. Nevertheless, active exploration programs are underway at both Blackbird and Blackpine, and it is likely that the known resources of both areas will be increased substantially. Furthermore, if prices for cobalt and copper remain at present levels, it is likely that current exploration activities will lead to significant future mining in the Blackbird-Blackpine area. This is possible, because much of the known cobalt (and copper) resources of the world are located in Zambia, where present and near-term political and economic conditions do not foster efficient production.

Bushveld Cr deposits

General Deposit Description

Layered, ultramafic to mafic intrusions, such as the Stillwater Complex, Montana, are uncommon in the geologic record (and in the United States) but are economically important because they can host magmatic ore deposits containing economic concentrations of chromium, nickel, copper, titanium, platinum-group elements (PGE) and gold. Chromite deposits in stratiform layered complexes are tabular sheets of rock enriched in the mineral chromite (Page, 1986a). Chromite is mineral that crystallizes from a mafic to ultramafic silicate magma and can be concentrated into layers by magmatic processes. Chromite abundance in individual layers ranges from those where chromite is only slightly enriched relative to adjacent layers to those that consist entirely of chromite. Chromite seams range from less than 1 cm to a few meters in thickness and are laterally persistent, commonly extending the strike-length of the layered intrusion. Chromite seams commonly are found in sequences of cyclically layered cumulates in the lower parts of the layered intrusions.

Stratiform chromite seams like those in the Bushveld chromium model can be enriched in PGE to the extent that they can be considered for development strictly on their PGE content alone. The UG2 chromite seam in the Bushveld Complex represents one of the major repositories of PGE in the world. The formation of a chromite seam may cause the exsolution of a small amount of immiscible sulfide liquid into which PGE will partition under favorable conditions. Base-metal sulfides and platinum-group minerals may occur as inclusions in or interstitially to chromite. Sulfide mineral abundances in chromitites are generally low, much less than 0.1 volume percent.

Chromite seams are typically found by geologic mapping in layered igneous complexes. Barren and PGE-enriched chromite seams are macroscopically indistinguishable and geochemical analysis is required to establish if chromite seams are enriched in PGE.

Grade and tonnage distributions have not been constructed for these chromite deposits. Sizes of deposits depend on the thickness and lateral continuity of the chromite-enriched layers (which is ultimately limited by the size of the host intrusion). Chromite ores also are classified by the composition of the ores (Cr_2O_3 content and Cr:Fe ratio). Grade and tonnage information for stratiform chromite deposits is summarized in DeYoung and others (1984), Stowe (1987), and Vermaak (1986). The largest resources are in the Bushveld Complex where 100’s of millions of tons of reserves and billions of tons of resources have been identified (Vermack, 1986).

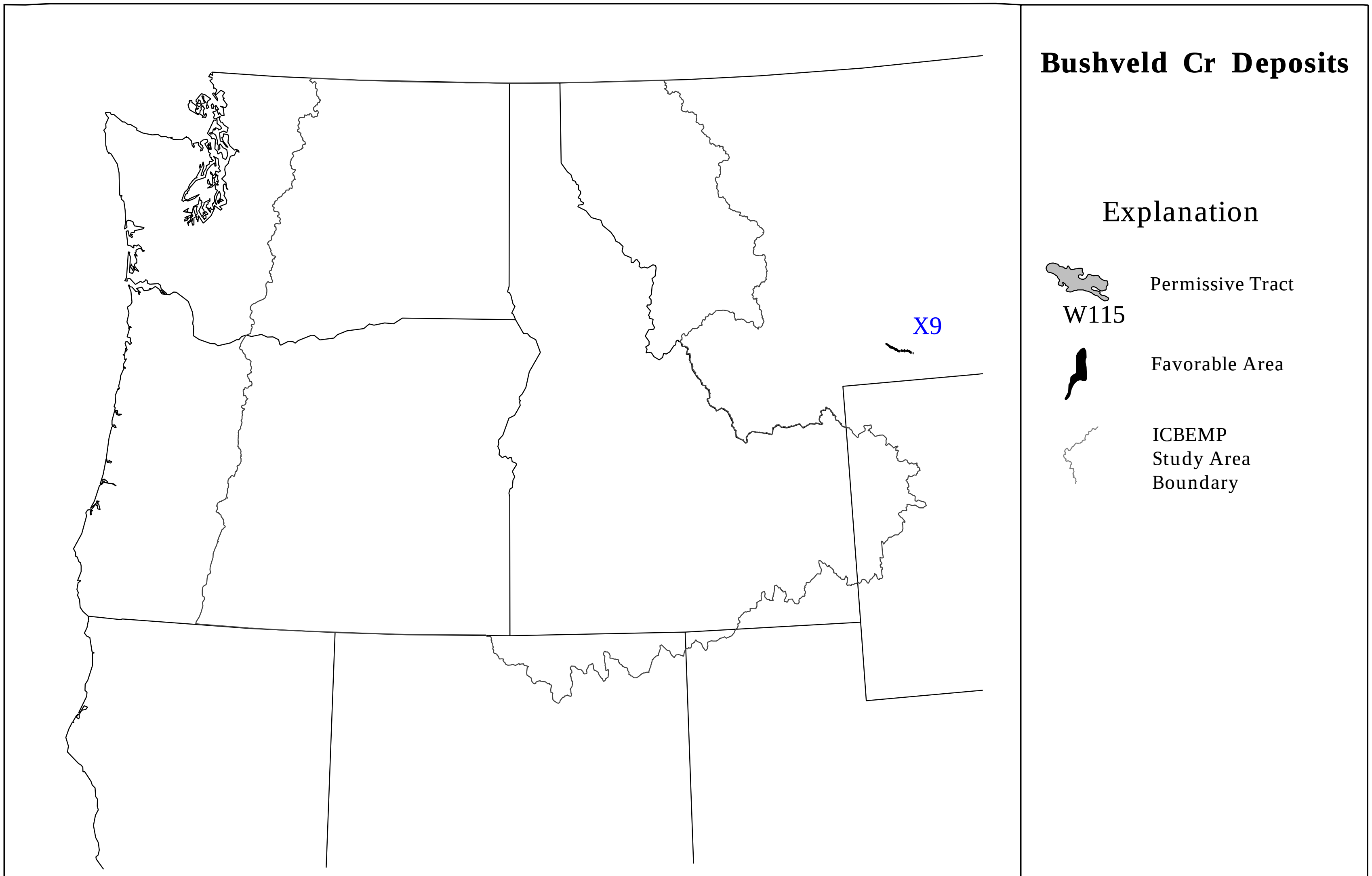


Figure 4a: Permissive and favorable tracts for Bushveld Cr deposits.

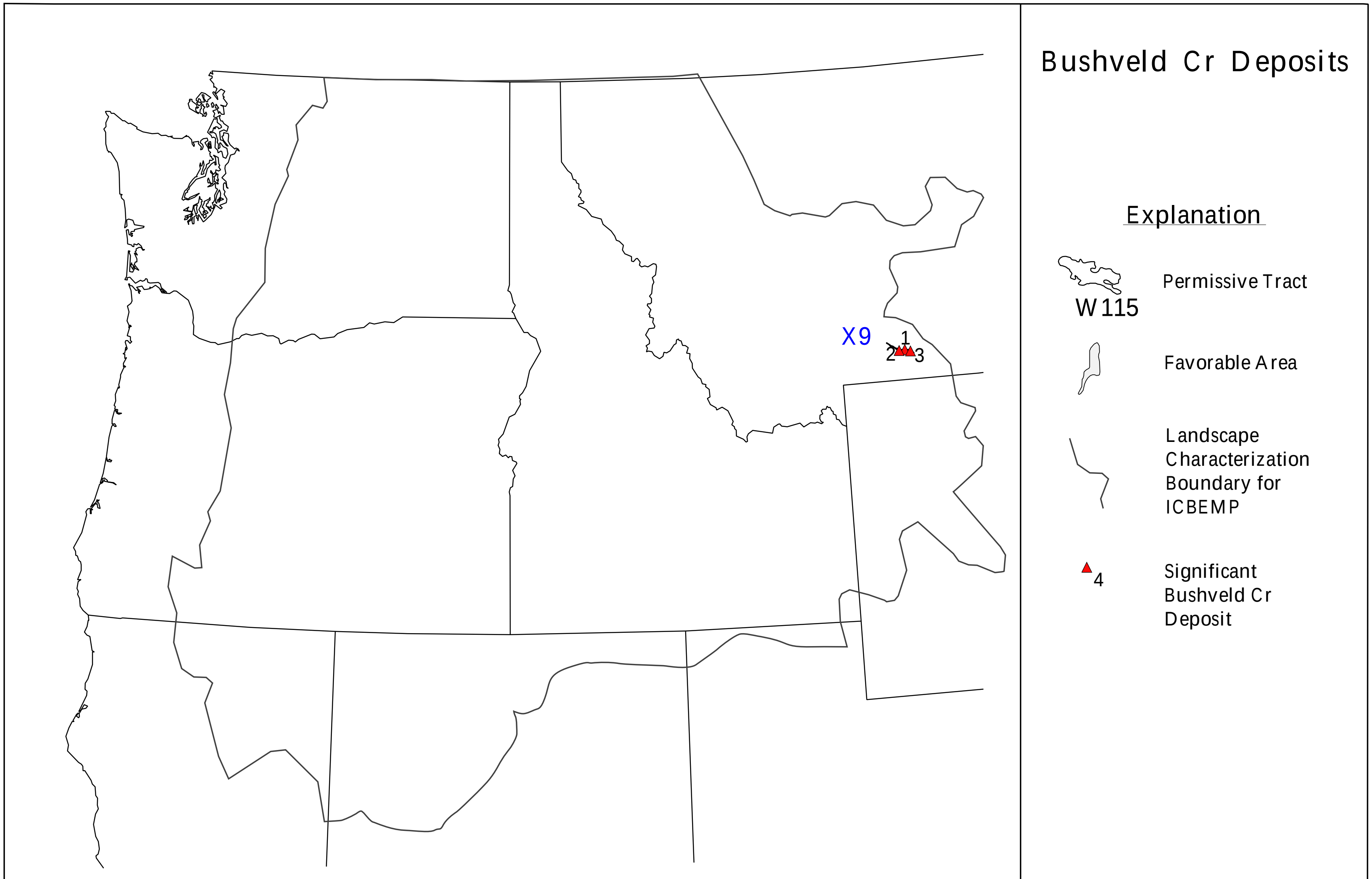


Figure 4b: Location of significant Bushveld Cr deposits in the map area.

Table 4: Significant Bushveld Cr deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	X9	Mouat-Sampson (Mountain View) Cr	Stillwater	Stillwater	MT	45.388	-109.906	I M
02	X9	West Fork B (Crescent Creek)	Stillwater	Sweet Grass	MT	45.382	-110.009	I D
03	X9	Benbow Cr	Stillwater	Stillwater	MT	45.364	-109.806	I M

Table 4: Significant Bushveld Cr deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name		Pd production (tonnes)	Pt production (tonnes)	Cr production (tonnes)		Pd resources (tonnes)	Pt resource (tonnes)	Cr resource (tonnes)
01	X9	Mouat-Sampson (Mountain View) Cr		none	none	246,200				2,740,600
02	X9	West Fork B (Crescent Creek)		none	none	none		6	2	278,336
03	X9	Benbow Cr		none	none	19,600				2,789,500

Tract Description

X9 **Bushveld Cr deposits** **Montana**

Descriptive Model 2a

No estimate of undiscovered deposits

by Michael L. Zientek

Rationale for Tract Delineation

The only layered, ultramafic to mafic intrusion in the map area is the Stillwater Complex in southwestern Montana (figure 4a). Chromite seams in the Stillwater Complex are typically associated with cyclic units in ultramafic rocks that comprise the Peridotite zone. The permissive tract delineated for the Bushveld chromium deposit type includes near surface exposures of the Peridotite zone (Zientek, 1993). The entire permissive tract is considered favorable for this deposit type.

Important Examples of Deposit Type

The Stillwater chromite deposits comprise most of the identified chromium resources in the United States. Chromite seams were discovered early in the exploration of the Stillwater Complex (Page and others, 1985b). Up to 13 chromite seams are present within the Peridotite zone, but chromite seams other than the A, B, G, H, and K are rarely more than a few centimeters thick (Jackson, 1968). Mining has focused on two chromite seams, the G (up to 3.6 m thick) and the H (up to 0.76 m thick) that occur in the middle of the Peridotite zone (Jackson, 1968). Ore averages 20 to 22 wt. percent Cr_2O_3 from which concentrates were produced that average approximately 38.5 to 41.5 wt. percent Cr_2O_3. The chromium- to- iron ratio is low, typically 1.44 to 1.61. Significant deposits are at the Mouat-Sampson mine(#1, Table 4), which may have 17.4 million metric tons of ore averaging 23 % Cr_2O_3 , and the Benbow mine (#3, Table 4), which may have 17.9 million metric tons of ore averaging 22 % Cr_2O_3 (Wetzel, 1986). Between 1952 and 1962, approximately 2.1 million tons of ore yielding 920,000 tons of concentrate averaging 38.5 wt. percent Cr_2O_3 were produced from the Mouat-Sampson mine. Mining was done under contract to the U.S. government as part of a program to create stockpiles of materials critical for U.S. defense needs. The stockpile was sold in 1973.

The platinum-group element enriched A and B chromite seams consists of one or more massive chromitite layers in a 1.5 to 4.5 m interval with disseminated chromite in olivine cumulate and thin chromitite layers in a cyclic unit near the base of the Peridotite zone. Resource investigations focused on these seams near the West Fork of the Stillwater River (#2, figure 4b), where they can be traced for 1.7 km on strike. Using a nominal mining width of 1.21 m, approximately 3.8 million metric tons of ore averaging 2.06 ppm palladium plus platinum were identified. Analyses of select samples can exceed 33 ppm PGE plus gold.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP study area, no estimate of the number of undiscovered Bushveld Cr deposits was made.

Carlin-type sediment-hosted Au deposits

General Deposit Description

Carlin-type sediment-hosted Au deposits are bulk-mineable gold deposits that are hosted mostly in sedimentary rocks that commonly contain pyrobitumen (a residue of thermally mature petroleum). Carlin-type deposits also commonly occur in association with felsic dikes and(or) hydrothermal jasperoids. Carlin-type gold ore is characterized by sub-micron sized "invisible" gold, which occurs as discrete grains and is incorporated within fine-grained disseminated pyrite (Berger and Bagby, 1992; Christensen, 1993). Arsenian pyrite, realgar, orpiment, arsenopyrite, native arsenic, cinnabar, stibnite, and base-metal sulfides and sulfosalts are characteristic ore minerals; and quartz, calcite, and barite are characteristic gangue minerals (Berger, 1986a; Hofstra and others, 1991). Characteristic alteration styles include decalcification, silicification, argillization, sulfidation, and introduction of the minerals barite and alunite (Christensen, 1993).

Silty dolomite and limestone (formed as carbonate turbidites in somewhat anoxic environments) are particularly favorable host rocks (Berger, 1986a), but siltstone, sandstone, conglomerate, and interbedded chert and shale may be mineralized also (Percival and others, 1988). Ore distribution is controlled by host-rock permeability, which may result from primary lithology, fracturing, and(or) chemical alteration, such as decalcification (Christensen, 1993).

According to Christensen (1993), deposits of the Carlin district are of three structural styles: 1) stratabound replacement deposits within silty carbonate units (commonly overlain or overthrusted by relatively impermeable argillitic cap rocks); 2) deeper vein-like mineralized feeder structures; and 3) shallower stockworks of veinlets.

Genetic models for Carlin-type deposits are strongly contested by adherents to three schools of thought, focused on: 1) sedimentary associations; 2) magmatic associations; or 3) structural controls. These are reflected in the criteria emphasized by different estimation teams. The northwest team emphasized sedimentary associations, the Utah team emphasized magmatic associations, and the Nevada team emphasized structural thickening of the sedimentary section by thrust faulting.

As noted by Christensen (1993) a large-scale process, capable of establishing large convection cells seems to be required in order to form long linear groupings and widely scattered examples of similar deposits. Thorman and others (1995) and Ilchik and Barton (1995) suggest that mineralization accompanied the onset of widespread crustal extension and heating, accompanied by widespread volcanism in Nevada between 42 and 34 Ma (Thorman and others, 1995; Folger and others, 1995; Ilchik and Barton, 1995).

Since the discovery of the Carlin deposit in 1961, thirty separate centers of gold mineralization have been identified along the Carlin trend (Christensen, 1993), and 49 economically significant deposits have been discovered in a region that includes the eastern two-thirds of Nevada, western Utah, and southern Idaho (Table 5). These large-tonnage deposits (median 6.6 million metric tonnes with median grade of 2.3 grams of gold per tonne: Mosier and others, 1992) have been the most important source of major new gold production in the United States in the last 30 years. Areas of exposed bedrock generally have been well explored, especially along the favorable trends. Therefore current and future exploration efforts will be increasingly directed toward covered deposits and deep extensions of known deposits along the favorable trends.

The upper parts of Carlin-type Au-Ag deposits are mined from open pits, and the gold is recovered from oxidized ore by heap leaching with dilute cyanide solutions. Zones of weathered and oxidized ore commonly extend to depths of several hundred feet. Oxidation of pyrite liberates gold and destroys pyrobitumen, which can interfere with recovery of gold from pregnant heap-leach solutions. Production from deep, unoxidized extensions of Carlin-type deposits will require underground mining, followed by oxidation of the ore in autoclaves (pressurized oxidation vessels), so that gold can be thoroughly extracted by cyanidation.

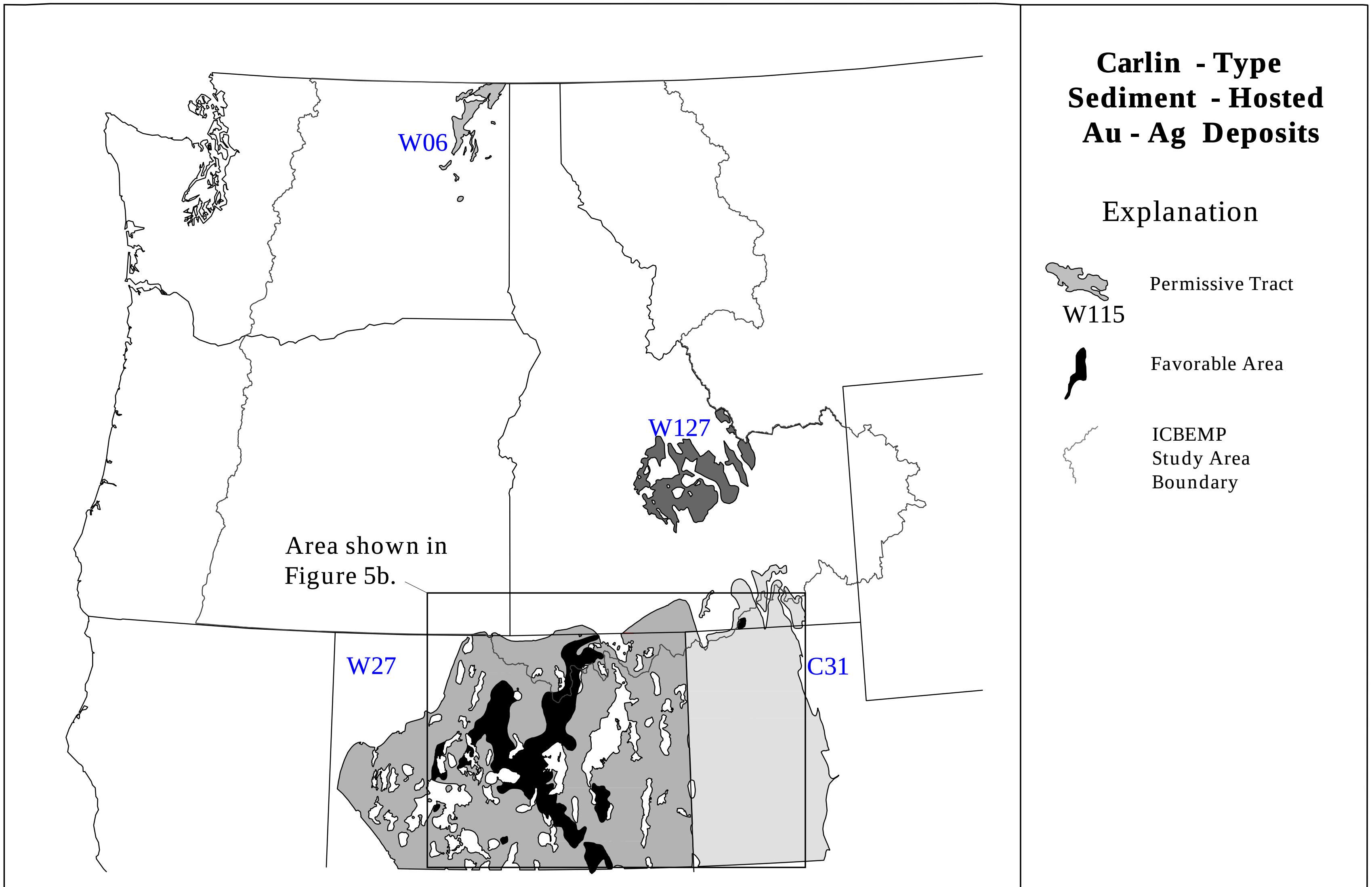


Figure 5a: Permissive and favorable tracts for Carlin-type sediment-hosted Au-Ag deposits.

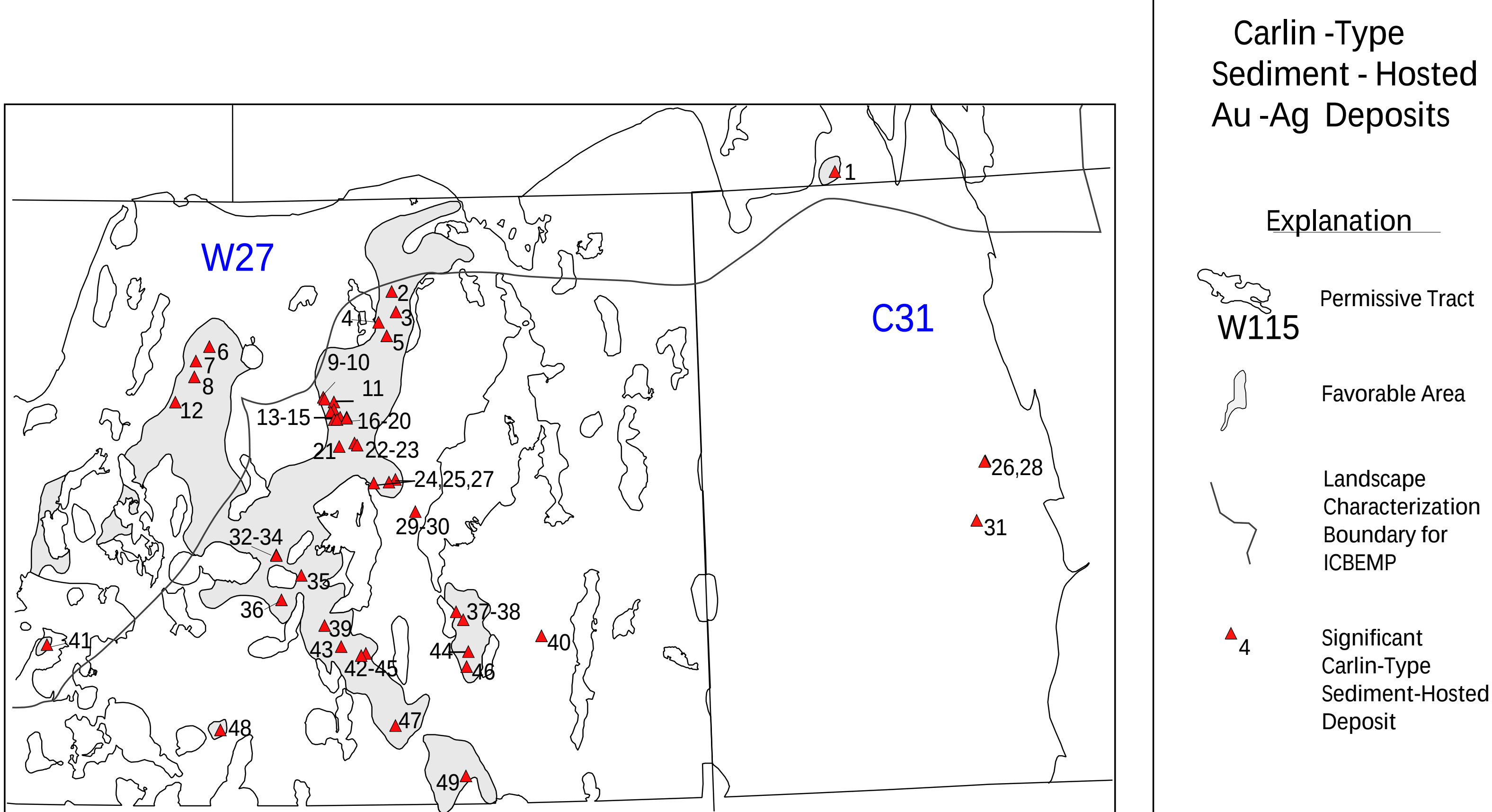


Figure 5b : Location of significant Carlin-type sediment-hosted Au-Ag deposits in the map area .

Table 5: Significant Carlin-type sediment-hosted Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
01	C31	Black Pine (Tallman)	Black Pine	Cassia	ID	42.078	-113.042
02	W27	Big Springs	Birch Creek	Elko	NV	41.550	-115.980
03	W27	Winters Creek	Burns Basin	Elko	NV	41.450	-115.950
04	W27	Wright Window	Burns Basin	Elko	NV	41.400	-116.069
05	W27	Burns Basin-Jerritt Canyon	Burns Basin	Elko	NV	41.340	-116.010
06	W27	Twin Creeks (Chimney-Rabbit Ck)	Potosi	Humboldt	NV	41.280	-117.170
07	W27	Getchell	Potosi	Humboldt	NV	41.210	-117.260
08	W27	Pinson	Potosi	Humboldt	NV	41.130	-117.270
09	W27	Dee Gold Mine	Bootstrap	Elko	NV	41.030	-116.430
10	W27	Bootstrap	Bootstrap	Elko	NV	41.020	-116.420
11	W27	Meikle	Carlin	Elko	NV	41.010	-116.360
12	W27	Preble - Kramer Hill	Potosi	Humboldt	NV	41.000	-117.390
13	W27	Goldstrike-Post	Lynn	Eureka	NV	40.970	-116.360
14	W27	North Star	Lynn	Eureka	NV	40.960	-116.380
15	W27	Bobcat	Lynn	Eureka	NV	40.950	-116.380
16	W27	Genesis - Blue Star	Lynn	Eureka	NV	40.930	-116.320
17	W27	Carlin	Lynn	Eureka	NV	40.930	-116.280
18	W27	Lantern	Lynn	Eureka	NV	40.920	-116.360
19	W27	Bullion Monarch	Lynn	Eureka	NV	40.920	-116.340
20	W27	Pete	Lynn	Eureka	NV	40.920	-116.280
21	W27	Tusc	Maggie Creek	Eureka	NV	40.800	-116.230
22	W27	Maggie Creek	Maggie Creek	Eureka	NV	40.790	-116.330
23	W27	Gold Quarry	Maggie Creek	Eureka	NV	40.790	-116.210
24	W27	Emigrant	Rain	Elko	NV	40.620	-115.970
25	W27	Rain - SMZ	Railroad	Elko	NV	40.610	-116.010
26	C31	Barney's Canyon	Barney's Canyon	Salt Lake	UT	40.610	-112.160
27	W27	Gnome	Rain	Eureka	NV	40.600	-116.110

Table 5: Significant Carlin-type sediment-hosted Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
28	C31	Melco	Melco	Salt Lake	UT	40.600	-112.170
29	W27	Dark Star		Elko	NV	40.458	-115.844
30	W27	Piñon Range - Cord Ranch		Elko	NV	40.458	-115.844
31	C31	Mercur	Mercur	Tooele	UT	40.320	-112.240
32	W27	Cortez Gold Mine	Bullion - Cortez	Lander	NV	40.260	-116.740
33	W27	Pipeline		Lander	NV	40.255	-116.740
34	W27	South Pipeline		Lander	NV	40.248	-116.740
35	W27	Cortez	Cortez	Lander	NV	40.150	-116.580
36	W27	Saddle (Toiyabe project)		Lander	NV	40.030	-116.710
37	W27	Bald Mountain	Bald Mountain	White Pine	NV	39.960	-115.590
38	W27	Little Bald Mountain	Bald Mountain	White Pine	NV	39.920	-115.550
39	W27	Tonkin Springs	Tonkin Springs	Eureka	NV	39.900	-116.430
40	W27	Golden Butte	Cherry Creek	White Pine	NV	39.830	-115.050
41	W27	Fondaway Canyon		Churchill	NV	39.800	-118.200
42	W27	Gold Pick	Antelope	Eureka	NV	39.800	-116.330
43	W27	Gold Canyon	Roberts	Eureka	NV	39.760	-116.170
44	W27	Alligator Ridge	Alligator Ridge	White Pine	NV	39.760	-115.520
45	W27	Gold Bar	Roberts	Eureka	NV	39.750	-116.200
46	W27	Yankee Mine	Bald Mountain	White Pine	NV	39.690	-115.530
47	W27	Ratto Canyon	Eureka	Eureka	NV	39.400	-115.990
48	W27	Austin Gold Venture		Lander	NV	39.380	-117.090
49	W27	Green Springs	White Pine	White Pine	NV	39.140	-115.550

Table 5: Significant Carlin-type sediment-hosted Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Status		Au prod (tonnes)	Ag prod (tonnes)		Au resource (tonnes)	Ag resource (tonnes)
01	C31	Black Pine (Tallman)	P		no	no		14	unk
02	W27	Big Springs	P		11.24	0.26		8.3	0.10
03	W27	Winters Creek	I D					6.4	
04	W27	Wright Window	I M		1.10			3.9	
05	W27	Burns Basin-Jerritt Canyon	P		21.25	0.46		147	
06	W27	Twin Creeks (Chimney-Rabbit Ck)	P		62.43	15		264	
07	W27	Getchell	P		54.94	4.1		41	
08	W27	Pinson	P		3.16	2.9		15	
09	W27	Dee Gold Mine	P		12.76	9.5		8.4	
10	W27	Bootstrap	F x		6.88			30	
11	W27	Meikle	P					206	
12	W27	Preble - Kramer Hill	I M r		373.89				
13	W27	Goldstrike-Post	P		126.70	2.9		705	
14	W27	North Star	P		0.13			11	
15	W27	Bobcat	F D					1.8	
16	W27	Genesis - Blue Star	P		0.73			47	
17	W27	Carlin	P		237.98	8.5		19	
18	W27	Lantern	F D					14	
19	W27	Bullion Monarch	F M x r					3.1	
20	W27	Pete	F D					15	
21	W27	Tusc	F D					29	
22	W27	Maggie Creek	P		12.50			0.87	
23	W27	Gold Quarry	P		45.00			611	
24	W27	Emigrant	F D					20	
25	W27	Rain - SMZ	P		4.23			36	
26	C31	Barney's Canyon	P		14.18				
27	W27	Gnome	F D					4.1	

Table 5: Significant Carlin-type sediment-hosted Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Status	Au prod (tonnes)	Ag prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)
28	C31	Melco	I M	6.75			
29	W27	Dark Star	I D			3.6	
30	W27	Piñon Range - Cord Ranch	I D			7.6	
31	C31	Mercur	P	96.70	6.8		
32	W27	Cortez Gold Mine	P	27.44	2.9	4.8	39
33	W27	Pipeline	F D			85	
34	W27	South Pipeline	F D			104	
35	W27	Cortez	I M	34.22	0.21	neg	neg
36	W27	Saddle (Toiyabe project)	I M	1.64	0.79	1.7	
37	W27	Bald Mountain	P	12.82	1.6	19	
38	W27	Little Bald Mountain	I M r	0.85	0.05	1.0	
39	W27	Tonkin Springs	F M	3.37	0.10	14	
40	W27	Golden Butte	I M r	1.30	0.53	2.8	neg
41	W27	Fondaway Canyon	S	0.40		18	
42	W27	Gold Pick	P			10	
43	W27	Gold Canyon	P			4.1	
44	W27	Alligator Ridge	P	24.40	3.5	21	
45	W27	Gold Bar	P	14.19	0.10		
46	W27	Yankee Mine	P	0.81		2.1	
47	W27	Ratto Canyon	I D			6.2	
48	W27	Austin Gold Venture	I M r	5.97			
49	W27	Green Springs	I M r	1.97	0.28		

Tract Descriptions

C31 — Carlin sediment-hosted Au-Ag Deposits — Utah, Idaho

Descriptive Model 26a

• 0.1 mean undiscovered deposits
(for portion of tract in ICBEMP area only)

by Douglas B. Stoeser

Rationale for Tract Delineation

The criteria used to define the permissive tract for sediment-hosted gold are broad; the basic requirement is the presence of thermally mature, hydrothermally altered, carbonaceous, calcareous sedimentary rocks and an intrusive heat source in the underlying crust. Suitable host rocks are primarily silty or argillaceous carbonaceous limestone and dolomite. Since such rocks underlie western Utah, most of the Great Basin province of Utah and southernmost Idaho was permissive. A favorable tract was outlined near the Black Pine mine based on knowledge of occurrences, exploration activity, and a US Bureau of Mines plot of mining claim density.

Important Examples of Deposit Type

One large (Mercur: # 31, figure 5b) and two small sediment-hosted gold deposits (Barney's Canyon [# 26, figure 5b], and Melco [# 28, figure 5b] occur in Utah. Another possibly relevant occurrence is King's Canyon, which is difficult to classify. In Idaho, the Black Pine deposit (# 1, figure 5b) is another example.

Rationale for Numerical Estimate (ICBEMP portion only)

The Black Pine deposit is located within the small portion of tract C31 that lies within the Interior Columbia Basin study area. The Black Pine Range has been well explored, and several geochemically anomalous areas have been tested by drilling with limited success, but the adjoining ranges are not as well explored as adjacent parts of Nevada and Utah (Virginia Gillerman, personal communication, 1995). For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 1, and 2 or more for deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Mosier and others (1992) in that portion of the tract that lies within the ICBEMP area.

W06 — Carlin sediment-hosted Au-Ag Deposits — Washington

Descriptive Model 26a

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for model choice

These deposits consist of very fine-grained gold and sulfide minerals disseminated in carbonaceous calcareous sedimentary rocks and associated jasperoids (Berger, 1986a). This model was considered to include disseminated gold deposits hosted in carbonaceous, silty, and shaley carbonate sequences. The host rocks were deposited below the wave-base along the Paleozoic continental slope.

Rationale for tract delineation

The host rock lithology of carbonaceous, silty, and shaley carbonate sequences was considered to be the primary criteria for inclusion in a permissive tract for this deposit type. Paleozoic miogeoclinal strata in northeastern Washington include this lithology. Strictly on the basis of host rock lithology, the Cambrian through Devonian miogeoclinal rocks of northeastern Washington (Stoffel and others, 1991) are considered permissive for Carlin-type, sediment-hosted gold deposits. However, there was disagreement within the team as to whether the host lithology is the most significant factor in the localization of these deposits, and whether the model is appropriate to northeastern Washington.

Significant examples of deposit type

No deposits or prospects of this deposit type are known from the permissive area or from the contiguous correlative area across the Canadian border in southern British Columbia.

Rationale for Numerical Estimate

Since a large number of gold exploration companies (including several with major producing sediment-hosted gold deposits in Nevada) have been actively exploring for gold deposits of several other types in the general vicinity, we presume that this area has been explored to some degree for deposits of this type. Given this presumed exploration history and the lack of known prospects, the assessment team judged the possibility of undiscovered deposits to be very low. However exposure in the area is poor, and forest cover is extensive, so that undiscovered deposits might still occur in the upper kilometer of the tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more for deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Mosier and others (1992).

W27 — Carlin sediment-hosted Au-Ag Deposits — Nevada, Oregon, Idaho

Descriptive Model 26a

• 2.1 mean undiscovered deposits
(for portion of tract in ICBEMP area only)

by D.P. Cox, S. D. Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

Delineation of tracts permissive for sediment-hosted gold deposits is difficult because: (1) the deposits occur in a wide variety of types and ages of host rock; (2) structures believed to control the distribution of deposits are too subtle to be shown on small-scale geologic maps; (3) direct determination of mineralization age by isotopic analysis is restricted by the lack of suitable minerals in the deposits; and (3) the genetic association of mineralization with igneous rocks is uncertain.

During the last two decades of intensive exploration for gold, sediment-hosted gold deposits have not been found in significant numbers outside of the Great Basin. If these deposits are unique to the Great Basin, then, as pointed out by Seedorff (1991), their origin must be related to some unique feature of the region. Berger and Henley (1989) point to overthickening of the crust by thrust faulting as an important characteristic of the part of the Great Basin occupied by known sediment-hosted gold deposits, adding that tectonic stacking of marine sedimentary deposits could have created large reservoirs of connate water. Existence of such a fluid reservoir is suggested by the geochemistry and isotopic composition of ore-stage fluid inclusions from these deposits (Rose and Kuehn, 1987; Hofstra and others, 1988).

Based on the assumed relationship between crustal thickening and sediment-hosted gold deposits, all sedimentary and metasedimentary rocks within the area of tectonically thickened crust are delineated as permissive for sediment-hosted gold deposits. Permissive tract delineation was based on distribution of allochthons, and, in the Sevier orogenic belt in eastern Nevada, by patterns of folding and thrust faulting shown on the geologic map of Stewart and

Carlson (1978). Favorable tracts in northwestern Nevada are based on "prospective" areas for Carlin-type deposits from an unpublished mineral resource assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994). Favorable tracts in northeastern Nevada were outlined based on knowledge of occurrences, exploration activity, and a US Bureau of Mines plot of mining claim density.

Important Examples of Deposit Type

Sediment-hosted gold deposits are distributed in three groups which reflect differences in host rocks, structures, and possibly, age of formation. The central group is represented by deposits in the Jerritt Canyon (Burns Basin) district (#2-5, figure 5b); the Carlin trend #13-24, figure 5b); deposits around Cortez; Tonkin Springs; and Northumberland. Many of these districts are situated on or close to the Roberts Mountains Thrust. Ages of some of these gold deposits have been indirectly estimated at between 36 and 39 Ma (Bonham, 1989; Berger and Bagby, 1991). The western group of sediment-hosted gold deposits is represented by deposits in the Getchell trend, Standard, and Fondaway Canyon. The Getchell trend deposits are hosted by siliceous shale and phyllite of Cambrian age. The eastern group of deposits is represented by the Bald Mountain, Golden Butte, Alligator Ridge, Illipah, Night Hawk, and Green Springs, mainly hosted in Cambrian carbonate rocks. Only the Jerritt Canyon (Burns Basin) district is located within the ICBEMP study area, but many of the others lie within the ICBEMP landscape characterization boundary, and most lie within the map area of figure 5b.

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W27 that lies within the ICBEMP study area (figure 5a). An estimate of the number of undiscovered Carlin-type sediment-hosted Au deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W27 lies within two counties. To arrive at the numerical estimate of undiscovered Carlin-type sediment-hosted Au deposits in the ICBEMP portion of tract W27, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 2.11 mean undiscovered Carlin-type sediment-hosted Au deposits for the part of the ICBEMP study that extends into tract W27 (including the minor permissive tract extensions into Oregon and Idaho). For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 1, 2, 3, 4, and 6 or more deposits consistent with the grade and tonnage model of Mosier and others (1992) is equivalent to the estimated mean number of undiscovered deposits derived above.

W127 — Carlin sediment-hosted Au-Ag Deposits — Idaho

Descriptive Model 26a

0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract for Carlin-type, sediment-hosted gold deposits was defined by the presence of suitable host rocks, primarily calcareous siltstones and silty or argillaceous carbonaceous limestone and dolomite deposited in Paleozoic continental slope environments. Carbonaceous calcareous deep-marine sediments of Paleozoic age in south-central Idaho near Sun Valley (Bond, 1978) are considered as appropriate lithologies. Widespread occurrences of jasperoid near Mackay are considered a further indication that appropriate mineralizing systems have operated in the region.

Important Examples of Deposit Type

No Carlin-type deposits are known from this tract. However widespread jasperoid occurrences suggest that appropriate mineralizing systems have operated in the region.

Rationale for Numerical Estimate

The geologic setting of this region is analogous to the setting of the Black Pine deposit (#1, figure 5b) to the south of the Snake River plain. However this tract was also extensively explored in the 1980's but has produced no serious prospects. On this basis we estimated a very low potential for undiscovered deposits (1% chance of one deposit, with a 99% chance of no deposits).

Coeur d'Alene Ag-Pb-Zn veins

General Deposit Description

Coeur d'Alene (CDA)-type polymetallic veins are mesothermal replacement veins that are deposited from metamorphically derived hydrothermal fluids along faults within regional metamorphic shear zones in clastic low-grade metasedimentary terranes (Frykland, 1964; Beaudoin and Sangster, 1992). Silver, lead, and zinc are the most important products derived from CDA veins. Copper, gold, antimony, arsenic, and cadmium are byproducts. Cobalt, tungsten, uranium, and mercury also may be geochemically enriched. Galena, sphalerite, and tetrahedrite are the main ore minerals and occur in various proportions. Typical gangue mineral assemblages include quartz + siderite $\pm$ other carbonates $\pm$ barite. Gangue minerals were deposited early, and continued to be deposited with the ore minerals. The typical sequence of ore-mineral deposition is: early magnetite, pyrrhotite, uraninite, and arsenopyrite, followed by intermediate galena, sphalerite, and tetrahedrite, and late chalcopyrite (Guilbert and Park, 1985, p. 486). Some veins are mined mostly for lead and zinc, whereas others are mined mostly for silver, and a few, which contain pyrite and scheelite, are mined mostly for gold.

Fluid inclusion data indicate that ore deposition occurred at about 350 to 250^{o}C, from hydrocarbon-bearing fluids that are interpreted as metamorphic-hydrothermal in origin (Leach and others, 1988). Replacement textures are common, with carbonate minerals and quartz replacing wall rocks, and ore minerals replacing earlier gangue and ore minerals. According to Lindgren (1933, p. 573), "metasomatic action, indicated by the presence of siderite in the quartzite, often spreads for 100 feet or more beyond the ore." Disseminated ore minerals also are found in the wall rocks of some veins (White, 1989). Tonnage-grade models have not yet been made for Coeur d'Alene type veins, but the median tonnage and grade for mines of the Coeur d'Alene district (calculated from the production and resource data of significant deposits in Table 6) is 1.85 million metric tonnes of ore with 179 g Ag/tonne, 4.55% Pb. Zinc contents of veins generally range from 0 to 10%. These tonnage-grade data are for mines, not individual ore shoots or veins. Tonnage-grade data for analogous deposits in Europe are incomplete. More than one model will be required, because lead-zinc veins have different tonnage-grade characteristics than silver veins and(or)hybrid silver-lead-zinc veins. Furthermore, veins of different structural sets also have different tonnage-grade characteristics, as do associated bodies of semi-massive to disseminated mineralization in the host rocks.

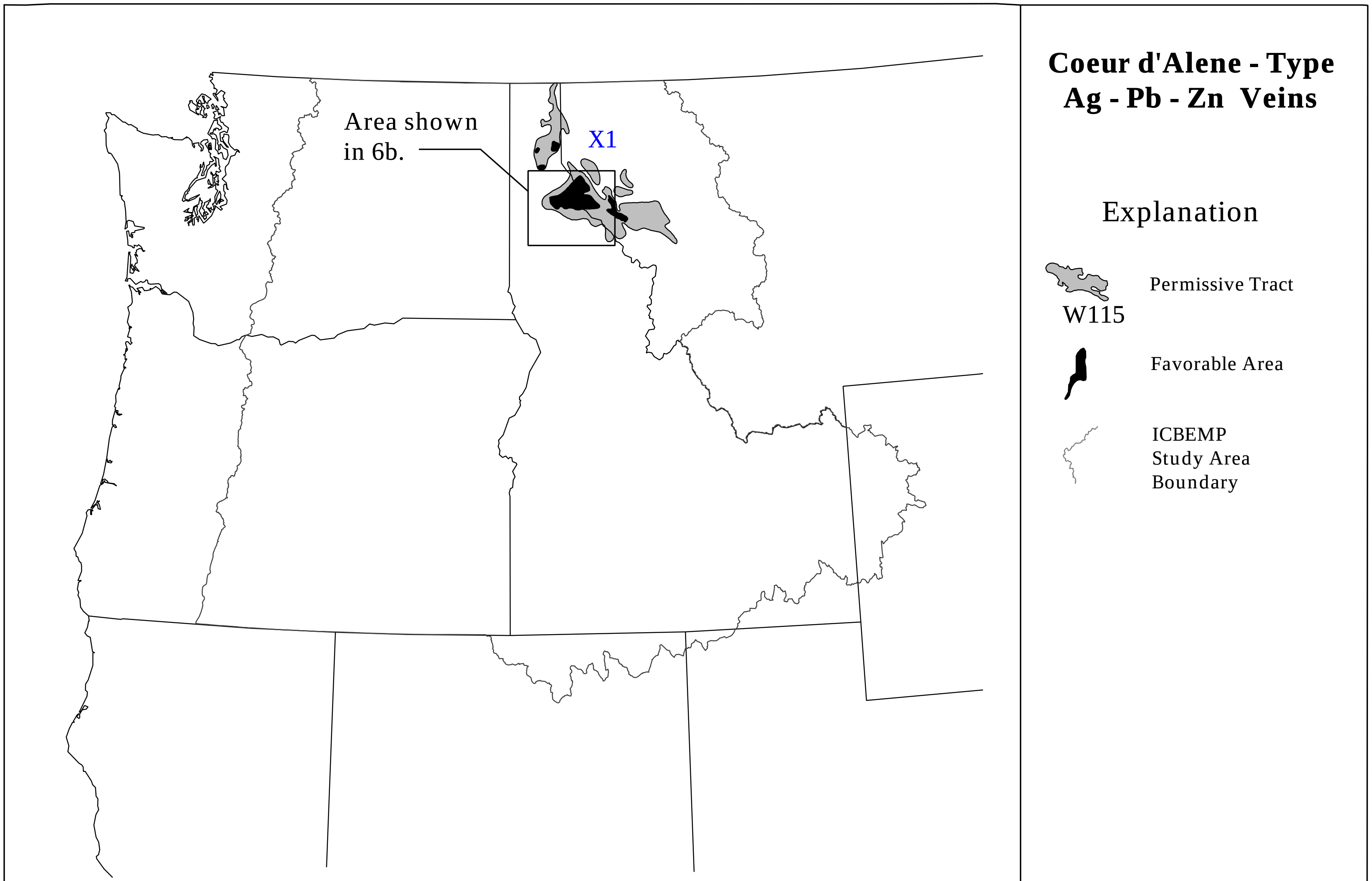
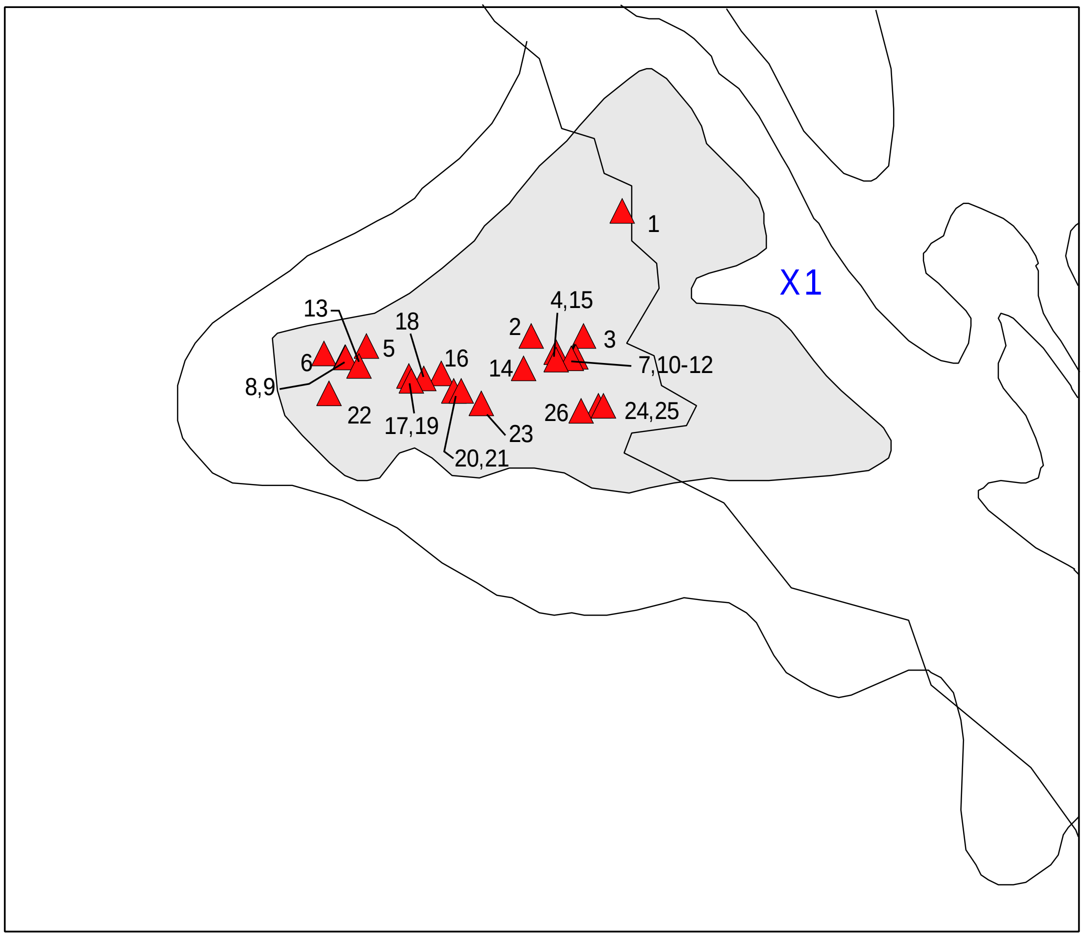


Figure 6a: Permissive and favorable tracts for Coeur d'Alene-type Ag-Pb-Zn Veins.



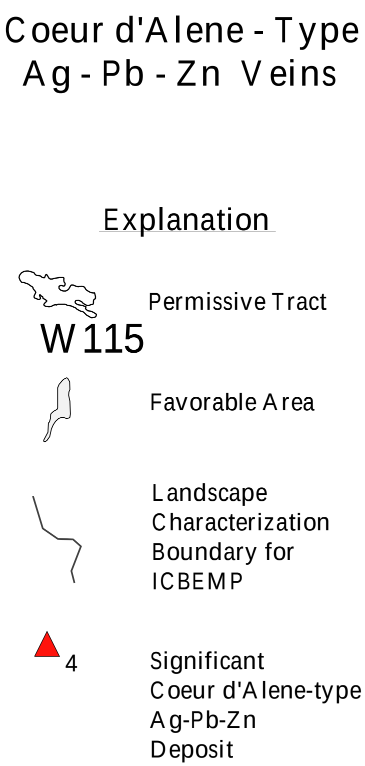


Figure 6b: Location of significant Coeur d'Alene-type Ag-Pb-Zn Vein deposits in the map area.

Table 6: Significant Coeur d'Alene Ag-Pb-Zn vein deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	X1	Jack Waite	Eagle	Shoshone	ID	47.668	-115.744	I M
02	X1	Interstate-Callahan	Coeur d'Alene	Shoshone	ID	47.544	-115.887	I M
03	X1	Hercules	Coeur d'Alene	Shoshone	ID	47.543	-115.808	I M
04	X1	Tamarack-Custer	Coeur d'Alene	Shoshone	ID	47.536	-115.848	I M
05	X1	Bunker Hill	Coeur d'Alene	Shoshone	ID	47.536	-116.138	I M r
06	X1	Page Group	Coeur d'Alene	Shoshone	ID	47.528	-116.201	I M
07	X1	Sherman	Coeur d'Alene	Shoshone	ID	47.525	-115.820	I M
08	X1	Senator Stewart	Coeur d'Alene	Shoshone	ID	47.525	-116.171	I M
09	X1	Caledonia	Coeur d'Alene	Shoshone	ID	47.524	-116.168	I M
10	X1	Tiger-Poorman	Coeur d'Alene	Shoshone	ID	47.523	-115.813	I M
11	X1	Hecla	Coeur d'Alene	Shoshone	ID	47.520	-115.814	I M
12	X1	Standard Mammoth	Coeur d'Alene	Shoshone	ID	47.519	-115.836	I M
13	X1	Last Chance	Coeur d'Alene	Shoshone	ID	47.517	-116.149	I M
14	X1	Dayrock	Coeur d'Alene	Shoshone	ID	47.512	-115.900	I M
15	X1	Helena-Frisco	Coeur d'Alene	Shoshone	ID	47.510	-115.850	I M
16	X1	Silver Summit	Coeur d'Alene	Shoshone	ID	47.506	-116.025	I M
17	X1	Crescent	Coeur d'Alene	Shoshone	ID	47.506	-116.073	I M
18	X1	Polaris	Coeur d'Alene	Shoshone	ID	47.502	-116.052	I M
19	X1	Sunshine Unit	Coeur d'Alene	Shoshone	ID	47.501	-116.068	P
20	X1	Mineral Point	Coeur d'Alene	Shoshone	ID	47.489	-116.006	I M
21	X1	Coeur	Coeur d'Alene	Shoshone	ID	47.489	-115.992	S
22	X1	Sidney	Coeur d'Alene	Shoshone	ID	47.488	-116.192	I M
23	X1	Galena	Coeur d'Alene	Shoshone	ID	47.477	-115.965	S
24	X1	Gold Hunter	Coeur d'Alene	Shoshone	ID	47.472	-115.785	F M
25	X1	Lucky Friday	Coeur d'Alene	Shoshone	ID	47.471	-115.780	P
26	X1	Star-Morning	Coeur d'Alene	Shoshone	ID	47.468	-115.812	I M

Table 6: Significant Coeur d'Alene Ag-Pb-Zn vein deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Pb resource (tonnes)	Zn resource (tonnes)
01	neg	17	24	53,325	12,815	unk	unk	unk	unk
02	neg	62	48	45,004	139,223	unk	unk	unk	unk
03	neg	932	1,706	348,971	4,362	unk	unk	unk	unk
04	neg	272	924	153,455	70,950	unk	unk	unk	unk
05	neg	4,106	8,822	2,373,298	1,063,256	463	unk	241,294	409,188
06	neg	454	1,236	245,652	246,556	unk	unk	unk	unk
07	neg	122	240	53,842	3,876	unk	unk	unk	unk
08	neg	206	218	68,459	147	unk	unk	unk	unk
09	neg	252	1,682	30,289	neg	unk	unk	unk	unk
10	neg	83	0.79	51,153	58	unk	unk	unk	unk
11	neg	1,269	2,253	645,965	33,488	47	unk	unk	unk
12	neg	1,055	248	315,384	6,684	unk	unk	unk	unk
13	neg	268	125	196,170	neg	unk	unk	unk	unk
14	neg	203	360	70,270	3,521	unk	unk	unk	unk
15	neg	191	358	96,707	79,364	unk	unk	unk	unk
16	neg	620	4,535	67	54	unk	unk	unk	unk
17	neg	751	3,380	1,479	264	123	unk	unk	unk
18	neg	229	997	1,670	13	unk	unk	unk	unk
19	neg	9,019	44,836	63,461	3,825	1,191	6,451	unk	unk
20	neg	182	4,541	58	neg	unk	unk	unk	unk
21	neg	1,127	14,485	150	215	309	3,236	unk	unk
22	neg	60	232	39,918	77,634	unk	unk	unk	unk
23	0.52	4,175	40,499	10,093	669	472	6,409	unk	1,237
24	neg	310	207	88,546	519	unk	unk	unk	unk
25	1.41	2,904	9,034	540,248	57,787	287	unk	70,549	12,482
26	neg	2,273	3,790	1,574,789	1,507,816	unk	unk	unk	unk

Tract Description

X1 — **Coeur d'Alene Ag-Pb-Zn veins** — **Idaho, Montana**

No published descriptive model
No estimate of undiscovered deposits

by A.A. Bookstrom and S.E. Box

Rationale for Tract Delineation

Mesothermal CDA-type veins of the northern Idaho and northwestern Montana are hosted mostly in quartzites and argillites of the Proterozoic Belt basin (Harrison, 1972). Mesothermal veins are common in the Wallace 1° x 2° quadrangle, and in adjacent parts of the Spokane and Sandpoint 1° x 2° quadrangles. Harrison, Leach, and others (1986) outlined tracts with 7 degrees of favorability for mesothermal polymetallic veins in the Wallace 1° x 2° quadrangle, based on their scoring of favorabilities of lithologies, structures, known mineral occurrences, and geochemical and geophysical characteristics. "Almost half of this area (about 17,000 km^2) shows evidence that is at least moderately suggestive of the presence of such veins" (Harrison, Leach, and others, 1986, sheet 2). The greater CDA mineral belt extends east-southeast from Pinehurst, Idaho to Superior, Montana , along the Lewis and Clark Line, a broad zone of deformed rocks that have undergone recurrent episodes of deformation since Proterozoic time (Harrison, 1972). The CDA mining district lies mostly in the upper CDA River basin, and extends from Pinehurst, east to Mullen, Idaho (a distance of nearly 40 km), and from Wallace, north to Murray, Idaho (a distance of nearly 20 km). CDA-type veins and associated geochemical anomalies are abundant in the CDA district (Gott and Cathrall, 1980). Clusters of CDA-like veins also are localized along the northwest-striking Hope fault zone, and in the upper plate of the north-striking Purcell detachment fault (in the Lakeview, Pend Oreille, and Clark Fork mining districts), located in northern Idaho, near Pend Oreille Lake. Favorable areas were defined using maps of Harrison, Leach, and others (1986) in the Wallace 1° x 2° quadrangle, and based on known occurrences and mining claim densities (based on a US Bureau of Mines plot).

Important Examples of Deposit Type

The Coeur d'Alene (CDA) mining district, located in northern Idaho, has the world's greatest recorded silver production, ranks as a major producer of lead and zinc, and has some of the largest, and deepest underground mines in North America (Bennett, undated). From 1886 through 1990, mines of the district have produced about 30,000 tonnes of silver, 7 million tonnes of lead, and 4 million tonnes of zinc, from 120 million tonnes of ore (Mitchell and Bennett, 1983; Bennett and Springer, 1990). Production and reserves of 26 significant known deposits are given in Table 6.

Veins of the CDA mining district commonly are 2 to 3 m thick, but range from 1 to 12 m thick; ore shoots within veins range from 0.1 to 1 km in strike length, and from 0.2 to 2 km in dip length (Lindgren, 1933; Hobbs and Frykland, 1968) Production records from significant mines of the CDA district (Table 6) indicate recovery-based ore grades in the following ranges: 25 to 860 g silver / tonne; 0 to 13 percent lead; 0 to 11 percent zinc; and 0 to 6 percent copper. According to Siems (1994) ore grades and metal ratios vary considerably between different vein sets, but vary little with depth. White (1989) noted that in the CDA district, dip-slip shearing during mineralization formed cleavage and lineation in argillic rocks, and caused alignment of flattened, elongate, disseminated grains of vein minerals in wall rock. Ore shoots tend to parallel the shear lineation (White 1989; Wavra and others, 1994). CDA-type districts generally show evidence of "repeated stages of hydraulic fracturing, mineral deposition, and dynamic metamorphism...and, sometimes, pluton emplacement" Siems (1994, p. 15).

Rationale for Numerical Estimate

The permissive tract for CDA type deposits has been well explored at the surface, and we do not expect that a new CDA district will be discovered there. Additional ore is being found by exploration from existing mines, located within the favorable tract for CDA deposits. Deep extensions of the Lucky Friday and Gold Hunter veins are being successfully explored at the Lucky Friday mine. The West Chance area is being successfully explored at the Sunshine Mine, and exploration is underway at the Galena mine. However, extensions of known deposits, and(or) deposits located within 1 km of known deposits, are not considered here as undiscovered deposits, but as extensions of known deposits. Inasmuch as the favorable area of the CDA district is very well explored, it is unlikely that undiscovered deposits will be found more than a km from any previously known deposit. For this reason, and because no tonnage-grade model is available for individual CDA-type ore shoots, no numerical estimate was made for undiscovered deposits, even though extensions of known deposits are very likely to be discovered.

Zones of disseminated ore minerals in host rocks around veins represent another possible target of future exploration and development. Low-grade bulk-mineable gold ore has been found in the wall rocks of the Golden Chest vein, a gold-bearing CDA-like vein, located near Murray, Idaho. No numerical estimate was made for deposits of this type, because no tonnage-grade model exists for such deposits.

Epithermal vein, Comstock

General Deposit Description

Epithermal Au-Ag veins consist of moderately to steeply dipping sheets of quartz with ribbon-like ore shoots of precious metal minerals deposited in throughgoing faults or fractures from hydrothermal waters within 300 m of the ground surface. These epithermal veins are divided into two types: pyrite-rich quartz-alunite and pyrite-poor quartz-adularia types. Quartz-adularia veins have been subdivided into three subtypes, Comstock, Sado, and Creede, based on their metal grades and the presumed character of the basement underlying the volcanic sequence in which they are found (Mosier, Menzie, and Kleinhampl, 1986). The Comstock subtype, rich in silver and low in base metals, is generally found in or near volcanic piles overlying low-grade metasedimentary basement rocks (Mosier, Singer, and Berger, 1986a). Where the ground surface from the time of vein formation is preserved, these silica-rich vein systems typically branch upward into a more dispersed system of stockwork veinlets, culminating in siliceous sinter (silica deposited in hot-springs pools) at the paleo-ground surface. The cluster of volcanic centers called the Yellowstone caldera system in northwestern Wyoming is an excellent example of a modern geothermal system. The deeper parts of systems like this are the environment where epithermal vein deposits form. Ore shoots typically form in the zone of boiling in epithermal veins.

Epithermal vein systems are formed in and around volcanic eruptive centers and/or buried igneous intrusions, which provide heat sources to drive the hydrothermal systems. Fracture and fault systems that were active during volcanism provide repeated openings for ascending hydrothermal waters, localizing repetitive deposition of epithermal vein minerals. Since epithermal veins typically form within the volcanic pile within 300-400 m of the ground surface, the presence of preserved volcanic piles is usually (though not always) required for the preservation from erosion of associated epithermal veins. Permissive tracts for epithermal veins are typically drawn around volcanic piles that have survived post-volcanic erosion. In the western U.S., volcanic fields of Tertiary age (0-65 million years old) are the typical host for epithermal vein systems. These narrow, relatively high-grade Au-Ag deposits (median tonnage=770,000 metric tonnes with median Au grade of 7.5 gram/tonne and median Ag grade of 110 grams/tonne; Mosier, Singer, and Berger, 1986b) are typically developed in underground mines.

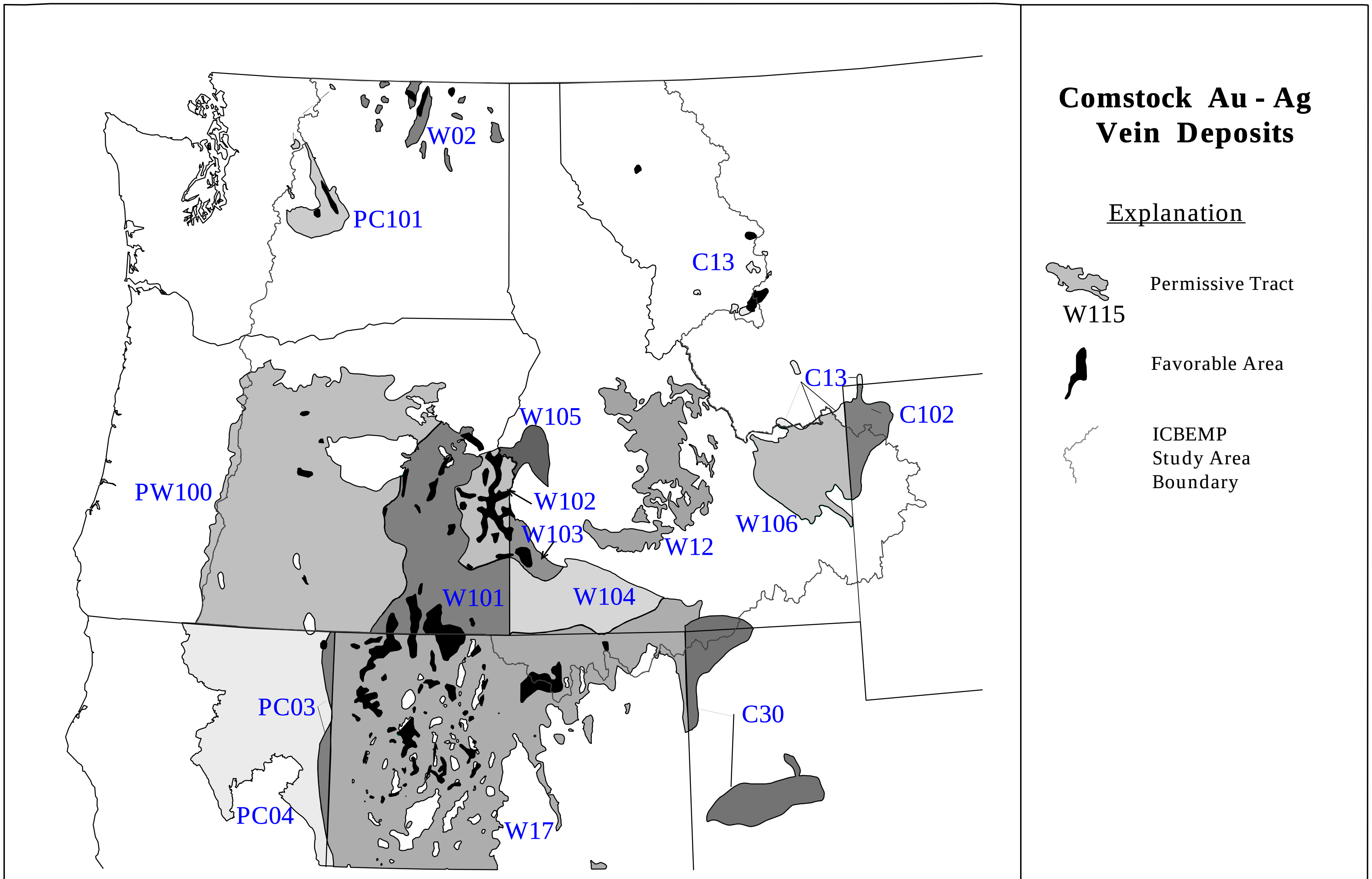


Figure 7a: Permissive and favorable tracts for Comstock Au-Ag vein deposits.

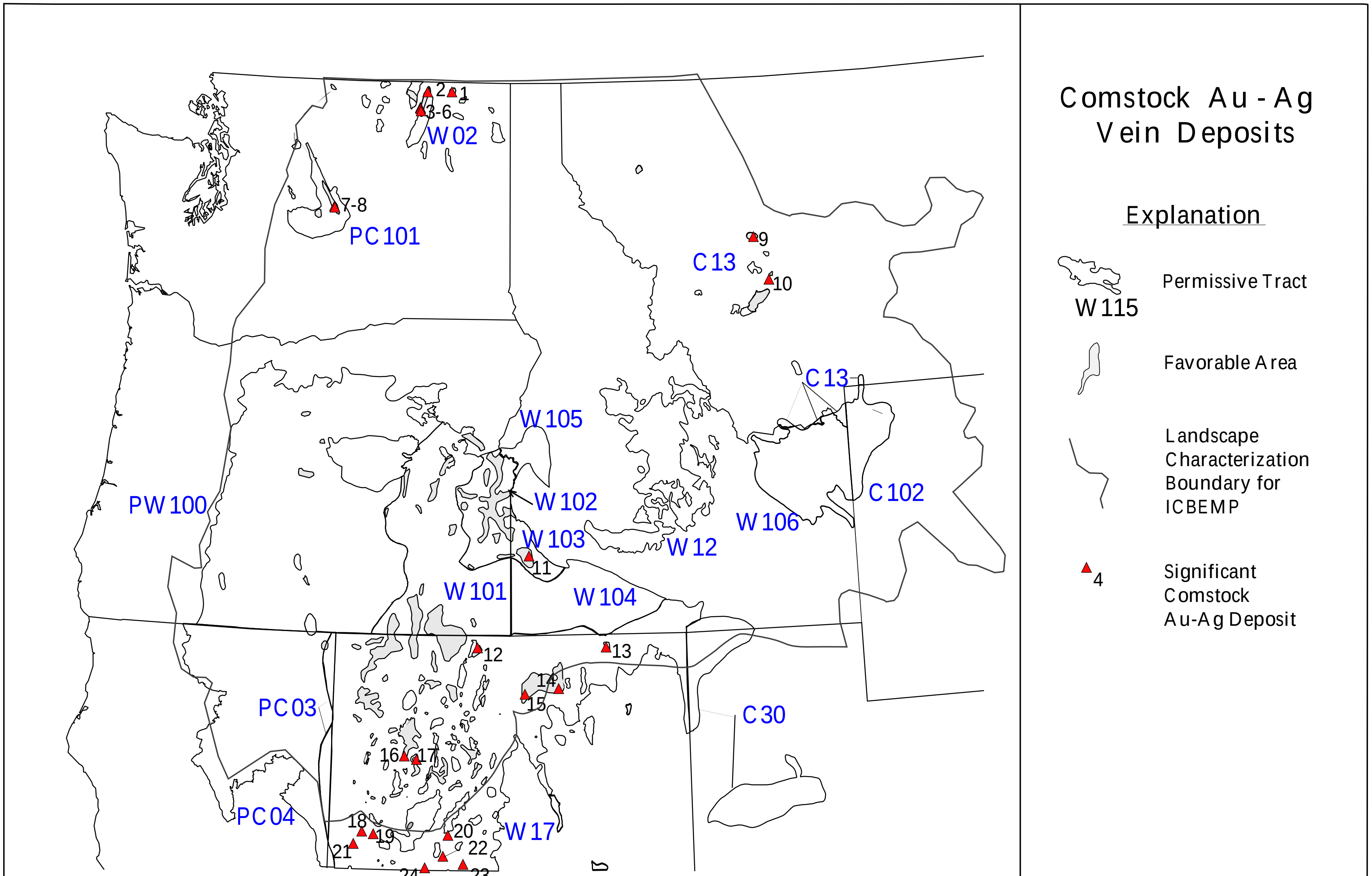


Figure 7b: Location of significant Comstock Au-Ag vein deposits in the map area.

Table 7: Significant Comstock-type Au-Ag epithermal vein deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W02	Orient	Orient	Stevens	WA	48.884	-118.159	I M
02	W02	Kettle River	Republic	Ferry	WA	48.879	-118.626	P
03	W02	Golden Eagle	Republic	Ferry	WA	48.680	-118.759	I D
04	W02	Knob Hill-Golden Promise	Republic	Ferry	WA	48.673	-118.758	I M x
05	W02	Last Chance	Republic	Ferry	WA	48.668	-118.755	I M x
06	W02	Republic	Republic	Ferry	WA	48.638	-118.745	I M x
07	PC101	Cannon	Wenatchee	Chelan	WA	47.396	-120.325	I M x
08	PC101	Lovitt	Wenatchee	Chelan	WA	47.382	-120.315	I M e
09	C13	Seven-Up Pete	Seven-Up Pete	Lewis & Clark	MT	46.972	-112.530	F D
10	C13	Basin Creek (Paupers Dream)	Rimini (Vaughn)	Lewis & Clark	MT	46.420	-112.290	I D
11	W103	War Eagle Project	French,Carson	Owyhee	ID	43.007	-116.711	I M
12	W17		National	Humboldt	NV	41.840	-117.590	I M
13	W17		Jarbidge	Elko	NV	41.840	-115.410	I M
14	W17		Tuscarora	Elko	NV	41.320	-116.220	I M
15	W17		Gold Circle	Elko	NV	41.250	-116.790	I M
16	W17		Seven Troughs	Pershing	NV	40.450	-118.790	I M
17	W17		Trinity	Pershing	NV	40.410	-118.590	I M
18	W17	Gooseberry	Ramsey	Storey	NV	39.480	-119.460	S
19	W17	Talapoosa Mines	Talapoosa	Lyon	NV	39.450	-119.270	F M
20	W17		Wonder	Churchill	NV	39.450	-118.050	I M
21	W17		Comstock Lode	Storey	NV	39.320	-119.590	P
22	W17		Fairview	Churchill	NV	39.180	-118.130	I M
23	W17		Bruner	Nye	NV	39.080	-117.800	I M
24	W17		Rawhide - Regent	Mineral	NV	39.030	-118.420	I M

Table 7: Significant Comstock-type Au-Ag epithermal vein deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)		Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Pb resource (tonnes)
01	W02	Orient	1.39	0.99	258	11	neg		2.6	1.9	486	20
02	W02	Kettle River	1.98	unk	neg	neg	neg		neg	neg	neg	neg
03	W02	Golden Eagle	none	none	none	none	none		35.7	unk	neg	neg
04	W02	Knob Hill-Golden Promise	69.46	278	neg	neg	neg		14	130	neg	neg
05	W02	Last Chance	4.51	unk	unk	unk	unk		unk	unk	unk	unk
06	W02	Republic	2.11	unk	neg	neg	neg		neg	neg	neg	neg
07	PC101	Cannon	31.50	52					3.5	30		
08	PC101	Lovitt	12.78	19								
09	C13	Seven-Up Pete							26			
10	C13	Basin Creek (Paupers Dream)							6.6			
11	W103	War Eagle Project	4.81	unk	neg	neg	neg		12	unk	neg	neg
12	W17		5.50	15	1.6	6.4						
13	W17		6.75	15								
14	W17		5.06	227	2.0	10			7.9	42		
15	W17		3.90	51	0.32	8.6						
16	W17		5.00	17		4.8	0.27					
17	W17			166								
18	W17	Gooseberry	0.54	30					18	58		
19	W17	Talapoosa Mines	0.02						25	343		
20	W17		2.30	213	3.2	2.0			5.2	602		
21	W17		256.20	5,953	35	25			36	399		
22	W17		1.60	159	13	1,217			6.7	160		
23	W17		1.60	7.0	3.1				12			
24	W17		15.16	110					45	631		

C13 — Epithermal Vein, quartz-adularia type — Montana

Descriptive Models 25C + 25D
• 3.1 mean undiscovered deposits (entire tract)
• 1.5 mean undiscovered deposits (ICBEMP portion only)

by David Frishman

Rationale for Tract Delineation

For the purpose of delineating the permissive tract, the three types of epithermal precious-metal vein deposits (quartz-adularia, quartz alunite, and hot-spring) were treated the same. It was judged that the criteria available to discriminate between the subtypes were too imprecise to use effectively. Probabilities of occurrence for the individual types were assigned separately. No distinction between the two quartz-adularia subtypes (Comstock and Sado types) was made for this tract.

Permissive areas that constitute the tract are generally small, and are scattered throughout western Montana. They were defined by the location of known active or fossil hot springs, the location of mines, prospects, and occurrences believed to represent epithermal deposits, and the location of Tertiary and Quaternary volcanic and hypabyssal rocks as shown on the Montana geologic map (Ross and others, 1955). The favorable tracts were defined by Frishman and James Elliot, based on knowledge of prospective occurrences and exploration activity.

Areas identified include the Hog Heaven volcanic field, the Lincoln volcanics (McDonald Meadows property), the Helena-Avon volcanics, several areas of the Lowland Creek volcanics southwest of Helena and north and west of Butte, the Virginia City-Alder Gulch area, an area of Challis volcanics exposed in the Horse Prairie area southwest of Dillon, the Marysville district, and small portions of Montana adjacent to the Yellowstone caldera in Wyoming.

Important Examples of Deposit Type

Epithermal veins of the quartz-adularia type occur in the Seven-up Pete and Rimini districts in western Montana. The Seven-Up Pete district consists of both a quartz-adularia vein deposit (Seven-Up Pete: #9, figure 7b) and a disseminated hot-spring deposit (McDonald Meadows: #2 on figure 11b). The Pauper's Dream property (or Basin Creek mine: #10, figure 7b) is a quartz-adularia vein deposit located southwest of Helena in the Rimini district. Other possible examples include some of the andesite-hosted veins (age unknown) in the Virginia City district, an epithermal vein in the Elkhorn Mountains, and chalcedony veins in the Clancy district south of Helena.

Rationale for Numerical Estimate

Since no distinction was made for whether the undiscovered deposits would be of the Comstock type or the Sado type, the estimate was made using a grade-tonnage model that combines the two types. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 1, 3, 5, 6, and 9 or more deposits consistent with the combined grade and tonnage models of Mosier, Singer, and Berger (1986b) and Mosier and Sato (1986). For that portion of the tract that lies within the ICBEMP study area (figure 7a), an estimate of 0, 2, 2, 3, and 5 or more undiscovered deposits was made.

C30 — Epithermal Vein, quartz-adularia type — Utah, Idaho

Descriptive Models 25C + 25D

• 0.01 mean undiscovered deposits (for ICBEMP portion of tract only)

by Douglas B. Stoeser

Rationale for Tract Delineation

No distinction between the two quartz-adularia subtypes (Comstock and Sado types) was made for this tract. Permissive rocks for quartz-adularia gold deposits consist of Tertiary intermediate to silicic volcanic fields that have undergone minimal erosion. These are present in three east-trending belts in western Utah and southernmost Idaho. In addition to the Miocene and older calc-alkaline belts which also have porphyry copper potential, the younger (20 Ma to present) extension-related, evolved, silicic systems are also prospective for epithermal gold deposits. Most of the silicic extensional magmatism also occurs within the three same areas that contain intrusion-related deposits (porphyry copper, polymetallic replacement, and skarn).

Important Examples of Deposit Type

No significant quartz-adularia gold deposits occur within this tract. South of the map area in west-central Utah, small Comstock-type gold deposits occur in similar host rocks and include Gold Mountain (Marysvale District), Stateline, and Escalante deposits. However the metal endowment of each of these deposits (combined production and resources) is too small to be considered a significant deposit.

Rationale for Numerical Estimate (ICBEMP portion only)

The lack of significant deposits or even important prospects within that portion of tract C30 that lies within the ICBEMP study area (figure 7a) leads us to give a low estimate for the potential for undiscovered Comstock-type gold deposits in that portion of tract C30. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the composite grade and tonnage model of Mosier, Singer, and Berger (1986b) and Mosier and Sato (1986) in that part of tract C30 that lies within the ICBEMP study area.

C102 — Epithermal Vein, Comstock type — Wyoming

Descriptive Model 25c

• 0.2 mean undiscovered deposits (entire tract)

• 0.1 mean undiscovered deposits (ICBEMP portion only)

by Steve Ludington and David Frishman

Rationale for Tract Delineation

The permissive tract is delineated to include the central part of the Pleistocene to Recent Yellowstone volcanic field in Wyoming, including the three Yellowstone calderas (White and others, 1988); some areas were excluded from the permissive tract where the volcanic rocks are known to be only a thin mantle of distal outflow facies. Most tract boundaries were derived from the geologic map of Wyoming by Love and Christiansen (1985).

Important Examples of Deposit Type

There are no known vein deposits within or near the tract, however, the area has been withdrawn from mineral entry since 1872 and there has been no exploration. There are several areas of intense hydrothermal activity and alteration, which are indicative of mineralization below. Areas currently experiencing hydrothermal activity and alteration include Mammoth Hot Springs, the Norris-Elk Park-Gibbon Geyser Basin area, the Lower, Midway, and Upper Geyser Basins, Yellowstone Canyon, the West Thumb Geyser Basin, the Heart Lake Geyser Basin, Washburn Hot Springs and a large area to the east that hosts Whistler geyser, Rainbow Springs, and Coffee Hot Springs, among others.

Rationale for Numerical Estimate

The presence of many active hydrothermal systems is indicative of mineralization. In addition, anomalous gold values (0.5 to 10 g/t) have been detected in sinter from Gibbon geyser basin and in hydrothermal quartz from Norris geyser basin (White and others, 1992). However, some deposits may be buried by younger rocks, and our estimate is smaller than the one for hot-spring Au-Ag in the corresponding tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 4, and 5 or more deposits (with a 90% chance of no deposits) in tract C102 consistent with the grade and tonnage model of Mosier, Singer, and Berger (1986b). For that part of the tract that lies within the ICBEMP boundary, the team estimated 0, 0, 0, 1, and 4 or more deposits (with a 95% chance of no deposits) consistent with the same model.

PC03 — Epithermal Vein, Comstock type — California

Descriptive Model 25c
No estimate of undiscovered deposits

by Roger Ashley

Rationale for Tract Delineation

All areas of Tertiary calc-alkaline volcanic rocks in this tract are considered permissive for Comstock-type deposits. Because these deposits usually have limited vertical extent (about 1000 m maximum), they could be present within the 1 km depth limit and have little surface manifestation. The tract boundaries are drawn to include all areas underlain predominantly by Cenozoic volcanic rocks between the Sierran front and the Nevada border, to the southern edge of the Great Basin. Where volcanic areas are covered by non-volcanic basin deposits of Tertiary or Quaternary age, the boundary is delineated where the cover is inferred to be 1 km thick, as derived from gravity models of the intermontane basins. A small favorable area in northeasternmost California is based on a map of "prospective" areas for Comstock deposits from an unpublished mineral assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994).

Important Examples of Deposit Type

The most prominent example is the Bodie district (south of the map boundary), which produced about 46 metric tons of gold and 31 metric tons of silver (Chesterman and others, 1986; Mosier, Menzie, and Kleinhampl, 1986).

Rationale for the Lack of a Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no estimate of undiscovered deposits was made.

PC04 — Epithermal Vein, Comstock type — California, Nevada

Descriptive Model 25C + 25D

No estimate of undiscovered deposits

by Michael F. Diggles

Rationale for Tract Delineation

The tract encompasses all Tertiary volcanic rocks in northeastern California, and was delineated using the geologic map of California (Jennings, 1977). Volcanic sequences include andesite and rhyolite domes of Tertiary age and other manifestations of volcanic centers where magmatic events might generate ore-depositing hydrothermal systems. The region also contains appropriate through-going fracture systems, major normal faults, and fractures related to doming (Rytuba, 1988; 1989). A small favorable area in northeasternmost California is based on the westward continuation of a "prospective" area for Comstock deposits from an unpublished mineral assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994), with the western boundary defined using mining claim densities from an unpublished US Bureau of Mines plot.

Important Examples of Deposit Type

There are no known quartz-adularia deposits in the area. The Skedaddle Mountain Wilderness Study Area on U.S. Bureau of Land Management land east of Susanville had over 280 lode claims for epithermal deposits (Diggles and others, 1988; Munts and Peters, 1987).

Rationale for the Lack of a Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no estimate of undiscovered deposits was made.

PC101 — Epithermal Vein, Comstock type — Washington

Descriptive Model 25c

• 2.7 mean undiscovered deposits

by Roger P. Ashley

Rationale for Tract Delineation

The tract includes late Eocene and Oligocene sandstones of the Chiwaukum graben, because mineralization in and near the Wenatchee district is localized where Eocene-Oligocene domes cut these rocks (Tabor, Waite, and others, 1982; Gresens, 1983; Margolis, 1989). The sandstones overlie a basement dominated by metasedimentary and plutonic rocks mostly of Cretaceous age. Such basement rocks are favorable for Comstock deposits (Mosier, Singer, and Berger, 1986a). The tract also includes early Eocene sandstones that host epithermal veins of the Swauk district, west of Wenatchee. Some pre-Tertiary rocks are included in a 3-km-wide zone around small Tertiary intrusions immediately east of the Chiwaukum graben (Tabor and others, 1987). Where flows of the Columbia River Basalt Group cover the early Tertiary sandstones on the southeast, the boundary is drawn where the younger basalt covers the sandstone to a depth of approximately 1 km (Drost and Whiteman, 1986). Favorable areas were defined using information on prospects, exploration activity, and mining claim densities around the Swauk district; the favorable tract in the Chiwaukum graben was extended to the northwest based on evidence for anomalous thermal alteration along the Eagle Creek fault (Evans, 1994).

Important Examples of Deposit Type

The most prominent example is the Wenatchee district (Cannon and Lovitt mines: #7 & #8, figure 7b), Chelan County, Washington, with total endowment (production and resources) of nearly 50 metric tons of gold and more than 100 metric tons of silver (Margolis, 1989). The Swauk district, in Kittitas County, has produced more than 0.25 metric tons of gold from lode mines, and considerably more from placers (Huntting, 1956).

Rationale for Numerical Estimate

For the 90th, 50th, and 10th percentiles, the team estimated 1, 3, and 4 or more Comstock epithermal-vein districts consistent with the grade and tonnage model of Mosier, Singer, and Berger (1986b). The single district estimated at the 90th percentile reflects reports that exploration continues at several mineralized sites near Wenatchee (Derkey, 1993). The estimate of three districts at the 50th percentile and an additional district at the 10th percentile expresses a relatively high perceived probability that additional districts may exist elsewhere in the tract, particularly in the Chiwaukum graben in a geologic setting similar to Wenatchee.

PW100 — Epithermal Vein, Comstock type — Oregon

Descriptive Model 25c

• 1.4 mean undiscovered deposits

by Roger Ashley

Rationale for Tract Delineation

Calc-alkaline volcanic rocks of the Cascade volcanic arc, mainly late Miocene to Quaternary in age, occupy the western part of the tract (Sherrod and Smith, 1989; Walker and MacLeod, 1991; Jennings, 1977). The tract includes calc-alkaline rocks of the Eocene Clarno Formation in north-central Oregon (Walker and MacLeod, 1991). South-central Oregon and northeastern California have back-arc Cascades andesites, and basalts and rhyolites of the bimodal suite of the Basin and Range Province (Walker and MacLeod, 1991; Jennings, 1977). High-level intrusions are locally associated with all volcanic sequences. All volcanic rocks in the tract are considered permissive for Comstock-type deposits. Favorable areas were drawn based on knowledge of known occurrences, exploration activity, and a US Bureau of Mines plot of mining claim densities.

In Oregon and northernmost California the west side of the tract is the boundary between Oligocene and Miocene rocks of the western Cascades and predominantly Quaternary volcanic rocks of the high Cascades. Ridge-capping flows of late Miocene and Pliocene age are included in the tract. In most of northern California, the tract includes both Tertiary and Quaternary rocks of the Cascades; here the west side of the tract is the boundary between Tertiary rocks and pre-Tertiary rocks of the Klamath Mountains province.

East of this tract is an area recognized in a mineral resource assessment of the Malheur-Jordan BLM Resource Area(work in progress) as favorable for epithermal precious metal deposits (tract W101 on figure 7a). The location of the boundary with the latter tract, in which hot-spring Au-Ag occurrences are relatively common, is somewhat arbitrary. The southeast edge of the tract, which closely follows the Oregon-Nevada and California-Nevada borders, is the boundary of the Great Basin region, which has abundant epithermal precious metal occurrences. The eastern and southeastern boundaries do not represent a geologic discontinuity or a distinct change in geologic features.

In north-central Oregon, the boundary is drawn where flows of the Columbia River Basalt Group cover the Cascade rocks to a depth of approximately 1 km. An isolated area of Columbia River Basalt Group rocks near the northeast corner of the tract is also excluded because it is underlain by pre-Tertiary rocks; favorable volcanic rocks of the Basin and Range bimodal suite and Clarno Formation are missing. Areas covered with more than 1 km of Quaternary alluvium in the Goose Lake, Summer Lake, and Klamath grabens are also excluded.

Important Examples of Deposit Type

The largest deposit of Comstock type in the tract is the Oregon King mine, Jefferson County, Oregon, which produced 0.075 metric tons of gold, 0.72 metric tons of silver, and small amounts of copper and lead (Libby and Corcoran, 1962). However its metal endowment is not large enough to qualify inclusion as a significant deposit in Table 7.

Rationale for Numerical Estimate

For the 90th, 50th, and 10th and 5th percentiles, the team estimated 0, 1, 3 and 5 or more Comstock epithermal-vein districts consistent with the grade and tonnage model of Mosier, Singer, and Berger (1986b). The estimates of one deposit at the 50th percentile and three deposits at the 10th percentile together express the perceived probability that exploration of known districts and prospects could yield deposits. Two additional districts are included at the 5th percentile because there is extensive favorable ground in the tract, but the density of known deposits is low, so there is a low probability that other districts large enough to fit the grade-tonnage model may exist.

W02 — Epithermal Vein, Comstock type — Washington

Descriptive Model 25c

• 2.4 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include the Eocene volcanic and volcaniclastic rocks of the Republic graben and nearby areas of northeastern Washington (Stoffel and others, 1991). There is a broad similarity within the tract in the stratigraphy (Pearson and Obradovich, 1977) and structural setting of the Eocene volcanic fields. Volcanism and mineralization were broadly contemporaneous with detachment faulting above the Okanogan, Kettle, and Priest River metamorphic core complexes. Shallow splays of the detachment faults host epithermal mineralization in the three productive epithermal districts in the tract (Republic, Kettle River, and First Thought districts). The 15 or so apparently separate volcanic fields in the tract may have originally been part of a more continuous volcanic province that was extended and dismembered by detachment faulting and erosion. Favorable tracts were delineated based on knowledge of known occurrences, exploration activity, and a US Bureau of Mines plot of mining claim densities.

Important Examples of Deposit Type

The Republic and adjacent areas of northeastern Washington contains numerous volcanic-hosted epithermal deposits, prospects, and occurrences. The Golden Promise mine in the Republic district (#4, figure 7b) is an important example of this type (Tschauder, 1989). The vein system has been mined for over 300 m down dip. The prominent vein system becomes a stockwork system in the upper part, and grades up into an overlying, hot-spring, Au-bearing sinter, which is being exploited as part of the underground mine. The Golden Eagle, Last Chance, and Republic deposits (#3, 5, and 6: figure 7b) occur along extensions of the same vein system as the Knob Hill-Golden Promise deposit. Other examples of productive vein districts in this tract are the Kettle River (#2, figure 7b) and Orient (#1, figure 7b) districts.

Rationale for Numerical Estimate

The widely scattered yet stratigraphically similar volcanic piles, their consistent structural setting, the existence of numerous Au prospects in the region, the great productivity of the Republic district, and the poor exposure caused us to give a fairly optimistic estimate of the number of undiscovered districts. Although Comstock veins in the area grade up into more disseminated hot-spring systems, erosion has removed much of the favorable ground for hot springs, and we made estimates only for undiscovered Comstock deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 1, 2, 4, 5, and 8 or more districts consistent with the grade and tonnage model of Mosier, Singer, and Berger (1986b).

W12 Epithermal Vein, Comstock type — Idaho

Descriptive Model 25c

No estimate of undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include the Eocene Challis volcanic field of south-central Idaho (Bond, 1978). Broad areas of known mineralization are associated with contemporaneous activity on the major northeast-trending, subvertical Trans-Challis fault zone (Kiilsgaard and others, 1986). Most of the known epithermal mineralization is associated with the older parts of the Challis volcanic pile. Over large areas the deeper parts of the Challis volcanic pile are covered by younger parts of the volcanic stratigraphy, so that mineralized areas may be effectively hidden from surface exposure.

Important Examples of Deposit Type

The Eocene Challis volcanic field in south-central Idaho is host to three major epithermal districts: the Thunder Mountain district in the Thunder Mountain caldera on the west, the Yankee Fork district in the northeast-trending Trans-Challis fault zone, and the Champagne deposit at the margin with the Snake River plain (a Pliocene feature). Active mines in each district exploit the stockwork, disseminated, upper parts of these hydrothermal deposits, which have the grade and tonnage characteristics of hot-spring Au-Ag deposits (#3,4,7, Table 11). However older mines, in the Yankee Fork district in particular, were concentrated on the deeper, vein portion of these hydrothermal deposits (Anderson, 1949).

Rationale for Lack of Numerical Estimate

Contemporaneous faulting and volcanism in the Trans-Challis fault zone, along with two known prospect areas there, lead us to consider the area of the intersection of the fault zone and the volcanic field as favorable for undiscovered epithermal districts. Irregular cover of the favorable lower part of the volcanic field by younger lavas and ash-flows of the unmineralized upper part of the field suggests exploration has not fully evaluated this area. However, because recent mining has focused on the bulk mineable part of the mineralized systems, we expect that most undiscovered Comstock type mineralization will be mined as part of an open pit operation that will result in a higher tonnage and lower grade production that better fits the hot-spring Au-Ag grade and tonnage model of Berger and Singer (1992). Therefore, since we estimate the number of undiscovered hot-spring Au-Ag deposits, we make no estimate for the number of undiscovered Comstock deposits.

W17

Epithermal Vein, Comstock type

Nevada
Idaho

Descriptive Model 25c
• 1.1 mean undiscovered deposits
(for portion of tract in ICBEMP area only)

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The known Comstock type deposits in Nevada are distributed in a crescent-shaped area, concave to the east, that corresponds poorly with the overall distribution of Tertiary volcanic rocks (Silberman and others, 1976; Stewart and others, 1977; Seedorff, 1991; Cox and others, 1991; Ludington and others, in press). This distribution of volcanic-hosted epithermal deposits cannot be explained by the absence of volcanic rocks inward from the crescent. On the contrary, eastern Nevada contains extensive outcrops of older interior andesite-rhyolite assemblage rocks (older than 27 Ma) in which epithermal vein deposits are virtually unknown.

In addition to active volcanism, faulting and fracture permeability are important in controlling the distribution of epithermal deposits. The crescent-shaped area described above corresponds closely to those areas which were undergoing faulting in an extensional tectonic regime during active volcanism. The synvolcanic deformation is important because it provides fracture permeability at the same time that hydrothermal systems related to volcanism are active and circulating, thus facilitating the formation of veins and stockworks. Where Miocene volcanic rocks are relatively unfaulted, for example in the Sierra Nevada of California and in the Cascade Range of Oregon and Washington, Comstock deposits are rare or absent.

The Walker Lane area, parallel to and near the Nevada-California border, contains well-developed normal faults, and is probably the best studied region of epithermal mineralization in Nevada (Stewart, 1988). Northwest-striking high-angle faults that predominate in this area have been shown by John and others (1989) to be at least as old as the earliest volcanic activity (22 Ma) in the Paradise Range suggesting that faulting and volcanism were synchronous throughout the period of andesite volcanism. This region is shown by Blakely (1988) to be characterized by a northwest trending grain in the pattern of magnetic anomalies that can be recognized about 50 km to the northeast of traditional boundaries of the Walker Lane that are based on topography and structure. This expanded area of characteristic magnetic fabric encompasses all of the volcanic-hosted epithermal districts in southwestern Nevada. The northeastern boundary of this magnetic anomaly pattern coincides with a line separating calderas younger and older than 27 Ma. (Best and others, 1989); the eastern boundary is the magnetic quiet zone (Blakely, 1988). Walker Lane deformation began locally at 27 Ma, and continued during succeeding volcanic episodes until the beginning of Basin and Range deformation at about 11 Ma, thus controlling the distribution of epithermal precious-metal deposits in this portion of Nevada. A strong negative correlation exists between the magnetic quiet zone and the distribution of volcanic-hosted epithermal deposits.

The permissive tract for Comstock epithermal districts is based on the distribution of volcanic rocks, of epithermal mineral deposits, prospects, and occurrences, on the distribution of synvolcanic faults, and on the magnetic anomaly patterns described above. Because some epithermal deposits occur in sedimentary rocks close to volcanic rocks, sedimentary rocks within and between the volcanic rock areas are included in the tract. The favorable tracts were adapted from "prospective" areas for Comstock deposits from an unpublished mineral assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994).

Important Examples of Deposit Type

Roughly 30 Comstock epithermal Au-Ag districts are known in Nevada. The Comstock district (deposit 21, figure7b), the largest in Nevada, are associated with volcanic rocks of the western Andesite assemblage. The National and Jarbidge districts (deposits 13 & 15, figure 7b) are related to the bimodal assemblage, and Tuscarora, to the andesite-rhyolite assemblage.

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W17 that lies within the ICBEMP study area in northeastern Nevada (figure 7a). Numbers of undiscovered Comstock districts have previously been estimated by county in northeastern Nevada (Singer, 1996). The ICBEMP portion of tract W17 lies within two counties. To arrive at the numerical estimate of undiscovered Comstock districts in the ICBEMP portion of tract W17, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 1.11 mean undiscovered Comstock districts for the part of the ICBEMP study that extends into northeastern Nevada. . The general lack of prospects in Miocene and younger rocks in the Idaho portion of the tract leads us to assume this estimate is valid for the whole ICBEMP portion of tract W17. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 1, 2, 3, and 4 or more undiscovered districts consistent with the grade and tonnage model of Mosier, Singer, and Berger (1986b) is equivalent to the estimated number of mean undiscovered districts derived above.

W101 — Epithermal Vein, Comstock type — Oregon

Descriptive Model 25c

• 4.7 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

In Southeastern Oregon, widespread Neogene felsic, intermediate, and mafic volcanic rocks, along with considerable Neogene normal faulting, provide a compositionally and structurally appropriate environment for epithermal vein occurrences. Known Au-Ag epithermal occurrences are of the quartz-adularia type. The permissive tract encircles essentially all Neogene volcanic and associated sedimentary rocks outside of the Ore-Ida graben in southeastern Oregon (Peters and others, 1994). The western boundary is drawn to separate much less favorable ground in central Oregon. Some basaltic volcanic rocks are included which may not be appropriate for the occurrence of Comstock veins. However insufficient data are available to outline only the compositionally appropriate volcanic rocks. Favorable areas were adapted from "prospective" areas for Comstock deposits from the mineral resource assessment study of the Malheur-Jordan-Andrews BLM Resource Areas (Peters and others, 1994).

Important Examples of Deposit Type

No significant Comstock-type Au-Ag deposits are known from this tract. However a number of hot-spring geothermal systems are known, and deeper, unexposed parts of these systems are likely to include tabular vein deposits of Comstock type.

Rationale for Numerical Estimate

An important factor considered in the development of estimates of the number of these deposits is that grade and tonnage values used in constructing the model include data from mining districts, as opposed to individual mines or deposits. District data are used where individual mines or deposits are spaced less than one mile apart, in which case the production and reserve data for the mines or deposits are aggregated. In this case several widely spaced hot-spring deposits at or near the surface may at depth be related to a system of epithermal veins, whose spacing is such that it would be treated as a district. This accounts for the lower estimated number of these deposits in comparison to the estimate for the number of hot-spring deposits for the same tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 2, 4, 7, 11 and 16 or more districts consistent with the grade and tonnage model of Mosier, Singer, and Berger (1986b) was made by combining the estimate for the Malheur-Jordan BLM Resource area from Spanski (1994) and for the Andrews BLM Resource Area (Greg Spanski, written communication, 1995).

W102 — Epithermal Vein, Comstock type — Oregon

Descriptive Model 25c

• 3.1 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include all the area of Neogene rocks within the Ore-Ida graben, a north-south structural feature controlling the distribution of Miocene and younger volcanic and sedimentary rocks (Peters and others, 1994). Within this tract, widespread occurrences of hydrothermal alteration, silica sinter, and anomalous concentrations of gold, silver, arsenic, antimony, and mercury in rocks, soil, and stream sediments indicates the presence of numerous extinct geothermal systems with precious metal contents (Peters and others, 1994). Commonly Comstock-type vein mineralization occurs in the deeper parts (below 100 m) of the geothermal systems. Since much of the Neogene section is buried under younger Neogene rocks, essentially all of the prospective Comstock vein horizons are buried. Favorable areas were adapted from "prospective" areas for Comstock deposits from the mineral assessment study of the Malheur and Jordan BLM Resource Area (Peters and others, 1994).

Important Examples of Deposit Type

The Grassy Mountain deposit (#6, figure 11b) is a large hot-spring Au-Ag deposit within the tract (Wheeler, 1988). Some portions of the deposit contain deeper vein-style epithermal mineralization that could be classified as Comstock-type. However all of the grade and tonnage of the Grassy Mountain deposit are included in the hot-spring model, since the deposit would be bulk-mined as one deposit.

Rationale for Numerical Estimate

An important factor considered in the development of estimates of the number of these deposits is that grade and tonnage values used in constructing the model include data from mining districts, as opposed to individual mines or deposits. District data is used where individual mines or deposits are spaced less than one mile apart, in which case the production and reserve data for the mines or deposits are aggregated. In this case several widely spaced hot-spring deposits at or near the surface may at depth be related to a system of epithermal veins, whose spacing is such that it would be treated as a district. This accounts for the lower estimated number of these deposits in comparison to the estimate for the number of hot-spring deposits for the same tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 2, 3, 4, 6, and 8 or more undiscovered districts consistent with the Au-Ag grade and tonnage model of Mosier, Singer, and Berger (1986b) was made by the USGS team assessing the mineral potential of the Malheur-Jordan BLM Resource Area (Spanski, 1994).

W103 Epithermal Vein, Comstock type — Idaho

Descriptive Model 25c

No estimate of undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

This permissive tract for undiscovered Comstock epithermal-vein districts was drawn to include the Idaho portion of the Ore-Ida graben, as interpreted from the state geologic map (Bond, 1978). This area is underlain by a voluminous pile of Miocene basaltic and felsic volcanic rocks and associated volcaniclastic rocks and encompasses Miocene and younger zone of pervasive north-south faulting. Three known Comstock deposits occur within Miocene felsic volcanic rocks within the tract. As some vein mineralization extends into Cretaceous granitic rocks within the tract, these rocks were also included in the tract. The tract is buried on the northeast by younger basaltic lavas of the northwest Snake River plain. The southern boundary of the tract was drawn just south of the southernmost prospects known in southwestern Idaho. Favorable areas were adapted from the eastward continuation of "prospective" areas for Comstock deposits from the mineral assessment study for the Malheur-Jordan-Andrews BLM Resource Areas in Oregon (Peters and others, 1994), using the locations of known prospects and a Bureau of Mines plot of mining claim densities in Idaho.

Important Examples of Deposit Type

The War Eagle deposit in Owyhee County (#11, figure 7b) is an important Comstock deposit within the permissive tract. This vein deposit cuts both Miocene rhyolites and underlying Cretaceous granitic rocks (Asher, 1968). Two other epithermal deposits in the tract (De Lamar and Stone Cabin: #8 & 9, figure 11b) are Comstock veins in Miocene rhyolites that grade up into hot-spring Au-Ag deposits, but are classified here as hot-spring deposits. However the contained metal contents of each of these three deposits overlaps the mean metal content of Comstock deposits in the grade and tonnage model of Mosier, Singer, and Berger (1986b).

Rationale for Lack of Numerical Estimate

It is thought that all Comstock-type deposits exposed at the surface in the tract area are known, and any undiscovered deposits must be covered. Since the area has been mostly subsiding since the Miocene, the team inferred that any undiscovered Comstock vein deposit will probably still be overlain by a more disseminated hot-spring Au-Ag deposit, for which exploration is fairly incomplete. These undiscovered Comstock vein systems will probably be mined along with their overlying hot-spring deposit, and will be incorporated into the grade and tonnage of any undiscovered hot-spring deposit. For this reason, we only make an estimate for undiscovered hot-spring deposits for this area, and make no estimate for undiscovered Comstock deposits.

W104 Epithermal Vein, Comstock type Idaho

Descriptive Model 25c

No estimate of undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract was drawn to include the entire area of Miocene rhyolitic volcanism southwest of the Pleistocene Snake River plain, and south of the Idaho portion of the Ore-Ida graben (Bond, 1978). The tract is underlain by two large Miocene caldera complexes, Juniper Mountain and Bruneau-Jarbidge (Ekren and others, 1982; Bonnichsen, 1982). Extensive rhyolitic ashflow tuffs erupted from the calderas, and these are overlain by Miocene basaltic lavas. A minor amount of older metamorphic and granitic rock is also included within the tract, since veins may extend into these lithologies, as they do in the Silver City area in the tract to the north.

Important Examples of Deposit Type

No examples of this deposit type are known within the tract.

Rationale for Lack of Numerical Estimate

The lack of known deposits within the tract and the dearth of information available on any exploration activity prevented the team from estimating the number of undiscovered deposits of this type.

W105 Epithermal Vein, Comstock type Idaho

Descriptive Model 25c

No estimate of undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

Hot-spring mercury mineralization at the Idaho Almaden mine near Weiser (Anderson, 1941) indicates the existence of extinct geothermal systems in this tract. Deeper parts of these systems may include veins of the Comstock type (Mosier, Singer, and Berger, 1986a). The tract was drawn around the Miocene Payette Formation, host rock of the Idaho Almaden mine, northwest of the western Snake River plain (Bond, 1978). The Miocene Payette Formation consists of fluvial arkosic sediments derived from the Idaho batholith and is capped by lavas of the Columbia River basalt. The surrounding area where the Payette Formation may occur within a kilometer of the surface beneath the overlying Columbia River basalt was also included.

Important Examples of Deposit Type

No examples of this deposit type are known in the tract. However, the existence of an extinct Au-bearing hot-spring hydrothermal system at the Idaho Almaden mine near Weiser suggests the possibility that Comstock-type vein systems may occur at depth. Gold occurs in subeconomic grades in the Idaho Almaden deposit.

Rationale for Lack of Numerical Estimate

The lack of known deposits within the tract and the dearth of information available on any exploration activity prevented the team from estimating the number of undiscovered deposits of this type.

Epithermal Vein, Comstock type

Descriptive Model 25c

No estimate of undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The Recent Yellowstone volcanic field to the east consists of Neogene felsic volcanic rocks with known recent hot springs, some with detectable gold contents (White and others, 1992). Some of these hot-spring systems are presumed to grade downward into structurally controlled vein systems of Comstock type. The permissive tract was delineated to include felsic volcanic rocks of the Pliocene to Recent Yellowstone volcanic field. These volcanic rocks are buried on the west by basaltic lavas of the Snake River Plain. The permissive tract was drawn to include the felsic volcanic rocks where they are covered by less than a kilometer of overlying basalt (Bond, 1978).

Important Examples of Deposit Type

The modern hot springs of Yellowstone National Park are taken to be active discharges of deeper, developing Comstock vein systems. However, no Comstock vein systems are presently known.

Rationale for Lack of Numerical Estimate

Since the Yellowstone volcanic field has not been strongly eroded and is buried by younger basalts on the west, any undiscovered Comstock-type deposit will probably be found beneath a high level stockwork and hot-spring deposit, and would probably be bulk mined along with the more disseminated high level deposit that will result in a higher tonnage and lower grade production that better fits the hot-spring Au-Ag grade and tonnage model of Berger and Singer (1992). Therefore, since we estimate the number of undiscovered hot-spring Au-Ag deposits, we make no estimate for the number of undiscovered Comstock deposits.

Massive sulfide, Cyprus-type deposits

General Deposit Description

Cyprus massive-sulfide deposits are massive, stratabound Cu-, Zn-, and Fe- sulfide accumulations deposited with submarine basalts in ophiolite sequences (Singer, 1986a). Recent work in modern ocean basins has identified active modern analogues at hydrothermal vents associated with modern mid-ocean ridge and back-arc basin spreading centers (Koski and others, 1994). These deposits are formed in deep ocean basin environments and are emplaced into and onto continental crust in a variety of complex boundaries between oceanic and continental plates.

The deposits typically consist of two parts: an upper, stratiform body of massive sulfides (>60% sulfides), and a lower, cross-cutting stockwork of sulfide veinlets with wallrock alteration (replacement of feldspars with secondary chlorite, epidote, calcite and quartz). Copper is typically the economic commodity, with subordinate values of zinc, lead, cobalt, gold and silver. The median size of a Cyprus massive sulfide deposit is 1.6 million metric tonnes with a median grade of 1.7% copper (Singer and Mosier, 1986a).

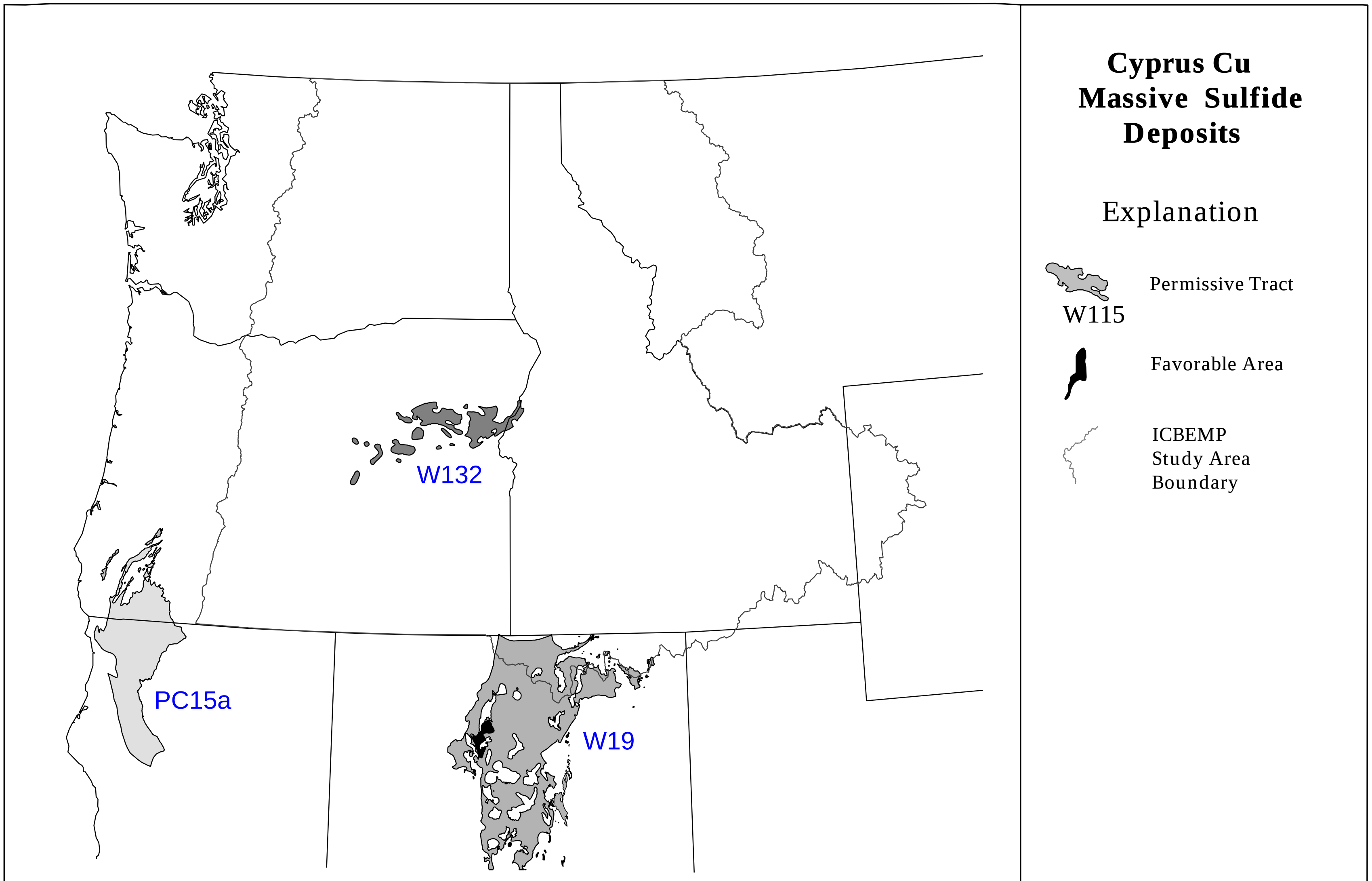


Figure 8a: Permissive and favorable tracts for Cyprus Cu massive sulfide deposits.

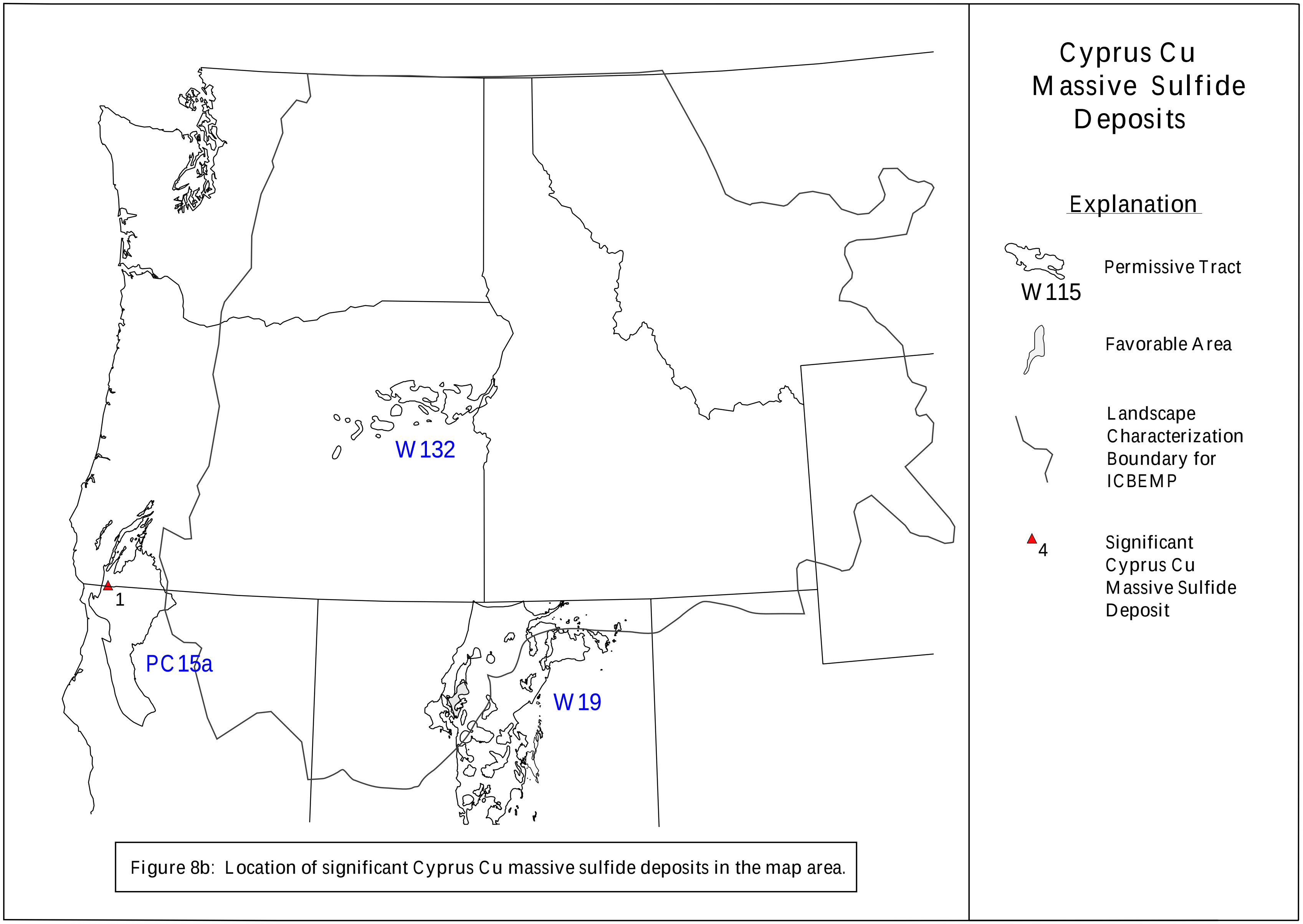


Figure 8b: Location of significant Cyprus Cu massive sulfide deposits in the map area.

Table 8: Significant Cyprus massive sulfide deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
01	PC15a	Turner-Albright	Waldo	Josephine	OR	42.007	-123.757

Table 8: Significant Cyprus massive sulfide deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Status	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Zn resource (tonnes)
01	PC15a	Turner-Albright	F D	11	60	45,497	101,358

Tract Descriptions

PC15a

Cyprus Cu massive sulfide deposits
Descriptive Model 24a
• 1.0 mean undiscovered deposits (OR portion only)

California
Oregon

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

Submarine basalts and associated ultramafic rocks ranging in age from Permian through Jurassic are widespread in the Klamath Terrane in the Klamath Mountains of northern California and southern Oregon. All sedimentary and volcanic rocks of these ages as well as the eastern part of the Josephine peridotite complex were delineated as permissive for Cyprus-type deposits.

Important Examples of Deposit Type

The Turner Albright deposit is considered to be a Cyprus massive sulfide deposit. It contains three million metric tons of massive sulfide ore averaging 1.46 percent copper, 3.33 percent zinc, 15 grams per metric ton silver, and 3.7 grams per metric ton gold (Kuhns and Baitis, 1987).

Rationale for Numerical Estimate

Since the area lies entirely outside the ICBEMP study area, the team did not make an estimate of undiscovered deposits for the entire tract. Because of the proximity of the Oregon portion of the tract to the ICBEMP study area, the team made an estimate for that portion of the tract. Because of the presence of one known deposit, and a few significant prospects, the estimators decided that there is an even chance of another undiscovered deposit, and that belief guided our estimate. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team made an estimate of 0, 1, 2, 2, and 3 or more undiscovered deposits consistent with the grade and tonnage model of Singer and Mosier (1986a) for the Oregon portion of the tract.

W19

Cyprus Cu massive sulfide deposits
Descriptive Model 24a
• 0.1 mean undiscovered deposits
(estimate for ICBEMP portion only)

Nevada

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The Roberts Mountains and Golconda allochthons are believed to contain remnants of closed oceanic basins. Portions of these assemblages that contain volcanic rocks form a tract permissive for Cyprus massive sulfide deposits. Parts of the Golconda allochthon include thick pillow basalt units, chert and turbidite as well as scattered bodies of serpentine indicating an oceanic depositional environment (Jones and Jones, 1991). The Roberts Mountains assemblage contains chert, argillite, and greenstone that also suggest an oceanic environment permissive for Cyprus-type deposits, but the eastern part of the Roberts mountains allochthon that is composed chiefly of shales of the Vinini Formation is considered less favorable. The favorable tract in the vicinity of the Big Mike deposit is based on a "favorable" area shown on maps of an unpublished mineral resource assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994).

Important Examples of Deposit Type

Rye, Roberts, and others (1984) conclude from textural and isotopic studies that the Big Mike copper deposit, which occurs in basalt of the Golconda assemblage, is probably a Cyprus-type deposit formed near a sea floor spreading center. The deposit produced about 100,000 tons of ore with a grade of 10.5% copper (too small for inclusion as a significant deposit on Table 8).

Rationale for Numerical Estimate

A numerical estimate was made only for that part of tract W19 that lies within the ICBEMP study area in northeastern Nevada (figure 8a). An estimate of the number of undiscovered Cyprus-type massive sulfide deposits by county in northeastern Nevada was previously made by Singer (1996). The ICBEMP portion of tract W19 lies within two counties. To arrive at the numerical estimate of undiscovered Cyprus massive sulfide deposits in the ICBEMP portion of tract W19, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 0.14 mean undiscovered deposits for the part of tract W19 within the ICBEMP study in northeastern Nevada. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 1, 2, and 3 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Singer and Mosier (1986a) is equivalent to the estimated number of mean undiscovered deposits derived above.

W132 — Cyprus Cu massive sulfide deposits — Oregon, Idaho

Descriptive Model 24a

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The Baker terrane is composed of a melange of crustal fragments of ocean basin and island arc origin in a highly deformed argillaceous matrix (Brooks and Vallier, 1978). Large and small fragments of ophiolite sequences occur widely throughout the terrane. The entire terrane as shown by Walker and MacLeod (1991) was considered permissive for Cyprus deposits.

Important Examples of Deposit Type

No known examples of this type of deposit are known from the Baker terrane, but some prospects are considered to have characteristics that could be indicative of this deposit type.

Rationale for Numerical Estimate

Although there are no deposits known, the estimators judged there was still some potential for undiscovered deposits. The exploration for them has not been thorough, and the potential exploration area is quite large. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, 1 or more undiscovered deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Singer and Mosier (1986a).

Distal Disseminated Ag-Au Deposits

General Deposit Description

Distal disseminated silver-gold deposits (Graybeal, 1981; Cox , 1992) are low-grade, precious-metal deposits found in carbonate-rich sedimentary rocks distal to porphyry copper deposits in the same districts as porphyry-related copper- and zinc-lead-skarns, polymetallic replacement deposits, and polymetallic veins. The model is similar to that of the Carlin-type, sediment-hosted Au deposits, but these deposits have significantly higher Ag grades. Ore minerals (native Au, native Ag, electrum, argentite, Ag sulfosalts, tetrahedrite, minor Pb, Zn, Cu and Fe sulfides) are sparsely disseminated or in stockwork of thin quartz-sulfide veinlets. Deposits occur in a wide variety of favorable host rocks, commonly carbonate-bearing sedimentary rocks but including non-calcareous clastic sedimentary rocks. They are typically found in folded and faulted shallow- and deep-marine sedimentary rocks that are intruded by I-type granitic rocks. These large tonnage deposits (median size=7.4 million metric tonnes; median Au grade=1.1 grams/tonne; median Ag grade=42 grams/tonne: Cox and Singer, 1992a) are typically developed in open-pit mines.

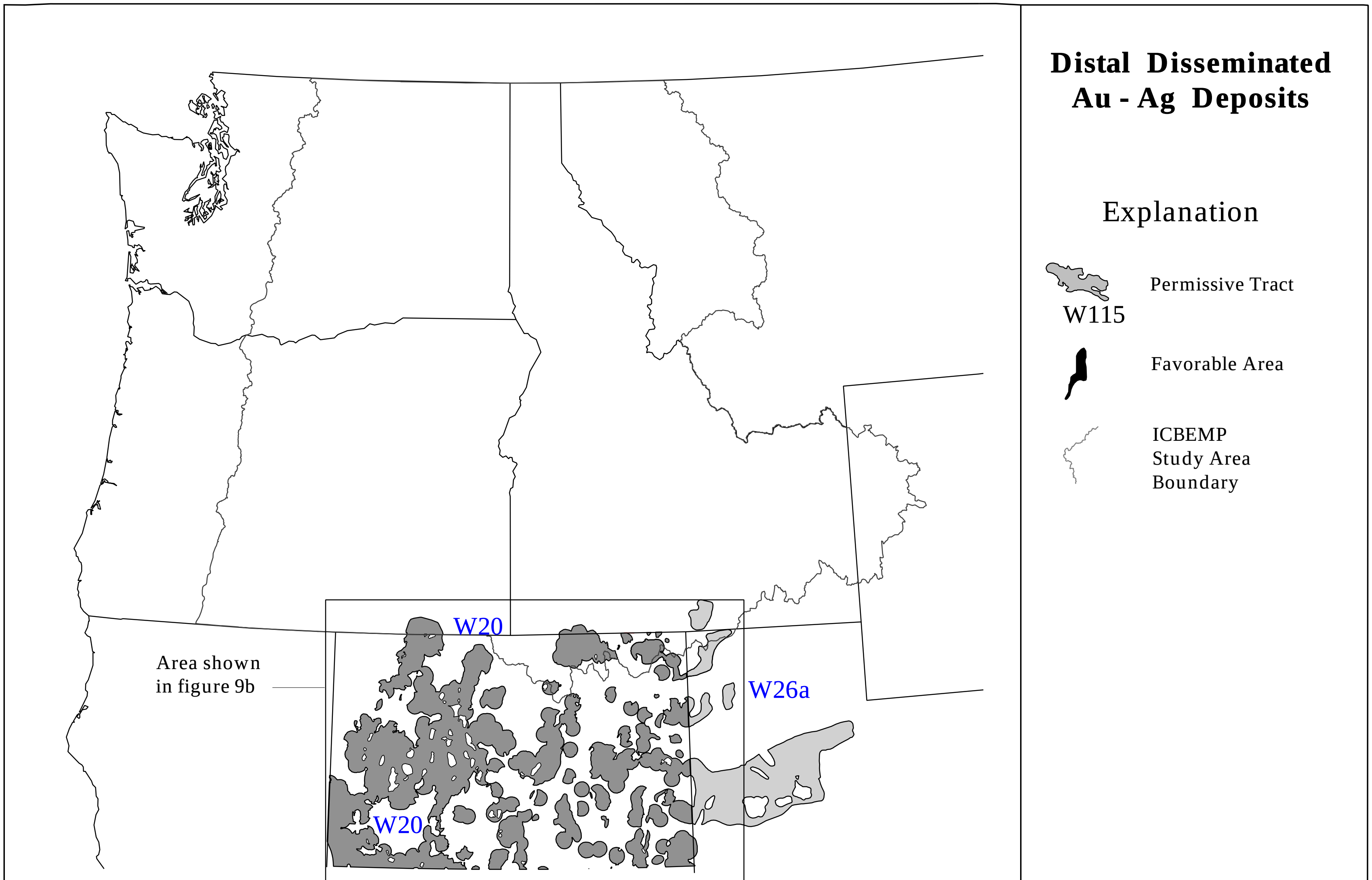
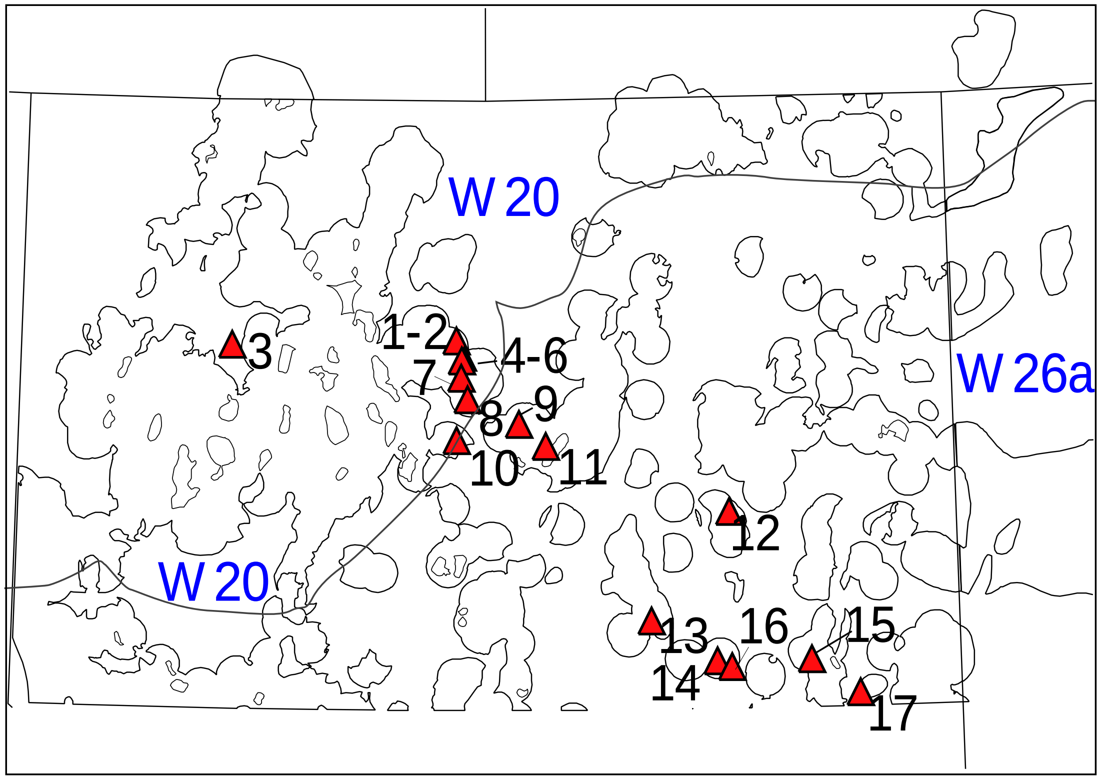


Figure 9a: Permissive and favorable tracts for Distal disseminated Au-Ag deposits.



Distal Disseminated Au - Ag Deposits

Explanation

Permissive Tract


Favorable Area


Landscape Characterization Boundary for ICBEMP

Significant Distal Disseminated Au-Ag Deposit

Figure 9b: Location of significant Distal disseminated Au-Ag deposits in the map area.

Table 9: Signifcant distal-disseminated Ag-Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W20	Lone Tree	Battle Mountain	Humboldt	NV	40.830	-117.210	P
02	W20	Stonehouse	Battle Mountain	Humboldt	NV	40.830	-117.210	P
03	W20	Rosebud	Rosebud	Pershing	NV	40.800	-118.650	F D
04	W20	Eight South	Battle Mountain	Humboldt	NV	40.742	-117.160	I M
05	W27	Marigold	Battle Mountain	Humboldt	NV	40.730	-117.180	P
06	W20	East Hill - UNR - Top	Battle Mountain	Humboldt	NV	40.729	-117.175	I D
07	W20	Trenton - Valmy	Battle Mountain	Humboldt	NV	40.645	-117.178	I D
08	W20	Reona	Battle Mountain	Lander	NV	40.540	-117.140	P
09	W20	Hilltop Mine	Hilltop	Lander	NV	40.420	-116.810	F D
10	W20	Cove - McCoy	McCoy	Lander	NV	40.340	-117.210	P
11	W20	Tenabo	Bullion	Lander	NV	40.310	-116.640	I M
12	W20	White Pine	White Pine	White Pine	NV	39.980	-115.480	S
13	W20	Windfall	Eureka	Eureka	NV	39.450	-115.980	I M
14	W20	Mt. Hamilton	White Pine	White Pine	NV	39.250	-115.570	F D
15	W20	Star Pointer	Robinson	White Pine	NV	39.250	-114.980	I M
16	W20	Treasure Hill	White Pine	White Pine	NV	39.220	-115.480	I M
17	W20	Taylor	Taylor	White Pine	NV	39.080	-114.680	S

Table 9: Signifcant distal-disseminated Ag-Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name		Au production (tonnes)	Ag production (tonnes)		Au resource (tonnes)	Ag resource (tonnes)
01	W20	Lone Tree		9.98			125	
02	W20	Stonehouse					9.1	
03	W20	Rosebud					18	172
04	W20	Eight South		sig	sig			
05	W27	Marigold		10.07	0.30		21	
06	W20	East Hill - UNR - Top					sig	sig
07	W20	Trenton - Valmy					18	
08	W20	Reona					25	
09	W20	Hilltop Mine					24	
10	W20	Cove - McCoy		43.92	734		83	4,256
11	W20	Tenabo		0.12			6.3	
12	W20	White Pine		0.80	0.01		2.0	
13	W20	Windfall		3.76			2.8	
14	W20	Mt. Hamilton					12	120
15	W20	Star Pointer		3.07	3.0		0.94	
16	W20	Treasure Hill			544			
17	W20	Taylor			88			122

W20

Distal Disseminated Ag-Au Deposits
Descriptive Model 19c, Bull. 2004
• 0.4 mean undiscovered deposits
(estimate for ICBEMP portion of tract only)

Nevada
Oregon
Idaho

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS) and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The tract permissive for distal disseminaed Ag-Au deposits is defined as an area extending 10 km outward from the outcrop of a pluton, or, in the case that the pluton has a geophysical expression as discussed by Grauch and others (1988), from the inferred subsurface boundary of the pluton, based on its geophysical expression. It also includes areas around plutons whose presence is inferred from geophysics or from the occurrence of skarn mineralization. The tract covers about 40 percent of the area of the state. Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in Nevada (Stewart, 1980), hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock.

About 72 percent of the permissive tract is covered by 1 km or less of Upper Tertiary and Quaternary rocks and sediments. Areas covered by more than 1 km (Blakely and Jachens, 1991) are excluded as are areas that are within a Tertiary caldera. In these latter areas, permissive pre-Tertiary host rocks are likely to be covered by more than 1 km of volcanic rock.

Important Examples of Deposit Type

Deposits of this type are numerous in Nevada. In permissive tract W20, Cove (#10, figure 9b) and Taylor (#17, figure 9b) are the most important. There are seventeen deposits known in the tract area, four of which were used to construct the grade-tonnage model (Cox and Singer, 1992a).

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W20 that lies within the ICBEMP study area (figure 9a). An estimate of the number of undiscovered distal disseminated Ag-Au deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W20 lies within two counties. To arrive at the numerical estimate of undiscovered distal disseminated Ag-Au deposits in the ICBEMP portion of tract W20, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 0.14 mean undiscovered distal disseminated Ag-Au deposits for the part of the ICBEMP study that extends into tract W20 (including the minor permissive tract extensions into Oregon and Idaho). For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 2, 4, and 6 or more deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model of Cox and Singer (1992a) is equivalent to the estimated number of mean undiscovered deposits derived above.

W26a — Distal Disseminated Ag-Au Deposits — Utah, Idaho

Descriptive Model 19c, Bull. 2004

• 0.01 mean undiscovered deposits
(estimate for ICBEMP portion of tract only)

by Dennis Cox and Steve Ludington

Rationale for Tract Delineation

The permissive tract for this deposit type is defined primarily by the distribution of intrusive rocks and suitable reactive host rocks, especially carbonate-bearing sedimentary rocks. It is made up of three east-trending belts in western Utah. The southernmost of the three is less deeply eroded than the other two, and any undiscovered replacement deposits in the south would most likely be concealed by the volcanic cover and alluvial cover. Aeromagnetic maps were employed to define areas of buried intrusive bodies.

Important Examples of Deposit Type

The Tecoma deposit, in northwest Utah near the Nevada border, is primarily considered a polymetallic replacement deposit (#11, figure 18b), but has some characteristics of distal disseminated Ag-Au deposits (Cox and Singer, 1992a). No other deposit of this type is known in tract W26a.

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W26a that lies within the ICBEMP study area (figure 9a). The lack of known prospects in the ICBEMP portion of the tract led us to make a low estimate of the number of undiscovered distal disseminated Ag-Au deposits in this tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, we estimate 0, 0, 0, 0, and 1 or more undiscovered deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Cox and Singer (1992a).

Homestake Au Deposits

General Deposit Description

Homestake Au deposits are stratiform deposits interlayered with iron-rich chemical sediments (silicate- and carbonate-facies iron formation) in Precambrian metavolcanic and metasedimentary terranes (Berger, 1986b). Ores are typically bedded, even finely laminated, in Fe-rich siliceous or carbonate-rich chemical sediments with underlying veins or stockworks in feeder zones to these sediments. Gold commonly is localized in and around low-sulfide gold-quartz veins, stringers, and pods that form during greenschist facies metamorphism of the stratiform ores. These deposits typically occur in Archean greenstone belts of regionally metamorphosed mafic and felsic metavolcanic rocks, komatiites, and volcaniclastic sediments interlayered with banded iron-formation. Deposits are commonly intruded by felsic plutonic rocks. The median size of Homestake Au deposits is 2.8 million metric tonnes with a gold grade of 7.2 g /tonne and byproduct Ag (Klein and Day, 1994).

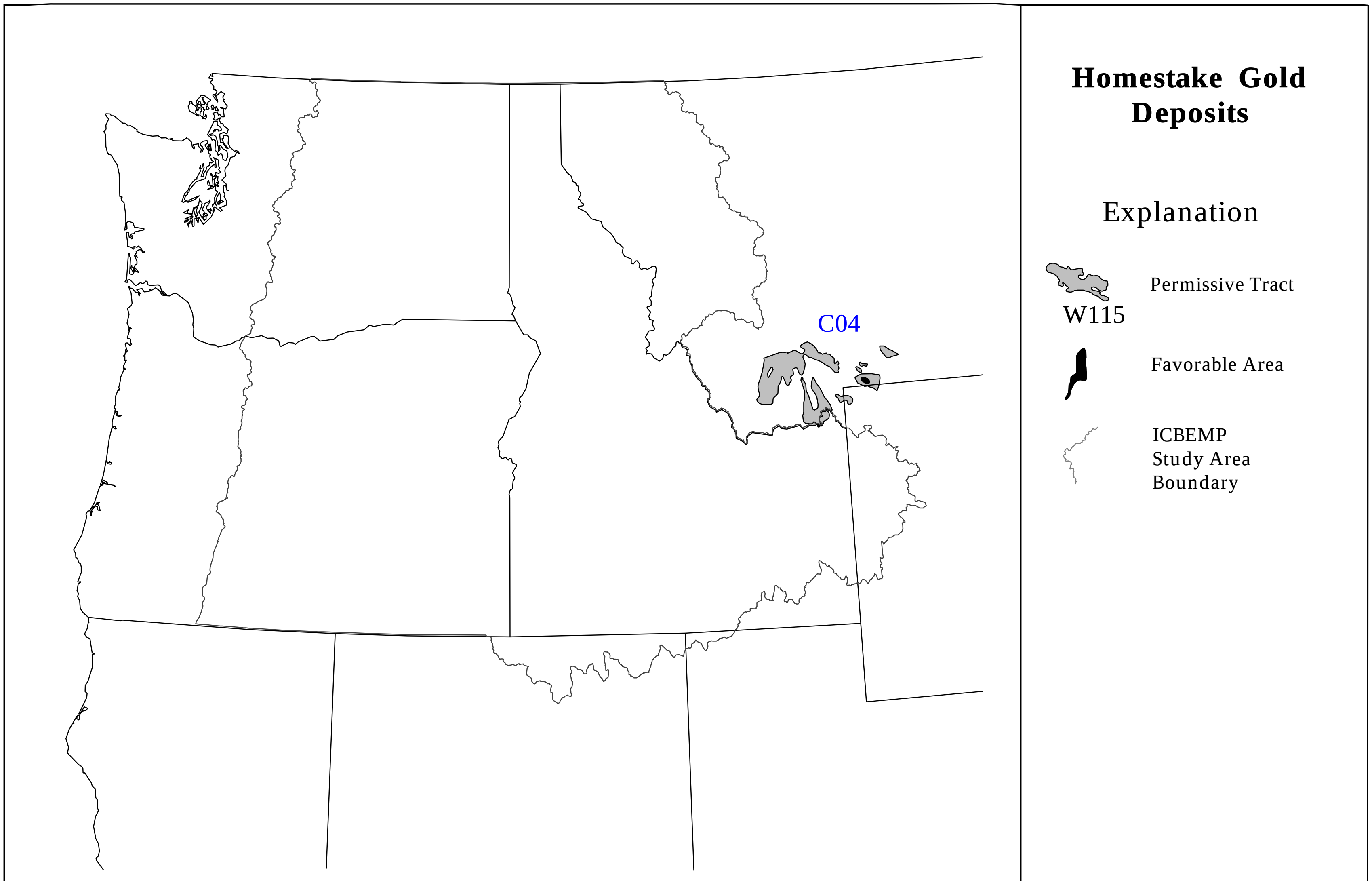


Figure 10a: Permissive and favorable tracts for Homestake gold Deposits.

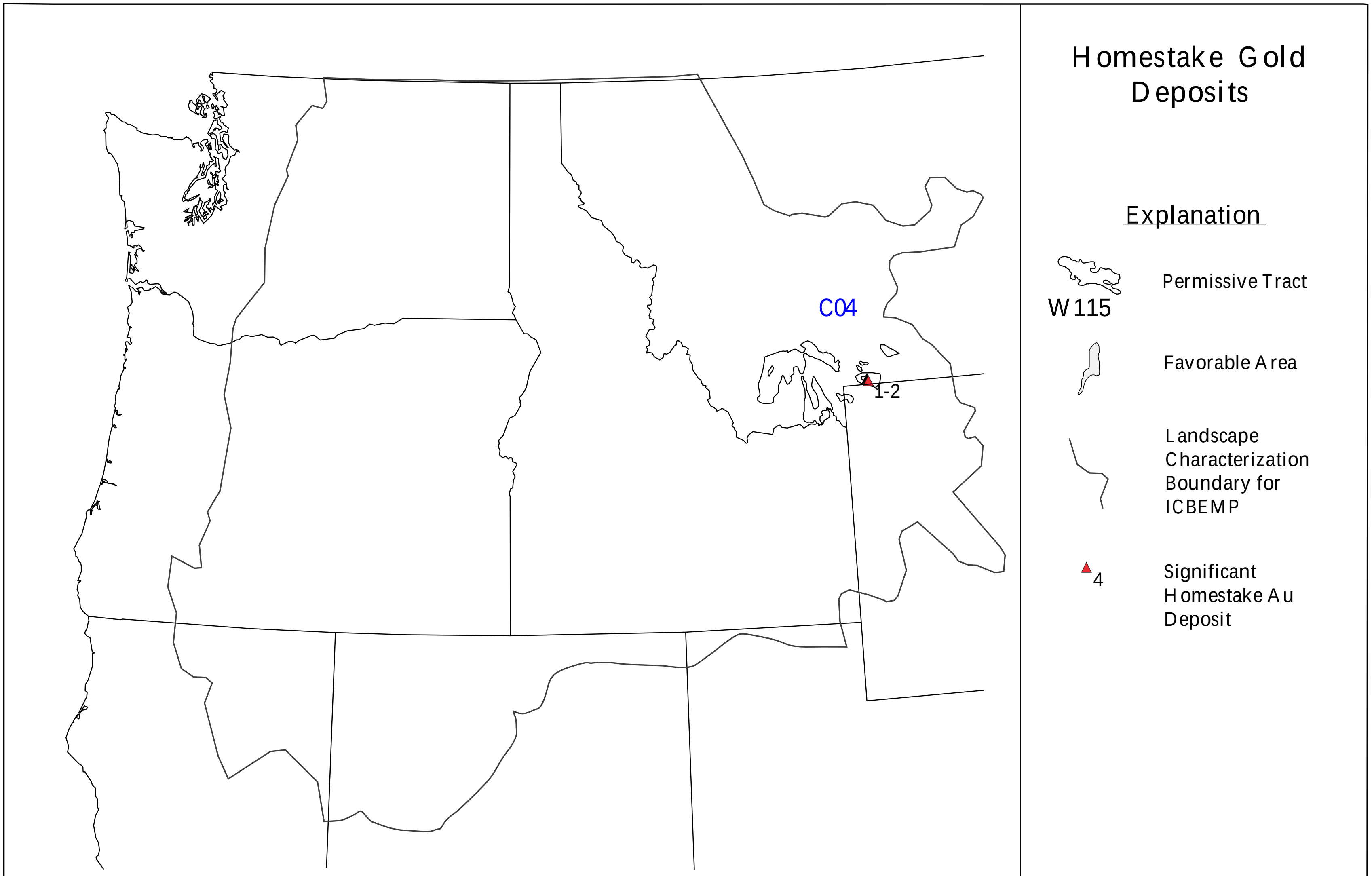


Figure 10b: Location of significant Homestake gold deposits in the map area.

Table 10: Significant Homestake Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status		Au prod (tonnes)	Ag prod (tonnes)		Au resource (tonnes)	Ag resource (tonnes)
01	C04	Mineral Hill	Sheepeater (Jardine)	Park	MT	45.080	-110.620	P		9.80	1.0		5.6	1.4
02	C04	Crevice Mountain	Sheepeater (Jardine)	Park	MT	45.046	-110.597	F D					12.4	sig

C04

Homestake Au Deposits

Descriptive Model 36b
• 2.1 mean undiscovered deposits

Montana
Wyoming, Idaho

by Jim Elliott

Rationale for Tract Delineation

Iron formations and related sedimentary exhalative deposits are exposed in several areas in Montana and nearby portions of Wyoming and Idaho, including the Gravelly and Ruby Ranges and the Tobacco Root and Beartooth Mountains (Bayley and James, 1973). These areas were deemed permissive for Homestake stratiform gold deposits due to the association of this deposit type with iron formations. It should be noted that, at the scale of this assessment, the permissive areas do not take into account how thin (10–70 m) the host iron formations actually are. The tracts define general areas where iron formations are exposed, not the much smaller area that they actually occupy. A favorable area was drawn around the area of the Mineral Hill (Jardine) and Crevice Mountain deposits (#1 and 2, figure 10b), with the boundaries reflecting the shape of the associated claim block (Hammarstrom and others, 1993).

Important Examples of Deposit Type

The Jardine (Mineral Hill) deposit in the western Beartooth Mountains, east of Gardiner, is a known Homestake type deposit (#1, figure 10b). In addition, a new deposit named Crevice Mountain (#1, figure 10b) has been recently discovered nearby. Jardine is somewhat different from the typical Homestake deposit in that both arsenic and tungsten were produced in the earlier part of this century (Seager, 1944).

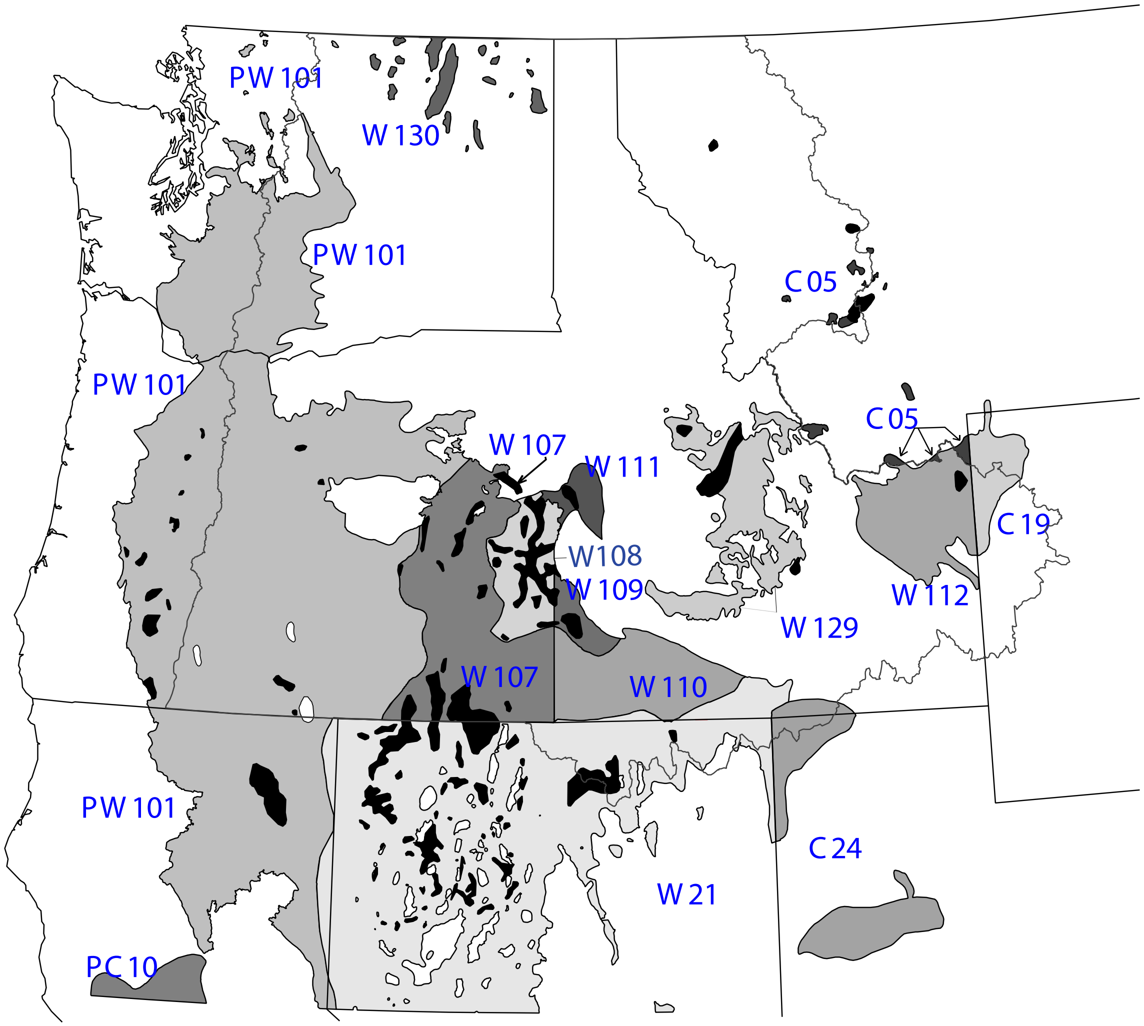
Rationale for Numerical Estimate

The permissive tract is relatively large, these deposits may have a minor surface expression, and there are two known deposits in the Beartooth Mountains. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 2, 4, 5, and 6 or more deposits consistent with the grade and tonnage model for Homestake stratiform gold deposits of Klein and Day (1994).

Hot Spring Au-Ag Deposits

General Deposit Description

Hot-spring Au-Ag deposits are surficial and (or) near-surface expressions of hydrothermal systems, driven by high heat-flow associated with intermediate to felsic volcanic fields. Hot spring Au-Ag deposits typically are localized in zones of extensional fractures or in dilational openings within transpresssional fracture zones (Berger, 1986c). Host rocks include volcanic and subvolcanic intrusive rocks as well as adjacent country rocks with high permeability or hydrothermally altered rocks with high fracture permeability (Berger, 1985). Hot-spring sinter is typically present at the paleo-surface and the disseminated or vein-type gold ore bodies occur below the sinter and are localized along through-going structures. The geothermal systems of Yellowstone National Park (where gold is known to occur in subeconomic grades) are considered to represent a modern analogue for this deposit type (White and others, 1992). Associated mineral deposits include hot-spring mercury deposits and antimony deposits. Hot springs deposits generally focus downward into a vein system of the Comstock, Sado, or quartz alunite type, and the boundary between the two deposit types is rather arbitrarily placed. Typically the hot spring deposits are much larger in tonnage and lower in grade than the underlying vein deposit. However, some epithermal deposits, mined by open pit methods, are more appropriately placed in the hot-spring category because of their reported tonnage and grade, even though evidence for a paleosurface is lacking. Hot springs Au-Ag deposits are large tonnage, low-grade deposits (median size = 13 million metric tonnes; median Au grade = 1.6 g/tonne; median Ag grade = 2.9 g/tonne; Berger and Singer, 1992).



Hot Spring Au - Ag Deposits

Explanation

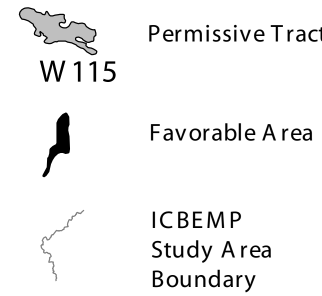


Figure 11a : Permissive and favorable tracts for Hot Spring Au-Ag deposits.

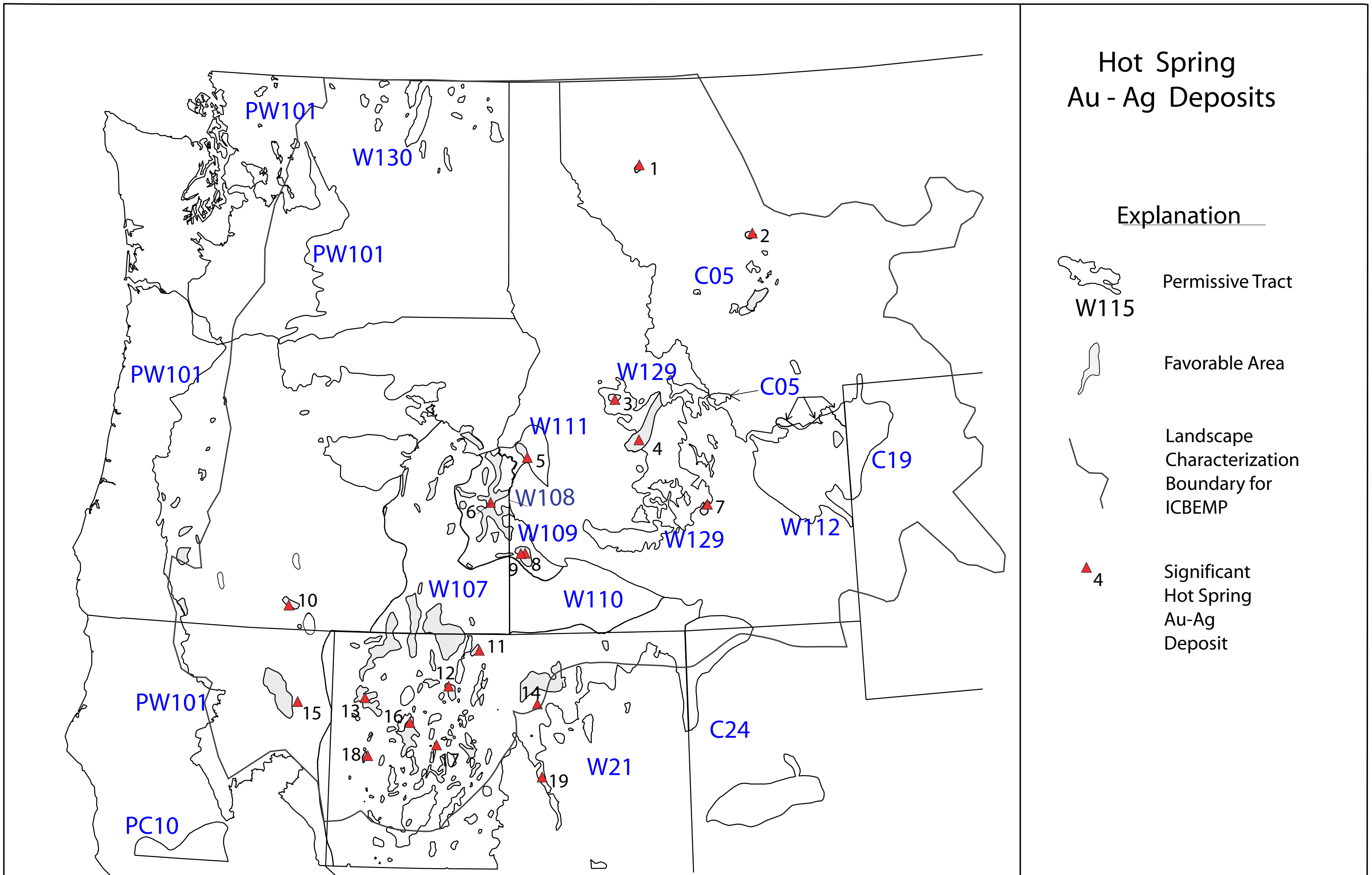


Figure 11b : Location of significant Hot Spring Au-Ag deposits in the map area.

Table 11: Significant hot spring Au-Ag deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
01	C05		Hog Heaven (Flathead)	Flathead	MT	47.923	-114.582
02	C05	McDonald Meadows	Seven-Up Pete	Lewis & Clark	MT	47.000	-112.525
03	W129	Dewey, Sunnyside	Thunder Mountain	Valley	ID	44.958	-115.142
04	W129	Sunbeam-Grouse Creek	Yankee Fork	Custer	ID	44.439	-114.736
05	W111	Idaho Almaden	Weiser	Washington	ID	44.240	-116.714
06	W108	Grassy Mountain		Malheur	OR	43.669	-117.360
07	W129	Champagne	Lava Creek	Butte	ID	43.594	-113.571
08	W109	Stone Cabin	Florida Mountain	Owyhee	ID	43.025	-116.756
09	W109	DeLamar	De Lamar	Owyhee	ID	43.020	-116.831
10	PW101	Quartz Mountain		Lake	OR	42.300	-120.800
11	W21	Buckskin National	National	Humboldt	NV	41.790	-117.540
12	W21	Sleeper	Slumbering Hills	Humboldt	NV	41.330	-118.050
13	W21	Western Hog Ranch	Leadville	Washoe	NV	41.160	-119.450
14	W21	Ivanhoe	Ivanhoe	Elko	NV	41.110	-116.560
15	PW101	Hayden Hill		Lassen	CA	41.080	-120.576
16	W21	Crofoot - Lewis	Sulphur	Humboldt	NV	40.860	-118.690
17	W21	Florida Canyon	Imlay	Pershing	NV	40.580	-118.240
18	W21	Wind Mountain	San Emidio	Washoe	NV	40.430	-119.390
19	W21	Buckhorn	Buckhorn	Eureka	NV	40.180	-116.490

Table 11: Significant hot spring Au-Ag deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Status	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)		Au resource (tonnes)	Ag resource (tonnes)
01	C05		S	0.15	213		13,963		1.3	645
02	C05	McDonald Meadows	F D						255	
03	W129	Dewey, Sunnyside	I M	0.61	neg	neg	neg		11	neg
04	W129	Sunbeam-Grouse Creek	P	1.26	13	7.4	11		26	517
05	W111	Idaho Almaden	I D	none	none	none	none		20	none
06	W108	Grassy Mountain	F D	none	none	none	none		31	77
07	W129	Champagne	I M r	2.08	11	neg	neg		2.3	51
08	W109	Stone Cabin	F M	4.12	480	neg	neg		24	367
09	W109	DeLamar	P	14.68	249	neg	neg		33	1,245
10	PW101	Quartz Mountain	F D						19	
11	W21	Buckskin National	I M	3.44	0.94				1.6	15
12	W21	Sleeper	P	44.97	52				53	209
13	W21	Western Hog Ranch	I M r	5.97	0.72				18	
14	W21	Ivanhoe	P	2.06					90	
15	PW101	Hayden Hill	P	3.61	unk	none	none		45	282
16	W21	Crofoot - Lewis	P	16.58	30				30	
17	W21	Florida Canyon	P	17.43	4.4				27	
18	W21	Wind Mountain	I M	6.13	35				6.1	35
19	W21	Buckhorn	F M x r	4.96	22				3.8	

C05 | ## Hot-spring Au-Ag Deposits | **Montana**

Descriptive Model 25a

• 3.1 mean undiscovered deposits (entire tract)

• 1.5 mean undiscovered deposits (ICBEMP portion only)

by David Frishman

Rationale for Tract Delineation

For the purpose of delineating the permissive tract, the three subtypes of epithermal precious-metal vein deposits (quartz-adularia, quartz alunite, and hot-spring) were treated the same. It was judged that the criteria available to discriminate between the subtypes were too imprecise to use effectively. Probabilities of occurrence for the individual types were assigned separately, however.

Permissive areas that constitute the tract are generally small, and are scattered throughout western Montana. They were defined by the location of known active or fossil hot springs, the location of mines, prospects, and occurrences believed to represent epithermal deposits, and the location of Tertiary and Quaternary volcanic and hypabyssal rocks as shown on the Montana geologic map (Ross and others, 1955). The favorable tracts were defined by Frishman and James Elliot, based on knowledge of prospective occurrences and exploration activity.

Areas identified include the Hog Heaven volcanic field, the Lincoln volcanics (McDonald Meadows property), the Helena-Avon volcanics, several areas of the Lowland Creek volcanics southwest of Helena and north and west of Butte, the Virginia City-Alder Gulch area, an area of Challis volcanics exposed in the Horse Prairie area southwest of Dillon, the Marysville district, and small portions of Montana adjacent to the Yellowstone caldera in Wyoming.

Important Examples of Deposit Type

Possible representatives of this class of deposit are all apparently Tertiary (<66 Ma) and include the volcanic-hosted McDonald Meadows deposit in the Seven-Up Pete district, south of Lincoln in Lewis and Clark County (#2, figure 11b); the Flathead and West Flathead mines in the Hog Heaven district (#1, figure 11b), and the Tuxedo prospect, west-northwest of Butte. The Seven-Up Pete district hosts both the McDonald Meadows disseminated hot-spring deposit and the Seven-Up Pete Comstock vein (#9, figure 11b). The Flathead and West Flathead mines and related Oligocene deposits in the Hog Heaven volcanic field west of Flathead Lake are included as deposits of this type with some uncertainty. The epithermal Pb-Ag deposits at the Flathead mine do not possess exactly the same attributes as the published model (Berger, 1986c). The deposits at the Flathead mine apparently occur at the very uppermost levels of the hydrothermal system (Lange and others, 1995), yet they are dominantly Pb-Ag deposits, not gold-rich deposits as might be expected according to some models.

Rationale for Numerical Estimate

For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 1, 3, 5, 6, and 9 or more deposits consistent with the grade and tonnage model of Berger and Singer (1992). It was estimated that about one-half of the undiscovered resources occur in the ICBEMP study area. For that portion of the tract within the ICBEMP study area (at the above percentiles), the team estimated 0, 2, 2, 3, and 5 or more undiscovered hot-spring Au-Ag deposits.

C19 — Hot-spring Au-Ag Deposits — Wyoming

Descriptive Model 25a

• 1.8 mean undiscovered deposits (entire tract)

• 0.9 mean undiscovered deposits (ICBEMP portion only)

by David Frishman

Rationale for Tract Delineation

The tract identified as permissive for hot-spring Au-Ag deposits is an area that encloses the three Yellowstone calderas (about 2.0, 1.3, and 0.6 Ma; White and others, 1988) and the surrounding area of thick rhyolitic ash flow tuffs and rhyolite flows as shown by Love and Christiansen (1985). The area inside and near the Yellowstone calderas in northwestern Wyoming and adjacent parts of Montana contains numerous thermal pools, springs, fumaroles, and geysers. Some areas were excluded from the permissive tract because the rhyolitic rocks exposed there are known to be only a thin mantle of distal outflow facies.

Important Examples of Deposit Type

There are no known hot-spring Au-Ag deposits within or near the Yellowstone calderas, but the area has been withdrawn from mineral entry since 1872 and there has been essentially no exploration. There are areas of intense hydrothermal activity and alteration, and hydrothermal activity has been taking place for the last 150,000 years or longer (White and others, 1988). Areas currently experiencing hydrothermal activity and alteration include Mammoth Hot Springs, the Norris-Elk Park-Gibbon Geyser Basin area, the Lower, Midway, and Upper Geyser Basins, Yellowstone Canyon, the West Thumb Geyser Basin, the Heart Lake Geyser Basin, Washburn Hot Springs and a large area to the east that hosts Whistler geyser, Rainbow Springs, and Coffee Hot Springs, among others.

Rationale for Numerical Estimate

The presence of many active hydrothermal systems was believed to be very favorable. In addition, anomalous gold values (0.5 to 10 g/t) have been detected in sinter from Gibbon geyser basin and in hydrothermal quartzite from Norris geyser basin (White and others, 1992). For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 2, 3, 4 and 5 or more undiscovered deposits consistent with the grade and tonnage model of Berger and Singer (1992) in the entire tract. For that portion of the tract within the ICBEMP study area, the team estimated (at the above percentiles) 0, 1, 1, 3, and 4 or more undiscovered hot-spring Au-Ag deposits.

C24 — Hot-spring Au-Ag Deposits — Utah, Idaho

Descriptive Model 25a

• 0.01 mean undiscovered deposits (estimate for ICBEMP portion only)

by Douglas B. Stoeser

Rationale for Tract Delineation

Three areas make up the permissive tract for hot-spring Au-Ag deposits. The two most important areas are defined by east-trending, dominantly calc-alkaline, Tertiary magmatic belts in the western part of the state which contain most of the significant base- and precious-metal deposits of Utah (Shawe and Stewart, 1976; Seedorff, 1991). Two adjacent belts, the Oquirrh-Uinta belt and the Tintic-Deep Creek belt, combine to form the north-central area. The southern area is collectively defined by the Pioche-Marysvale (or Wah Wah-Tushar) and Delamar-Iron Springs belts. The erosional level on the north-central area is deeper than the southern area, such that much of the once-extensive volcanic rocks have been removed, whereas to the south, extensive areas of volcanic rocks are still preserved. Thus, the southern area is more favorable for hot-spring Au-Ag deposits, which form near the paleosurface. In addition to the two areas identified above, a third area in the northwest is also recognized. The northwestern area is underlain by local volcanic and minor intrusive rocks, and is also permissive for hot-spring Au-Ag deposits. The three permissive terranes have approximately 70 percent alluvial cover less than 1 km thick.

Important Examples of Deposit Type

There are no known hot-spring Au-Ag deposits in Utah, nor are there any significant prospects.

Rationale for Numerical Estimate (ICBEMP portion only)

The lack of significant prospects in the ICBEMP portion of tract C24 led to a low estimate for undiscovered hot-springs deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, we estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) in the ICBEMP portion of tract C24 consistent with the grade and tonnage model of Berger and Singer (1992).

PC10 — Hot-spring Au-Ag Deposits — California

Descriptive Model 25a

No estimate of undiscovered deposits

by James J. Rytuba

Rationale for Tract Delineation

Permissive terranes include intermediate to felsic volcanic fields and areas of emplacement of subvolcanic intrusive rocks within zones of extensional tectonism. Factors that would exclude areas from such permissive terranes would include location outside of known volcanic belts and the presence of deeply emplaced plutonic rocks, with no subsequent igneous activity. Favorable areas are delineated by the presence of known economic and subeconomic hot-spring gold deposits or deposits commonly associated with these deposits.

Hot-spring Au-Ag deposits in the Coast Ranges of California are closely associated with Miocene to Recent volcanic fields.(Peters, 1991) The intermediate to felsic volcanism resulted from passage of the Mendocino triple junction as it migrated northward along the coast of California. Magmatic activity above the slab window, the area of thin crust underlain by hot asthenosphere that replaces the subducting slab, is characterized by andesitic to rhyolitic dome and ash-flow fields and associated plutons and batholiths. The volcanic fields and associated intrusive rocks extend eastward from the Coast Ranges into the Great Valley of California. Permissive tracts for undiscovered hot-spring Au-Ag deposits were delineated to include those areas with known Miocene to Recent volcanic and intrusive rocks and areas above the slab window where intrusive rocks can be expected to occur.

Important Examples of Deposit Type

The McLaughlin gold deposit (Lehrman, 1986), located south of the tract boundary in the same geologic setting, is the largest and only active hot spring gold deposit in the Coast Range of California.

Rationale for Lack of Numerical Estimate

Since tract PC10 lies outside the ICBEMP study area, no estimate of undiscovered hot-spring deposits was made.

PW101 | **Hot-spring Au-Ag Deposits** | **Washington Oregon California**

Descriptive Model 25a

• 1.5 mean undiscovered deposits (entire tract)

• 1.1 mean undiscovered deposits (ICBEMP portion only)

by Roger Ashley

Rationale for Tract Delineation

Criteria for tract delineation are similar to those for Sado- and Comstock-type vein deposits, and this tract is coextensive with the combined Sado and Comstock tracts that cover the Cascade Range and central Oregon. All areas containing intermediate to silicic volcanic rocks are considered permissive for hot-spring Au-Ag deposits. Because these deposits usually have a very limited vertical extent, they could be present within 1 km of the surface and have little surface manifestation.

The tract includes all volcanic and volcaniclastic rocks and associated small plutonic bodies of the Cascades arc (Oligocene to Holocene in age), as shown on maps of Smith (1993), Walker and MacLeod (1991), Sherrod and Smith (1989), and Jennings (1977). On the west side of the tract in both Oregon and Washington, Eocene marine sandstone units and pre-Cascades volcanic rocks, predominantly of basaltic composition, are excluded. Where the Cascades-related rocks are covered by non-volcanic Quaternary deposits, the boundary is drawn where the younger rocks are approximately 1 km thick. Batholiths of Tertiary age in the northern Cascades of Washington are excluded because they indicate an environment too deep for the presence of epithermal deposits. Volcanic rocks of Eocene-Oligocene age in the northern Cascades are included, however, although some may predate Cascade arc volcanism.

In central Washington, Eocene and Oligocene sandstones in and west of the Chiwaukum graben are included because they host significant Comstock-type deposits. A small area of pre-Tertiary basement rocks east of Mt. Rainier is also included.

The tract includes calc-alkaline rocks of the Eocene Clarno Formation in north-central Oregon. In south-central Oregon and northeastern California, it includes Tertiary basalts and rhyolites of the bimodal suite of the Basin and Range Province and Tertiary back-arc Cascade rocks of intermediate composition (Walker and MacLeod, 1991; Sherrod and Smith, 1989; Jennings, 1977). The eastern boundary in eastern Oregon and northeastern California separates this tract from tracts in southeastern Oregon and the Great Basin that have numerous epithermal occurrences and are more favorable for undiscovered deposits.

The basaltic lavas of the Columbia Plateau are excluded. In north-central Oregon and east-central Washington, the boundary is drawn where flows of the Columbia River Basalt Group cover the Cascade rocks to a depth of approximately 1 km (Drost and Whiteman, 1986). An isolated area of thin Columbia River Basalt Group rocks in east-central Oregon is excluded because it is underlain by pre-Tertiary rocks; favorable volcanic rocks of the Basin and Range bimodal suite and Clarno Formation are missing. Areas covered with more than 1 km of Quaternary alluvium in the Goose Lake, Summer Lake, and Klamath grabens are also excluded.

Favorable tracts were defined around a northwesterly trend of known prospects around the Quartz Mountain deposit in south-central Oregon, around the rhyolite host of the Hayden Hill deposit in northeastern California, and around several prospect areas of abundant prospects in southwestern Oregon. Mining claim density maps (provided by the US Bureau of Mines) were used to determine the boundaries of the favorable tracts.

Important Examples of Deposit Type

The largest hot-spring Au-Ag deposit in the tract is Quartz Mountain, in Lake County, south-central Oregon (#10, figure 11b: Sawlan and Russell, 1991). It is associated with rhyolite domes related to bimodal volcanism. Although subeconomic at this time, it is credited with more than 60 metric tons of gold reserves (Wiley, 1991). Hayden Hill, in California(#15, figure 11b) in northern California is also associated with rhyolite domes.

Several isolated precious-metal occurrences in the southern Oregon Cascades may be hot-spring deposits, and other poorly-known precious-metal occurrences in the western Cascades districts of Oregon could be hot-spring deposits as well. The recently-explored Mashel River prospect, in the western Cascades of Washington (Pierce County), may be a hot-spring deposit.

Rationale for Numerical Estimate

For the 90th, 50th, and 10th percentiles, the team estimated 0, 1, and 3 or more hot-spring Au-Ag deposits consistent with the grade and tonnage model of Berger and Singer (1992). This estimate reflects the perception that additional exploration in the vicinity of Quartz Mountain and in several western Cascades districts could yield deposits. The additional deposits included at the 5th and 1st percentiles (5 and 7) reflect the probability that other districts large enough to fit the grade-tonnage model may exist, particularly in the southern Cascade Range of Oregon and Ochoco Mountains of north-central Oregon, where there are many hot-springs mercury deposits, or where through-going fracture systems cut late Tertiary rocks of the bimodal suite in south-central Oregon and northeastern California (Rytuba, 1988, 1989). For that portion of tract PW101 that lies within the ICBEMP study area, the team estimated (at the above percentiles) 0, 1, 2, 3, and 3 or more undiscovered hot-spring Au-Ag deposits.

W21 — Hot-spring Au-Ag Deposits

Nevada
Idaho

Descriptive Model 25a

• 1.3 mean undiscovered deposits
(estimate for ICBEMP portion only)

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

In Nevada, known hot-spring gold-silver deposits are distributed in a crescent-shaped area, concave to the east, that corresponds poorly with the overall distribution of Tertiary volcanic rocks (Silberman and others, 1976; Stewart and others, 1977; Seedorff, 1991; Cox and others, 1991; Ludington and others, in press). This distribution of hot-spring gold deposits cannot be explained by the absence of volcanic rocks inward from the crescent. On the contrary, eastern Nevada contains extensive outcrops of older interior andesite-rhyolite assemblage rocks (older than 27 Ma) in which epithermal vein deposits are virtually unknown.

In addition to active volcanism, faulting and fracture permeability are important in controlling the distribution of epithermal deposits. The crescent-shaped area described above corresponds closely to those areas which were undergoing faulting in an extensional tectonic regime during active volcanism. The synvolcanic deformation is important because it provides fracture permeability at the same time that hydrothermal systems related to volcanism are active and circulating, thus facilitating the formation of veins and stockworks. Where Miocene volcanic rocks are relatively unfaulted, for example in the Sierra Nevada of California and in the Cascade Range of Oregon and Washington, epithermal mineral deposits are rare or absent.

The Walker Lane area contains well-developed normal faults, and is probably the best studied region of epithermal mineralization in Nevada (Stewart, 1988). Northwest-striking high-angle faults that predominate in this area have been shown by John and others (1989) to be at least as old as the earliest volcanic activity (22 Ma) in the Paradise Range suggesting that faulting and volcanism were synchronous throughout the period of andesite volcanism.

This region is shown by Blakely (1988) to be characterized by a northwest-trending grain in the pattern of magnetic anomalies that can be recognized about 50 km to the northeast of traditional boundaries of the Walker Lane that are based on topography and structure. This expanded area of characteristic magnetic fabric encompasses all of the volcanic-hosted epithermal districts in southwestern Nevada. The northeastern boundary of this magnetic anomaly pattern coincides with a line separating calderas younger and older than 27 Ma (Best and others, 1989), the eastern boundary is the magnetic quiet zone (Blakely, 1988). We believe that the Walker Lane deformation began locally at 27 Ma, and continued during succeeding volcanic episodes until the beginning of Basin and Range deformation at about 11 Ma, thus controlling the distribution of hot-spring precious-metal deposits in this part of Nevada.

Two northwest-striking linear permissive areas in central Nevada were drawn to enclose basalt flows, dike swarms and linear magnetic anomalies associated with the northern Nevada rift (Blakely, 1988). The northern segment of this area contains the Fire Creek and Buckhorn hot-spring gold deposits. Basalt outcrops and magnetic anomalies die out at the southern end of this segment near Eureka, but shallow magnetic sources indicate a southern continuation that is slightly offset, but parallel to the northern one.

The permissive tract is based on the distribution of volcanic rocks, of epithermal mineral deposits, prospects, and occurrences, on the distribution of synvolcanic faults, and on the magnetic anomaly patterns described above. Superficial deposits younger than the mineralized rocks cover about 47 percent of the tract. The high-level environments permissive for hot-spring deposits are difficult to separate from those for other epithermal deposits using published geologic data. The favorable tracts were adapted from "prospective" areas for hot springs Au-Ag deposits from an unpublished mineral assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994).

Important Examples of Deposit Type

The Sleeper and Hog Ranch deposits (#12, 13, figure 11b) occur in rocks of the Miocene bimodal basalt-rhyolite assemblage. The Crofoot-Lewis deposit (#16, figure 11b) occurs in nearby Miocene sedimentary rocks or sediments. The Buckhorn deposit (#19, figure 11b) is hosted in basaltic andesite and presumably lies above mafic dikes related to the Northern Nevada magnetic anomaly described by Blakely (1988).

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W21 that lies within the ICBEMP study area (figure 11a). Numbers of undiscovered hot spring deposits have previously been estimated by county in northeastern Nevada (Singer, 1996). The ICBEMP portion of tract W21 lies within two counties in Nevada. To arrive at the numerical estimate of undiscovered hot spring deposits in the ICBEMP portion of tract W21, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 1.33 mean undiscovered hot spring deposits for the part of the ICBEMP study that extends into northeastern Nevada. The general lack of prospects in Miocene and younger rocks in the Idaho portion of the tract leads us to assume this estimate is valid for the whole ICBEMP portion of tract W21. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 1, 3, 3, and 4 or more deposits consistent with the grade and tonnage model of Mosier and others (1992) is equivalent to the estimated number of mean undiscovered deposits derived above.

W107 Hot-spring Au-Ag Deposits — Oregon

Descriptive Model 25a

• 6.8 mean undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

In Southeastern Oregon, widespread Neogene felsic volcanic rocks, along with considerable Neogene normal faulting, provide a compositionally and structurally appropriate environment for hot-spring Au-Ag deposits (Berger, 1986c). Tract W107 encircles essentially all Neogene volcanic and associated sedimentary rocks outside of the Ore-Ida graben in southeastern Oregon (Peters and others, 1994). The Ore-Ida graben, the most prospective area in southeastern Oregon, is separated into a distinct tract (W108). Some basaltic volcanic rocks and/or thick Quaternary alluvial cover are included in this tract which may not be appropriate for the occurrence of hot-spring deposits. However insufficient data are available to exclude these unfavorable parts of the tract. Favorable areas were adapted from "prospective" areas for Comstock deposits from the mineral resource assessment study of the Malheur and Jordan BLM Resource Areas (Peters and others, 1994).

Important Examples of Deposit Type

No significant hot-spring Au-Ag deposits are known from this tract, although the Grassy Mountain deposit (# 6, figure 11b) occurs in similar age rocks in the adjacent tract to the north and east (Wheeler, 1988). Evidence for a number of hot-spring type geothermal systems are known within this tract, but none have had significant production or known reserves.

Rationale for Numerical Estimate

The area has lesser potential for undiscovered hot-spring deposits than the Ore-Ida graben to the north and east. In this tract, there is less support for the existence of widespread geothermal activity. Surface erosion has been minimal, so most deposits were probably buried rather than eroded away. However, the accumulated Neogene section is thinner and the opportunity for stacking deposits is more limited than in the adjacent Ore-Ida graben. For this reason the team expressed less confidence in its estimate for this tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate 2, 6, 10, 16, and 30 or more deposits, consistent with the Au-Ag grade and tonnage model for hot-spring deposits of Berger and Singer (1992), was made combining estimates for the Malheur and Jordan BLM Resource Areas (Spanski, 1994) and for the Andrews BLM Resource Area (Greg Spanski, written communication, 1995).

W108 Hot-spring Au-Ag Deposits — Oregon

Descriptive Model 25a

• 12.3 mean undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include all the area of Neogene rocks within the Ore-Ida graben (Peters and others, 1994), a north-south structural feature controlling the distribution of Miocene bimodal volcanic and sedimentary rocks. Within this tract, widespread occurrences of hydrothermal alteration, silica sinter, and anomalous concentrations of gold, silver, arsenic, antimony, and mercury in rocks, soil, and stream sediments indicates the presence of numerous extinct geothermal systems with precious metal contents. Since much of the Neogene section is buried under younger Neogene rocks, much of the prospective ground is buried. Pervasive north-south Neogene faulting, recurring volcanism, evidence of numerous extinct hot springs, and overall subsidence within the Ore-Ida graben suggest the entire upper km of the tract is favorable for this deposit type. Favorable areas were adapted from "prospective" areas for Comstock deposits from the mineral assessment study of the Malheur-Jordan-Andrews BLM Resource Areas (Peters and others, 1994).

Important Examples of Deposit Type

The Grassy Mountain deposit (# 6, figure 11b) is a large Au-Ag hot-spring deposit within the tract (Wheeler, 1988). The deposit occurs within basin of Miocene arkosic sedimentary rocks within the broader bimodal volcanic province of the Ore-Ida graben. The deposit is capped by an extensive zone of silica sinter.

Rationale for Numerical Estimate

The widespread occurrence of silica sinter confirms the existence of recent geothermal activity throughout the graben area. Based on his investigations in the area, J. Rytuba (U.S. Geological Survey, personal commun., 1993) infers that geothermal activity has persisted throughout the Miocene to recent period of subsidence and filling of the graben, suggesting that deposits of this type may be found associated with deeper stratigraphic horizons, representing earlier ground surfaces in the graben. This suggests there is a uniform likelihood for deposit occurrence throughout the km below the present surface. Combined with an exploration history dating back only to the early 1980s for this type of deposit in this area, and the shallow depth targets for this exploration for bulk mineable deposits, the team estimated 6, 12, 18, 24, and 30 or more deposits at the 90th, 50th, 10th, 5th, and 1st percentiles (Spanski, 1994). These deposits would be consistent with the Au-Ag grade and tonnage model for hot-spring deposits of Berger and Singer (1992).

W109 — Hot-spring Au-Ag Deposits — Idaho

Descriptive Model 25a

• 1.5 mean undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

This permissive tract for undiscovered hot-spring Au-Ag deposits was drawn to include the Idaho portion of the Ore-Ida graben, as interpreted from the state geologic map (Bond, 1978). This tract is underlain by a voluminous pile of Miocene basaltic and felsic volcanic rocks and associated volcaniclastic rocks and encompasses a Miocene and younger zone of pervasive north-south faulting. Minor amounts of Cretaceous granitic rocks are exposed beneath the Miocene rocks and locally contain epithermal mineralization; they are also included in the tract. The tract is buried on the northeast by younger basaltic lavas of the northwest Snake River plain. The southern boundary of the tract was drawn just south of the southernmost prospects known in southwestern Idaho. Favorable areas were adapted from the eastward continuation of "prospective" areas for Comstock deposits from the mineral assessment study for the Malheur-Jordan-Andrews BLM Resource Areas in Oregon (Peters and others, 1994), using the locations of known prospects and a Bureau of Mines plot of mining claim densities in Idaho.

Important Examples of Deposit Type

Three epithermal Au-Ag deposits (DeLamar, Stone Cabin, and War Eagle) are known within the permissive tract. Two of the deposits (DeLamar, Stone Cabin: deposits #9 and #8, figure

11b) grade downward from disseminated hot-spring type mineralization to more focused vein-type mineralization in different parts of the deposits (Asher, 1968). These two deposits have gold contents at and just below the mean Au content of hot-spring Au-Ag deposits. Silver contents are well above the mean for this deposit type.

Rationale for Numerical Estimate

It is thought that all Comstock-type deposits exposed at the surface in the tract area are known, and any undiscovered deposits must be covered. Since the area has been mostly subsiding since the Miocene, we concluded that any undiscovered Comstock vein deposit will probably still be overlain by a more disseminated Au-Ag hot-spring deposit, for which exploration is fairly incomplete. These undiscovered Comstock vein systems will probably be mined along with their overlying hot-spring deposit, and will be incorporated into the grade and tonnage of any undiscovered hot-spring deposit. For this reason, we only make an estimate for undiscovered hot-spring deposits for the area of this tract, and make no estimate for undiscovered Comstock-type deposits. Since a lot of the tract is covered by rock younger than the favorable Miocene rhyolite horizon, much of the ground is open for the occurrence of undiscovered deposits. Exploration for this deposit type has been incomplete, having begun only in the 1980s. For the 90th, 50th, 10th, 5th and 1st percentiles, the team estimated 0, 1, 3, 5, and 5 or more undiscovered hot-spring Au-Ag deposits, consistent with the grade and tonnage model of Berger and Singer (1992).

W110 — Hot-spring Au-Ag Deposits — Idaho

Descriptive Model 25a

No estimate of undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract was drawn to include the entire area of Miocene rhyolitic volcanism southwest of the Pleistocene Snake River plain and south of the Idaho portion of the Ore-Ida graben (Bond, 1978). The tract is underlain by two large Miocene caldera complexes, Juniper Mountain and Bruneau-Jarbidge (Eckren and others, 1982; Bonnichsen, 1982). Extensive rhyolitic ashflow tuffs erupted from the calderas, and these are overlain by Miocene basaltic lavas. A minor amount of older metamorphic and granitic rock is also included within the tract, since veins may extend into these lithologies, as they do in the Silver City area in the tract to the north. Hot-spring Au-Ag mineralization occurs in tracts to the north and west that have generally similar geology.

Important Examples of Deposit Type

No examples of this deposit type are known within the tract, and little is known about the exploration history.

Rationale for Lack of Numerical Estimate

The lack of known deposits within the tract and the dearth of information available on any exploration activity precluded estimation of the number of undiscovered deposits of this type.

W111 Hot-spring Au-Ag Deposits — Idaho

Descriptive Model 25a

No estimate of undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract is underlain by Miocene Payette Formation (Bond, 1978), consisting of arkosic sediments derived from the Idaho batholith, and is capped by Miocene lavas of the Columbia River basalt. Hot-spring mercury mineralization, with subeconomic gold grade, at the Idaho Almaden mine near Weiser (Anderson, 1941) indicates the existence of extinct geothermal systems. Although rhyolitic magmatism typically associated with the hot-spring deposits (Berger, 1986c) is not known, the occurrence of extinct hot spring systems indicates the tract is permissive for this deposit type. The surrounding area where the Payette Formation may occur within a km of the surface beneath the overlying Columbia River basalt is also included. A favorable area was drawn to include the Idaho Almaden mine and the northwest trend of its controlling structures and associated prospects. The boundaries of the favorable tract were guided by mining claim densities, as shown on an unpublished plot by the US Bureau of Mines.

Important Examples of Deposit Type

No examples of this deposit type are known in the tract. However, hot-spring mercury system at the Idaho Almaden mine near Weiser has similar structural characteristics and abundant silica deposits characteristic of this deposit type. Gold occurs in subeconomic grades in the Idaho Almaden deposit (#5, figure 11b).

Rationale for Lack of Numerical Estimate

The lack of known deposits within the tract and the dearth of information available on any exploration activity precluded estimation of the number of undiscovered deposits of this type.

W112 Hot-spring Au-Ag Deposits — Idaho

Descriptive Model 25a

•0.4 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include felsic volcanic rocks of the Pliocene to Recent Yellowstone volcanic field (Bond, 1978). The Yellowstone volcanic field consists of Neogene felsic volcanic rocks with known recent hot springs. Gold is known to occur in subeconomic grades in modern hot springs in Yellowstone National Park to the east (White and others, 1992). The tract also includes the Pliocene rhyolites of the Island Mountain caldera. These volcanic rocks are buried on the west by basaltic lavas of the Snake River Plain. The permissive tract was drawn to include the felsic volcanic rocks where they are covered by less than a kilometer of overlying basalt. The favorable tract was defined by a cluster of anomalous associated elements from stream sediment data along the eastern flank of the Pliocene Island Park caldera, collected during the National Uranium Resource Evaluation (NURE) program..

Important Examples of Deposit Type

The modern hot springs of Yellowstone National Park indicate that hydrothermal systems are associated with this rhyolitic volcanic province, some with anomalous gold concentrations (White and others, 1972). Although no economic deposits are known, some anomalous Au, Hg, and As concentrations in stream sediments in the area indicate potential for undiscovered deposits (Shannon, 1980).

Rationale for Numerical Estimate

Since the Pliocene precursor of the Yellowstone volcanic field has not been strongly eroded and is buried by younger basalts on the west, undiscovered hot-spring Au-Ag deposits could be buried beneath younger, unmineralized volcanic rocks with no surface indication of mineralization. Based on the few stream sediment anomalies and the lack of known prospects, the team estimated a low probability of undiscovered deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 2, 3, and 4 or more deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model of Berger and Singer (1992).

W129 — Hot-spring Au-Ag Deposits — Idaho

Descriptive Model 25a

• 2.5 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include the Eocene Challis volcanic field of south-central Idaho (Bond, 1978), the host of three known deposits. This intermediate to felsic volcanic field was erupted synchronously with faulting along the Trans-Challis fault zone, a major northeast-trending feature. In this tract, older mining concentrated on the vein system in underground mines. Associated hot-spring type mineralization is known to occur around the older mining districts and elsewhere in the Eocene Challis volcanic field. Favorable tracts were delineated to include the districts with known hot-springs mineralization discussed below. The shapes were controlled by the spread of associated prospects, known exploration activity, and by the density of related mining claims (from US Bureau of Mines plot).

Important Examples of Deposit Type

The Eocene Challis volcanic field in south-central Idaho is host to three major deposits or districts of this type, each of which has an open-pit mine operating in 1994: the Thunder Mountain district in the Thunder Mountain caldera (#3, figure 11b), the Sunbeam-Grouse Creek deposit in the northeast-trending Trans-Challis fault zone (#4, figure 11b), and the Champagne deposit (#7, figure 11b) at the margin of the Snake River plain (a Pliocene feature). The Yankee Fork district encompasses an area of older mines which exploited associated Comstock-type mineralization.

Rationale for Numerical Estimate

Contemporaneous faulting and volcanism in the Trans-Challis fault zone, along with two known prospect areas there, lead us to consider the area of the intersection of the fault zone and the volcanic field as favorable for undiscovered hot-spring deposits. Irregular cover of the favorable lower part of the volcanic field by younger lavas and ash-flows of the unmineralized upper part of the field suggests that exploration has not fully evaluated this area. At the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 2, 5, 7, and 8 or more deposits consistent with the grade and tonnage model of Berger and Singer (1992).

Hot-spring Au-Ag Deposits

Descriptive Model 25a
No estimate of undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract was delineated to include the Eocene volcanic and volcaniclastic rocks of the Republic graben and adjacent areas of northeastern Washington (Stoffel and others, 1991). Volcanism and mineralization were broadly contemporaneous with detachment faulting above the Okanogan, Kettle, and Priest River metamorphic core complexes. Eocene, gold-bearing hydrothermal systems are known from several of these volcanic sequences. Hot-spring Au-Ag deposits are known in the Republic mining district (Tschauder, 1989), although they appear to be small deposits in the upper part of associated Comstock-type deposits.

Important Examples of Deposit Type

The Republic and adjacent areas of northeastern Washington contains numerous volcanic-hosted Au-Ag deposits, prospects, and occurrences. Each of these appears to be primarily a Comstock vein system with a subordinate hot-spring deposit in its upper part. The Golden Promise mine (#4, figure 7b) in the Republic district is an important example of this type (Tschauder, 1989). The vein system has been mined for over 300 m down dip. The prominent vein system becomes a stockwork system in the upper part, and grades into an overlying hot-spring Au-bearing sinter, which has been mined as part of the underground mine.

Rationale for Lack of Numerical Estimate

Since Comstock veins in the area grade up into more disseminated hot-spring systems, our estimate for undiscovered Comstock deposits includes both deposit types as part of the same system (Mosier, Menzie, and Kleinhampl, 1986), and we do not make a separate estimate for hot-spring Au-Ag deposits.

Massive sulfide, Kuroko-type deposits

General Deposit Description

Kuroko massive sulfide deposits are stratabound accumulations of massive Fe-sulfides with subordinate (but economically significant) layers and lenses of Cu, Zn, and Pb sulfide minerals (Singer, 1986b). These are deposited on the seafloor around hydrothermal vents associated with felsic and intermediate volcanic rocks in and around island arc volcanic complexes. Kuroko massive sulfide deposits form in marine volcanic rocks of intermediate to felsic composition that include marine rhyolite, dacite, and subordinate basalt and associated sediments. These rock types are present in tectonostratigraphic terranes derived from island-arc and/or back-arc basin volcanism.

Volcanogenic massive sulfide deposits have been an historically important source of Cu, Zn, Ag, and Au. Their relatively high grades, simple metallurgy, and potential for large deposits make these deposits attractive exploration targets, and exploration for, and development of, these deposits continues. Two grade/tonnage models are used: a general kuroko model (Singer and Mosier, 1986b) and the Sierran kuroko model (Singer, 1992), used for deposits of Triassic or Jurassic age. The median size of a deposit from the general kuroko model is 1.5 million metric tonnes with 1.3% copper and 2% zinc, with subordinate values of lead, gold and silver. The median size of a deposit from the Sierran kuroko model is significantly smaller at 0.31 million metric tonnes with 1.4% copper and 2.9% zinc.

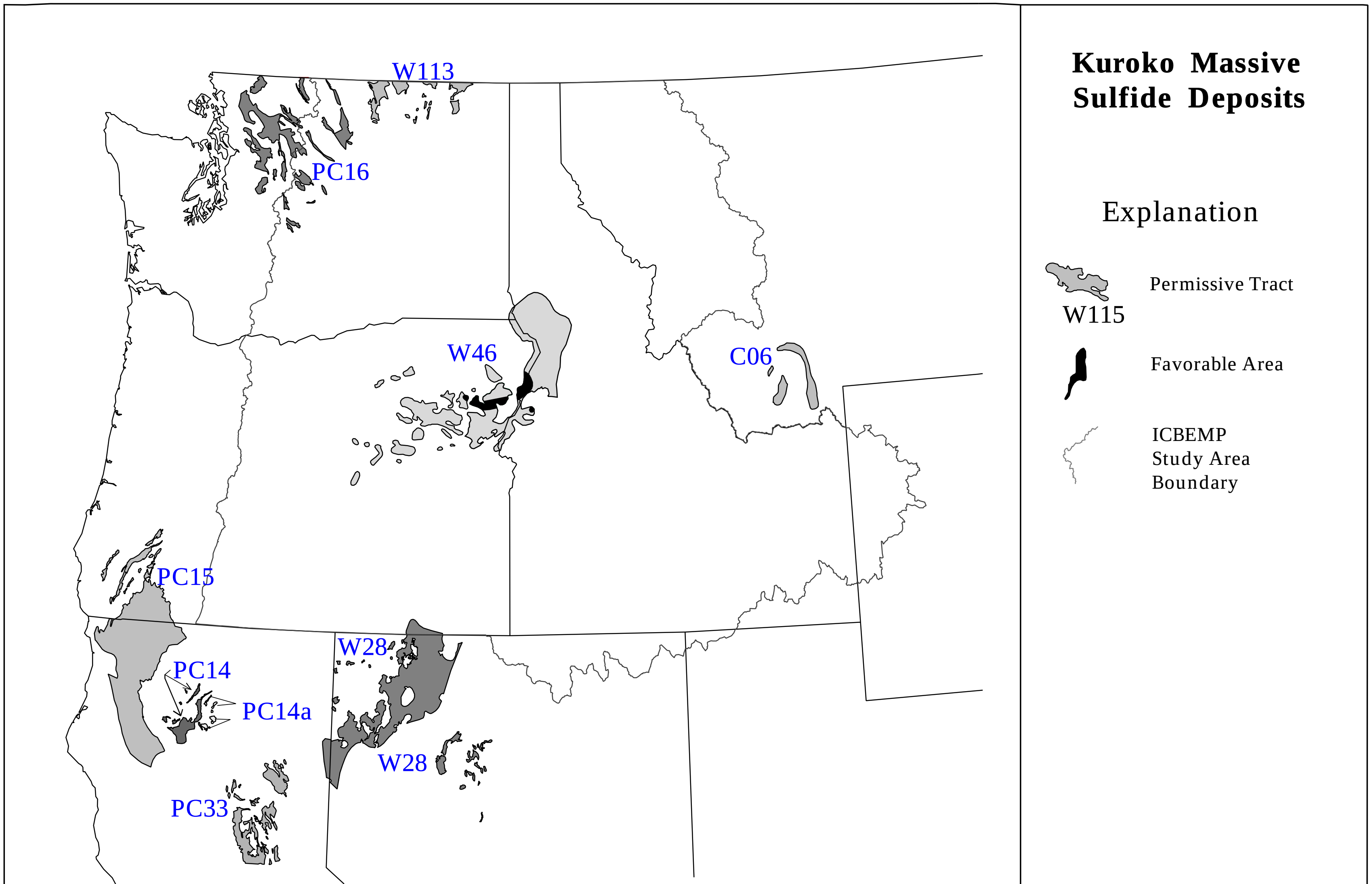


Figure 12a: Permissive and favorable tracts for Kuroko massive sulfide deposits.

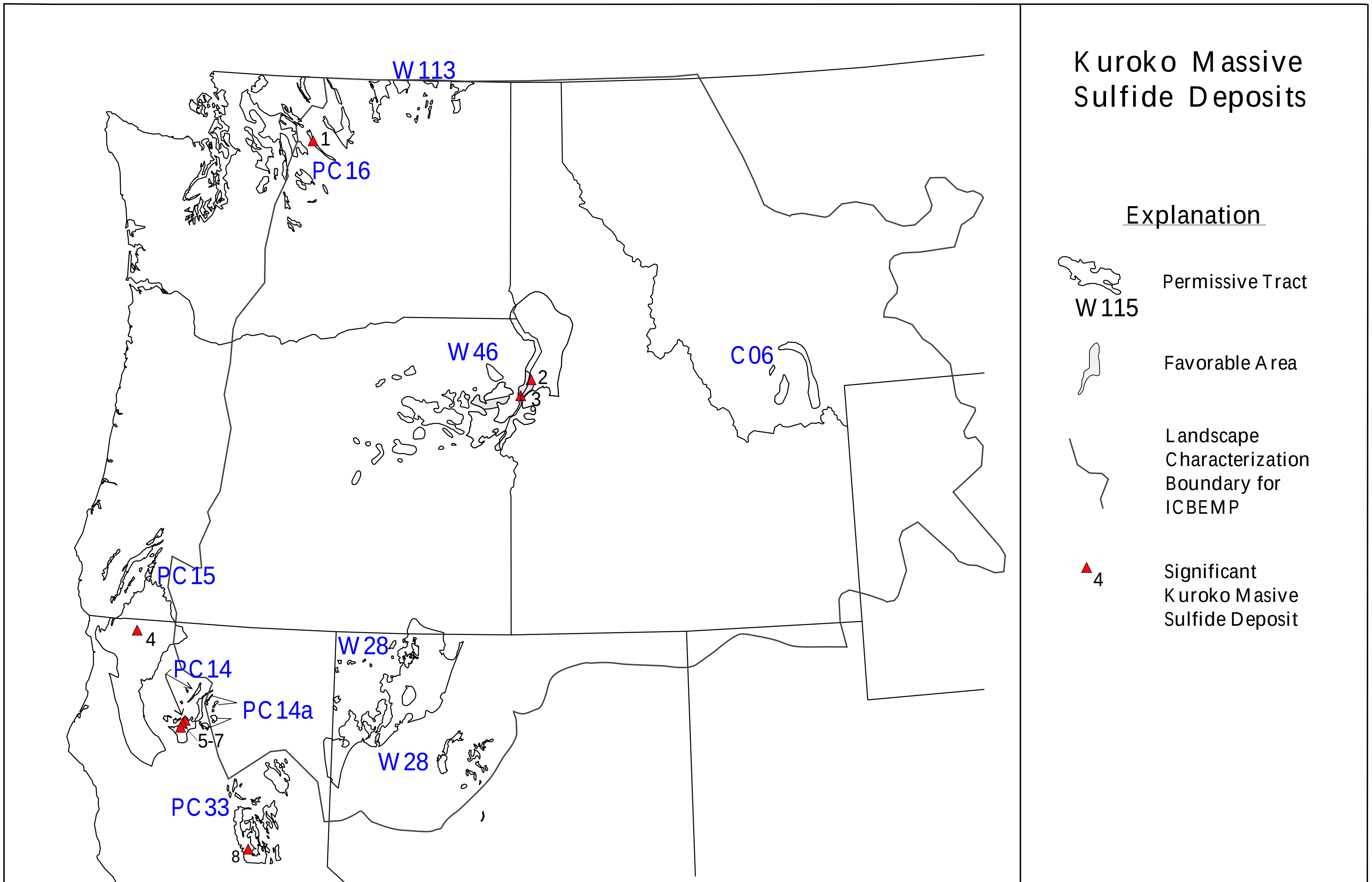


Figure 12b: Location of significant Kuroko massive sulfide deposits in the map area.

Table 12: Significant Kuroko massive sulfide deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	PC16	Holden	Railroad Creek	Chelan	WA	48.197	-120.780	I M
02	W46	Red Ledge	Seven Devils	Adams	ID	45.226	-116.664	I D
03	W46	Iron Dyke	Seven Devils	Baker	OR	45.026	-116.849	I M r
04	PC15	Gray Eagle	Happy Camp	Siskiyou	CA	41.863	-123.371	F M
05	PC14	Mammoth	West Shasta	Shasta	CA	40.763	-122.454	I M
06	PC14	Balaklala	West Shasta	Shasta	CA	40.725	-122.498	I M
07	PC14	Iron Mountain	West Shasta	Shasta	CA	40.673	-122.524	I M r
08	PC33	Western World		Yuba	CA	39.175	-121.292	F D

Table 12: Significant Kuroko massive sulfide deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Zn prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Zn resource (tonnes)
01	PC16	Holden	18.68	62	96,192	18,129	5.6	9.7	29,946	8,167
02	W46	Red Ledge	none	none	none	none	5.0	485	54,000	174,000
03	W46	Iron Dyke	1.09	15	15,100	unk	2.5	7.1	7,961	unk
04	PC15	Gray Eagle	8.21	23	50,540					
05	PC14	Mammoth	4.12	245	132,477	142,297				
06	PC14	Balaklala	2.01	72	58,800	27,300				
07	PC14	Iron Mountain	10.50	1,073	155,400	41,241				
08	PC33	Western World	unk	unk	unk	unk	1.4	18	33,276	unk

Tract Descriptions

C06 — **Kuroko Massive Sulfide Deposits** — **Montana**

Descriptive Model 28a

• 0.01 mean undiscovered deposits

by B.R. Berger and Alan Wallace

Rationale for Tract Delineation

The tract consists of areas of Archean metamorphic rocks in the southern Ruby Range and the Gravelly Range that contain metabasalts with some associated sulfides. In the Ruby Range, the rocks contain silica- and alumina-rich minerals, including anthophyllite and corundum, that may represent a metamorphosed alteration assemblage. This association may indicate a kuroko massive sulfide environment. Apparently these are very local within the larger package of Archean metamorphic rocks.

Important Examples of Deposit Type

No deposits of this type are known from this tract.

Rationale for Numerical Estimate

Based upon the limited information available, the team judged that the presence of metabasalts could allow massive sulfide deposits to be present, although a bimodal volcanic assemblage is not known. The possible metamorphosed alteration assemblage could indicate siliceous alteration, which would suggest a kuroko-type setting. Lacking further positive information, the team made a small estimate. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model for kuroko massive sulfide deposits (Singer, 1986b).

PC14 — **Kuroko Massive Sulfide Deposits** — **California**

Descriptive Model 28a

No estimate of undiscovered deposits

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

The permissive tract is based on the extent of the Devonian Copley Greenstone and Balaklala Rhyolite, host rocks for Kuroko massive sulfide deposits in the West Shasta district (Kinkel and others, 1956).

Important Examples of Deposit Type

The West Shasta District, in the Klamath Mountains (#5,6,7, figure 12b), has been an important mineral producer from Kuroko massive sulfide deposits in the past. The Iron Mountain mine (#7, figure 12b) is one of the larger examples of volcanogenic massive sulfide deposits in the United States, and has produced nearly 11 metric tons of gold.

Rationale for Lack of Numerical Estimate

Since tract PC 14 lies entirely outside the ICBEMP study area, no estimate was made of undiscovered Kuroko massive sulfide deposits in this tract.

PC14a — Kuroko Massive Sulfide Deposits (Sierran Type) — California

Descriptive Model 28a.1
No estimate of undiscovered deposits

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

The permissive tract is based on the extent of the Triassic Dekkas Andesite and Bully Hill Rhyolite, host rocks for the Kuroko massive sulfide deposits in the East Shasta district (Albers and Robertson, 1961). The Sierran kuroko model, which is defined to be restricted to deposits of Triassic and Jurassic age (Singer, 1992), was selected because the known deposits are in Triassic rocks.

Important Examples of Deposit Type

Deposits in this district are small. The district produced less than 700,000 metric tons of ore, mainly from two massive sulfide deposits, the Afterthought and Bully Hill-Rising Star.

Rationale for Lack of Numerical Estimate

Since tract PC14a lies entirely outside the ICBEMP study area, no estimate was made of undiscovered Kuroko massive sulfide deposits in this tract.

PC15 — Kuroko Massive Sulfide Deposits (Sierran Type) — California, Oregon

Descriptive Model 28a.1
No estimate of undiscovered deposits

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

All map units containing sequences of submarine volcanic rocks have been included and define the permissive tract for volcanogenic massive sulfide deposits. Paleozoic, Triassic, and Jurassic rocks are present in the tract. Although some of this tract may also be permissive for Besshi- and Cyprus-type massive sulfide deposits, the team assessed only for kuroko-type massive sulfide deposits, because of lack of detailed stratigraphic information in the area. The Sierran kuroko model, which is defined to be restricted to deposits of Triassic and Jurassic age (Singer, 1992), was selected because the known deposits are in Jurassic rocks.

Important Examples of Deposit Type

The Gray Eagle mine in the Happy Camp district, California (# 4, figure 12b), produced over 50,000 metric tons of copper (Singer, 1992). Two smaller deposits are known in Oregon.

Rationale for Lack of Numerical Estimate

Since tract PC15 lies entirely outside the ICBEMP study area, no estimate was made of undiscovered Kuroko massive sulfide deposits in this tract.

PC16 — Kuroko Massive Sulfide Deposits (Sierran Type) — Washington

Descriptive Model 28a.1

• 0.1 mean undiscovered deposits (for entire tract)

• 0.1 mean undiscovered deposits (for ICBEMP portion of tract)

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

All map units containing sequences of submarine volcanic rocks in the Northern Cascades have been included and define the permissive area for kuroko massive sulfide deposits. Although some of these areas may be permissive for Cyprus and Besshi deposits, the team assessed only for kuroko, because of lack of detailed stratigraphic information in the area. The Sierran kuroko model, which is defined to be restricted to deposits of Triassic and Jurassic age, is used for this tract because the only known deposit is hosted in a belt of gneiss and hornblende schist of Late Triassic age (Dragovitch and Derkey, 1994).

Important Examples of Deposit Type

The Holden deposit, in the ICBEMP portion of the tract (#1, figure 12b), produced 9 million metric tons of ore averaging 1.06 percent Cu, 0.2 percent Zn, 6.8 grams per metric ton Ag, and 2 grams per metric ton Au between 1938 and 1957 (McWilliams, 1958). This deposit is larger than all other deposits in the Sierran kuroko grade and tonnage model, but this difference is not deemed sufficient to rule out the use of that model.

Rationale for Numerical Estimate

The metamorphic rock unit that hosts the Holden deposit lies mostly within the ICBEMP study area. A significant exploration effort in the 1970's and 1980's failed to generate any prospects that warranted further exploration efforts. However the host rock unit extends under cover of the Miocene Columbia River Basalt on the east, allowing for a significant unevaluated area for undiscovered deposits. For the 90th, 50th, 10th, and 5th percentiles, the team estimated 0, 0, 1, 2, and 2 or more Sierran kuroko deposits (with a 90% chance of no deposits) in the ICBEMP portion of tract PC16, consistent with the grade and tonnage model of Singer (1992). Since the most prospective area occurs within the ICBEMP, the team felt the same estimate was also valid for the entire tract.

PC33 — Kuroko Massive Sulfide Deposits (Sierran Type) — California

Descriptive Model 28a.1

No estimate of undiscovered deposits

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

All map units in the foothills of the Sierra Nevada that contain sequences of submarine volcanic rocks have been included and define the permissive tract for kuroko massive sulfide deposits. The tract extends westward under the Great Valley where the depth to Jurassic basement is no more than one kilometer, based on drillhole data (Wentworth and others, in press).

Important Examples of Deposit Type

The Western World (#8, figure 12b) deposit in the Sierra Nevada foothills has no significant production but does have significant resources, based on active exploration in recent years.

Rationale for Lack of Numerical Estimate

Since tract PC33 lies entirely outside the ICBEMP study area, no estimate was made of undiscovered Kuroko massive sulfide deposits in this tract.

W28 Kuroko Massive Sulfide Deposits (Sierran Type)

Descriptive Model 28a.1

• 0.01 mean undiscovered deposits
(estimate for ICBEMP portion of tract only)

Nevada
Oregon
California

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The Jurassic Black Rock and Triassic Koipato assemblages are delineated as permissive for kuroko massive sulfide deposits because they contain intermediate to felsic marine volcanic rocks in many localities. Singer (1992) has shown that Mesozoic kuroko deposits, typified by deposits in the western foothills of the Sierra Nevada, tend to have lower tonnage than other kuroko deposits. Since the permissive rocks for kuroko deposits in Nevada are of Triassic and Jurassic age, the Sierran kuroko grade and tonnage model is believed to best represent undiscovered deposits in Nevada.

Important Examples of Deposit Type

Examples of kuroko deposits are rare and not well documented in Nevada. Sorensen and others (1987, p. B12) briefly described the Red Boy and other prospects that probably belong to this type in the South Jackson Mountains.

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W28 that lies within the ICBEMP study area in northeastern Nevada (figure12a). An estimate of the number of undiscovered Kuroko-type massive sulfide deposits by county in northeastern Nevada was previously made by Singer (1996). The ICBEMP portion of tract W28 lies within two counties. To arrive at the numerical estimate of undiscovered Kuroko massive sulfide deposits in the ICBEMP portion of tract W28, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 0.01 mean undiscovered deposits for the part of tract W28 within the ICBEMP study in northeastern Nevada. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Singer and Mosier (1986b) is equivalent to the estimated number of mean undiscovered deposits derived above.

W46 Kuroko Massive Sulfide Deposits

Descriptive Model 28a

• 3.3 mean undiscovered deposits (entire tract)
• 1.7 mean undiscovered deposits (ID only)
• 1.6 mean undiscovered deposits (OR-WA only)

Idaho
Oregon
Washington

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

Island arc volcanic terranes in the Blue Mountains of northeastern Oregon are considered permissive environments for kuroko massive sulfide deposits. These include the Wallowa and

Huntington terranes in Oregon, Idaho and southeasternmost Washington (Brooks and Vallier, 1978; Walker and MacLeod, 1991). The Baker melange terrane is also included because it incorporates some fragments of arc volcanic and plutonic rocks. Plutonic bodies that intrude these terranes were excluded from the permissive tracts. Favorable areas were based on the distribution of known deposits and occurrences, known exploration activity, and the distribution and density of mining claims (from an unpublished claim density plot by the US Bureau of Mines).

Important Examples of Deposit Type

Two kuroko deposits are known in Permian volcanic rocks of the Blue Mountains of Oregon. In the Hells Canyon area of Oregon and Idaho, the Red Ledge (Fifarek and others, 1994) and Iron Dyke (Bussey and Anderson, 1994) deposits of Permian age (#2 and #3, figure 12b) have grade and tonnage characteristics that fit the kuroko grade and tonnage model of Singer and Mosier (1986b). In addition, several more prospects of this type are known in the Hells Canyon area in Idaho and south of the Wallowa Mountains in Oregon.

Rationale for Numerical Estimate

Within the tract, only the Hells Canyon and south Wallowa Mountains areas are considered favorable for the presence of undiscovered deposits. Despite the presence of two deposits and several more prospects in the Hells Canyon area, the poor economics for any but the largest of these has led to an incomplete exploration effort. The tendency for these deposits to occur in clusters leads us to further optimism. The uncertainty, given the presence of only two known deposits in the area, is rather high. For the 90th, 50th, and 10th percentiles, the team estimated 1, 3, and 6 or more kuroko deposits consistent with the grade and tonnage model of Singer and Mosier (1986b). The team felt that slightly more than half of the undiscovered deposits lie on the Idaho side of the Snake River. For that part of the tract in Idaho, the team estimated 0, 2, 2, 4, and 8 or more undiscovered deposits (at the above percentiles). For that part of the tract in Oregon and Washington, the team estimated 0, 2, 2, 4, and 6 or more undiscovered deposits (at the above percentiles).

W113 — Kuroko Massive Sulfide Deposits — Washington

Descriptive Model 28a

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

All of the Permian through Jurassic rocks of the Quesnellia terrane are considered permissive for kuroko massive sulfide deposits (Stoffel and others, 1991). The Quesnellia terrane in northeastern Washington consists of Permian through Jurassic arc volcanic rocks and associated sediments (Mortimer, 1986).

Important Examples of Deposit Type

Although no known Kuroko massive sulfide deposits are known from this terrane in Washington, there are known deposits in the Quesnellia terrane in British Columbia to the north.

Rationale for Numerical Estimate

The lack of known deposits or prospects of massive sulfide deposits in northeastern Washington led the team to give a very low estimate for the occurrence of an undiscovered deposit here. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more kuroko deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Singer and Mosier (1986b).

Low-sulfide Au-quartz vein Deposits

General Deposit Description

Low-sulfide Au-quartz vein deposits consist of gold-bearing massive quartz veins that typically contain a small amount of arsenopyrite and other sulfide minerals (<5 percent). The veins are vertically and horizontally persistent and have typically been deformed into pinch-and-swell structures due to compressive deformation (Berger, 1986d). As compared to gold-bearing polymetallic veins, which may also be mined primarily for gold, low-sulfide gold-quartz veins have lower contents of silver and higher ratios of gold to silver (See Polymetallic veins and disseminated deposits, Table 17, this report). These veins occur in belts of regionally metamorphosed (low to moderate metamorphic grade), marine sedimentary and volcanic rocks, which are penetratively deformed and cut by high-angle, regional-scale faults . Significant deposits of low-sulfide Au-quartz veins are typically localized along major, deep-seated, through-going structural features. The median size of these small, high-grade deposits is 30,000 metric tonnes with 16 g Au/tonne (Bliss, 1986).

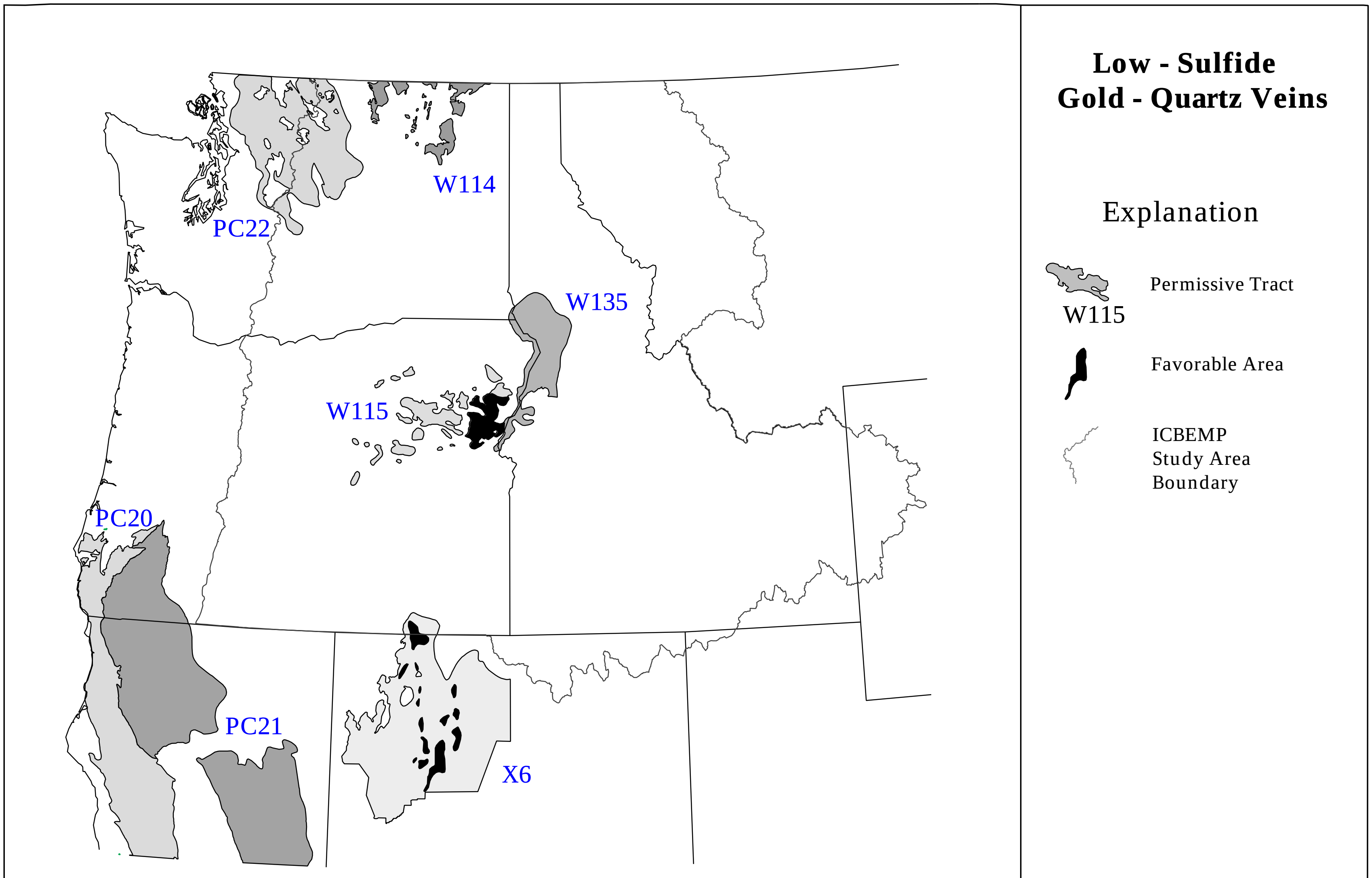


Figure 13a: Permissive and favorable tracts for Low-sulfide Au- quartz deposits.

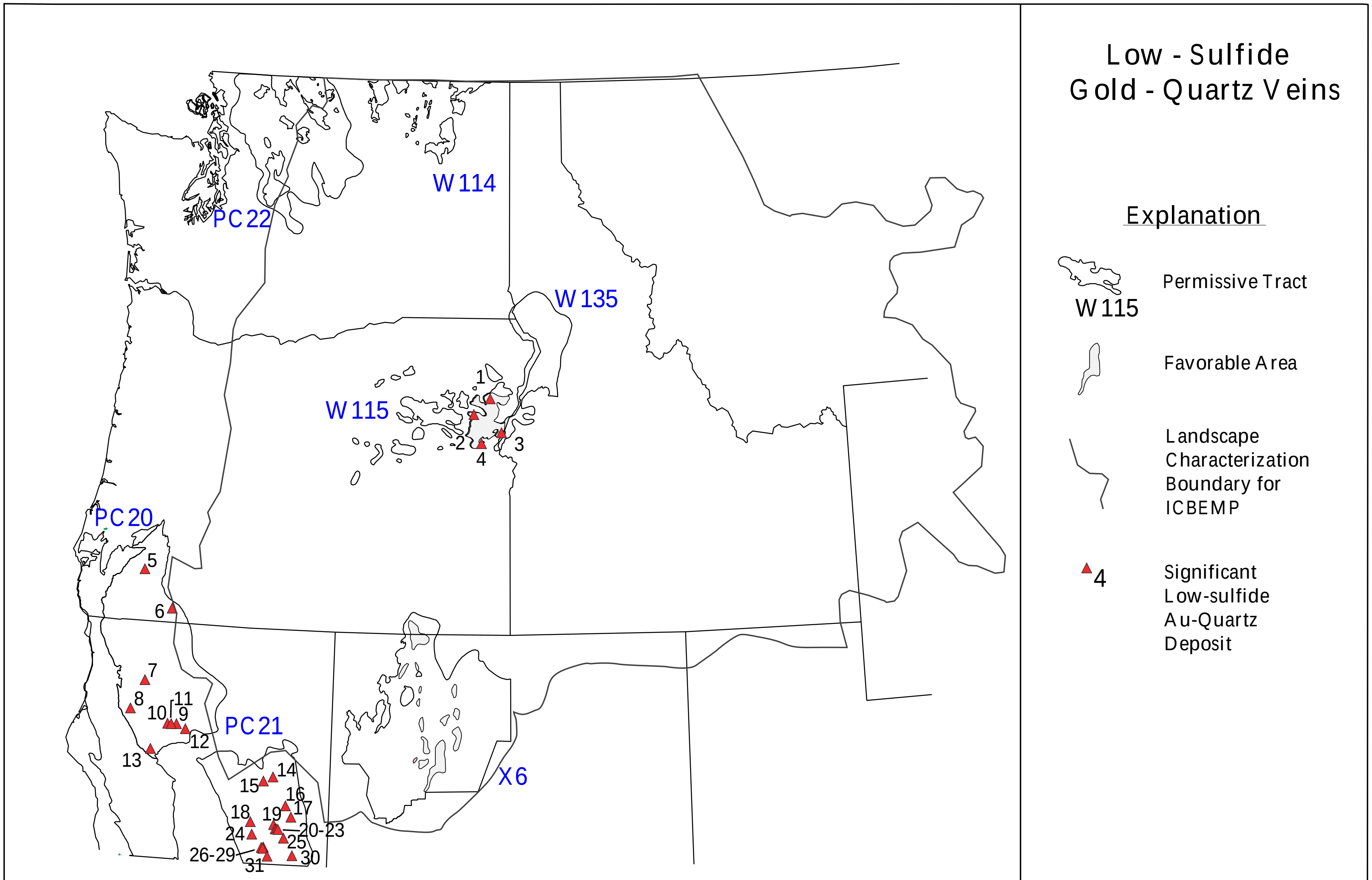


Figure 13b: Location of significant Low-Sulfide Au- Quartz deposits in the map area.

Table 13: Significant low-sulfide Au-quartz deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
01	W115	Sanger	Eagle	Baker	OR	44.994	-117.408
02	W115	Virtue	Virtue	Baker	OR	44.793	-117.697
03	W115	Connor Creek	Connor Cr.	Baker	OR	44.566	-117.201
04	W115	Mormon Basin	Mormon Basin	Baker / Malheur	OR	44.425	-117.555
05	PC21	Greenback	Greenback	Josephine	OR	42.654	-123.306
06	PC21		Ashland	Jackson	OR	42.182	-122.791
07	PC21	Black Bear	Liberty	Siskiyou	CA	41.252	-123.161
08	PC21	Globe	Dedrick-Canyon Ck	Trinity	CA	40.880	-123.367
09	PC21	Gladstone	French Gulch	Shasta	CA	40.724	-122.584
10	PC21	Brown Bear	Deadwood	Trinity	CA	40.720	-122.730
11	PC21	Milkmaid-Franklin	French Gulch	Shasta	CA	40.719	-122.669
12	PC21	Reid	Old Diggings	Shasta	CA	40.666	-122.429
13	PC21	Midas	Harrison Gulch	Shasta	CA	40.535	-122.985
14	PC21		Crescent Mills	Plumas	CA	40.214	-120.937
15	PC21	Rich Gulch	Virgilia	Plumas	CA	40.062	-121.088
16	PC21	Plumas-Eureka	Johnsville	Plumas	CA	39.758	-120.708
17	PC21		Sierra City	Sierra	CA	39.619	-120.610
18	PC21		Forbestown	Butte	CA	39.535	-121.268
19	PC21	Brush Creek	Alleghany	Sierra	CA	39.512	-120.889
20	PC21	Sixteen-to-one	Alleghany	Sierra	CA	39.464	-120.847
21	PC21	Oriental	Alleghany	Sierra	CA	39.460	-120.858
22	PC21	Rainbow	Alleghany	Sierra	CA	39.457	-120.835
23	PC21	Plumbago	Alleghany	Sierra	CA	39.453	-120.812
24	PC21		Brown's Valley	Yuba	CA	39.378	-121.235
25	PC21	Dinero		Nevada	CA	39.346	-120.717
26	PC21	Idaho-Maryland	Grass Valley	Nevada	CA	39.224	-121.038
27	PC21		Grass Valley	Nevada	CA	39.218	-121.036
28	PC21	Golden Center	Grass Valley	Nevada	CA	39.215	-121.069
29	PC21	Empire-Star	Grass Valley	Nevada	CA	39.206	-121.045
30	PC21	Herman		Placer	CA	39.127	-120.564
31	PC21	Rising Sun	Colfax	Placer	CA	39.107	-120.968

Table 13: Significant low-sulfide Au-quartz deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Status		Au production (tonnes)	Ag production (tonnes)		Au resource (tonnes)	Ag resource (tonnes)
01	W115	Sanger	I M		2.20	neg		unk	neg
02	W115	Virtue	I M		4.59	neg		unk	neg
03	W115	Connor Creek	I M		1.91	neg		unk	neg
04	W115	Mormon Basin	I M		3.87	1.1		unk	unk
05	PC21	Greenback	I M		5.45				
06	PC21		I M		3.78				
07	PC21	Black Bear	I M		4.50				
08	PC21	Globe	I M		3.55	0.83		2.2	0.57
09	PC21	Gladstone	I M		10.40				
10	PC21	Brown Bear	F M		12.05				
11	PC21	Milkmaid-Franklin	I M		3.77				
12	PC21	Reid	I M		3.77			4.8	
13	PC21	Midas	I M		7.82				
14	PC21		I M		7.56				
15	PC21	Rich Gulch	S		2.40			46	
16	PC21	Plumas-Eureka	I M		12.05				
17	PC21		I M		25.66				
18	PC21		I M		3.01				
19	PC21	Brush Creek	I M e		6.03				
20	PC21	Sixteen-to-one	P		37.76				
21	PC21	Oriental	I M		4.29				
22	PC21	Rainbow	I M		3.77				
23	PC21	Plumbago	I M		3.78				
24	PC21		I M		6.24				
25	PC21	Dinero	I M		3.00				
26	PC21	Idaho-Maryland	F M		105.46				
27	PC21		I M		110.92				
28	PC21	Golden Center	I M		3.77				
29	PC21	Empire-Star	I M		195.85				
30	PC21	Herman	I M		3.00				
31	PC21	Rising Sun	F M		3.08				

Tract Descriptions

PC20

Low-sulfide Au-quartz Vein Deposits
Descriptive Model 36a
0.01 mean undiscovered deposits
(Oregon portion of tract only)

Oregon
California

by William J. Pickthorn and Michael F. Diggles

Rationale for Tract Delineation

This tract was defined principally by the presence of belts of low- to moderate-grade regionally metamorphosed marine sedimentary and volcanic rocks in the Franciscan complex in the California Coast Ranges. One small district containing low-sulfide Au-quartz vein mines and prospects is reported from the Coast Ranges. Based on the rock type, geologic setting, and the presence of low-sulfide gold-quartz vein systems, this tract is considered permissive for undiscovered resources of this deposit type.

Important Examples of Deposit Type

Although there are no recognized major low-sulfide Au-quartz vein deposits in the Coast Ranges, small amounts of placer gold are found in almost all streams draining the Franciscan complex rocks. South of the map boundary in southern Monterey County the Los Burros mining district, which produced approximately 0.16 metric tons of gold from low-sulfide Au-quartz veins, is localized in greenschist facies rocks of the Franciscan complex that are intruded by serpentine (Hart, 1966). Similar higher-grade metamorphic rocks may be present elsewhere in the Coast Ranges.

Rationale for Numerical Estimate (Oregon portion only)

Since the area lies entirely outside the ICBEMP study area, the team did not make an estimate of undiscovered deposits for the entire tract. Because of the proximity of the Oregon portion of the tract to the ICBEMP study area, the team made an estimate for that portion of the tract. The lack of known low-sulfide Au-quartz deposits or prospects in tract PC20 led the team to give a very low estimate for the portion of the tract located in Oregon. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) in the Oregon portion of the tract consistent with the grade and tonnage model of Bliss (1986).

PC21

Low-sulfide Au-quartz Vein Deposits
Descriptive Model 36a
0.01 mean undiscovered deposits
(Oregon portion of tract only)

California
Oregon

by William J. Pickthorn and Michael F. Diggles

Rationale for Tract Delineation

The permissive tract was defined principally by the location of low- to moderate-grade regionally metamorphosed marine sedimentary and volcanic rocks of Jurassic and older age, based on the state geologic maps for California and Oregon (Jennings, 1977; Walker and MacLeod, 1991) and the personal knowledge of the assessors. Geophysical evidence was used to extend the tracts into areas of valley fill or thin Quaternary, Tertiary, or Cretaceous cover. In California and Oregon most of the tract contains known gold deposits and includes those deposits in the famed California Mother Lode and the Ashland district in southern Oregon. In southern California, metavolcanic and metasedimentary rocks that enclose, or occur as roof pendants in the major batholiths were also considered permissive. These rocks host small low-sulfide gold-quartz veins in the Julian-Banner district.

Important Examples of Deposit Type

The low-sulfide Au-quartz grade and tonnage model is based on deposits containing 100 metric tonnes of ore (Bliss, 1986), and many of the deposits to construct this model are located within this tract (#5-31, figure 13b). These include deposits of the California Mother Lode in the Grass Valley district in the Sierra Nevada foothills, and deposits in the Klamath, Siskiyou, and Trinity Mountains in northern California and southern Oregon. Two significant deposits occur in southern Oregon (#5,6, figure 13b). The only major mine in the tract that is currently active is the Sixteen-to-one mine in Sierra County in California (#20 on Map 13). About 80% of the historic production from lode deposits in this tract came from the Grass Valley district in Nevada County, California (#26-29, figure 13b).

Rationale for Numerical Estimate (Oregon portion only)

Since the area lies entirely outside the ICBEMP study area, the team did not make an estimate of undiscovered deposits for the entire tract. Because of the proximity of the Oregon portion of the tract to the ICBEMP study area, the team made an estimate for that portion of the tract. Most of the known reserves and future potential for undiscovered deposits of this type occur in the California portion of this tract. Given the long history of exploration for this deposit type in the area, the team felt there was a low potential for undiscovered deposits in the Oregon portion of the tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) in the Oregon portion of the tract consistent with the grade and tonnage model of Bliss (1986).

PC22 — Low-sulfide Au-quartz Vein Deposits — Washington

Descriptive Model 36a

• 0.01 mean undiscovered deposits
(ICBEMP portion of tract only)

by William J. Pickthorn and Michael F. Diggles

Rationale for Tract Delineation

The Northern Cascades contains belts of low- to moderate-grade regionally metamorphosed marine sedimentary and volcanic rocks which are penetratively deformed and cut by high-angle regional scale faults and crosscutting serpentine bodies. This tract was defined principally on the presence of these belts in the Northern Cascades as depicted on the Washington State geologic map (Huntting and others, 1961) and the personal knowledge of the assessors. Although this tract contains no major low-sulfide Au-quartz vein deposits, several major low-sulfide Au-quartz vein districts in similar or possibly equivalent rocks are found to the north in Canada.

Important Examples of Deposit Type

No major low-sulfide Au-quartz deposits are recognized in this tract.

Rationale for Numerical Estimate (ICBEMP portion only)

An estimate of undiscovered deposits was made only for that portion of the tract within the ICBEMP study area (figure 13a). The lack of known low-sulfide Au-quartz deposits or prospects in the tract led the team to give a very low estimate for the occurrence of undiscovered low-sulfide Au-quartz vein deposits in the ICBEMP portion of tract PC22. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Bliss (1986).

W114 — Low-sulfide Au-quartz Vein Deposits — Washington

Descriptive Model 36a

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract outlines the rocks of the Quesnellia terrane and the Covada Group in northeastern Washington (Stoffel and others, 1991), which consist of regionally metamorphosed, low- to moderate-grade, marine sedimentary and volcanic rocks. The tract boundaries were drawn to include areas that are covered by less than a km of younger rocks. Younger cross-cutting granitic plutons were excluded.

Important Examples of Deposit Type

No major low-sulfide Au-quartz deposits are recognized in this tract in northeastern Washington. Small deposits north of Republic, Washington near Danville are considered by some to be examples of this type of deposit (Tschauder, 1989). However several small deposits are known in correlative rocks in British Columbia less than 100 km to the north.

Rationale for Numerical Estimate

The lack of known low-sulfide Au-quartz deposits or prospects led the team to give a very low estimate for the occurrence of an undiscovered deposit here. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Bliss (1986).

W115 — Low-sulfide Au-quartz Vein Deposits — Oregon

Descriptive Model 36a

• 0.2 mean undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

Pre-Cenozoic rocks of northeastern Oregon and adjacent west-central Idaho and southeasternmost Washington consist of andesitic and basaltic volcanic rocks, marine clastic and pelagic sedimentary rocks, dismembered ophiolitic sequences, and cross-cutting granitic rocks (Walker and MacLeod, 1991). Except for the granitic rocks, these rocks are moderately to strongly deformed and metamorphosed to greenschist facies. Because the area of these rocks in west-central Idaho is currently under study for its mineral resource potential (Bruce Johnson, U.S. Geological Survey, personal commun., 1994), we have separated that portion of the area as a separate tract (W135). In northeast Oregon all rocks of the Wallowa, Baker, and Olds Ferry terranes are included as part of the permissive tract (Brooks and Vallier, 1978). Major cross-cutting, post-metamorphic Jurassic and Cretaceous plutons are excluded from the tract. The favorable tract is based on the distribution of the four deposits listed below, of associated prospects, and of placer Au accumulations (probably derived from this deposit type in this area), and on “prospective" areas from a mineral resource assessment of the Malheur-Jordan-Andrews BLM Resource Areas (Peters and others, 1994).

Important Examples of Deposit Type

The deposits from four mining districts in northeastern Oregon are considered here to be examples of this type (Mormon Basin, Connor Creek, Sanger and Virtue districts: #1-4, figure 13b), all in the Baker terrane. The tonnage, Au grade and Ag grade of these deposits overlap the median on the grade and tonnage model for low sulfide Au-quartz vein deposits of Bliss (1986).

Other, apparently related, Au-bearing quartz veins in northeastern Oregon differ from the above districts in their higher sulfide content and higher silver grade. Recently Bliss (1994a) suggested that all of the mesothermal vein deposits in northeastern Oregon represent a distinct deposit-type, although he noted the similarity of some of the above deposits to the low-sulfide Au-quartz vein deposit type. For this assessment, we consider only the deposits of the above-named districts as representative of the low-sulfide Au-quartz vein deposit type.

Rationale for Numerical Estimate

Extensive exploration for this deposit type occurred in the late 1800s, and most of the known deposits and prospects were developed at that time. We presume that any exposed deposits have been discovered and thoroughly explored. However areas covered by younger rocks have received little exploration. Because of the relatively small unexplored area and the small size of the known deposits within the tract, the team made a relatively low estimate with a high uncertainty. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 3, and 8 or more undiscovered deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Bliss (1986).

W135 — Low-sulfide Au-quartz Vein Deposits

Descriptive Model 36a

•0.4 mean undiscovered deposits

Idaho
Oregon
Washington

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

Pre-Cenozoic rocks of northeastern Oregon and adjacent west-central Idaho and southeasternmost Washington consist of andesitic and basaltic volcanic rocks, marine clastic and pelagic sedimentary rocks, dismembered ophiolitic sequences, and cross-cutting granitic rocks (Walker and MacLeod, 1991; Bond, 1978). Except for the granitic rocks, these rocks were moderately to strongly deformed and metamorphosed to greenschist facies during Triassic and Jurassic time. Amphibolite-facies metamorphism of Early Cretaceous age is localized along Salmon River suture, which constitutes the northeast margin of the tract (Lund and Snee, 1988). The area of these rocks in west-central Idaho is currently under study for its mineral resource potential (Bruce Johnson, U.S. Geological Survey, personal commun., 1994), and this tract includes all the pre-Cenozoic rocks of the Wallowa, Baker, and Olds Ferry terranes east of the western rim of the Snake River canyon (Brooks and Vallier, 1978). Where large enough, cross-cutting, post-metamorphic Jura-Cretaceous plutons are excluded from the tract.

Important Examples of Deposit Type

Although several prospects of this deposit type occur within the tract, no significant deposits are known. The Black Lake deposit in the Seven Devils mining district produced about 11,000 metric tons of ore averaging 15 g/metric ton of Au (Livingston and Laney, 1920). This is smaller than 85 percent of the deposits used to construct the grade-tonnage model for low-sulfide Au-quartz veins by Bliss (1986), but the grade is near the median for such deposits. In addition four deposits are known in the generally similar rocks in the tract immediately to the west. Recently Bliss (1994a) suggested that all of the mesothermal vein deposits in northeastern Oregon and adjacent western Idaho represent a distinct deposit-type, although he noted the similarity of some of the above deposits to the low-sulfide Au-quartz vein deposit type.

Rationale for Numerical Estimate

Thorough exploration for placer and lode gold in this region in the late 1800s and early 1900s probably led to the discovery of almost all deposits that are exposed at the surface. However some of the target rock units are covered by younger rocks along the margin of the tract and locally within it. Possibly some of the known prospects, upon more thorough testing, might be found to be deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 2, 4, and 7 or more undiscovered deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model of Bliss (1986).

X6 — Low-sulfide Au-quartz deposits

Nevada
Oregon

Descriptive Model 36a

• 0.01 mean undiscovered deposits
(ICBEMP portion of tract only)

by Stephen Peters

Rationale for Tract Delineation

Criteria considered permissive for the occurrence of low-sulfide gold-quartz vein deposits are zones of accreted terranes of oceanic origin where rocks have been metamorphosed to prehnite-pumpellyite up to middle amphibolite facies. Pre-Tertiary plutons and margins of pre-Tertiary batholiths are also permissive. Accreted terranes included in permissive tract X6 encompass parts of the Black Rock, Jackson, Jungo, and Golconda terranes (Silberling and others, 1987). Small, high-grade, low-sulfide gold-quartz veins were mined historically (prior to the 1940's) in small underground mines within the tract. The favorable tracts are based on "prospective" areas from a mineral resource assessment of the Malheur-Jordan-Andrews BLM Resource Areas (Peters and others, 1994) and an unpublished USGS mineral resource assessment of the Winnemucca-Surprise BLM Resource Areas. These favorable areas were drawn to include clusters of known mineral occurrence.

Important Examples of Deposit Type

In tract X9 known low-sulfide gold-quartz veins are present in shear zones cutting pre-Tertiary rocks in a broad north-striking zone shown as favorable on figure 13a. Veins occur within the Jackson, Jungo, and Golconda terranes (Silberling and others, 1987). Where hosted by Cretaceous granitic rocks or metavolcanic rocks of the Triassic Koipato Group (or other Mesozoic sedimentary rocks), most deposits are rich in lead and antimony, and were mined principally for their silver contents, as in the Rochester, Star, Sierra, and Unionville districts. Where the veins are hosted by marine metasedimentary and metavolcanic rocks or mafic to intermediate intrusive rocks (Desert, Denio, and Dun Glenn districts), the veins are richer in copper and gold, and the deposits were worked primarily for their gold content. Other districts hosting low-sulfide gold-quartz veins include the Imlay, Trinity, SanJacinto, East Antelope, Haystack, Jungo, northern Mill City, Ten Mile, Awakening, Florence, Varyville, and Warms Springs mining districts. Deposits in these districts all have characteristics which are similar to those in the model of low-sulfide gold-quartz veins (Berger, 1986d). They typically consist of shear-zone-hosted, milky white metamorphic quartz veins, locally with ribbon texture or in contorted configurations. Narrow alteration halos with sericite and silicification are typical. None of these districts produced a sufficient amount of gold (2 metric tonnes) to be included in the table of significant deposits (Table 13).

Rationale for Numerical Estimate (ICBEMP portion only)

Thorough exploration for placer and lode gold in this region in the late 1800s and early 1900s and the small size of known districts in the area led us to make a low estimate for the number of undiscovered low-sulfide gold-quartz vein deposits in ICBEMP portion of tract X9. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Bliss (1986).

Merensky Reef PGE deposits

General Deposit Description

Stratiform, disseminated sulfide [reef-type] mineralization in layered, cumulate mafic-ultramafic plutons can be enriched in platinum group elements (PGE) and is a major source of PGE in the world (Page, 1986c). Sulfide mineral abundance in these deposits is low, typically in the range of 1 to 5 volume percent. The mineralized interval is thin (tens of centimeters to a few meters) relative to the thickness of layered rocks in the host intrusion (kilometers). Mineralized intervals are laterally persistent and typically extend the length of the layered intrusion (up to hundreds of kilometers). In most deposits and prospects, sulfide minerals are concentrated near an interval that marks a major lithologic and petrologic change in the cumulate stratigraphic section. Pegmatoidal textures are common in some deposits. The exsolution of immiscible sulfide liquid from a mafic silicate magma is the fundamental ore forming process. The textures and mineralogy of sulfide ores record a prolonged and complex process of solid state transformation and recrystallization starting after solidification of the sulfide liquid. For the Stillwater Complex, the sulfide mineralogy resulting from the solid state recrystallization of high-temperature sulfide phases is dominated by pyrrhotite, pentlandite, and chalcopyrite. Most of the platinum resides in discrete platinum-group minerals whereas most of the palladium is in solid-solution in pentlandite.

There are few examples of this type of mineralization. PGE is being mined from two PGE-enriched stratiform layers: the Merensky Reef in South Africa, and the J-M Reef in Montana. Even though PGE exploration efforts worldwide in the late 1980's found several lower grade and currently subeconomic deposits, there are still too few deposits to construct statistically robust grade and tonnage distributions.

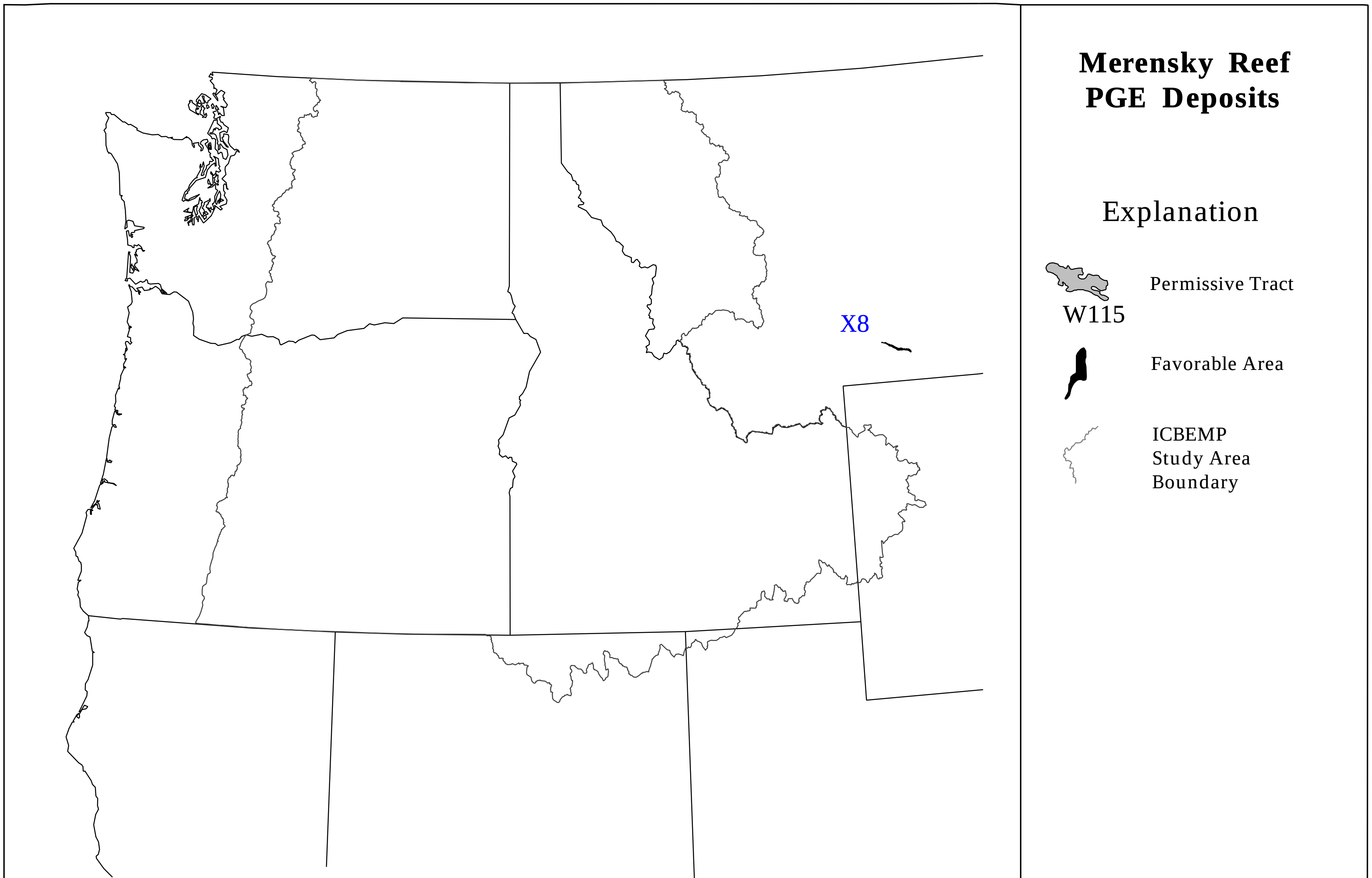
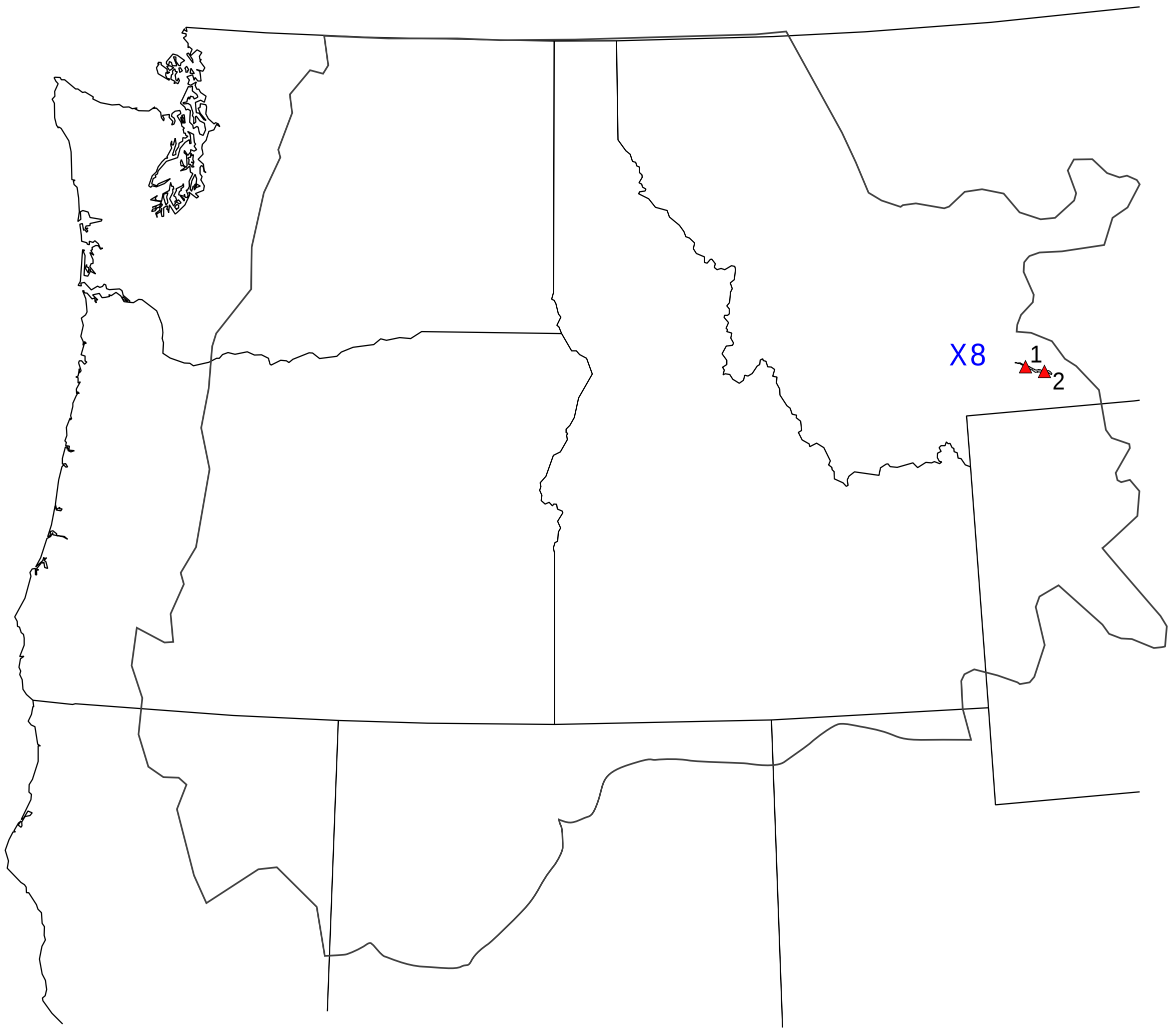


Figure 14a: Permissive and favorable tracts for Merensky Reef PGE deposits.



Merensky Reef
PGE Deposits

Explanation

Permissive Tract


Favorable Area


Landscape Characterization Boundary for ICBEMP

Significant Merensky Reef PGE Deposit

Figure 14b: Location of significant Merensky Reef PGE deposits in the map area.

Table 14: Significant Merensky Reef-type PGE deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	X8	East Boulder Project	Stillwater	Sweet Grass	MT	45.454	-110.138	F D
02	X8	Stillwater Mine	Stillwater	Stillwater	MT	45.389	-109.871	P

Table 14: Significant Merensky Reef-type PGE deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Au prod (tonnes)	Cu prod (tonnes)	Pd prod (tonnes)	Pt prod (tonnes)	Au resource (tonnes)	Cu resource (tonnes)	Pd resource (tonnes)	Pt resource (tonnes)	Ni resource (tonnes)
01	none	none	none	none	16	20776	448	142	35616
02	0.75	sig	42 (est)	12 (est)	3.8	4480	234	69	6720

X8 — Merensky Reef PGE Deposits — Montana

Descriptive Model 2b

No estimate of undiscovered deposits

by Michael L. Zientek

Rationale for Tract Delineation

The permissive (and overlapping favorable) tract for reef-type mineralization in the Stillwater Complex is defined by two characteristics shared by known deposits and prospects. (1) Reef-type deposits are found in a restricted part of the stratigraphic section of layered intrusions. Two deposits, the Main sulfide zone of the Great Dyke, Zimbabwe and the Main sulfide layer of the Munni Munni Complex, Australia occur a few tens of meters below the contact separating ultramafic cumulates (below) and rocks containing abundant cumulus plagioclase (above). This position would correspond to the interval just below the contact between the Ultramafic series and the Lower Banded series in the Stillwater Complex. The Merensky Reef (Bushveld Complex, Republic of South Africa), the J-M Reef (Stillwater Complex, Montana), and the Sompujärvi Reef (Penikat intrusion, Finland) occur in rocks with cumulus plagioclase that are less than a kilometer stratigraphically above sections that are dominated by ultramafic cumulates. (2) Mineralization is localized at or near major lithologic changes in parts of the stratigraphic section that are comprised of conspicuously layered cumulates. Using these two criteria, the tract was delineated to include rocks that stratigraphically lie between the uppermost part of the Ultramafic series and the base of the Middle Banded series of the Stillwater Complex.

Important Examples of Deposit Type

The J-M Reef of the Stillwater Complex consists of a 1 to 3 m thick interval containing 1 to 2 volume percent PGE-enriched magmatic sulfide minerals that lies near the base of a cyclic unit in olivine-bearing zone I in the Lower Banded series (Todd and others, 1982; Raedeke and Vian, 1986). The mineralized interval has not been defined over the vertical extent over which it will be technically feasible to mine the deposit; depending on the depth to which the ore is projected, geologic resource estimates range from 116 million metric tons of ore to 421 million metric tons of ore at 18.8 ppm palladium plus platinum (Zientek, 1993). The deposit is being mined by selective underground mining methods near the Stillwater River valley (Stillwater Mine: #1, Table14 and fig. 14b) and a second mine (East Boulder project: #2, Table 14 and fig. 14b) is proposed.

Although the J-M Reef is mined for its platinum and palladium content, copper, nickel, rhodium, and gold are recovered as by-products. Although the gold grade is low for an underground mine (approximately 0.31 ppm), the quantity of gold in the J-M Reef deposits is sufficient to meet the criteria for inclusion in the significant deposit table (2 tonnes).

Rationale for Lack of Numerical Estimate

Since tract X8 lies entirely outside the ICBEMP study area, no estimate is made here of undiscovered Merensky Reef PGE deposits in this tract. Appraisal of the undiscovered mineral potential for this tract is given in Zientek (1993).

Mississippi Valley Pb-Zn Deposits

General Deposit Description

Mississippi Valley Pb-Zn deposits (also known as Southeast Missouri Pb-Zn deposits) are stratabound deposits of galena, sphalerite, chalcopyrite, and pyrite hosted in dolomitic carbonate rocks (Briskey, 1986b). Host rocks are shallow-water marine carbonates, commonly with prominent facies control by reefs growing on the flanks of paleotopographic basement highs. Calcarenites are the most common host lithology. Deposits are considered to have a low-temperature replacement origin.

The median size of a Mississippi Valley Pb-Zn deposit of this type is 35 million metric tonnes of ore with 4% Zn, 0.87% Pb, and 0.48 g Ag/tonne (Mosier and Briskey, 1986).

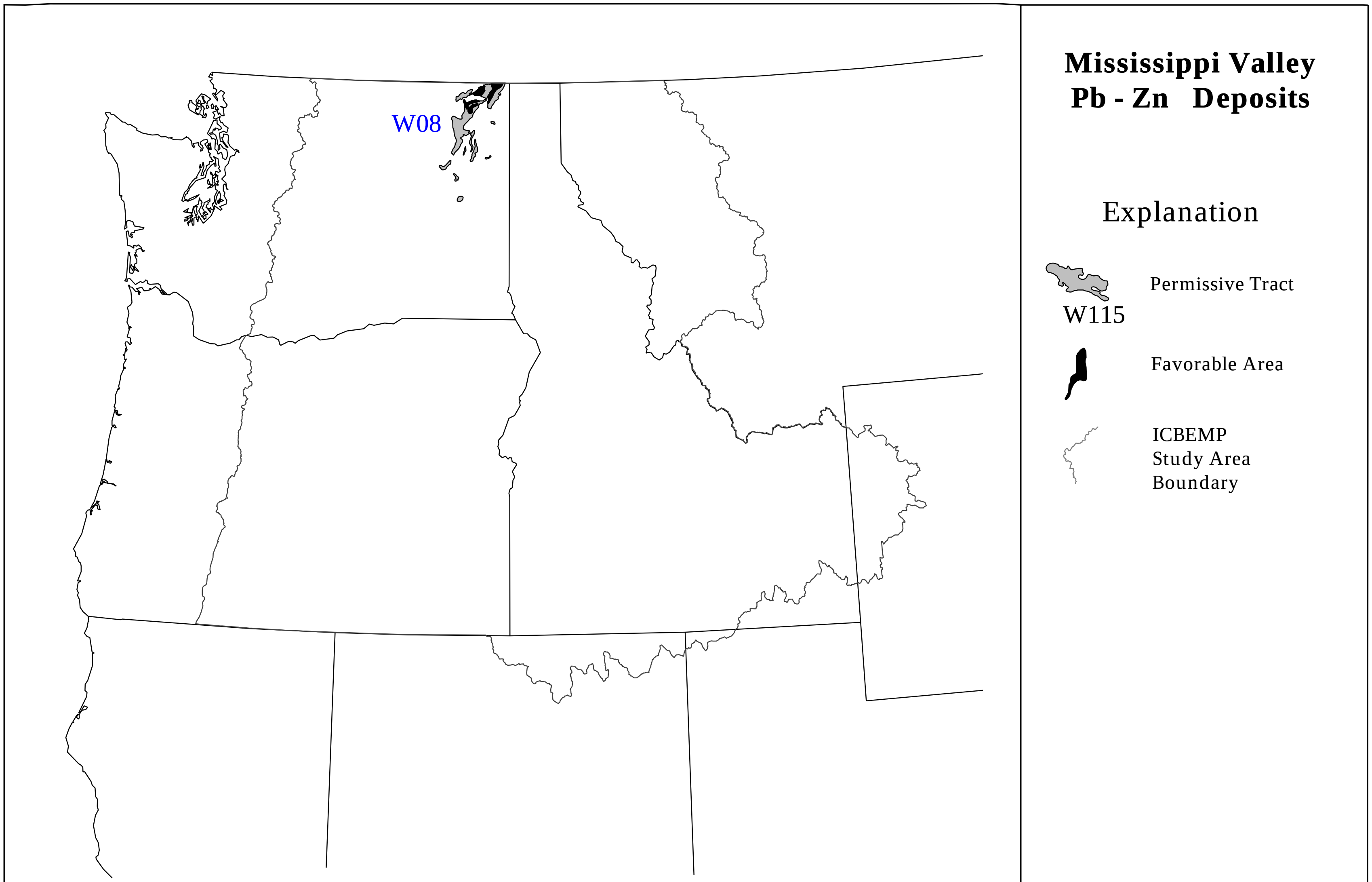


Figure 15a: Permissive and favorable tracts for Mississippi Valley Pb-Zn deposits.

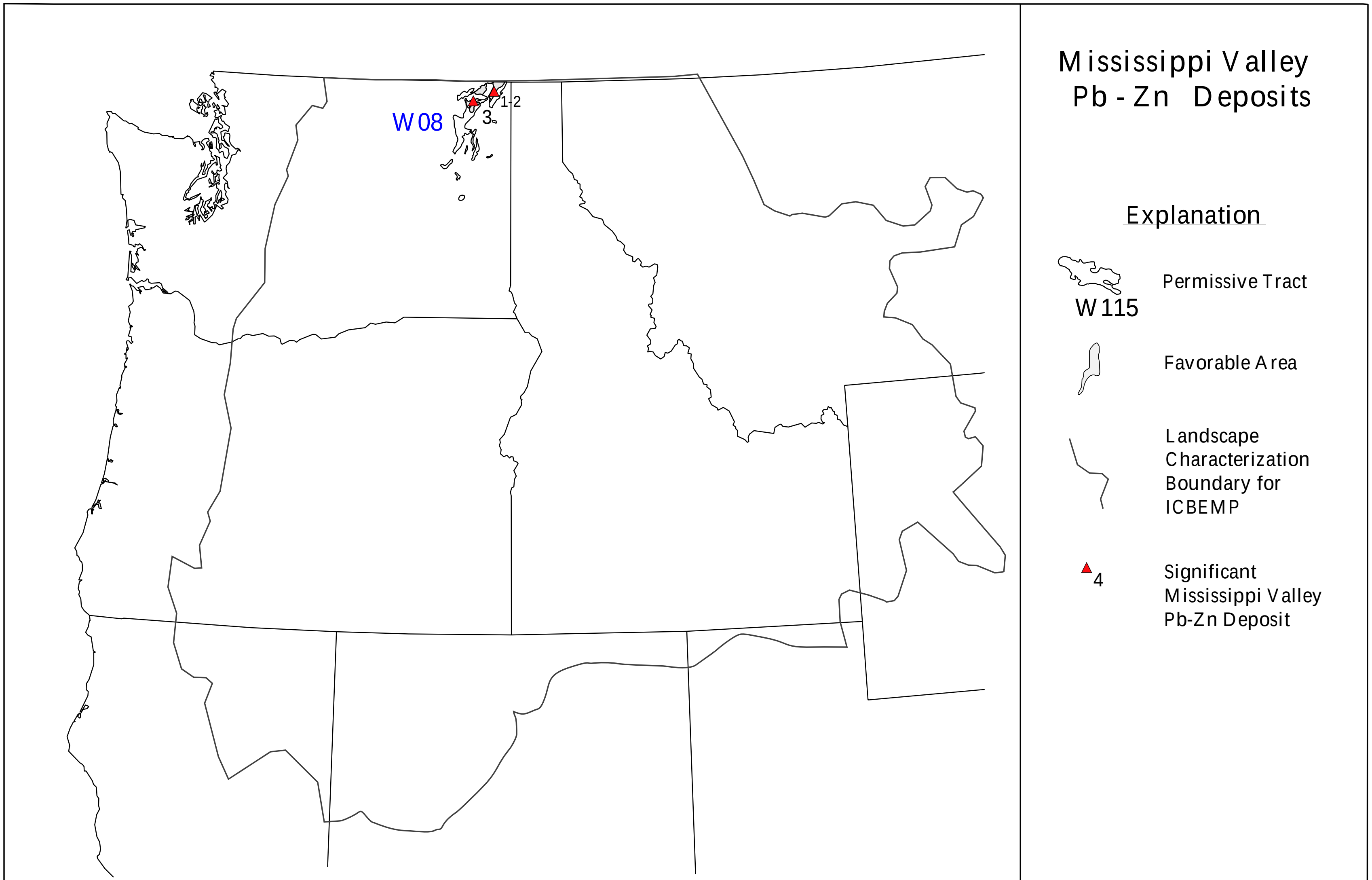


Figure 15b: Location of significant Mississippi Valley Pb-Zn deposits in the map area.

Table 15: Significant Mississippi Valley Zn-Pb deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W08	Yellowhead	Metaline	Pend Oreille	WA	48.883	-117.371	F M
02	W08	Pend Oreille	Metaline	Pend Oreille	WA	48.882	-117.360	F M
03	W08	Van Stone	Bossburg	Stevens	WA	48.761	-117.757	S

Table 15: Significant Mississippi Valley Zn-Pb deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Pb production (tonnes)	Zn production (tonnes)	Pb resource (tonnes)	Zn resource (tonnes)
01	W08	Yellowhead	207	1,067	59,466	341,149
02	W08	Pend Oreille	165,109	381,020	635	8,382
03	W08	Van Stone	6,018	58,786	21,773	94,348

Tract Descriptions

W08 Mississippi Valley Pb-Zn Deposits — Washington

Descriptive Model 32a

• 0.8 mean undiscovered deposits

By Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The team used a simple approach, considering all carbonate shelf sedimentary sequences in the map area as permissive for Mississippi Valley Pb-Zn (MVT) deposits (figure 15a). Rocks in the permissive tract are part of the Paleozoic craton-margin shelf in northeastern Washington. Permissive lithologic units include the Cambrian and Ordovician stratigraphic units in northeastern Washington (Stoffel and others, 1991). Favorable areas are based on the distribution of prospects of this type and of exploration activity, and on the density of mining claims, as shown on an unpublished plot by the US Bureau of Mines.

Examples of Deposit Type

Two districts of significant production from this deposit type are known in northeastern Washington (Table 15): Metaline and Van Stone (deposits #1-3 , figure 15b: Mills, 1976, 1977). In Canada, along strike, other districts include Robb Lake and Monarch-Kicking Horse. An alternative interpretation is that they are sediment-hosted, syndepositional exhalative deposits similar to the Irish carbonate-hosted deposits (Morton, 1992). However, the ages of the deposits in the Washington and British Columbia indicates mineralization occurred well after deposition of the host rocks, which supports the MVT deposit model. Pb isotopic data from galena of the Metaline-area deposits indicate mineral deposition well after sedimentation (Devonian mineralization in Cambro-Ordovician sedimentary rocks; S.E. Church, U.S. Geological Survey, personal communication, 1993). Deposits along strike to the north in Canada have yielded Devonian mineralization ages.

Rationale for Numerical Estimate

The grade and tonnage models for MVT deposits are for districts, as opposed to individual deposits. The grade and tonnage of the two known districts in Washington are on the low side of the median, as are the two Canadian deposits along strike, Robb Lake and Monarch-Kicking Horse. It was decided to use a revised tonnage model for Cordilleran MVT deposits that consists only of the smaller half of the deposits in the worldwide model. There seemed to be room for one or two more districts in the favorable area west of Metaline and north of Van Stone. Two clusters of Pb-Zn prospects in that area were deemed to indicate potential for undiscovered districts. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 1, 1, 2, and 2 or more Mississippi Valley Type Pb-Zn deposits consistent with the modified grade and tonnage model of Mosier and Briskey (1986).

Overlook-type Au deposits

General Deposit Description

Overlook-type gold deposits refer to a deposit type presently known only in northeastern Washington. The origin of these deposits is controversial. The following incomplete description of this deposit type is based on characteristics of the several known examples.

Overlook-type gold deposits are associated with stratiform bodies of massive magnetite. Typically the magnetite bodies are in sharp contact with limestone on one side, and in fault contact with siltite-argillite on the other side. The deposits contain two types of ore: massive and veinlet. The massive ore consists of silicified, gold-bearing magnetite + pyrrhotite + pyrite + hematite. The veinlet ore consists of gold-bearing quartz-pyrite-chalcopyrite veinlets and disseminated sulfides, in silicified argillite-siltite (Tschauder, 1989; Carden and others, 1992; Derkey, 1993; Rasmussen, 1993; Carden, 1995). The massive and veinlet ores commonly are in fault contact, and much of the massive ore is brecciated. Contacts of massive ore with unmineralized limestone are sharp and cuspate, and the limestone appears unaltered. Quartz-veined argillite-siltite is silicified, sericitized, and bleached. Gold grade is about 5 g Au/tonne in both ore types, and at Lame Foot the gold resource is about evenly divided between the two ore types. In both types of ore, gold is closely associated with sulfides, quartz veinlets, and pervasively silicified host rocks (silicified massive ore, brecciated and silicified massive ore, and silicified argillite-siltite). The median deposit size (of the three deposits in Table 16) is 2.7 million metric tonnes with 4.8 g Au/tonne.

The origin of these deposits is controversial. In one model, massive magnetite-pyrrhotite-pyrite deposits are interpreted as epigenetic replacement deposits, hosted in limestone; and quartz-sulfide veinlets are interpreted as hydrothermal fracture fillings, hosted in argillite-siltite (Tschauder, 1989). In the other model, the massive magnetite-pyrrhotite-pyrite bodies are interpreted as sea-floor volcanogenic massive oxide-sulfide deposits, similar to Australian deposits described by Davidson (1992), and the quartz-sulfide veinlets are interpreted as epigenetic veinlets, superimposed during a later hydrothermal event (Rasmussen, 1993).

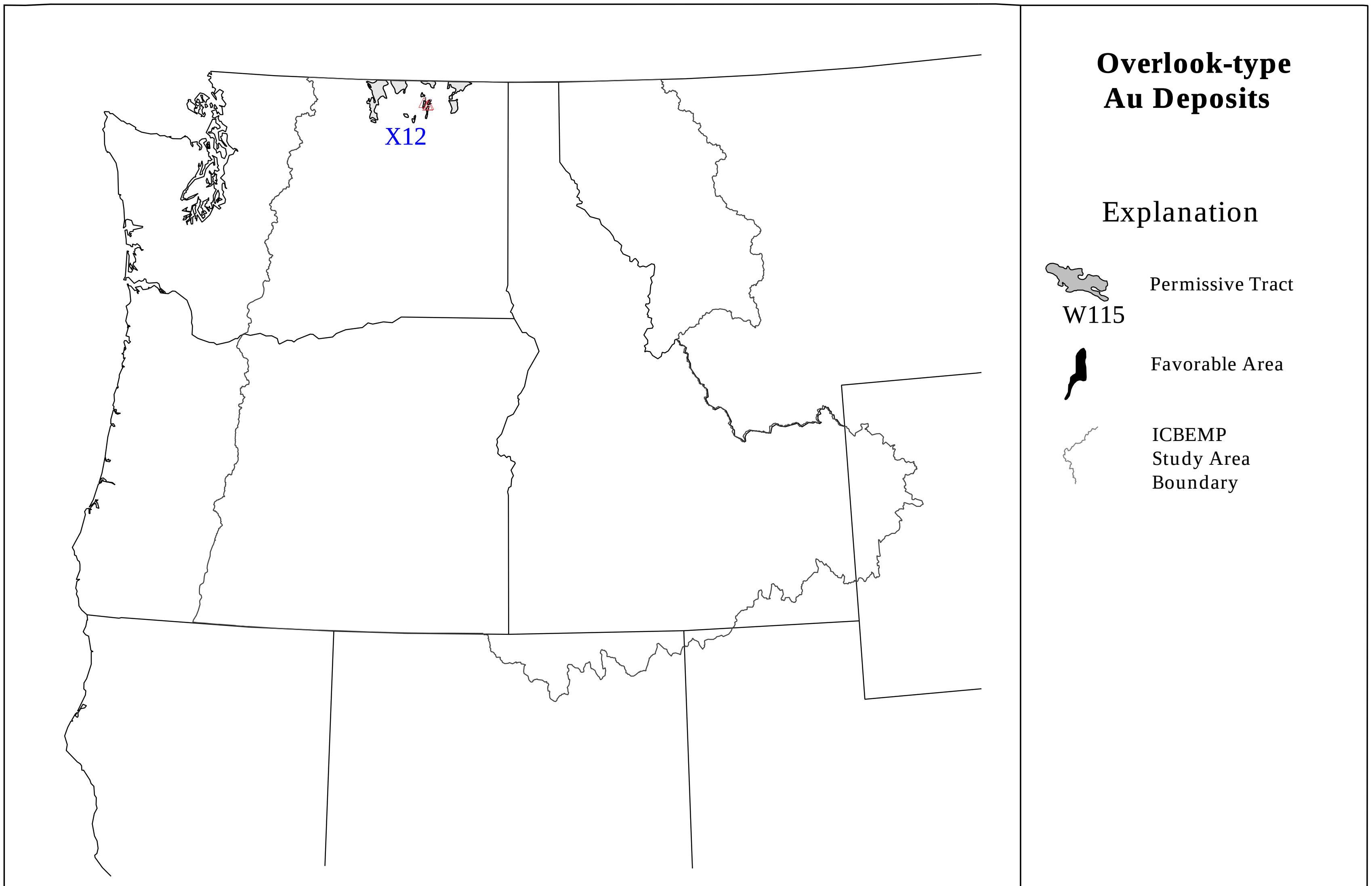


Figure 16a: Permissive and favorable tracts for Overlook- type Au deposits.

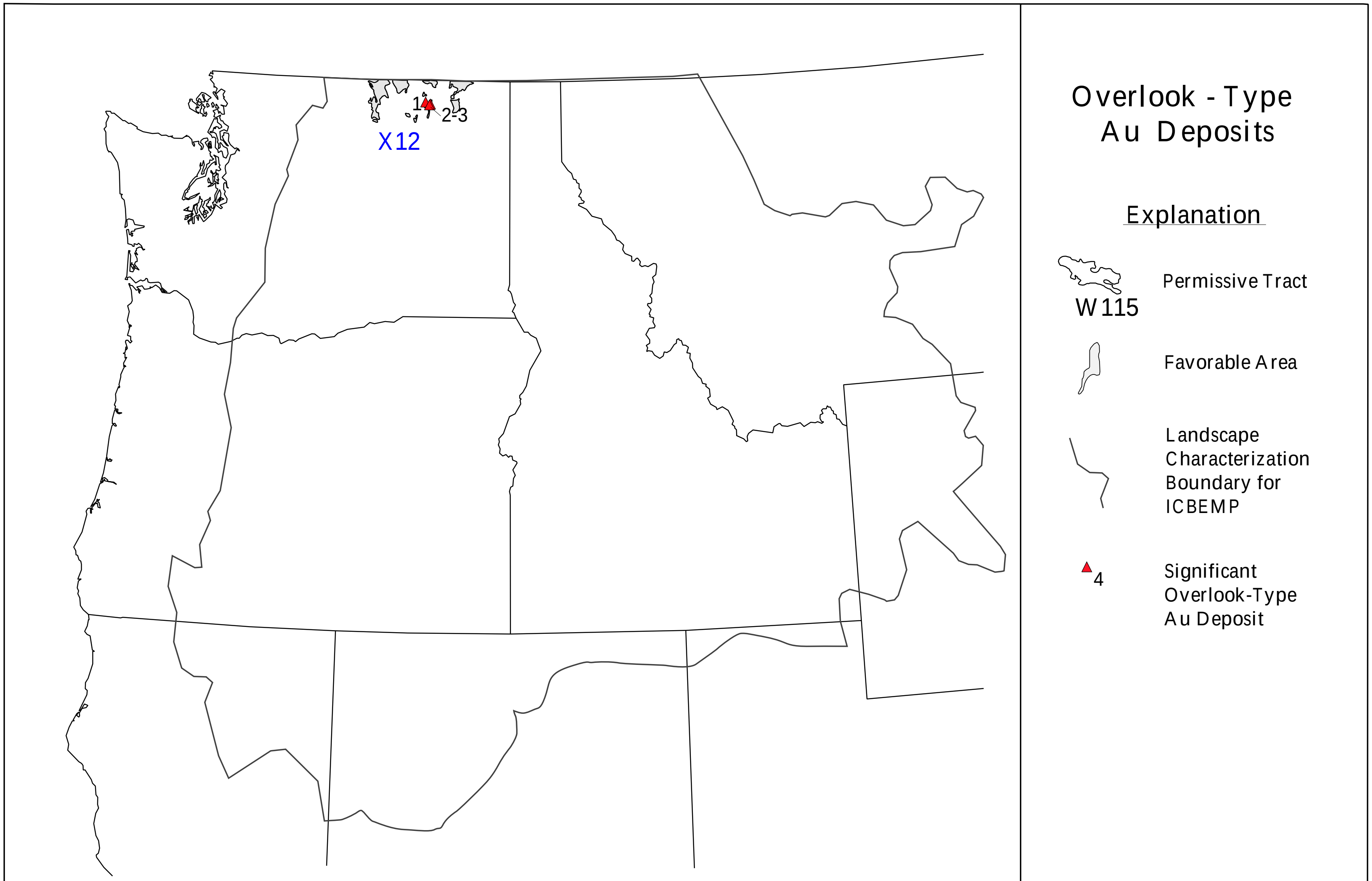


Figure 16b: Location of significant Overlook- type Au deposits in the map area.

Table 16: Significant Overlook-type Au deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status		Au production (tonnes)		Au resource (tonnes)
01	X12	Lamefoot	Republic	Ferry	WA	48.734	-118.646	P		significant		15
02	X12	Key East - Key West	Republic	Ferry	WA	48.710	-118.551	P		4.00		unknown
03	X12	Overlook zone	Republic	Ferry	WA	48.699	-118.569	P		23.00		unknown

Tract Description

X12 — **Overlook-type Au deposits** — **Washington**

No published descriptive model
No estimate of undiscovered deposits

by S.E. Box and A.A. Bookstrom

Rationale for Tract Delineation

As all four known deposits of this type are hosted in limestone and siliciclastic turbidites of the Quesnellia terrane of northeastern Washington (Stoffel and others, 1991), we restricted the permissive tract to that terrane. In the known deposits, limestone makes up a important host component of these deposits, yet the widespread occurrence of small limestone bodies and the great structural complexity within the Quesnellia terrane do not allow us to use this correlation to restrict the permissive tract further. This uncertainty as to the distribution of necessary lithologies, and , indeed, the uncertainties in the nature of the geologic controls of this type of mineralization led us to consider the whole permissive tract as favorable for this deposit type.

Important Examples of Deposit Type

Three deposits of this type (#1-3, figure 16b) are hosted in the accreted Quesnellia island arc terrane, all within a relatively small area near to town of Republic in northeastern Washington. Gold grade is about 5 g Au/tonne in both ore types, and deposit size ranges from one to four million metric tonnes. At Lame Foot the gold resource is about evenly divided between the massive and veinlet ore types.

Rationale for Lack of Numerical Estimate

Descriptive and grade-tonnage models have not been compiled for Overlook-type gold deposits. Therefore, no estimates were made for undiscovered mineral resources of this type.

Polymetallic Au-Ag, vein and disseminated

General Deposit Description

Polymetallic quartz veins containing gold and silver, as well as lesser values of base metals, are widely distributed within and around the Idaho batholith in Idaho and southwest Montana and throughout the Blue Mountains of northeastern Oregon. As compared to low-sulfide gold-quartz veins, these polymetallic veins contain a wider variety of ore minerals and(or) have higher contents of silver (Berger, 1986d; Bliss, 1994a, 1994b). Where these veins occur in clusters and(or) have disseminated ore minerals in their wall rocks, they can be considered as large-tonnage, low-grade deposits with a distinctly different grade/tonnage distribution than that for individual vein deposits. Many significant placer gold deposits of the region were derived from such veins and vein clusters.

Polymetallic quartz vein deposits in the Blue Mountains are "predominantly narrow, quartz-rich fissure veins, breccia fillings, and associated replacement bodies along faults and shear zones" in argillite and granodiorite (Brooks and Ramp, 1968, p. 51). Quartz, pyrite, sphalerite, galena, chalcopyrite, tetrahedrite, and arsenopyrite are common in these veins. Pyrargyrite, proustite, stephanite, stibnite, cinnabar, petzite, and hessite are sparse to rare. Vein textures indicate mineral deposition by replacement and open-space filling. Veins are most abundant near contacts of Jurassic-Cretaceous plutons. Mineral assemblages of some vein sets are zoned with respect to the margins of such plutons (Hewett, 1931). Free gold is more common in oxidized parts of the veins than in reduced parts (below the water table), where much of the gold is contained in other ore minerals. The median size of this deposit type in the Blue Mountains is 76,000 metric tonnes with 18 g Au/tonne and 12 g Ag/tonne (Bliss, 1994a)

In and around the Idaho batholith, most polymetallic Au-Ag veins occupy steeply dipping faults and fissures, and many of them are localized within or near roof pendants or inclusions of metasedimentary rocks in the Idaho batholith. These veins generally are quartz-rich, and commonly contain less than 5 percent of a wide variety of fine-grained ore minerals. Arsenopyrite, pyrite, galena, sphalerite, chalcopyrite, tetrahedrite, and stibnite are common. Bournonite, proustite, argentite, and electrum are sparse. Heubnerite, scheelite, hessite, cinnabar, and zinc-mercury sulfides are rare, but are characteristic of some veins. These veins commonly show evidence of multiple episodes of fracturing and healing by multiple generations of quartz, with various assemblages of ore minerals (Kiilsgaard and Bennett, 1987; Gammons, 1988; Kiilsgaard and Bacon, in press). The composition of an individual vein depends on its particular history of fracturing and healing during multiple pulses of mineralization in hydrothermal systems that changed with time. Wall rocks of some veins are pervasively silicified and sericitized, and contain disseminated ore minerals. Wall rocks of other veins are relatively unaltered. Free gold is more common in weathered and oxidized parts of the veins, than in reduced parts (below the water table), where much of the gold is contained in other ore minerals. The median size of this deposit type in Idaho is 14,000 metric tonnes with 13 g Au/tonne and from 0 to 55 g Ag/tonne (Bliss, 1994b).

Disseminated polymetallic gold-silver deposits are like polymetallic veins of the gold-silver subset, but they are large-tonnage, low-grade deposits that can be mined in-bulk for gold and silver. These deposits consist of multiple sets of veins, mineralized breccias, and stockworks of veinlets, in silicified and sericitized host rocks that contain disseminated ore minerals. They occur along broad fault zones that show evidences of repeated breakage, movement, and hydrothermal mineralization. Multiple generations of quartz, with different combinations of ore minerals, indicate complicated histories of recurrent fracturing and mineralization within long-lived hydrothermal systems that changed from mesothermal to epithermal over time (Cookro and others, 1988; Bartels and others, 1990; Kiilsgaard and Bacon, in press). The known deposits of this disseminated type are located in and around the Idaho batholith. No similar disseminated deposits are known around the Blue Mountain vein systems in northeastern Oregon (Roger Ashley, USGS, oral communication, 1995). For the Idaho disseminated deposits, the median tonnage is 6.1 million metric tonnes with 1.75 g Au/tonne and from 0 to 14 g Ag/tonne (median of the 12 Idaho deposits listed in Table 17).

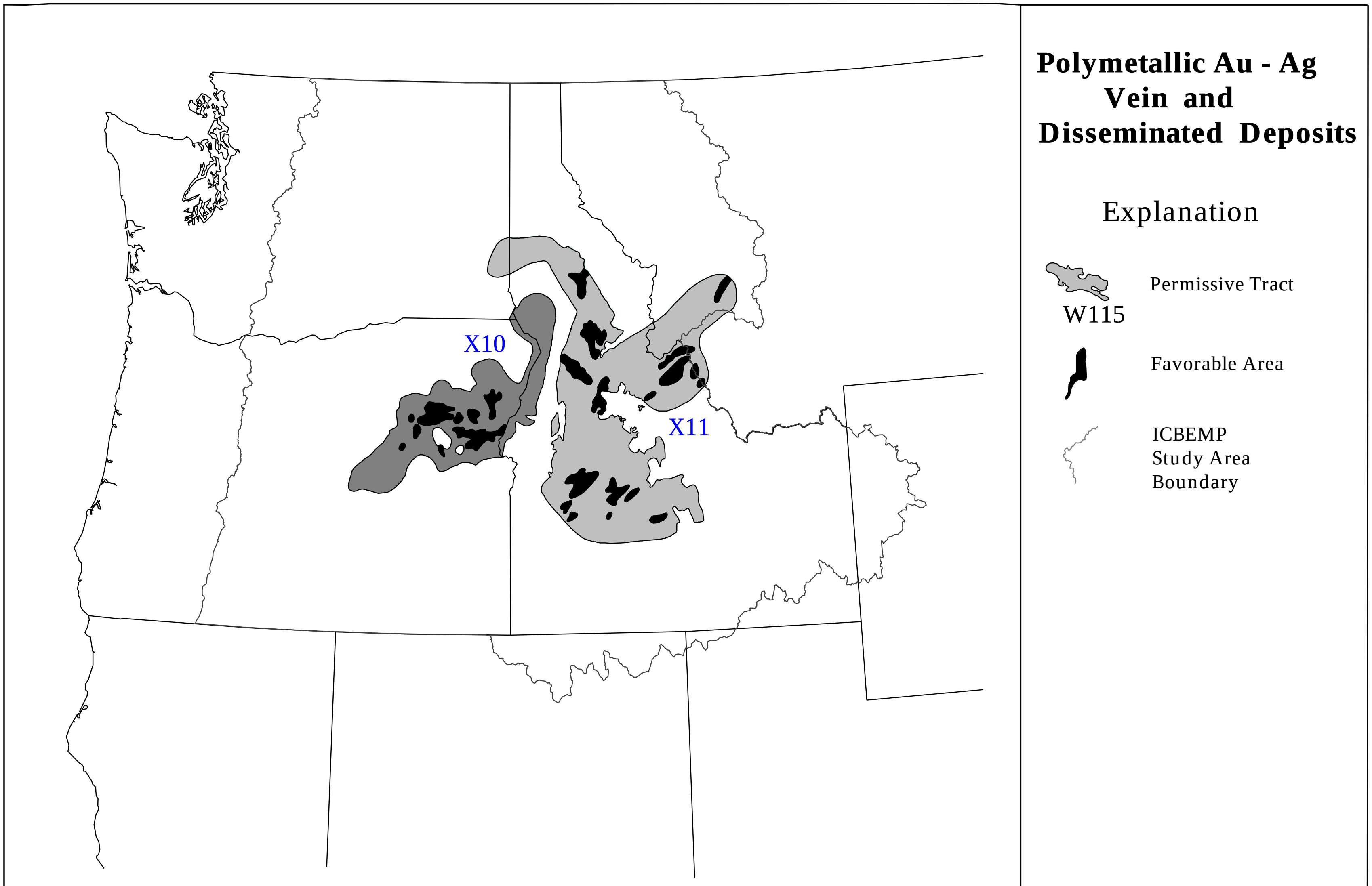
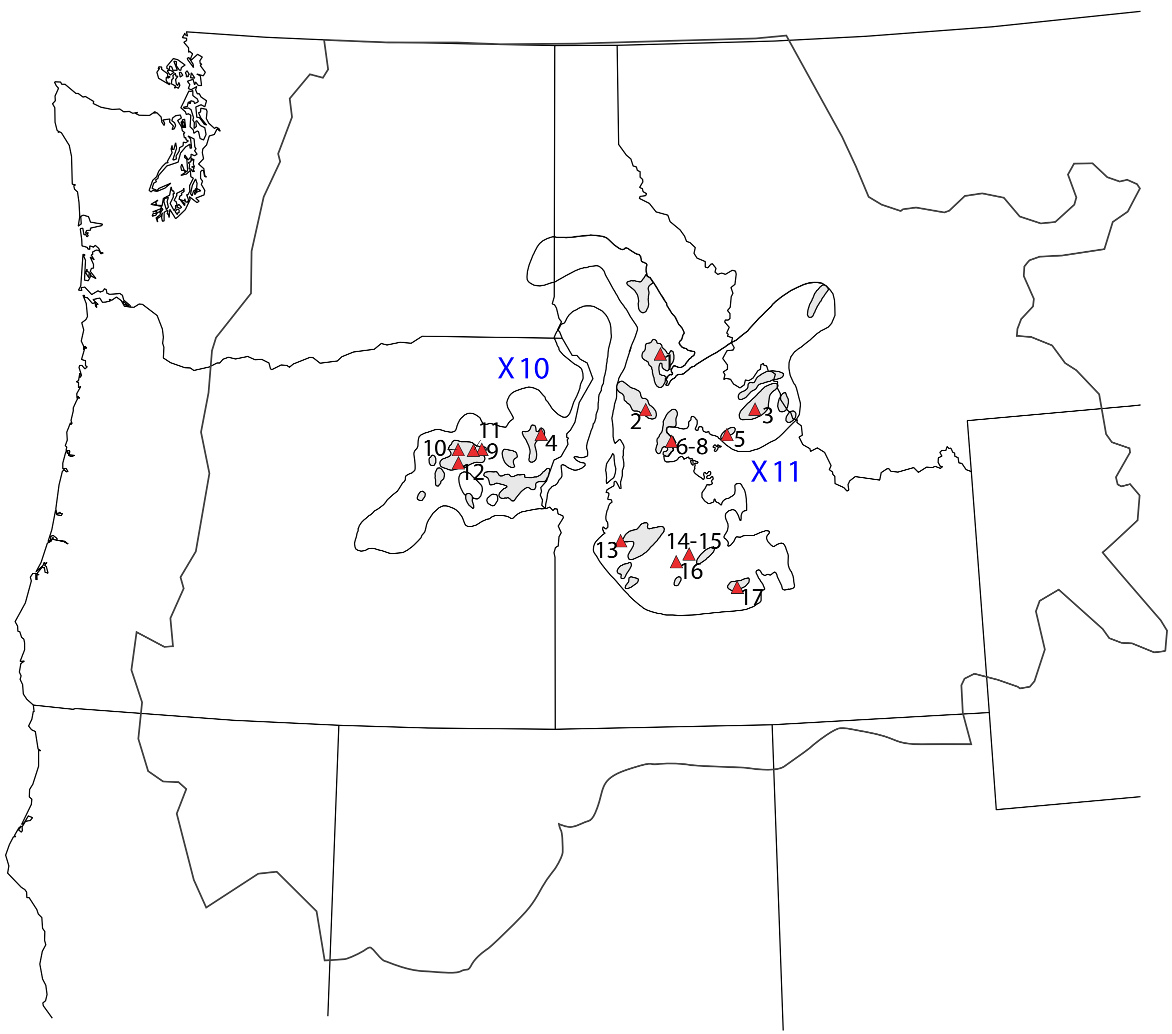


Figure 17a: Permissive and favorable tracts for Polymetallic Au-Ag vein and disseminated deposits.



Polymetallic Au - Ag Vein and Disseminated Deposits

Explanation

W115 Permissive Tract

Favorable Area

Landscape Characterization Boundary for ICBEMP

4 Significant Polymetallic Au-Ag Vein and Disseminated Deposit

Figure 17b: Location of significant Polymetallic Au-Ag vein and disseminated deposits in the map area.

Table 17: Significant polymetallic Au-Ag vein and disseminated deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	X11		Elk City	Idaho	ID	45.825	-115.471	F M
02	X11		Warren	Idaho	ID	45.258	-115.700	I M
03	X11	Beartrack	Mackinaw	Lemhi	ID	45.233	-114.113	P
04	X10		Cornucopia	Baker	OR	45.010	-117.217	I M
05	X13	Yellow Jacket	Yellow Jacket	Lemhi	ID	44.9819	-114.5272	I M
06	X11	Homestake	Stibnite	Valley	ID	44.950	-115.320	I M x r
07	X11	West End	Stibnite	Valley	ID	44.947	-115.308	P
08	X11	Yellow Pine	Stibnite	Valley	ID	44.927	-115.332	S
09	X10		Rock Creek	Baker	OR	44.853	-118.070	I M
10	X10		Granite	Grant	OR	44.847	-118.413	I M
11	X10		Cracker Cr.	Baker	OR	44.842	-118.195	I M
12	X10		Greenhorn	Baker/Grant	OR	44.710	-118.408	I M
13	X11		Boise Basin	Boise	ID	43.917	-116.083	I M
14	X11	Atlanta district veins	Atlanta	Elmore	ID	43.771	-115.118	F M
15	X11	Atlanta district disseminated	Atlanta	Elmore	ID	43.771	-115.118	F M
16	X11		Rocky Bar	Elmore	ID	43.694	-115.299	I M
17	X11	Hailey gold belt	Camas	Blaine	ID	43.417	-114.450	I M

Table 17: Significant polymetallic Au-Ag vein and disseminated deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name		Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)		Au resource (tonnes)	Ag resource (tonnes)
01	X11			4.44	unk	neg		neg		7.2	unk
02	X11			2.92	1.8	neg		neg		unk	unk
03	X11	Beartrack		neg	neg	none		no		63	unk
04	X10			13.00	62	90,200		neg		unk	unk
05	X13	Yellow Jacket		neg	neg	2	3.47	neg		1.9	unk
06	X11	Homestake		2.39	0.52	neg		neg		neg	neg
07	X11	West End		2.20	0.80	neg		neg		4.9	unk
08	X11	Yellow Pine		9.62	51	21		7.7		13	unk
09	X10			2.26	19	neg		neg		unk	unk
10	X10			3.31	47	neg		neg		unk	unk
11	X10			20.22	12	neg		neg		2.9	unk
12	X10			4.78	4.0	neg		neg		unk	unk
13	X11			20.82	sig	neg		neg		unk	unk
14	X11	Atlanta district veins		9.20	81	neg		neg		8.5	unk
15	X11	Atlanta district disseminated		neg	neg	neg		neg		28	76
16	X11			8.40	unk	neg		neg		unk	unk
17	X11	Hailey gold belt		4.01	36	neg		neg		unk	unk

X10 — Polymetallic Au-Ag, vein and disseminated

Oregon
Idaho

No published descriptive model
No estimate of undiscovered deposits

by A. A. Bookstrom and S. E. Box

Rationale for Tract Delineation

Polymetallic Au-Ag veins in northeastern Oregon, and their associated placer gold accumulations, were significant producers of precious metals before the middle part of this century. These veins are hosted in a structurally complex assemblage of low-grade metamorphosed andesitic and basaltic volcanic rocks, marine clastic and pelagic sedimentary rocks, dismembered ophiolitic sequences, and cross-cutting granitic rocks (Brooks and Ramp, 1968; Walker and MacLeod, 1991). The host rocks constitute the Wallowa, Baker, and Olds Ferry terranes of northeastern Oregon and adjacent west-central Idaho and southeasternmost Washington (Brooks and Vallier, 1978). Most deposits appear to be areally associated with large or small bodies of Jurassic and Cretaceous granitic rocks (Brooks and Ramp, 1968). The permissive tract was outlined to encompass the area where these terranes and their Mesozoic intrusive rocks occur within a kilometer of the surface. Favorable areas are based on the distribution of known deposits and prospects, on the structural trends of the deposits and prospects, on the density and distribution of lode mining claims around these occurrences, and the distribution of placer Au (deposits, occurrences, and claims) throughout the permissive tract.

Important Examples of Deposit Type

Cracker Creek, Cornucopia, Greenhorn, Granite, and Rock Creek mining districts each contain significant polymetallic Au-Ag vein deposits (#4 and #9-12, fig. 17b). A new grade-tonnage model for Blue Mountain-type Au-Ag polymetallic veins has been completed recently by Bliss (1994a). According to that model, the geometric mean deposit size is 76,000 tonnes, and most of the known deposits have gold grades between 13 and 23 g Au/tonne, and between 2 and 300 g Ag/tonne. The median size of the area with mines is 95 hectares (Bliss, 1994a, p 2). No associated disseminated deposits have been identified in the Blue Mountains.

Rationale for Lack of Numerical Estimate

No estimate was made for undiscovered Au-Ag polymetallic veins nor for potentially associated Au-Ag polymetallic disseminated deposits. At present no grade-tonnage model exists for the latter deposit type, so a meaningful estimate could not be made. A model for Au-Ag polymetallic veins of the Blue Mountains does exist (Bliss, 1994a), but its definition of "undiscovered" deposits makes their numerical estimation difficult. In the model of Bliss (1994a), all mines within 1.6 km (1 mi) or less of each other were considered to represent one deposit. Therefore, if previously unknown vein ore lies less than 1.6 km from a known deposit, it is considered an *extension* of the known deposit, not an *undiscovered* deposit. Veins of this type generally occur in groups, and tract X10 has been well explored for such veins. We suggest that although there is potential for extensions of known deposits in tract X10, there is little potential for undiscovered vein deposits of this type, except in areas of continuous post-ore cover. The regional scope, small map scales, and time limitations of this study do not allow us to undertake the detailed studies needed to allow well-founded numerical estimates of undiscovered resources of this type to be made.

by A. A. Bookstrom and S. E. Box

Rationale for Tract Delineation

In Idaho, host rocks for the known deposits are granitic rocks of the Idaho batholith, and roof pendants or inclusions of metasedimentary rocks within the Idaho batholith, and metamorphic rocks around the Idaho batholith (figure 17a). The permissive tract was drawn to include intrusive rocks of the Idaho batholith and its metamorphosed and(or) hydrothermally altered host rocks (Bond, 1978). In addition the permissive tract extends eastward into Montana to include the Boulder batholith and other petrographically similar plutons and their metamorphosed and(or) altered host rocks (Ross and others, 1955). Favorable areas are based on the distribution of known deposits and prospects, on the structural trends of the deposits and prospects, on the density and distribution of lode mining claims around these occurrences, and the distribution of placer Au (deposits, occurrences, and claims) throughout the permissive tract.

Important Examples of Deposit Type

Polymetallic veins of the Atlanta district (#14, figure 17b) have significant known production and reserves of silver and gold; veins of the Hailey gold belt (#17, figure 17b), and of the Rocky Bar, Elk City, and Warren districts (#16, #1, and #2, figure 17b) have produced significant amounts of gold. Bliss (1994b) has recently compiled tonnage-grade models for mixed base- and precious-metal veins of the Idaho batholith, but disseminated deposits were not modeled. For the veins, six different components of mineralization were modeled, as follows: 1) gold veins with byproduct silver, copper, and lead + zinc; 2) silver veins with byproduct gold, copper, and lead + and(or) zinc; 3) Ag-Pb veins with byproduct copper, and gold + zinc; 4) copper veins with byproduct gold, and silver + zinc; 5) copper-lead-zinc veins with byproduct gold + primary silver; and 6) simple antimony deposits with byproduct gold + silver. Deposits may contain one to three components, but most contain only one component, and most are gold veins. Geometric mean deposit size for the polymetallic veins is 13,000 tonnes. Geometric mean gold grade in gold veins is 13 g Au / tonne; in other components, gold grade is commonly less than 10 g Au / tonne. Silver grades vary from 1 to 10,000 g Ag / tonne. The median size of the area with mines is 2.9 square km (Bliss, 1994b).

Significant known polymetallic disseminated gold-silver deposits (Table 17) are: 1) the Homestake, West End, and Yellow Pine deposits in the Stibnite district (#6-8 on figure 17b: Cookro and others, 1988); bulk-tonnage deposits in the Atlanta district (#15 on figure 17b: Kiilsgaard and Bacon, in press); the Beartrack deposit in the Mackinaw district ((#3 on figure 17b: Bartels and others, 1990); reserves of the Yellow Jacket deposit in the Yellow Jacket district (# 5 on figure 17b; Kiilsgaard and others, 1989) and bulk-tonnage deposits in the Elk City district (#1 on figure 17b). The Yellow Pine mine was a major producer of antimony and tungsten, as well as gold and silver. Arsenic and mercury are relatively widely dispersed around some deposits of this type, and may therefore be useful geochemical indicators of hidden deposits.

In the Stibnite district polymetallic vein, stockwork, and disseminated deposits lie within dilational northeast-striking fault jogs and splays along north-striking right-lateral shear zones. In the Atlanta district polymetallic gold-silver vein and disseminated deposits lie along a northeast-trending fault-vein system that is south of and en echelon to the regional, northeast-trending Trans-Challis fault zone. Large-tonnage, low-grade pyritic gold deposits of the

Mackinaw and Yellow Jacket districts lie along the Trans-Challis fault zone. For the disseminated deposits, gold grades typically are on the order of one to four g/tonne and silver grades from one to 15 g/tonne. Tonnages range from 0.5 to 33 million metric tonnes, with a median tonnage of about 8 million tonnes

Rationale for Lack of Numerical Estimate

No estimate was made for undiscovered Au-Ag polymetallic veins nor for associated Au-Ag polymetallic disseminated deposits in tract X11. At present no grade-tonnage model exists for the latter deposit type, so a meaningful estimate could not be made. A model for Au-Ag polymetallic veins of the Idaho Batholith does exist (Bliss, 1994b), but its definition of "undiscovered" deposits makes their numerical estimation difficult. In the model of Bliss (1994b), all mines within 1.6 km (1 mi) or less of each other were considered to represent one deposit. Therefore, if previously unknown vein ore lies less than 1.6 km from a known deposit, it is considered an *extension* of the known deposit, not an *undiscovered* deposit. Veins of this type generally occur in groups, and tract X11 has been well explored for such veins. We suggest that although there is potential for extensions of known deposits in tract X11, there is little potential for undiscovered vein deposits of this type, except in areas of continuous post-ore cover. The regional scope, small map scales, and time limitations of this study do not allow us to undertake the detailed studies needed to allow well-founded numerical estimates of undiscovered resources of this type to be made. We suggest that although small miners will continue to explore for high-grade extensions of known vein deposits, larger mining companies will be more interested in exploration for disseminated deposits that may be mined in bulk.

Polymetallic Replacement Deposits

General Deposit Description

Polymetallic replacement deposits are hydrothermal epigenetic deposits that consist of silver-, lead-, zinc-, and copper-bearing minerals in massive lenses, pipes, and veins. They are hosted in carbonate sedimentary rocks that are intruded by porphyritic calc-alkaline plutons (Morris, 1986). They are typically associated with, but distal from, porphyry copper mineralization. Types of alteration include dolomitization and silicification. On a district scale, the deposits are commonly zoned from a copper-rich central area, through a wide lead-silver zone, outward to a manganese- and zinc-rich fringe. Polymetallic replacement ores, also referred to as "manto-type deposits", contain galena, sphalerite, tetrahedrite, and other silver sulfosalts. Mineral zoning is common with inner zones rich in chalcopyrite or enargite and outer zones containing only sphalerite and rhodochrosite. Jasperoid is frequently found near ore bodies. Median size of these deposits is 1.8 million metric tonnes with 5.2% Pb, 3.9% Z, 0.094 % Cu, 150 g Ag/tonne, and 0.19g Au/tonne (Mosier, Morris, and Singer, 1986).

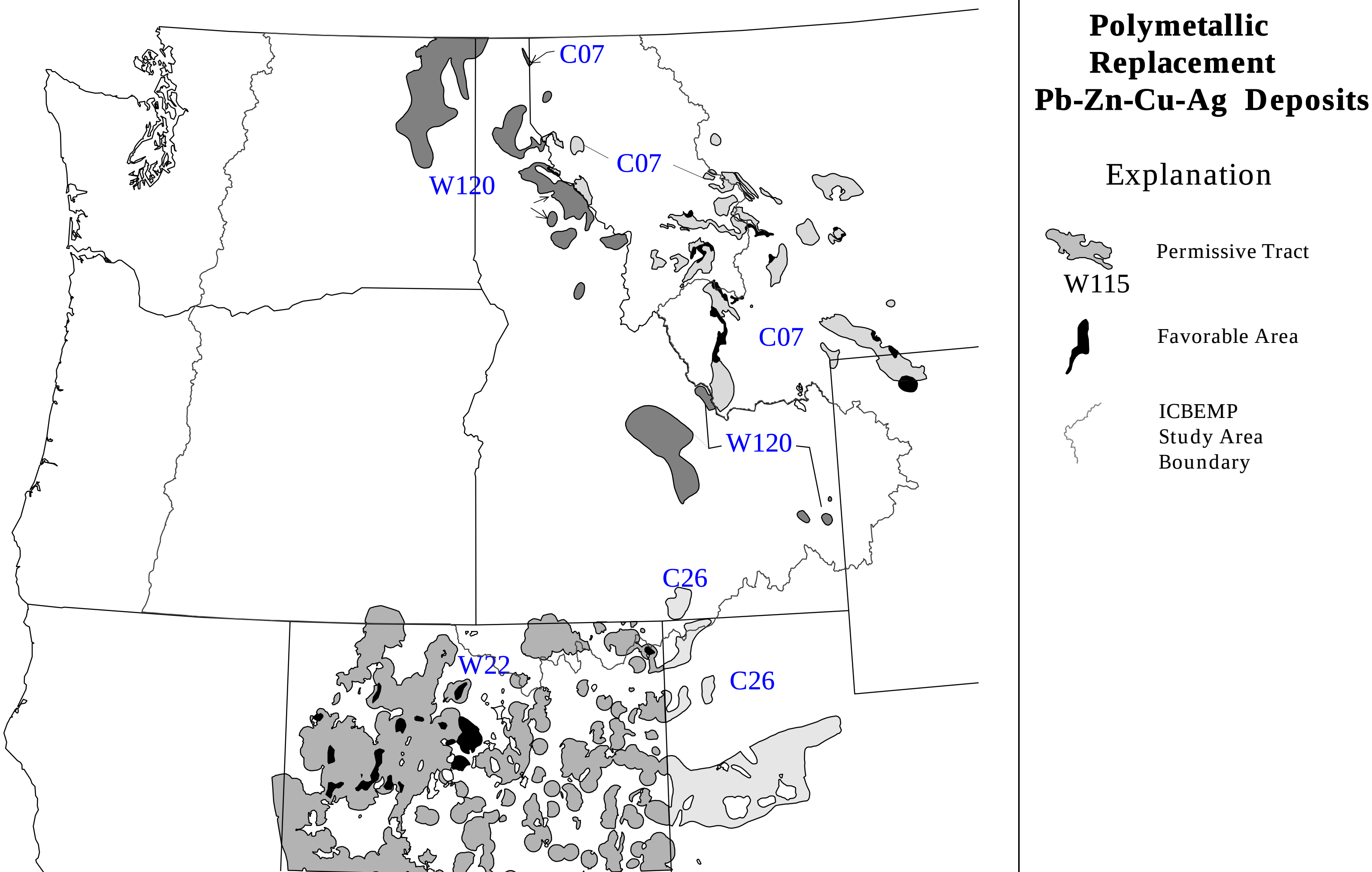
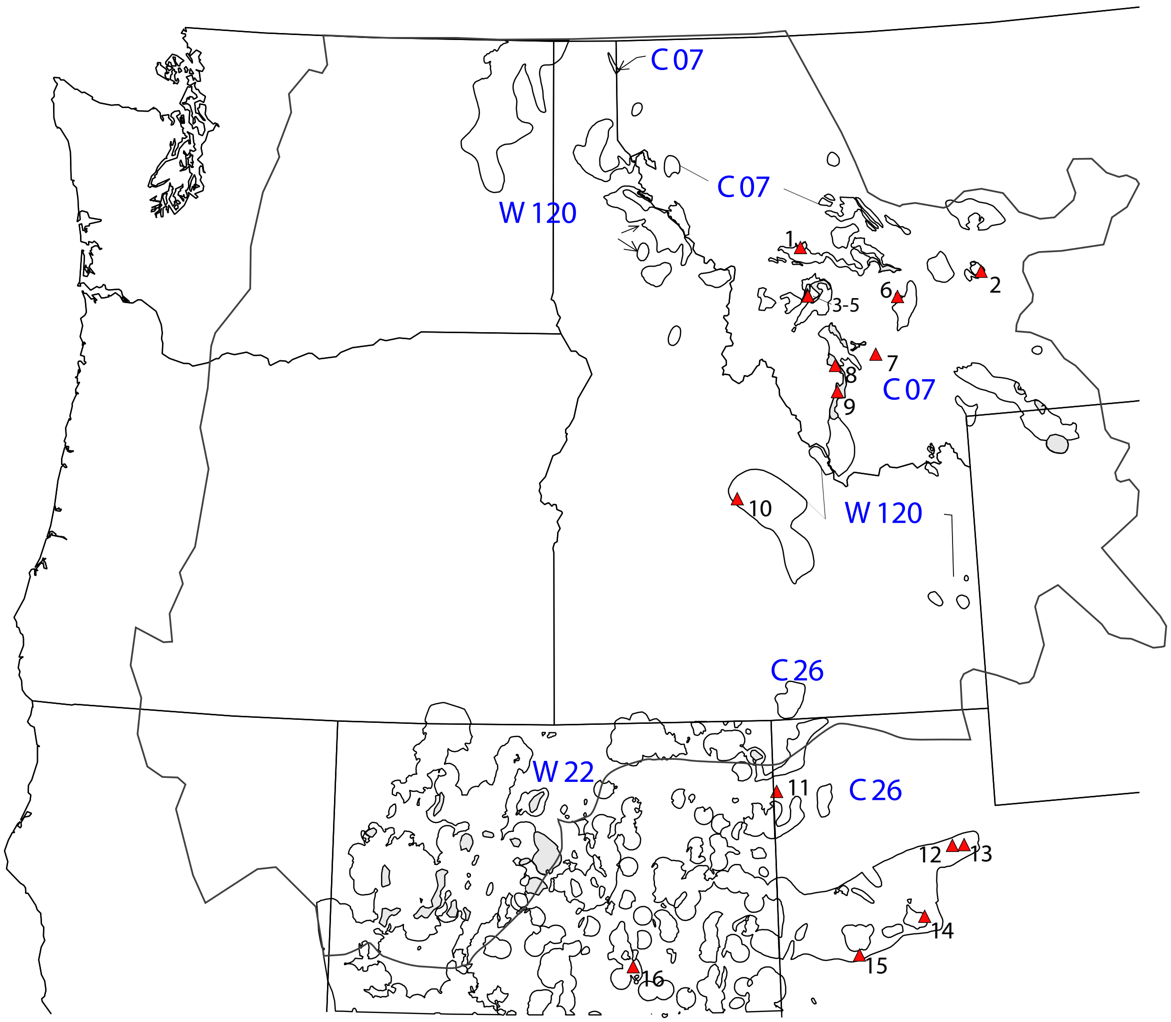


Figure 18a: Permissive and favorable tracts for Polymetallic replacement Pb-Zn-Cu-Ag deposits.



Polymetallic Replacement Pb-Zn-Cu-Ag Deposits

Explanation

Permissive Tract

Favorable Area

Landscape Characterization Boundary for ICBEMP

Significant Polymetallic Replacement Pb-Zn-Cu-Ag Deposit

Figure 18b: location of significant Polymetallic replacement Pb-Zn-Cu-Ag deposits in the map area.

Table 18: Significant polymetallic replacement deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	C07	Garnet district (Dewey mine)	Garnet (First Chance)	Granite	MT	46.827	-113.343	F M
02	C07		Castle Mountain	Meagher	MT	46.470	-110.680	I M
03	C07	Hope	Philipsburg	Granite	MT	46.344	-113.274	I M
04	C07	Scratch Awl - True Fissure	Philipsburg	Granite	MT	46.332	-113.266	I M
05	C07	Trout	Philipsburg	Granite	MT	46.329	-113.267	I M
06	C07	Elkhorn (old)	Elkhorn	Jefferson	MT	46.273	-111.942	I M
07	C07		Silver Star - Iron Rod	Madison	MT	45.696	-112.314	I M
08	C07		Hecla (Bryant) 1873-1965	Beaverhead	MT	45.605	-112.913	I M
09	C07		Argenta (Montana)	Beaverhead	MT	45.335	-112.904	I M
10	W120	Clayton Silver	Bayhorse	Custer	ID	44.283	-114.410	S
11	C26		Tecoma	Box Elder	UT	41.267	-114.000	I M
12	C26		Little & Big Cottonwood	Salt Lake	UT	40.620	-111.670	I M
13	C26		Park City	Wasatch	UT	40.620	-111.510	I M
14	C26		Tintic	Utah-Juab	UT	39.910	-112.100	I M e
15	C26	Detroit	Detroit	Juab	UT	39.550	-112.990	I M
16	W22		Eureka	Eureka	NV	39.500	-115.980	F M x

Table 18: Significant polymetallic replacement deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No		Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)		Au resource (tonnes)	Ag resource (tonnes)	Pb resource (tonnes)	Zn resource (tonnes)
01		1.87	3.7	138	none	none		unk	unk	unk	unk
02			67		12,670	66					
03			124	1,361	181						
04			187	680	6,804	24,948					
05			156		2,268	6,804					
06		0.62	460		6,353						
07		3.61	3.6	37	157						
08		0.57	416	3,752	51,022	1,738					
09		2.70	21	329	9,901	1,094					
10		neg	206	641	37,871	12,485		neg	unk	unk	unk
11		1.91	93								
12		0.75	409	4,469	81,912	145					
13		45.10	7,879	58,488	1,228,118	674,757					
14		86.10	8,459	115,193	1,034,013	204,081					
15		3.73		76							
16		4.60	98	943	27,478	6,474		16	553	115,903	259,998

Tract Descriptions

C07 | **Polymetallic Replacement Deposits** | **Montana Wyoming**

Descriptive Model 19a

• 3.9 mean undiscovered deposits (entire tract)

• 1.2 mean undiscovered deposits (ICBEMP portion of tract)

by James E. Elliott

Rationale for Tract Delineation

Permissive tract C07 for polymetallic replacement deposits is made up of areas in northwestern, southwestern, and south-central Montana and northwestern Wyoming. It consists of those parts of the porphyry copper permissive tract that have sedimentary carbonate rocks at the surface or at shallow depths (less than 1 km) below the surface, based on geologic maps of Montana (Ross and others, 1955) and Wyoming (Love and Christiansen, 1985). The more favorable parts of these areas are where sedimentary carbonate rocks are near igneous contacts, especially near margins of Late Cretaceous or Eocene granite, granodiorite, or dacite porphyry. The most favorable sedimentary carbonate rocks are Paleozoic, and include the Meagher and Pilgrim Formations of Cambrian age, the Jefferson Formation of Devonian age, and the Madison Group of Mississippian age. Less favorable carbonate rocks are Mesozoic (Lower Cretaceous Kootenai Formation and Jurassic Ellis Group) and Middle Proterozoic (Belt Supergroup: Newland, Empire, Helena, and Wallace Formations). The favorable tracts are based on the occurrence of the favorable carbonate horizons and of prospects of this type, and on knowledge of exploration activity.

Important Examples of Deposit Type

There are many known polymetallic replacement deposits or districts in southwestern Montana (#1-9, figure 18b) and numerous prospects in southwestern and south-central Montana and northwestern Wyoming. These have been important producers of silver and lead and were less important for zinc, copper, and gold. The known deposits are the Elkhorn mine, Elkhorn district (#6, figure 18b: Klepper and others, 1957); the Hecla district (#8, figure 18b: Karlstrom, 1948); the Castle Mountain district (#2, figure 18b: Winters, 1968); and the Hope mine, Philipsburg district (#3, figure 18b Emmons and Calkins, 1913). The prospects occur in many districts where plutons of granitic, granodioritic, or dacitic composition are in contact with sedimentary carbonate rocks, especially those of Paleozoic age.

Ore bodies at the Elkhorn mine consisted of saddle-reefs, pipe-like bodies, and irregular masses in Cambrian limestone (Pilgrim Limestone) below the contact with a shale-limestone sequence (Red Lion Formation). The Elkhorn district is located near the margin of Boulder batholith (Late Cretaceous), and was a large producer of lead and silver and small amounts of gold.

In the Hecla district, stratiform, pipe-like, and irregular-shaped ore bodies in Cambrian limestone and dolomite (Meagher and Pilgrim Formations) were mined mainly for lead and silver. Small amounts of gold and copper were also produced. Ore zones in the Hecla district were controlled by anticlines and structural domes. The district is located near the northern margin of the Pioneer batholith, a granitic composite pluton of Late Cretaceous age.

Pipe-, pod-, and irregular-shaped ore bodies that are generally conformable to bedding were exploited in the Castle Mountain mining district. Host rocks for these deposits are limestones of Mississippian (Madison Group), Cambrian (Pilgrim Limestone), and Devonian (Jefferson Limestone) age. The district is located along the margin of a granite pluton and ore bodies are commonly localized along Tertiary dacite porphyry intrusives that are younger than the granite. The district is a large producer of lead and silver.

The Philipsburg district is famous as a large producer of silver and manganese from vein and replacement deposits. One of the principal mines of the district, the Hope mine, is a polymetallic replacement deposit with ore bodies in saddle reefs and irregular stratiform masses that parallel bedding in Devonian limestone (Jefferson Limestone). The district is located near the margins of the Late Cretaceous Philipsburg batholith (granodiorite). The Hope mine was a large producer of silver with minor production of copper, manganese, and lead.

Rationale for Numerical Estimate

For the assessment of polymetallic replacement deposits, the grade-tonnage model of Mosier, Morris, and Singer (1986) was used. This set of 52 deposits has a median size of 1.8 million metric tons and median grades of: 5.2 percent lead; 3.9 percent zinc; 0.09 percent copper; 150 g/t silver; and 0.19 g/t gold. The known deposits in Montana are mainly lead-silver deposits and thus differ from the above median grades by having higher grades of lead and silver and lower grades of zinc, copper, and gold. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 1, 4, 6, 8, and 12 or more districts consistent with the grade and tonnage model of Mosier, Morris, and Singer (1986). For that portion of the tract within the ICBEMP study area, the team estimated (for the above percentiles) 0, 1, 2, 4, and 7 or more districts consistent with the grade and tonnage model of Mosier, Morris, and Singer (1986).

C26 — Polymetallic Replacement Deposits — Utah, Idaho

Descriptive Model 19a

• 0.01 mean undiscovered deposits (ICBEMP portion of tract only)

by Douglas B. Stoeser

Rationale for Tract Delineation

Permissive tract C26 for polymetallic replacement deposits is defined primarily by the distribution of intrusive rocks and suitable reactive host rocks, especially carbonate-bearing sedimentary rocks. It is made up of three east-trending belts in western Utah. The southernmost of the three is less deeply eroded than the other two, and any undiscovered replacement deposits in the south would most likely be concealed by the volcanic cover and alluvial cover. Aeromagnetic maps were employed to define areas of buried intrusive bodies.

Important Examples of Deposit Type

Other than the Bingham Canyon porphyry copper deposit, polymetallic replacement (and associated vein deposits) comprise by far the most important type of metallic mineral deposits in Utah. Major districts are all in the north-central area of the permissive tract and are Park City (#13, figure 18b), Little and Big Cottonwood (#12, figure 18b), Bingham Canyon (Lark and U.S. mines), Tintic (#14, figure 18b) and East Tintic. Tecoma (#11, figure 18b) is also listed as a polymetallic replacement deposit, although some authors consider it to be a distal-disseminated Ag-Au deposit (Cox and Singer, 1992a). Minor deposits within the north-central area include West Tintic, Detroit, Fish Springs, and Gold Hill, and in the southern area, Preuss, Deer Trail, Bradshaw, Lucin, and Silver Island.

Many polymetallic replacement districts contained polymetallic veins as well, and production figures for some, if not most, of these districts reflects combined production from replacement and vein orebodies.

Rationale for Numerical Estimate (ICBEMP portion only)

All of the known deposits and significant prospects for this deposit type in tract C26 occur outside of the ICBEMP portion of the tract. Given the long exploration history in this area, we believe that the tract has a low potential for the occurrence of undiscovered polymetallic replacement deposits. . For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more districts (with a 99% chance of no undiscovered districts) consistent with the grade and tonnage model of Mosier, Morris, and Singer (1986).

W22 — Polymetallic Replacement Deposits

Descriptive Model 19a
• 0.1 mean undiscovered deposits (ICBEMP portion of tract only)

Nevada Oregon Idaho

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The tract permissive polymetallic replacement deposits is defined as an area extending 10 km outward from the outcrop of a pluton, or, in the case that the pluton has a geophysical expression as discussed by Grauch and others (1988), from the inferred subsurface boundary of the pluton, based on its geophysical expression. It also includes areas around plutons whose presence is inferred from geophysics or from the occurrence of skarn mineralization. The tract covers about 40 percent of the area of the state. Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in Nevada (Stewart, 1980), hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock. About 72 percent of the permissive tract is covered by 1 km or less of Upper Tertiary and Quaternary rocks and sediments. Areas covered by more than 1 km (Blakely and Jachens, 1991) are excluded as are areas that are within a Tertiary caldera. In these latter areas, permissive pre-Tertiary host rocks are likely to be covered by more than 1 km of volcanic rock.

Most major zinc-lead skarn and polymetallic replacement districts tend to be associated with plutons of Cretaceous age, but a few major districts and a large number of occurrences are known around Tertiary intrusive centers. A few occurrences are associated with Jurassic plutons in northeast and southwest Nevada. Most of the deposits and occurrences are situated in the part of Nevada underlain by Precambrian continental crust, and the host-rocks for most deposits belong to the lower Paleozoic carbonate assemblage. The first carbonate beds above or within the thick Precambrian and lower Cambrian quartzite sequences have long been known to be the most productive (Woodward, 1972; Ivosevic, 1978). Some deposits are known in upper Paleozoic rocks and a few are found in the Luning Formation of Triassic age.

Favorable tracts are based on areas delineated as "prospective" for skarns and replacement deposits in an unpublished USGS mineral resource assessment of the Winnemucca-Surprise BLM Resource Area (Stephen Peters, USGS, written comm., 1994).

Important Examples of Deposit Type

A significant cluster of polymetallic replacement deposits in this tract is Eureka (#16, figure 18b), associated with Cretaceous intrusions. The West Archimedes deposit is a recently discovered deposit that is part of the Eureka district (Dilles and others, 1995). Overall in Nevada, more than 80 percent of known deposits and occurrences are near plutons of Cretaceous or Tertiary age. The known districts in Nevada are well represented by this model.

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract W22 that lies within the ICBEMP study area (figure 18a). An estimate of the number of undiscovered polymetallic replacement deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W22 lies within two counties. To arrive at the numerical estimate of undiscovered polymetallic replacement deposits in the ICBEMP portion of tract W22, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 0.14 mean polymetallic replacement deposits for the part of the ICBEMP study that extends into tract W22 (including the minor permissive tract extensions into Oregon and Idaho). For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 1, 2, and 3 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Mosier, Morris, and Singer (1986) is equivalent to the estimated number of mean undiscovered deposits derived above.

W120 — Polymetallic Replacement Deposits

Idaho, Washington

Descriptive Model 19a

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Model Choice

These deposits are hydrothermal epigenetic deposits that consist of silver-, lead-, zinc-, and copper-bearing minerals in massive lenses, pipes, and veins in carbonate sedimentary rocks near igneous intrusions (Morris, 1986). Associated igneous rocks are commonly calc-alkaline and porphyritic. Types of alteration include dolomitization and silicification. On a district scale, the deposits are commonly zoned from a copper-rich central area, through a wide lead-silver zone, outward to a zinc- and manganese-rich fringe.

Rationale for Tract Delineation

A permissive tract for polymetallic replacement deposits in Idaho and northeastern Washington is based on the widespread occurrence of Jurassic, Cretaceous, and Tertiary calc-alkaline plutonic rocks and of carbonate-bearing sedimentary sequences. The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract. Host sedimentary packages include Paleozoic rocks in northeastern Washington, the Wallace Formation of the Proterozoic Belt Group in northern Idaho, and Paleozoic rocks in south-central Idaho (Stoffel and others, 1991; Bond, 1978).

Important Examples of Deposit Type

The Clayton Silver deposit in south-central Idaho (#10, figure 18b) is considered to be a polymetallic replacement deposit (Ross, 1937). The deposit occurs as an elongate cigar-shaped stratabound replacement of a carbonate member of the Cambrian Kinnikinnik Quartzite. The mine produced significant silver, lead, and zinc.

Rationale for Numerical Estimate

The low estimate for porphyry copper for this tract, the rarity of known prospects of this deposit type, and the long exploration history of the region led the team to make a very low estimate for undiscovered deposits of this type. For the 90th, 50th, 10th, and 5th percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Mosier, Morris, and Singer (1986).

Porphyry Cu deposits

General Deposit Description

Porphyry copper deposits are large tonnage, low-grade hydrothermal ore deposits associated with altered, intermediate to felsic porphyritic intrusions and surrounding country rocks (Cox, 1986c). Copper sulfide minerals occur in stockwork veinlets (+/- quartz) and as disseminated grains. These minerals are deposited from hot, saline solutions derived from cooling magma bodies within a few kilometers of the surface. Associated mineral deposits include polymetallic veins, base- and precious-metal skarn, and(or) base-metal replacement deposits (Cox, 1986c). Where erosion has exposed these deposits to the surface or near-surface environment, they are commonly capped by leached zones, containing copper oxides over carbonates in weathered outcrops, or barren outcrops with fractures coated by hematitic limonite. Enriched zones of secondary chalcocite and other copper sulfides may form at the water-table (or paleo-water-table) by replacement of primary pyrite and chalcopyrite (Cox, 1986c).

Porphyry copper deposits are generally found in magmatic belts associated with convergent plate margins. These deposits are associated with plutonic rocks of a wide variety of igneous compositions, ranging from diorite to granite. However, gabbros and high-silica granites are seldom associated with porphyry copper deposits. Compositionally appropriate granitic plutons of Mesozoic and Tertiary age are widely scattered throughout the interior Columbia Basin and adjacent area.

Porphyry copper deposits commonly have significant gold and(or) molybdenum as byproduct commodities. Cox and Singer (1992b) divided porphyry copper deposits into three subtypes based on their gold and molybdenum contents. Porphyry copper-gold deposits have ratios of Au (in ppm) to Mo (in wt. %) of 30 or greater. Porphyry copper-molybdenum deposits have Au/Mo ratios (as above) of 3 or less. Deposits with Au/Mo ratios (as above) between 3 and 30 are considered porphyry copper-gold-molybdenum deposits. From the worldwide data set, median tonnages are largest for the porphyry copper-molybdenum deposits (500 million tonnes) and smallest for the porphyry copper-gold deposits (160 million tonnes), and are intermediate for the porphyry copper-gold-molybdenum deposits (390 million tonnes).

As gold and molybdenum contents are reported for only a few of the porphyry copper deposits in the Pacific Northwest, it is not possible to classify the known deposits into the three subtypes. Instead two regional grade/tonnage models were used to characterize these deposits: a North American subset of the general porphyry Cu model (Hammarstrom and others, 1993), used for areas underlain by Precambrian continental crust (e.g. Montana, Idaho, Wyoming), and a subset of the North American subset for significantly smaller deposits of British Columbia and Alaska (Menzies and Singer, 1993), used for areas underlain by Phanerozoic accreted terranes (e.g. Oregon, western Washington). The median size of a deposit from the North American porphyry Cu model is 142 million metric tonnes with 0.5% Cu and byproduct values of Ag, Au, and Mo (Hammarstrom and others, 1993). The median size of a deposit from the British Columbia-Alaska porphyry Cu model is 86 million metric tonnes with 0.37% Cu (Menzie and Singer, 1993).

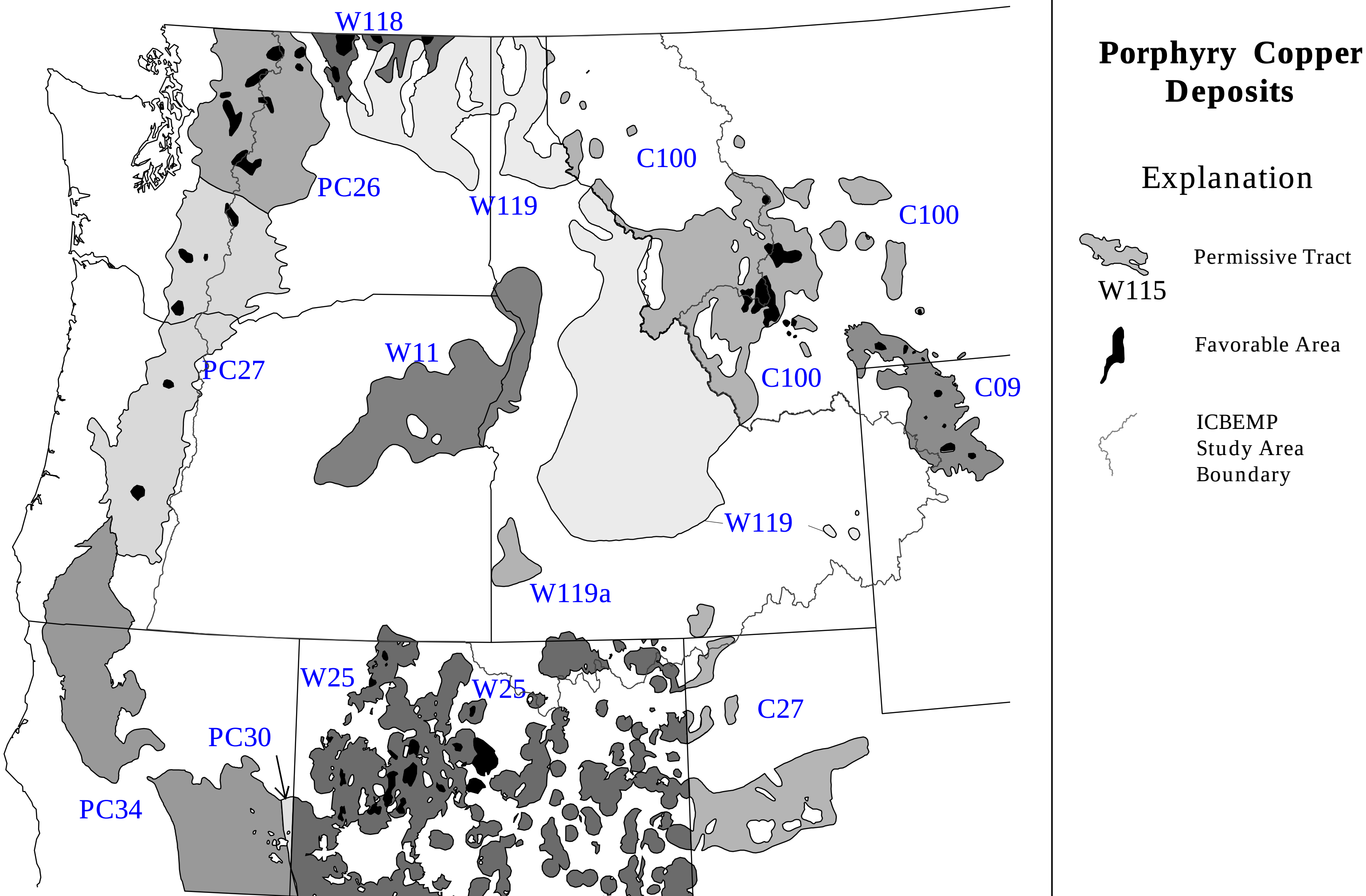


Figure 19a: Permissive and favorable tracts for Porphyry Copper deposits.

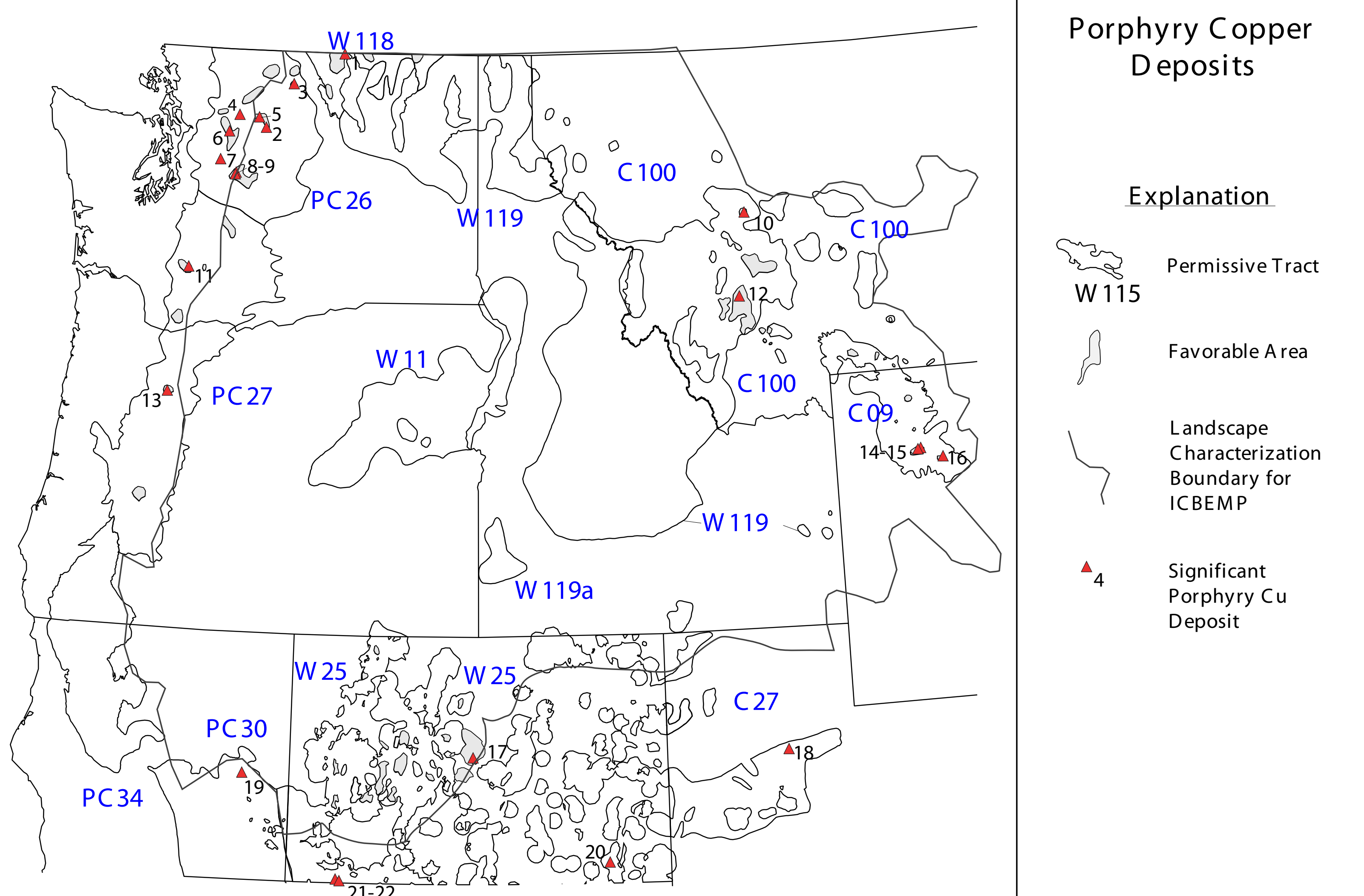


Figure 19b: Location of significant Porphyry Cu deposits in the map area.

Table 19: Significant porphyry copper deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W118	Kelsey	unnamed	Okanogan	WA	48.995	-119.478	I D
02	PC26	Red Mountain	Chiwawa	Chelan	WA	48.076	-120.849	I D
03	PC26	Mazama	Mazama	Okanogan	WA	48.615	-120.382	F D
04	PC26	Gold Mountain		Snohomish	WA	48.216	-121.334	I D
05	PC26	Glacier Peak	Sampson	Snohomish	WA	48.198	-120.979	I D
06	PC26	Sunrise	Sultan Basin	Snohomish	WA	48.009	-121.504	I D
07	PC26	North Fork	Snoqualmie	King	WA	47.669	-121.636	I D
08	PC26	Clipper - Three Brothers	Middle Fork Snoqualmie	King	WA	47.518	-121.344	I D
09	PC26	Condor-Hemlock	Middle Fork Snoqualmie	King	WA	47.497	-121.360	I D
10	C100	Heddleston	Heddleston	Lewis and Clark	MT	47.026	-112.360	I D
11	PC27	Margaret	St. Helens	Skamania	WA	46.356	-122.081	I D
12	C100	Continental	Butte	Silver Bow	MT	46.020	-112.526	P
13	PC26	Bornite		Marion	OR	44.850	-122.310	P
14	C09	Stinkingwater	Stinkingwater Cu	Park	WY	44.040	-109.639	I D
15	C09	Silver Creek	Stinkingwater Cu	Park	WY	44.028	-109.689	I D
16	C09	Kirwin	Kirwin Cu-Mo	Park	WY	43.917	-109.283	I D
17	W25	Copper Canyon	Battle Mountain	Lander	NV	40.540	-117.120	I M x
18	C27	Bingham Canyon	Bingham Canyon	Salt Lake	UT	40.540	-112.140	P
19	PC34	Lights Creek	Lights Creek	Plumas	CA	40.300	-120.750	I M
20	W23	Ely	Robinson	White Pine	NV	39.260	-115.000	F M
21	W24	Macarthur	Yerington	Lyon	NV	39.050	-119.240	P
22	W24	Bear Prospect	Yerington	Lyon	NV	39.030	-119.180	I D

Table 19: Significant porphyry copper deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)	Mo prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Mo resource (tonnes)
01	none	none	none	none	none		unk	unk	334,662	10,796
02								238	30,844	
03									1,576,000	
04									199,600	
05									5,757,000	13,020
06							4.9	119	248,800	27,439
07									199,580	
08									16,400	
09									788,700	22,077
10									469,019	46,586
11							126	827	1,884,400	57,580
12		162	239,953						1,192,416	182,000
13	none	none	none	none	none		1.5	40	51,511	
14									206,500	
15									120,000	
16									480,000	
17			54,783				7.8	144	72,197	
18	590.63	7,891	11,984,762	2,036,303	855,241	732,400	312	2,163	4,578,200	344,700
19			71,600						1,066,000	
20	83.20	8.5	2,528,000				94		1,262,733	20,551
21									119,700	
22									1,814,000	

C09 — Porphyry Cu Deposits — Montana, Wyoming

Descriptive Model 17

• 3.8 mean undiscovered deposits

by James E. Elliott

Rationale for Tract Delineation

Permissive areas for porphyry copper deposits are located in south-central Montana and northwestern Wyoming, coincident with an Eocene volcano-plutonic belt. Most of the known deposits and prospects are situated within the northwest-trending Absaroka-Gallatin volcanic province (Chadwick, 1970). The criteria used to define the permissive tract in south-central Montana and northwestern Wyoming are: (1) Mapped areas of Eocene intrusive and extrusive rocks of the Absaroka Volcanic Supergroup in the Absaroka ranges of Montana and Wyoming, as shown on the geologic map of Montana (Ross and others, 1955) and Wyoming (Love and Christiansen, 1985); (2) Predicted presence of subsurface intrusive rocks based on gravity and magnetic data; (3) Presence of known mines, prospects, and occurrences of this deposit type. Favorable areas were defined using the maps of Hammarstrom and others (1993).

Important Examples of Deposit Type

The Kirwin deposit (#16, figure 19b) and 11 porphyry copper prospects are located along this belt (Hausel, 1982). The Kirwin deposit is located in the southern part of the Absaroka-Gallatin volcanic province (Chadwick, 1970) in northwestern Wyoming. It is associated with rhyolitic tuffs and breccias that intruded andesitic volcanic and volcaniclastic rocks. The deposit is contained within an area of intense hydrothermal alteration associated with a volcanic vent complex. The mineralized zone consists of stockworks with pyrite, chalcopyrite, and molybdenite in quartz-calcite veins and disseminated sulfides in altered rocks. A secondary enriched blanket containing chalcocite, digenite, and covellite overlies a portion of the stockworks (Hausel, 1982).

Eleven other porphyry copper prospects are known and are located along two northwesterly-trending belts in the Absaroka-Gallatin province in northwestern Wyoming and south-central Montana. These prospects are New World, Independence, Emigrant, Silver Creek (#15, figure 19b), Stinkingwater (#14, figure 19b), Sunlight, Eagle Creek, Clouds Home Peak, Robinson Creek, Birthday, and Yellow Ridge.

Rationale for Numerical Estimate

A comprehensive analysis of part of the Absaroka-Gallatin volcanic province by Hammarstrom and others (1993) was used as a guide for the whole of that province. For the assessment, a North American subset of the porphyry copper tonnage and grade model of Singer, Mosier, and Cox (1986) was used (Hammarstrom and others, 1993). This subset of 107 deposits, which range in age from Late Cretaceous through middle Tertiary, has a median size of 142 million metric tons and a median copper grade of 0.5 percent. Byproducts include silver, gold, and molybdenum. Although deposits from western Montana (tract C100) have relatively high contents of molybdenum, the Wyoming deposits in this tract have no reported molybdenum or gold resource, so their deposit subtype is uncertain. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 1, 4, 6, 7, and 9 or more undiscovered porphyry copper deposits consistent with the grade and tonnage model of Hammarstrom and others (1993).

C27 Porphyry Cu Deposits — Utah, Idaho

Descriptive Model 17

• 0.01 mean undiscovered deposits
(ICBEMP portion of tract only)

by Douglas B. Stoeser

Rationale for Tract Delineation

Delineation of a permissive tract for porphyry copper deposits in Utah is based on the occurrence of Tertiary calc-alkaline intermediate to silicic intrusive rocks, associated volcanic rocks, and intrusive-related mineral deposits (porphyry copper, polymetallic vein and replacement, and skarn). Two east-west trending, dominantly calc-alkaline Tertiary magmatic belts in the western part of the State contain most of the significant base and precious metal deposits of Utah (Shawe and Stewart, 1976; Seedorff, 1991). In the north, two adjacent belts, the Oquirrh-Uinta belt and the Tintic-Deep Creek belt, combine to form the permissive tract. The igneous rocks here range in age from approximately 43 to 32 Ma, and range from intermediate to silicic. The silicic volcanic rocks are mainly associated with ash-flow calderas (Steven and Rowley, 1984; Best, 1989; Stoeser, 1993). These igneous rocks are relatively deeply eroded, such that the majority of the once extensive volcanic rocks of the area have been removed. Because of the deep erosion level, the tract has significant area of exposed plutonic rocks and is characterized by mineral deposits related directly to intrusive centers. The northernmost portion of tract C27, in the extreme northwest corner of Utah, contains local volcanic rocks with minor intrusives. The tract is approximately 70 percent covered by alluvium. Aeromagnetic surveys were used to define areas with a magnetic signature that might indicate intrusions at depth. A few minor base and precious metal occurrences associated with small intrusions are located in the eastern Uinta Mountains, but this area was considered to have insignificant mineral potential for intrusive-related deposits.

Important Examples of Deposit Type

Utah contains one of the largest and richest porphyry copper deposits in the world at Bingham Canyon, a porphyry copper-gold-molybdenum deposit (#18, figure 19b: Lanier and others, 1978). This, however, is the only porphyry copper deposit that has been exploited in the state. Six other prospects occur in the southern permissive tract, (Park Premier, Southwest Tintic, West Tintic, Detroit, Dugway, and Gold Hill), and some of them could become significant deposits if they were fully explored.

Rationale for Numerical Estimate (ICBEMP portion only)

The lack of known prospects and the long exploration history in the ICBEMP portion of the tract leads us to give a very low potential for undiscovered porphyry copper deposits in that area. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered porphyry copper deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Hammarstrom and others (1993).

Porphyry Cu Deposits

Descriptive Model 17

• 1.6 mean undiscovered deposits (entire tract)

• 0.8 mean undiscovered deposits (ICBEMP portion only)

by James E. Elliott

Rationale for Tract Delineation

The tract is located in western Montana, coincident with Cretaceous and Eocene volcanic and plutonic belts. Most of the known deposits and prospects are situated along a northeasterly-trending "Idaho-Montana porphyry belt" (Rostad, 1978), in southwestern Montana. The criteria used to define the permissive tract in western Montana are: (1) mapped areas of Cretaceous and Eocene volcanic, hypabyssal, and plutonic rocks as shown on the geologic map of Montana (Ross and others, 1955); (2) the predicted extent or presence of subsurface intrusive rocks based on gravity and magnetic data; (3) the presence of known mines, prospects, and occurrences of this deposit type.

Important Examples of Deposit Type

The only known deposit of Late Cretaceous age is the Continental deposit in the Butte district (#12, figure 19b). This deposit and other prospects of this age are associated with plutonic and hypabyssal intrusive rocks of the Boulder, Pioneer, Idaho, and Tobacco Root batholiths and other intrusive bodies of southwestern Montana. Several prospects also exist, that have either low grade or are incompletely explored. They include Beaverton, Golconda, areas on the east flank of the Elkhorn Range, Rochester, Jackson Creek, West Fork of the Bitterroot, Cold Springs-Bannack, Argenta, Westside Tobacco Root, and Gold Hill.

The famous Butte district, in southwestern Montana, has been recognized as a porphyry copper district as well as one of the largest and most productive polymetallic vein districts in the world. The Continental porphyry copper-molybdenum deposit, presently being mined, is hosted by the Butte Quartz Monzonite (Boulder batholith) of Late Cretaceous (Meyer and others, 1968; Ratcliff, 1973). Hypogene copper and molybdenum minerals occur as disseminations and in stockwork veinlets. Much of the ore-grade mineralized rock results from oxidation and supergene enrichment of hypogene minerals.

The Heddleston deposit (#10, figure 19b), of Eocene age, is located in the west-central part of Montana near Lincoln (Hunt and others, 1970). The deposit is associated with porphyritic intrusive rocks that invaded metasedimentary rocks of the Middle Proterozoic Belt Supergroup. These intrusions may be related to the nearby Lincoln andesitic and rhyolitic volcanic rocks. The Heddleston deposit consists of disseminated chalcopyrite and molybdenite and quartz-molybdenite veinlets in Eocene quartz monzonite, quartz monzonite porphyry, and a breccia pipe. A blanket-like supergene deposit is superimposed on the hypogene mineralized zones. The host rocks for this deposit are metasedimentary and metaigneous rocks of Proterozoic age.

Rationale for Numerical Estimate

For the assessment, a North American subset of the porphyry copper tonnage and grade model of Singer, Mosier, and Cox (1986) was used (Hammarstrom and others, 1993). This subset of 107 deposits, which range in age from Late Cretaceous through middle Tertiary, has a median size of 142 million metric tons and a median copper grade of 0.5 percent. Byproducts include silver, gold, and molybdenum. Montana deposits have relatively high contents of molybdenum and thus are distinctly different than most other porphyry copper deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 1, 3, 6, and 7 or more deposits consistent with the grade and tonnage model of Hammarstrom and others (1993). For the ICBEMP portion of the tract, the team estimated (at above percentiles) 0, 0, 2, 4, and 5 or more deposits consistent with the grade and tonnage model of Hammarstrom and others (1993).

Descriptive Model 17

• 7.6 mean undiscovered deposits (entire tract)

•3.5 mean undiscovered deposits (ICBEMP portion only)

by Roger P. Ashley

Rationale for Tract Delineation

The tract includes all significant exposures of Tertiary intrusive rocks in the Cascades from the Olympic-Wallowa lineament, which approximately marks the northern limit of extensive Tertiary volcanic rocks in the Cascade Range, northward to the Canadian border (Smith, 1993). It also includes concealed magnetic plutons shown on an interpretive geophysical map prepared from aeromagnetic and gravity data (Blakely and Plouff, 1991). Parts of the western boundary represent an approximate projection of plutonic or metamorphic rocks under 1 km of Quaternary cover. Locally, the west boundary is defined by exposed plutons; a buffer zone about 3 km wide has been drawn around these exposures. The southeast boundary represents the projection of plutonic, metamorphic, and Tertiary volcanic rocks under flows of the Miocene Columbia River Basalt Group (Drost and Whiteman, 1986), where they are <1 km thick.

Important Examples of Deposit Type

The Glacier Peak deposit (# 5, figure 19b) is the largest known porphyry copper deposit in this tract, having a reserve of 1.7 billion metric tons of ore containing 0.334 percent copper (Derkey and others, 1990). Other known deposits in the tract include Mazama, Gold Mountain, Sunrise, North Fork, Clipper/Three Brothers, and Condor-Hemlock (#3-7, figure 19b: Peterson, 1991; Derkey and others, 1990). The tract also contains three copper-bearing breccia pipes (i.e. Red Mountain and Bornite deposits: #2 and #13, figure 19b) that contain substantial known ore reserves. These are not included here as known porphyry copper deposits because their grades are too high and tonnages too low to fit the published porphyry copper models. However, because several of the known porphyry deposits include breccia pipes in addition to stockwork mineralization, the breccia pipes are regarded as porphyry prospects.

Rationale for Numerical Estimate

For the 90th, 50th, and 10th percentiles, the team estimated respectively, 3, 6, and 15 deposits consistent with the grade and tonnage model of porphyry copper deposits of the British Columbia-Alaska subtype (Menzie and Singer, 1993). This estimate expresses the belief that additional exploration of known prospects would disclose porphyry deposits. Note that at the 10th percentile, more than half of the known prospects are expected to yield deposits. The lack of additional deposits at lower percentiles reflects the perception that exploration of this tract for this deposit type has been relatively thorough, and there is a very low probability that completely undiscovered prospects remain.

Five out of eight of the known deposits in tract PC26 occur within the ICBEMP study area, but the team felt that the ICBEMP portion of the tract has slightly lower potential for undiscovered deposits as compared to that of the portion outside the ICBEMP. For the 90th, 50th, and 10th percentiles, the team estimated 1, 2, and 8 or more undiscovered porphyry-copper deposits in the ICBEMP portion of tract PC26 consistent with the grade and tonnage model of Menzie and Singer (1993).

PC27 **Porphyry Cu Deposits** **Oregon, Washington**

Descriptive Model 17

• 4.4 mean undiscovered deposits (entire tract)

•1.0 mean undiscovered deposits (ICBEMP portion only)

by Roger P. Ashley

Rationale for Tract Delineation

Granitic stocks and batholiths intrude the Tertiary volcanic rocks of the western Cascades in Oregon and southern Washington. One known porphyry copper deposit is associated with these subvolcanic intrusions, and there are about a dozen porphyry-type prospects (Peterson, 1991), indicating that magmatism in the Cascade arc produced a favorable environment for these deposits. The permissive tract includes all significant exposures of intrusive rocks in the Cascades south of the Olympic-Wallowa lineament. In the eastern part of the Cascades in southern Washington and throughout the Cascades of Oregon, exposures of intrusive rocks are scattered throughout the extensive Tertiary volcanic rocks, and regional maps for Oregon (Sherrod and Smith, 1989; Walker and MacLeod, 1991) do not distinguish phaneritic intrusions from finer-grained bodies. Therefore, in Oregon and in much of the area in Washington, the tract includes both volcanic and intrusive rocks of Tertiary age. The tract also includes concealed magnetic plutons shown on an interpretive geophysical map prepared from aeromagnetic and gravity data (Blakely and Plouff, 1991).

In detail, the western boundary of the tract in Washington is drawn to include all exposed intrusions, both coarse-grained and fine-grained, shown on the regional geologic maps of Smith (1993) and Walsh and others (1987). A buffer zone about 3 km wide has been drawn around individual exposed intrusions. Tertiary rocks without intrusions that are likely older than the Cascades arc have been excluded. Outlines of inferred concealed plutons lie east of this boundary. The western boundary in Oregon is drawn to include all Cascades volcanic, volcaniclastic, and intrusive rocks, but in most places is located at the approximate projection of these rocks under Columbia River Basalt Group or Quaternary deposits, where they are <1 km thick. North of Eugene, the tract has been expanded to include an inferred concealed intrusion.

The southern boundary of the tract is the southern edge of an area where concealed intrusions can be inferred. Although intrusions exist in the Tertiary Cascades farther south in Oregon and northern California, they are dikes, sills, and small plugs, mostly fine-grained, and thus are unlikely sources for porphyry copper deposits. Also, there are no known base-metal vein occurrences or other signs of porphyry systems in Tertiary rocks south of the tract, so we conclude that porphyry mineralization, if it exists, is deeper than 1 km.

The eastern boundary in Washington and northern Oregon represents the approximate projection of Tertiary volcanic rocks under flows of the Miocene Columbia River Basalt Group (Drost and Whiteman, 1986) and Quaternary volcanic rocks, where they are <1 km thick. Inliers of pre-Cascades rocks are included in the tract east of Mt. Rainier because many Tertiary intrusions are exposed there. In Oregon, the eastern boundary represents the approximate projection of Tertiary volcanic rocks under Quaternary High Cascades volcanic rocks, where they are <1 km thick.

Important Examples of Deposit Type

The Margaret deposit of southwestern Washington (#11, figure 19b) is the only known porphyry copper deposit in this tract. The deposit is classified as a porphyry copper-gold-molybdenum deposit and contains an estimated ore reserve of at least 523 million metric tons grading 0.36 percent copper, with significant amounts of molybdenum, gold, and silver (Derkey and others, 1990). The tract also contains two copper-bearing breccia pipes that contain substantial known reserves of copper, molybdenum, gold, and silver. These are not included here as known porphyry copper deposits because their grades are too high and tonnages too low to fit the published porphyry copper models. However, because several of the known porphyry deposits in the northern Cascades include breccia pipes in addition to stockwork mineralization, the breccia pipes are regarded as porphyry prospects.

Rationale for Numerical Estimate

The porphyry copper grade and tonnage model for British Columbia and Alaska (Menzie and Singer, 1993) is used here because known deposits in the north Cascades of Washington fit this model, and deposits in the southern Cascades are expected to be similar. Our estimate reflects the belief that additional exploration of known prospects would disclose deposits. Note that at the 10th percentile, almost all known prospects are expected to yield deposits. The lack of additional deposits below the 10th percentile reflects the perception that, although exploration of this tract for this deposit type has not been as thorough as it has in the northern Cascades, the potential for new deposits lies almost entirely within known polymetallic vein districts, which constitute or contain the known porphyry prospects in this tract. Thus, there is a very low probability that completely undiscovered prospects remain. For the 90th, 50th, and 10th percentiles, the team estimated 1, 3, and 10 or more porphyry-copper deposits consistent with the grade and tonnage model of Menzie and Singer (1993).

Both of the known deposits and much of the favorable area occur in that portion of tract PC27 outside the ICBEMP study area, and the team felt that the ICBEMP portion of the tract has a lesser potential for undiscovered deposits. For the 90th, 50th, and 10th percentiles, the team estimated 0, 1, and 2 or more undiscovered porphyry-copper deposits in the ICBEMP portion of tract PC27 consistent with the grade and tonnage model of Menzie and Singer (1993).

PC30 — Porphyry Cu Deposits — California

Descriptive Model 17

No estimate of undiscovered deposits

by Dennis P. Cox

Rationale for Tract Delineation

The permissive tract encompasses many small plutons that intrude Precambrian metamorphic, and Precambrian and Paleozoic sedimentary rocks in a highly faulted part of the Mesozoic continental margin. Plutons, mainly of Jurassic age, are closely associated with copper- and lead-zinc skarns and polymetallic replacement and vein deposits in the Great Basin of California. One or more of these plutons could have given rise to a porphyry copper system, although few examples are known. Small areas of basin fill more than 1 km in depth are excluded from the tract.

Important Examples of Deposit Type

No significant porphyry copper deposits are known within the tract.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered porphyry copper deposits was made.

Porphyry Cu Deposits

Descriptive Model 17

No estimate of undiscovered deposits

by Dennis P. Cox and Roger P. Ashley

Rationale for Tract Delineation

The permissive tract includes all the major plutons of the Sierra Nevada and Klamath Mountains. Plutons permissive for porphyry copper deposits are believed to be emplaced at shallow levels in the crust, but because we have no way to distinguish this environment on a regional scale, the entire tract is considered permissive. Despite the apparent scarcity of pluton-related deposits in the Klamath Mountains, this part of the tract is considered permissive for several types of pluton-related deposits. Of these, polymetallic veins might be indicators of concealed porphyry copper systems. The only vein deposits that clearly fit the polymetallic vein model are quartz veins rich in silver and base metal sulfides in the South Fork district, located in the Shasta Bally pluton at the southern edge of the Klamath Mountains (Silberman and Danielson, 1993). Some occurrences in the Gold Hill, Ashland, and Applegate districts of Oregon may also be polymetallic veins.

Important Examples of Deposit Type

The Lights Creek porphyry copper deposit (#19, figure 19b: Storey, 1978) is located in the northernmost part of the Sierra Nevada, in the Plumas County copper belt of Knopf (1935). Lights Creek consists of two mineralized zones 3 km apart. It differs from typical porphyry copper systems in that magnetite is more abundant than pyrite and chlorite is the main alteration mineral. Zoned potassic and phyllic alteration typical of porphyry copper deposits is indistinct. The copper belt includes the Engels and Superior copper vein deposits near Lights Creek (Anderson, 1931) and the Walker vein deposit 20 km to the southeast. The vein deposits are large compared to polymetallic vein median tonnage, and contain magnetite, tourmaline and actinolite in addition to chalcopyrite, bornite and other sulfides. Deposits in the Plumas County copper belt are all related to stocks of gabbroic to granodioritic composition that are older than the major batholiths in the northern Sierra Nevada. The abundance of magnetite in these deposits suggests an affinity with porphyry copper-gold systems, but no gold grades for the deposits are available. The general porphyry copper grade and tonnage model (Singer, Mosier, and Cox, 1986) was used in the assessment. The Lights Creek bodies contain 315 million metric tons of mineralized rock that average 0.34 percent copper. The Engels and Superior veins together produced about four million metric tons of ore averaging 1.79 percent copper (Storey, 1978). In the Klamath Mountains, the most important polymetallic vein deposit is the Silver Falls-Chicago Consolidated mine in the South Fork district, which produced $1,000,000 worth of metal, mainly silver (Hotz, 1971).

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered porphyry copper deposits was made.

W11

Porphyry Cu Deposits

Descriptive Model 17

• 0.2 undiscovered deposits (entire tract)
• 0.1 undiscovered deposits (OR-WA portion only)
• 0.1 undiscovered deposits (ID portion only)

Oregon
Washington
Idaho

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

All areas with shallowly emplaced (<5 km) convergent margin plutonic rocks of any age are considered permissive for porphyry copper deposits. Factors that exclude areas from such permissive terranes would include location outside of known plutonic belts, the presence of gabbroic or high-silica granites only, or the presence of only deeply emplaced plutonic rocks. Both large and small bodies of Jurassic and Cretaceous granitic rocks occur throughout the Wallowa, Baker, and Olds Ferry terranes of eastern Oregon and adjacent parts of west-central Idaho and southeasternmost Washington (Walker and MacLeod, 1991). Areas of Eocene volcanic and volcaniclastic rocks (Clarno volcanics) are included since they are typically intruded by coeval hypabyssal dikes, sills, and plugs of intermediate to felsic composition. The boundaries of the tract are generally delimited where the cover of younger rocks is greater than 1 km. Porphyry copper deposits in Mesozoic accreted terranes in British Columbia and Alaska are somewhat smaller than the well-known Arizona deposits, and have been characterized by a separate grade and tonnage model used here (Menzie and Singer, 1993).

Important Examples of Deposit Type

No porphyry Cu deposits are known within the tract, but the area contains several small skarn Cu deposits in a belt from the Seven Devils Mountains to the Wallowa batholith. Five or more areas with acid sulfate alteration are known in the Mineral district of western Idaho. These areas might be related to porphyry Cu systems at depth.

Rationale for Numerical Estimate

Although no porphyry Cu deposits are known, the estimate was influenced by the presence of the small Cu skarns around the Wallowa batholith in Oregon and in the Mineral district in Idaho. Some major copper companies have had exploration programs in the area, so the lack of even a single known deposit is an indication for relatively low likelihood for undiscovered deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 2, and 5 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Menzie and Singer (1993). The team felt that the larger part of the tract in Oregon and Washington has considerably more potential for undiscovered deposits than the Idaho portion. For the Oregon and Washington portion, the team estimated (at the above percentiles) 0, 0, 1, 1, and 3 or more undiscovered deposits (with a 90% chance of no deposits). For the Idaho portion, the team estimated 0, 0, 0, 1, and 2 or more undiscovered porphyry copper deposits (with a 95% chance of no deposits).

W25 | Nevada, Oregon, Idaho

Porphyry Cu Deposits

Descriptive Model 17

• 0.4 mean undiscovered deposits (ICBEMP portion only)

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The permissive tract for porphyry copper deposits in northern Nevada is defined as an area extending 10 km outward from the outcrop of a pluton, or, in the case that the pluton has a geophysical expression as discussed by Grauch and others (1988), from the inferred subsurface boundary of the pluton based on its geophysical expression. It also includes areas around plutons whose presence is inferred from geophysics or from the occurrence of skarn mineralization. Plutons in northern Nevada are of Jurassic, Cretaceous, and Tertiary age, and all are considered permissive for porphyry copper deposits. Because only very general paleodepth information is available for many plutons in Nevada (Barton and others, 1988), no part of the tract could be excluded on this basis (porphyry copper deposits tend to form in and around epizonal plutons rather than deep-seated batholiths). Much of the permissive tract is covered by 1 km or less of Upper Tertiary and Quaternary rocks and sediments. Areas covered by more than 1 km (Blakely and Jachens, 1991) are excluded as are areas that are within a Tertiary caldera. In these latter areas, permissive pre-Tertiary host rocks are likely to be covered by more than 1 km of volcanic rock. Where the pluton is Tertiary in age, however, the enclosing Tertiary volcanic rocks are delineated as permissive (Wallace, 1979).

Important Examples of Deposit Type

The Copper Canyon deposit (#17, figure 19b) is associated with a Tertiary pluton. The deposit is small by porphyry copper standards, containing about 18 million metric tons of 0.8 percent copper ore. The ore bodies produced byproduct metals, especially gold and silver, and satellite deposits to these are now being mined for gold (Theodore and Blake, 1975).

Porphyry copper skarn-related deposits, an important variant of this model characterized by chalcopyrite-bearing quartz-sulfide stockwork veinlets in porphyritic intrusive rock and adjacent skarn are formed where porphyry systems are emplaced in carbonate or other reactive wall rocks. Examples in Nevada include the Tertiary Battle Mountain district.

Rationale for Numerical Estimate (ICBEMP portion of tract only)

A numerical estimate was made only for that part of tract W25 that lies within the ICBEMP study area (figure 19a). An estimate of the number of undiscovered porphyry copper deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W25 lies within two counties. To arrive at the numerical estimate of undiscovered porphyry copper deposits in the ICBEMP portion of tract W25, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and of the total area of permissive tract within those two counties. This yields an estimated 0.33 mean porphyry copper deposits for the part of the ICBEMP study that extends into tract W25 (including the minor permissive tract extensions into Oregon and Idaho). For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 2, 3, and 4 or more deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model of Mosier, Morris, and Singer (1986) is equivalent to the estimated number of mean undiscovered deposits derived above.

W118 Porphyry Cu Deposits — Washington

Descriptive Model 17

• 0.4 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract encompasses Triassic, Jurassic, and(or) Cretaceous intermediate composition plutons that intrude the Quesnellia terrane (Stoffel and others, 1991). The tract is at the southern end of the British Columbia porphyry copper belt, a 1,300-km-long belt of Late Triassic-Early Jurassic deposits associated with mildly alkaline intermediate plutons. Plutons of this age are widely scattered throughout the Quesnellia terrane. Since the locations of unexposed plutons within a kilometer of the surface are not well known, the entire Quesnellia terrane is considered permissive.

Examples of Deposit Type

The Kelsey deposit (#1, figure 19b: Derkey and others, 1990), along the Washington-British Columbia border, is the southernmost known (and the only U.S. representative) in the British Columbia porphyry copper belt, a 1,300-km-long belt of Late Triassic-Early Jurassic deposits associated with mildly alkaline intermediate plutons. The deposit has a tonnage greater than about 60 percent of those shown on the tonnage distribution of Menzie and Singer (1993), but has a copper grade (0.286 percent) lower than 90 percent of those shown on the grade distribution. However, the contained metal is about equal to the median size of these deposits.

Rationale for Numerical Estimate

Polymetallic veins occur in two clusters south of the Kelsey deposit, and a gold skarn associated with a separate Mesozoic pluton occurs to the east. The relatively small favorable areas, and knowledge of the extensive exploration for these deposits in the region in the 1960s and 1970s, limits our estimate of the number of undiscovered deposits. For the 90th, 50th, 10th, and 5th percentiles, the team estimated 0, 0, 2, 3, and 4 or more deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model of Menzie and Singer (1993).

W119 Porphyry Cu Deposits — Washington, Idaho

Descriptive Model 17

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract includes most of the Eocene and older rocks of northeastern Washington and Idaho north of the Snake River plain in which intermediate plutons of Cretaceous and Tertiary age are widespread (Stoffel and others, 1991; Bond, 1978). Since the deposit model requires shallow (<5 km) emplacement depths for the ore-related plutons, the deeply emplaced western part of the Cretaceous Idaho batholith and the Tertiary uplifted metamorphic core complexes (i.e., Okanagan, Kettle, Priest River-Spokane, and Pioneer core complexes) are excluded, except where intruded by shallow Eocene plutons. Areas north of the Idaho batholith, where no plutonic rocks are known at the surface and geophysical evidence for plutons at depth is not known, were also excluded from the tract.

Important Examples of Deposit Type

No copper deposits of this type are known from this tract. Several porphyry molybdenum deposits, some with significant copper resources, do occur in the tract, but are characterized by a separate deposit model (Theodore, 1986; Menzie and Theodore, 1986).

Rationale for Numerical Estimate

The lack of known deposits or prospects of this deposit type in the tract, combined with relatively thorough exploration in the 1960s and 1970s led the team to give a very low estimate for the number of undiscovered deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Hammarstrom and others (1993).

W119a — Porphyry Cu Deposits — Idaho

Descriptive Model 17

0.01 undiscovered deposits

by Stephen Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract delineates an area of Eocene and older rocks surrounded by Tertiary volcanic and sedimentary rocks. The geology is a southwest continuation of the Idaho batholith and its country rock across the Neogene Snake River plain to the northeast.

Important Examples of Deposit Type

No porphyry Cu deposits or prospects are known from this tract.

Rationale for Numerical Estimate

The lack of known deposits or prospects of this deposit type in the tract, combined with its small size and the apparent relatively thorough exploration led the team to give a very low estimate for undiscovered porphyry copper deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more porphyry-copper deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Hammarstrom and others (1993).

Porphyry Mo Deposits

General Deposit Description

Two types of bulk-mineable porphyry molybdenum deposits are present in the Interior Columbia Basin: 1) low-fluorine type (Mo>Cu), and 2) Climax-type (Mo only) deposits (Carten and others, in press). Significant molybdenum resources are also present in porphyry copper-molybdenum deposits, discussed in the section on porphyry copper deposits. The estimates of undiscovered deposits made here only apply to the low-fluorine type porphyry molybdenum deposits.

Low-fluorine porphyry molybdenum deposits consist of stockworks of veinlets of quartz, molybdenite, and(or) chalcopyrite, in association with porphyritic intrusions of tonalite, granodiorite, or monzogranite (Theodore, 1986). The Thompson Creek deposit, located in south-central Idaho, fits the low-fluorine type porphyry molybdenum model of Menzie and Theodore (1986).

Climax-type deposits consist of stockworks of veinlets of quartz and molybdenite, in association with porphyritic intrusions of silica-rich, fluorine-bearing granite-rhyolite (Ludington, 1986). The Big Ben and Bald Butte deposits, located in central Montana, and the Mount Hope deposit, located in east-central Nevada, are transitional to Climax-type porphyry molybdenum deposits.

For the low-fluorine porphyry molybdenum model, median tonnage is 94 million metric tonnes of ore with 0.085% Mo (Menzie and Theodore, 1986). For the Climax porphyry molybdenum model, median tonnage is 200 million metric tonnes of ore , with 0.19% Mo (Singer, Theodore, and Mosier, 1986).

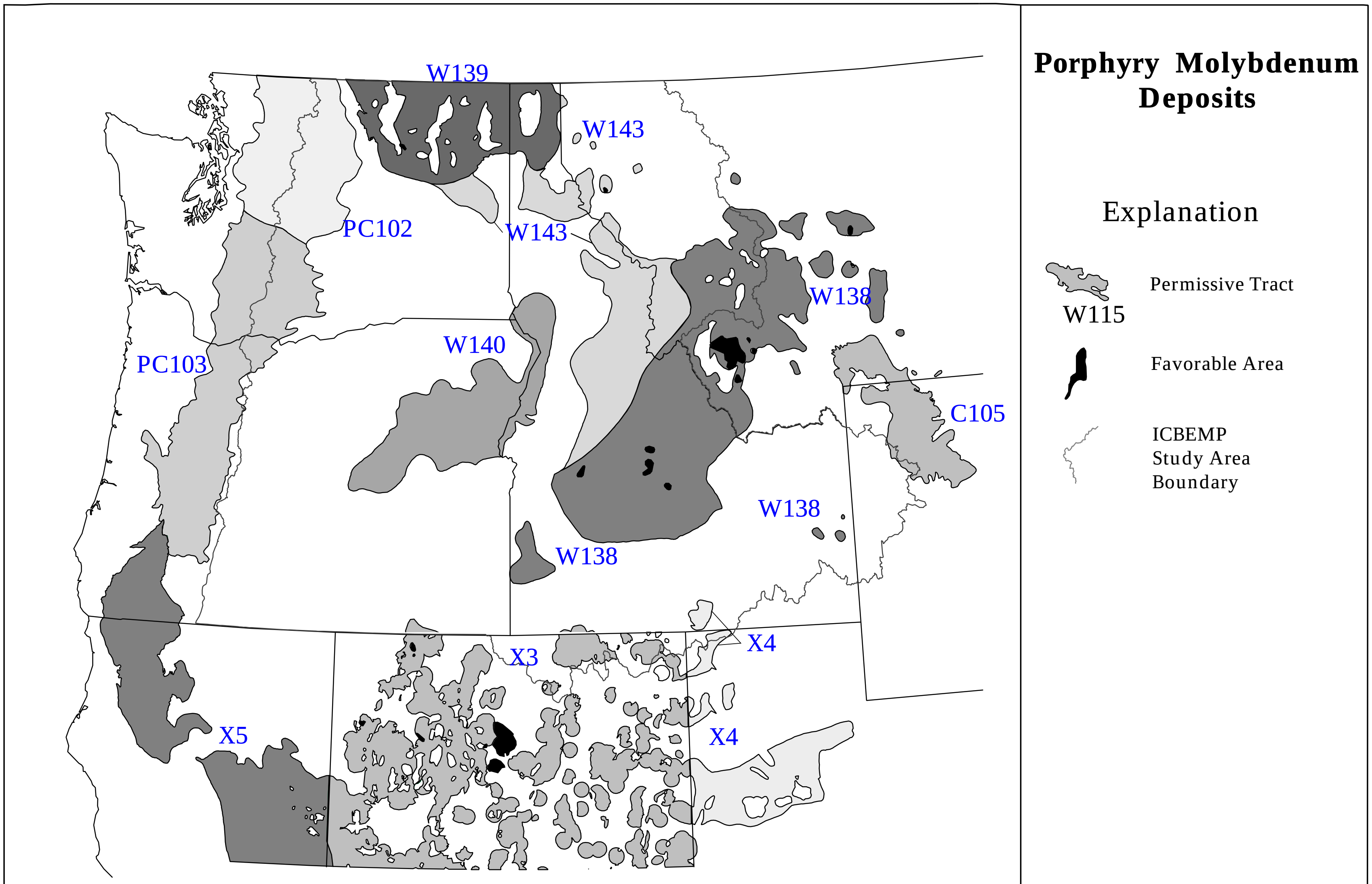


Figure 20a: Permissive and favorable tracts for Porphyry molybdenum deposits.

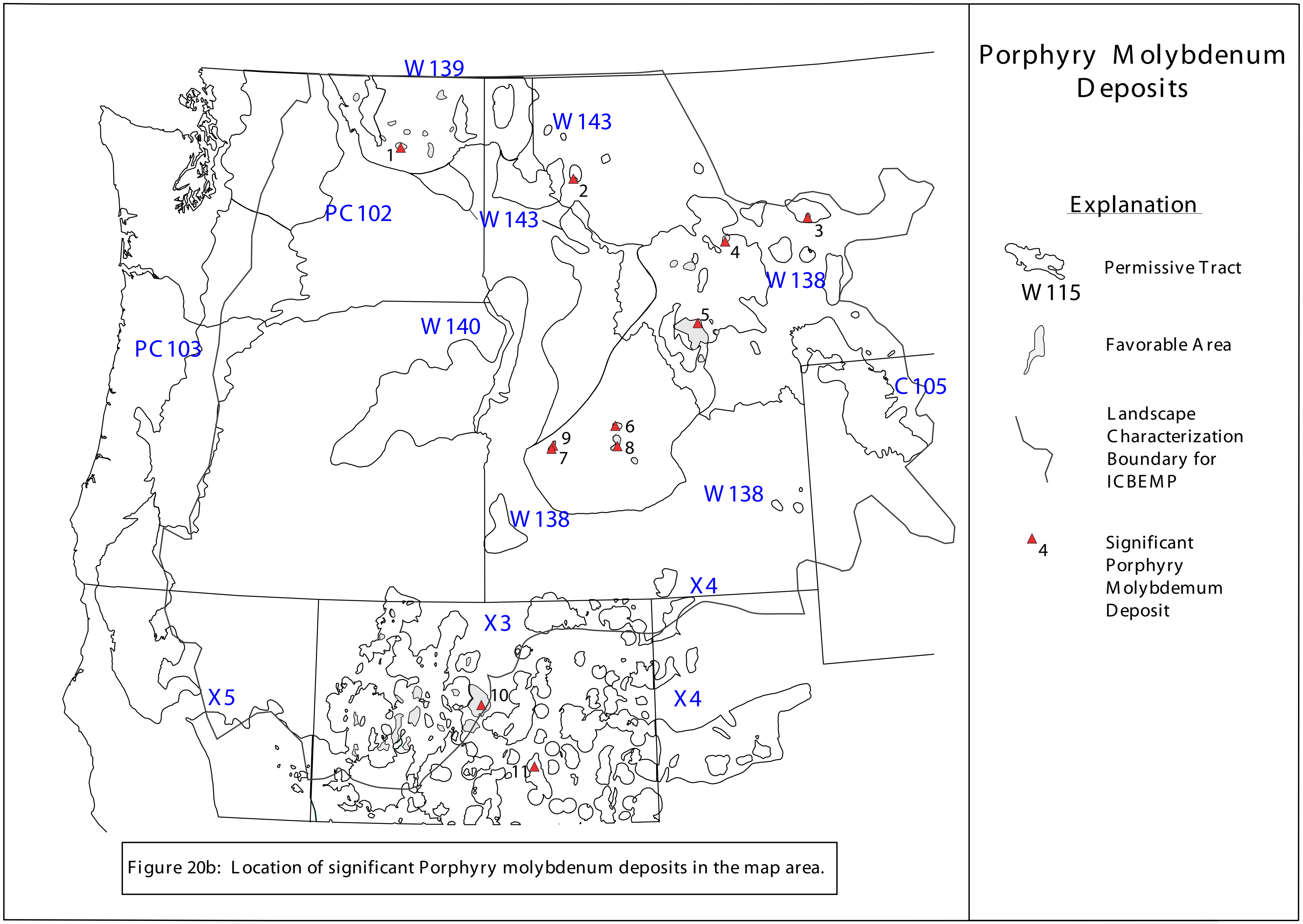


Figure 20b: Location of significant Porphyry molybdenum deposits in the map area.

Table 20: Significant porphyry molybdenum deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W139	Mt Tolman	Sanpoil, Keller	Ferry	WA	48.057	-118.692	I D
02	W143	Liver Peak		Sanders	MT	47.642	-115.267	I D
03	W138	Big Ben	Neihart	Cascade	MT	46.966	-110.712	I D
04	W138	Bald Butte	Marysville	Lewis and Clark	MT	46.723	-112.346	I D
05	W138	Cannivan	Quartz Hill	Beaverhead	MT	45.655	-112.956	I D
06	W138	Thompson Ck	Bayhorse	Custer	ID	44.327	-114.587	P
07	W138	Little Falls		Boise	ID	44.083	-115.750	I D
08	W138	L. Boulder Ck	Bayhorse Ck	Custer	ID	44.056	-114.558	I D
09	W138	Cumo	Grimes Pass	Boise	ID	44.038	-115.783	I D
10	X3	Buckingham		Lander	NV	40.617	-117.075	I D
11	X3	Mount Hope		Eureka	NV	39.788	-116.158	F D

Table 20: Significant porphyry molybdenum deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name		Mo production (tonnes)		Cu resource (tonnes)	Mo resource (tonnes)
01	W139	Mt Tolman				713,700	444,080
02	W143	Liver Peak					446,342
03	W138	Big Ben					98,100
04	W138	Bald Butte					14,000
05	W138	Cannivan					177,600
06	W138	Thompson Ck		49,805			160,376
07	W138	Little Falls					27,216
08	W138	L. Boulder Ck					121,653
09	W138	Cumo				930,920	742,220
10	X3	Buckingham				440,980	752,260
11	X3	Mount Hope					510,000

Tract Descriptions

C105

Porphyry Mo Deposits
Descriptive Model 21b
• 0.01 undiscovered deposits

Montana
Wyoming

by James E. Elliott

Rationale for Tract Delineation

Compositionally appropriate intrusions of Tertiary age occur in porphyry molybdenum permissive tract C105, which coincides with the Absaroka magmatic province of northwestern Wyoming and southwestern Montana, and with porphyry copper tract C09.

Important Examples of Deposit Type

No porphyry molybdenum deposits are known in tract C105, but porphyry copper-molybdenum deposits are present in the coincident porphyry copper tract (C09).

Rationale for Numerical Estimate

The lack of known porphyry molybdenum deposits in tract C105 led the team to give a very low estimate for undiscovered low-fluorine porphyry molybdenum deposits in this tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more low-fluorine porphyry-molybdenum deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Menzie and Theodore (1986). Numerical estimates for porphyry copper and porphyry copper-molybdenum and deposits in this area are given in the description of porphyry copper tract C09.

PC102

Porphyry Mo Deposits
Descriptive Model 21b
• 0.01 undiscovered deposits

Washington

by Arthur A. Bookstrom, Stephen E. Box, and Michael L. Zientek

Rationale for Tract Delineation

Tract PC102 is located in the North Cascades of Washington, north of the Olympic-Wallowa lineament. The tract is delineated to include intrusions of intermediate to felsic composition of Tertiary age , which may be associated with porphyry copper and(or) porphyry molybdenum deposits.

Important Examples of Deposit Type

No porphyry molybdenum deposits are known in tract PC102, but molybdenum-bearing porphyry copper deposits are present in the coincident porphyry-copper permissive tract PC26.

Rationale for Numerical Estimate

The lack of known porphyry molybdenum deposits in tract PC102 led the team to give a very low estimate for undiscovered low fluorine porphyry molybdenum deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more low-fluorine porphyry-molybdenum deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Menzie and Theodore (1986).

PC103

Porphyry Mo Deposits
Descriptive Model 21b
• 0.01 undiscovered deposits

Oregon
Washington

by Arthur A. Bookstrom, Stephen E. Box, and Michael L. Zientek

Rationale for Tract Delineation

Tract PC103 is located in the Cascade Mountains of southern Washington and Oregon. The tract is delineated to include intrusions of intermediate to felsic composition, of Tertiary age, which may be associated with porphyry molybdenum deposits.

Important Examples of Deposit Type

No porphyry molybdenum deposits are known, but molybdenum-bearing porphyry copper deposits are present in the coincident porphyry-copper permissive tract PC27.

Rationale for Numerical Estimate

The lack of known deposits or prospects of this deposit type in the tract led the team to give a very low estimate for undiscovered low fluorine porphyry molybdenum deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more low-fluorine porphyry-molybdenum deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Menzie and Theodore (1986).

W138

Porphyry Mo Deposits
Descriptive Model 21b
• 3.0 undiscovered deposits (entire tract)
• 1.8 undiscovered deposits (ICBEMP portion only)

Idaho
Montana

by Arthur A. Bookstrom, Stephen E. Box, and Michael L. Zientek

Rationale for Tract Delineation

Porphyry molybdenum deposits and occurrences of Idaho and Montana are concentrated in tract W138, which is located along a northeast-trending zone of faults, porphyritic intrusions, and hydrothermal systems, known as the Trans-Challis fault zone, or the Great Falls tectonic zone.

Important Examples of Deposit Type

The Thompson Creek deposit (#6, figure 20b) is an important low-fluorine porphyry molybdenum deposit that is the site of a large open-pit mine (Schmidt and others, 1983). The Cumo, Little Falls, Little Boulder Creek, and Cannivan Gulch deposits are low-fluorine porphyry molybdenum deposits that have not yet been mined (#5, 7, 8, 9, figure 20b). The Big Ben and Bald Butte deposits (#3, 4 figure 20b) are transitional Climax-type porphyry molybdenum deposits. Although they are considered with porphyry copper deposits, the Continental and Heddleston porphyry copper-molybdenum deposits also contain significant Mo resources (#10, 12, table 19).

Rationale for Numerical Estimate

In addition to the eight known porphyry molybdenum and porphyry copper-molybdenum deposits listed above, tract W138 contains about 31 partially tested prospects, and about 150 molybdenum occurrences that are listed in the Mineral Resource Documentation System of the U.S.Geological Survey. Although exploration for porphyry molybdenum deposits was intense during the 1970's, such exploration was abruptly abandoned in the early 1980's, when the price of molybdenum fell as a result of increased supply and decreased demand. Although no unannounced discoveries are known, it is probable that at least two, and possibly as many as ten or more undiscovered low-fluorine porphyry molybdenum deposits may exist in tract W138. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 2, 7, 8, and 10 or more undiscovered deposits in the entire tract consistent with the grade and tonnage model for low-fluorine porphyry molybdenum deposits by Menzie and Theodore (1986). For that portion of the tract that falls within the ICBEMP boundary, the team estimated 0, 1, 4, 6, and 8 undiscovered deposits consistent with the grade and tonnage model for low-fluorine porphyry molybdenum deposits by Menzie and Theodore (1986).

W139

Porphyry Mo Deposits
Descriptive Model 21b
• 0.2 undiscovered deposits

Washington
Idaho

by Arthur A. Bookstrom, Stephen E. Box, and Michael L. Zientek

Rationale for Tract Delineation

Porphyry-molybdenum permissive tract W139 is located in northeastern Washington and northern Idaho. This tract lies at the southern end of a regional zone of porphyry molybdenum and porphyry copper-molybdenum deposits and occurrences that extends northward into Canada. Permissive tract W139 includes areas of high-level porphyritic intrusions, many of which are associated with molybdenite occurrences, and(or) with veins and alteration minerals that commonly accompany low-fluorine porphyry molybdenum deposits. Metamorphic core complexes are excluded from the permissive tract, because they do not host the high-level porphyritic intrusions necessary to formation of porphyry molybdenum deposits.

Important Examples of Deposit Type

The Mount Tolman deposit, located in northeastern Washington (#1, figure 20b), is a very large, low-grade low-fluorine porphyry molybdenum deposit, which contains at least 444,080 tonnes of molybdenum in 793 million tonnes of ore, averaging 0.056% of molybdenum and .090% of copper. In neighboring British Columbia, the Carmi and Trout Lake deposits also are of this type, but the Brenda deposit fits the porphyry copper-molybdenum model of Cox (1986d).

Rationale for Numerical Estimate

In addition to the known Mount Tolman deposit, there are about 60 clusters of molybdenum occurrences in this permissive terrane, at least 19 of which have some characteristics of low-fluorine porphyry molybdenum deposits, and 5 of which (Stranger Mountain, Ramore, Squaw Mountain, Keno Trail, and Germania) may represent incompletely tested low-fluorine porphyry molybdenum systems (Aubertin and others, 1984). For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 3, and 5 or more undiscovered deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model for low-F porphyry molybdenum deposits by Menzie and Theodore (1986).

W140

Porphyry Mo Deposits
Descriptive Model 21b
• 0.01 undiscovered deposits

Oregon
Washington
Idaho

by Arthur A. Bookstrom, Stephen E. Box, and Michael L. Zientek

Rationale for Tract Delineation

Porphyry molybdenum deposits are associated with porphyritic intrusions of intermediate to felsic composition. Tract W140 is considered permissive for porphyry molybdenum deposits, because it contains many felsic intrusions of Jurassic and Cretaceous age, which occur throughout the Wallowa, Baker, and Olds Ferry terranes of eastern Oregon and adjacent parts of west-central Idaho and southeasternmost Washington. Areas of Eocene volcanic and volcaniclastic rocks (Clarno volcanics) are included, because they contain coeval intrusions of intermediate to felsic composition. The boundaries of the tract are generally defined where the cover of younger rocks is greater than 1 km.

Important Examples of Deposit Type

No significant low-fluorine porphyry molybdenum deposits are known to exist in this permissive tract. However, molybdenite is present in some copper skarns of the Seven Devils area, and in the Cuddy Mountains, at the IXL porphyry copper-molybdenum prospect, and the Kismet breccia pipe.

Rationale for Numerical Estimate

Although the geology of this tract is permissive for low-fluorine porphyry molybdenum deposits, the absence of significant known deposits of this type led the team to consider the probability for undiscovered deposits of this type to be very low in this tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model for low-F porphyry molybdenum deposits by Menzie and Theodore (1986).

W143

Porphyry Mo Deposits
Descriptive Model 21b
• 0.01 mean undiscovered deposits

Washington
Idaho
Montana

by Arthur A. Bookstrom, Stephen E. Box, and Michael L. Zientek

Rationale for Tract Delineation

Tract W143 is delineated to include widely distributed Cretaceous and Tertiary intrusions of intermediate to felsic composition, which are considered permissive for porphyry molybdenum mineralization.

Important Examples of Deposit Type

The Liver Peak stockwork porphyry molybdenum-tungsten deposit (#2, figure 20b) is the single known porphyry molybdenum deposit in tract W143. Drill core and descriptions provided by Noranda Exploration, Inc., show that the Liver Peak deposit is associated with a buried composite pluton of leucocratic quartz monzonite porphyry. According to Harrison, Leach, Kleinkopf, and Long (1986), the age of the pluton is about 45-50 million years, and the age of the mineralization is about 40 Ma. The pluton intrudes metasedimentary rocks of the Prichard and Revett Formations. Carbonate-bearing rocks of the overlying Wallace Formation contain tremolite. Host rocks that contain no carbonate are altered to biotite hornfels. The principal ore minerals are molybdenite, which occurs in a stockwork of veinlets in the pluton, and scheelite, which occurs in the calc-silicate contact metamorphic zone (Harrison, Leach, Kleinkopf, and Long, 1986).

Rationale for Numerical Estimate

The Liver Peak porphyry molybdenum deposit is the only known molybdenum deposit in tract W143. According to Harrison, Leach, Kleinkopf , and Long (1986), the composite Liver Peak intrusion is unique in composition among the known plutons of the Wallace 1^{o}x2^{o}quadrangle, and it has a unique geophysical signature. A large positive aeromagnetic anomaly, caused by the high magnetite content of the quartz monzonite porphyry, correlates with a distinct gravity low, caused by the low density of the pluton and its low-resistivity altered zone. The uniqueness of the Liver Peak deposit led the team to give a very low estimate for undiscovered low-fluorine porphyry molybdenum deposits in tract W143. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered low-fluorine porphyry-molybdenum deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Menzie and Theodore (1986).

X3

Porphyry Mo Deposits

Descriptive Model 21b

• 0.4 mean undiscovered deposits (estimate for ICBEMP portion only)

Nevada
Oregon
Idaho

by Stephen G. Peters, Dennis P. Cox, and Arthur A. Bookstrom

Rationale for Tract Delineation

The rationale for delineation of low-fluorine porphyry-molybdenum permissive tract X3 (fig. 20a) is similar to that for delineation of porphyry copper tract W25 (fig. 19a). The X3 permissive tract for porphyry molybdenum deposits in northern Nevada is defined by areas extending 10 km outward from outcrops of plutons, or from inferred subsurface boundaries of plutons, based on their geophysical expressions. It also includes areas around plutons whose presence is inferred from occurrences of skarns, arrays of veins, zones of hydrothermal alteration, and(or) geophysical anomalies. Plutons in northern Nevada are of Jurassic, Cretaceous, and Tertiary age. All are considered permissive for porphyry molybdenum deposits. Porphyry molybdenum deposits tend to form in and around epizonal plutons rather than deep-seated batholiths, but no part of the tract could be excluded on this basis, because insufficient paleodepth information is available. Areas covered by more than 1 km of Upper Tertiary and Quaternary rocks and sediments are excluded. Tertiary plutons within Tertiary volcanic rocks are considered permissive, but pre-Tertiary plutons beneath Tertiary calderas are excluded.

Important Examples of Deposit Type

The Buckingham deposit (#10, figure 20b) is a major low-fluorine porphyry molybdenum deposit, located in the northern Battle Mountains, near the town of Battle Mountain, in Lander County, Nevada. The geology of the Buckingham deposit has been described by Theodore and others (1992). The Mount Hope deposit (#11, figure 20b) is a major transitional Climax-type deposit, located in the southeastern Roberts Mountains, northeast of the town of Eureka, in Eureka County, Nevada. The geology of the Mount Hope deposit has been described by Westra and Riedell (1995).

Rationale for Numerical Estimate (ICBEMP portion only)

A numerical estimate was made only for that part of tract X3 that lies within the ICBEMP study area in northeastern Nevada (figure 20a). Numbers of undiscovered porphyry molybdenum deposits have previously been estimated by county in northeastern Nevada

(Singer, 1996). The ICBEMP portion of tract X3 lies within two counties. To arrive at the numerical estimate of undiscovered porphyry molybdenum deposits in the ICBEMP portion of tract X3, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and total area of permissive tract within those two counties. This yields an estimated 0.36 mean undiscovered deposits for the part of the ICBEMP study that extends into northeastern Nevada. The general lack of prospects in the portions of tract X3 that extend into Oregon and leads us to assume this estimate is valid for the whole ICBEMP portion of tract X3. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 2, 3, and 5 or more deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model of Menzie and Theodore (1986) is equivalent to the estimated number of mean undiscovered deposits derived above.

X4 — Porphyry Mo Deposits — Utah, Idaho

Descriptive Model 21b

• 0.01 mean undiscovered deposits
(estimate for ICBEMP portion only)

by Douglas B.Stoeser and Arthur A. Bookstrom

Rationale for Tract Delineation

The rationale for delineation of porphyry molybdenum permissive-tract X4 is similar to that for delineation of porphyry-copper permissive tract C27. In northern Utah, two adjacent, east-west trending belts of igneous intrusions and intrusion-related mineral deposits (the Oquirrh-Uintah belt and the Tintic-Deep Creek belt) combine to form a large east-west trending permissive tract. Igneous rocks range from intermediate to silicic in composition, and from 43 to 32 Ma in age. Once-extensive silicic volcanic rocks have been eroded, so that much of the area is characterized by mineral deposits related directly to outcropping intrusive centers. Nevertheless, about 70 percent of the area is covered by alluvium.

Important Examples of Deposit Type

No porphyry molybdenum deposits are known in this tract. However, the Bingham Canyon porphyry copper-gold-molybdenum deposit (#18, figure 20b) is one of the largest producers of molybdenum in the world.

Rationale for Numerical Estimate (ICBEMP portion only)

The lack of known prospects and the long exploration history in the ICBEMP portion of tract X4 leads us to give a very low potential for undiscovered porphyry molybdenum deposits in that area. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered porphyry copper deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Menzie and Theodore (1986).

X5 — Porphyry Mo Deposits — California, Oregon

Descriptive Model 21b

No estimate of undiscovered deposits

by Dennis P. Cox, Roger P. Ashley and Arthur A. Bookstrom

Rationale for Tract Delineation

The rational for delineation porphyry-molybdenum permissive tract X5 is similar to that for delineation of porphyry copper tract PC 34. These permissive tracts include the major plutons and polymetallic vein sets of the Sierra Nevada and Klamath Mountains. Many of the major plutons of this tract are mafic to intermediate in composition, and probably are more likely to be associated with porphyry copper or copper-gold deposits than with porphyry copper-molybdenum or porphyry molybdenum deposits.

Important Examples of Deposit Type

No significant porphyry molybdenum deposits are known in tract X5.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered porphyry molybdenum deposits was made.

Sediment-hosted Cu, Revett-type deposits

General Deposit Description

Revett-type Cu deposits are one of three subtypes of sediment-hosted copper deposits that are distinguished based on geologic setting, tonnage, and grade (Dennis Cox, written communication, 1994). Revett-type Cu deposits occur in quartzite beds of the Revett Formation of the middle Proterozoic Belt Supergroup in western Montana and adjacent areas (Harrison, 1972). The deposits consist of elongate, stratiform bodies in which argentiferous copper sulfides and native silver occur as intergranular cements and as irregular replacement of clasts (Hayes and Einaudi, 1986). The sulfide and gangue components vary in mineralogy across a typical deposit, forming mappable zones of particular sulfide and gangue association (i.e. pyrite-calcite, chalcopyrite-ankerite, hematite, etc.). The median size of a Revett-type sediment-hosted copper deposit is 19 million tonnes with 0.86 % Cu and 40 grams/tonne Ag (Spanski, 1992).

The sediment-hosted copper deposits form from a redox reaction between an oxidized brine (containing dissolved copper) and a reductant. The brine, in equilibrium with hematite and free of sulfide, maintains the copper in solution as a stable complex ion. The source of the brines may be trapped seawater or fluids derived from evaporite basins. The copper in the brines may be derived from volcanic rock clasts and labile clastic minerals in redbeds, hydrous ferrous oxide cements in redbeds, or subaerial mafic volcanic rocks. Deposits of the Revett model are a silver-rich variant of the sediment-hosted copper deposits. Cu-bearing oxidized brines migrated into reduced, permeable quartzites to form roll-front-like, mineralogically-zoned deposits at the redox boundary.

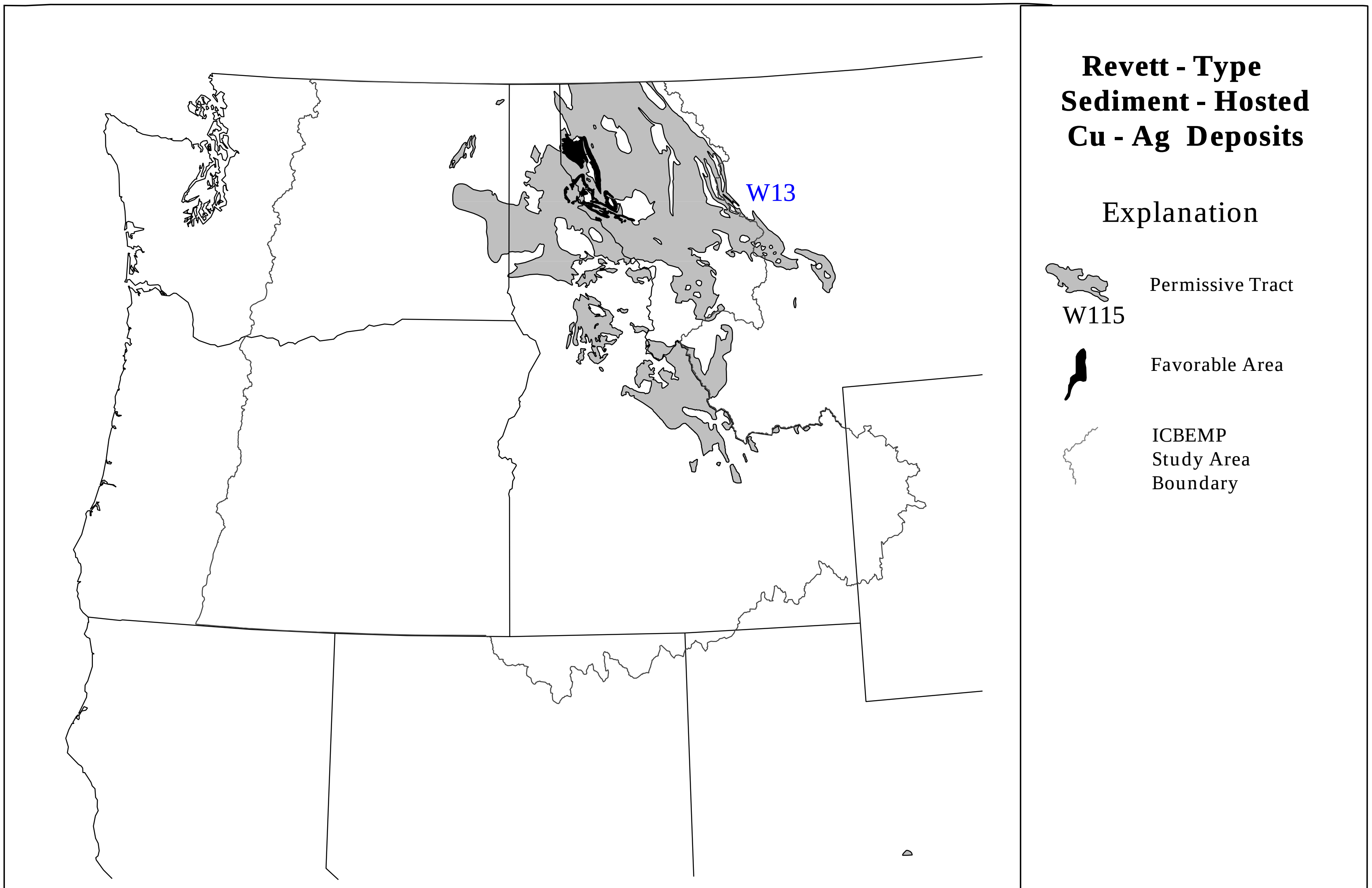
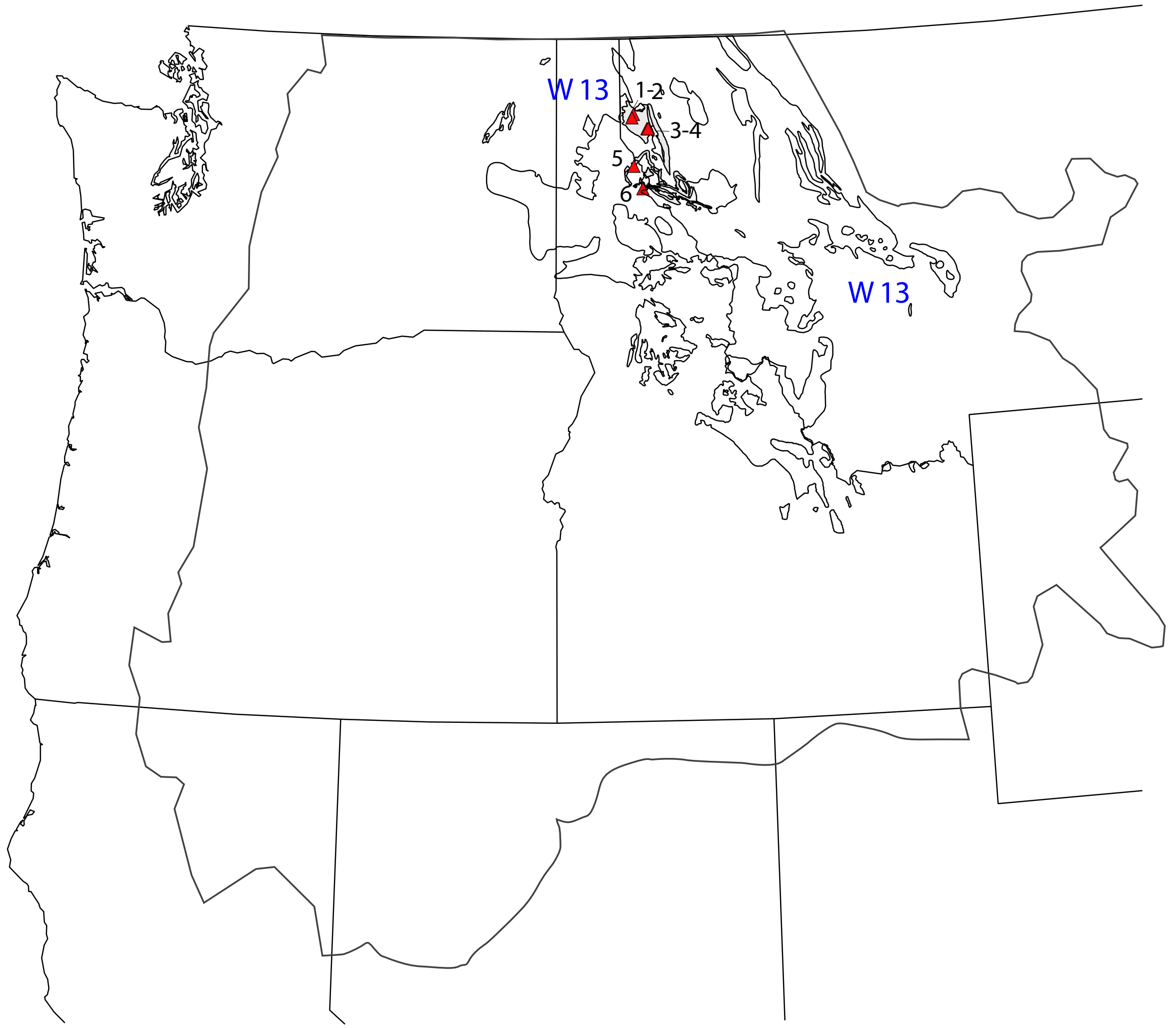


Figure 21a: Permissive and favorable tracts for Revett-type sediment-hosted Cu-Ag deposits.



Revett - Type Sediment - Hosted Cu - Ag Deposits

Explanation

W 115 — Permissive Tract

Favorable Area

Landscape Characterization Boundary for ICBEMP

4 — Significant Revett-Type Sediment-Hosted Cu-Ag Deposit

Figure 21b: Location of significant Revett-type sediment-hosted Cu-Ag deposits in the map area.

Table 21: Significant Revett-type sedimentary Cu-Ag deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
01	W13	Troy (Spar Lake)	Cabinet Mountains	Lincoln	MT	48.230	-115.860
02	W13	J-F	Cabinet Mountains	Lincoln	MT	48.193	-115.883
03	W13	Rock Creek	Cabinet Mountains	Lincoln	MT	48.080	-115.660
04	W13	Rock Lake (Montanore)	Cabinet Mountains	Lincoln	MT	48.080	-115.640
05	W13	Eagle Creek		Shoshone	ID	47.698	115.863
06	W13	Snowstorm	Coeur d'Alene	Shoshone	ID	47.467	-115.733

Table 21: Significant Revett-type sedimentary Cu-Ag deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Status		Ag production (tonnes)	Cu production (tonnes)		Ag resource (tonnes)	Cu resource (tonnes)
01	W13	Troy (Spar Lake)	S		2,344	333,000		unk	74,011
02	W13	J-F	F D					630	56,000
03	W13	Rock Creek	F D		none	none		8,924	1,043,352
04	W13	Rock Lake (Montanore)	F D		none	none		7,613	1,159,402
05	W13	Eagle Creek	I D					240	70,500
06	W13	Snowstorm	I M		138	26,215		138	26,000

Tract Descriptions

W13 — Sediment-hosted Cu Deposits, Revett-Type

Montana
Idaho
Washington

Descriptive Model 30B.3
• 11.3 mean undiscovered deposits (entire tract)
• 11.3 mean undiscovered deposits (ICBEMP portion only)

by Michael L. Zientek, Stephen E. Box, and Arthur Bookstrom

Rationale for Tract Delineation

The Revett grade and tonnage model (Spanski, 1992) is based on deposits from the Belt Supergroup, and is clearly the model of choice. Permissive lithologic units in this area include the entire mid-Proterozoic Belt Supergroup above the Prichard Formation and the Yellowjacket Formation and Lemhi Group in Idaho. Although sandstone bodies that host known ore deposits are limited to those areas underlain by the Revett Formation in Idaho and western Montana (Spanski, 1992), reduced sandstone bodies large enough to host deposits comparable in size to Revett orebodies are present throughout the permissive area. For example, arenite-hosted silver-bearing copper deposits occur in Spokane Formation in the eastern part of the Belt basin (Lange and others, 1989) and sediment-hosted Cu-Ag mineralization has been reported to occur in the Yellowjacket Formation and Lemhi group in Idaho (C.R. Allen, personal commun., 1994).

Important Examples of Deposit Type

Numerous deposits and occurrences, including those that comprise the Revett grade and tonnage model are known from the Libby trough in western Montana and Idaho (Lange and Sherry, 1986; Harrison, Domenico, and Leach, 1986; Spanski, 1992). Examples include the Spar Lake deposit (#1, figure 21b: Hayes and Einaudi, 1986) and the Montanore deposit (#4, figure 21b: Adkins, 1993). Green-bed Cu-Ag deposits in the Spokane Formation in the Choteau 1°x2° quadrangle, Montana may have potential for Revett-type mineralization. Green bed-type mineralization is commonly found in the upper part of the Spokane formation in a stratigraphic interval that represents a upwards transition from a predominately oxidized redbed sequence to the reduced siliciclastic-carbonate rocks of the Empire Formation. Earhart and others (1981) describe mineralized zones that range up to 3 m in thickness and may extend for 49 km on strike. Earhart and others (1981) estimate that one zone in the upper part of the Spokane Formation may contain about 35 million tons of submarginal resources that average 0.1 percent Cu and 7.1 g/t Ag. This interval of mineralized Spokane Formation is also described by Lange and others (1989). Although copper grades are lower than most Revett-type deposits, tonnages are comparable (Spanski, 1992). In Idaho, sediment hosted Cu-Ag occurrences reported in a diamictite in the Lemhi Group in the Lemhi Range and at the Freeman Creek area in the Yellowjacket Formation in the Bitterroot Range are large enough to be considered as exploration targets (C.R.. Allen, personal commun., 1994). We do not have enough information on these deposits in Idaho to differentiate them into the Revett or redbed models.

Rationale for Numerical Estimate

The estimate for Revett-type deposits was based on earlier quantitative estimates for the most prospective area in western Montana (Spanski, 1992) and from consultation with industry geologists with extensive knowledge of the geology and exploration activity of this region. In the Kootenai National Forest, which covers most, but not all, of the area favorable for Revett-type deposits, Spanski (1992) describes 26 occurrences of Revett-type mineralization. Of these, 13 are sufficiently explored to assure their status as deposits. Four of the 13 have reported grades and tonnages, leaving 9 as only partially determined. The estimation team used this number of partially explored deposits for their estimate for the 90th percentile. Spanski (1992) estimated the following distribution for undiscovered Revett-type deposits for one tract in the Kootenai Forest: 25 deposits at the 90th percentile, 50 at the 50th percentile and 85 at the 10th percentile. The team consulted with members of the estimation team for the Kootenai Forest and with exploration geologists in private industry. Based on these discussion, the team made a lower estimate for undiscovered deposits in the Belt Basin than was earlier reported for the Kootenai Forest. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 9, 10, 15, 20, and 30 or more Revett-type deposits consistent with the grade and tonnage model of Spanski (1992). Since most of the permissive tract and all of the favorable areas lie within the ICBEMP, the estimate for the ICBEMP portion of the tract is the same as that given above.

Sedimentary Exhalative Zn-Pb Deposits

General Deposit Description

These stratabound, massive Zn-Pb sulfide deposits, more conveniently referred to as sedex deposits, form by the precipitation of sulfide and sulfate minerals from metalliferous brines that were exhaled along submarine faults that were active during deposition of the enclosing sedimentary sequence (Large, 1980). The mineral deposits are dominantly Fe sulfide accumulations, which enclose economic ore deposits as layers and lenses rich in Zn and Pb sulfides. Bedded barite deposits occur in close association with sedex deposits in some areas. These syngenetic deposits are hosted in reduced, organic-rich marine sedimentary rocks in epicratonic and intracratonic basins, often associated with synsedimentary faults (Briskey, 1986a). The median size of a deposit of this type is 15 million metric tonnes with median grades of 5.6% Zn, 2.8% Pb, and 160 g Ag/tonne (Menzie and Mosier, 1986).

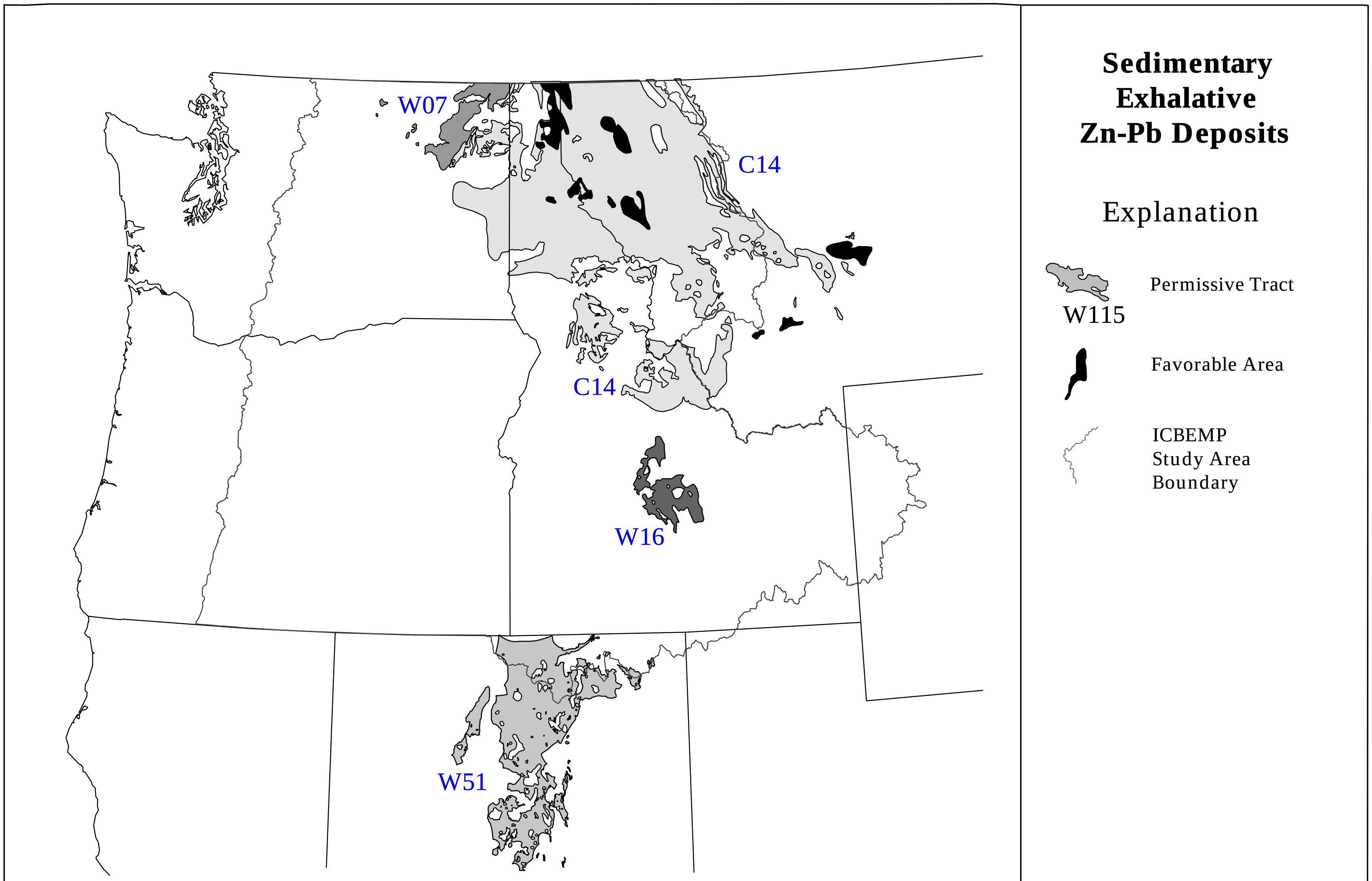


Figure 22a: Permissive and favorable tracts for Sedimentary exhalative Zn-Pb deposits.

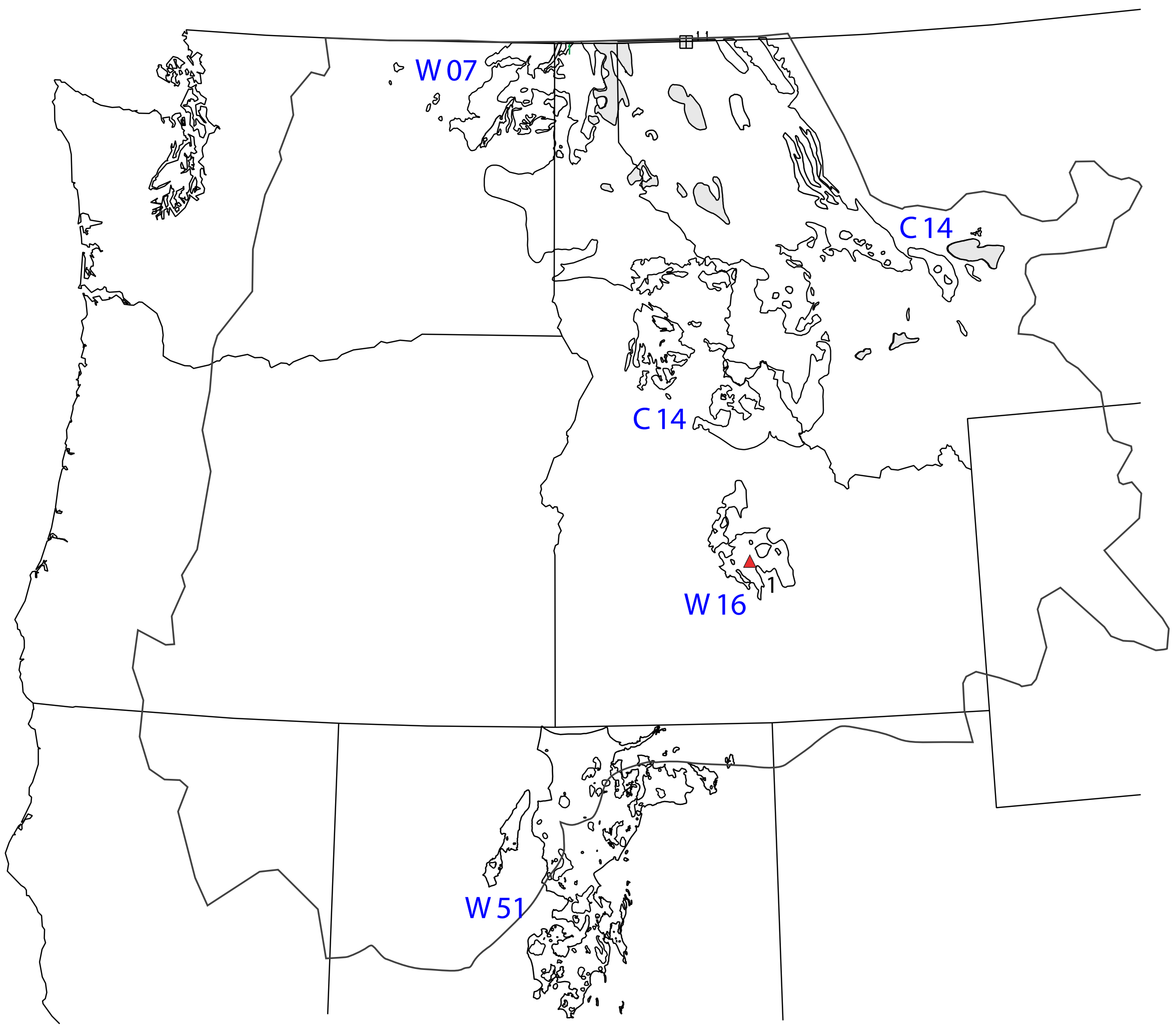


Figure 22b: Location of significant Sedimentary exhalative Zn-Pb deposits in the map area.

Sedimentary Exhalative Zn-Pb Deposits

Explanation

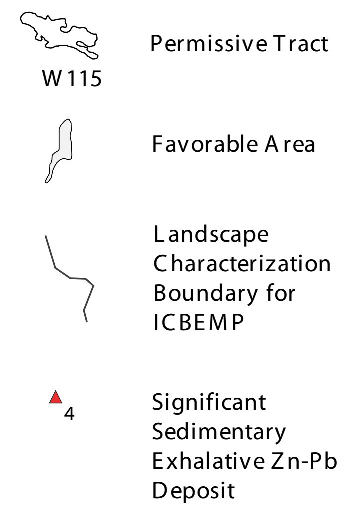


Table 22: Significant sedimentary-exhalative Zn-Pb deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W16	Triumph	Warm Springs	Blaine	ID	43.665	-114.284	I M

Table 22: Significant sedimentary-exhalative Zn-Pb deposits in the map area
(see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Pb resource (tonnes)	Zn resource (tonnes)
01	W16	Triumph	2.35	258	neg	38,840	63,477	0.69	76	neg	11,442	18,700

C14 | **Sedimentary Exhalative Zn-Pb Deposits** | **Montana Washington Idaho**

Descriptive Model 31a

• 2.2 mean undiscovered deposits (entire tract)

• 1.4 mean undiscovered deposits (ICBEMP portion only)

by Michael Zientek, Stephen E. Box, and Arthur Bookstrom

Rationale for Tract Delineation

Proterozoic sedimentary rocks deposited in intracratonic basins that formed along the rifted continental margin of North America (Belt-Yellowjacket basin) have Zn-Pb deposits and occurrences as well as evidence for syndepositional faulting and fluid movement. Traditionally, exploration for sedimentary exhalative Zn-Pb deposits in the Belt basin has focused on a particular horizon (the host horizon of the Sullivan deposit) in the Prichard Group, the lowest member of the Belt Supergroup. More recent exploration strategies have expanded the search to all black shale horizons throughout the Belt basin. Two other black shale horizons are now known from the lower Belt. In the central and western parts of the basin, one black shale horizon in the Ravalli Group, one in the middle Belt carbonates, and up to four in the upper Belt are considered viable targets. Thus, the permissive area for undiscovered deposits was defined by the outcrop of the entire Proterozoic Belt Supergroup rocks in northern Idaho and western Montana (including highly metamorphosed areas marginal to the Idaho batholith) as well as rocks mapped as Yellowjacket Formation and Lemhi Group in Idaho.

Examples of Deposit Type

Only one large sedimentary exhalative Zn-Pb deposit is known in the Belt basin: the Sullivan deposit in southeastern British Columbia (Hamilton and others, 1982). That deposit is much larger than the median or mean deposit size of the grade and tonnage distributions of Menzie and Mosier (1986).

Rationale for Numerical Estimate

We examined the general applicability of the grade and tonnage model of Menzie and Mosier (1986) to the Proterozoic Belt basin. Are the grade and tonnages of Proterozoic and Phanerozoic deposits around the world different? No differences in grade and tonnage are apparent, and we decided that no modification of the grade and tonnage models is warranted.

Exhalative massive sulfide deposits are known only from the informally named "lower Belt" , which includes the Prichard, Aldridge, and Newland Formations, and the Yellowjacket Formation. Exhalative mineralization includes Zn-Pb deposits such as the Sullivan mine in Canada but also Cu-Co deposits at Sheep Creek, Montana and Blackbird, Idaho. In addition to these 3 deposits with reported grades and tonnages, exploration for sedimentary-exhalative deposits in the lower Belt basin has identified 11 prospects or districts that have been drilled or mined that have ore grades and 55 exploration targets that have unknown grade but meet 2 or more of the following criteria: (1) appropriate depositional environment, (2) evidence of syndepositional extensional tectonics, (3) evidence for the circulation of hydrothermal fluids, and (4) evidence of synsedimentary sulfide mineralization (J.W. Whipple, personal commun., 1993). Seven of the exploration targets are in British Columbia, 12 are in Idaho, and 36 are in Montana. Information on the location of these targets was not available. These are exhalative targets and may contain either Zn-Pb or Cu-Co mineralization.

Although we lack specific information about the location of all the deposits, prospects, and exploration targets summarized above, some favorable areas can be identified. Zn-Pb mineralization has been reported near the Cu-Co deposit at Sheep Creek, Montana (#1, figure

3b) and in the Highland Mountains (Soap Gulch prospect), Montana (Thorson, 1984; Thorson, 1993; Zieg and Leitch, 1993). Areas favorable for Sullivan-type Pb-Zn mineralization were identified in both the Wallace (the Perma-Plains area) and Dillon (Highland Mountains) 1° x 2° sheet mineral resource assessments (Pearson and others, 1990; Harrison and others, 1986). Tourmalinization is the alteration type most closely related to mineralization at Sullivan (Turner and others, 1993); Slack (1993) identified at least 30 locations in Proterozoic sedimentary rocks in the United States that may have some relation to sedimentary-exhalative mineralization. At least two of these localities, Trestle Creek (Beaty and others, 1988) and Morning Glory (J.F. Slack, oral comm., 1994), have been drilled. Synsedimentary massive sulfide mineralization has also been described in the Whitehall area (Foster and others, 1993).

Although extensive exploration efforts have focused on the Prichard Formation (and stratigraphic equivalents), only one large Pb-Zn deposit, Sullivan, has been found. One industry source indicated that over $15 million has been expended for exploration in the Prichard in the U.S. over a 15 year period. Mineralized Pb-Zn occurrences that have less than a million metric tons of rock have been identified but no mineable deposits have been found.

Despite this apparent lack of exploration success, several factors suggest the continuing possibility of the discovery of new deposits. Exploration efforts have focused on the lower Belt; reports of sedex-type mineralization in the Middle Belt suggest that some of the other argillaceous units in the Belt may be prospective and are underexplored. All may not be equally prospective, however; the Wallace breccias appear to be more favorable. One industry source offered the following conservative estimates for the discovery of a mineable Pb-Zn deposit in various parts of the Proterozoic basin: 50 percent chance in the Prichard Formation, 50 percent chance in the Helena embayment, 25 percent chance in Wallace breccias within the Middle Belt carbonate, <10 percent chance in the Yellowjacket, and <10 percent chance in the argillaceous units in the Ravalli-Missoula group.

The large permissive area, the presence of one very large known deposit, and many prospective areas are suggestive that undiscovered deposits exist in the upper kilometer of the crust in the permissive tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 2, 4, 6, and 8 or more undiscovered deposits consistent with the grade and tonnage model of Menzie and Mosier (1986) for the entire permissive tract. A lesser estimate of 0, 1, 3, 4, and 7 or more undiscovered deposits is made for the ICBEMP portion of the tract.

W07 — Sedimentary Exhalative Zn-Pb Deposits — Washington

Descriptive Model 31a

• 0.1 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

Paleozoic black shale units in northeastern Washington were deposited in a rifted continental margin slope-and-rise setting and are appropriate hosts for this deposit type. All sedimentary units with significant black shales in northeastern Washington (exclusive of the Belt Supergroup and equivalents) are regarded as permissive for Zn-Pb sedimentary exhalative deposits. The permissive tract is defined by lithologic units that include the Late Proterozoic Windermere Group, the Lower Paleozoic Metaline sequence and the Paleozoic Covada Group (Stoffel and others, 1991).

Examples of Deposit Type

Three small prospects occur in Paleozoic deep-water strata in northeastern Washington, although they are too small to be considered significant deposits. Two of these occur in the Covada Group, an Upper Paleozoic continental slope-and-rise sequence. One prospect is known east of the Covada Group in Lower Paleozoic shales of the Metaline continental shelf-slope sequence. Numerous barite occurrences and Pb and Zn prospects in the area could also be examples of this deposit type, although other Pb- and Zn-bearing deposit types are also present in the area.

Rationale for Numerical Estimate

None of the known prospects is large enough to be comparable to deposits in the grade and tonnage model of Menzie and Mosier (1986). Cominco has had an exploration effort in northeastern Washington for many years, so the assessment team considered the area to have been thoroughly explored. However exposure in the area is poor, structure is complex, and forest cover is extensive, so that the team judged that some undiscovered deposits might remain. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 2, and 4 or more for deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Menzie and Mosier (1986).

W16 — Sedimentary Exhalative Zn-Pb Deposits — Idaho

Descriptive Model 31a

• 0.1 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

Paleozoic sedimentary rocks in central Idaho east of the Idaho batholith consist of complexly deformed black shale units (Hall, 1986). The tract was drawn to encompass the Lower and Upper Paleozoic, deep-marine sedimentary rocks of the Wood River Valley region in south-central Idaho (Bond, 1978). Abrupt facies changes and interstratified slump breccias suggest the presence of synsedimentary faults. Numerous lead and zinc occurrences within the tract, as well as one known deposit of this type, suggest the possibility of undiscovered deposits.

Examples of Deposit Type

The Triumph deposit (#1, figure 22b: Kiilsgaard, 1950) near Ketchum, Idaho is considered to be a deposit of this type. The deposit is small relative to those of the grade and tonnage distributions of Menzie and Mosier (1986). Although the grade of lead and zinc are higher than 80 percent and 60 percent, respectively, of the model deposits, the tonnage is less than 10 percent of the median value. As a result the total metal content of the Triumph deposit (production and reserves) is only about 3 percent of that of typical deposits of this type.

Rationale for Numerical Estimate

The Triumph deposit is very small relative to other deposits in the grade and tonnage distributions for sedimentary exhalative Zn-Pb deposits (Menzie and Mosier, 1986). One other deposit (Minnie Moore mine) had lead and zinc production only slightly less than the minimum requirements for a "significant deposit".. The region was extensively explored for this deposit type in the 1970s and 1980s by Exxon and Noranda, with no new discoveries reported. However the occurrence of a known deposit and several prospects, along with the complex structure of the region and the possibility of structurally or stratigraphically buried deposits that could elude exploration, the team judged that there was a low but still viable chance for undiscovered deposits in this tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 2, and 3 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model of Menzie and Mosier (1986).

W51 **Sedimentary Exhalative Zn-Pb Deposits** **Nevada**

Descriptive Model 31a

• 0.01 mean undiscovered deposits
(ICBEMP portion only)

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

Turner and others (1989) noted similarities between the Roberts Mountains assemblage in Nevada and lower Paleozoic strata in the northern Canadian Cordillera which host numerous large sedimentary exhalative Zn-Pb deposits. The permissive tract consists of the Roberts Mountains assemblage in Nevada. The eastern part of the tract, underlain by shale and chert of the Vinini Formation, probably has a higher probability of deposits because these rocks are most similar to the host rocks typical of sedex deposits.

Examples of Deposit Type

There are no known examples of this type in Nevada, However bedded barite deposits, which occur in close association with sedex deposits in some areas, are widespread in the Roberts Mountain assemblage. Ketner (1991) described stratabound gossans containing high values of lead, zinc, and silver in lower Middle Ordovician and Lower Silurian rocks in northeastern Nevada that are strongly suggestive of sedex deposits.

Rationale for Numerical Estimate (ICBEMP portion of tract only)

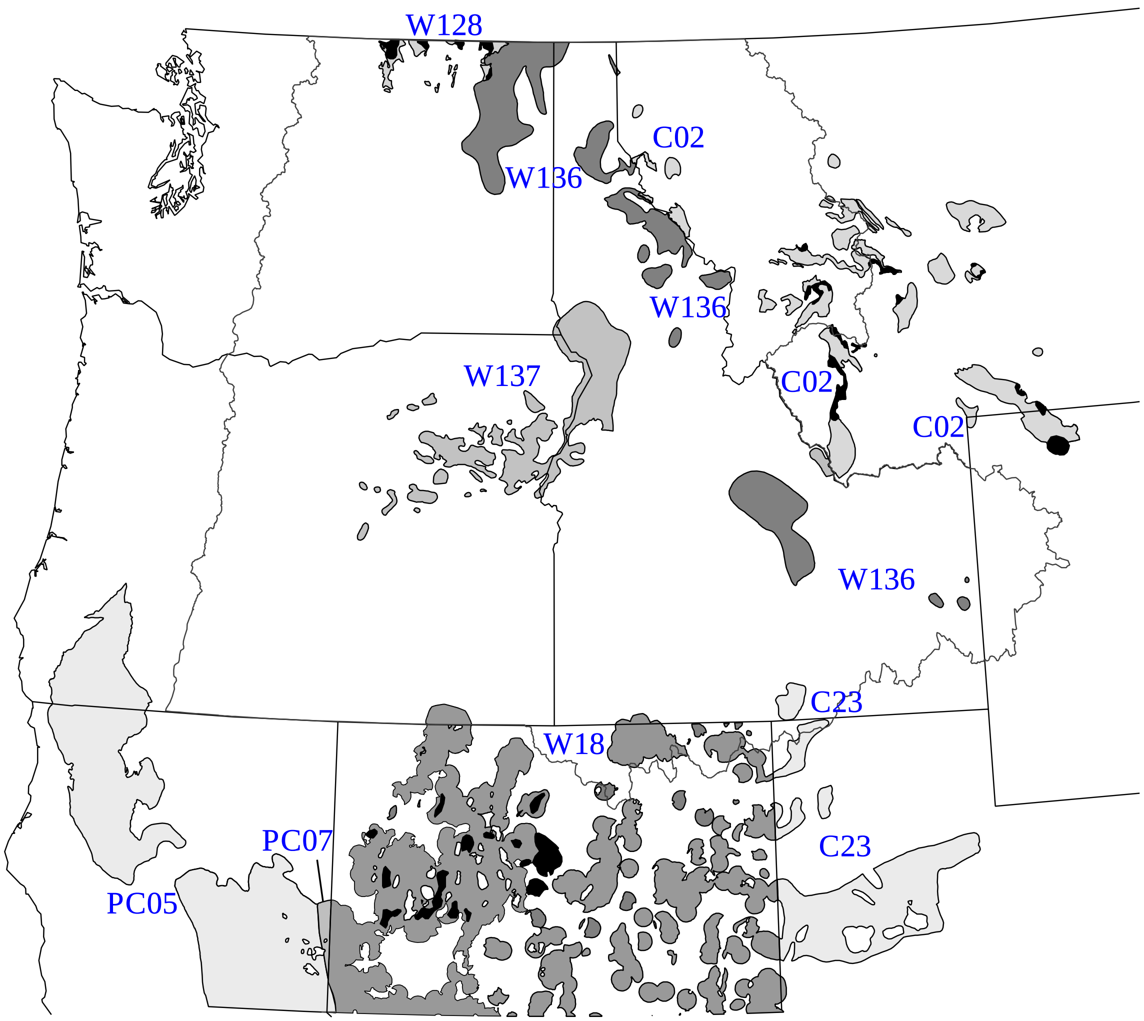
A numerical estimate was made only for that part of tract W51 that lies within the ICBEMP study area (figure 22a). An estimate of the number of undiscovered sedimentary exhalative Zn-Pb deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W51 lies within two counties. To arrive at the numerical estimate of undiscovered sedimentary exhalative Zn-Pb deposits in the ICBEMP portion of tract W51, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and of the total area of permissive tract within those two counties. This yields an estimated 0.01 mean porphyry copper deposits for the part of the ICBEMP study that extends into tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Menzie and Mosier (1986) is equivalent to the estimated number of mean undiscovered deposits derived above.

Skarn Au Deposits

General Deposit Description

Skarns are metallic sulfide and oxide replacement deposits that occur in carbonate host lithologies adjacent to shallow plutonic bodies with metal-bearing hydrothermal systems (Einaudi and others, 1981). Pyroxene and garnet are the most important diagnostic skarn minerals. Skarn Au deposits are a subset of a spectrum of skarn types that are variously copper-, zinc-lead-, or iron-rich . Theodore and others (1991) recognize a class of skarn deposits as gold-bearing skarn if they have an average gold grade of at least 1 g/t and typical skarn mineralogy. They recognize two subtypes of gold-bearing skarns: gold-skarn and byproduct gold-skarn. They define gold-skarns as skarn deposits where gold is the principal commodity, and byproduct gold skarns as deposits where gold had been or is being recovered as a byproduct. Only the gold-skarn subtype is considered here, because byproduct gold skarns are primarily Cu skarn and Pb-Zn skarn and these deposit types are considered elsewhere.

The main criteria used for this model are: (1) The deposits must have an average gold grade of at least 1 g/t, and (2) the mineral assemblage of the deposit must be representative of a skarn environment. Gold-bearing skarns are commonly the result of large-scale metasomatic transfer of components between hydrothermal fluids and predominately carbonate rocks. They are generally calcic exoskarns associated with intense retrograde hydrosilicate alteration. The carbonate bodies that host the mineralization need not be regionally extensive, but can be small local bodies that are widely scattered. The igneous rocks act as the heat source and, in most cases, the source of components for the hydrothermal fluids. Gold-bearing skarns can be associated with porphyry copper or copper-molybdenum, polymetallic replacement, and polymetallic vein deposits. The median deposit for this model (Theodore and others, 1991) is quite small (213,000 metric tons at 8.6 g/t equaling 59,000 oz Au).



Skarn Au Deposits

Explanation

Permissive Tract
W115

Favorable Area

ICBEMP
Study Area
Boundary

Figure 23a: Permissive and favorable tracts for Skarn Au deposits.

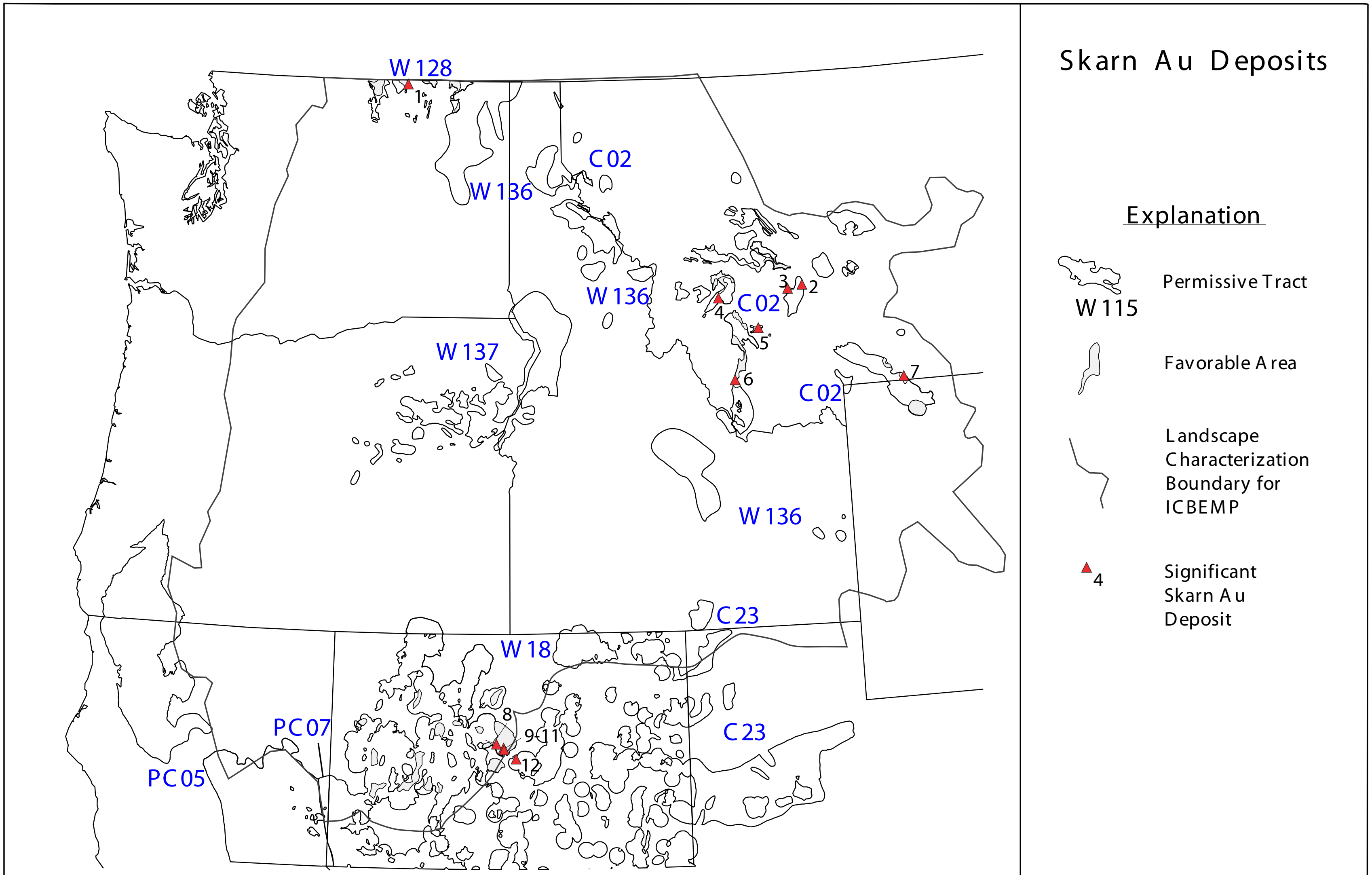


Figure 23b: Location of significant Skarn Au deposits in the map area.

Table 23: Significant Au skarn deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	W128	Buckhorn Mountain (Crown Jewel)	Meyers Creek	Okanogan	WA	48.956	-118.983	F D
02	C02	Diamond Hill	Indian Creek (Hassel)	Broadwater	MT	46.313	-111.675	F M
03	C02	Elkhorn (Swan Gold?)	Elkhorn	Jefferson	MT	46.273	-111.942	F D
04	C02	Cable	Georgetown (Cable)	Deer Lodge	MT	46.200	-113.216	P
05	C02	Butte Highlands	Highland	Silver Bow	MT	45.797	-112.516	I M e
06	C02	Bannack district	Bannack	Beaverhead	MT	45.155	-112.985	I M
07	C02	New World	New World	Park	MT	45.060	-109.960	F M
08	W18	Buffalo Valley	Battle Mountain	Lander	NV	40.600	-117.250	I M
09	W18	Fortitude - Surprise	Battle Mountain	Lander	NV	40.550	-117.130	I M x
10	W18	Northeast Extension (Silver King)	Battle Mountain	Lander	NV	40.550	-117.130	I M x
11	W18	Tomboy-Minnie	Battle Mountain	Lander	NV	40.530	-117.120	I M x
12	W18	Horse Canyon	Lewis	Lander	NV	40.410	-116.920	P

Table 23: Significant Au skarn deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)
01	W128	Buckhorn Mountain (Crown Jewel)	none	none	none	none	50	unk	unk
02	C02	Diamond Hill	0.81				17		
03	C02	Elkhorn (Swan Gold?)					16		
04	C02	Cable	4.67	4.0					
05	C02	Butte Highlands	2.00	0.09					
06	C02	Bannack district	3.12	8.9	105	157			
07	C02	New World	1.94	2.9	891				81,864
08	W18	Buffalo Valley	1.77						
09	W18	Fortitude - Surprise	59.41	156			4.5	39	
10	W18	Northeast Extension (Silver King)					4.1	21	1,540
11	W18	Tomboy-Minnie					11	34	32
12	W18	Horse Canyon	1.55				4.2		

Tract Descriptions

C02 | **Au Skarn** | **Montana Wyoming**

Descriptive Model Bull. 1930

• 12.8 mean undiscovered deposits (entire tract)

• 3.9 mean undiscovered deposits (ICBEMP portion only)

by James E. Elliott

Rationale for Tract Delineation

The permissive tract for gold-bearing skarns is the same as that for polymetallic replacement deposits (C07); these areas are located in northwestern, southwestern, and south-central parts of Montana. The tract is made up of those parts of the porphyry copper permissive tracts that have sedimentary carbonate rocks at the surface or at shallow depths (less than 1 km) below the surface, based on geologic maps of Montana (Ross and others, 1955) and Wyoming (Love and Christiansen, 1985). The more favorable parts of these areas are where sedimentary carbonate rocks are near igneous contacts, especially near margins of Late Cretaceous or Eocene granite, granodiorite, or dacite porphyry. The most favorable environment for the occurrence of gold-bearing skarns is at or near an intrusive-sedimentary carbonate contact whereas polymetallic replacement deposits can form at some distance from an intrusive contact.

The most favorable sedimentary carbonate rocks are Paleozoic, and include the Meagher and Pilgrim Formations of Cambrian age, the Jefferson Formation of Devonian age, and the Madison Group of Mississippian age. Less favorable carbonate rocks are Mesozoic (Lower Cretaceous Kootenai Formation and Jurassic Ellis Group) and Middle Proterozoic (Belt Supergroup: Newland, Empire, Helena, and Wallace Formations).

Important Examples of Deposit Type

There are several important gold-bearing skarn deposits and districts in southwestern and south-central Montana. The most important ones are the Bannack district (#6, figure 23b: Loen and Pearson, 1989; Theodore and others, 1991); the Butte Highlands district (#5, figure 23b: Sahinen, 1950); the Silver Star district (Loen and Pearson, 1989); the Cable mine in the Georgetown district (#4, figure 23b Emmons and Calkins, 1913); the New World district (#7, figure 23b Elliott and others, 1992); and the Diamond Hill mine (#2, figure 23b). All of the gold-bearing skarns are located at contacts of intrusive rocks. Two (Butte Highlands and Silver Star) are located at contacts of the Late Cretaceous Boulder batholith with Cambrian sedimentary carbonate rocks, three (Bannack, Cable, and Diamond Hill) are located along margins of small Late Cretaceous stocks, and several deposits in the New World district are located at contacts with Eocene dacitic porphyritic intrusive complexes. Host rocks for these deposits are mostly Paleozoic sedimentary carbonate rocks. The most favorable host rocks are the Cambrian Meagher (or Silver Hill) and Pilgrim (or Hasmark) Formations. The Diamond Hill mine is unusual in that no carbonate rocks are present; the ore bodies occur in garnet-diopside-epidote skarn that replaced Cretaceous volcanic rocks.

Rationale for Numerical Estimate

Within the permissive tract for gold-bearing skarns, six subtracts or areas are favorable for the occurrence of undiscovered gold-bearing skarn deposits. Separate estimates were made for undiscovered gold-bearing skarns in each of these areas. A seventh estimate was made for undiscovered deposits in the remaining less-favorable permissive area. The estimates considered the presence of known deposits, prospects, and favorability of geologic setting. The favorable areas are: (1) the Absaroka-Gallatin volcanic province (Chadwick, 1970) in south-central Montana and northwestern Wyoming; (2) the Dillon area including the eastern margin of the Pioneer batholith and southern margin of the Boulder batholith in southwestern Montana; (3) the Elkhorn area, along the eastern side of the Boulder batholith; (4) the Helena area, along the northern side of the Boulder batholith; (5) the southern Flint Creek Range in southwestern Montana, and (6) the Garnet area, east of Missoula. The individual estimates are:

percentile	90th	50th	10th	5th	1st
Absaroka-Gallatin	2	5	8	10	12
Dillon	0	2	3	4	5
Elkhorn	1	1	2	3	4
Helena	1	1	2	3	4
Flint Creek Range	1	2	3	4	5
Garnet	0	1	1	2	3
Other areas	0	0	1	2	3

Combining these estimates, for the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 5, 12, 20, 28, and 36 or more undiscovered gold skarn deposits consistent with the grade and tonnage model of Theodore and others (1991). For that part of the tract that lies within the ICBEMP study area boundary, the team estimated 1, 4, 6, 9, and 12 or more undiscovered gold skarn deposits.

C23 — Au Skarn, truncated

Utah
Idaho

Descriptive Model Bull. 1930

• 0.01 mean undiscovered deposits
(estimate for ICBEMP portion only)

by Douglas B. Stoeser

Rationale for Tract Delineation

Gold skarns are found in the same areas as skarns enriched in other metals, where epizonal calc-alkaline granitoid stocks intrude carbonate rocks. Theodore and others (1991) indicated that the associated intrusions are typically "compositionally expanded I-type felsic and intermediate plutons, dikes, sills, or stocks that may or may not be porphyritic." They also state that host rocks include a wide variety of sedimentary and igneous rocks, including limestone, dolomite, clastic sedimentary rocks, volcanic rocks, and granitoids, with a calcareous component typically being present. The Tertiary magmatic belts of western Utah contain appropriate intrusives, and because of the approximately seventy percent alluvial cover within the magmatic belts, the unknown distribution of rock types beneath that cover, and the fact that the bulk of the these terranes are underlain by a sedimentary shelf sequence dominated by carbonate sedimentary rocks, we use the same permissive terranes for gold skarns as for porphyry copper deposits.

Important Examples of Deposit Type

There are no significant gold skarn deposits in Utah and the only known occurrence is the Midas deposit in the Gold Hill district that produced 600 metric tons of ore with a grade of 25 g/t Au (Theodore and others, 1991).

Rationale for Numerical Estimate (ICBEMP portion only)

A small portion of the northern part of tract C23 lies within the ICBEMP boundary (figure 23a), and a numerical estimate of undiscovered deposits was made only for that portion of the tract. The lack of known prospects for either skarns or associated porphyry deposits and the long exploration history in the ICBEMP portion of the tract leads us to give a very low potential for undiscovered gold skarn deposits in that area. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered gold skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model (truncated to include only those deposits with more than 15,000 metric tons of mineralized rock) of Theodore and others (1991) for the ICBEMP portion of the tract.

PC05 — Au skarn

California
Oregon

Descriptive Model Bull. 1930
No estimate of undiscovered deposits

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract. The plutons of the Klamath Mountains and the northern Sierra Nevada include felsic rocks that, in places, intrude minor Triassic and older carbonate-bearing rocks (Jennings, 1977; Walker and MacLeod, 1991). Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in this area , hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock.

Important Examples of Deposit Type

The only important skarn deposit in the Klamath Mountains is the King Solomon mine in the Cecilville district, whose production (nearly a metric ton of gold) renders it too small for the minimum size on the significant deposits on Table 23 (Hotz, 1971). There are no significant gold or copper skarn deposits in the tract.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered gold skarn deposits was made.

PC07 — Au skarn

California

Descriptive Model Bull. 1930
No estimate of undiscovered deposits

by Dennis P. Cox

Rationale for Tract Delineation

The permissive tract encompasses many small plutons that intrude Precambrian metamorphic, and Precambrian and Paleozoic sedimentary rocks in a highly faulted part of the Mesozoic continental margin. Plutons, mainly of Jurassic age, are closely associated with copper- and lead-zinc skarns and polymetallic replacement and vein deposits in the Great Basin of California. One or more of these plutons could have given rise to a porphyry copper system, although few examples are known. Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in this area , hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock. Small areas of basin fill more than 1 km in depth are excluded from the tract.

Important Examples of Deposit Type

No significant gold skarn deposits are known within the tract.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered gold skarn deposits was made.

W18

Au Skarn, truncated

Descriptive Model Bull. 1930
• 0.4 mean undiscovered deposits
(estimate for ICBEMP portion only)

Nevada
Idaho
Oregon

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The tract permissive for gold skarn deposits is defined as an area extending 10 km outward from the outcrop of a pluton, or, in the case that the pluton has a geophysical expression as discussed by Grauch and others (1988), from the inferred subsurface boundary of the pluton, based on its geophysical expression. It also includes areas around plutons whose presence is inferred from geophysics or from the occurrence of skarn mineralization. Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in the tract area (Stewart, 1980), hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock.

About 72 percent of the permissive tract is covered by 1 km or less of Upper Tertiary and Quaternary rocks and sediments. Areas covered by more than 1 km (Blakely and Jachens, 1991) are excluded as are areas that are within a Tertiary caldera. In these latter areas, permissive pre-Tertiary host rocks are likely to be covered by more than 1 km of volcanic rock.

Meinert (1989) suggested that host rocks for gold skarns are typically carbonate-bearing sequences with an important clastic or volcaniclastic component. These rocks commonly represent parts of accreted terranes. Because the known examples in Nevada are related to Tertiary plutons, a favorable area for gold skarns might be based on the intersection of Tertiary plutons and accreted terranes of the Black Rock, Paradise, Pine Nut, Golconda, and Roberts Mountains assemblages and the overlying Mesozoic carbonate assemblage. Undiscovered deposits are believed to exist mainly in concealed parts of the permissive tract.

Important Examples of Deposit Type

Skarn deposits with gold as the principal product are important in Nevada, as illustrated by the gold production from the Copper Canyon and McCoy areas. Theodore and others (1991) found that the presence of gold is the only consistent difference between gold-bearing and non gold-bearing base-metal skarns. Deposits in which gold is the major product are included in this model. Five of these are in the Battle Mountain district (#8-12, figure 23b); all are above the median tonnage; but only one deposit, Fortitude, is richer than the median gold grade (8.6 g/mt).

Rationale for Numerical Estimate (ICBEMP portion only)

A small portion of the northern part of tract W18 lies within the ICBEMP boundary (figure 23a), and a numerical estimate of undiscovered deposits was made only for that portion of the tract. For the entire state of Nevada, an estimate of 3.5 undiscovered gold skarn deposits was made by the USGS Nevada assessment team (Stephen Ludington, written communication, 1995). The team felt that of those undiscovered deposits, something less than 0.5 deposits occur in the ICBEMP portion of the tract. The small portion of the ICBEMP tract in Oregon and Idaho would not add significantly to that estimate of undiscovered gold skarn deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 2, 4, and 8 or more undiscovered gold skarn deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model (truncated to include only those deposits with more than 15,000 metric tons of mineralized rock) of Theodore and others (1991) in the ICBEMP portion of the tract.

W128 — Au Skarn, truncated — Washington

Descriptive Model Bull. 1930

• 1.5 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract is drawn to encompass the sedimentary rocks of the Quesnellia terrane in northeastern Washington (Stoffel and others, 1991). This terrane includes a belt of Triassic and Jurassic plutons that have generated a string of porphyry copper deposits in British Columbia and northern Washington, along with associated Au and Cu skarn deposits. Carbonate units are irregularly scattered through the Quesnellia terrane, such that the entire terrane is permissive.

Important Examples of Deposit Type

Only one gold-bearing skarn, Buckhorn Mountain, is known in northeastern Washington (#1, figure 23b: Hickey, 1992). This gold skarn deposit is localized within rocks of the Quesnellia terrane around a pluton of uncertain but probable Mesozoic age, and lies to the south of a cluster of gold skarn deposits in southern British Columbia (Theodore and others, 1991), which also occur around Mesozoic plutons in the Quesnellia terrane. The known deposit has very large tonnage greater than 90 percent of the deposits in the tonnage distribution of Theodore and others (1991), with a contained Au content more than 10 times larger than the median Au content from the grade and tonnage distributions.

Rationale for Numerical Estimate

Seven deposits of this type are known in the Quesnellia terrane, all but one in British Columbia. The Buckhorn deposit in Washington, a prospect for nearly one hundred years, was only recently proved to be a significant deposit, and at least five other similar prospects are known in Okanagan County, Washington (Derkey and others, 1990). The association of this deposit type with magnetite mineralization makes buried targets easy to delineate. Since the discovery of the Buckhorn deposit, exploration for this deposit type has been brisk. For these reasons the team expressed cautious optimism about the potential for undiscovered deposits in this tract. Because the grade and tonnage model of Theodore and others (1991) includes some very small deposits, we felt we could estimate more accurately using a model that is truncated to include only those deposits with more than 15,000 metric tons of mineralized rock. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 1, 3, 5, and 7 or more deposits that are comparable in grade and tonnage to the gold skarn grade and tonnage model (truncated) of Theodore and others (1991).

W136 — Au Skarn, truncated — Idaho, Washington

Descriptive Model Bull. 1930

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract. Permissive sedimentary packages include the Paleozoic sequence of northeastern Washington, the middle Belt carbonate units of the Belt Supergroup in northern Idaho, and the Paleozoic sequence of south-central Idaho (Bond, 1978; Stoffel and others, 1991).

Important Examples of Deposit Type

No significant deposits of this type are known from the tract.

Rationale for Numerical Estimate

The lack of known deposits of this type and the lack of known porphyry copper deposits in this tract lead the team to give a very low estimate. Because the grade and tonnage model of Theodore and others (1991) includes some very small deposits, we felt we could estimate more accurately using a model that is truncated to include only those deposits with more than 15,000 metric tons of mineralized rock. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more gold skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model (truncated) of Theodore and others (1991).

W137

Au Skarn, truncated

Descriptive Model Bull. 1930

• 0.01 mean undiscovered deposits

Washington
Oregon
Idaho

by Stephen Box and Arthur Bookstrom

Rationale for tract delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract., and consists of the Wallowa, Baker, and Huntington terranes of northeastern Oregon, west-central Idaho, and southeasternmost Washington (Brooks and Vallier, 1978; Walker and MacLeod, 1991). Plutonic rocks of Jurassic and Cretaceous(?) age are widely scattered through these terranes, and where large enough, these were excluded from the permissive tract. Small, irregular carbonate horizons occur throughout all three structurally complex terranes such that carbonates could be present in the subsurface of any part of these terranes. The Izee terrane of north-central Oregon lacks carbonates and was excluded from the tract.

Important Examples of Deposit Type

No significant deposits are known from this tract.

Rationale for Numerical Estimate

The lack of known deposits of this type and the lack of known porphyry copper deposits in this tract lead the team to give a very low estimate. Because the grade and tonnage model of Theodore and others (1991) includes some very small deposits, we felt we could estimate more accurately using a model that is truncated to include only those deposits with more than 15,000 metric tons of mineralized rock. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more deposits (with a 99% chance of no deposits) that are comparable in grade and tonnage to the gold skarn grade and tonnage model (truncated) of Theodore and others (1991).

Skarn Zn-Pb Deposits

General Deposit Description

Skarns are metallic sulfide and oxide replacement deposits that occur in carbonate host lithologies adjacent to plutonic bodies with metal-bearing hydrothermal systems (Einaudi and others, 1981). Pyroxene and garnet are the most important diagnostic skarn minerals. Zn-Pb skarns are an end-member of a spectrum of skarn deposit types that are variously copper-, zinc-lead-, or iron-rich (Cox, 1986e). The deposits are associated with shallow intermediate plutons, commonly those that are host to porphyry-style mineralization. Zinc-lead skarn deposits are found where carbonate rocks are intruded by granitoids and typically are formed farther from the mineralizing intrusive rock than are copper and iron skarns. Their geologic environment of formation and geographic distribution is similar to the more numerous polymetallic replacement deposits. The carbonate bodies that host the mineralization need not be regionally extensive, but can be small local bodies that are widely scattered essentially throughout the map area. The median size for a Zn-Pb skarn deposit is 1.4 million metric tonnes with 5.9% Zn, 2.8% Pb, and 58 g Ag/tonne (Mosier, 1986b).

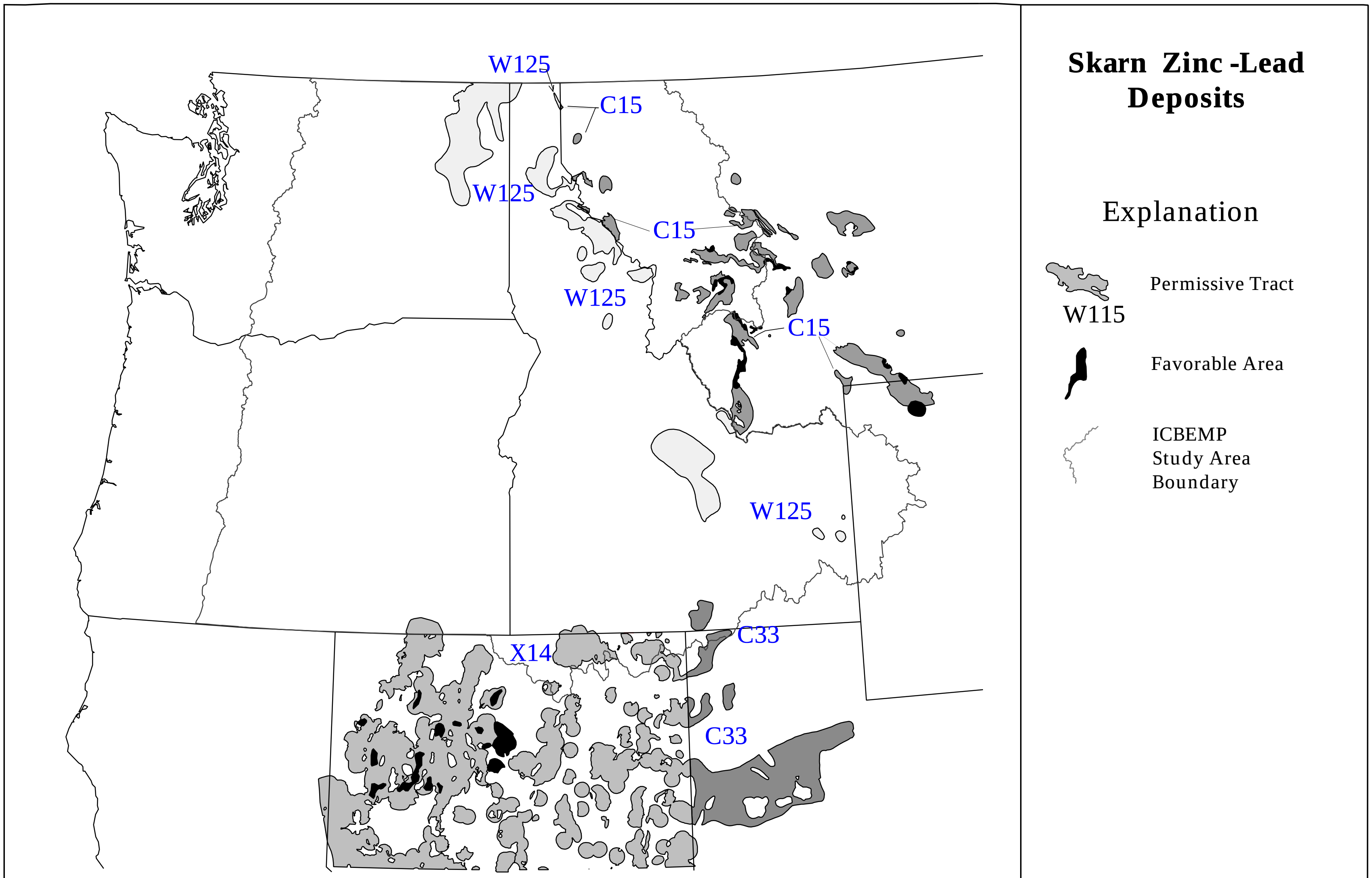


Figure 24a: Permissive and favorable tracts for Skarn Zn-Pb deposits.

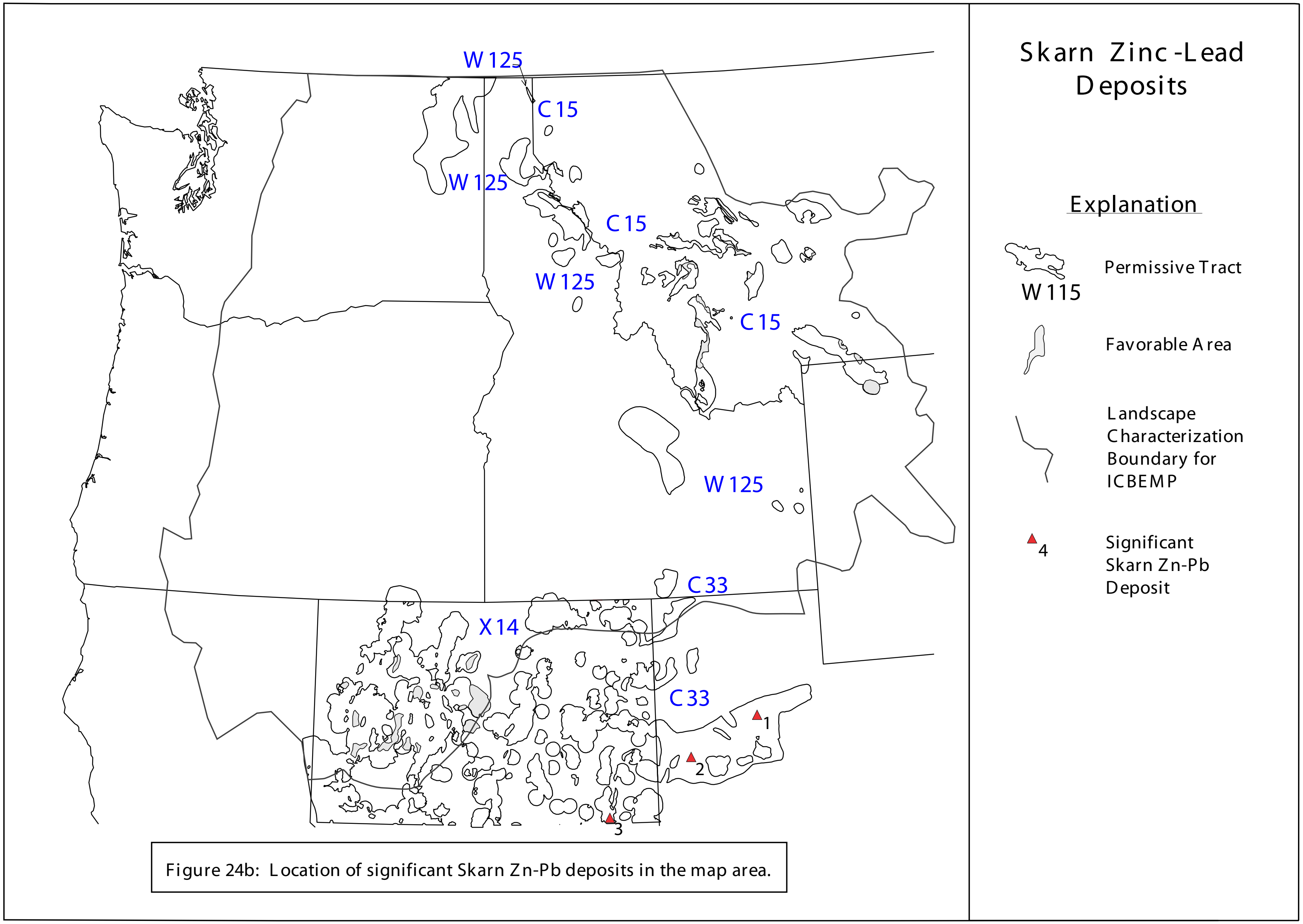


Figure 24b: Location of significant Skarn Zn-Pb deposits in the map area.

Table 24: Significant Zn-Pb skarn deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status
01	C33		Ophir	Tooele	UT	40.380	-112.270	I M
02	C33	Crypto	Fish Springs	Juab	UT	39.860	-113.450	F M
03	X14	Ward	Ward	White Pine	NV	39.080	-114.880	S

Table 24: Significant Zn-Pb skarn deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Pb resource (tonnes)	Zn resource (tonnes)
01	C33		0.27	358	12,706	74,332	3,782					
02	C33	Crypto	0.02	83	2.2	7,844	1	sig	sig	unk	unk	843,700
03	X14	Ward		8.2	927	640	10,480		98	14,300	24,000	112,000

Tract Descriptions

C15 — **Skarn Zn-Pb Deposits** — **Montana Wyoming**

Descriptive Model 18c

• 0.4 mean undiscovered deposits (entire tract)

• 0.1 mean undiscovered deposits (ICBEMP portion only)

by David Frishman

Rationale for Tract Delineation

The maps of Ross and others (1955) and Love and Christiansen (1985) were used to delineate areas where Cretaceous or Tertiary intrusive rocks were emplaced into or were in close proximity to carbonates. Precambrian (Belt Supergroup) and Phanerozoic carbonates were considered separately. The permissive tract for Zn-Pb skarn deposits is identical to the corresponding polymetallic replacement tract. It is within the porphyry copper permissive tracts where sedimentary carbonates are present, either at the surface or at a shallow depth. Areas that make up the tract are located in northwestern, southwestern, and south-central Montana and another area extends southeastward from south of Livingston into northwestern Wyoming.

Important Examples of Deposit Type

No important Zn-Pb skarn deposits are known in either Montana or Wyoming. Very small Pb-skarn deposits (the Mary and Edna mine and the McKinley mine) occur between the Hughsville stock and limestones of the Madison Group in the Barker (Hughsville) mining district in Cascade and Judith Basin Counties, Montana (Witkind, 1973). These deposits, probably between about 45 and 51 Ma in age, contained an insignificant proportion of the 20,000 metric tons of lead, 8,000 metric tons of zinc, and 80 metric tons of silver produced from the district; almost all the production from the district was from polymetallic vein deposits. Polymetallic vein and replacement deposits containing Zn and Pb also occur in close association with Cretaceous or Tertiary intrusive rocks in many mining districts such as the Barker, Elkhorn, Hecla, and Castle Mountain districts, and skarns could occur in these environments.

Rationale for Numerical Estimate

Probably the best prospective area for Zn-Pb skarn deposits is in carbonate terranes near the Pioneer Batholith. The Pioneer Batholith is similar to the Boulder Batholith, and is the host for, or genetically related to many varied base-metal deposits. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 2, 4, and 6 or more deposits (with an 80% chance of no deposits) consistent with the grade and tonnage model for Zn-Pb skarns (Mosier, 1986b). For the ICBEMP portion of the tract, the team estimated 0, 0, 1, 2, and 3 or more deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model for Zn-Pb skarns (Mosier, 1986b).

C33 — Skarn Zn-Pb Deposits

Utah
Idaho

Descriptive Model 18c
• 0.01 mean undiscovered deposits
(ICBEMP portion only)

by Douglas B. Stoeser

Rationale for Tract Delineation

The permissive tract for this deposit type is defined primarily by the distribution of intrusive rocks and suitable reactive host rocks, especially carbonate-bearing sedimentary rocks. Because of the extensive occurrence of carbonate sedimentary rocks in western Utah, and the genetic association with porphyry copper type deposits, we used the same geographic areas as for porphyry copper deposits. The tract consists of three east-trending belts in western Utah. The southernmost of the three is less deeply eroded than the other two, and any undiscovered skarn deposits would most likely be concealed by the volcanic and alluvial cover. Aeromagnetic surveys were employed to define areas of high magnetics that might indicate a buried intrusive body adjacent to which might be concealed skarn deposits.

Important Examples of Deposit Type

Although a relatively rare deposit world-wide, western Utah has two deposits of this type: one in the Ophir district (#1, figure 24b), and the Crypto deposit in the Fish Springs District (#2, figure 24b). Of interest is that Crypto was a blind orebody. There are no known prospects.

Rationale for Numerical Estimate (ICBEMP portion of tract only)

A small portion of the northern part of tract C33 lies within the ICBEMP boundary (figure 24a), and a numerical estimate of undiscovered deposits was made only for that portion of the tract. The lack of known prospects for either skarns or associated porphyry deposits and the long exploration history in the ICBEMP portion of the tract leads us to give a very low potential for undiscovered zinc-lead skarn deposits in that area. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered Zn-Pb skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of (Mosier, 1986b) in the ICBEMP portion of the tract.

W125 — Skarn Zn-Pb Deposits

Idaho
Washington

Descriptive Model 18c
• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract. Permissive sedimentary packages include the Paleozoic sequence of northeastern Washington, the middle Belt carbonate units of the Belt Supergroup in northern Idaho, and the Paleozoic sequence of south-central Idaho (Bond, 1978; Stoffel and others, 1991).

Important Examples of Deposit Type

No significant deposits of this type are known from the tract. A small Zn-Pb skarn mined at the Horseshoe mine near Mackay, Idaho is very small compared to the grade and tonnage distributions of Mosier (1986b).

Rationale for Numerical Estimate

The lack of significant known deposits of this type and the lack of known porphyry copper deposits in this tract lead the team to give a very low estimate. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more Zn-Pb skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Mosier (1986b).

X14

Zn-Pb Skarn Deposits
Descriptive Model 18c
• 0.1 mean undiscovered deposits
(ICBEMP portion only)

Nevada
Idaho
Oregon

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology)

Rationale for Tract Delineation

The tract permissive for zinc-lead skarn deposits is defined as an area extending 10 km outward from the outcrop of a pluton, or, in the case that the pluton has a geophysical expression as discussed by Grauch and others (1988), from the inferred subsurface boundary of the pluton, based on its geophysical expression. It also includes areas around plutons whose presence is inferred from geophysics or from the occurrence of skarn mineralization. The tract covers about 40 percent of the area of the state. Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in Nevada (Stewart, 1980), hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock. Zinc-lead skarn deposits are possible in the same environment as polymetallic replacement deposits.

Areas covered by more than 1 km of Upper Tertiary and Quaternary rocks and sediments (Blakely and Jachens, 1991) are excluded as are areas that are within a Tertiary caldera. In these latter areas, permissive pre-Tertiary host rocks are likely to be covered by more than 1 km of volcanic rock.

Important Examples of Deposit Type

We recognize 16 zinc-lead skarn deposits and occurrences in Nevada, the Ward district (#3, figure 24b) being the most important. Most major zinc-lead skarn and polymetallic replacement districts tend to be associated with plutons of Cretaceous age, but a few major districts and a large number of occurrences are known around Tertiary intrusive centers. A few occurrences are associated with Jurassic plutons in northeast Nevada. Most of the deposits and occurrences are situated in the part of Nevada underlain by Precambrian continental crust, and the host-rocks for most deposits belong to the lower Paleozoic carbonate assemblage. The first carbonate beds above or within the thick Precambrian and lower Cambrian quartzite sequences have long been known to be the most productive (Woodward, 1972; Ivosevic, 1978). Some deposits are known in upper Paleozoic rocks and a few are found in the Luning Formation of Triassic age.

Rationale for Numerical Estimate (ICBEMP portion of tract only)

A numerical estimate was made only for that part of tract X14 that lies within the ICBEMP study area (figure 24a). An estimate of the number of undiscovered Zn-Pb skarn deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract X14 lies within two counties. To arrive at the numerical estimate of undiscovered Zn-Pb skarn deposits in the ICBEMP portion of tract X14, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and of the total area of permissive tract within those two counties. This yields an estimated 0.14 mean Zn-Pb skarn deposits for the part tract X14 within the ICBEMP study area (including the minor permissive tract extensions into Oregon and Idaho). For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 0, 0, 1, 2, and 3 or more undiscovered Zn-Pb skarn deposits (with a 90% chance of no deposits) consistent with the grade and tonnage model Mosier (1986b) is equivalent to the estimated number of mean undiscovered deposits derived above.

Stillwater Ni-Cu deposits

General Deposit Description

Layered, ultramafic to mafic intrusions, such as the Stillwater Complex, Montana, are uncommon in the geologic record (and in the United States) but are economically important because they can host magmatic ore deposits containing economic concentrations of chromium, nickel, copper, titanium, platinum-group elements (PGE) and gold. Stillwater nickel-copper deposits are concentrations of disseminated to massive sulfide minerals enriched in copper and nickel, commonly found near the margins of ultramafic to mafic layered intrusions (Page, 1986c). Sulfide abundance is about 3 to 5 volume percent but large tonnages of matrix and massive sulfide ores are typically present. Typically, sulfide minerals are not uniformly distributed, although, in a general sense, the concentration of sulfide minerals within the intrusion systematically increase towards its contact with its host rocks. Concentrations of sulfide minerals are commonly present in the country rocks adjacent to mineralized igneous rock. Commonly, igneous rocks hosting sulfide deposits are texturally and lithologically heterogeneous, exhibiting changes in texture and mineral proportions on a variety of scales (centimeters to tens of meters). The exsolution of immiscible sulfide liquid from a mafic silicate magma is the fundamental ore forming process. The textures and mineralogy of sulfide ores record a prolonged and complex process of solid state transformation and recrystallization starting after solidification of the sulfide liquid. For the Stillwater Complex, the sulfide mineralogy resulting from the solid state recrystallization of high-temperature sulfide phases is dominated by pyrrhotite, pentlandite, and chalcopyrite.

There are too few deposits of this type to construct statistically robust grade and tonnage distributions. Sizes of deposits range up to hundred’s of millions of tons.

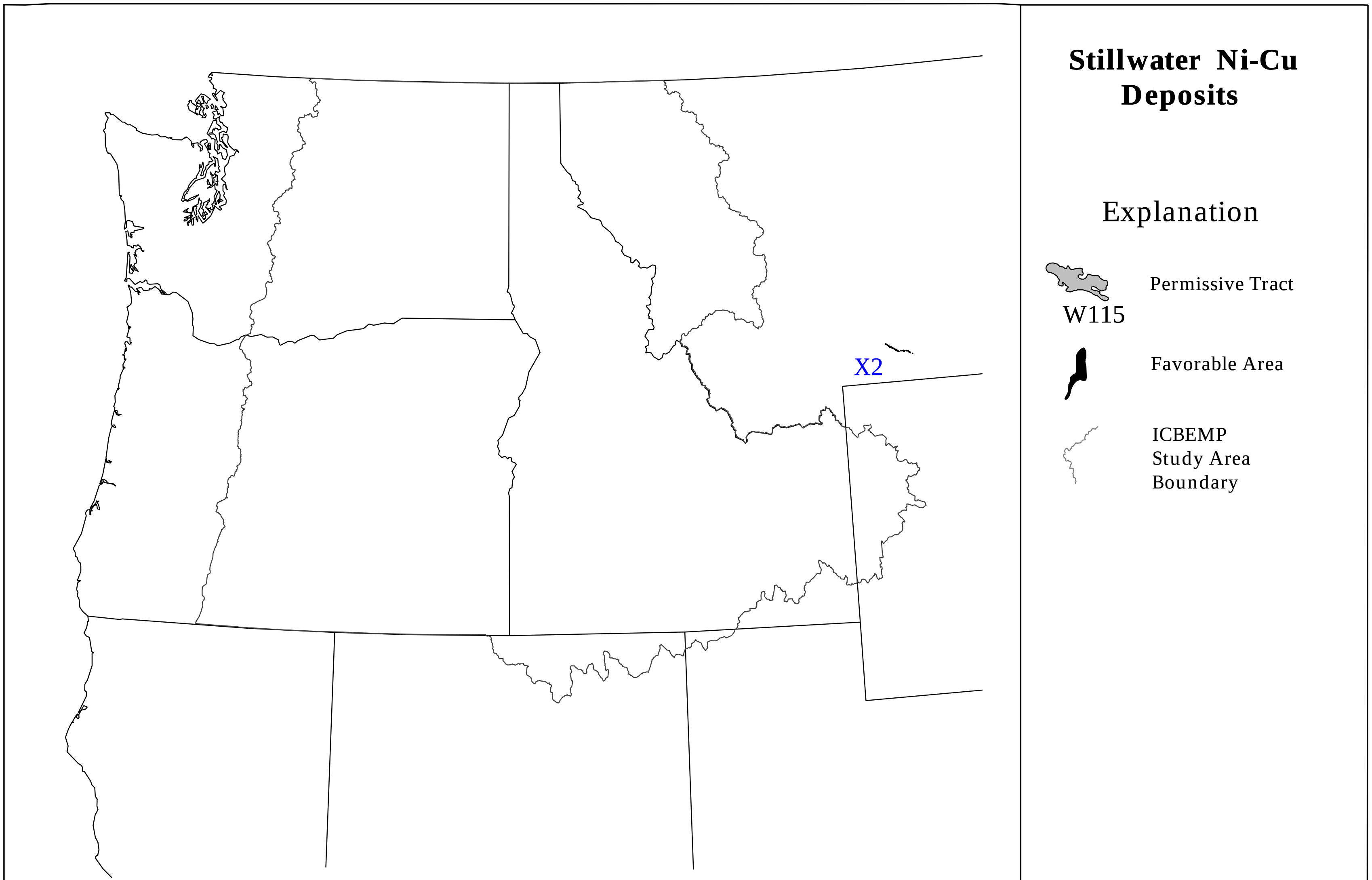


Figure 25a: Permissive and favorable tracts for Stillwater Ni- Cu deposits.

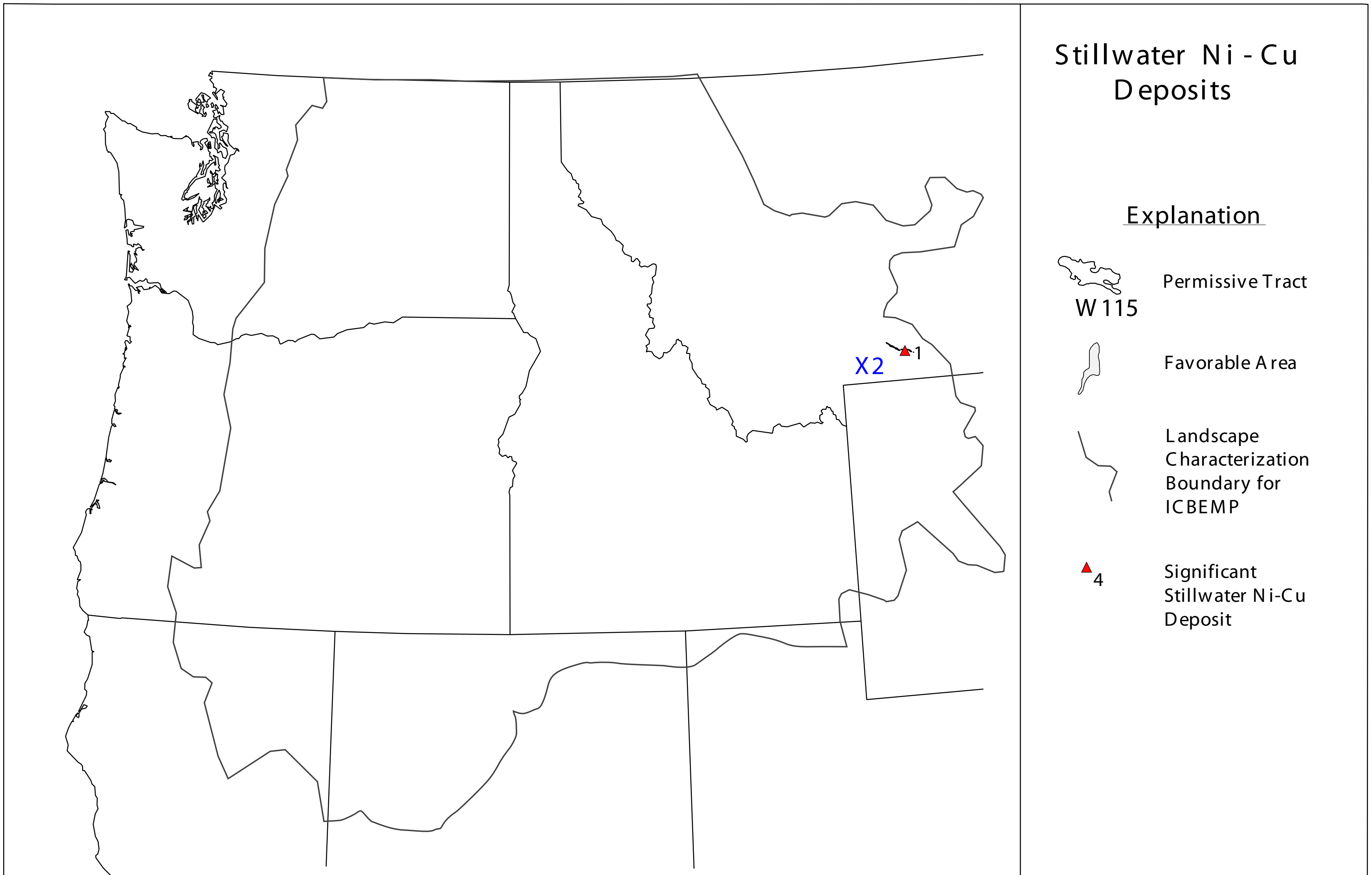


Figure 25b: Location of significant Stillwater Ni-Cu deposits in the map area.

Table 25: Significant Stillwater Ni-Cu deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude	Status	Cu resource (tonnes)	Ni resource (tonnes)
01	X2	Mouat Ni-Cu	Stillwater	Stillwater	MT	45.377	-109.899	I D	381,640	407,960

Tract Descriptions

X2 **Stillwater Ni-Cu** **Montana**

Descriptive Model 1

No estimate of undiscovered deposits

by Michael L. Zientek

Rationale for Tract Delineation

The only layered, ultramafic to mafic intrusion in the map area is the Stillwater Complex in southwestern Montana. This type of nickel-copper mineralization was discovered in the 1880's in the eastern part of the complex but subsequently the stratigraphic horizon that hosts this type of mineralization has been mapped along the length of the complex. The permissive tract for the Stillwater Ni-Cu deposit type is drawn to include the near surface extent of the Basal series and the Peridotite zone of the Ultramafic series of the Stillwater Complex. The tract boundary was extended to include metasedimentary rocks where the lower contact of the complex is exposed because mineralization in the Stillwater Complex commonly extends into underlying metasedimentary rocks. Deposits tend to be localized toward the southern margin of the tract, near the lower, intrusive contact of the Stillwater Complex.

Important Examples of Deposit Type

Based on extensive recent exploration work, sulfide mineralization is known to be widely distributed in rocks near the base of the complex, and a number of subeconomic large-tonnage, low-grade deposits, prospects, and occurrences have been identified (Zientek, 1993). Only the Mouat and Camp deposits are explored adequately to allow estimates of contained resources and only the Mouat deposit contains enough copper (381,640 metric tons) to meet the criteria for inclusion in the significant deposit table (#1, Table 25). Significant resources are present in incompletely defined deposits and prospect and in extensions and inferred fault-offsets of known prospects and deposits. Undefined resources in extensions of known prospects in the Basal series may contain 1.2 million metric tons of nickel and 1.2 million metric tons of copper; potential for similar undiscovered mineral deposits exist in the lower plate of thrust faults (0.23 million metric tons of nickel and 0.23 million metric tons of copper).

The grade of nickel-copper mineralization near the base of the Stillwater Complex is below what is currently considered to be economic; laterally continuous domains of higher-grade mineralization within these deposits have not been identified. This mineralization also contains cobalt and platinum-group elements (PGE) but not in concentrations that substantially add to its value. The sulfide mineralization is pyrrhotite-rich and difficult to treat metallurgically.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered porphyry copper deposits was made.

Polymetallic veins, porphyry-related

General Deposit Description

Porphyry-related polymetallic veins are quartz-carbonate veins with Au and Ag associated with base metal sulfides. The veins fill near-surface fractures and breccias that are peripherally associated with hypabyssal calc-alkaline to alkaline intrusions (Cox, 1986b). The veins are commonly located in distal positions with respect to nearby porphyry-style hydrothermal cells developed over the tops of cooling plutonic bodies. They occur within wide propylitic alteration zones around the associated intrusive bodies, and are commonly flanked by narrow sericitic and argillic alteration zones. If carbonate-rich strata are present, the veins may be associated with polymetallic replacement deposits. Vein mineralogy is typically zoned with copper and gold closer to the associated intrusive body outward to zinc-lead-silver veins, with manganese-rich veins at the periphery. The median size of individual porphyry-related polymetallic veins is quite small, with a median tonnage of 7,600 metric tonnes of ore with 2.1% Zn, 2.4% Pb, variable Cu, 0.13 g/tonne Au, and 820 g/tonne Ag (Bliss and Cox, 1986).

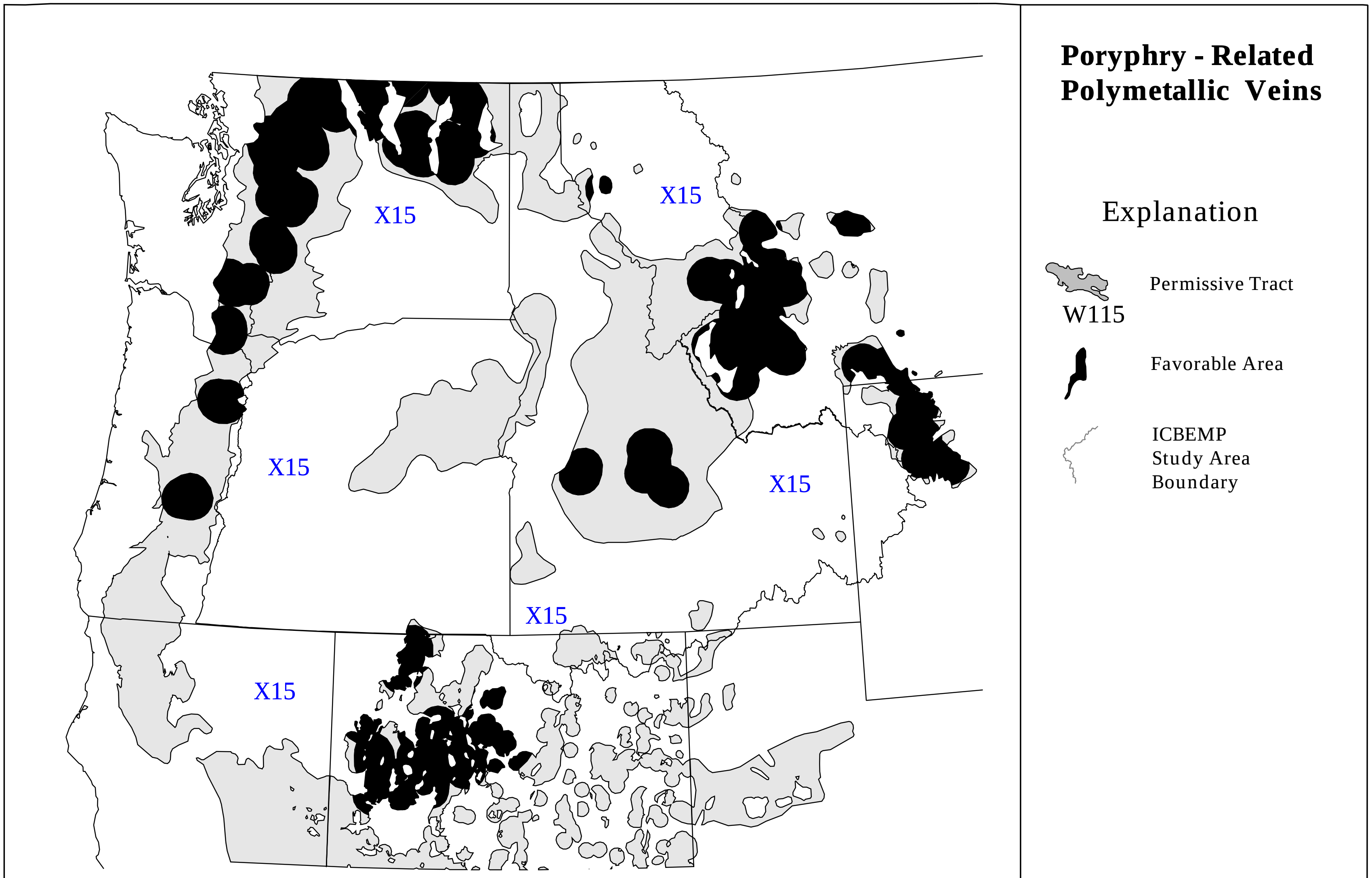


Figure 26a: Permissive and favorable tracts for Poryphry-related polymetallic vein deposits.

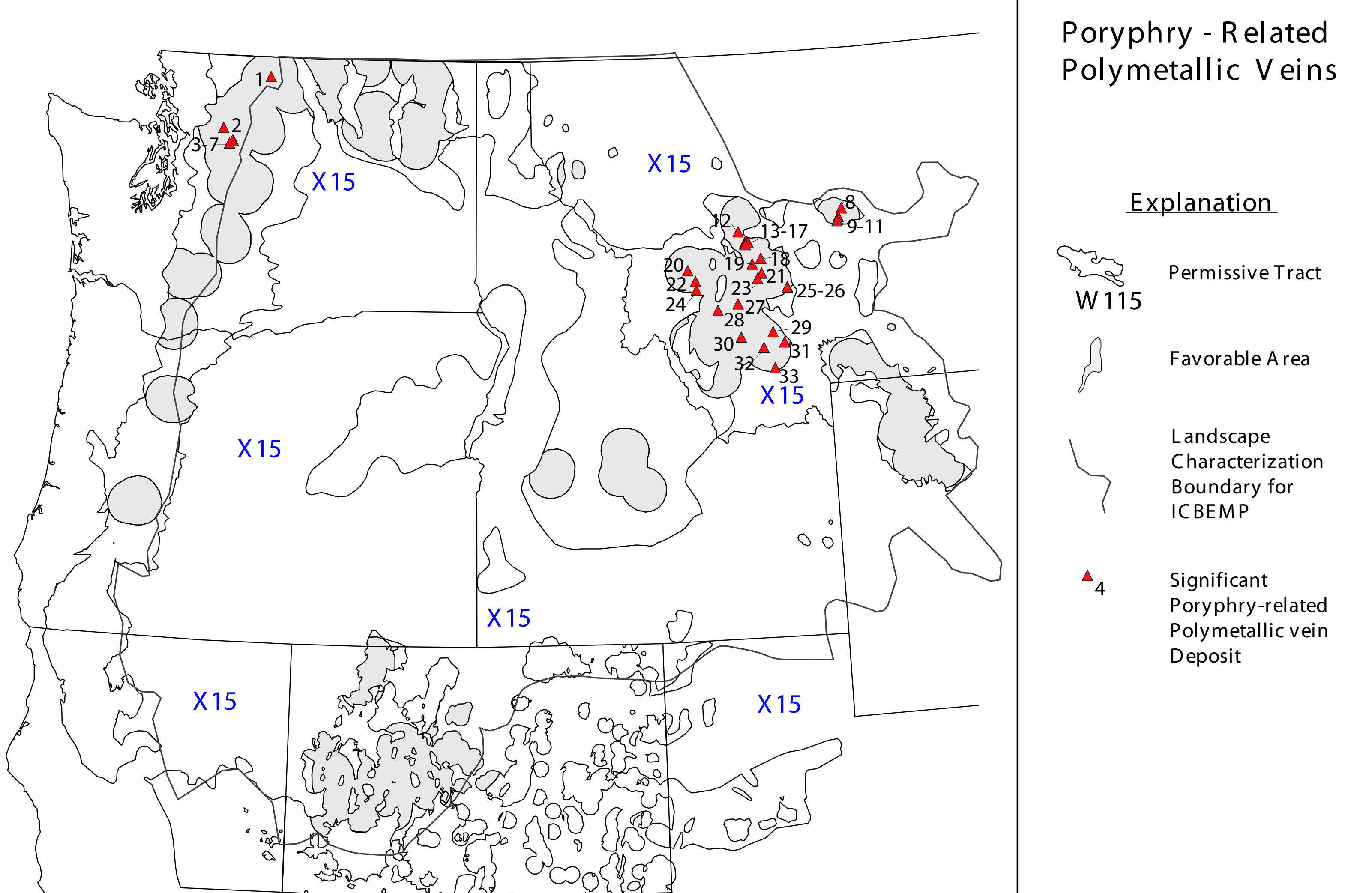


Figure 26b: Location of significant Poryphry-related polymetallic vein deposits in the map area.

Table 26: Significant porphyry-related polymetallic vein deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Tract No	Deposit Name	District	County	State	Latitude	Longitude
01	X13		Slate Creek	Whatcom	WA	48.768	-120.742
02	X13		Silverton	Snohomish	WA	48.130	-121.546
03	X13	Mystery	Monte Cristo	Snohomish	WA	47.981	-121.369
04	X13	Pride of the Mountains	Monte Cristo	Snohomish	WA	47.981	-121.369
05	X13	New Discovery	Monte Cristo	Snohomish	WA	47.980	-121.358
06	X13	Justice	Monte Cristo	Snohomish	WA	47.980	-121.379
07	X13	New York-Seattle	Silver Creek	Snohomish	WA	47.949	-121.430
08	X13	Block P	Barker	Cascade	MT	47.084	-110.632
09	X13	Silver Dyke	Neihart (Montana)	Cascade	MT	46.984	-110.694
10	X13	Big Seven	Neihart (Montana)	Cascade	MT	46.949	-110.705
11	X13	Broadwater	Neihart (Montana)	Cascade	MT	46.934	-110.724
12	X13	Jay Gould	Stemple-Gould	Lewis & Clark	MT	46.882	-112.459
13	X13	Piegan-Gloster	Marysville	Lewis & Clark	MT	46.762	-112.341
14	X13	Cruse-Belmont-Empire	Marysville	Lewis & Clark	MT	46.749	-112.321
15	X13	Drumlummon	Marysville	Lewis & Clark	MT	46.743	-112.296
16	X13	Penobscot	Marysville	Lewis & Clark	MT	46.731	-112.356
17	X13	Bald Butte	Marysville	Lewis & Clark	MT	46.723	-112.346
18	X13	Whitlatch-Union	Helena	Lewis & Clark	MT	46.548	-112.093
19	X13	Rimini district 1865-1928	Rimini (Vaughn)	Lewis & Clark	MT	46.486	-112.247
20	X13		Black Pine (Combination)	Granite	MT	46.448	-113.366
21	X13	Alta	Wickes (Colorado)	Jefferson	MT	46.372	-112.093
22	X13	Granite-Bimetallic	Philipsburg	Granite	MT	46.316	-113.242
23	X13	Comet	Boulder, Cateract, Basin or Wickes	Jefferson	MT	46.310	-112.167
24	X13	Southern Cross	Georgetown (Southern Cross)	Deer Lodge	MT	46.210	-113.235
25	X13	Keating	Radersburg	Broadwater	MT	46.188	-111.661
26	X13	Ohio-Keating	Radersburg	Broadwater	MT	46.185	-111.668
27	X13		Butte	Silver Bow	MT	46.020	-112.530
28	X13	Beal Mountain	Siberia (German Gulch)	Silver Bow	MT	45.954	-112.881
29	X13		Pony (Mineral Hill and So. Boulder)	Madison	MT	45.664	-111.956
30	X13		Rochester (Rabbit)	Madison	MT	45.620	-112.505
31	X13		Norris (Upper & Lower Hot Springs)	Madison	MT	45.534	-111.771
32	X13		Sheridan-Twin Bridges	Madison	MT	45.481	-112.130
33	X13		Virginia City	Madison	MT	45.232	-111.960

Table 26: Significant porphyry-related polymetallic vein deposits in the map area (see footnotes to Table 1 for explanation of abbreviations)

Map No	Status	Au prod (tonnes)	Ag prod (tonnes)	Cu prod (tonnes)	Pb prod (tonnes)	Zn prod (tonnes)	Au resource (tonnes)	Ag resource (tonnes)	Cu resource (tonnes)	Pb resource (tonnes)	Zn resource (tonnes)
01	I M	4.66									
02	I M	3.57									
03	I D						0.02	0.36	8,022	30,853	46,279
04	I D						0.08	725	21,135	117,241	140,381
05	I D						12	90	1,588	9,301	29,946
06	I D						4.1	55	272	5,608	8,031
07	I D						37		127,042		
08	I M	0.10	80	343	19,391	8,096					
09	I M	0.05	99	3,381	7,424	3.8					
10	I M	0.55	72	29	237						
11	I M	0.05	172	28	7,709	12,053					
12	I M	3.92	18								
13	I M	5.86	12	0.85							
14	I M	2.41	4.8	1.8							
15	I M	15.02	233								
16	I M	2.57	2.7	0.94	8.5	0.25					
17	I M	5.61	9.3		222						
18	I M	8.24	16								
19	I M	1.61	119	131	18,813	5,000					
20	I M	0.10	86	1,058	130				3,888	477	
21	I M	4.11	588	4,016	59,827						
22	I M	1.56	1,400	91	454				11	57	
23	F M	5.80	470	1,014	12,943	10,653					
24	I M e	8.46	10	473							
25	I M	6.37	1.8	1,255			unk	unk	unk	unk	unk
26	I M	1.93					unk	unk	unk	unk	unk
27	I M	86.43	21,119	8,349,809	387,839	2,227,406				38,505	136,152
28	P	5.44	5.4								
29	I M	9.33	7.8	651	6,804						
30	I M	3.27	3.5	1,175	347						
31	I M	4.76	11	123	192						
32	I M	2.96	19	240	2,910	344					
33	I M	5.31	116	37	118						

X15 — Polymetallic veins, porphyry-related

Descriptive model 22c
No estimate of undiscovered deposits

Montana, Idaho
Washington, Oregon
California, Nevada
Utah, Wyoming

by M.L. Zientek, S.E. Box, and A.A. Bookstrom

Rationale for Tract Delineation

Since this deposit type is spatially associated with porphyry deposits, permissive tract X15 was drawn by combining all of the permissive tracts for porphyry copper and porphyry molybdenum deposits in the Pacific Northwest (figures 19a, 20a). Favorable areas were drawn by putting a 20 km buffer around the favorable areas for porphyry copper and porphyry molybdenum deposits (figures 19a, 20a), as these deposits are typically peripheral to porphyry mineralization systems (Cox, 1986b). All of the significant known deposits fall within favorable areas defined this way (figure 26b).

Important Examples of Deposit Type

Thirty-three significant porphyry-related polymetallic vein deposits are located in the Pacific Northwest (table 26, figure 26b). In some cases, available production and resource data are for individual veins, in others for mines that may have produced from multiple veins, and in others for districts, which include multiple mines. Many deposits of this type are clustered around porphyry copper and molybdenum systems that are located in southwestern Montana (around Butte, #8-33, figure 26b), and in the North Cascades of Washington (#1-7, figure 26b).

The extremely productive Butte district consists of a giant cluster of high-grade polymetallic veins above a deeper stockwork porphyry copper-gold-molybdenum deposit, an up-faulted part of which is mined as the Continental deposit (#12, Table 19). Veins of an early east-west set are cut by veins of a later northwest-southeast set. Individual ore shoots are thousands of feet long and deep. The district is crudely zoned with a central zone of copper-rich mineralization flanked by crudely concentric zones of zinc- and manganese-rich mineralization.

The Monte Cristo district in the North Cascades of Washington was an historic producer primarily of gold and silver from polymetallic veins, and contains significant resources of gold, silver, copper lead and zinc (deposits #3-6, Table 26). The district is localized in a belt of Tertiary sedimentary and volcanic rocks between two large Miocene batholiths (Tabor and others, 1982). The veins are hosted in Eocene volcanic strata and in Miocene granitic rocks that intrude them. Spurr (1901) indicates that the vein mineralogy is vertically zoned, with only pyrite and arsenopyrite at the deepest levels, successively joined upward by chalcopyrite, sphalerite, and galena.

Rationale for Lack of Numerical Estimate

The giant swarm of polymetallic veins at Butte, Montana represents the upper-level expression of a porphyry copper system. Similar giant swarms of polymetallic veins are known at Tintic, Utah, Magma and Bisbee, Arizona, and Cerro de Pasco and Morococha, Peru. These giant deposits are several orders of magnitude larger than any of the deposits included in the tonnage-grade model for porphyry-related polymetallic veins by Bliss and Cox (1986). The western United States has been well explored for polymetallic vein swarms, and we do not expect that another giant Butte-like deposit remains to be discovered in the Interior Columbia Basin. We have made no numerical estimate for undiscovered giant veins swarms like Butte, because we have no appropriate tonnage-grade model.

Although there are over 600 known porphyry-related polymetallic vein deposits in the Interior Columbia Basin, we have not made numerical estimates for undiscovered deposits of this type. The regional scope and short time constraints of this project did not allow us to review the geological settings of the hundreds of known veins at large-enough map scales, or in sufficient detail to permit science-based estimates of undiscovered veins to be made. Furthermore, the available tonnage-grade model by Bliss and Cox (1986) cannot be confidently used as a basis for prediction of the metal contents of undiscovered deposits of this type in the Interior Columbia Basin. About 60 percent of the deposits used to construct that model are located in the Slocan mining district, British Columbia, Canada. No significant known polymetallic vein deposits of the Interior Columbia Basin are included in the model.

Exposed polymetallic veins are easy to find, and the western United States has been well explored for them. Such veins tend to occur in groups, or along structural trends near porphyritic intrusions. We are confident that many known veins contain additional resources, and that unknown veins will be found near known veins. However, such deposits are classified as extensions of known deposits unless they are located more than a kilometer away from a known deposit. Most undiscovered veins of this type probably are covered by post-vein sedimentary or volcanic rocks. Such veins will be difficult to predict, find, and evaluate, except by projection of known structures, and(or) by detailed geologic, geochemical, and geophysical exploration. In general, such work probably is not warranted by the current economic potential of such deposits, which must be mined by high-cost, small-scale underground methods.

Although many small miners will continue to work on polymetallic vein deposits, most future exploration by major mining companies will seek larger, bulk-mineable deposits of disseminated ore minerals in wall rocks adjacent to and(or) between polymetallic veins. We have no tonnage-grade models for such deposits, which in most cases should be considered as extensions of known deposits, rather than as undiscovered deposits. Therefore, numerical estimates were not be made for undiscovered deposits of this type.

Sediment-hosted Cu, redbed-type deposits

General Deposit Description

Redbed Cu deposits are the smallest of three subtypes of sediment-hosted copper deposits that are distinguished based on geologic setting, tonnage, and grade (Dennis Cox, written communication, 1994). Redbed Cu deposits are relatively stratiform bodies hosted within redbed alluvial sedimentary rock sequences in epicratonic and intracratonic basins. Principal ore minerals are chalcocite and other copper sulfide minerals. Ore minerals typically replace sandstone matrix, cement, and, in some deposits, fossil plant trash. Metal sulfide zoning, present in most examples, ranges from grain- to deposit-scale and reflects directions of fluid flow and/or geochemical gradients during mineral deposition (David Lindsey, written commun., 1994). The median size of these deposits is 0.12 million metric tonnes of ore with a median grade of 2.8% copper (Dennis Cox, written communication, 1994).

The formation of sediment-hosted copper deposits depends on a redox reaction between an oxidized brine (containing dissolved copper) and a reductant. The brine, in equilibrium with hematite and free of sulfide, maintains the copper in solution as a stable complex ion. The source of the brines may be trapped seawater or fluids derived from evaporite basins. The copper in the brines may be derived from volcanic rock clasts and labile clastic minerals in redbeds, hydrous ferrous oxide cements in redbeds, or subaerial mafic volcanic rocks. Reductants in redbed Cu deposits are typically accumulations of organic material or discontinuous reduced facies lenses within the redbed sequence (Kirkham, 1989).

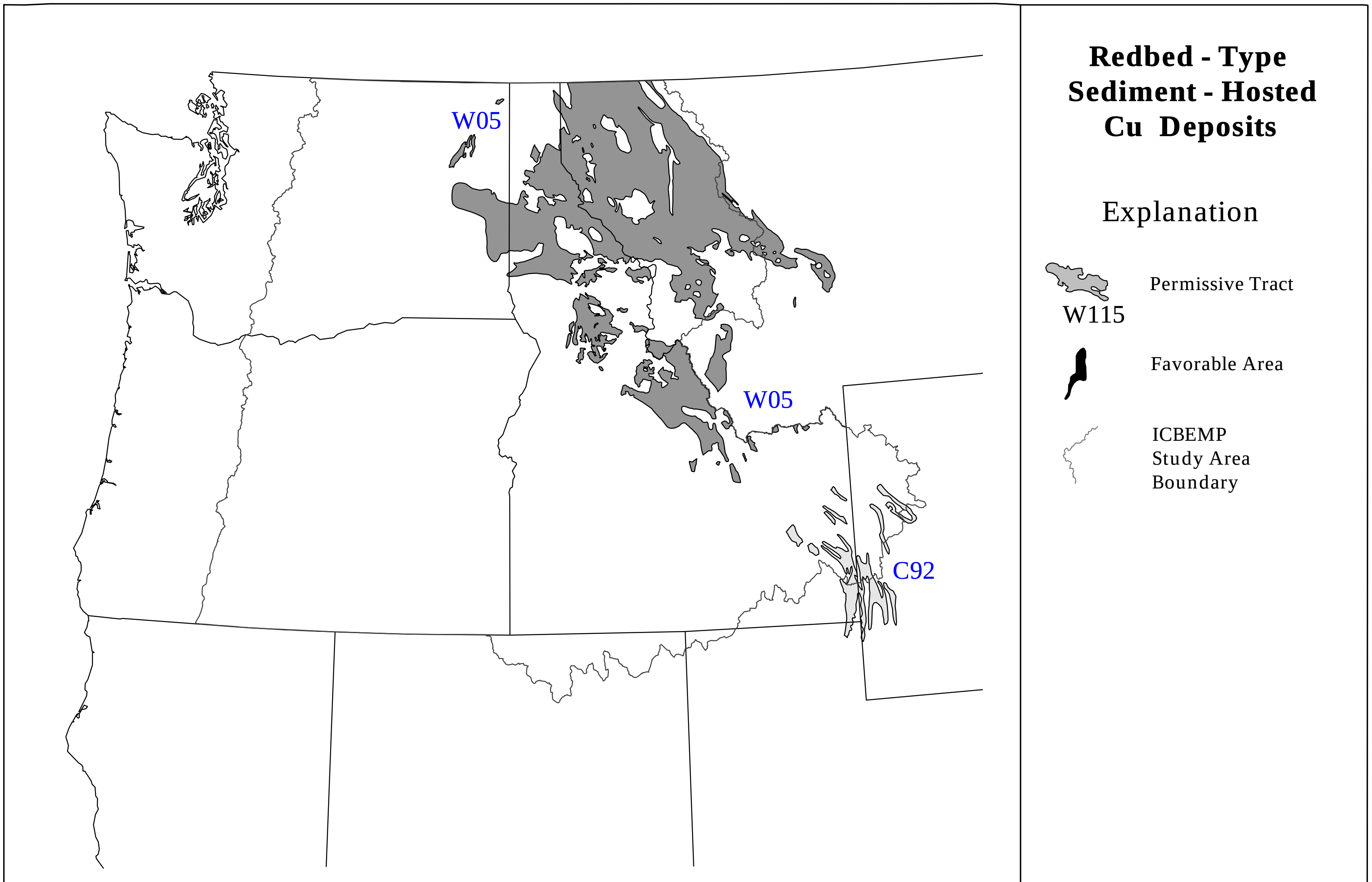


Figure 27a: Permissive and favorable tracts for Redbed-type sediment-hosted Cu deposits.

Tract Descriptions

C92

Sediment-hosted Cu Deposits, Redbed Type
Descriptive Model 30B.2
No estimate of undiscovered deposits

Idaho
Utah
Wyoming

by David Lindsey and Dennis Cox

Rationale for Tract Delineation

Deposits in the Jurassic and Triassic Nugget Sandstone of western Wyoming and southeastern Idaho occur in bleached zones of otherwise oxidized (red) sandstone (Love and Antweiler, 1973). Most occurrences are near the top of the Nugget and below the basal breccia bed of the Gypsum Spring Member of the Jurassic Twin Creek Limestone. No plant matter is associated with copper, but in places the host sandstone is petroliferous. Concentrations of silver and zinc accompany the copper. These characteristics indicate that the Nugget occurrences belong to the redbed model, with oil probably serving as the reductant. All deposits are within the Nugget Sandstone, and it constitutes the permissive tract, along with underlying Triassic rocks, which may be linked with the Nugget in geologic setting, including the history of diagenesis and oil migration.

Important Examples of Deposit Type

The Griggs mine in the Lake Alice district is the most important copper occurrence in the Nugget Sandstone. According to Love and Antweiler (1973), copper was mined in the Lake Alice district from about 1895 to 1920; they did not tabulate production.

Rationale for Lack of Numerical Estimate

Only two other occurrences, about 80 km north of the Lake Alice district, have been reported in the Nugget (Love and Antweiler, 1973). Not enough is known about the distribution of occurrences or other potentially mineralized areas in reduced zones of the Nugget to warrant numerical estimation.

W05

Sediment-hosted Cu Deposits, Redbed Type
Descriptive Model 30B.2
No estimate of undiscovered deposits

Montana
Idaho
Washington

by Michael L. Zientek

Rationale for Tract Delineation

Permissive lithologic units in this area include the entire mid-Proterozoic Belt Supergroup above the Prichard Formation. (see Harrison, 1972) and the Yellowjacket Formation and Lemhi Group in Idaho. Small, laterally impersistent, sediment-hosted copper deposits and occurrences, known as green-bed-type deposits, occur in all formations in the Belt Supergroup above the Lower Belt (Prichard and stratigraphic equivalents) (Lange and Sherry, 1986). This style of mineralization is similar to those deposits described in the redbed model and consists of copper-sulfide minerals localized in gray or green beds of argillite, siltite, or sandstone in thinly bedded, alternating red bed-green bed stratigraphic sequences. They are particularly common in tidal flat and shallow shelf facies of the Ravalli and Missoula Groups (Harrison, Domenico, and Leach, 1986).

Important Examples of Deposit Type

There are no known deposits of this type in the permissive tract, although numerous prospects and occurrences are known. An example of this type of mineralization in the Ravalli Group at Blacktail Mountain in the Kalispell 1°x2° quadrangle is described by Harrison and Reynolds

(1979) and Rye, Roberts, and others (1984). Prospects in the Missoula Group are described by Stanley and Sinclair (1989). Descriptions and locations of Belt “green-bed” mineralization can also be found in Harrison, Domenico, and Leach (1986), Pearson and others (1990), Earhart and others (1981), and Elliott and others (1992). Sediment hosted Cu-Ag occurrences are also reported in a diamictite in the Lemhi Group in the Lemhi Range, Idaho and at the Freeman Creek area in the Yellowjacket in the Bitterroot Range, Idaho (C.R. Allen, personal commun., 1994). We do not have enough information on these deposits in Idaho to differentiate them into the Revett or redbed models.

Rationale for Lack of Numerical Estimate

Because the copper resource held in deposits of this type is small, they are generally not economically significant. Numerous small occurrences of mineralization of this type occur throughout the Belt basin, but little systematic exploration for this deposit type has occurred (C. Allen, Cominco, personal communication, 1995). The regional scope and short time constraints of this project did not allow us to review the geological settings of the many known occurrences at large-enough map scales, or in sufficient detail to permit science-based estimates of undiscovered deposits to be made. Furthermore, the available tonnage-grade models (Dennis Cox , written communication, 1994) are constructed primarily from Phanerozoic examples and cannot be confidently used as a basis for prediction of the metal contents of undiscovered deposits of this type in the Proterozoic Belt basin, given the different type and mode of occurrences of organic material in the Proterozoic. For these reasons, we have not made numerical estimates for undiscovered deposits of this type.

Sediment-hosted Cu, reduced-facies type deposits

General Deposit Description

Reduced-facies Cu deposits are one of three subtypes of sediment-hosted copper deposits that are distinguished based on geologic setting, tonnage, and grade (Dennis Cox, written communication, 1994). Deposits of the reduced facies model are stratabound, disseminated copper sulfide deposits localized around fossils and carbonaceous clots or fragments that occur along the contact of the oxidized and reduced facies (Kirkham, 1989). These deposits can be quite large and are found where oxidized continental clastic rocks (redbeds) or basaltic to intermediate subaerial volcanic rocks are overlain by laterally extensive reduced marine or lacustrine shales or carbonates. Any reduced-facies beds, such as black shale or stromatolitic carbonate, in contact with the oxidized beds, would be a likely site for the occurrence of reduced-facies deposits. The median size of a reduced-facies, sediment-hosted copper deposit is 33 million metric tonnes of ore with a median grade of 2.2% copper (Dan Mosier, Donald Singer, and Dennis Cox, written communication, 1994).

The formation of sediment-hosted copper deposits depends on a redox reaction between an oxidized brine (containing dissolved copper) and a reductant. The brine, in equilibrium with hematite and free of sulfide, maintains the copper in solution as a stable complex ion. The source of the brines may be trapped seawater or fluids derived from evaporite basins. The copper in the brines may be derived from volcanic rock clasts and labile clastic minerals in redbeds, hydrous ferrous oxide cements in redbeds, or subaerial mafic volcanic rocks.

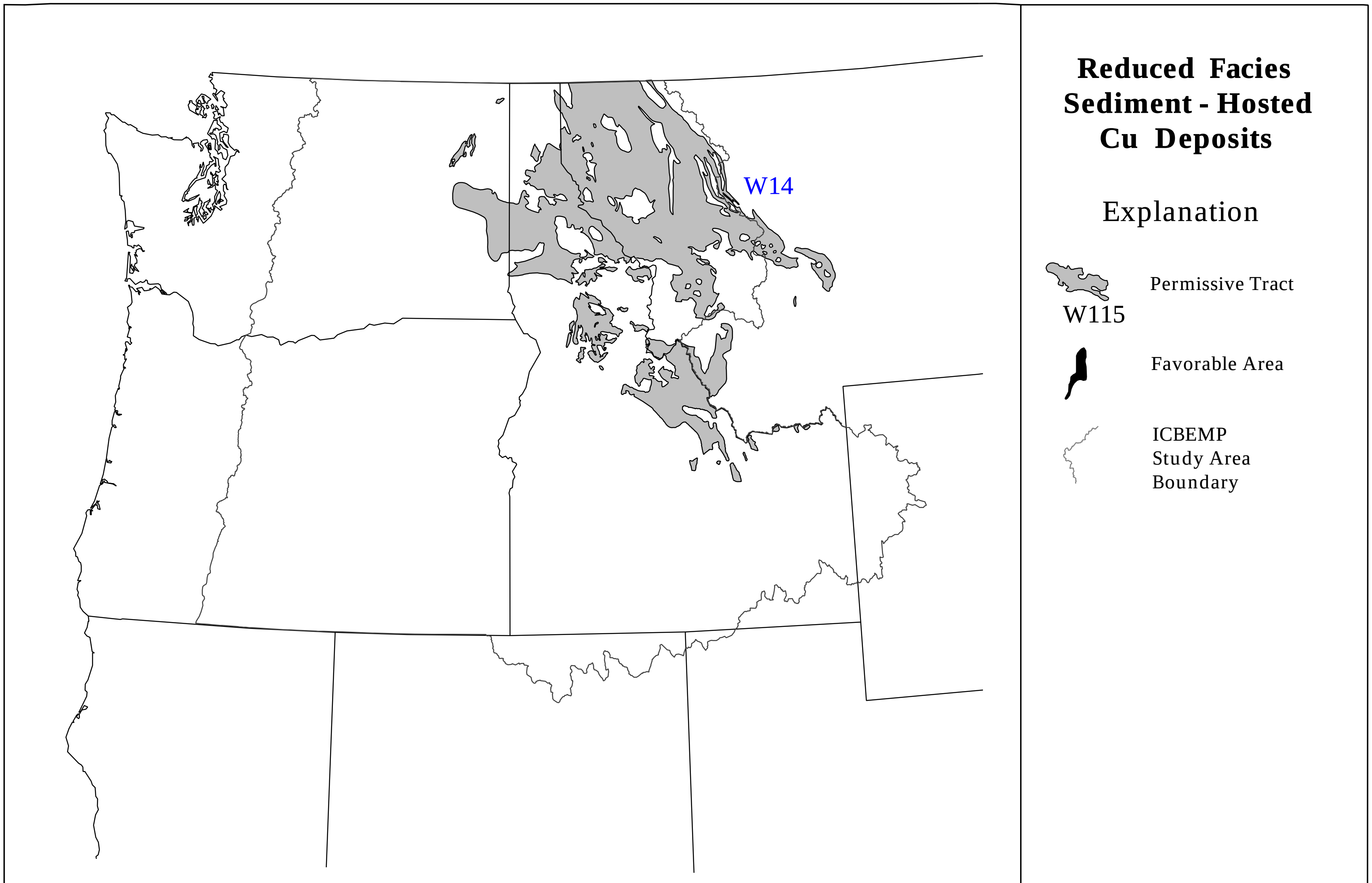


Figure 28a: Permissive and favorable tracts for Reduced facies sediment-hosted Cu deposits.

W14 — Reduced-facies Cu Deposits — Montana, Idaho, Washington

Descriptive Model 30B.1

• 0.2 mean undiscovered deposits (entire tract)

• 0.2 mean undiscovered deposits (ICBEMP portion of tract)

by Michael L. Zientek, Stephen E. Box, and Arthur Bookstrom

Rationale for Tract Delineation

Permissive lithologic units in this area include the entire mid-Proterozoic Belt Supergroup above the Prichard Formation and the Yellowjacket Formation and Lemhi Group in Idaho. Areas favorable for deposits of the reduced facies model would include thick sequences of laterally extensive reduced shales or carbonates. One such favorable interval is the base of the Middle Belt carbonates. The transition from the Ravalli Group to the Middle Belt carbonates represents a major marine transgression that places reduced lithologies over oxidized, redbed sequences (J.W. Whipple, personal commun., 1994).

Important Examples of Deposit Type

Carbonate-type copper mineralization occurs throughout the Middle Belt carbonates (Empire, Helena, and Wallace Formations) where local accumulations of organic material (such as algal mats) appear to control metal deposition (see Harrison, 1972). No examples of identified deposits are known, but occurrences at Red Mountain and Wolf Creek, Montana have been described by Lange and Sherry (1986). Additional deposits that occur in this stratigraphic interval near these prospects are described by Elliott, Loen, and others (1992). Laterally extensive, low-grade mineralization in this same stratigraphic interval has been described in Alberta and British Columbia (Binda and others, 1989). These prospects and occurrences indicate that the processes that generate reduced-facies deposits did operate in the Belt Basin.

Rationale for Numerical Estimate

Although small examples of this mineralization type occur in the tract, no significant deposits of this type are known. A long exploration history for copper deposits in the region leads us to give a low estimate of the number of undiscovered deposits of this type. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 1, 3, and 5 or more reduced facies deposits consistent with the grade and tonnage model of Mosier, Singer, and Cox (written communication, 1994). Since most of the tract is within the ICBEMP study area, the team felt the same estimate applies to the ICBEMP portion of the tract.

Epithermal Au-Ag veins, Sado type deposits

General Deposit Description

Epithermal Au-Ag veins consist of moderately to steeply dipping sheets of quartz with ribbon-like ore shoots of precious metal minerals deposited in throughgoing faults or fractures from hydrothermal waters within 300 m of the ground surface. These epithermal veins are divided into two types: pyrite-rich quartz-alunite and pyrite-poor quartz-adularia types. Quartz-adularia veins have been subdivided into three subtypes (Comstock, Sado, and Creede) based on their metal grades and the presumed character of the basement underlying the volcanic sequence in which they are found (Mosier, Menzie, and Kleinhampl, 1986; Mosier, Singer, Sato, and Page, 1986). The Sado subtype, relatively rich in copper, consists of gold, chalcopyrite, sulfosalts, and argentite in banded, vuggy veins of quartz, adularia, calcite, and pyrite (Mosier, Berger, and Singer, 1986). These deposits are typically hosted in felsic to intermediate volcanic rocks that overlie older volcanic sequences or igneous intrusions. Veins are deposited in fractures and faults that were intermittently active during the volcanic history. Major, throughgoing extensional faults generally were mineralized repeatedly and host the widest veins. The median size of a deposit of this type is 300,000 metric tonnes with median grades of 6 g Au/tonne, 38 g Ag/tonne, and byproduct Cu (Mosier and Sato, 1986).

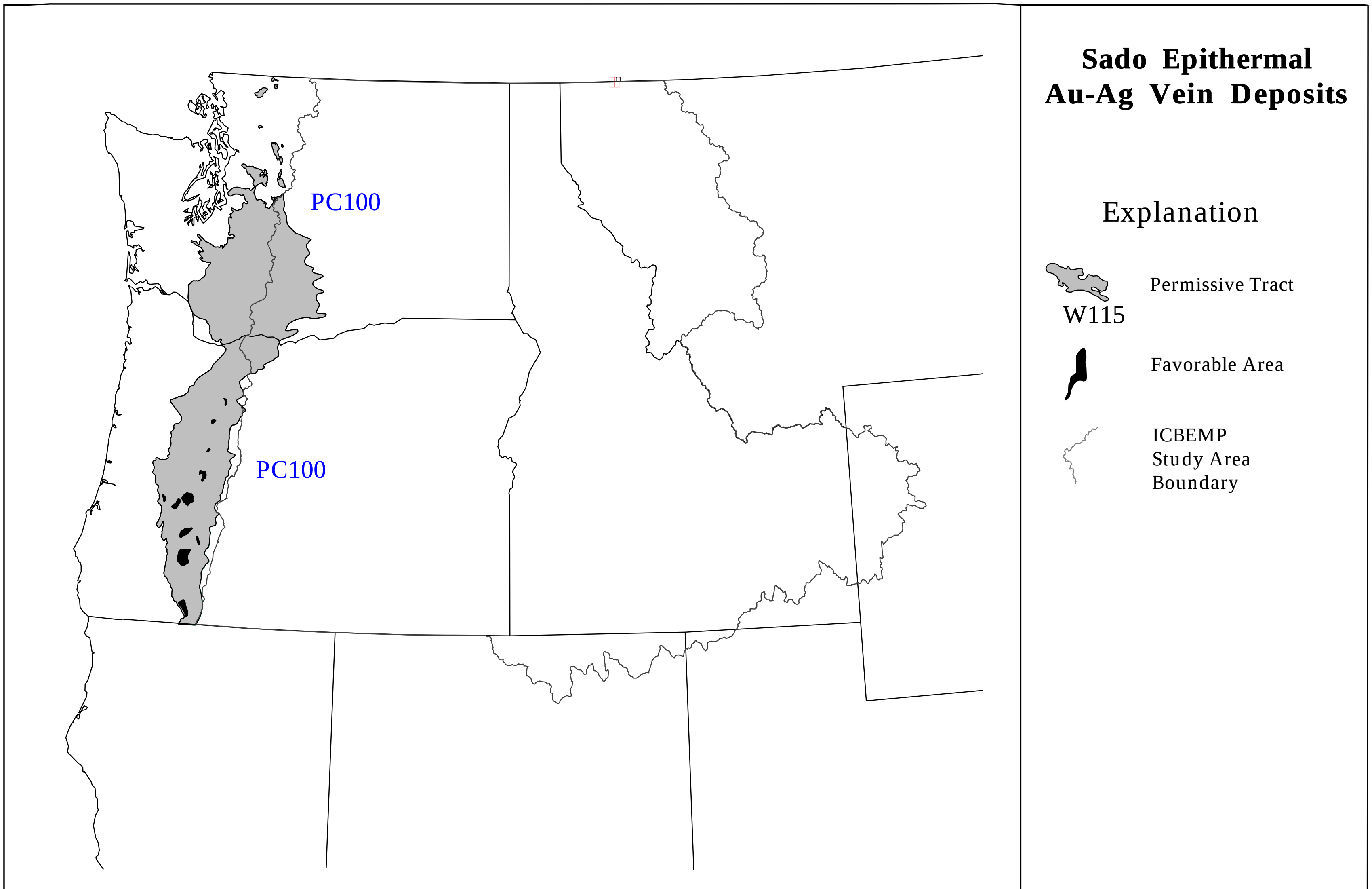


Figure 29a: Permissive and favorable tracts for Sado epithermal Au-Ag deposits.

Tract Descriptions

PC100

Epithermal vein, Sado Type Deposits

Descriptive Model 25d

• 2.5 mean undiscovered deposits (entire tract)

• 0.01 mean undiscovered deposits (ICBEMP portion only)

Oregon
Washington

by Roger P. Ashley

Rationale for Tract Delineation

Calc-alkaline volcanic rocks of Tertiary and Quaternary age related to the Cascade arc are widespread in western Oregon and Washington. Arc volcanic sequences include volcanic centers in which magmatic events can generate ore-depositing hydrothermal systems. Several Sado-type deposits are present in the western Cascade Range, where the Tertiary arc rocks are mainly exposed. Geophysical and isotopic data indicate that pre-Tertiary basement rocks are thin or missing beneath the western Cascade Range of west-central Oregon and southwestern Washington (Couch and Riddihough, 1989; Church and others, 1986). Oceanic crust of Eocene age is inferred to lie beneath the Cascades rocks and extends to depths greater than 10 km. This basement geology is favorable for Sado type deposits rather than Comstock type deposits (Mosier, Berger, and Singer, 1986).

All areas of calc-alkaline volcanic rocks in the western Cascades are considered permissive for Sado-type deposits. Because these deposits usually have limited vertical extent (a few hundred meters), they could be present within the 1 km depth limit while having little surface manifestation.

The tract includes mainly volcanic and volcaniclastic rocks and associated plutonic bodies (dikes, sills, stocks, and small batholiths) of the Cascades arc (Oligocene and Miocene in age), as shown on maps of Smith (1993), Walker and MacLeod (1991), and Sherrod and Smith (1989). On the west side of the tract in both Oregon and Washington, Eocene marine sandstone units and pre-Cascades volcanic rocks, predominantly of basaltic composition, are excluded. Where the Cascades-related rocks are covered by non-volcanic Quaternary deposits, the boundary is drawn where the younger deposits are approximately 1 km thick. Batholiths of Tertiary age in the northern Cascades of Washington are excluded because they indicate an environment too deep for the presence of epithermal deposits.

In Oregon and northern California, the east side of the tract is the boundary between Oligocene and Miocene rocks of the western Cascades and predominantly Quaternary volcanic rocks of the high Cascades. Ridge-capping flows of late Miocene and Pliocene age are excluded from the tract. In Washington, on the east, the boundary is drawn where flows of the Columbia River Basalt Group cover the Oligocene and Miocene Cascade rocks to a depth of approximately 1 km (Drost and Whiteman, 1986). Quaternary volcanic rocks of Mt. Rainier, Mount St. Helens, Mt. Adams, and the Indian Heaven volcanic fields, which locally cover the Tertiary Cascades rocks in Washington, are included. A pre-Tertiary inlier east of Mt. Rainier is also included. Along the northeast edge of the tract, a small area of Eocene sandstone is included. North of Mt. Rainier, volcanic rocks of Eocene-Oligocene age are included, some of which predate Cascade arc volcanism.

Important Examples of Deposit Type

Sado-type deposits with recorded precious metal production, all relatively small, include the Quartzville district, the Blue River district, and the Al Sarena mine in Oregon, and the Wind River mine in Washington. The Quartzville district has the largest production that can definitely be attributed to Sado-type veins, with 0.27 metric tons gold and 0.09 metric tons silver recorded (Brooks and Ramp, 1968), and possibly considerably more that is unrecorded (Munts, 1978). All of these deposits have insufficient endowment of Au or Ag to rank as significant deposits for this report.

Rationale for Numerical Estimate

For the 90th, 50th, 10th, and 5th percentiles, the team estimated 0, 2, 5, and 8 or more Sado deposits consistent with the grade and tonnage model of Mosier and Sato (1986). Known Sado-type prospects and occurrences, although mostly small and not numerous, are widely distributed throughout the tract. Hydrothermally-altered areas, many of which are favorable for epithermal deposits as well as porphyry deposits, are common in the Tertiary volcanic rocks of the western Cascades (Peck and others, 1964; Power, 1984). The estimates of two deposits at the 50th percentile and five deposits at the 10th percentile together express a relatively high perceived probability that exploration of known districts and prospects could yield additional deposits. Recent exploration drilling in several districts has produced ore-grade intercepts. The three additional deposits estimated at the 5th percentile reflects the perception that extensive favorable ground exists, but the density of known deposits is low, thus some, but probably not many, new Sado-type districts could be discovered in the tract.

Since most of the permissive tract and all of the favorable areas lie outside of the ICBEMP study area, the team felt that there is a low potential for undiscovered deposits in the ICBEMP portion of the tract. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more Sado deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Mosier and Sato (1986) for the ICBEMP portion of the tract.

Skarn Cu Deposits

General Deposit Description

Skarns are metallic sulfide and oxide replacement deposits that occur in carbonate rocks adjacent to plutonic bodies with metal-bearing hydrothermal systems (Einaudi and others, 1981). Pyroxene and garnet are the most important diagnostic skarn minerals. Copper skarns are an end-member of a spectrum of skarn deposit types that are variously copper-, zinc-lead-, or iron-rich (Cox and Theodore, 1986). The deposits are associated with shallow intermediate plutons, commonly those that are host to porphyry-style mineralization. The carbonate bodies that host the mineralization need not be regionally extensive, but can be small local bodies that are widely scattered essentially throughout the map area. Cu skarns can be associated with porphyry copper or copper-molybdenum, polymetallic replacement, and polymetallic vein deposits. The median size of a Cu skarn deposit is 560,000 metric tonnes of ore with a median grade of 1.7% copper (Jones and Menzie, 1986).

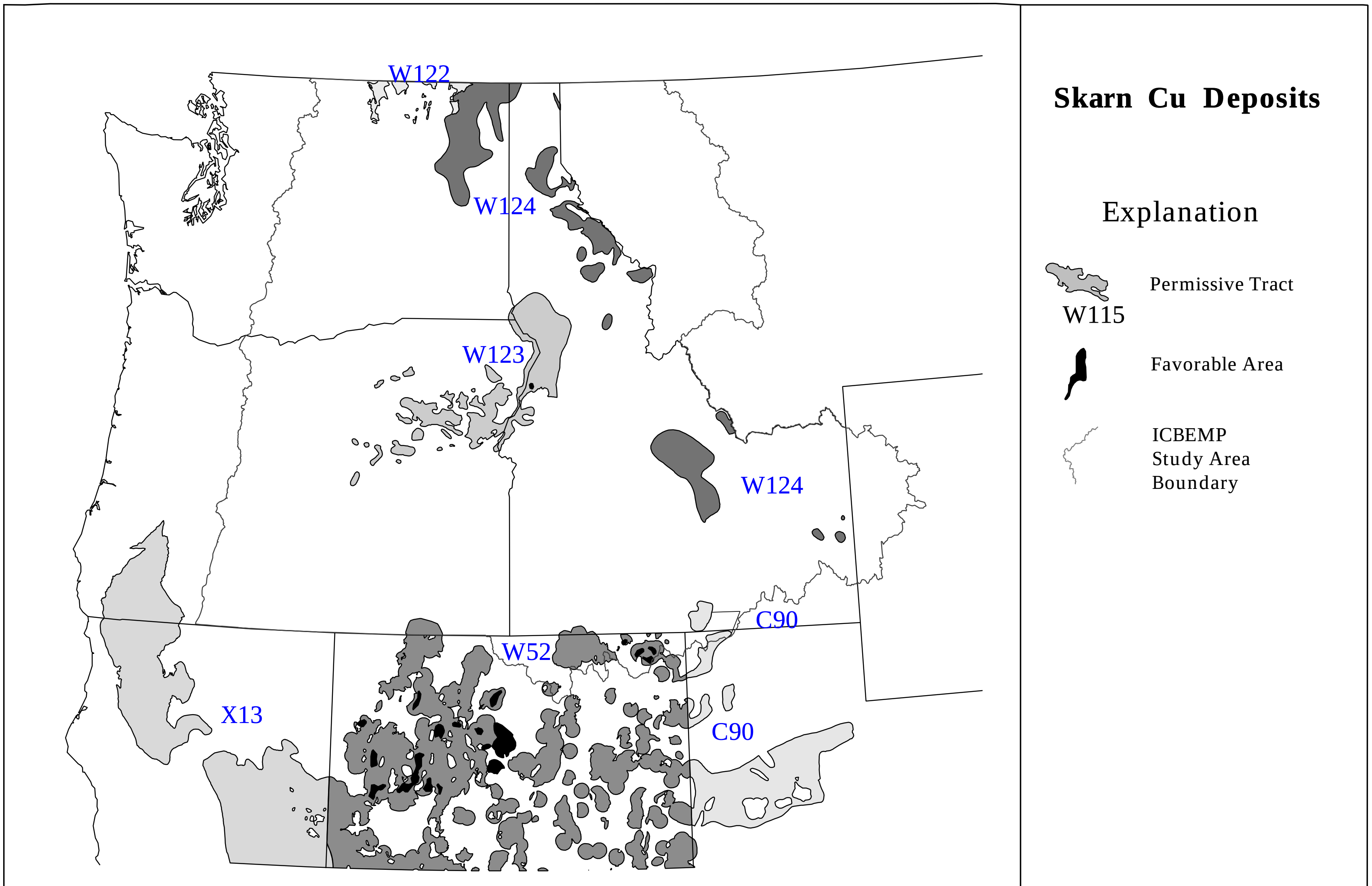


Figure 30a: Permissive and favorable tracts for Skarn Cu deposits.

Tract Descriptions

C90 — **Skarn Cu Deposits** — **Utah, Idaho**

Descriptive Model 18b

• 0.01 mean undiscovered deposits (ICBEMP portion only)

by Douglas B. Stoeser

Rationale for Tract Delineation

The basis for the tract delineation is areas where epizonal calc-alkaline granitic stocks intrude carbonate rocks. Thus, the permissive tract has the same geographic boundaries as the one for skarn-related porphyry copper deposits and other types of skarns.

Important Examples of Deposit Type

There are no significant examples of this type of deposit in Utah. Seven minor occurrences of this type are listed in Reid (1991) for western Utah, but it is not clear whether all are actually copper skarns.

Rationale for Numerical Estimate (ICBEMP portion of tract only)

A small portion of the northern part of tract C90 lies within the ICBEMP boundary (figure 30a), and a numerical estimate of undiscovered deposits was made only for that portion of the tract. The lack of known prospects for either skarns or associated porphyry deposits and the long exploration history in the ICBEMP portion of the tract leads us to give a very low potential for undiscovered gold skarn deposits in that area. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more undiscovered copper skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Jones and Menzie, (1986).

W52 — **Skarn Cu Deposits** — **Nevada, Oregon, Idaho**

Descriptive Model 18b

• 1.3 mean undiscovered deposits (ICBEMP portion only)

by D.P. Cox, Steve Ludington, B.R. Berger, M.G. Sherlock, and D.A. Singer, (USGS); and J.V. Tingley (Nevada Bureau of Mines and Geology).

Rationale for Tract Delineation

The tract permissive for copper skarn deposits is defined as an area extending 10 km outward from the outcrop of a pluton, or, in the case that the pluton has a geophysical expression as discussed by Grauch and others (1988), from the inferred subsurface boundary of the pluton, based on its geophysical expression. It also includes areas around plutons whose presence is inferred from geophysics or from the occurrence of skarn mineralization. Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in the tract (Stewart, 1980), hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock. Those parts of the tract that do contain assemblages rich in carbonate rocks, however, are considered favorable. Areas covered by more than 1 km of Upper Tertiary and Quaternary rocks and sediments (Blakely and Jachens, 1991) are excluded as are areas that are within a Tertiary caldera. In these latter areas, permissive pre-Tertiary host rocks are likely to be covered by more than 1 km of volcanic rock.

Important Examples of Deposit Type

Copper skarns are numerous in Nevada with more than 50 occurrences listed in 20 localities. The seven deposits from Nevada included in the copper skarn grade and tonnage model of Jones and Menzie (1986) are significantly lower in tonnage and higher in grade than the other deposits in the model. However, because these seven deposits are all located in the same general area near Yerington, and because we believe that undiscovered copper skarn deposits are, for the most part, located elsewhere in Nevada, we have relied on the original unmodified model. Copper skarns in the Copper Canyon and Robinson districts are included with the porphyry copper deposits.

Most of the known deposits are in the Yerington district and are of Jurassic age. The Victoria deposit and other skarns in the Dolly Varden district are also Jurassic. The Contact district in northeastern Nevada contains many occurrences of unrecorded grade and tonnage associated with Jurassic plutons. Two deposits associated with Cretaceous plutons are in the Adelaide and Santa Fe districts. Tertiary copper skarn deposits occur in the Battle Mountain district. Other copper skarn occurrences near Tertiary plutons are numerous.

Rationale for Numerical Estimate (ICBEMP portion of tract only)

A numerical estimate was made only for that part of tract W52 that lies within the ICBEMP study area (figure 30a). An estimate of the number of undiscovered copper skarn deposits in northeastern Nevada was previously made by county (Singer, 1996). The ICBEMP portion of tract W52 lies within two counties. To arrive at the numerical estimate of undiscovered copper skarn deposits in the ICBEMP portion of tract W52, we apportioned the two county estimates of Singer (1996) on the basis of the ratio of the areas of permissive tracts located within the ICBEMP study area and of the total area of permissive tract within those two counties. This yields an estimated 1.30 mean copper skarn deposits for the part tract W52 within the ICBEMP study area (including the minor permissive tract extensions into Oregon and Idaho). For the 90th, 50th, 10th, 5th, and 1st percentiles, an estimate of 1, 1, 2, 3, and 3 or more undiscovered copper skarn deposits consistent with the grade and tonnage model Jones and Menzie (1986) is equivalent to the estimated number of mean undiscovered deposits derived above.

W122 — Skarn Cu Deposits — Washington

Descriptive Model 18b

• 0.01 mean undiscovered deposits

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The permissive tract is drawn to encompass the sedimentary rocks of the Quesnellia terrane in northeastern Washington (Stoffel and others, 1991). This terrane includes a belt of Triassic and Jurassic plutons that have generated a string of porphyry copper deposits in British Columbia and northern Washington, along with associated Au and Cu skarn deposits. Carbonate units are irregularly scattered through the Quesnellia terrane, such that the entire terrane is permissive.

Important Examples of Deposit Type

Two large skarn Cu (+Au) deposits are known just north of the Canadian border in southern British Columbia: Phoenix and Greenwood-Motherlode. No significant deposits are known within the tract, although several small occurrences of copper-bearing skarn mineralization are known around Mesozoic plutons within the tract.

Rationale for Numerical Estimate

The lack of significant skarn Cu deposits within the tract, even around the known porphyry copper deposit at Kelsey, led the team to be conservative in their estimate. The occurrence of significant Au in both the British Columbia deposits, enough to consider them gold skarns, led the team to judge that, whereas some undiscovered skarn Au deposits may have significant copper resources, the chance of a gold-poor copper skarn is low. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more copper skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Jones and Menzie, (1986).

W123 — Skarn Cu Deposits — Idaho, Oregon Washington

Descriptive Model 18b

• 3.1 mean undiscovered deposits (entire tract)
• 2.1 mean undiscovered deposits (ID only)
• 1.0 mean undiscovered deposits (OR-WA only)

by Stephen Box and Arthur Bookstrom

Rationale for tract delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract., and consists of the Wallowa, Baker, and Huntington terranes of northeastern Oregon, west-central Idaho, and southeasternmost Washington (Brooks and Vallier, 1978; Walker and MacLeod, 1991). Plutonic rocks of Jurassic and Cretaceous(?) age are widely scattered through these terranes, and where large enough, these were excluded from the permissive tract. Small, irregular carbonate horizons occur throughout all three structurally complex terranes such that carbonates could be present in the subsurface of any part of these terranes. The Izee terrane of north-central Oregon lacks carbonates and was excluded from the tract.

Important Examples of Deposit Type

The Peacock deposit is a copper skarn deposit located near Cuprum, east of the Snake River. Grade and tonnage information on the deposit (Terry Close, U.S. Bureau of Mines, personal commun., 1994) indicate it is larger than the median of the grade and tonnage distributions of Jones and Menzie (1986). This deposit and about a dozen other prospects occur in small carbonate bodies within a roof pendant to an Early Jurassic quartz diorite pluton in the Wallowa terrane. Numerous small prospects are also known around the Wallowa batholith in northeastern Oregon.

Rationale for Numerical Estimate

The presence of a number of copper skarn prospects, most of which have not been adequately explored, indicates reasonable potential for undiscovered deposits (including prospects that prove to be deposits with further exploration). The Payette National Forest, which makes up much of the Idaho part of the tract, has most of the known prospects. Using a recent U.S. Geological Survey assessment of mineral potential in the Payette National Forest in Idaho (Bruce Johnson, U.S. Geological Survey, written communication, 1994), we estimate (at the 90th, 50th, 10th, 5th, and 1st percentiles) 0, 2, 3, 7, and 10 or more undiscovered copper skarn deposits consistent with the grade and tonnage model of Jones and Menzie (1986) for the Idaho portion of the tract. The part of the tract in Oregon and Washington is less prospective; the team estimated (at the above percentiles) 0, 0, 3, 4, and 5 or more undiscovered copper skarn deposits in that part of the tract. Summing these for the entire tract, the team estimated 0, 3, 5, 9, and 12 (at the above percentiles)) or more undiscovered copper skarn deposits consistent with the grade and tonnage model of Jones and Menzie (1986).

W124 — Skarn Cu Deposits

Descriptive Model 18b

• 0.01 mean undiscovered deposits

Idaho, Washington

by Stephen E. Box and Arthur Bookstrom

Rationale for Tract Delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract. Permissive sedimentary packages include the Paleozoic sequence of northeastern Washington, the middle Belt carbonate units of the Belt Supergroup in northern Idaho, and the Paleozoic sequence of south-central Idaho (Bond, 1978; Stoffel and others, 1991).

Important Examples of Deposit Type

The Empire mine near Mackay, Idaho is the only copper skarn deposit known in the tract. This deposit is large and rich, compared with the grade and tonnage distributions of Jones and Menzie (1986). However the Cu production from the deposit was too small to be considered a significant deposit for this report. Significant gold grades (1.6 g/metric ton) occur in the Empire deposit. The deposit is localized in a Pennsylvanian limestone around an Eocene granodiorite stock on the east side of the Idaho batholith. A small Zn-Pb skarn and a small Fe skarn occur on the opposite side of the stock from the Empire deposit.

Rationale for Numerical Estimate

The occurrence of only one known deposit of this type and the lack of known porphyry copper deposits in this tract lead the team to give a very low estimate. For the 90th, 50th, 10th, 5th, and 1st percentiles, the team estimated 0, 0, 0, 0, and 1 or more copper skarn deposits (with a 99% chance of no deposits) consistent with the grade and tonnage model of Jones and Menzie (1986).

X13 — Skarn Cu Deposits

Descriptive Model 18b

No estimate of undiscovered deposits

California, Oregon

by Dennis Cox, Steve Ludington, and Michael F. Diggles

Rationale for Tract Delineation

The tract was delineated by excluding areas without significant carbonate rocks from the corresponding porphyry Cu tract. The plutons of the Klamath Mountains and the northern Sierra Nevada include felsic rocks that, in places, intrude minor Triassic and older carbonate-bearing rocks (Jennings, 1977; Walker and MacLeod, 1991). Carbonate-bearing and calcareous sedimentary rocks are present in all sedimentary assemblages in this area , hence, no areas were excluded from the permissive tract on the basis of age or composition of intruded country rock.

Important Examples of Deposit Type

The only important skarn deposit in the Klamath Mountains is the King Solomon mine in the Cecilville district, which produced nearly a metric ton of gold (Hotz, 1971). There are no significant copper skarn deposits in the tract.

Rationale for Lack of Numerical Estimate

Since the tract lies entirely outside the ICBEMP boundary, no numerical estimate of undiscovered copper skarn deposits was made.

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Appendix A

Appendix A presents (in tabular and graphic form) the results of a Monte Carlo simulation model of the tonnage of contained metals and rock ore for each permissive tract within the ICBEMP study area (listed alphabetically by tract identification letter and number) for which an estimate of the number of undiscovered deposits was made. The simulation ("Mark 3 simulation") applies the probability estimates of the expert team (estimated numbers of deposits at 90%, 50%, 10%, 5% and 1% probabilities) to the statistical distribution of metal grades and ore tonnages of historically mined or explored deposits of that type (the specific grade/tonnage data file referred to by "Mark3 Index number") to produce a probability distribution of quantities of contained metals and mineralized rock for each permissive tract (Root and others, 1992).

The tabular display gives the estimates of contained metal and mineralized rock (in metric tonnes) at five different probability quantiles: probabilities of 95%, 90%, 50%, 10% and 5%. The mean values of all the estimates of the 4999 Mark3 numerical simulation follow the five probability quantiles. The probabilities of the mean estimate and of the presence of zero deposits in the tract are also given.

The results of the Mark3 simulation of the estimated number of undiscovered deposits are displayed graphically in two ways: (1) in cumulative histograms of contained metal and mineralized rock against probability from 0% to 100%, with the mean value marked, and (2) in histograms of contained metal and mineralized rock against the proportion of the 4999 simulations run for each tract.

The tract ID is C02 (ICB only)

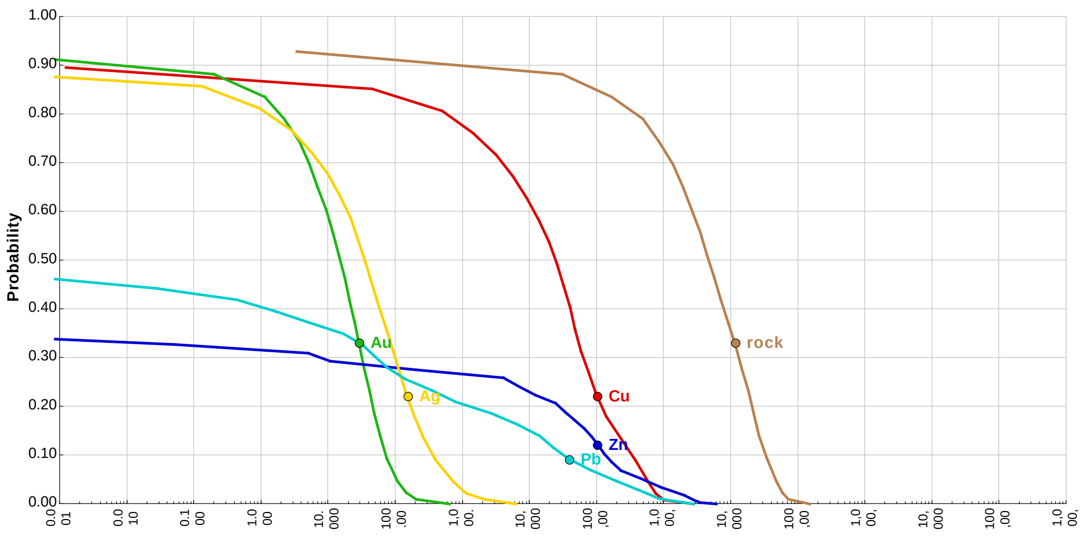
The Mark3 Index is 82: **Skarn Au**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 4 or more deposits.
There is a 10% or greater chance of 6 or more deposits.
There is a 5% or greater chance of 9 or more deposits.
There is a 1% or greater chance of 12 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

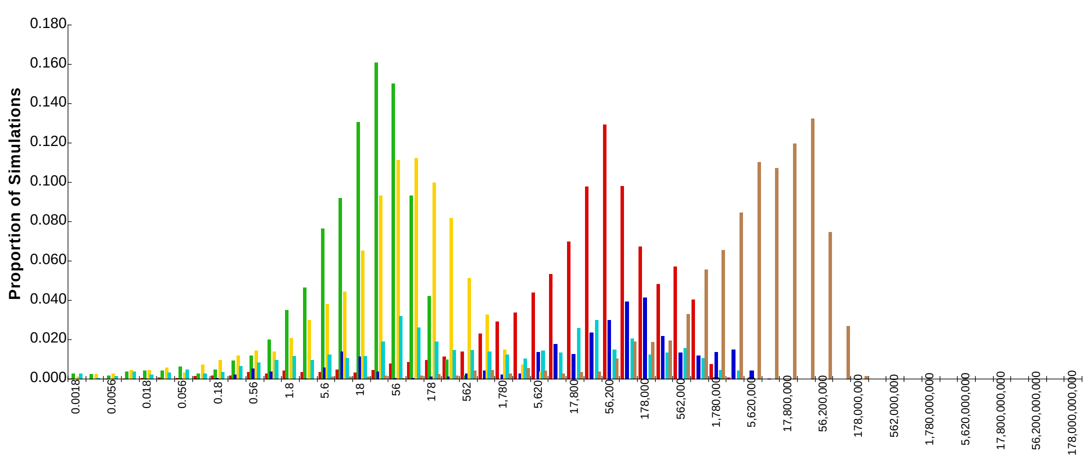
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	2,800
0.50	24,000	15	0	35	0	4,600,000
0.10	340,000	72	130,000	360	30,000	33,000,000
0.05	560,000	110	490,000	670	170,000	46,000,000
mean	**100,000**	**29**	**100,000**	**150**	**39,000**	**12,000,000**
Probability of mean	0.22	0.33	0.12	0.22	0.09	0.33
Probability of zero	0.10	0.07	0.66	0.10	0.53	0.07

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Zn Ag Pb rock

The tract ID is C05 (ICB only)

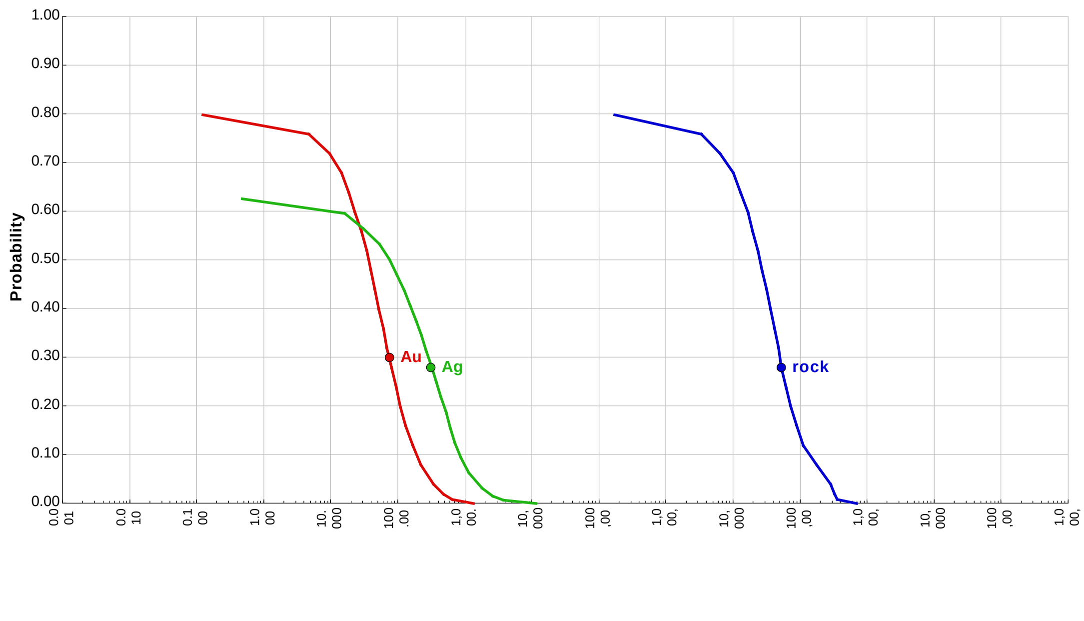
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

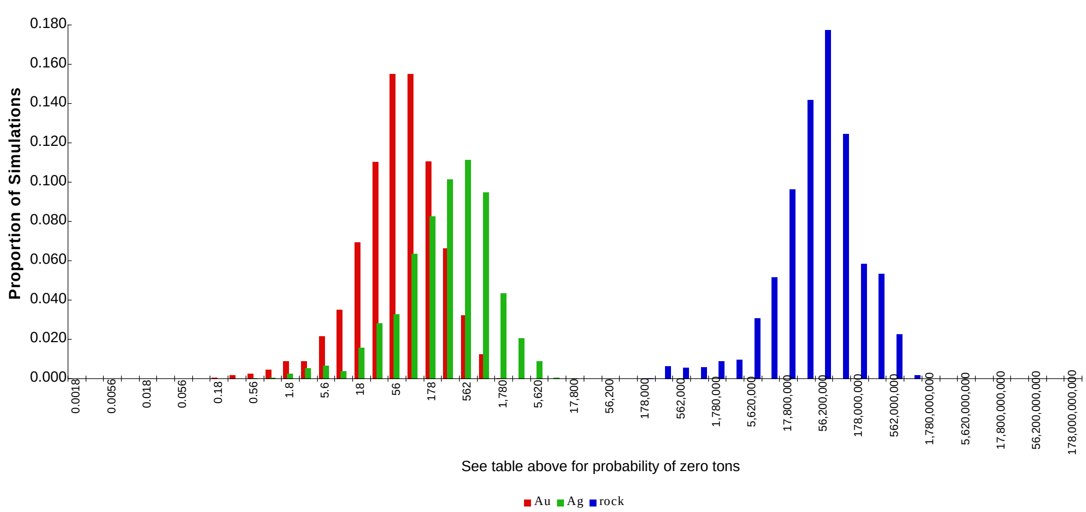
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	37	75	25,000,000
0.10	190	830	130,000,000
0.05	300	1,300	250,000,000
mean	**75**	**310**	**52,000,000**
Probability of mean	0.30	0.28	0.28
Probability of zero	0.20	0.37	0.20

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C07 (ICB only)

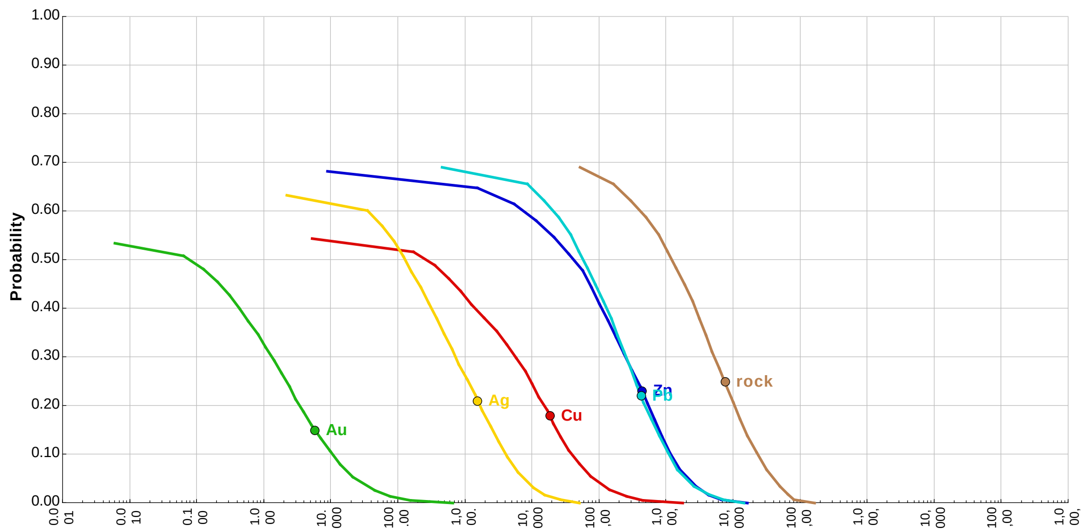
The Mark3 Index is 47: **Polymetallic replacement**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 7 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

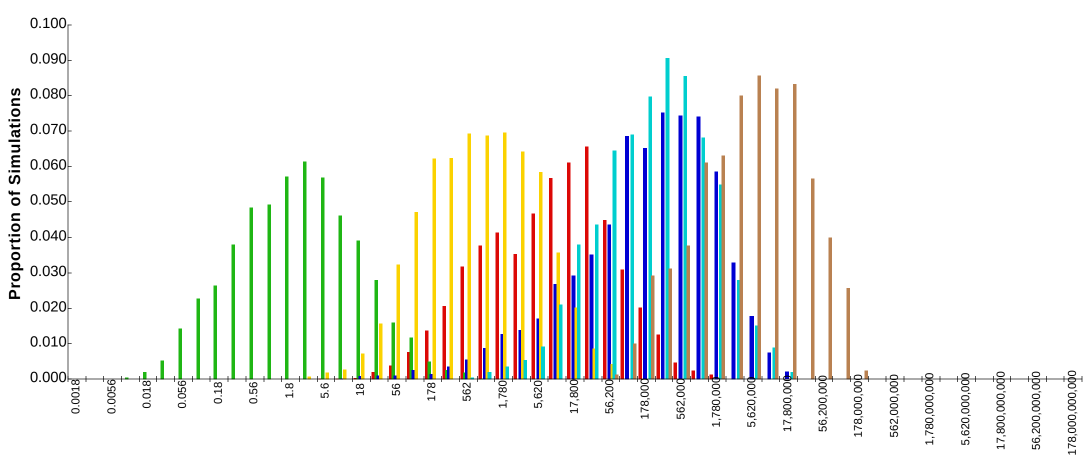
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	280	0	41,000	130	58,000	1,200,000
0.10	39,000	11	1,200,000	4,100	1,100,000	23,000,000
0.05	84,000	23	2,100,000	7,600	1,900,000	40,000,000
mean	**19,000**	**6**	**430,000**	**1,500**	**420,000**	**7,600,000**
Probability of mean	0.18	0.15	0.23	0.21	0.22	0.25
Probability of zero	0.46	0.47	0.32	0.37	0.31	0.31

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Zn Ag Pb rock

The tract ID is C13 (ICB only)

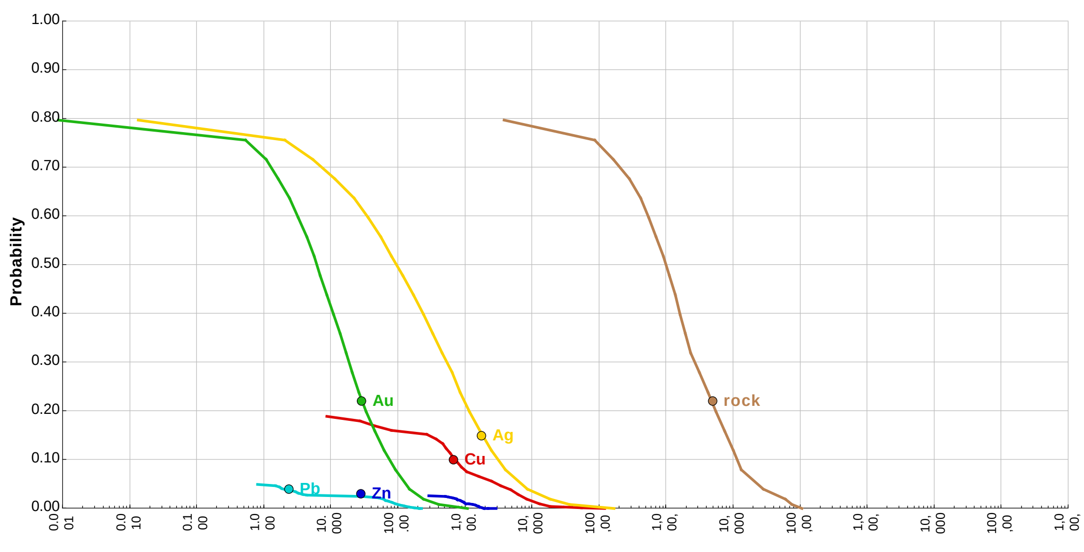
The Mark3 Index is 25: **Epithermal vein, quartz-adularia**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

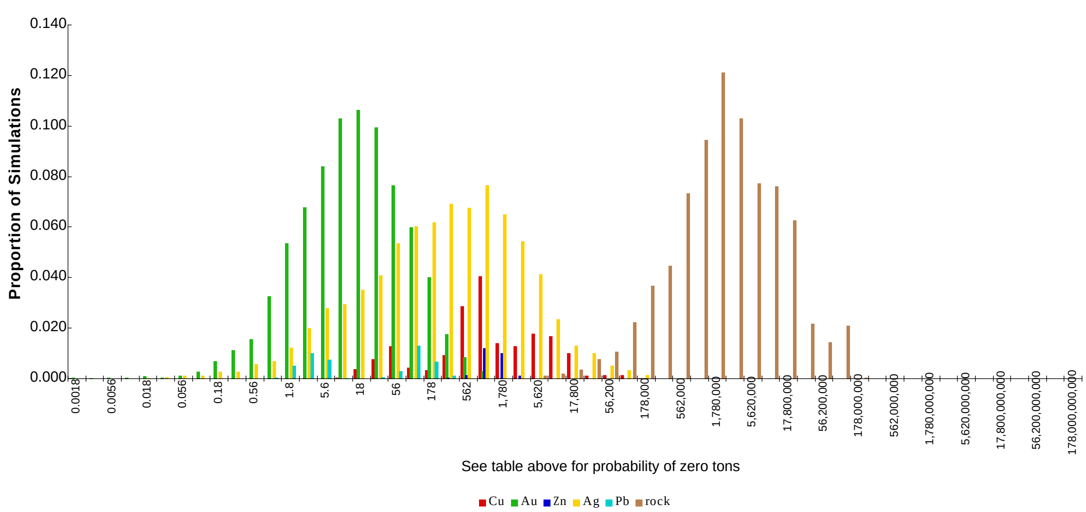
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	6	0	94	0	990,000
0.10	710	75	0	3,100	0	12,000,000
0.05	3,200	120	0	6,700	0	21,000,000
mean	**680**	**29**	**27**	**1,800**	**2**	**4,900,000**
Probability of mean	0.10	0.22	0.03	0.15	0.04	0.22
Probability of zero	0.81	0.20	0.97	0.20	0.95	0.20

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C14 (ICB only)

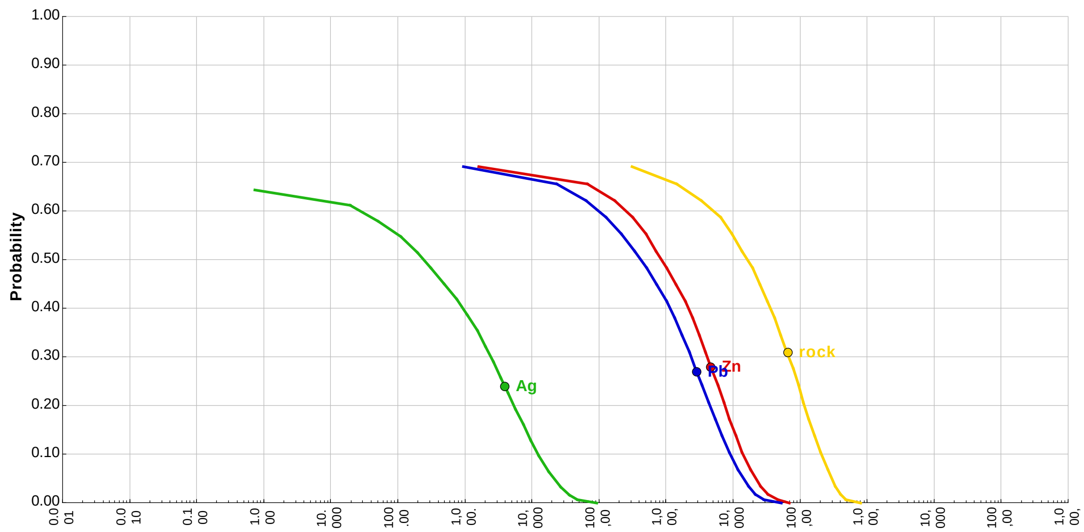
The Mark3 Index is 13: **Sedimentary exhalative Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 7 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

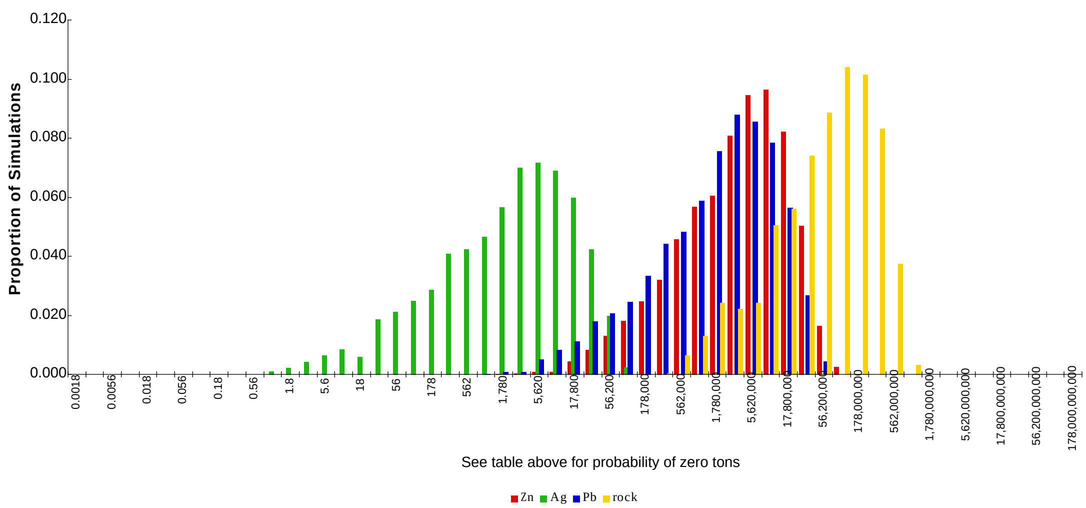
quantile	Zn	Ag	Pb	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	850,000	250	430,000	16,000,000
0.10	14,000,000	12,000	9,100,000	210,000,000
0.05	21,000,000	21,000	14,000,000	290,000,000
mean	**4,600,000**	**3,900**	**2,900,000**	**65,000,000**
Probability of mean	0.28	0.24	0.27	0.31
Probability of zero	0.31	0.36	0.31	0.31

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C15 (ICB only)

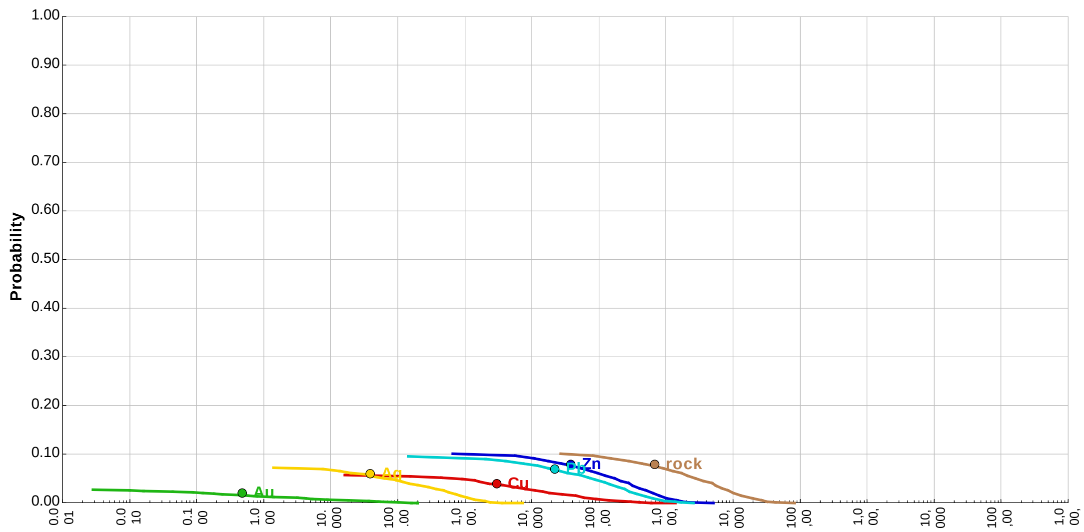
The Mark3 Index is 22: **Skarn Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

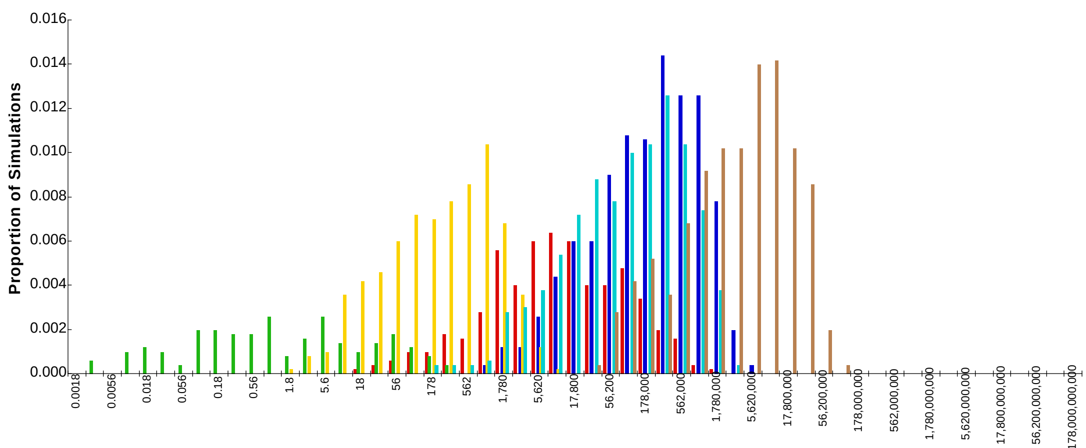
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	2,000	0	0	54,000
0.05	820	0	180,000	70	80,000	2,900,000
mean	**3,000**	**1**	**38,000**	**38**	**22,000**	**670,000**
Probability of mean	0.04	0.02	0.08	0.06	0.07	0.08
Probability of zero	0.94	0.97	0.90	0.93	0.90	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is C19 (ICB only)

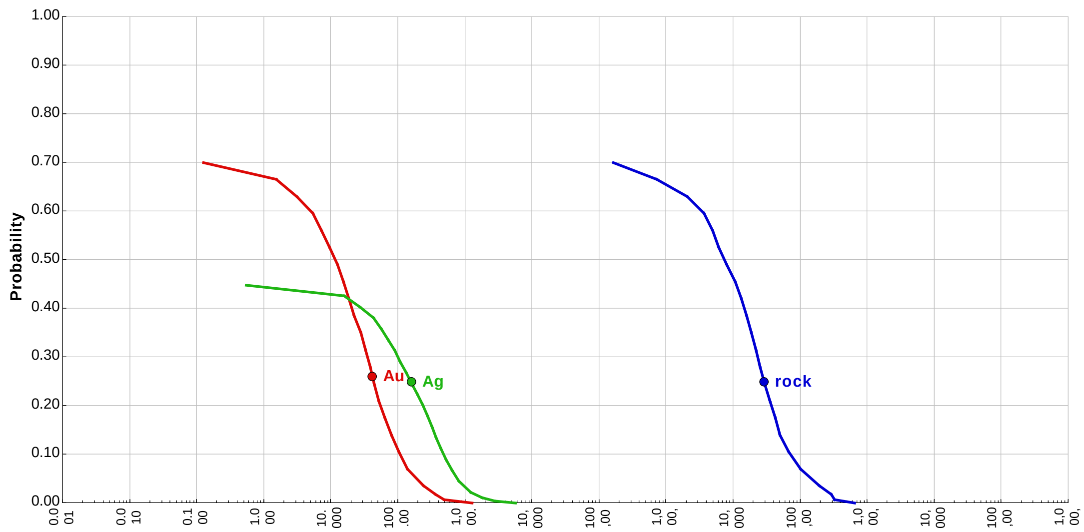
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

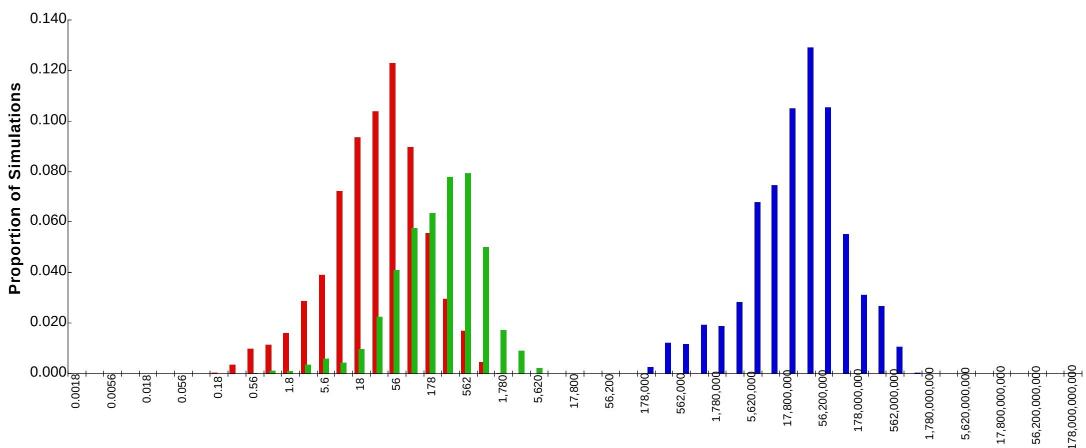
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	12	0	7,400,000
0.10	110	480	71,000,000
0.05	180	750	130,000,000
mean	**41**	**160**	**29,000,000**
Probability of mean	0.26	0.25	0.25
Probability of zero	0.30	0.55	0.30

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is C23 (ICB only)

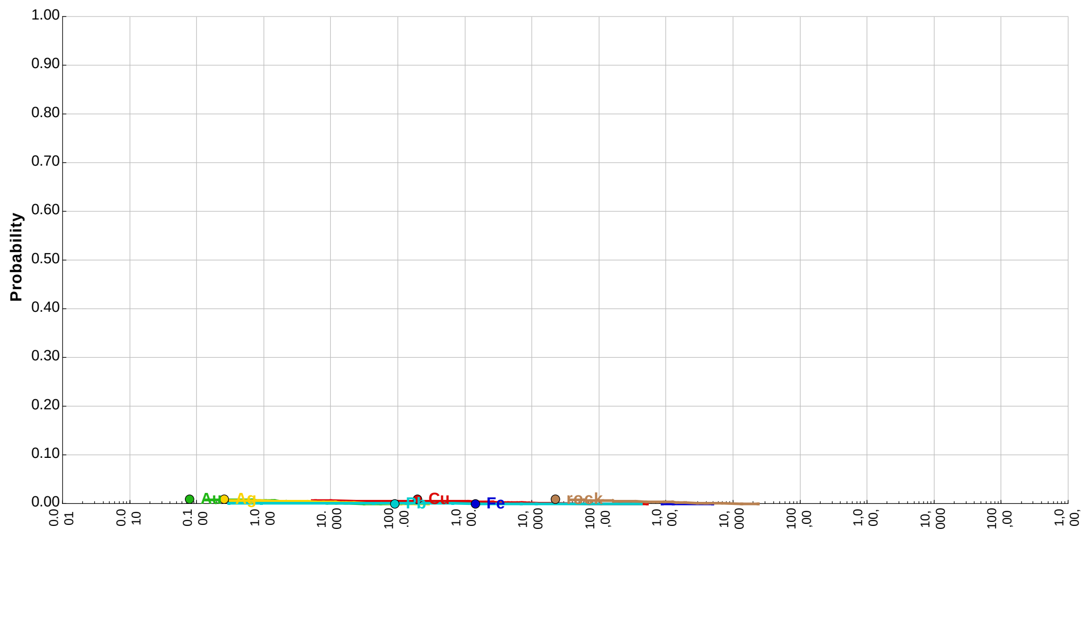
The Mark3 Index is 105: **Skarn Au, truncated**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

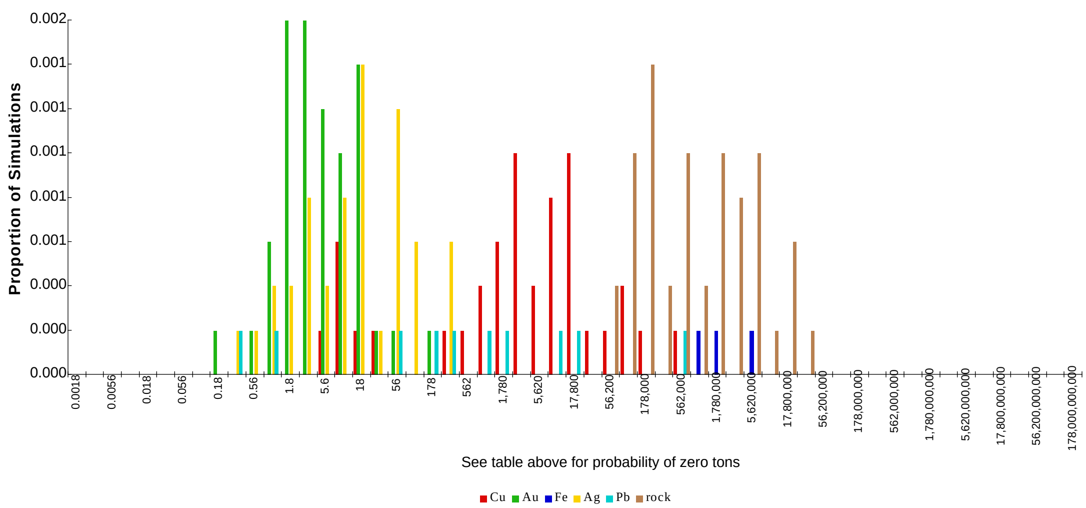
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Fe	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**190**	**0**	**1,400**	**0**	**89**	**22,000**
Probability of mean	0.01	0.01	0.00	0.01	0.00	0.01
Probability of zero	0.99	0.99	1.00	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



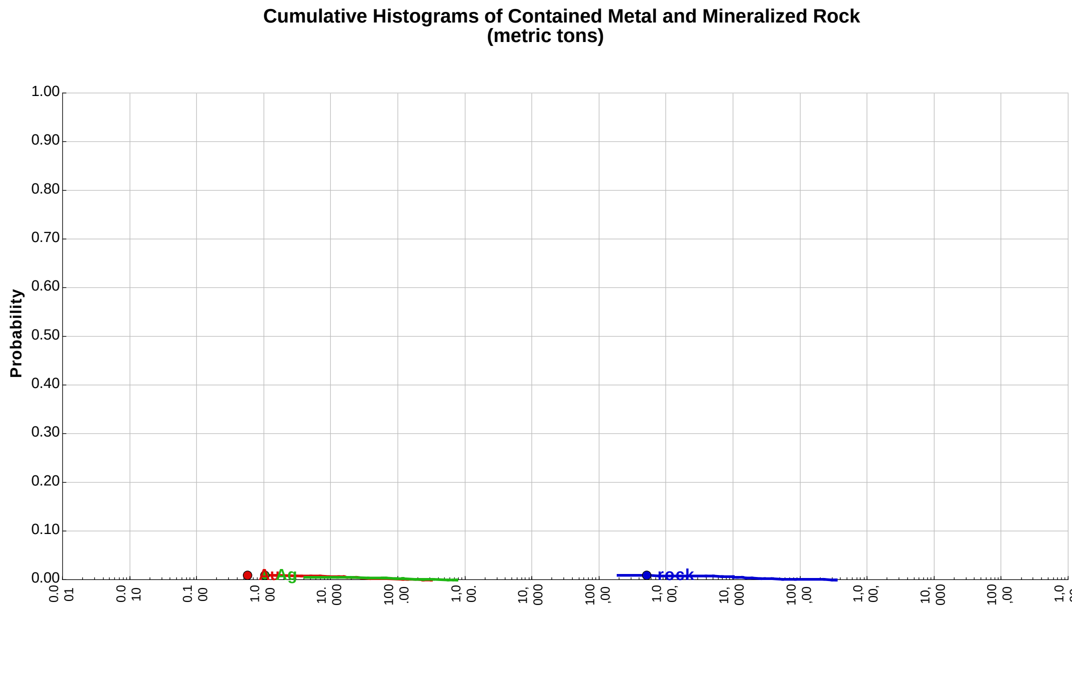
The tract ID is C24 (ICB only)

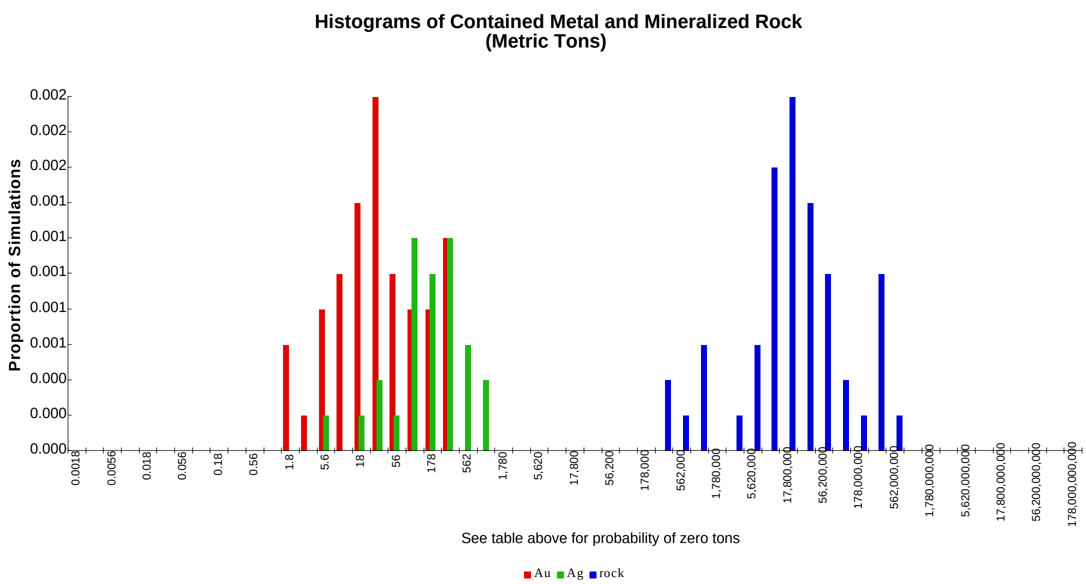
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**1**	**1**	**510,000**
Probability of mean	0.01	0.01	0.01
Probability of zero	0.99	0.99	0.99





The tract ID is C26 (ICB only)

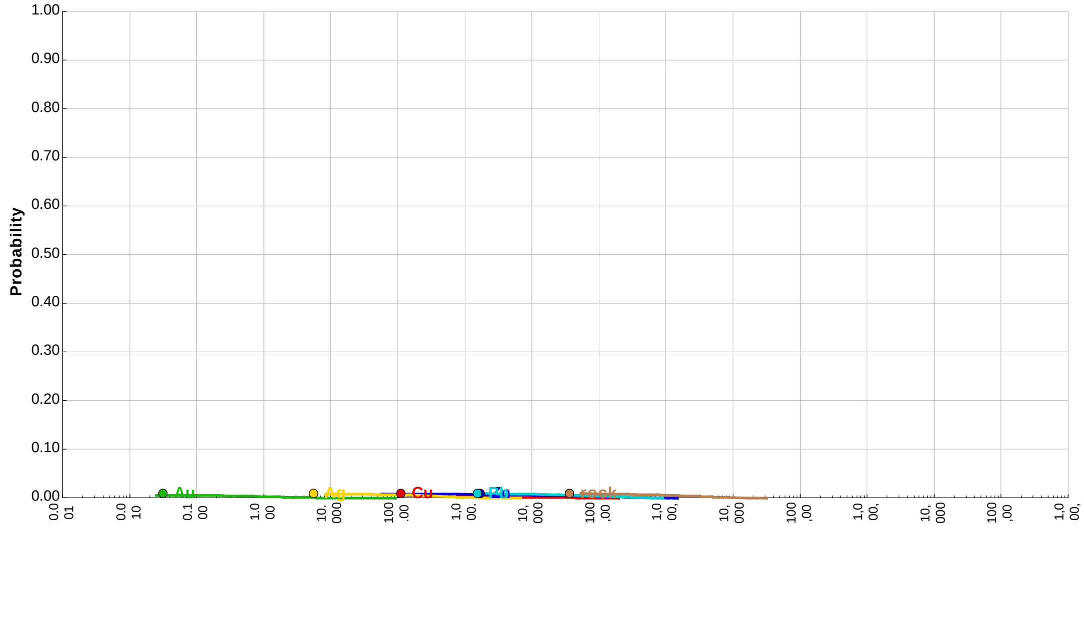
The Mark3 Index is 47: **Polymetallic replacement**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

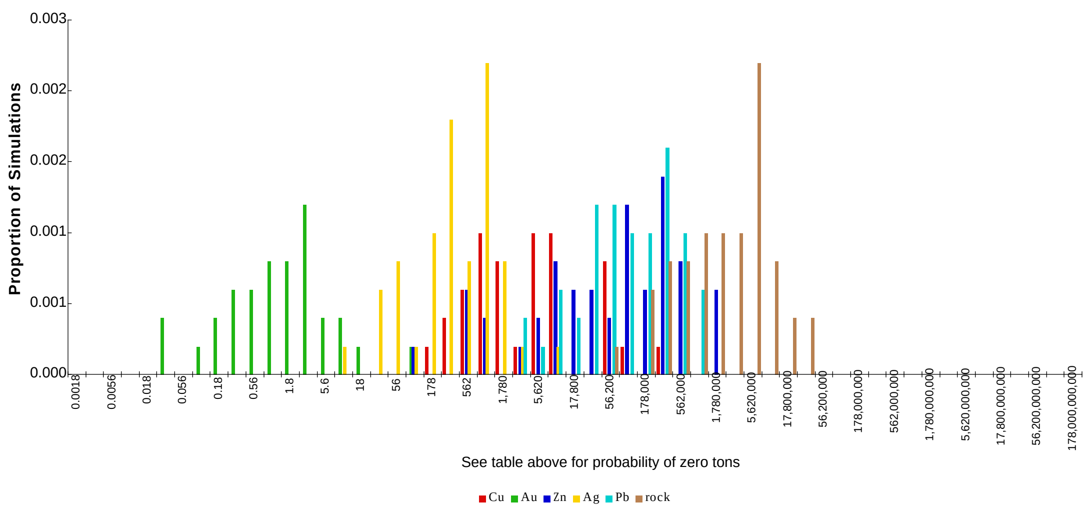
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**110**	**0**	**1,700**	**5**	**1,500**	**36,000**
Probability of mean	0.01	0.01	0.01	0.01	0.01	0.01
Probability of zero	0.99	0.99	0.99	0.99	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C27 (ICB only)

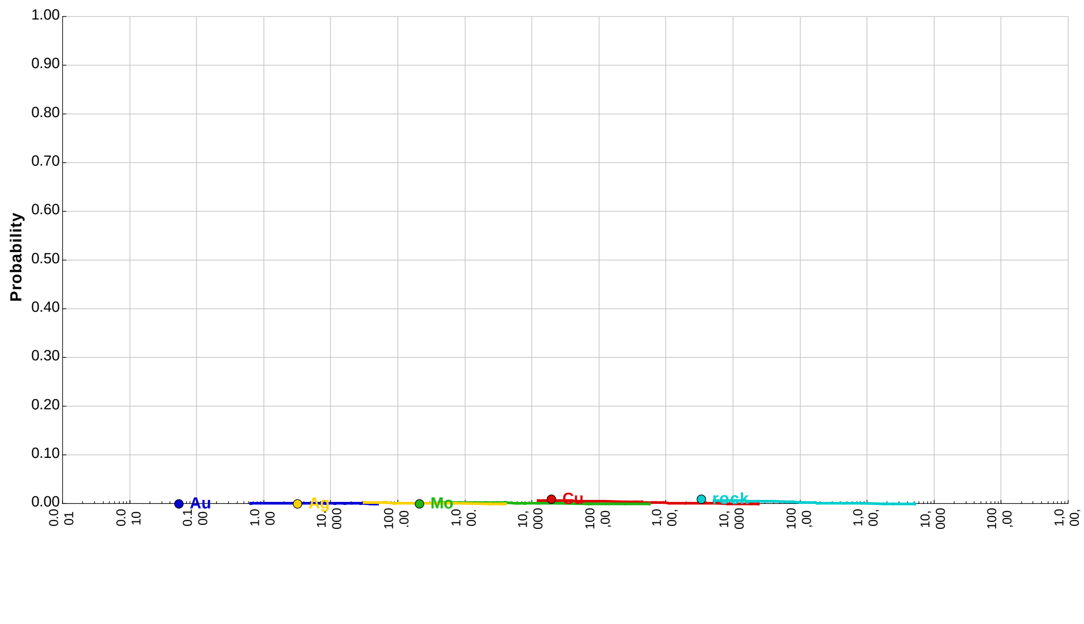
The Mark3 Index is 81: **Porphyry Cu (North America)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

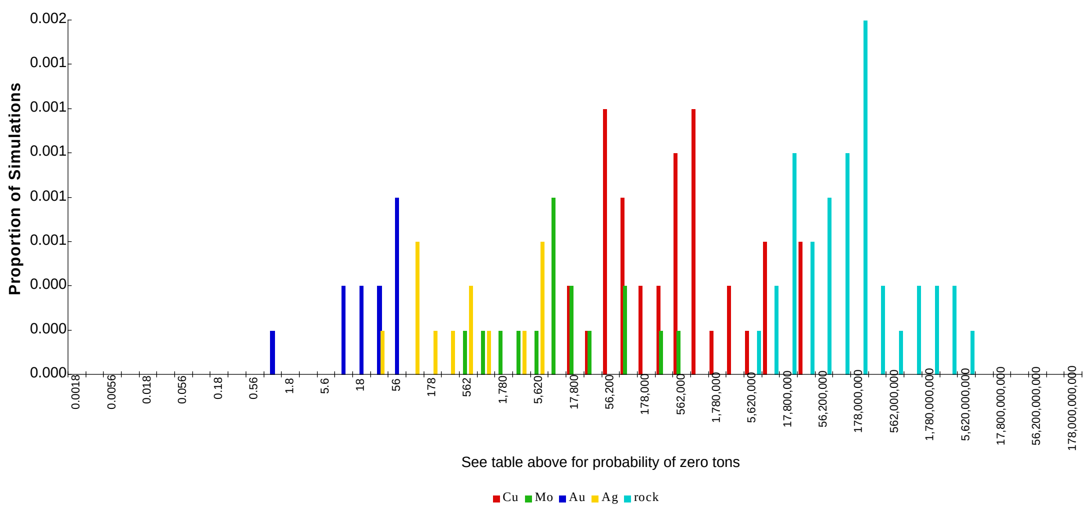
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	0	0	0	0	0
mean	**20,000**	**210**	**0**	**3**	**3,400,000**
Probability of mean	0.01	0.00	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C30 (ICB only)

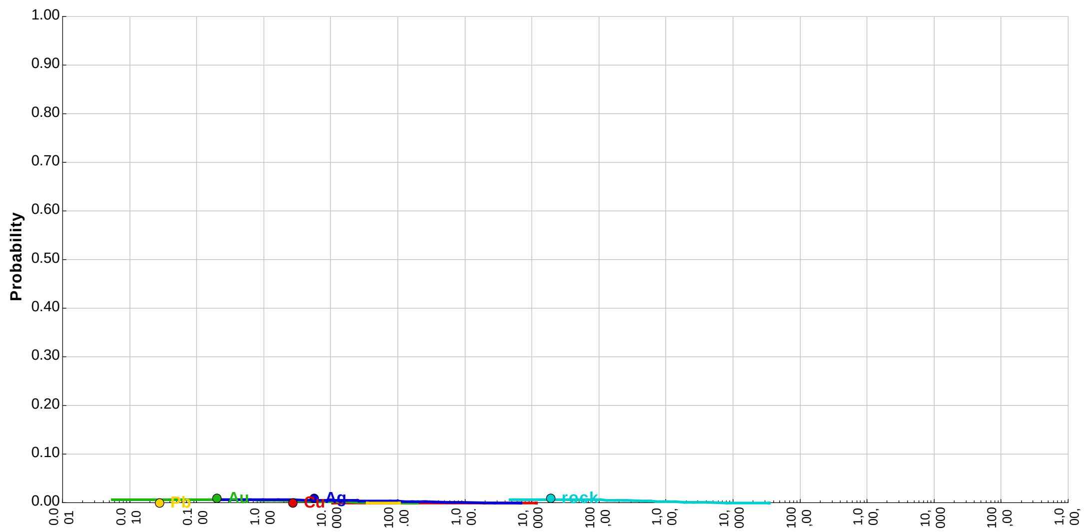
The Mark3 Index is 25: **Epithermal vein, quartz-adularia**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

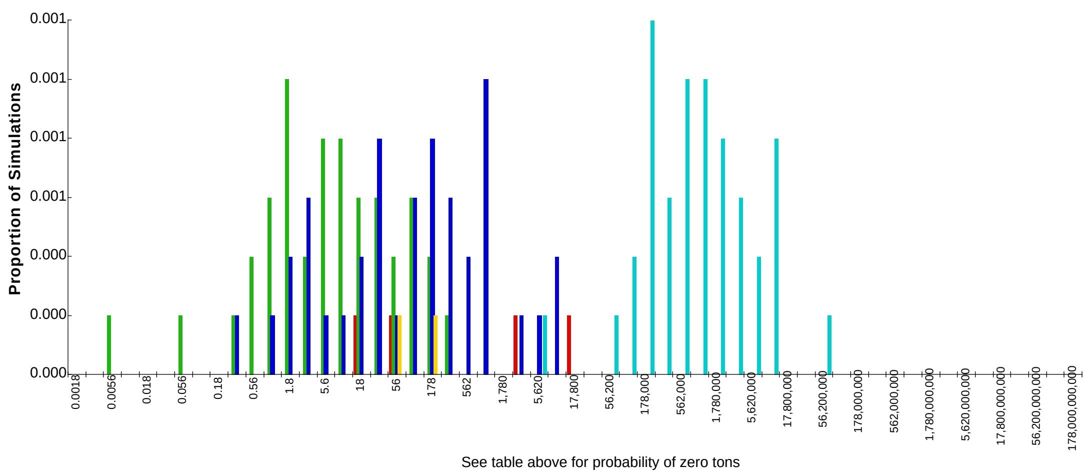
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	Pb	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	0	0	0	0	0
mean	**3**	**0**	**6**	**0**	**19,000**
Probability of mean	0.00	0.01	0.01	0.00	0.01
Probability of zero	1.00	0.99	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Ag Pb rock

The tract ID is C31 (ICB only)

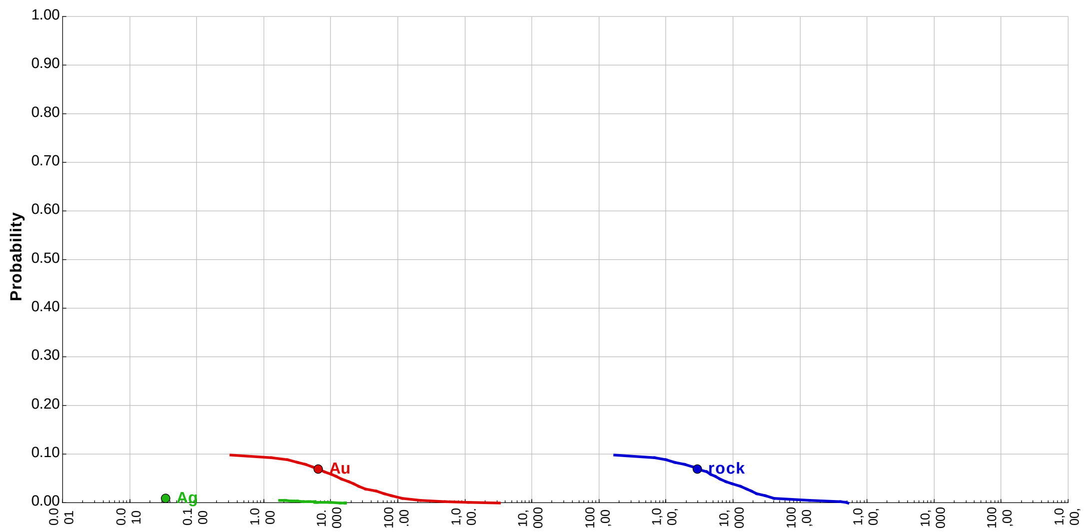
The Mark3 Index is 17: **Sediment-hosted Au**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 1 or more deposits.
There is a 1% or greater chance of 2 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

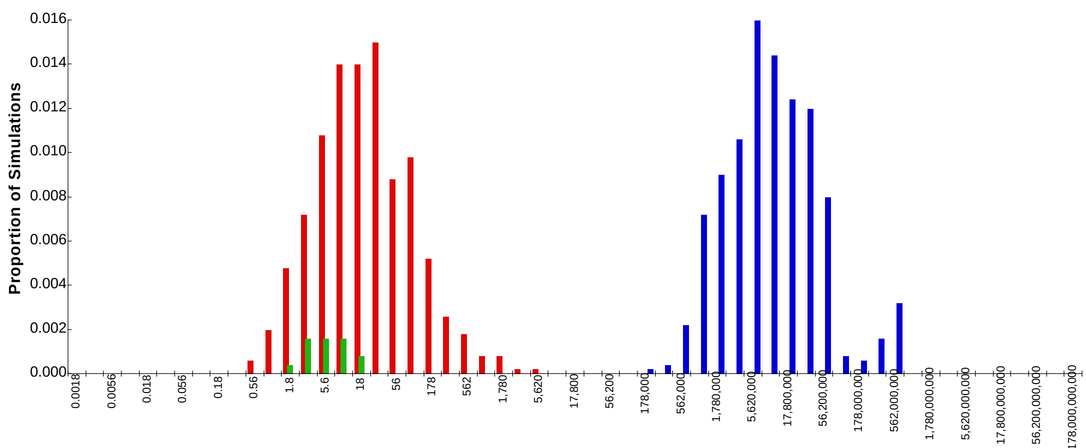
quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	14	0	6,200,000
mean	**6**	**0**	**2,900,000**
Probability of mean	0.07	0.01	0.07
Probability of zero	0.90	0.99	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

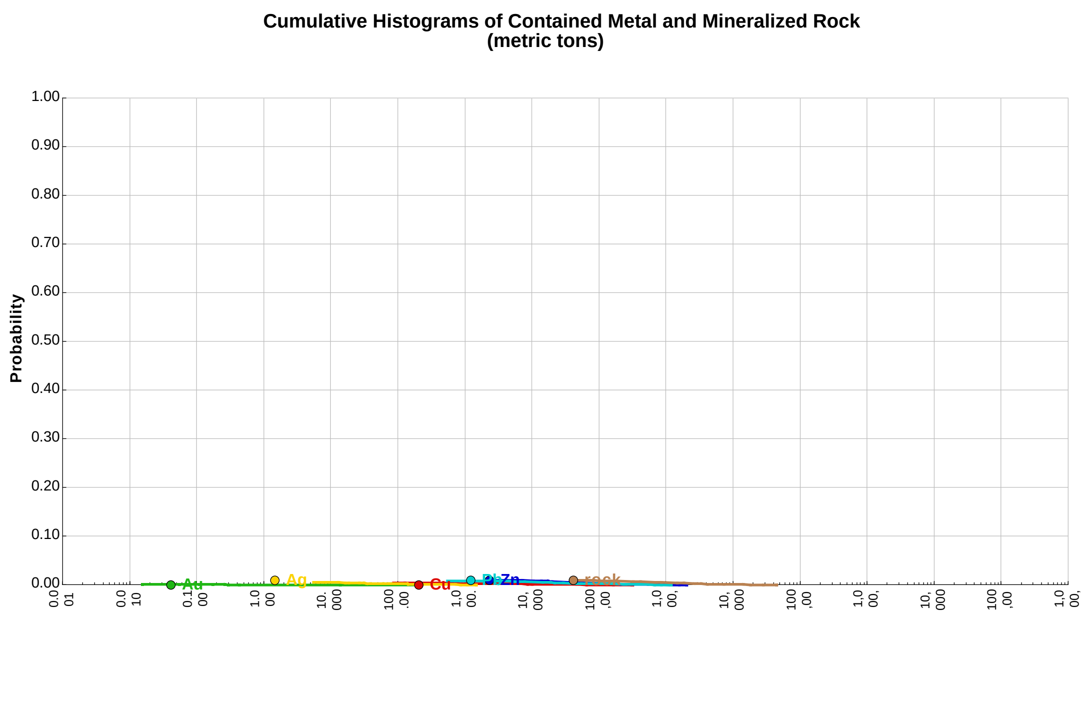
The tract ID is C33 (ICB only)

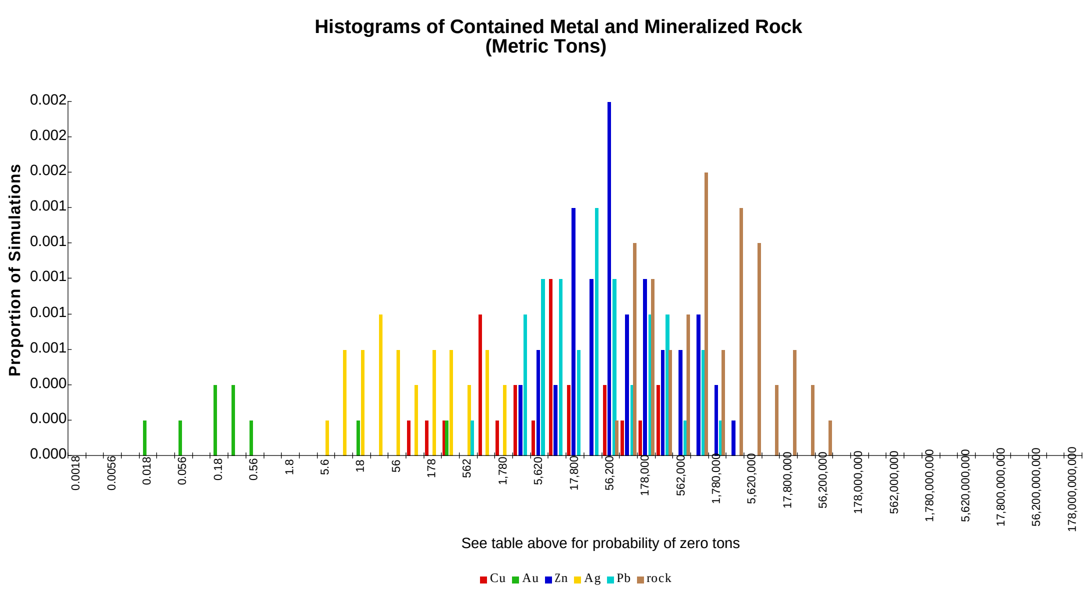
The Mark3 Index is 22: **Skarn Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**200**	**0**	**2,300**	**1**	**1,200**	**41,000**
Probability of mean	0.00	0.00	0.01	0.01	0.01	0.01
Probability of zero	1.00	1.00	0.99	0.99	0.99	0.99





The tract ID is C90 (ICB only)

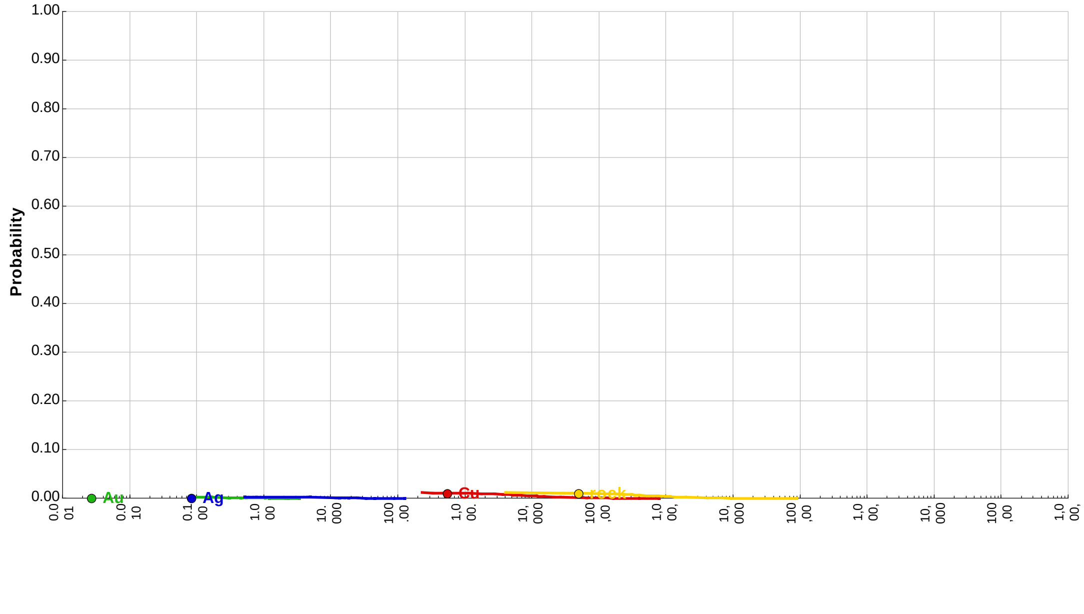
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

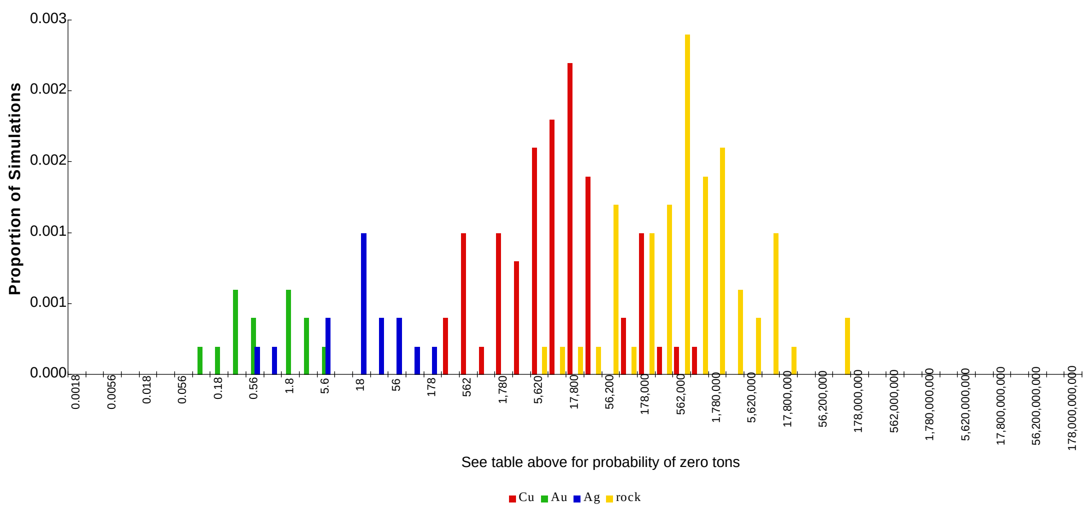
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	0	0	0	0
0.05	0	0	0	0
mean	**540**	**0**	**0**	**50,000**
Probability of mean	0.01	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C100 (ICB only)

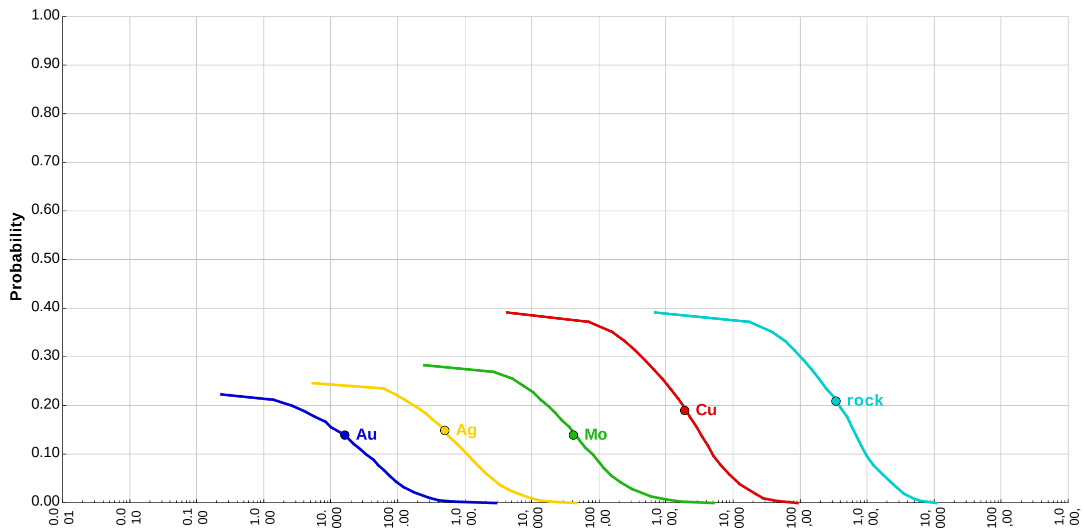
The Mark3 Index is 81: **Porphyry Cu (North America)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

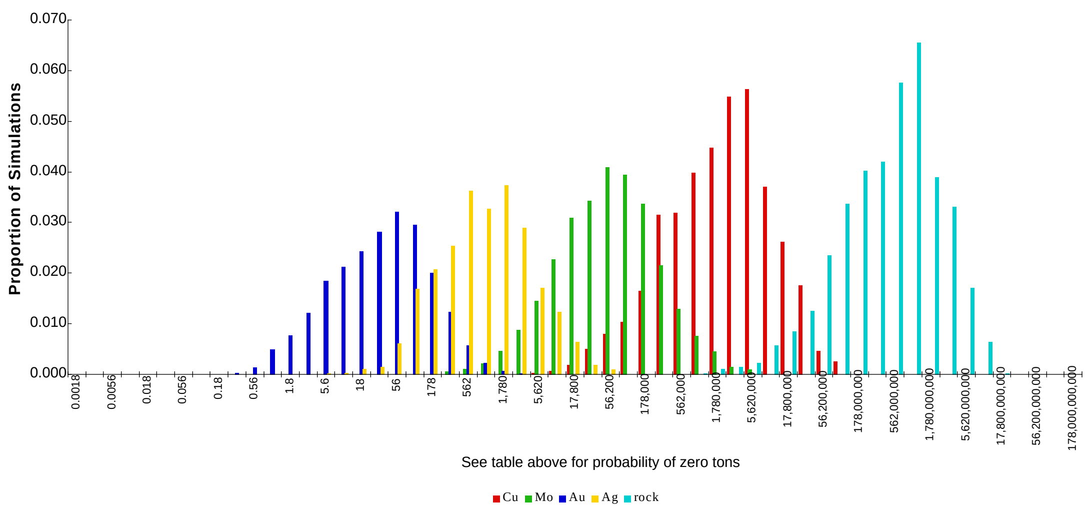
quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	4,900,000	79,000	34	1,100	970,000,000
0.05	10,000,000	180,000	84	2,600	2,000,000,000
mean	**1,900,000**	**41,000**	**16**	**500**	**340,000,000**
Probability of mean	0.19	0.14	0.14	0.15	0.21
Probability of zero	0.61	0.72	0.78	0.75	0.61

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is C102 (ICB only)

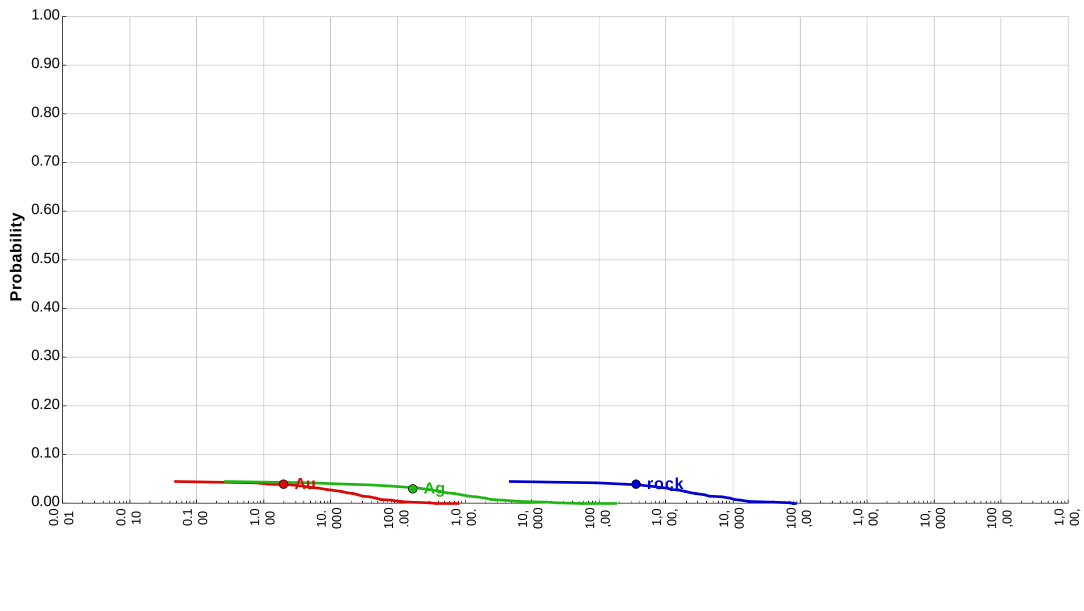
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 1 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

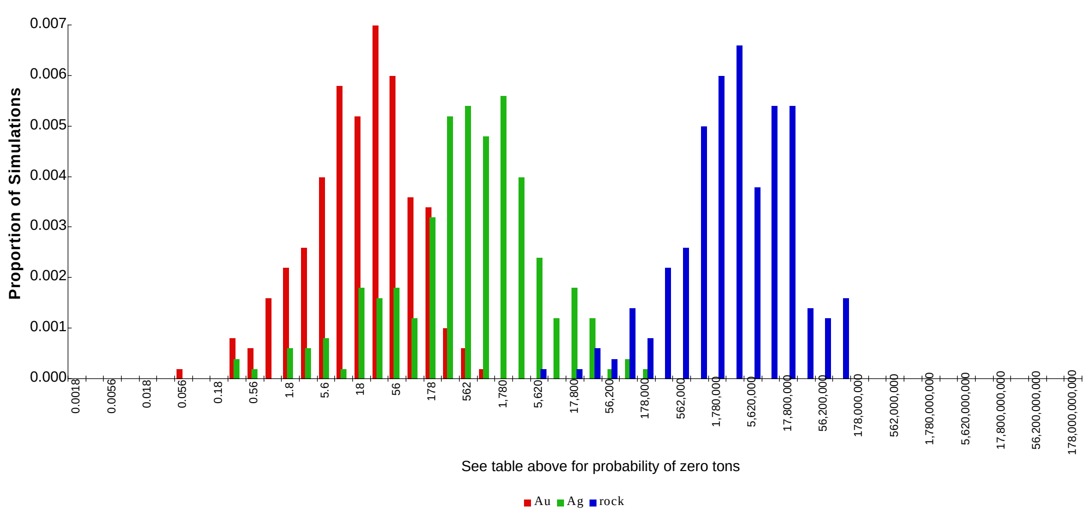
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**2**	**170**	**350,000**
Probability of mean	0.04	0.03	0.04
Probability of zero	0.96	0.96	0.96

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is PC16 (ICB only)

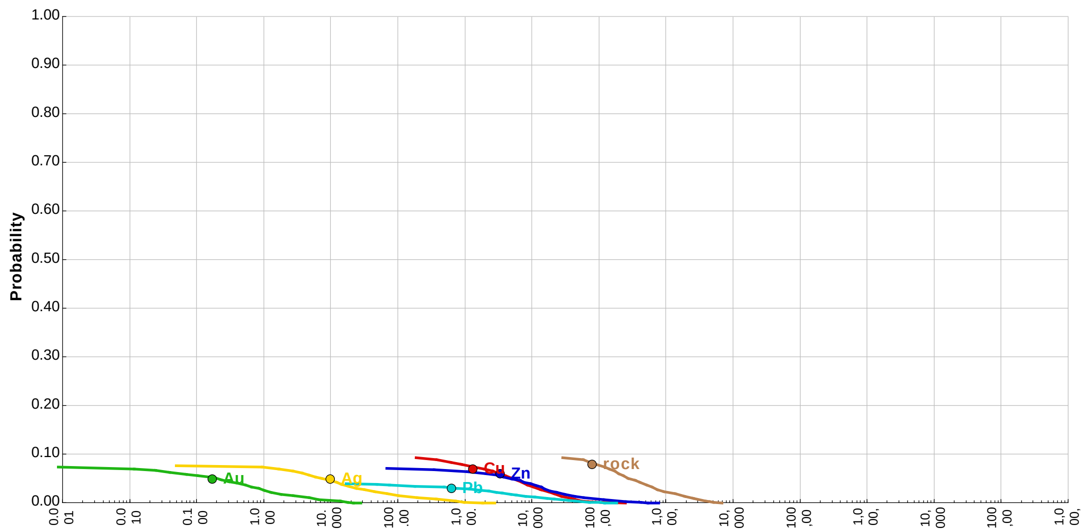
The Mark3 Index is 44: **Massive sulfide, Sierran kuroko**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 2 or more deposits.

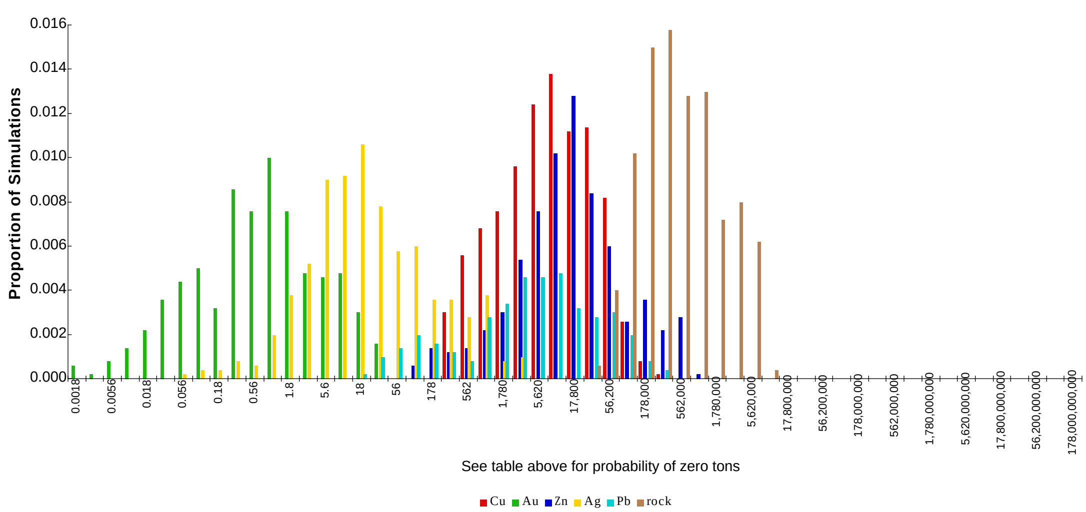
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	5,100	0	5,200	8	0	280,000
mean	**1,300**	**0**	**3,300**	**10**	**620**	**79,000**
Probability of mean	0.07	0.05	0.06	0.05	0.03	0.08
Probability of zero	0.91	0.93	0.93	0.92	0.96	0.91

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is PC22 (ICB only)

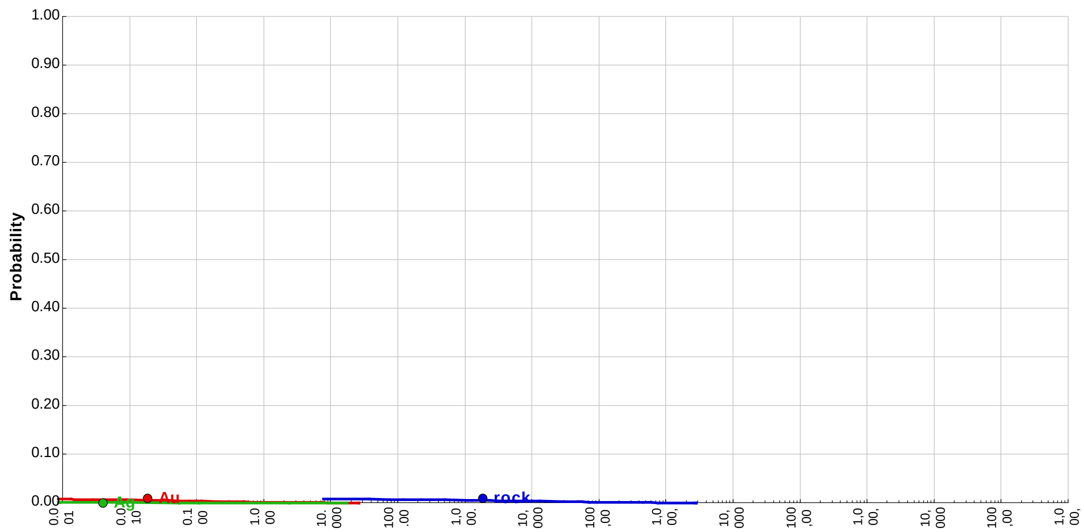
The Mark3 Index is 27: **Low sulfide Au-quartz vein**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

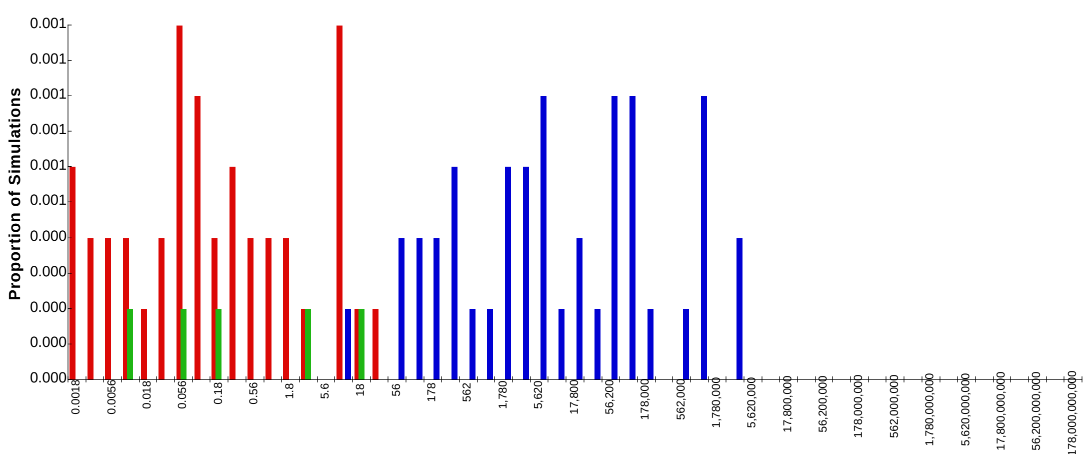
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**0**	**0**	**1,900**
Probability of mean	0.01	0.00	0.01
Probability of zero	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Au ■ Ag ■ rock

The tract ID is PC26 (ICB only)

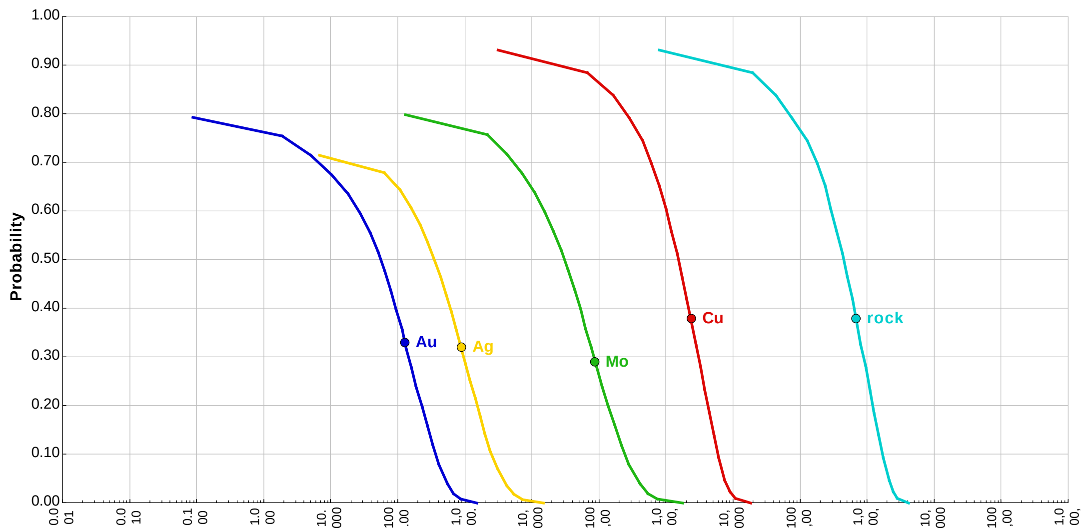
The Mark3 Index is 89: **Porphyry Cu (BC-AK)**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 8 or more deposits.
There is a 5% or greater chance of 8 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

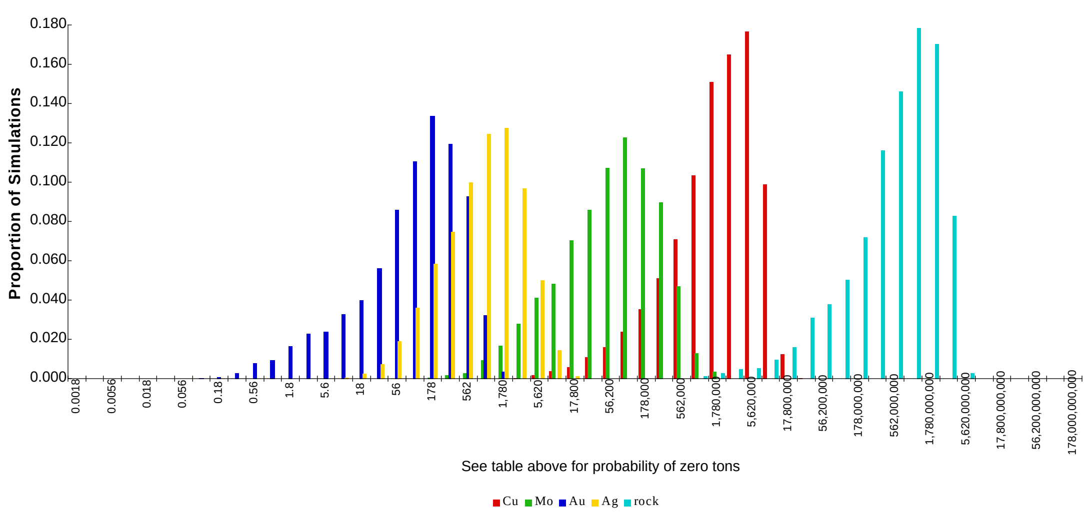
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	42,000	0	0	0	13,000,000
0.50	1,500,000	30,000	55	350	450,000,000
0.10	5,900,000	240,000	360	2,500	1,700,000,000
0.05	7,300,000	360,000	490	3,600	2,100,000,000
mean	**2,400,000**	**86,000**	**130**	**890**	**670,000,000**
Probability of mean	0.38	0.29	0.33	0.32	0.38
Probability of zero	0.07	0.20	0.21	0.28	0.07

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is PC27 (ICB only)

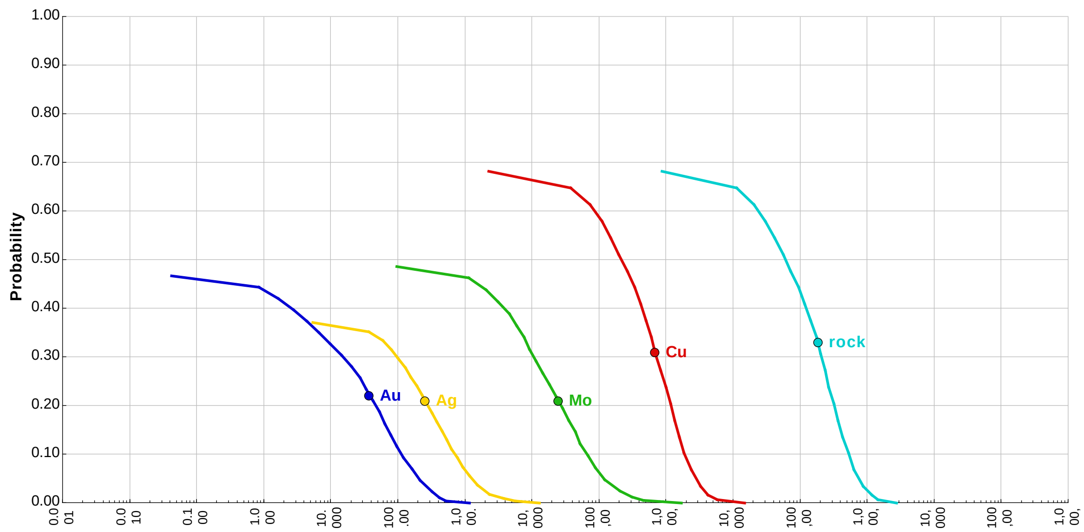
The Mark3 Index is 89: **Porphyry Cu (BC-AK)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 2 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

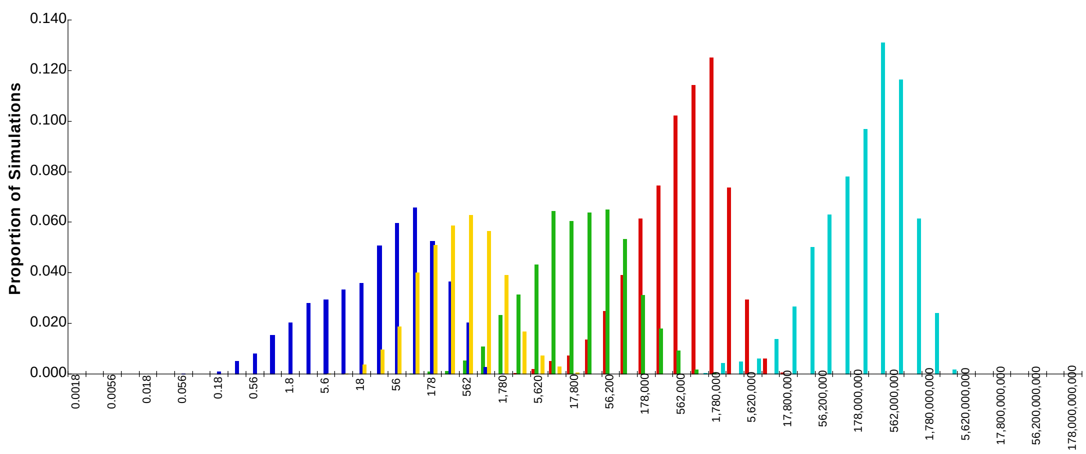
quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	220,000	0	0	0	61,000,000
0.10	1,900,000	66,000	110	710	530,000,000
0.05	2,800,000	120,000	210	1,200	720,000,000
mean	**670,000**	**24,000**	**36**	**250**	**180,000,000**
Probability of mean	0.31	0.21	0.22	0.21	0.33
Probability of zero	0.32	0.51	0.53	0.63	0.32

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is PC100 (ICB only)

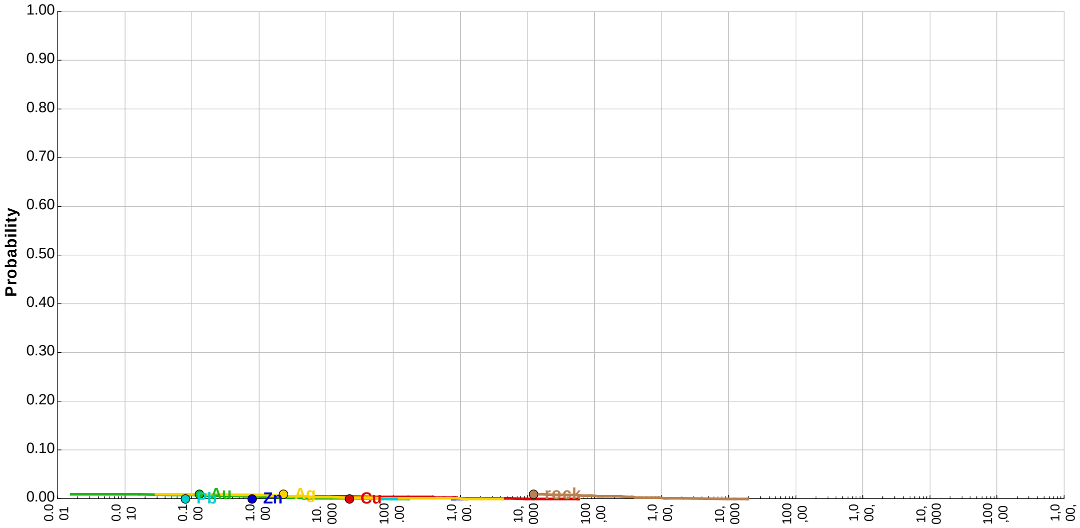
The Mark3 Index is 28: **Epithermal vein, Sado**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

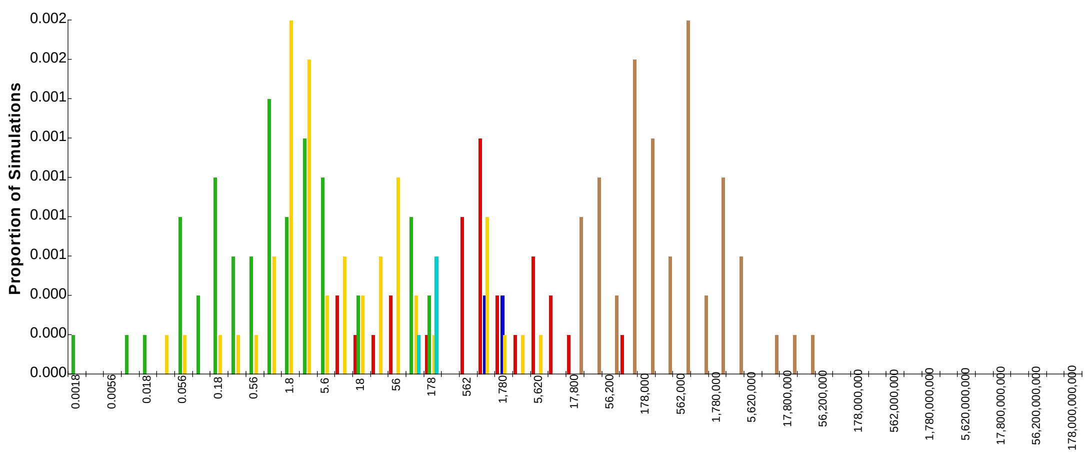
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**22**	**0**	**1**	**2**	**0**	**12,000**
Probability of mean	0.00	0.01	0.00	0.01	0.00	0.01
Probability of zero	0.99	0.99	1.00	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is PC101

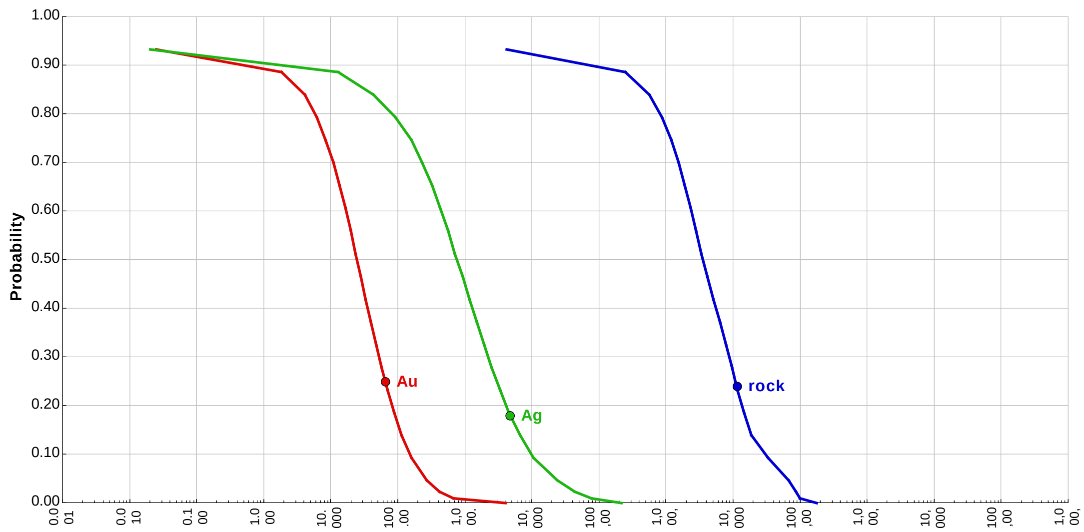
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 3 or more deposits.
There is a 10% or greater chance of 4 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

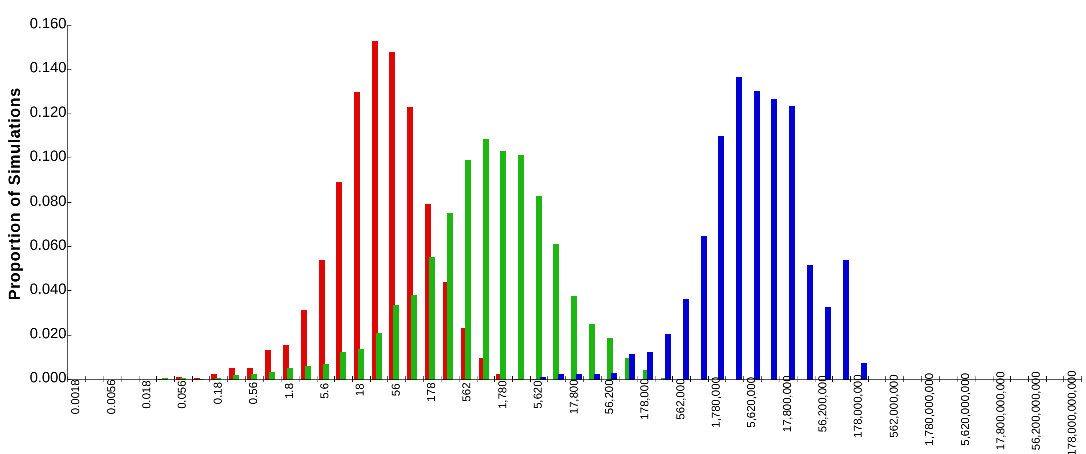
quantile	Au	Ag	rock
0.95	0	0	0
0.90	1	7	160,000
0.50	24	760	3,500,000
0.10	150	9,500	28,000,000
0.05	250	22,000	64,000,000
mean	**64**	**4,700**	**11,000,000**
Probability of mean	0.25	0.18	0.24
Probability of zero	0.07	0.07	0.07

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is PW100

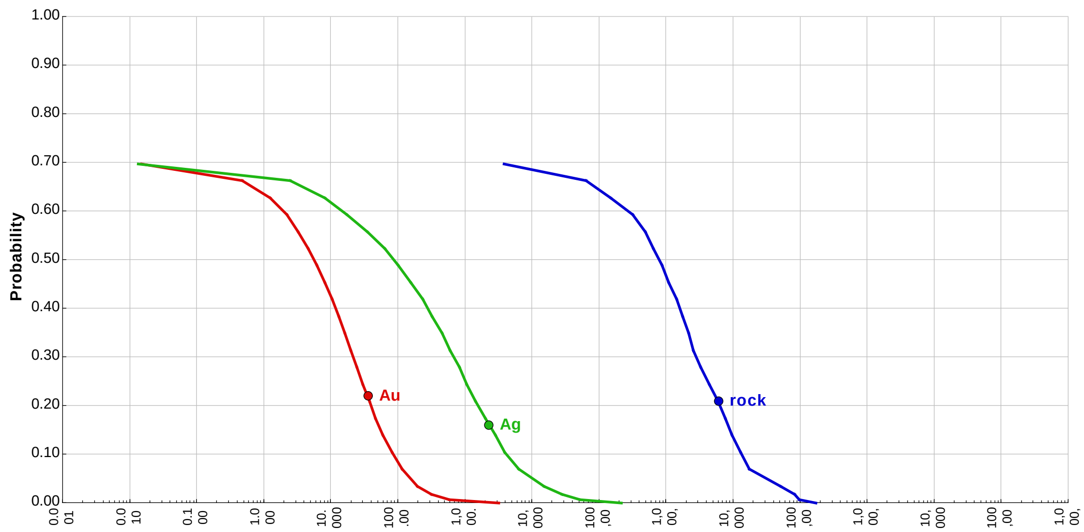
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 5 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

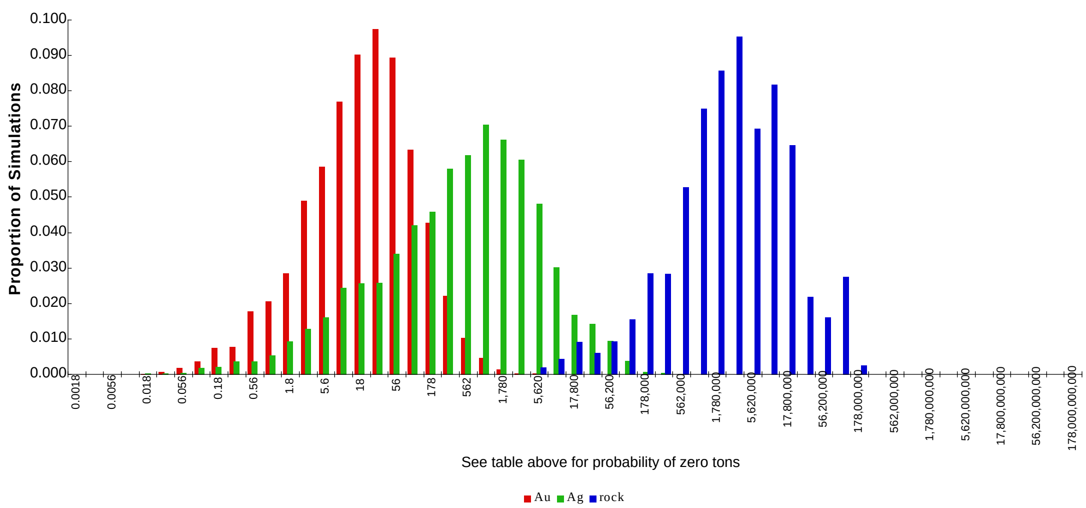
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	6	87	780,000
0.10	85	4,100	14,000,000
0.05	150	9,400	28,000,000
mean	**36**	**2,300**	**6,000,000**
Probability of mean	0.22	0.16	0.21
Probability of zero	0.30	0.30	0.30

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is PW101 (ICB only)

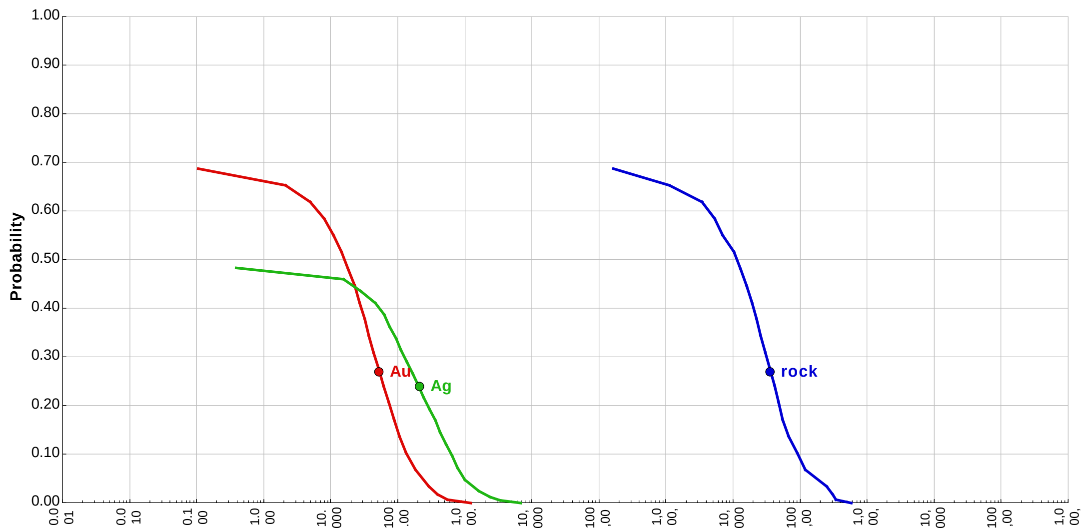
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

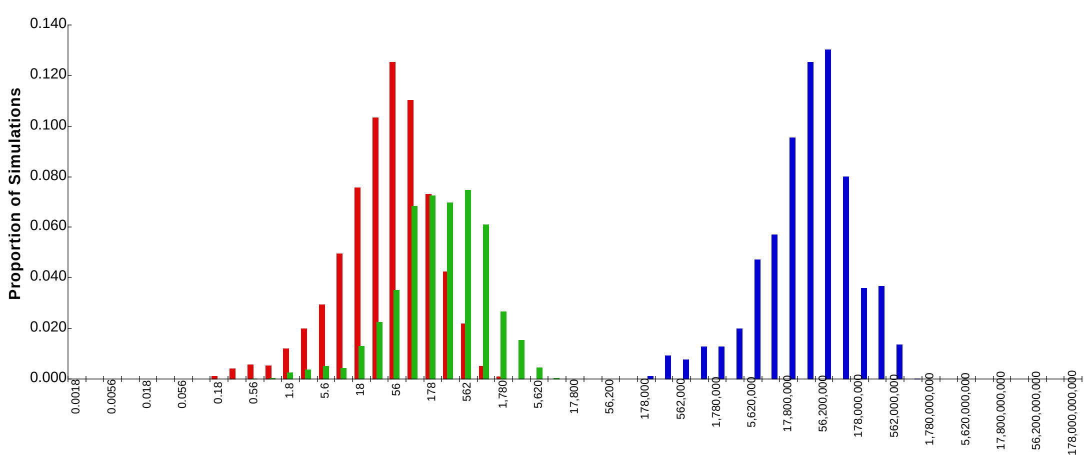
quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	16	0	11,000,000
0.10	140	620	92,000,000
0.05	230	970	180,000,000
mean	**51**	**210**	**35,000,000**
Probability of mean	0.27	0.24	0.27
Probability of zero	0.31	0.52	0.31

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is W02

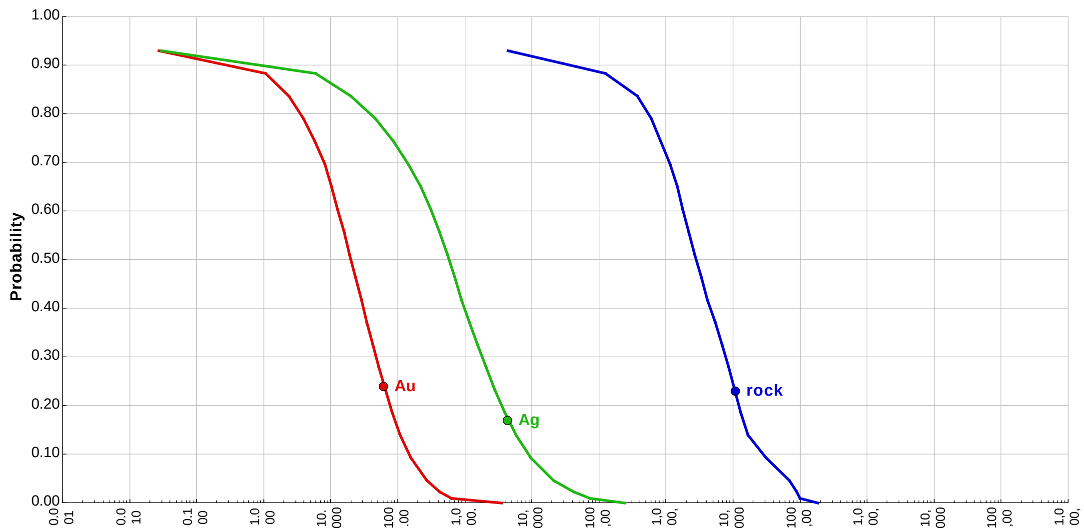
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 4 or more deposits.
There is a 5% or greater chance of 5 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

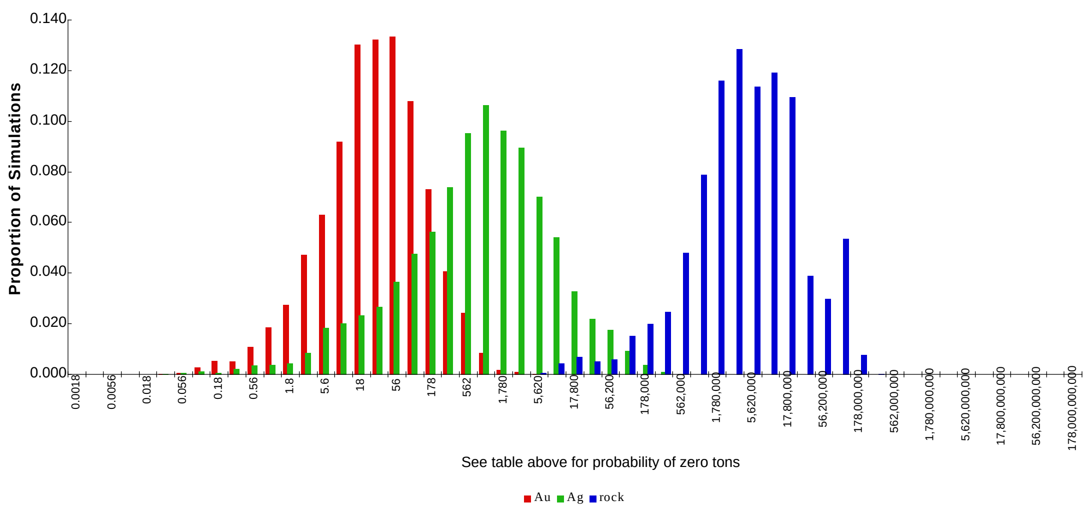
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	1	3	71,000
0.50	20	590	2,800,000
0.10	140	8,800	27,000,000
0.05	250	19,000	66,000,000
mean	**61**	**4,300**	**11,000,000**
Probability of mean	0.24	0.17	0.23
Probability of zero	0.07	0.07	0.07

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W06

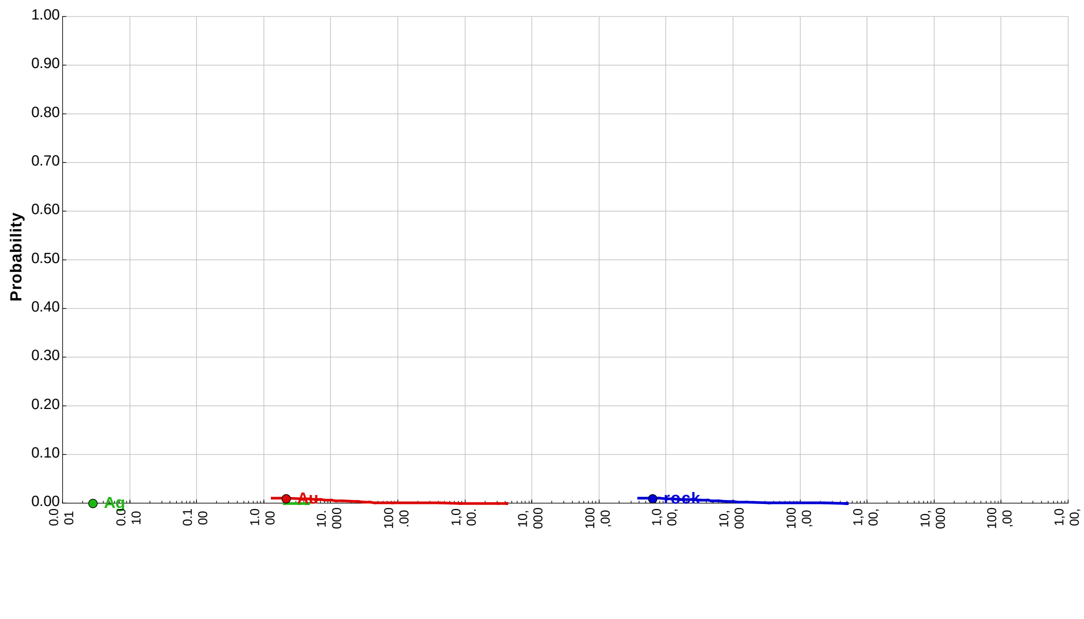
The Mark3 Index is 17: **Sediment-hosted Au**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

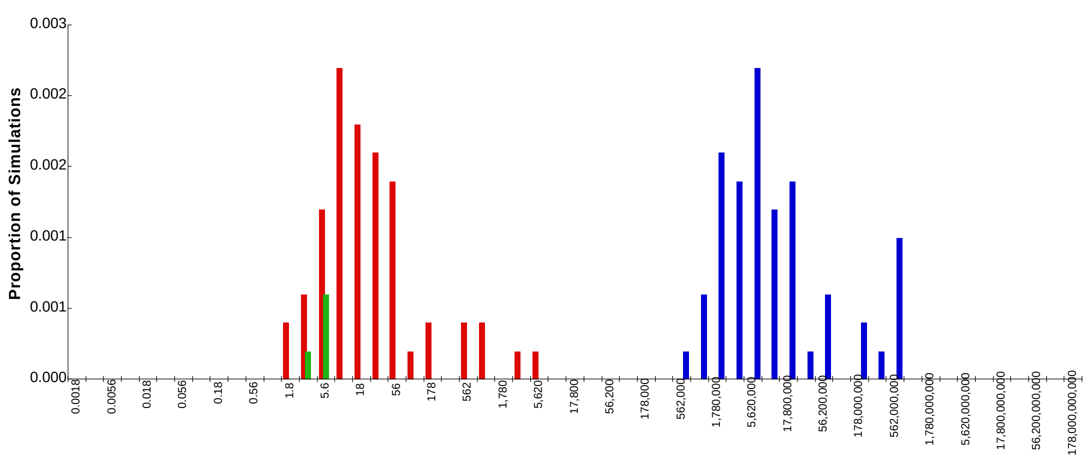
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**2**	**0**	**630,000**
Probability of mean	0.01	0.00	0.01
Probability of zero	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Au ■ Ag ■ rock

The tract ID is W07

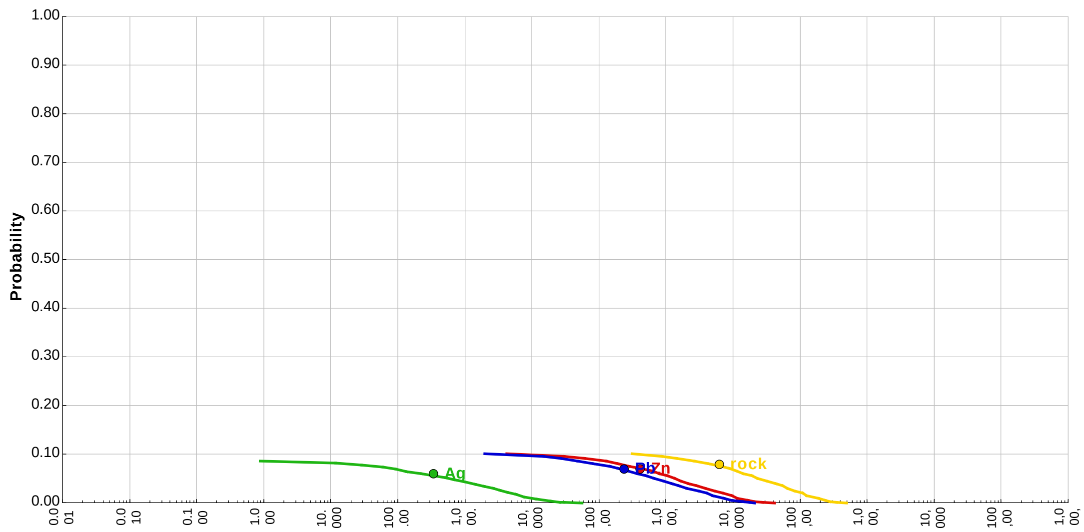
The Mark3 Index is 13: **Sedimentary exhalative Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

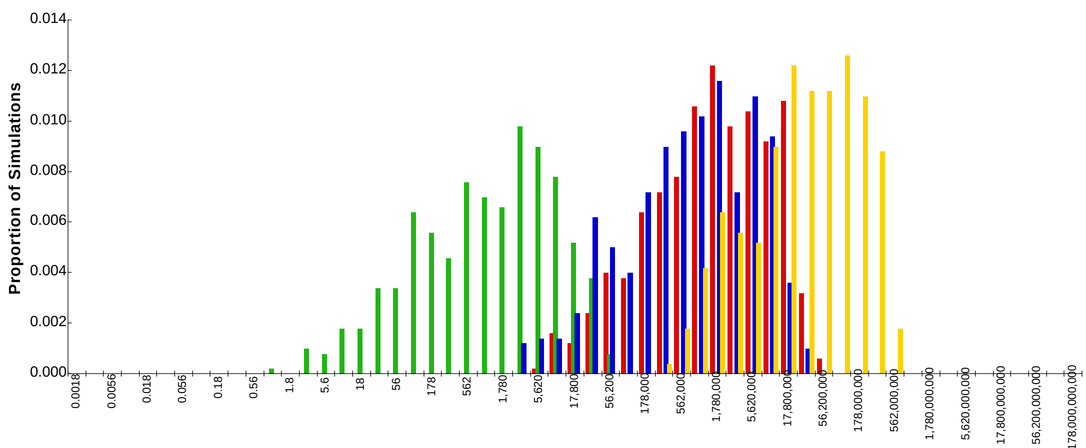
quantile	Zn	Ag	Pb	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	9,600	0	3,600	430,000
0.05	1,400,000	580	700,000	24,000,000
mean	**410,000**	**330**	**230,000**	**6,200,000**
Probability of mean	0.07	0.06	0.07	0.08
Probability of zero	0.90	0.91	0.90	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Zn Ag Pb rock

The tract ID is W08

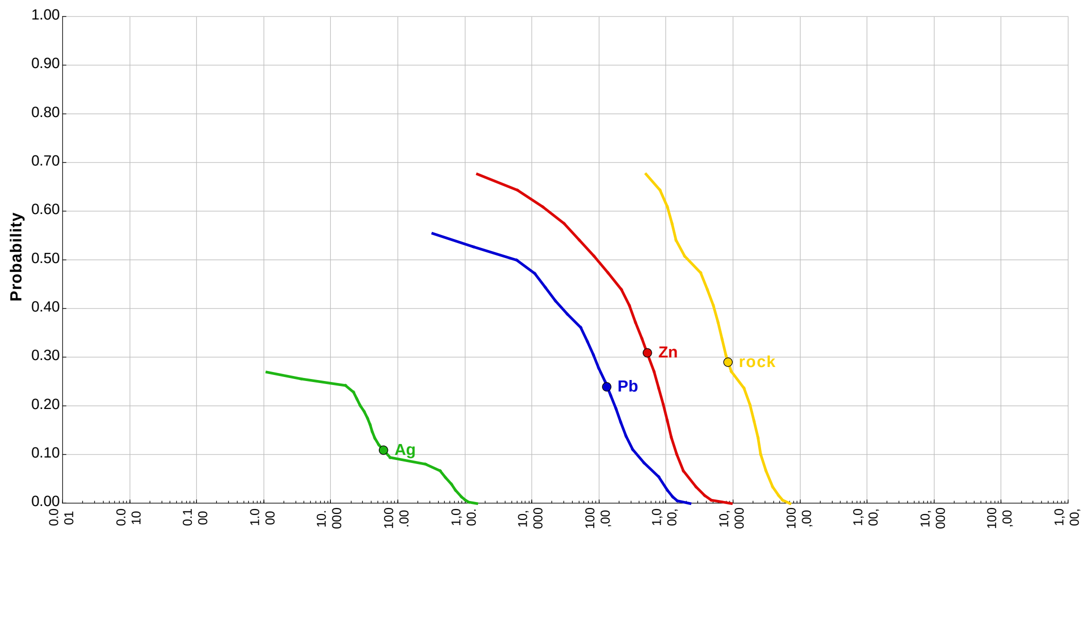
The Mark3 Index is 94: **Mississippi Valley, minor**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 2 or more deposits.

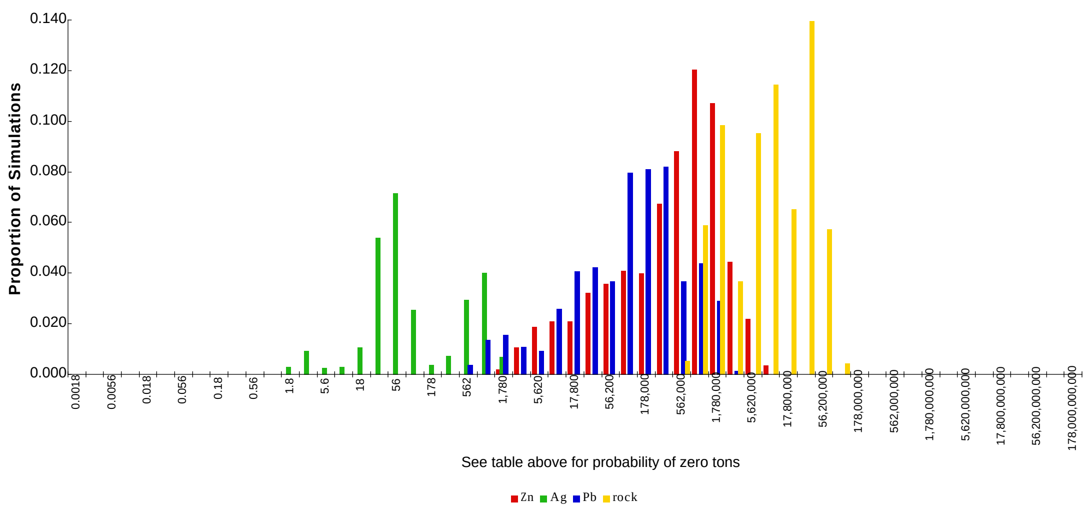
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Zn	Ag	Pb	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	93,000	0	5,900	2,100,000
0.10	1,400,000	68	370,000	26,000,000
0.05	2,300,000	540	830,000	33,000,000
mean	**520,000**	**60**	**130,000**	**8,400,000**
Probability of mean	0.31	0.11	0.24	0.29
Probability of zero	0.32	0.73	0.44	0.32

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is W11

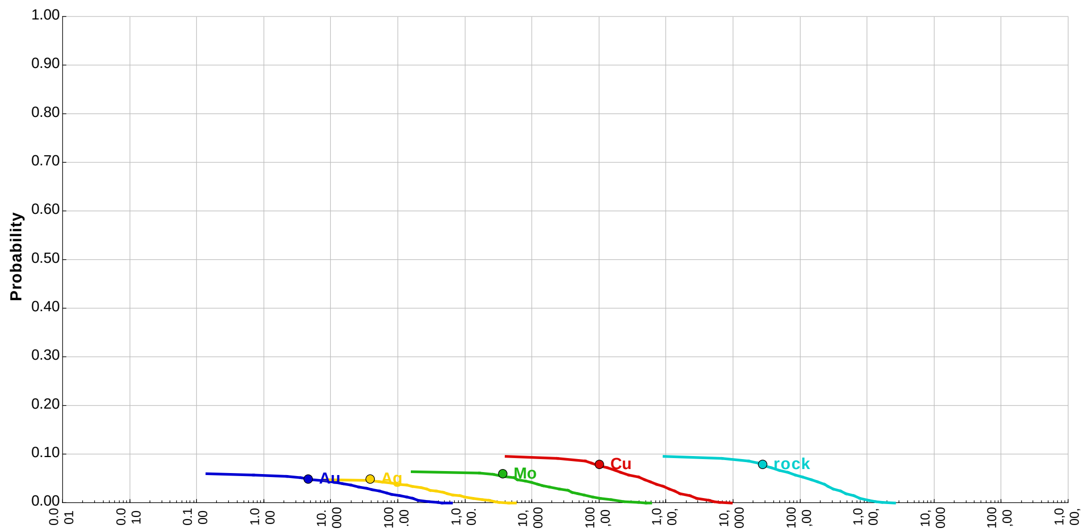
The Mark3 Index is 89: **Porphyry Cu (BC-AK)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

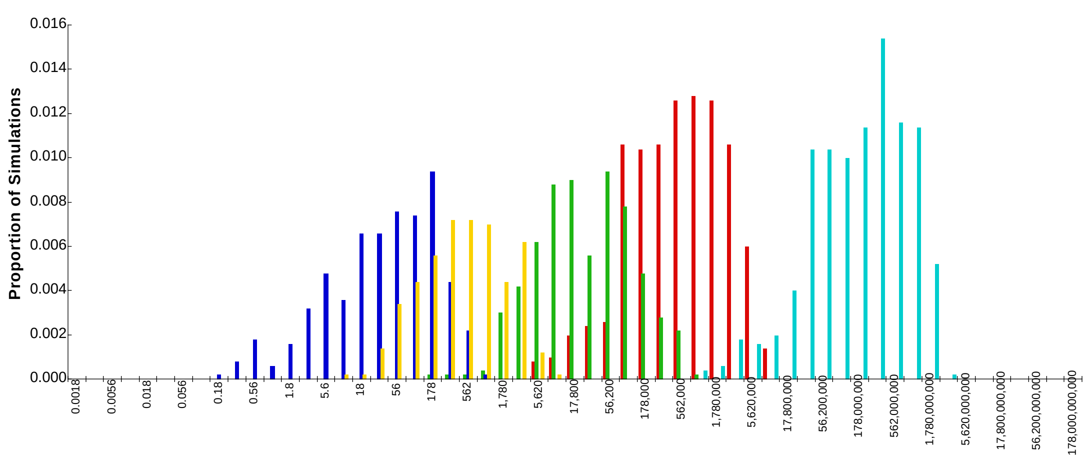
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	450,000	5,900	4	0	140,000,000
mean	**100,000**	**3,600**	**5**	**38**	**28,000,000**
Probability of mean	0.08	0.06	0.05	0.05	0.08
Probability of zero	0.90	0.94	0.94	0.95	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Mo Au Ag rock

The tract ID is W11 (Idaho only)

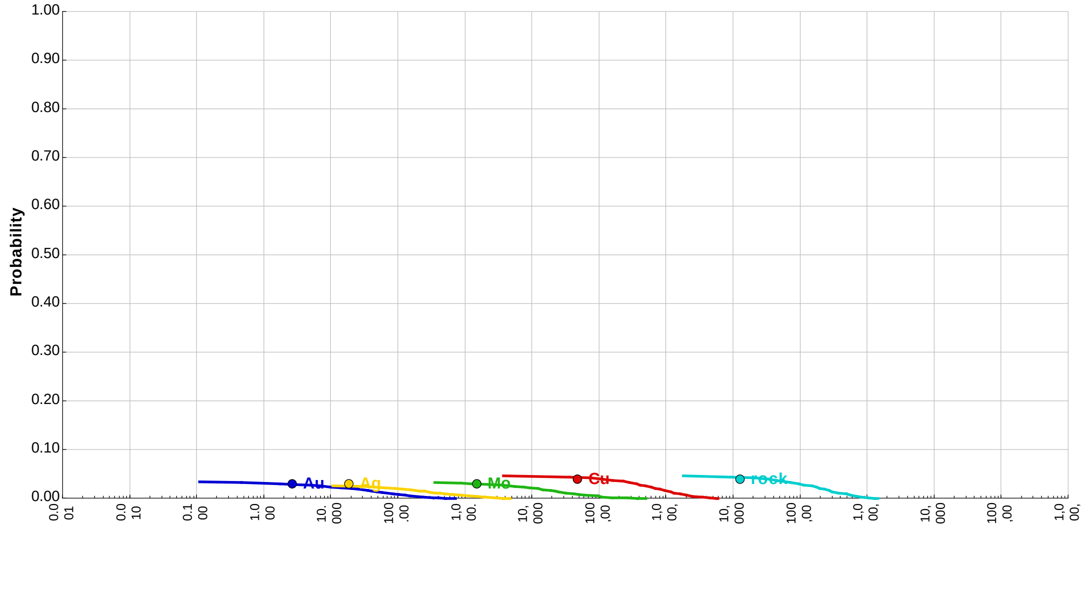
The Mark3 Index is 89: **Porphyry Cu (BC-AK)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 1 or more deposits.
There is a 1% or greater chance of 2 or more deposits.

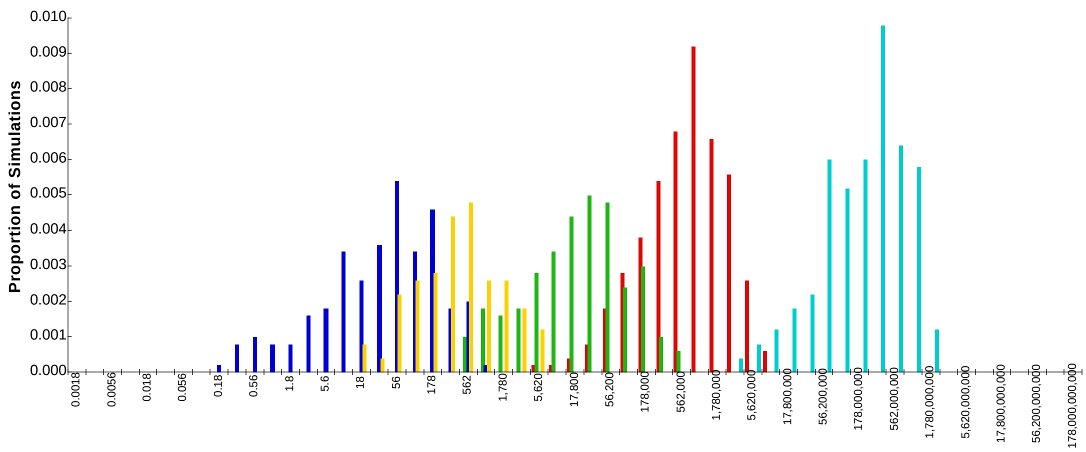
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	0	0	0	0	0
mean	**47,000**	**1,500**	**3**	**18**	**13,000,000**
Probability of mean	0.04	0.03	0.03	0.03	0.04
Probability of zero	0.95	0.97	0.97	0.97	0.95

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Mo Au Ag rock

The tract ID is W11 (OR-WA only)

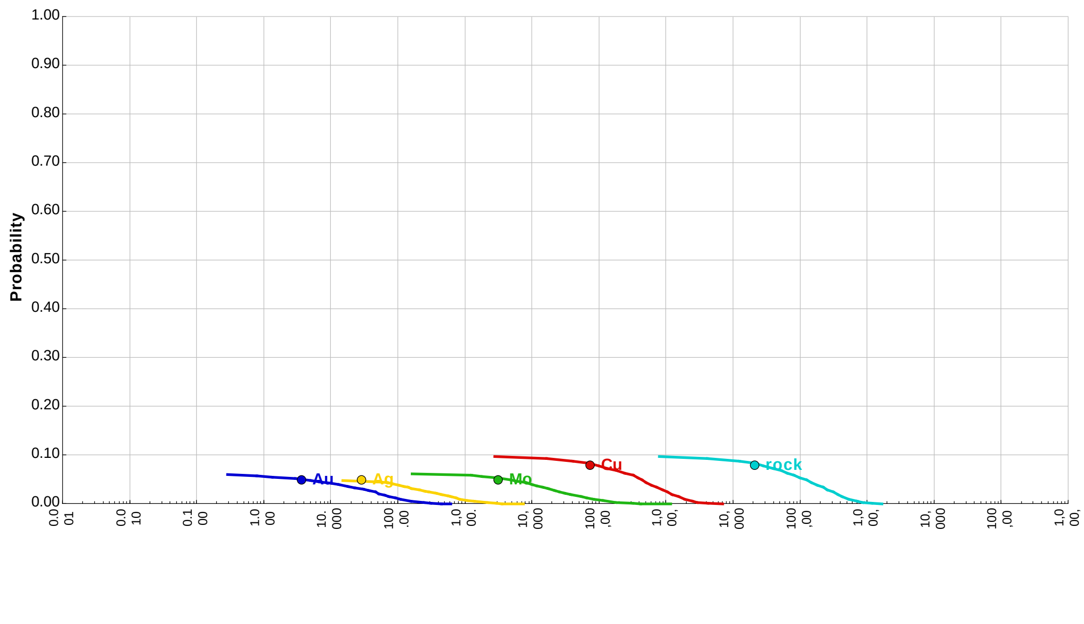
The Mark3 Index is 89: **Porphyry Cu (BC-AK)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 1 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

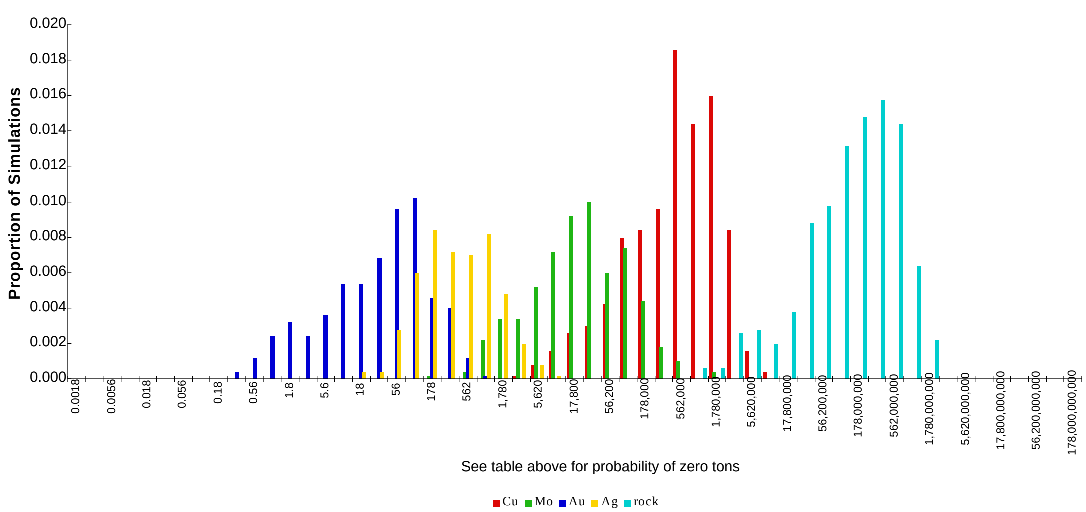
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	430,000	4,700	4	0	120,000,000
mean	**73,000**	**3,100**	**4**	**28**	**21,000,000**
Probability of mean	0.08	0.05	0.05	0.05	0.08
Probability of zero	0.90	0.94	0.94	0.95	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W13 (ICB only)

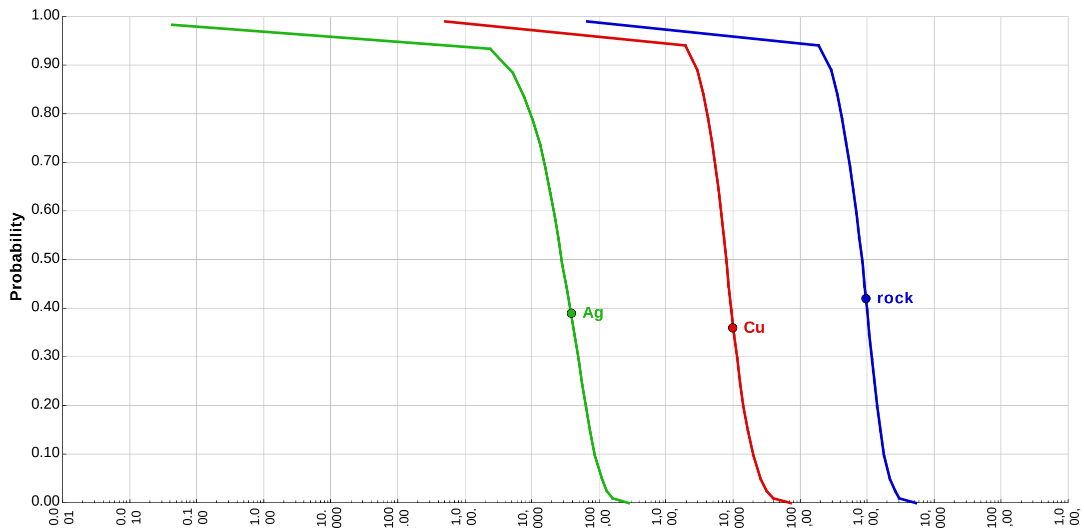
The Mark3 Index is 64: **Sediment-hosted Cu, Revett**

There is a 90% or greater chance of 9 or more deposits.
There is a 50% or greater chance of 10 or more deposits.
There is a 10% or greater chance of 15 or more deposits.
There is a 5% or greater chance of 20 or more deposits.
There is a 1% or greater chance of 30 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

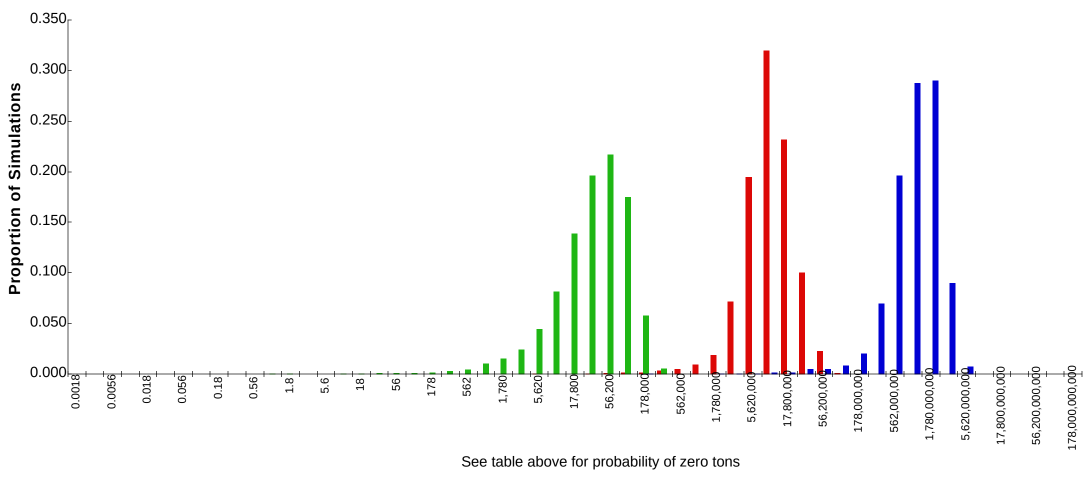
quantile	Cu	Ag	rock
0.95	1,700,000	1,400	160,000,000
0.90	2,700,000	4,200	270,000,000
0.50	7,800,000	28,000	830,000,000
0.10	20,000,000	86,000	1,800,000,000
0.05	25,000,000	110,000	2,200,000,000
mean	**9,900,000**	**38,000**	**940,000,000**
Probability of mean	0.36	0.39	0.42
Probability of zero	0.01	0.02	0.01

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W14 (ICB only)

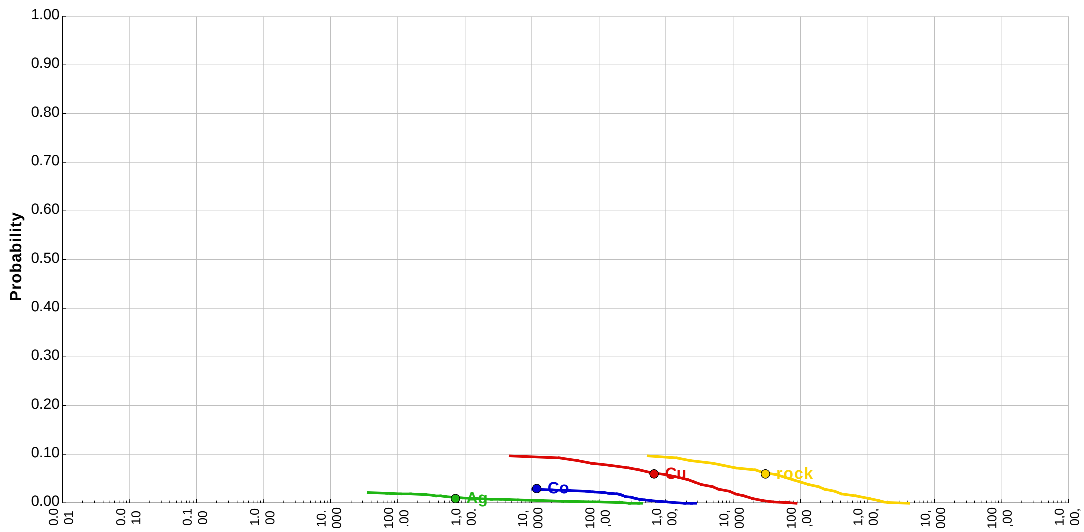
The Mark3 Index is 96: **Sediment-hosted Cu, reduced facies**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

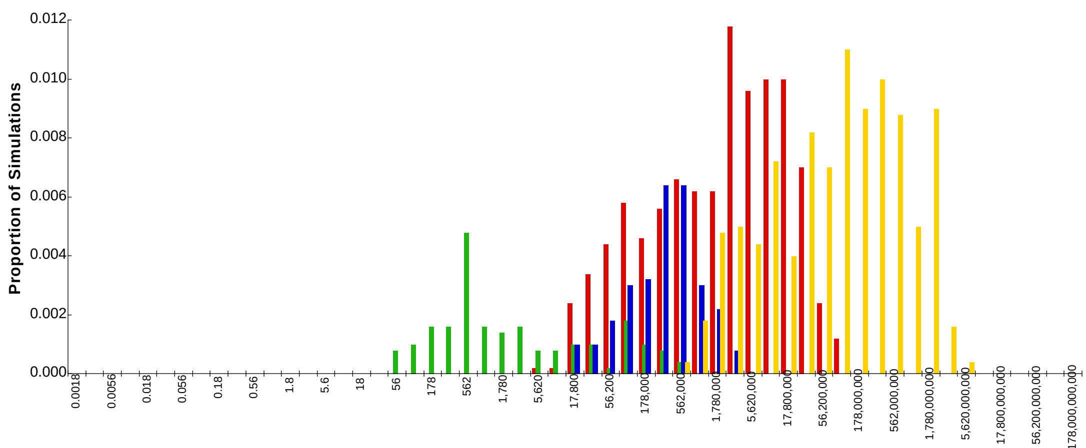
quantile	Cu	Ag	Co	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	0	0	0	0
0.05	2,000,000	0	0	75,000,000
mean	**660,000**	**710**	**12,000**	**30,000,000**
Probability of mean	0.06	0.01	0.03	0.06
Probability of zero	0.90	0.98	0.97	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W16

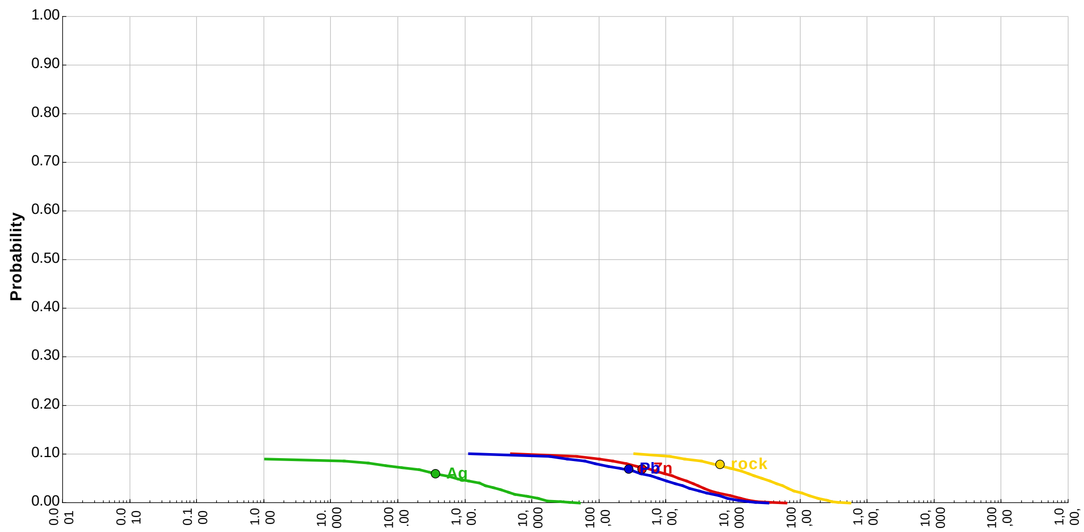
The Mark3 Index is 13: **Sedimentary exhalative Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

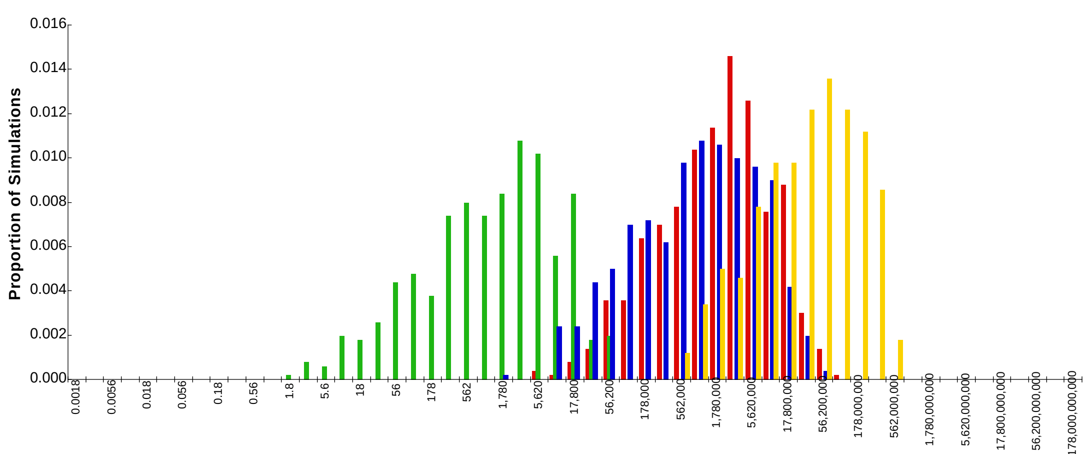
quantile	Zn	Ag	Pb	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	17,000	0	8,200	590,000
0.05	1,500,000	800	810,000	27,000,000
mean	**440,000**	**360**	**270,000**	**6,300,000**
Probability of mean	0.07	0.06	0.07	0.08
Probability of zero	0.90	0.91	0.90	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Zn Ag Pb rock

The tract ID is W17 (ICB only)

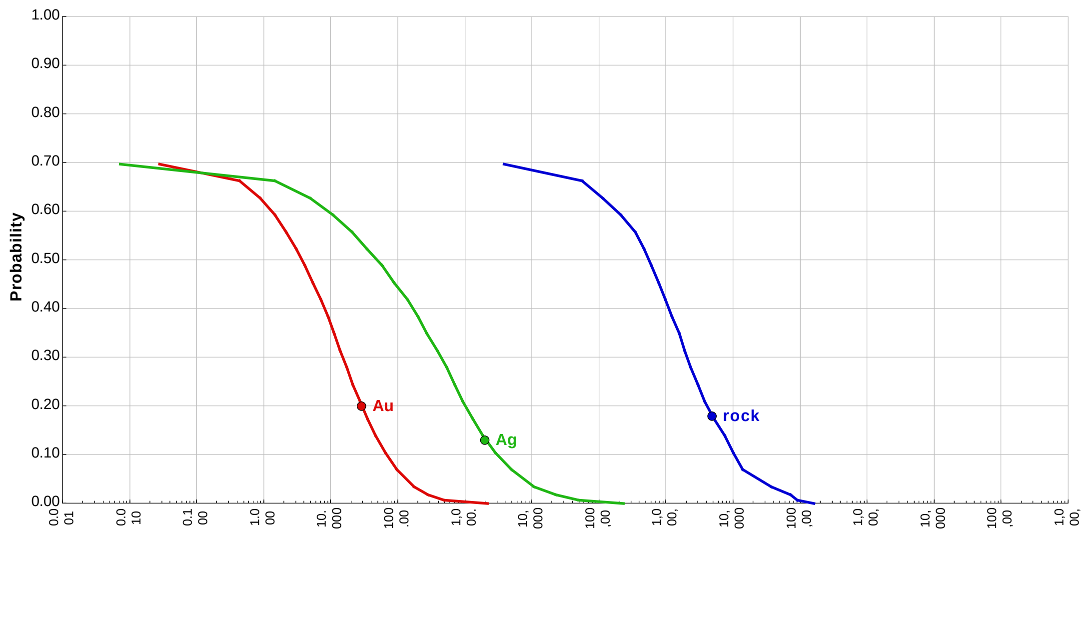
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

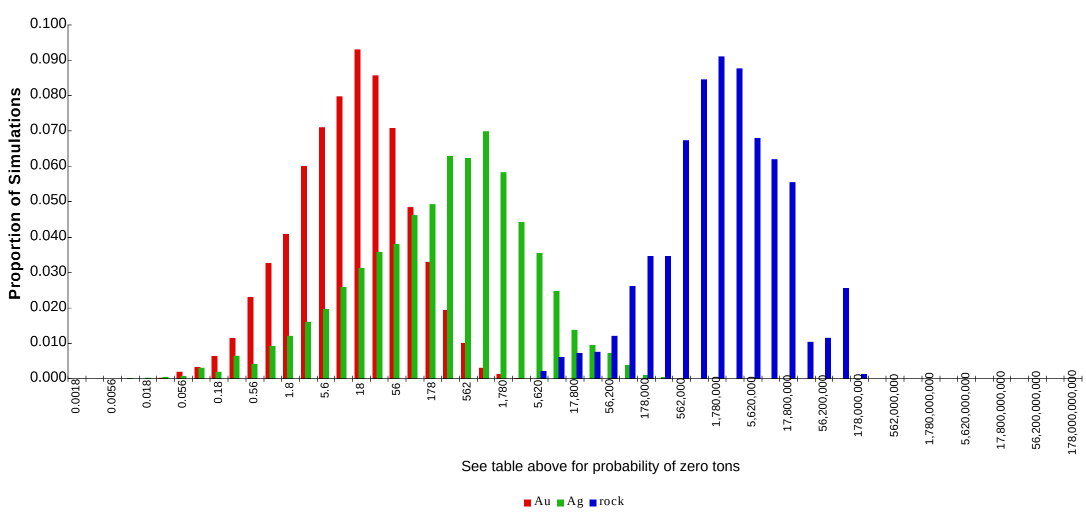
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	4	50	560,000
0.10	67	3,000	11,000,000
0.05	130	7,200	17,000,000
mean	**28**	**1,900**	**4,800,000**
Probability of mean	0.20	0.13	0.18
Probability of zero	0.30	0.30	0.30

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W18 (ICB only)

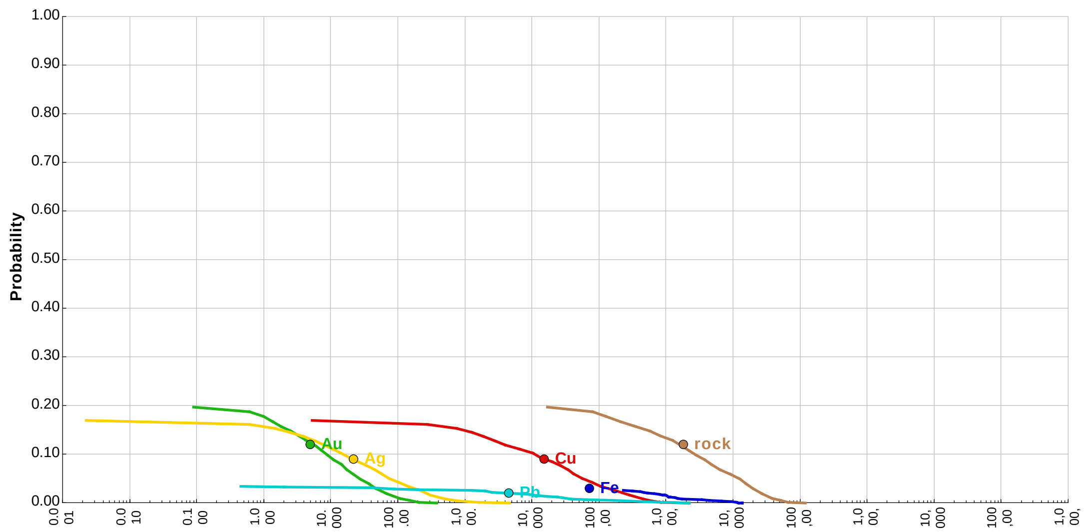
The Mark3 Index is 105: **Skarn Au, truncated**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

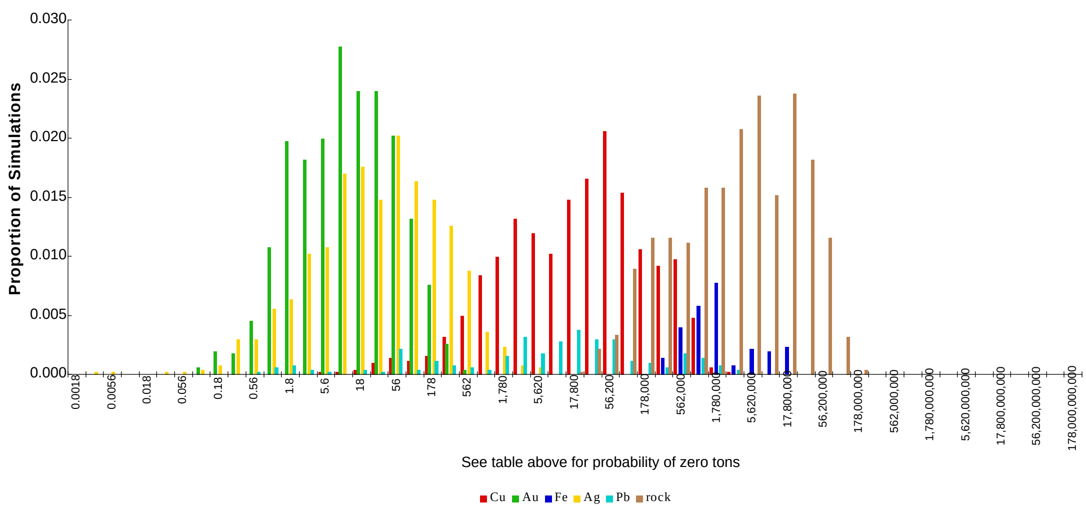
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Fe	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	11,000	9	0	15	0	2,700,000
0.05	59,000	27	0	75	0	12,000,000
mean	**15,000**	**5**	**71,000**	**22**	**4,500**	**1,800,000**
Probability of mean	0.09	0.12	0.03	0.09	0.02	0.12
Probability of zero	0.83	0.80	0.97	0.83	0.97	0.80

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is W19 (ICB only)

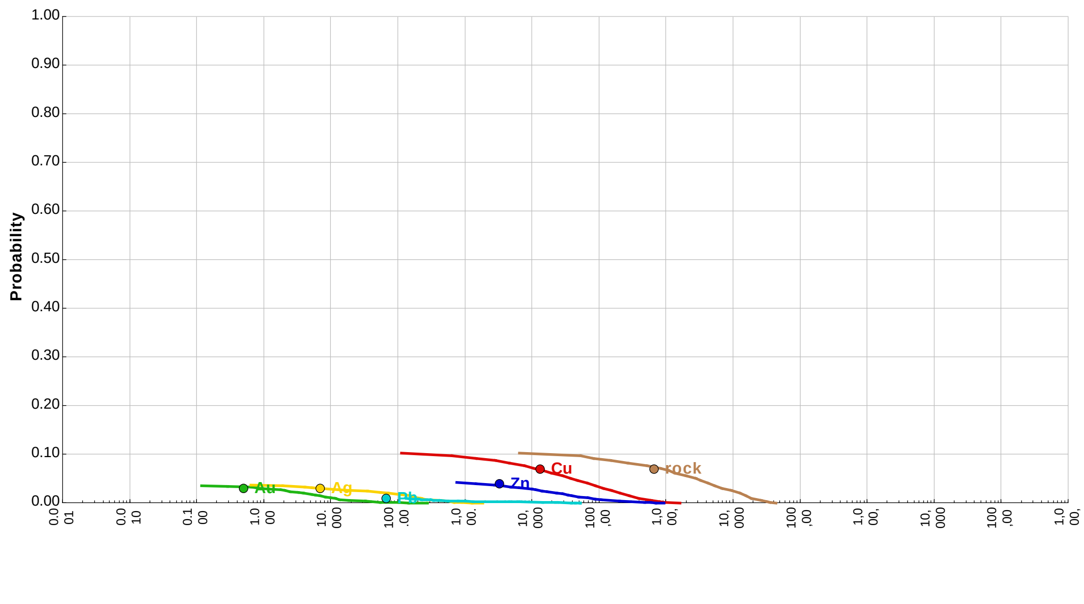
The Mark3 Index is 11: **Massive sulfide, Cyprus**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

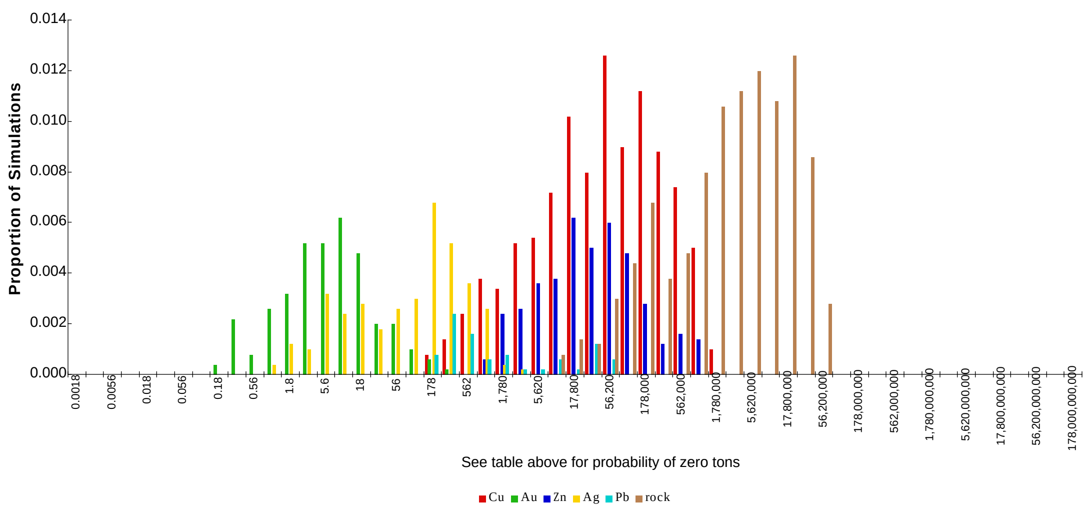
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	350	0	0	0	0	23,000
0.05	39,000	0	0	0	0	2,900,000
mean	**13,000**	**1**	**3,200**	**7**	**66**	**660,000**
Probability of mean	0.07	0.03	0.04	0.03	0.01	0.07
Probability of zero	0.90	0.96	0.96	0.96	0.99	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W20 (ICB only)

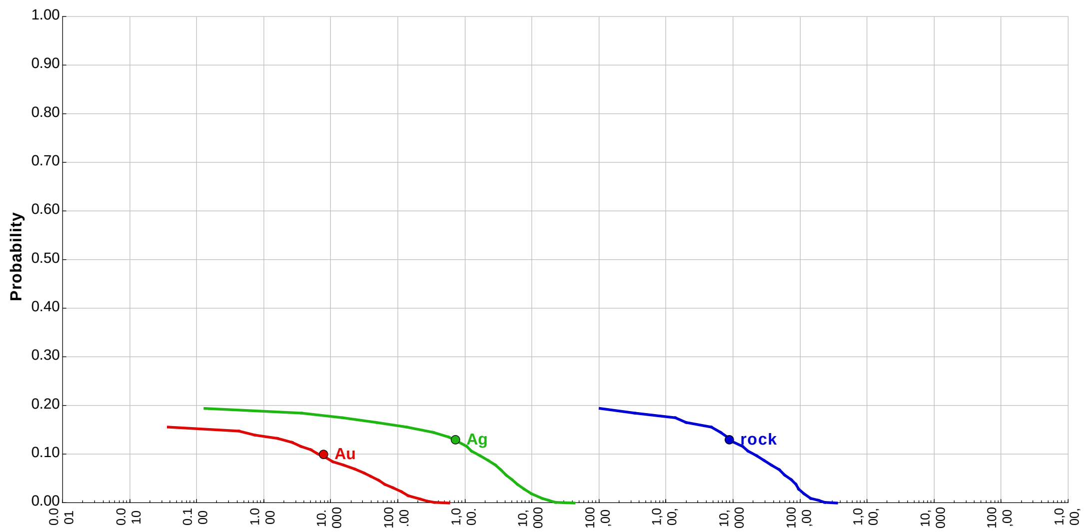
The Mark3 Index is 18: **Distal disseminated Ag-Au**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 6 or more deposits.

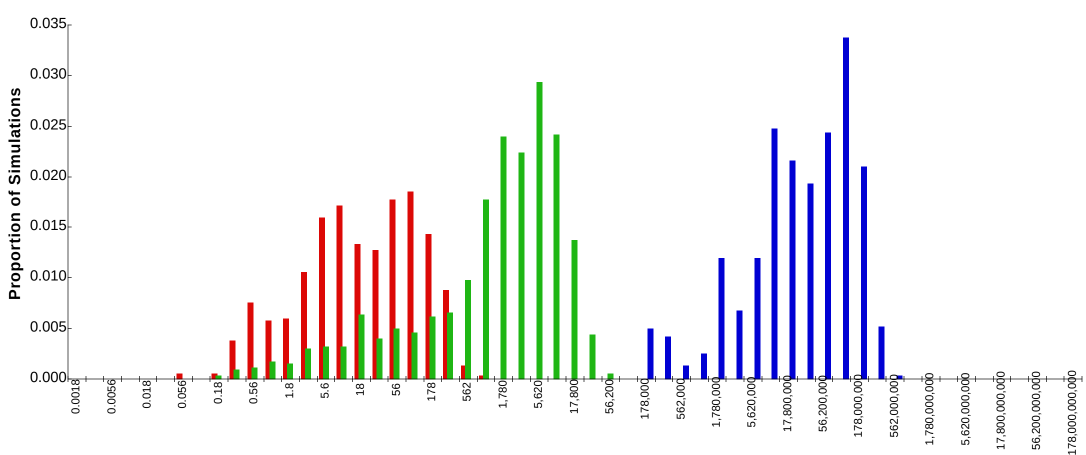
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	7	1,500	21,000,000
0.05	45	4,800	70,000,000
mean	**8**	**710**	**8,600,000**
Probability of mean	0.10	0.13	0.13
Probability of zero	0.84	0.81	0.81

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is W21 (ICB only)

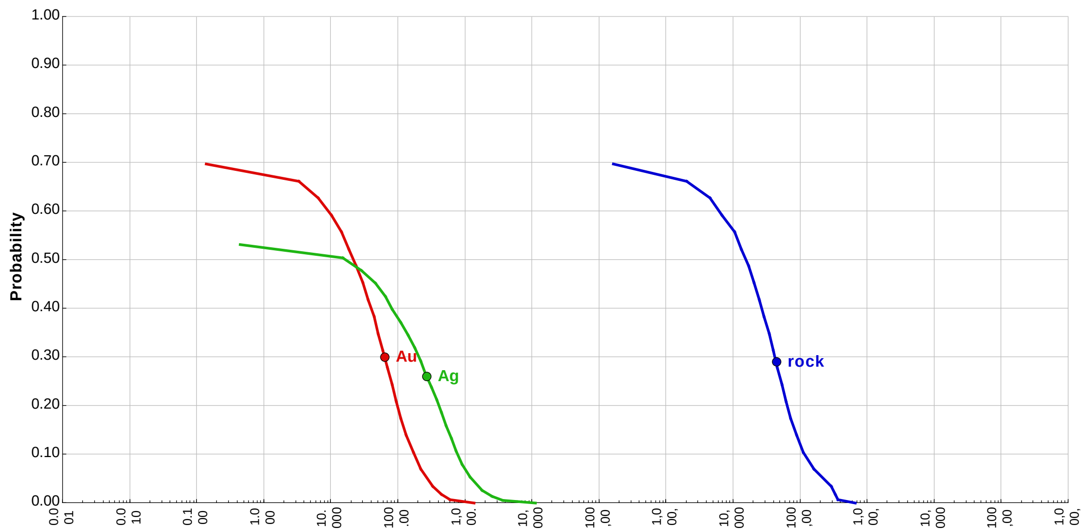
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

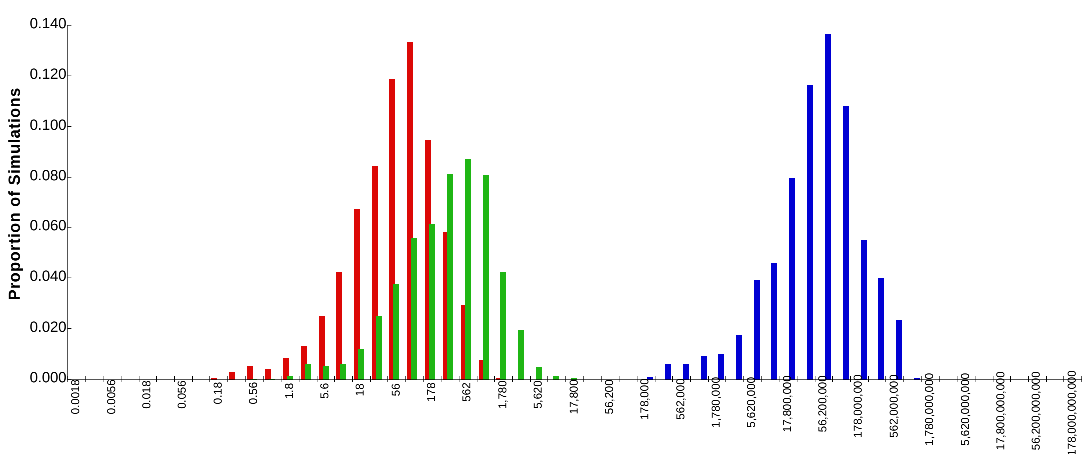
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	22	18	16,000,000
0.10	170	770	110,000,000
0.05	280	1,200	220,000,000
mean	**63**	**270**	**44,000,000**
Probability of mean	0.30	0.26	0.29
Probability of zero	0.30	0.47	0.30

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

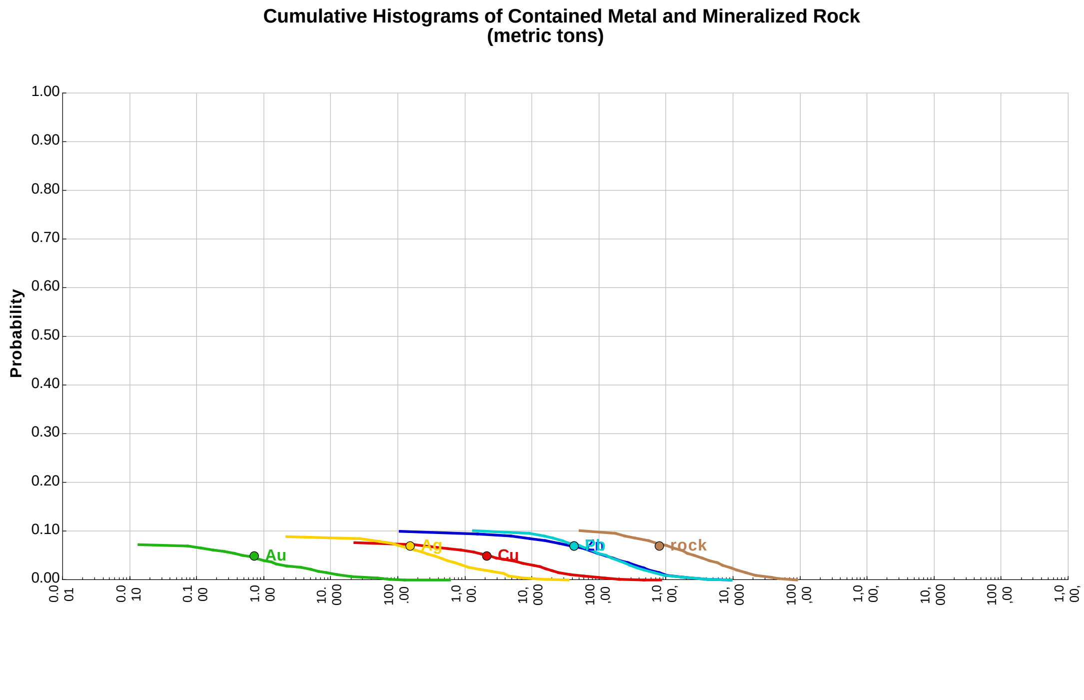
The tract ID is W22 (ICB only)

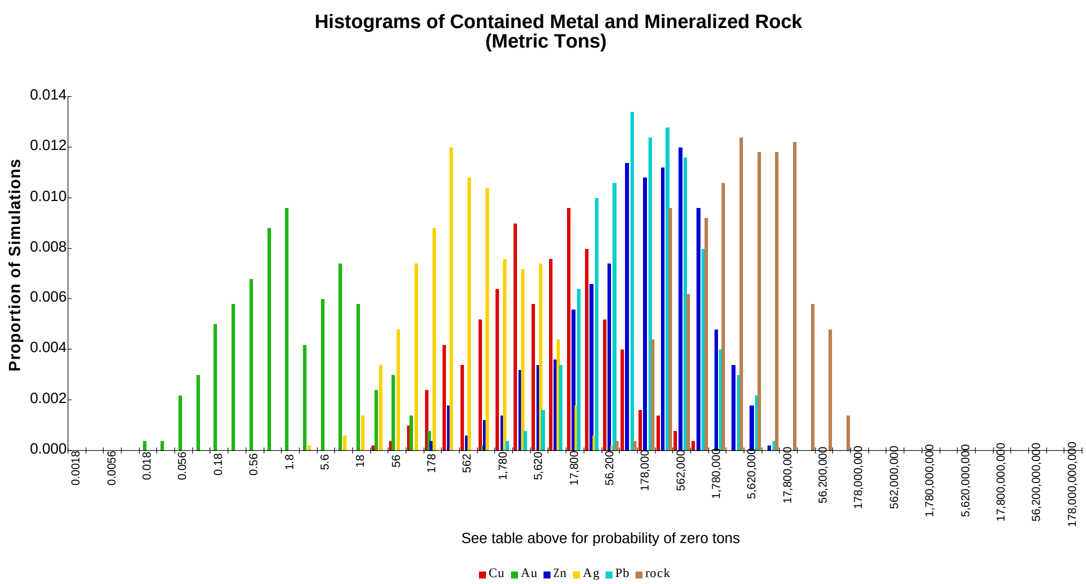
The Mark3 Index is 47: **Polymetallic replacement**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	180	0	3,200	110,000
0.05	2,300	1	130,000	330	130,000	2,700,000
mean	**2,100**	**1**	**42,000**	**150**	**42,000**	**790,000**
Probability of mean	0.05	0.05	0.07	0.07	0.07	0.07
Probability of zero	0.92	0.93	0.90	0.91	0.90	0.90





The tract ID is W25 (ICB only)

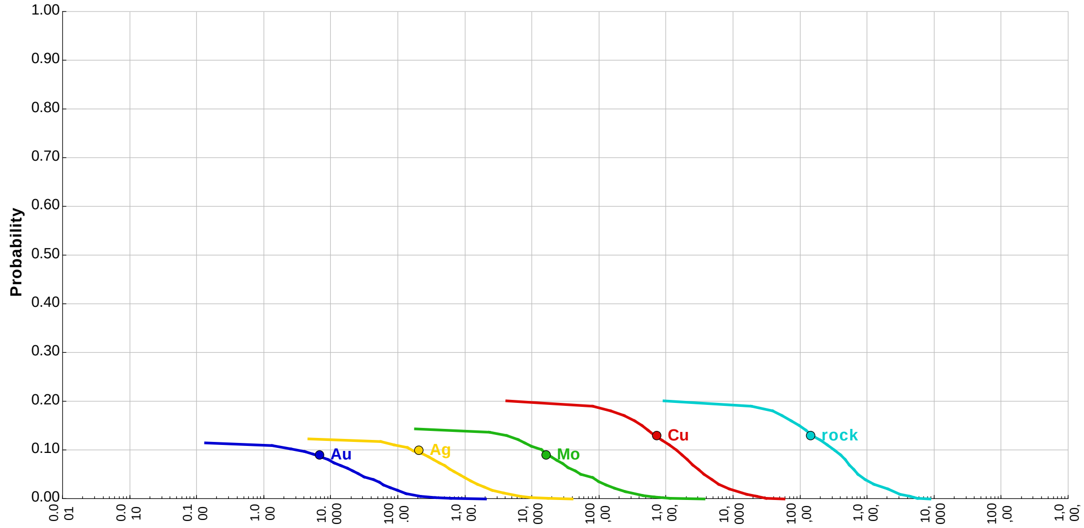
The Mark3 Index is 81: **Porphyry Cu (North America)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

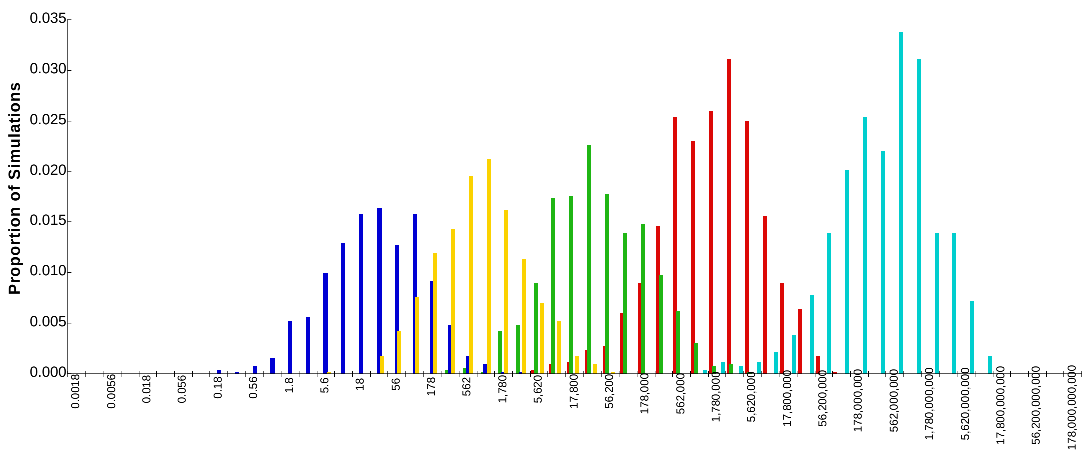
quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	1,500,000	14,000	3	170	330,000,000
0.05	3,700,000	56,000	27	820	730,000,000
mean	**720,000**	**16,000**	**7**	**200**	**140,000,000**
Probability of mean	0.13	0.09	0.09	0.10	0.13
Probability of zero	0.80	0.86	0.89	0.88	0.80

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is W26a (ICB only)

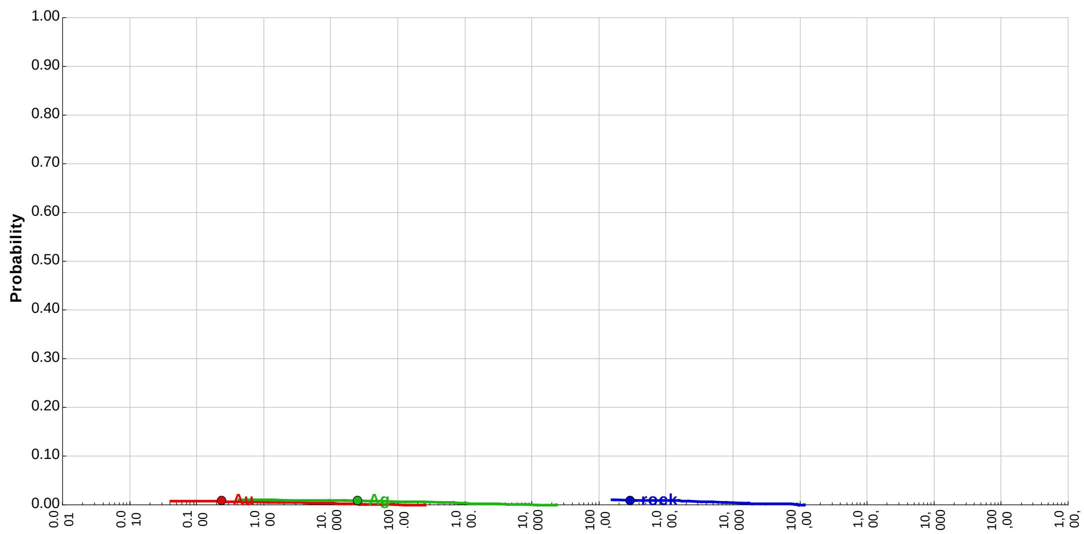
The Mark3 Index is 18: **Distal disseminated Ag-Au**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

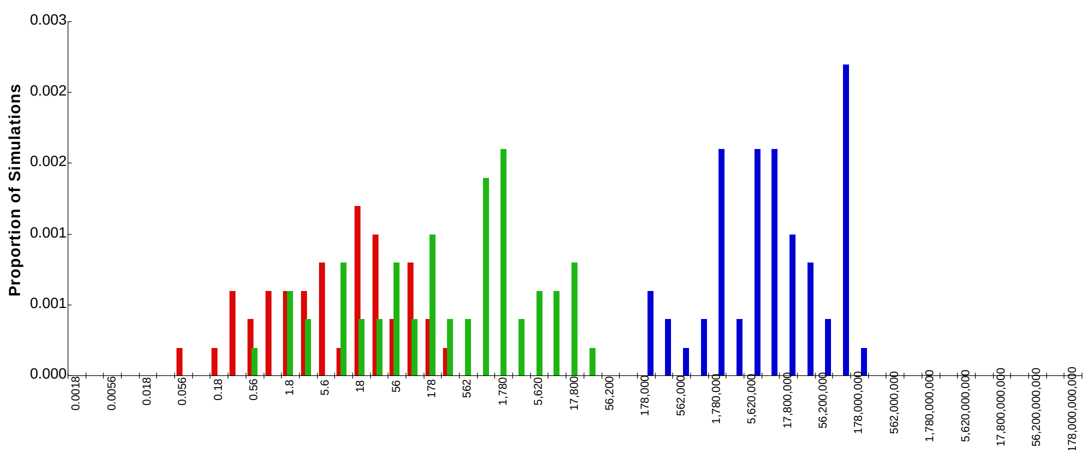
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**0**	**25**	**290,000**
Probability of mean	0.01	0.01	0.01
Probability of zero	0.99	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

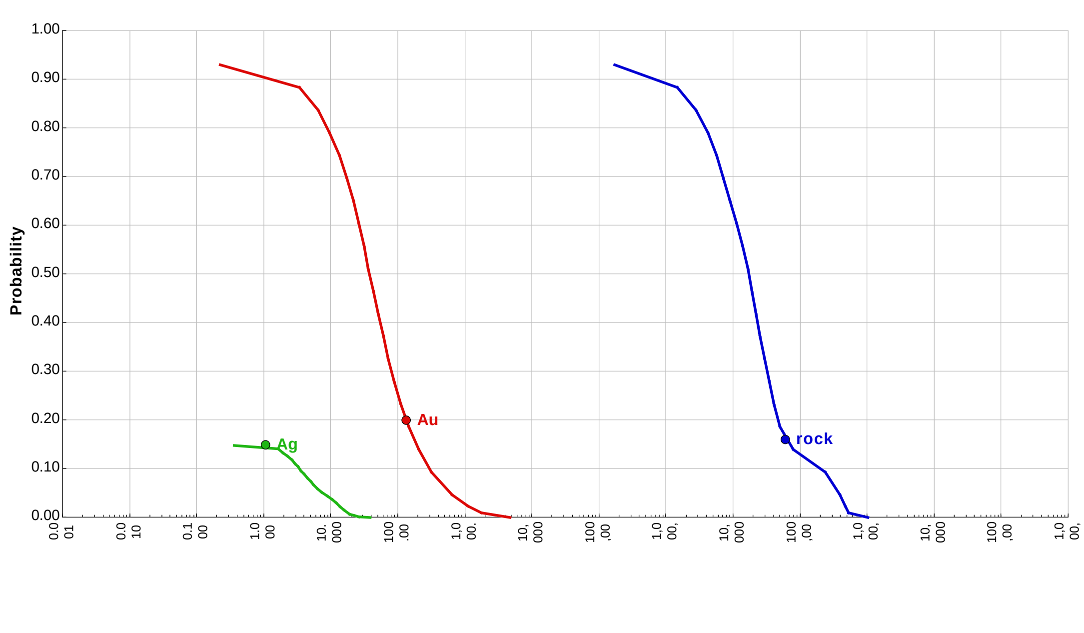
The tract ID is W27 (ICB only)

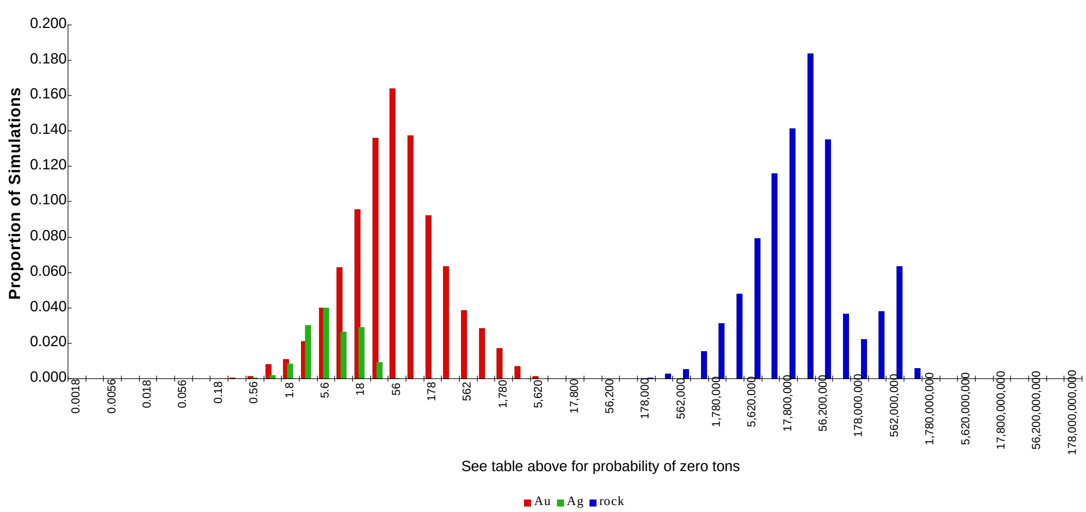
The Mark3 Index is 17: **Sediment-hosted Au**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 6 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	2	0	1,100,000
0.50	38	0	17,000,000
0.10	290	3	220,000,000
0.05	610	7	380,000,000
mean	**130**	**1**	**60,000,000**
Probability of mean	0.20	0.15	0.16
Probability of zero	0.07	0.85	0.07





The tract ID is W28 (ICB only)

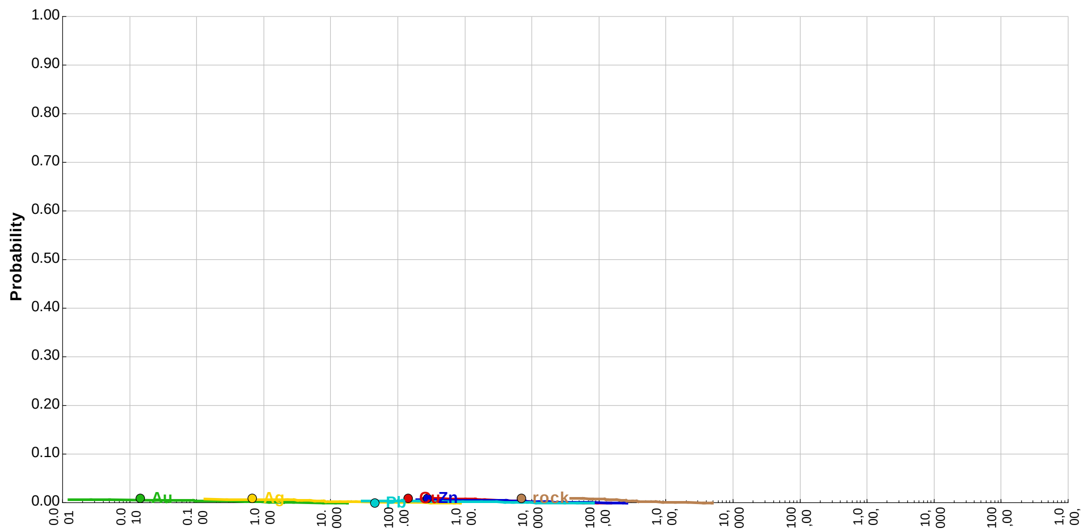
The Mark3 Index is 44: **Massive sulfide, Sierran kuroko**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

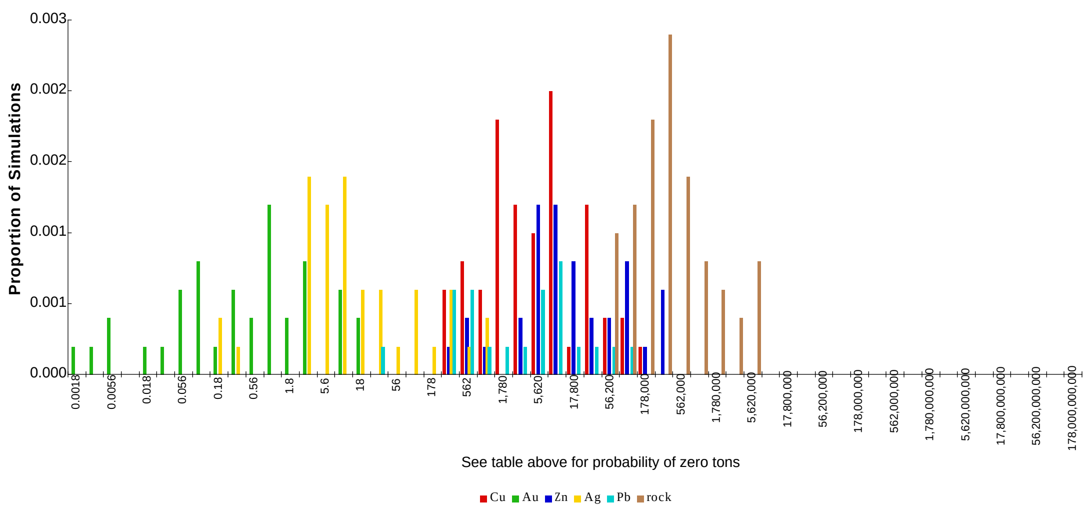
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**140**	**0**	**270**	**1**	**45**	**7,000**
Probability of mean	0.01	0.01	0.01	0.01	0.00	0.01
Probability of zero	0.99	0.99	0.99	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W46

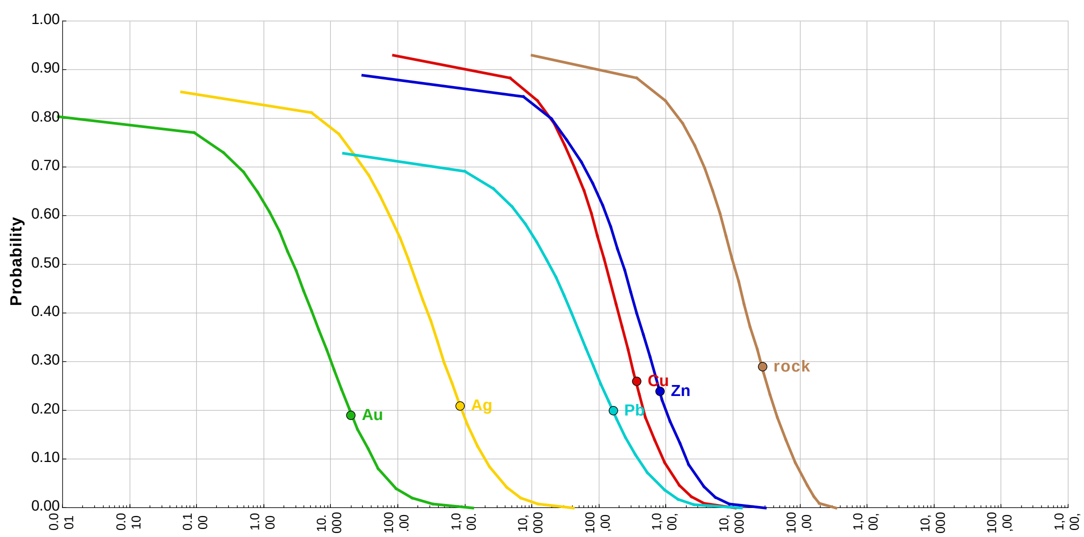
The Mark3 Index is 93: **Massive sulfide, kuroko**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 3 or more deposits.
There is a 10% or greater chance of 6 or more deposits.
There is a 5% or greater chance of 6 or more deposits.
There is a 1% or greater chance of 6 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

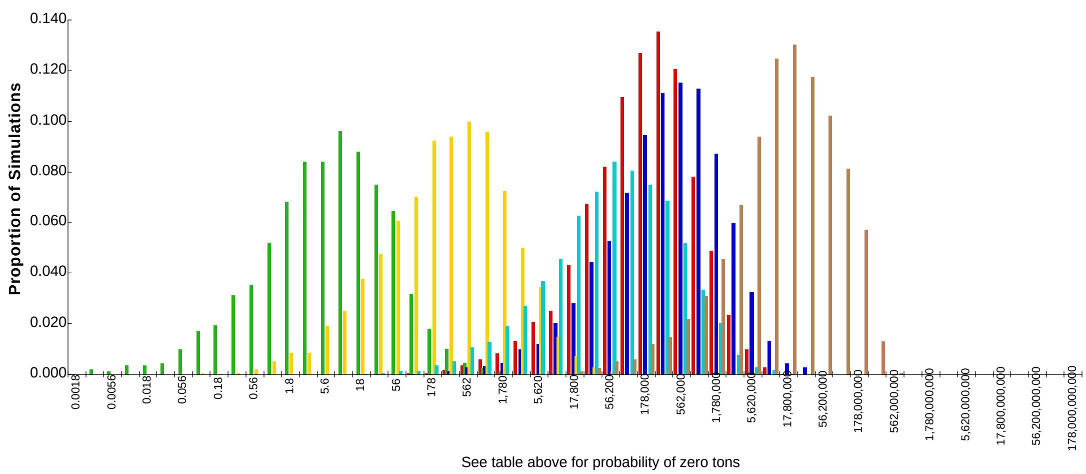
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	2,700	0	0	0	0	210,000
0.50	130,000	3	230,000	150	18,000	10,000,000
0.10	880,000	43	2,000,000	2,000	380,000	78,000,000
0.05	1,500,000	77	3,400,000	3,700	750,000	120,000,000
mean	**360,000**	**20**	**810,000**	**840**	**160,000**	**27,000,000**
Probability of mean	0.26	0.19	0.24	0.21	0.20	0.29
Probability of zero	0.07	0.19	0.11	0.15	0.27	0.07

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is W46 (ID only)

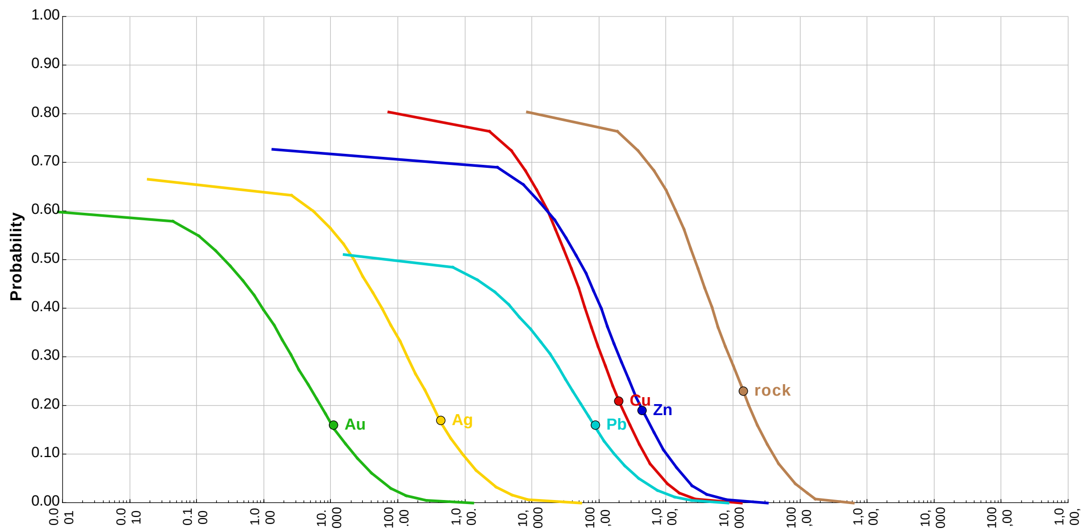
The Mark3 Index is 93: **Massive sulfide, kuroko**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

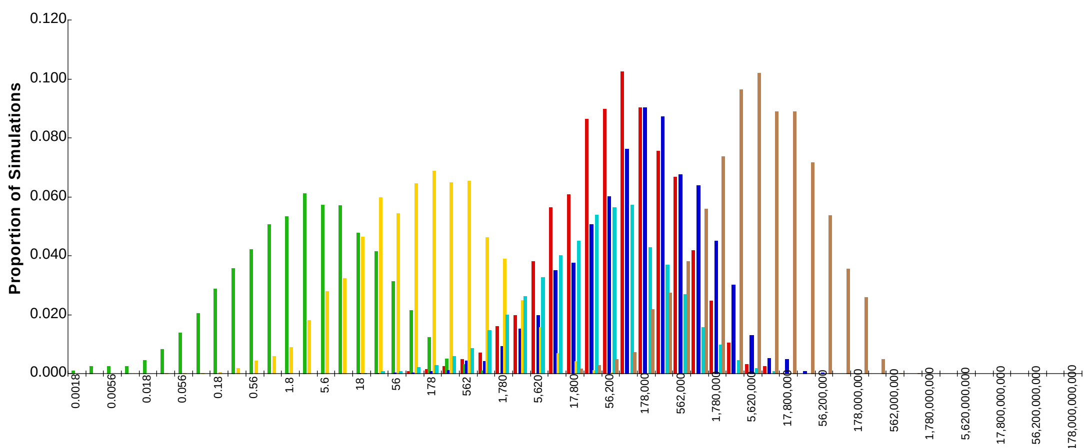
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	34,000	0	49,000	22	260	2,700,000
0.10	480,000	22	1,000,000	910	170,000	39,000,000
0.05	860,000	50	2,000,000	1,900	400,000	70,000,000
mean	**200,000**	**11**	**440,000**	**430**	**88,000**	**14,000,000**
Probability of mean	0.21	0.16	0.19	0.17	0.16	0.23
Probability of zero	0.20	0.39	0.27	0.33	0.49	0.20

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

The tract ID is W46 (OR-WA only)

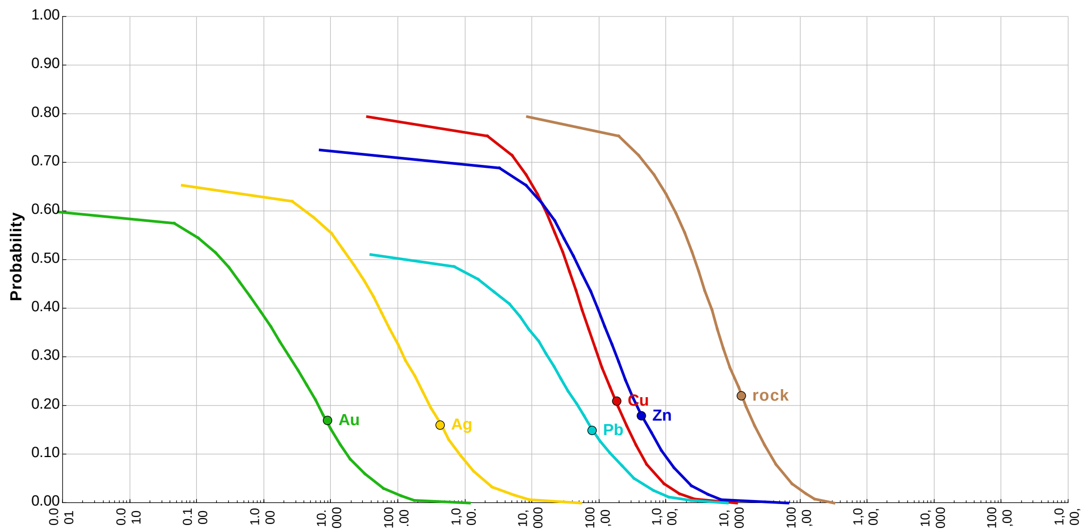
The Mark3 Index is 93: **Massive sulfide, kuroko**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 6 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

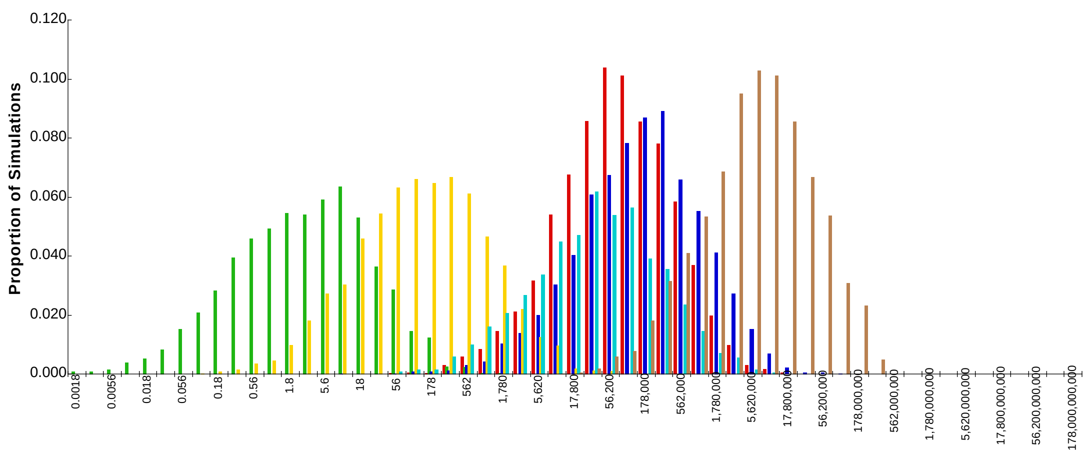
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	32,000	0	45,000	19	330	2,700,000
0.10	420,000	17	940,000	840	150,000	36,000,000
0.05	760,000	40	1,900,000	1,700	340,000	62,000,000
mean	**180,000**	**9**	**420,000**	**430**	**78,000**	**13,000,000**
Probability of mean	0.21	0.17	0.18	0.16	0.15	0.22
Probability of zero	0.21	0.39	0.27	0.35	0.49	0.21

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Zn Ag Pb rock

The tract ID is W47 (ICB only)

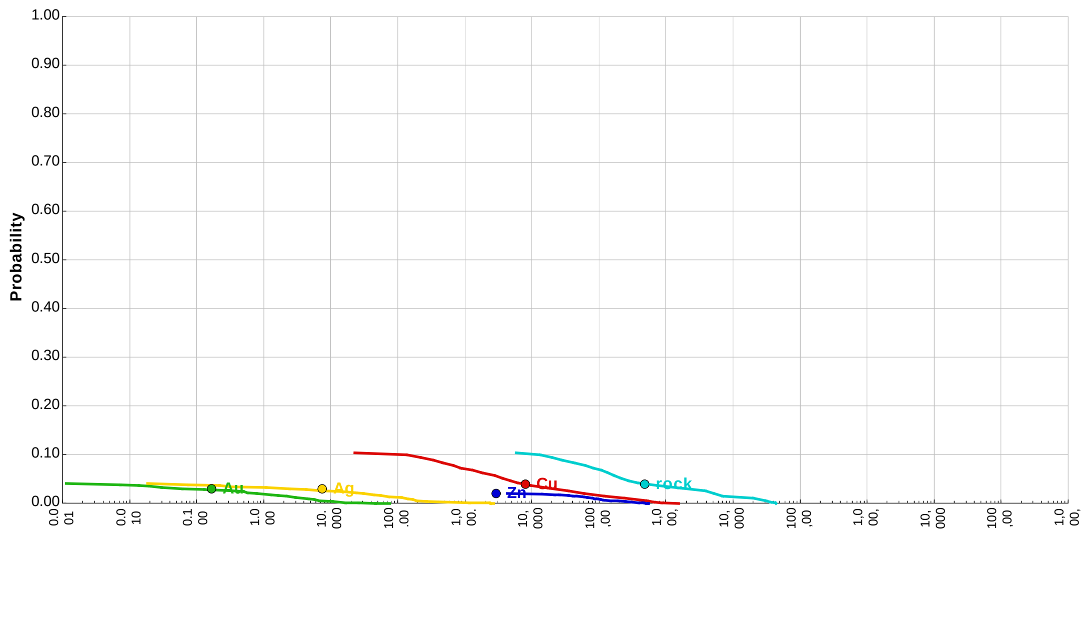
The Mark3 Index is 30: **Massive sulfide, Besshi**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

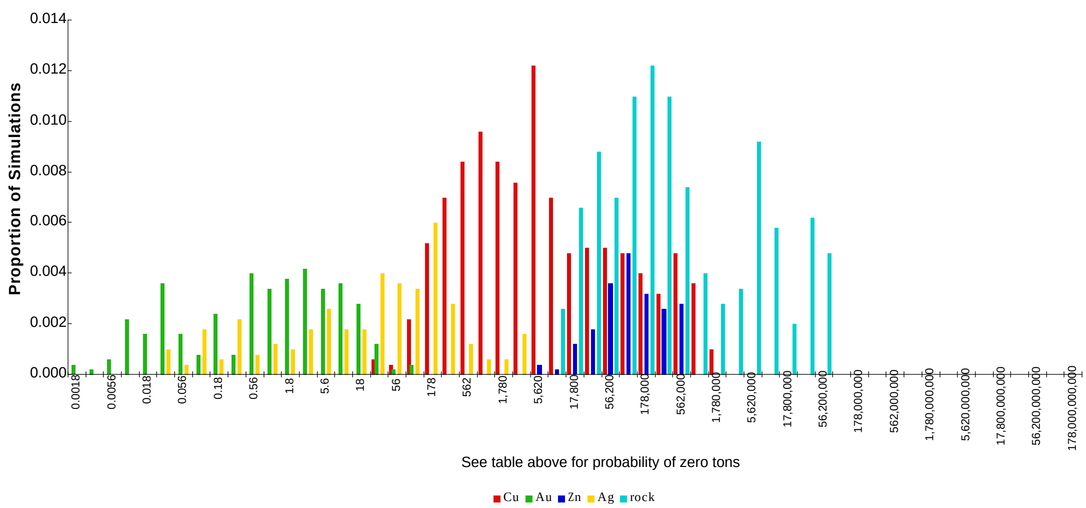
quantile	Cu	Au	Zn	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	130	0	0	0	13,000
0.05	4,100	0	0	0	230,000
mean	**8,000**	**0**	**2,900**	**7**	**470,000**
Probability of mean	0.04	0.03	0.02	0.03	0.04
Probability of zero	0.90	0.96	0.98	0.96	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W51 (ICB only)

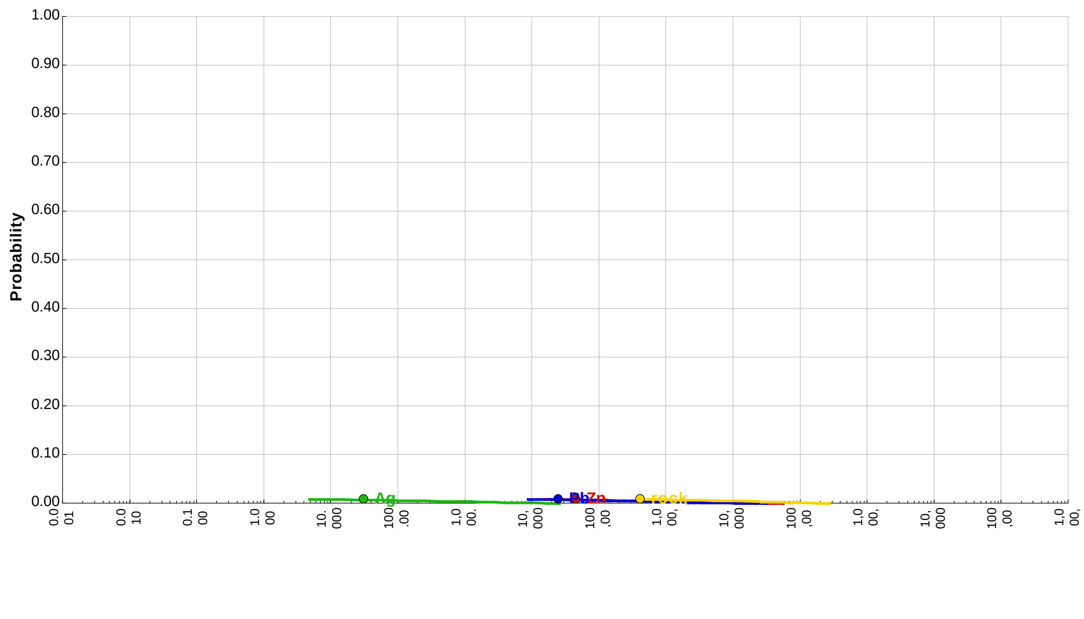
The Mark3 Index is 13: **Sedimentary exhalative Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

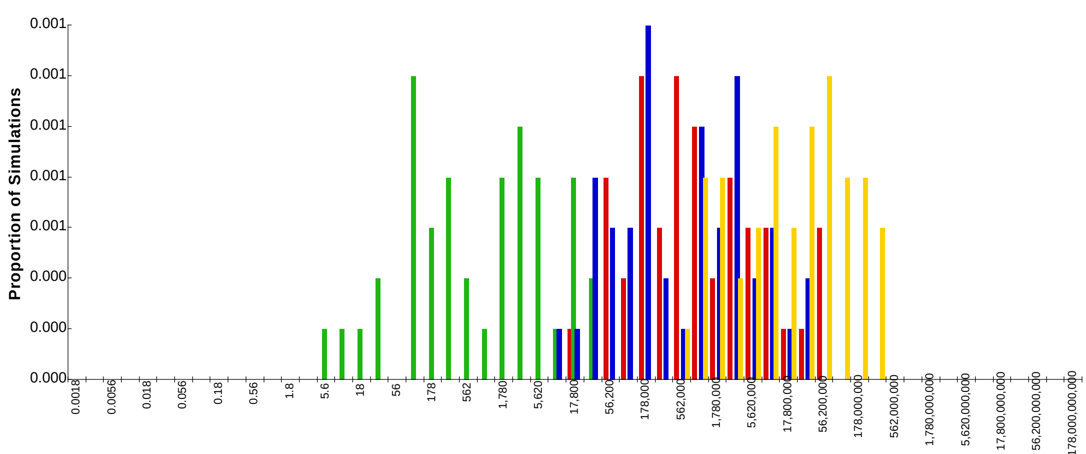
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Zn	Ag	Pb	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	0	0	0	0
0.05	0	0	0	0
mean	**44,000**	**30**	**24,000**	**400,000**
Probability of mean	0.01	0.01	0.01	0.01
Probability of zero	0.99	0.99	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W52 (ICB only)

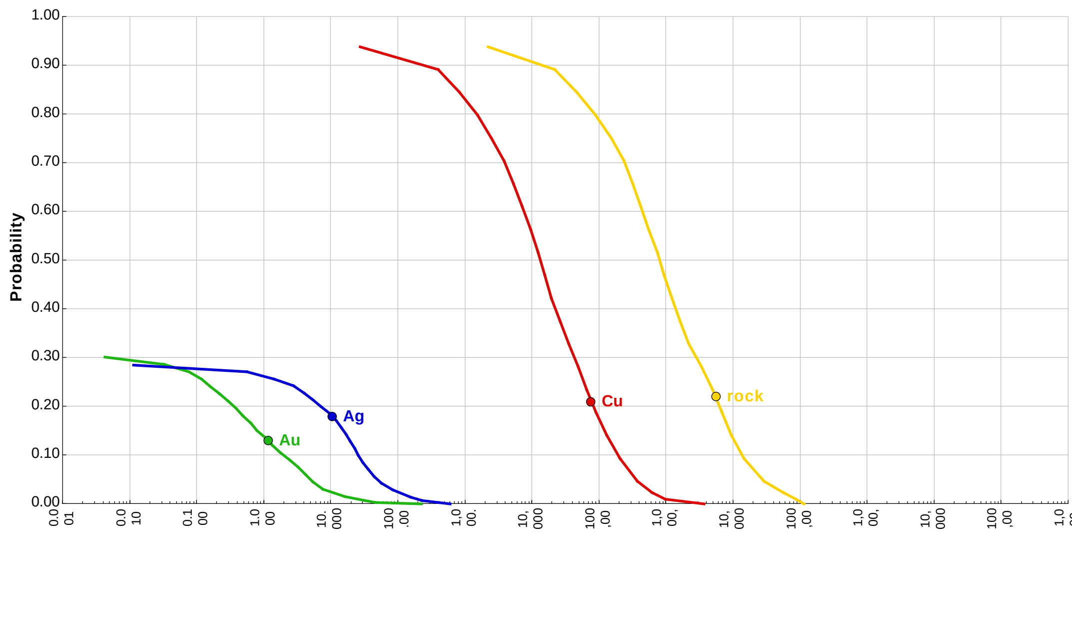
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 1 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

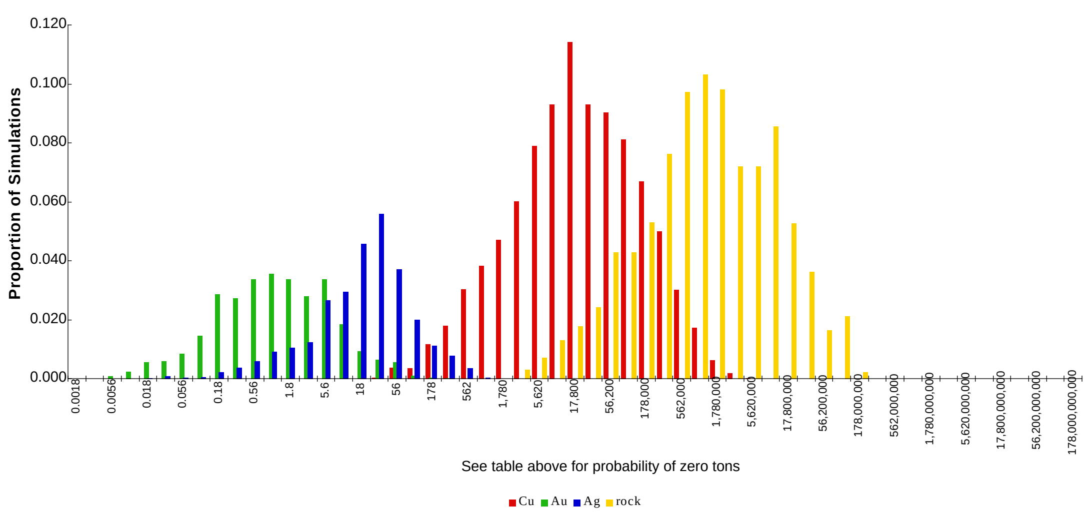
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	330	0	0	17,000
0.50	13,000	0	0	800,000
0.10	190,000	2	25	14,000,000
0.05	350,000	5	49	27,000,000
mean	**75,000**	**1**	**10**	**5,500,000**
Probability of mean	0.21	0.13	0.18	0.22
Probability of zero	0.06	0.70	0.72	0.06

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W100

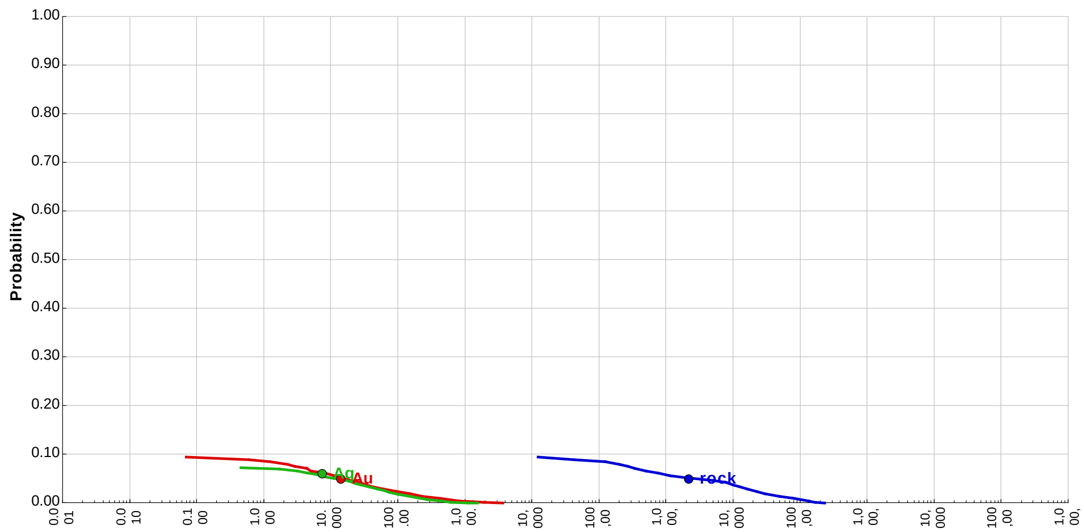
The Mark3 Index is 80: **Alkaline Au-Te**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

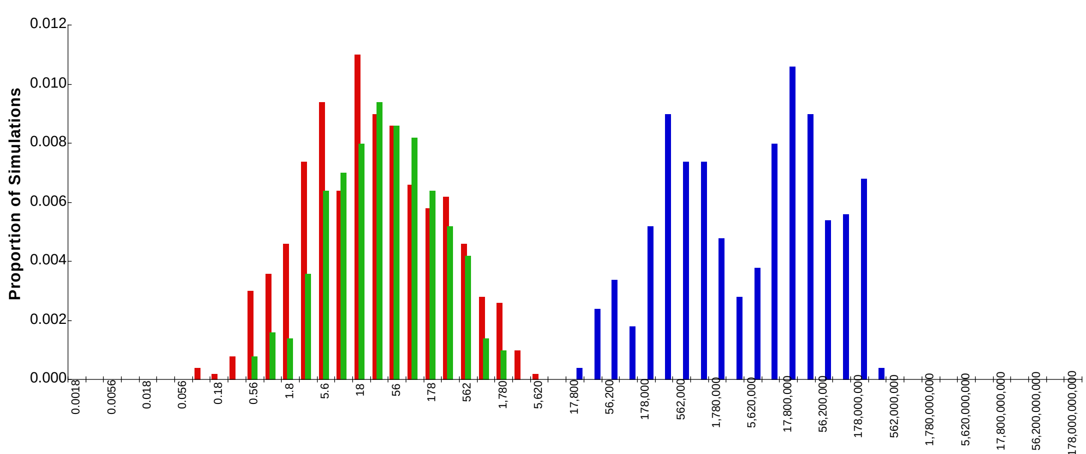
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	16	13	2,600,000
mean	**14**	**7**	**2,100,000**
Probability of mean	0.05	0.06	0.05
Probability of zero	0.91	0.93	0.91

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is W101

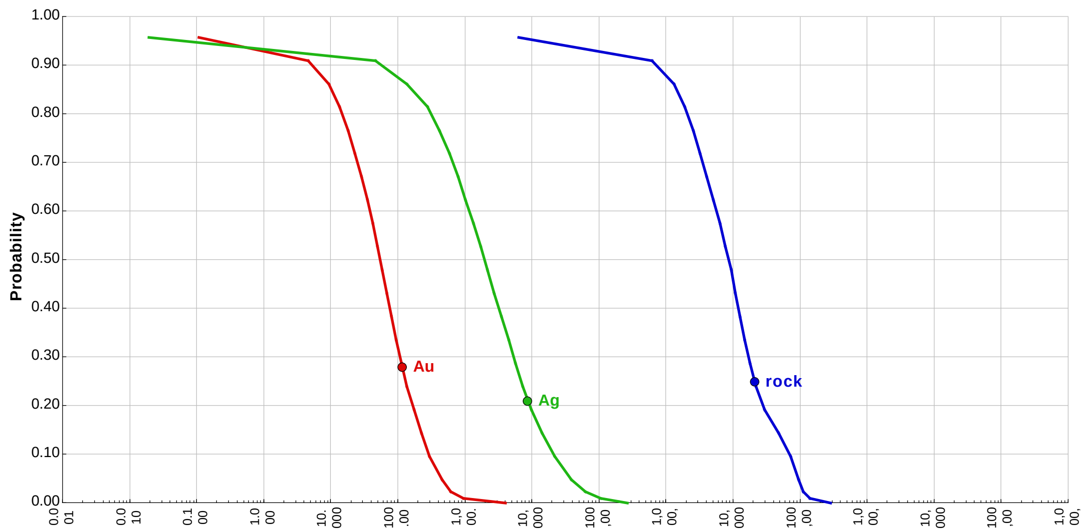
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 2 or more deposits.
There is a 50% or greater chance of 4 or more deposits.
There is a 10% or greater chance of 7 or more deposits.
There is a 5% or greater chance of 11 or more deposits.
There is a 1% or greater chance of 16 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

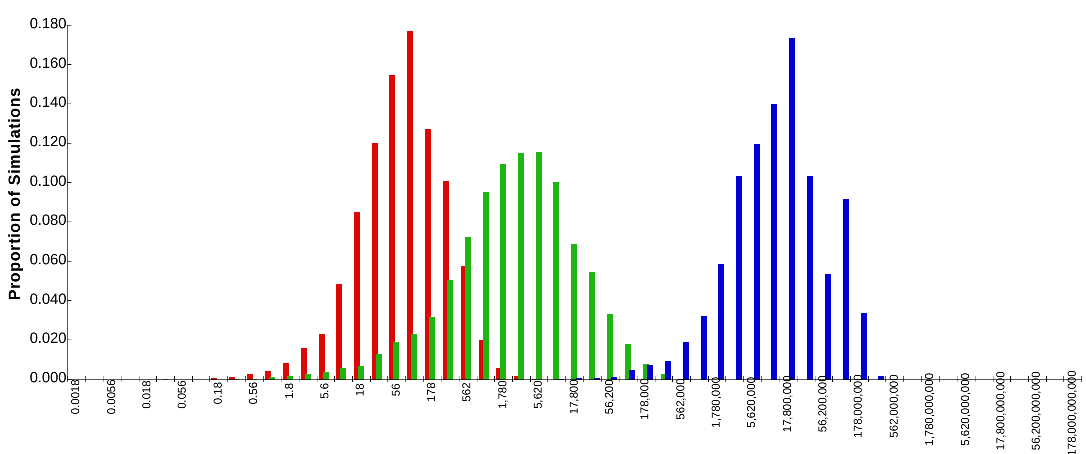
quantile	Au	Ag	rock
0.95	1	3	98,000
0.90	6	60	750,000
0.50	55	1,900	8,500,000
0.10	290	21,000	69,000,000
0.05	440	38,000	94,000,000
mean	**120**	**8,400**	**21,000,000**
Probability of mean	0.28	0.21	0.25
Probability of zero	0.04	0.04	0.04

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Au ■ Ag ■ rock

The tract ID is W102

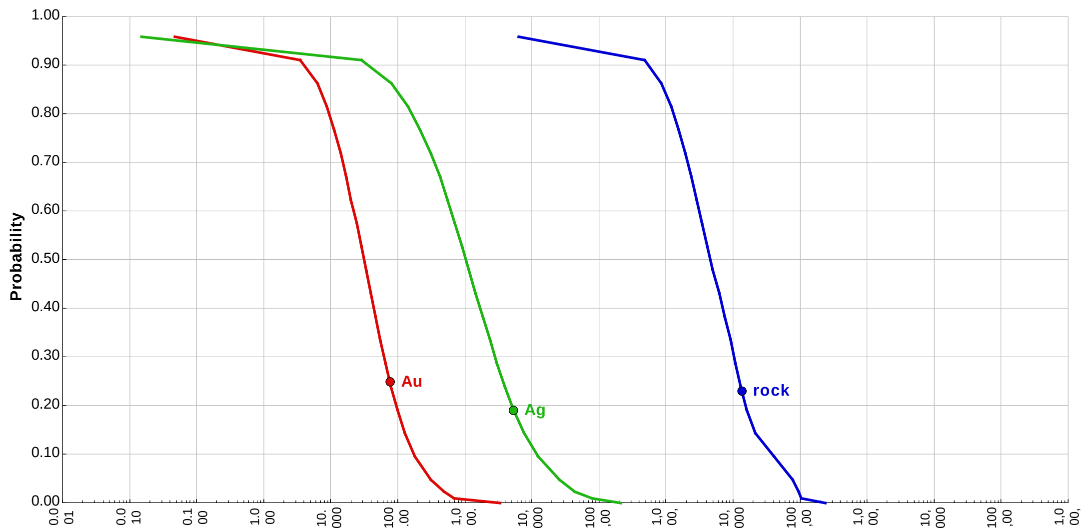
The Mark3 Index is 16: **Epithermal vein, Comstock**

There is a 90% or greater chance of 2 or more deposits.
There is a 50% or greater chance of 3 or more deposits.
There is a 10% or greater chance of 4 or more deposits.
There is a 5% or greater chance of 6 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

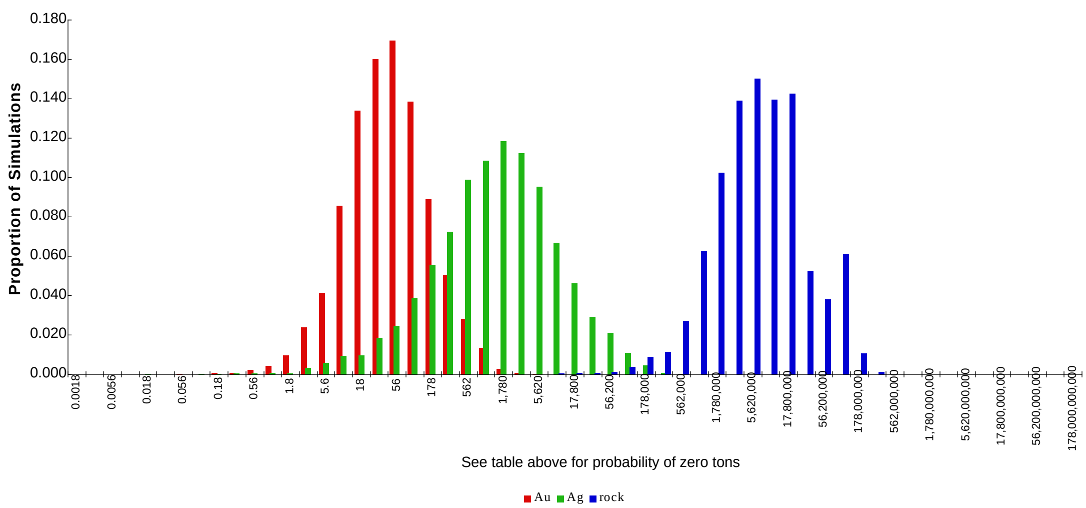
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	1	4	120,000
0.90	4	38	580,000
0.50	31	1,100	4,600,000
0.10	170	12,000	38,000,000
0.05	300	24,000	73,000,000
mean	**76**	**5,300**	**13,000,000**
Probability of mean	0.25	0.19	0.23
Probability of zero	0.04	0.04	0.04

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W107

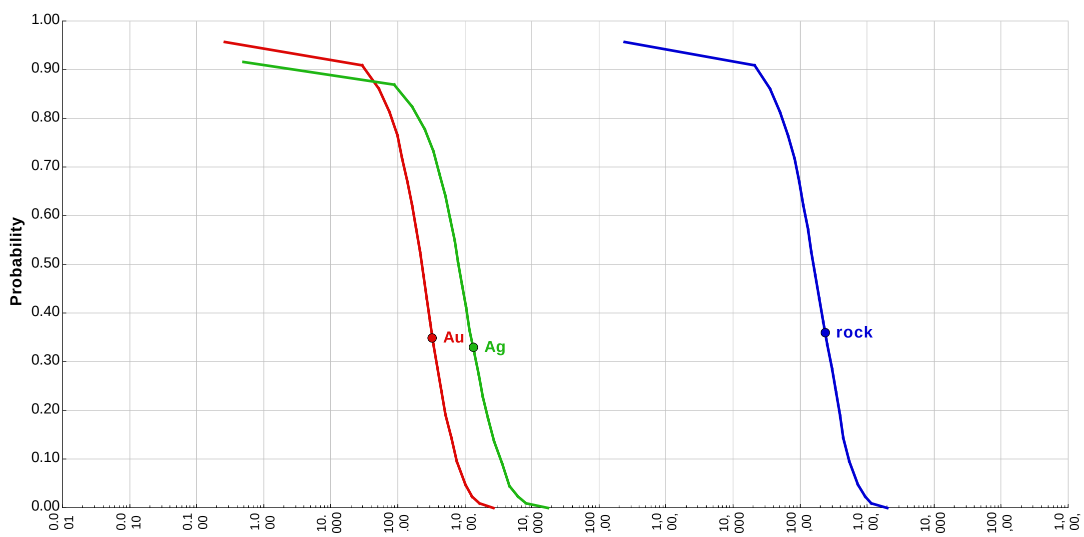
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 2 or more deposits.
There is a 50% or greater chance of 6 or more deposits.
There is a 10% or greater chance of 10 or more deposits.
There is a 5% or greater chance of 16 or more deposits.
There is a 1% or greater chance of 30 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

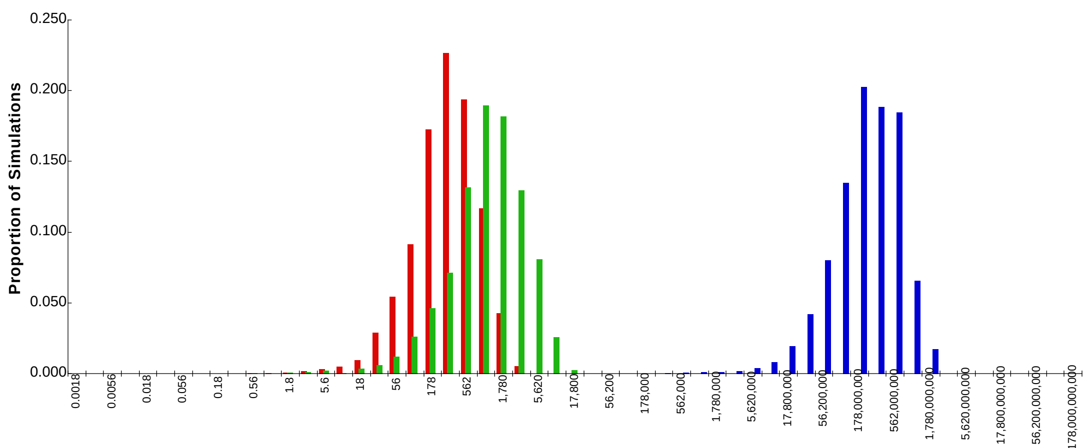
quantile	Au	Ag	rock
0.95	6	0	3,500,000
0.90	35	34	24,000,000
0.50	230	800	160,000,000
0.10	750	3,300	520,000,000
0.05	990	4,500	710,000,000
mean	**320**	**1,300**	**230,000,000**
Probability of mean	0.35	0.33	0.36
Probability of zero	0.04	0.08	0.04

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is W108

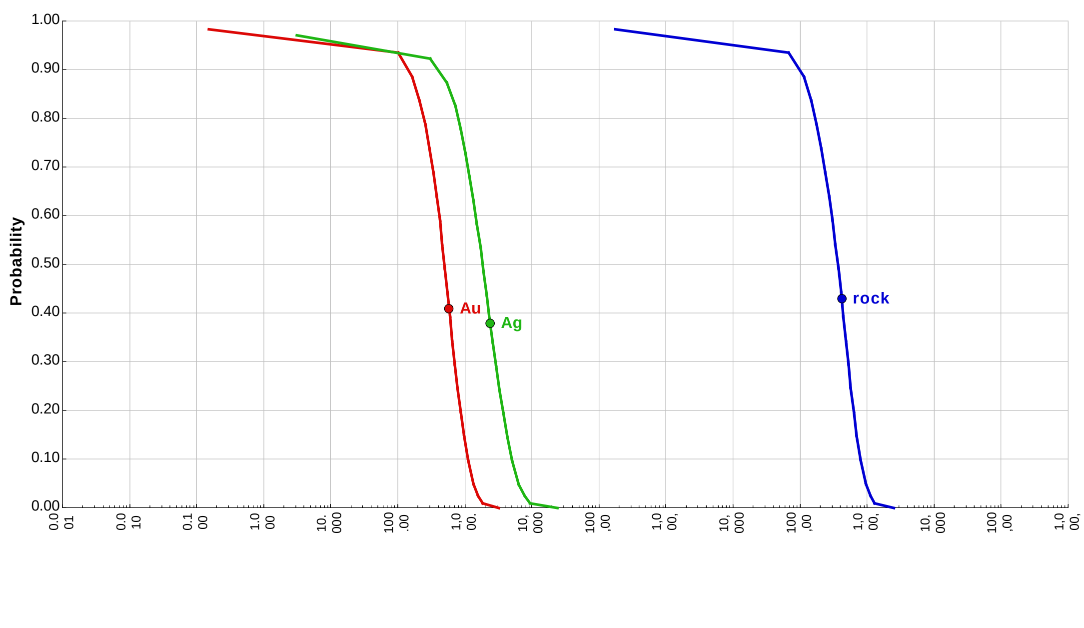
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 6 or more deposits.
There is a 50% or greater chance of 12 or more deposits.
There is a 10% or greater chance of 18 or more deposits.
There is a 5% or greater chance of 24 or more deposits.
There is a 1% or greater chance of 30 or more deposits.

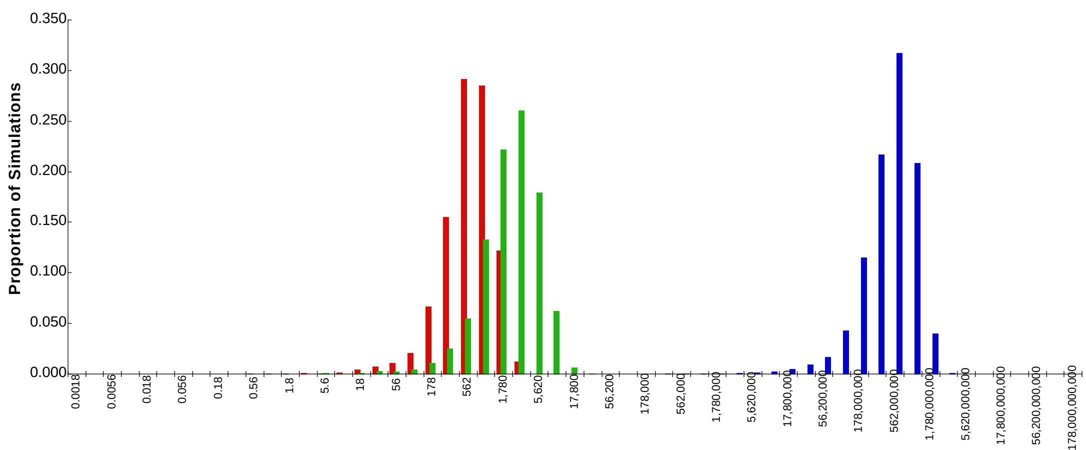
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	68	160	47,000,000
0.90	150	430	100,000,000
0.50	490	1,800	360,000,000
0.10	1,100	4,900	790,000,000
0.05	1,300	6,200	950,000,000
mean	**570**	**2,400**	**410,000,000**
Probability of mean	0.41	0.38	0.43
Probability of zero	0.02	0.03	0.02

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Au ■ Ag ■ rock

The tract ID is W109

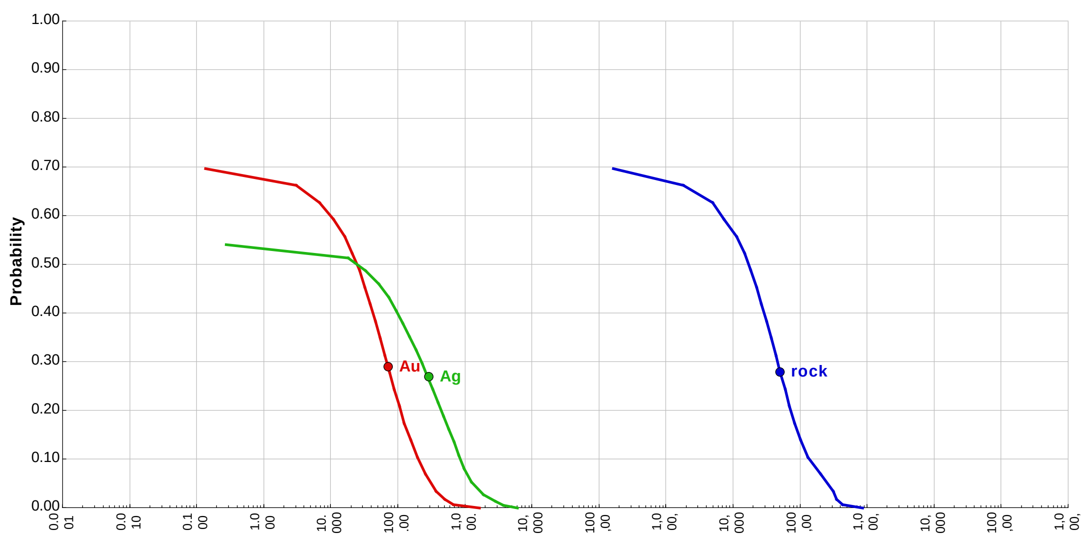
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 5 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

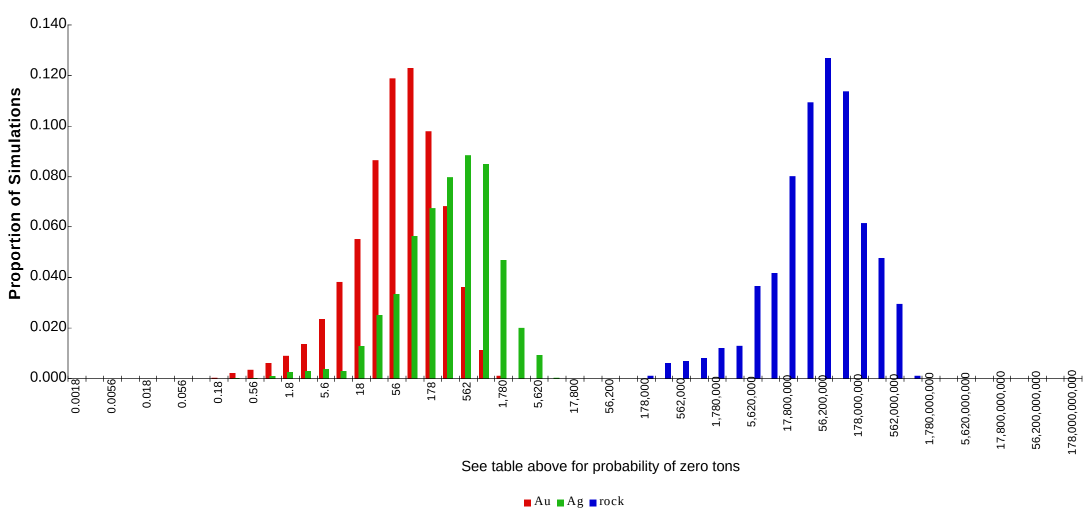
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	24	24	17,000,000
0.10	200	850	140,000,000
0.05	310	1,300	260,000,000
mean	**71**	**290**	**50,000,000**
Probability of mean	0.29	0.27	0.28
Probability of zero	0.30	0.46	0.30

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W112

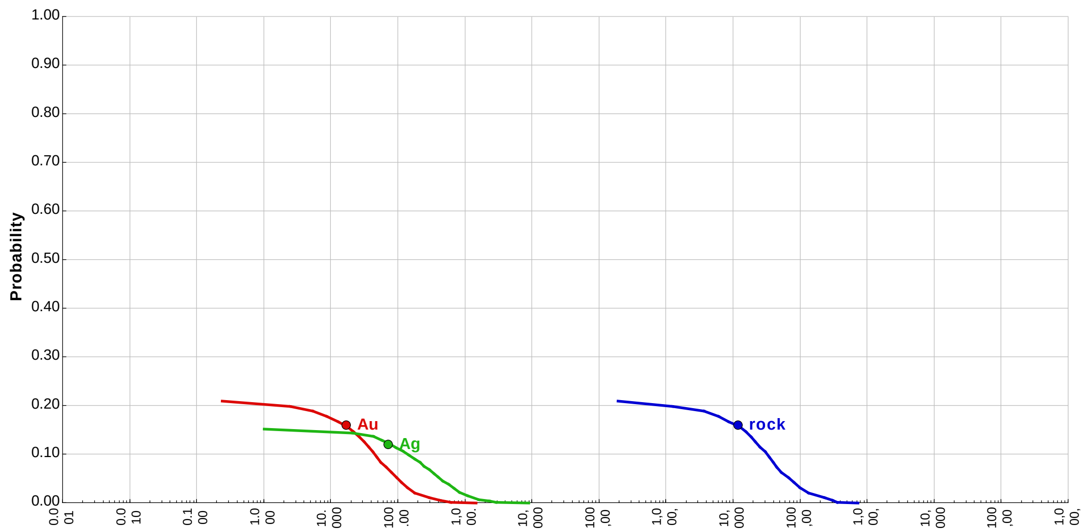
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

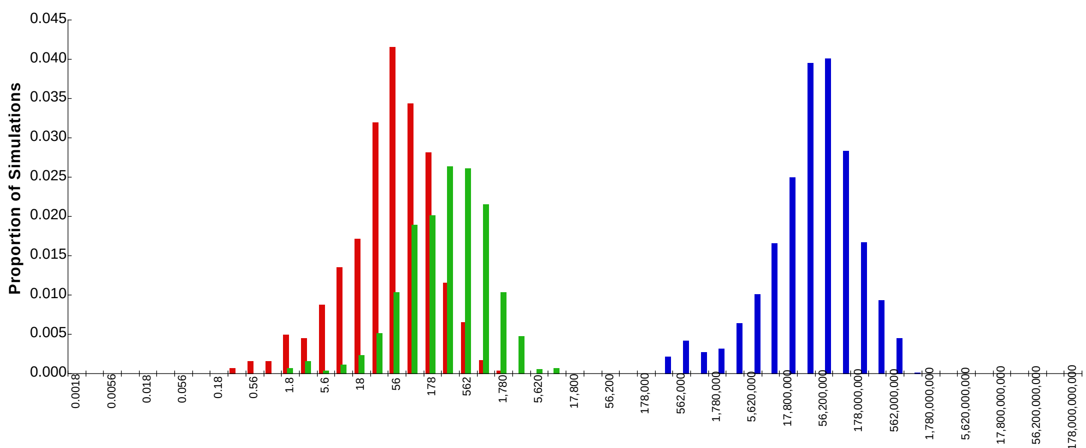
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	45	140	32,000,000
0.05	98	430	69,000,000
mean	**17**	**71**	**12,000,000**
Probability of mean	0.16	0.12	0.16
Probability of zero	0.79	0.85	0.79

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

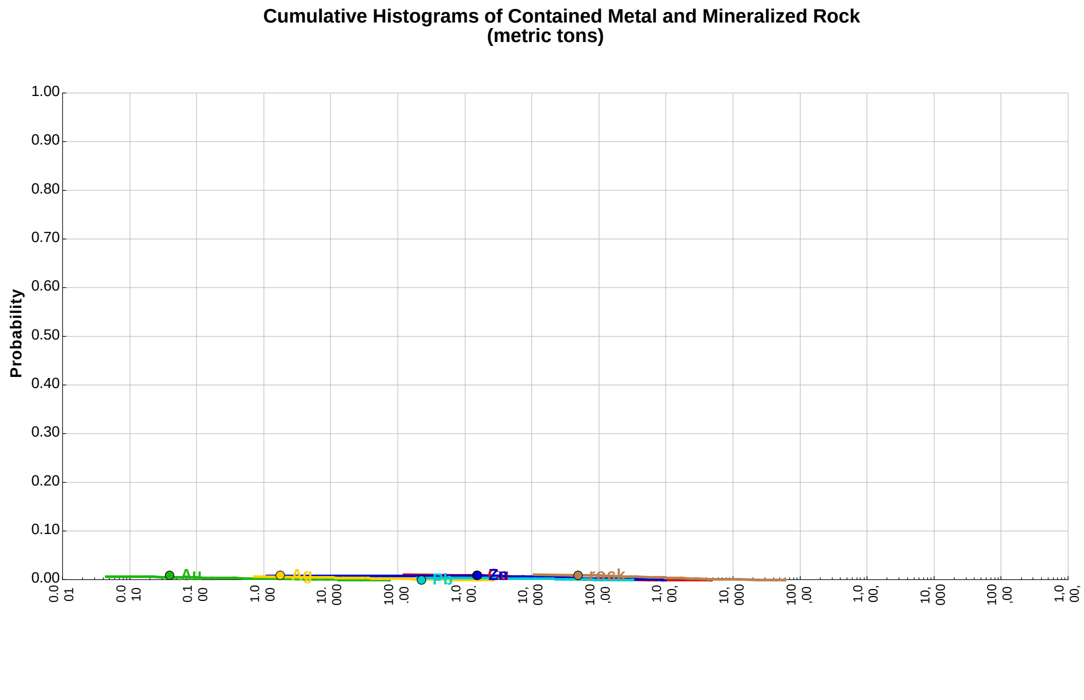
The tract ID is W113

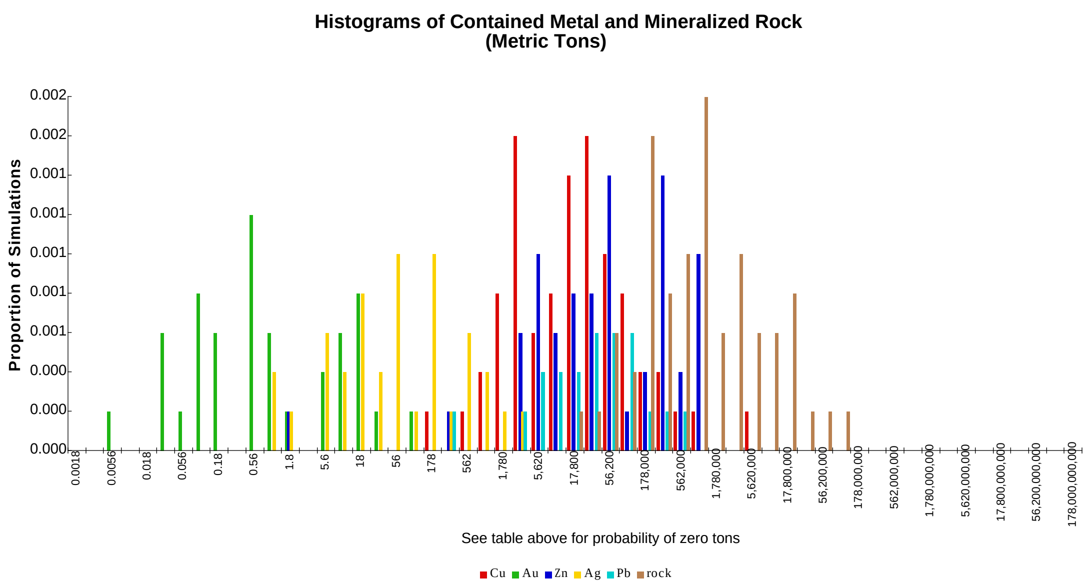
The Mark3 Index is 93: **Massive sulfide, kuroko**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**1,500**	**0**	**1,500**	**2**	**220**	**49,000**
Probability of mean	0.01	0.01	0.01	0.01	0.00	0.01
Probability of zero	0.99	0.99	0.99	0.99	1.00	0.99





The tract ID is W114

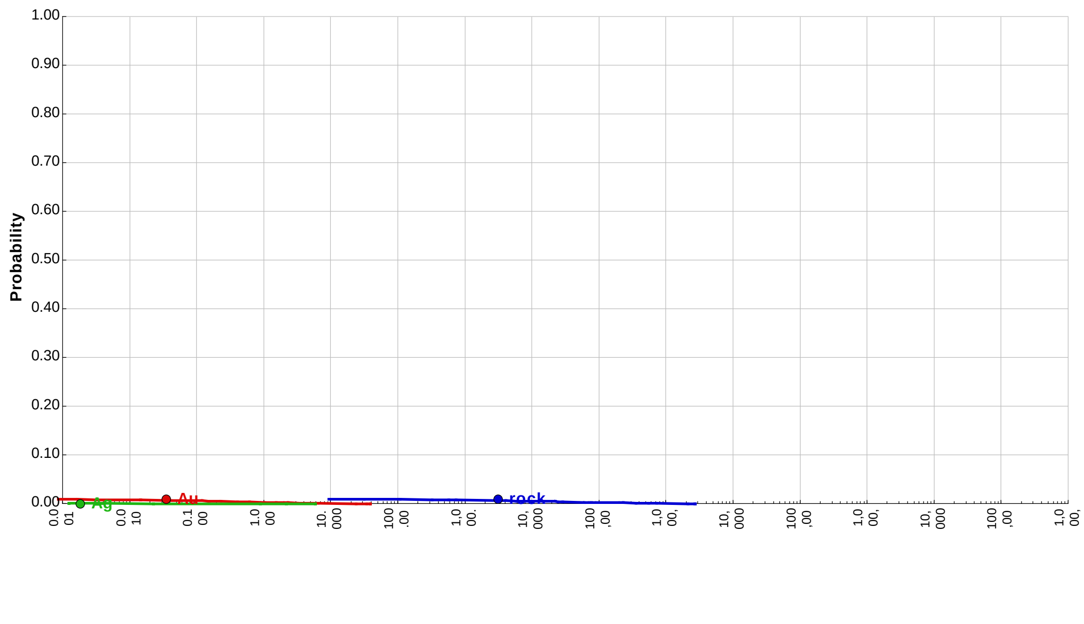
The Mark3 Index is 27: **Low sulfide Au-quartz vein**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

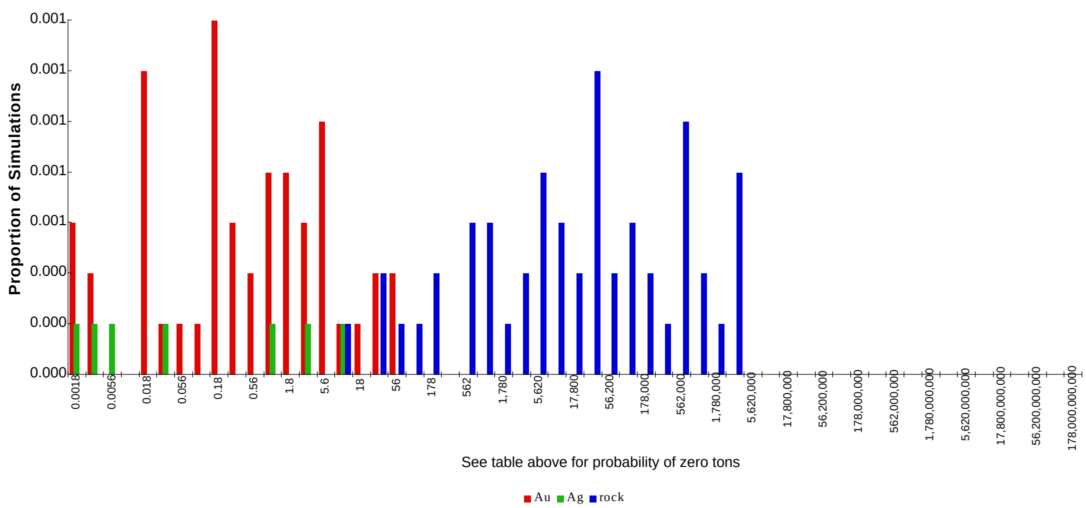
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**0**	**0**	**3,100**
Probability of mean	0.01	0.00	0.01
Probability of zero	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W115

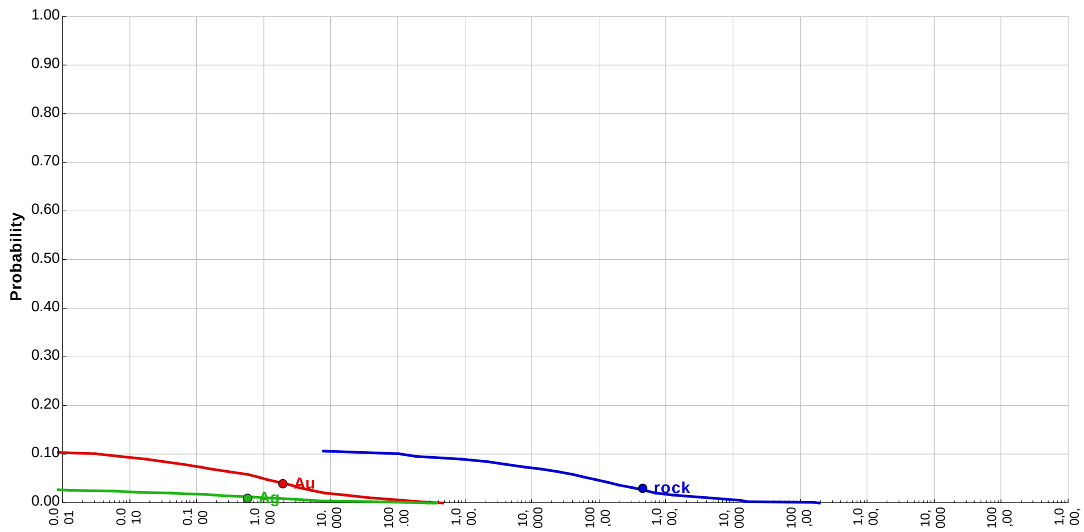
The Mark3 Index is 27: **Low sulfide Au-quartz vein**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

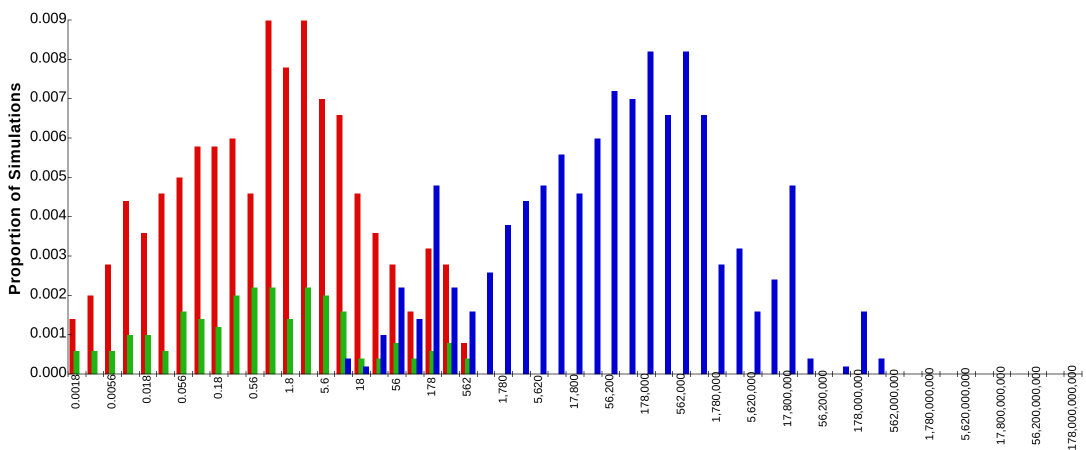
quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	130
0.05	1	0	80,000
mean	**2**	**1**	**440,000**
Probability of mean	0.04	0.01	0.03
Probability of zero	0.89	0.97	0.89

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is W118

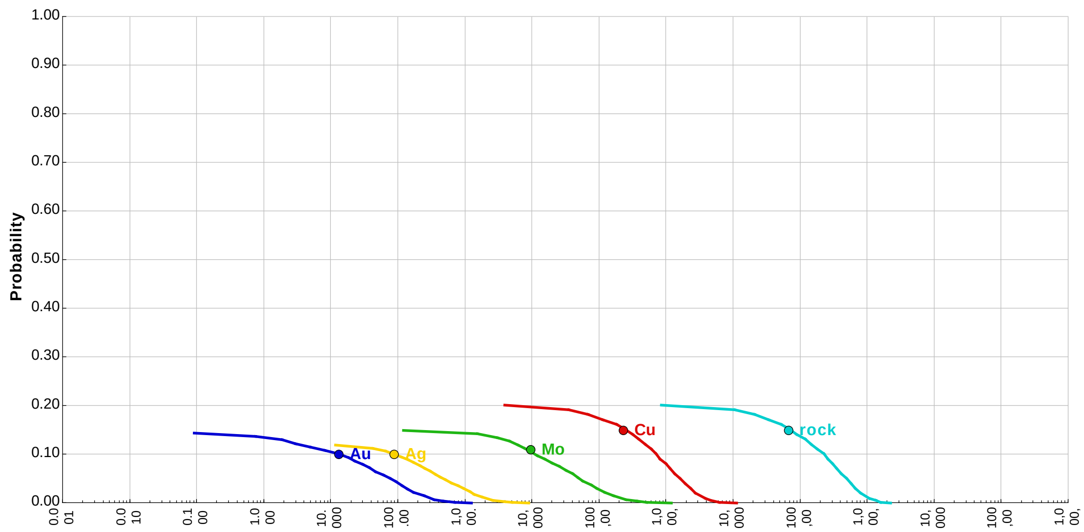
The Mark3 Index is 89: **Porphyry Cu (BC-AK)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 4 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

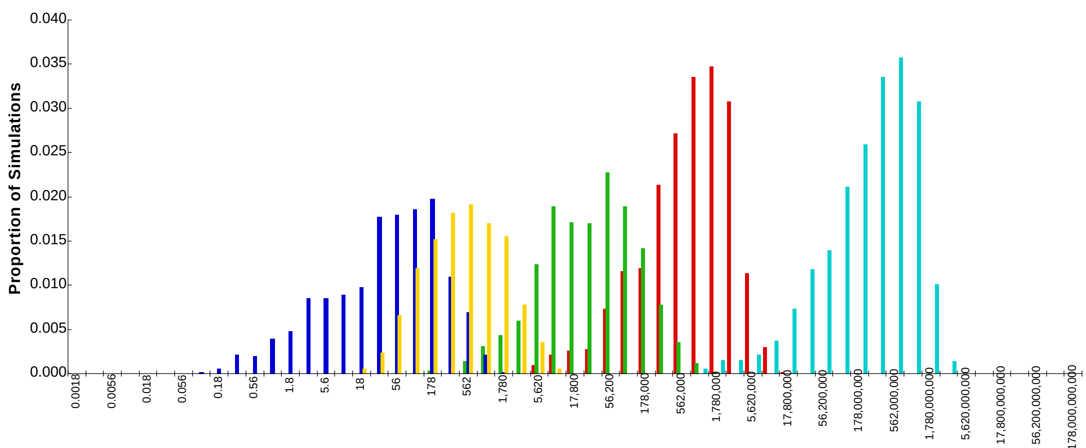
quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	710,000	11,000	14	89	230,000,000
0.05	1,600,000	51,000	78	480	500,000,000
mean	**230,000**	**9,500**	**13**	**87**	**67,000,000**
Probability of mean	0.15	0.11	0.10	0.10	0.15
Probability of zero	0.80	0.85	0.86	0.88	0.80

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Mo Au Ag rock

The tract ID is W119

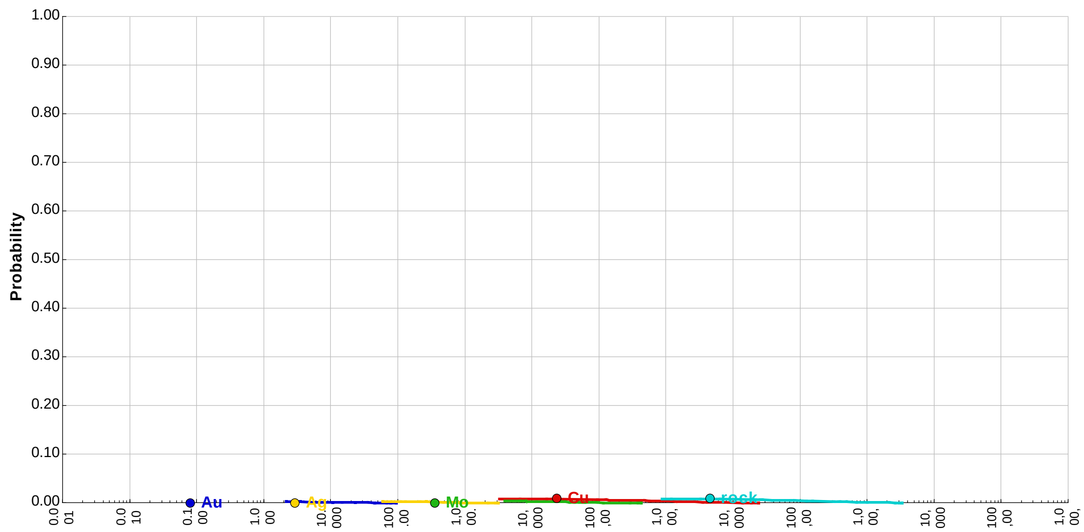
The Mark3 Index is 81: **Porphyry Cu (North America)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

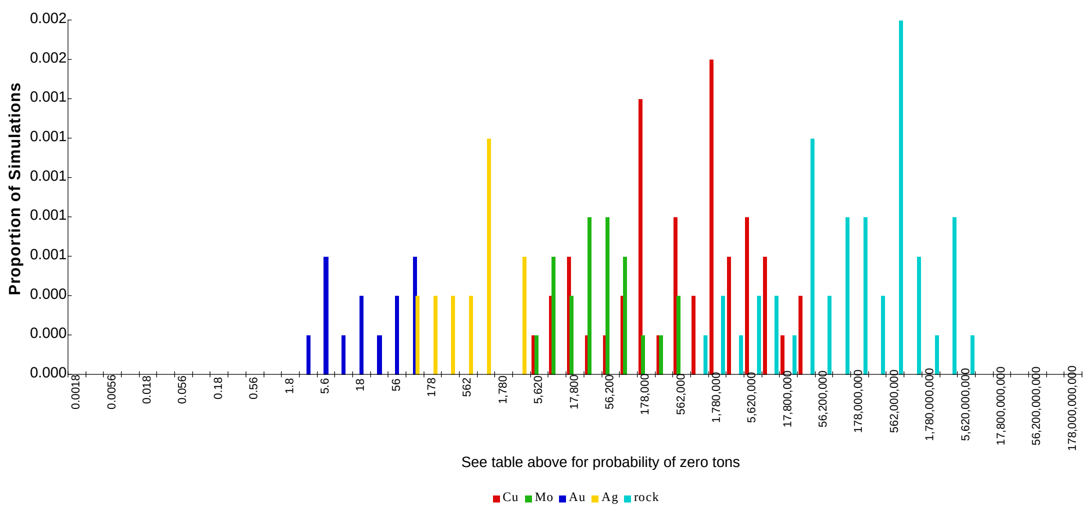
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	0	0	0	0	0
mean	**23,000**	**350**	**0**	**3**	**4,500,000**
Probability of mean	0.01	0.00	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

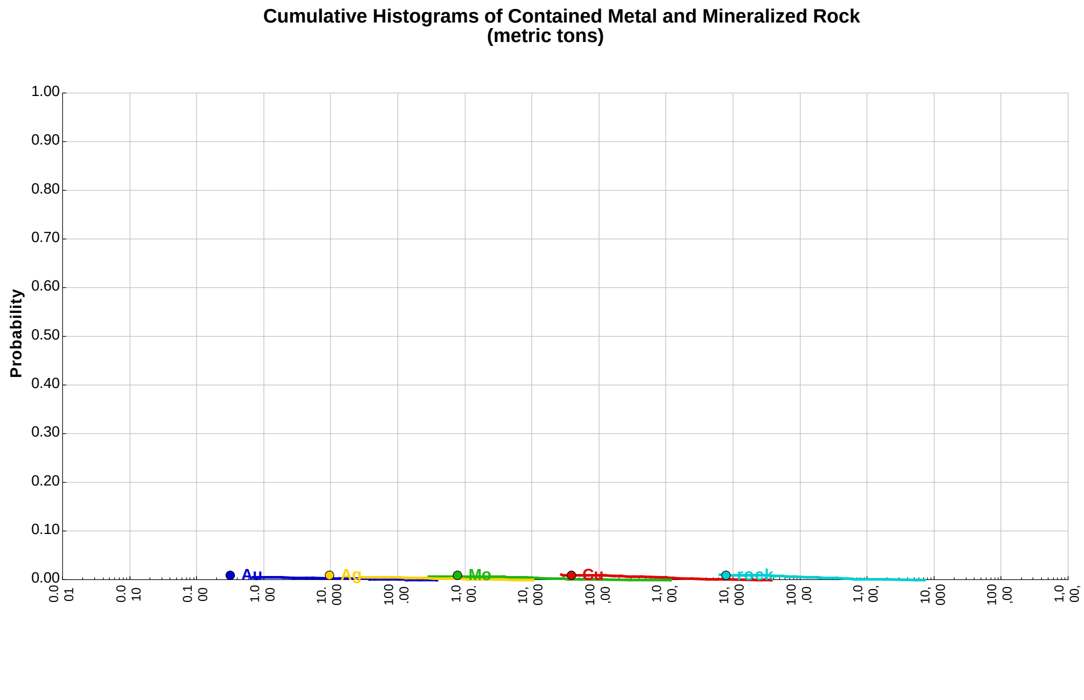
The tract ID is W119a

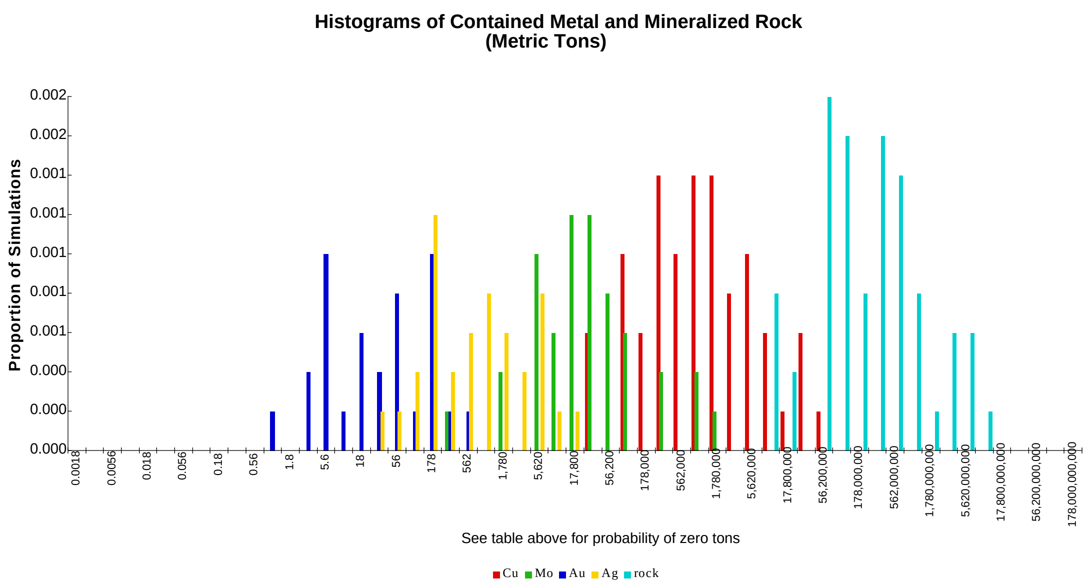
The Mark3 Index is 81: **Porphyry Cu (North America)**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Mo	Au	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	0	0	0	0	0
mean	**38,000**	**780**	**0**	**9**	**7,700,000**
Probability of mean	0.01	0.01	0.01	0.01	0.01
Probability of zero	0.99	0.99	0.99	0.99	0.99





The tract ID is W120

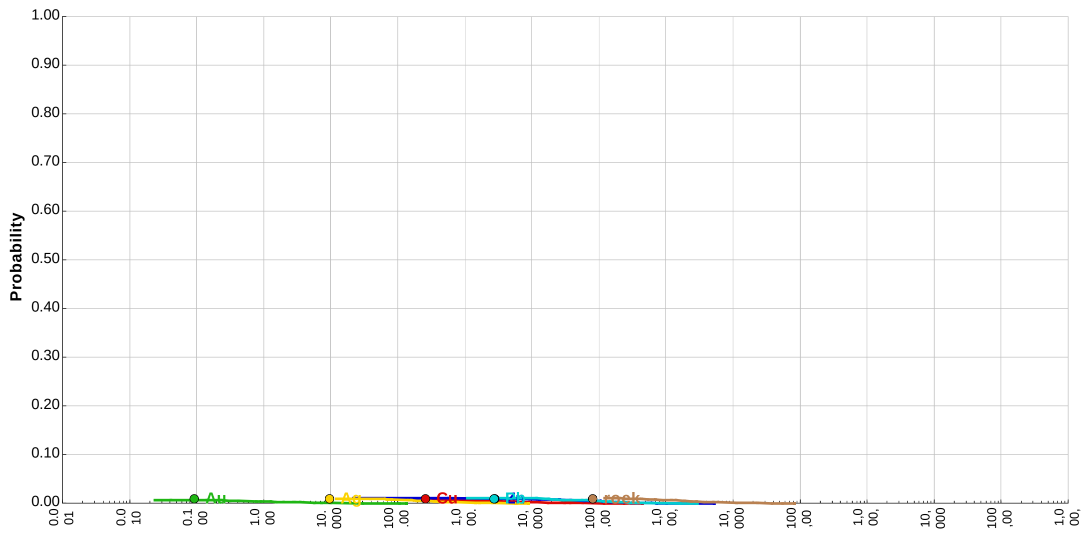
The Mark3 Index is 47: **Polymetallic replacement**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

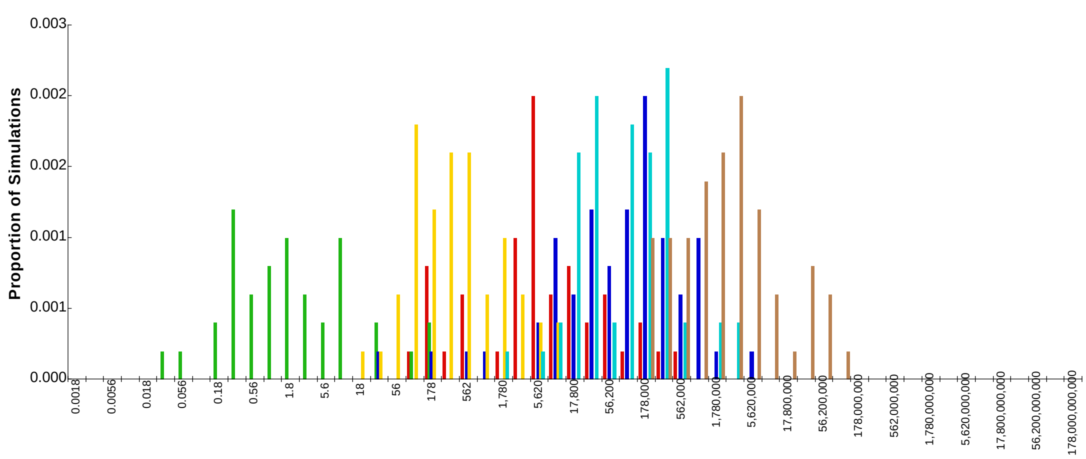
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**250**	**0**	**2,800**	**10**	**2,700**	**80,000**
Probability of mean	0.01	0.01	0.01	0.01	0.01	0.01
Probability of zero	0.99	0.99	0.99	0.99	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

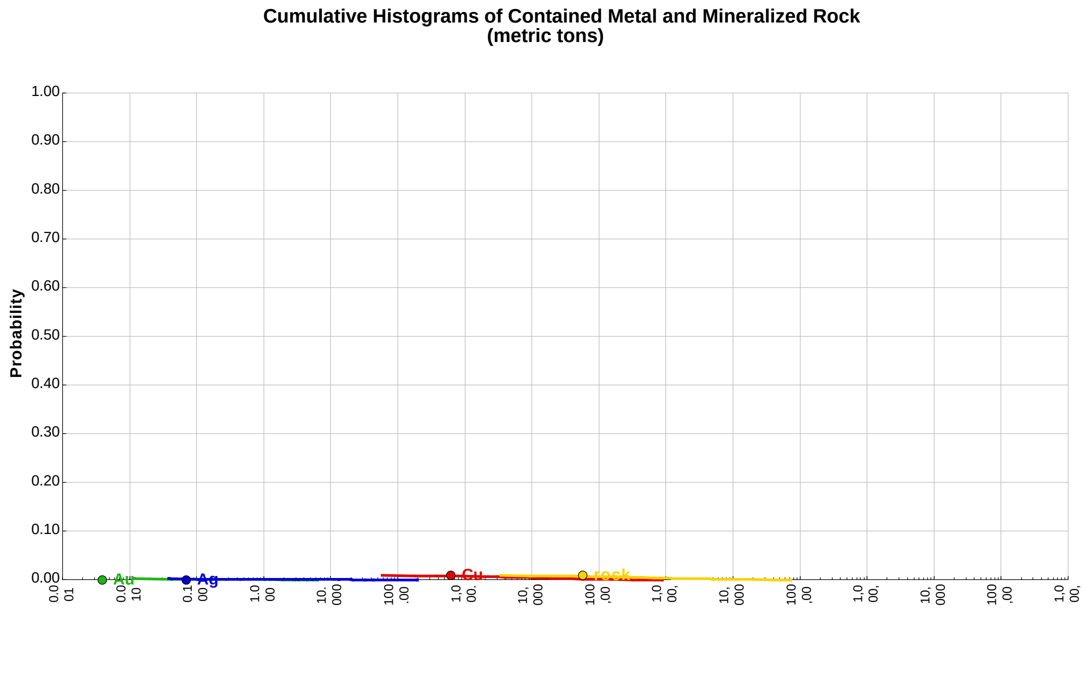
The tract ID is W122

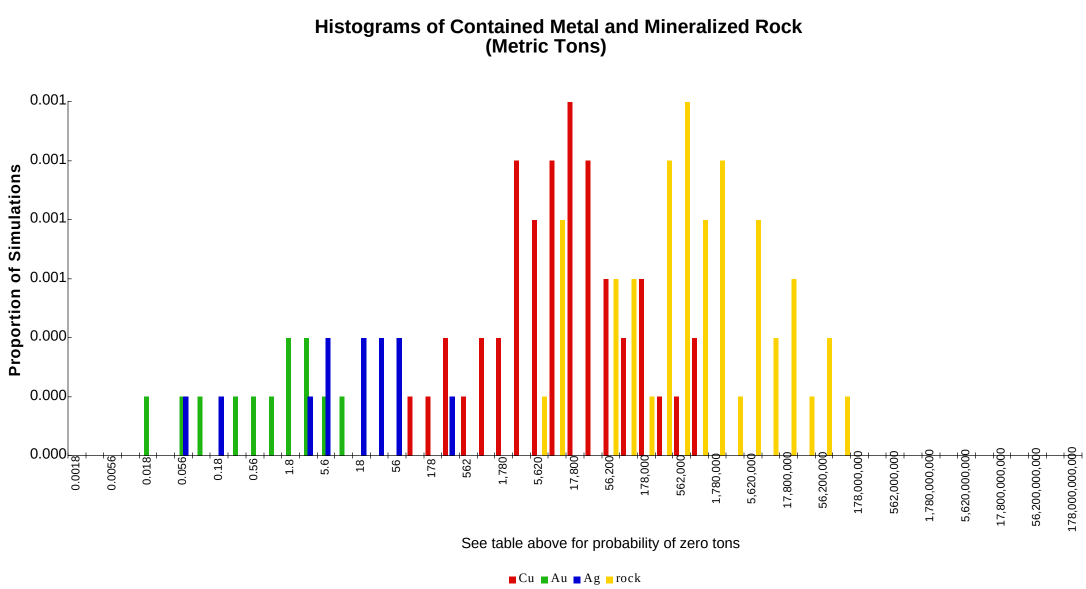
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	0	0	0	0
0.05	0	0	0	0
mean	**600**	**0**	**0**	**56,000**
Probability of mean	0.01	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	0.99





The tract ID is W123

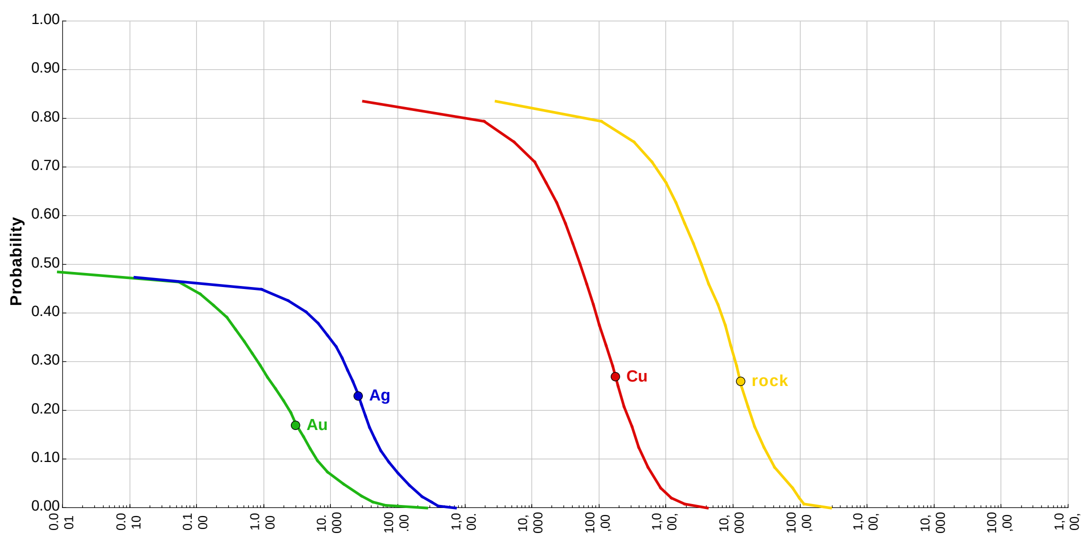
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 3 or more deposits.
There is a 10% or greater chance of 5 or more deposits.
There is a 5% or greater chance of 9 or more deposits.
There is a 1% or greater chance of 12 or more deposits.

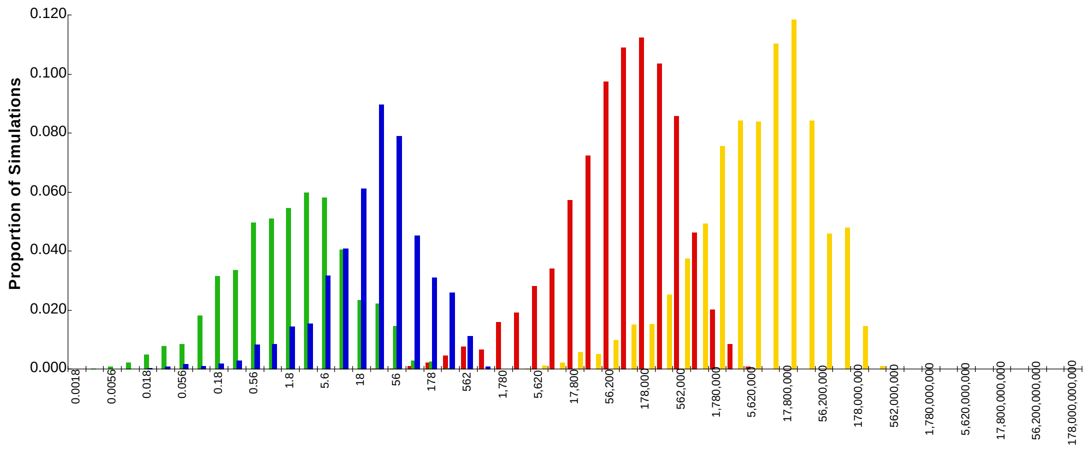
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	52,000	0	0	3,400,000
0.10	460,000	6	67	35,000,000
0.05	740,000	15	140	70,000,000
mean	**170,000**	**3**	**25**	**13,000,000**
Probability of mean	0.27	0.17	0.23	0.26
Probability of zero	0.16	0.51	0.53	0.16

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W123 (Idaho only)

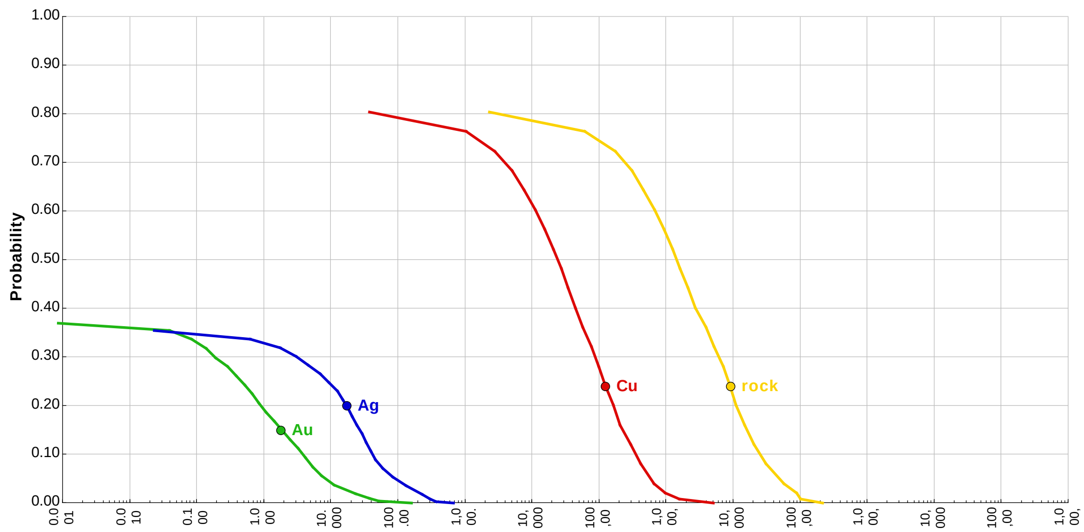
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 7 or more deposits.
There is a 1% or greater chance of 10 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

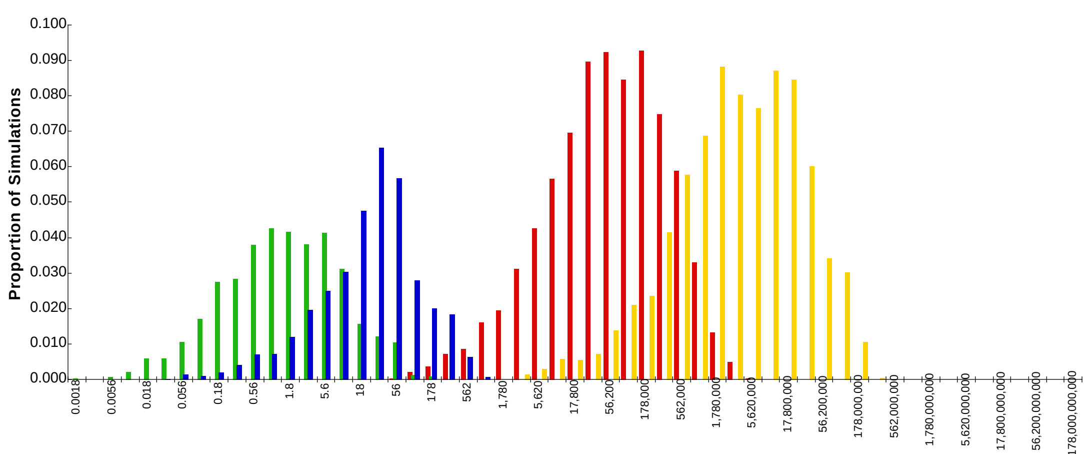
quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	24,000	0	0	1,400,000
0.10	340,000	4	41	26,000,000
0.05	570,000	8	90	49,000,000
mean	**120,000**	**2**	**17**	**9,200,000**
Probability of mean	0.24	0.15	0.20	0.24
Probability of zero	0.20	0.63	0.65	0.20

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Ag rock

The tract ID is W123 (OR-WA only)

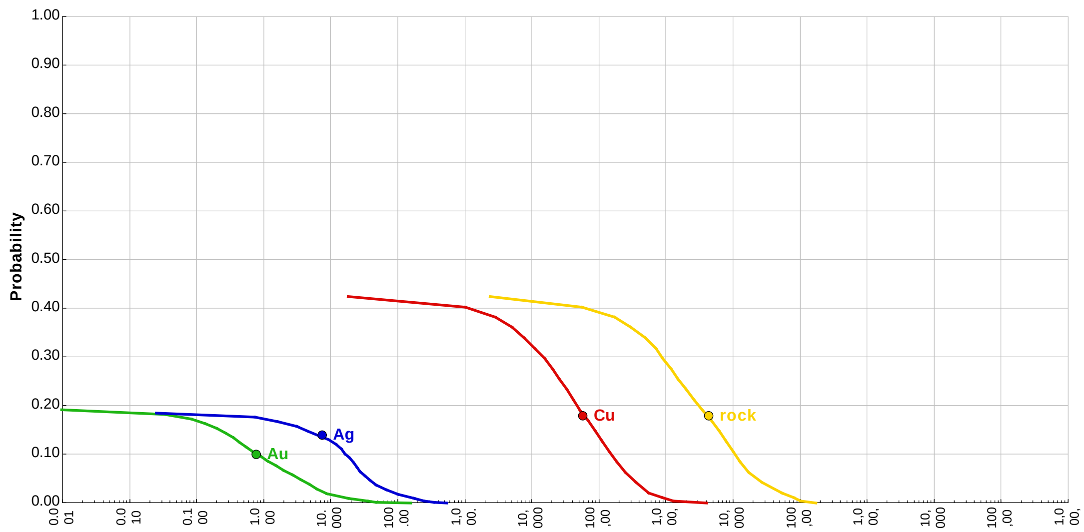
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

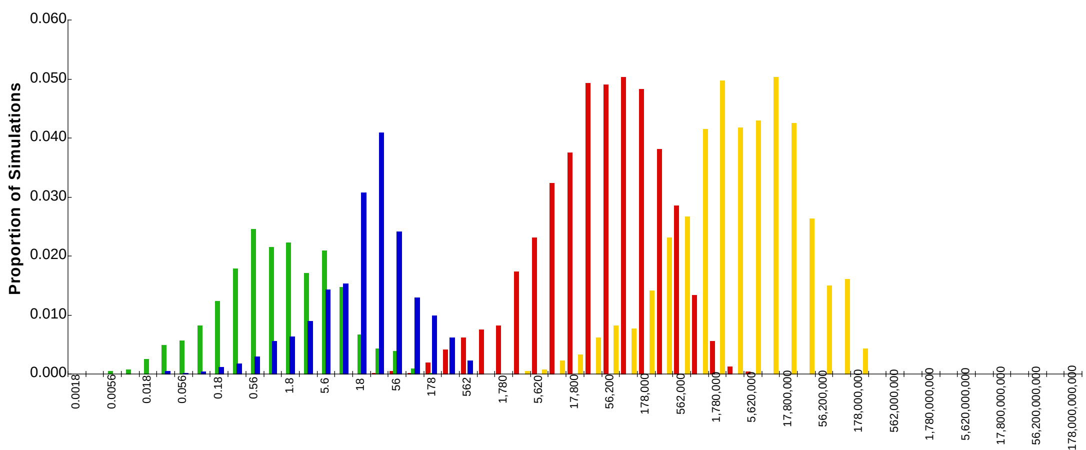
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	150,000	1	17	10,000,000
0.05	310,000	3	36	23,000,000
mean	**57,000**	**1**	**7**	**4,300,000**
Probability of mean	0.18	0.10	0.14	0.18
Probability of zero	0.58	0.81	0.81	0.58

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■Cu ■Au ■Ag ■rock

The tract ID is W124

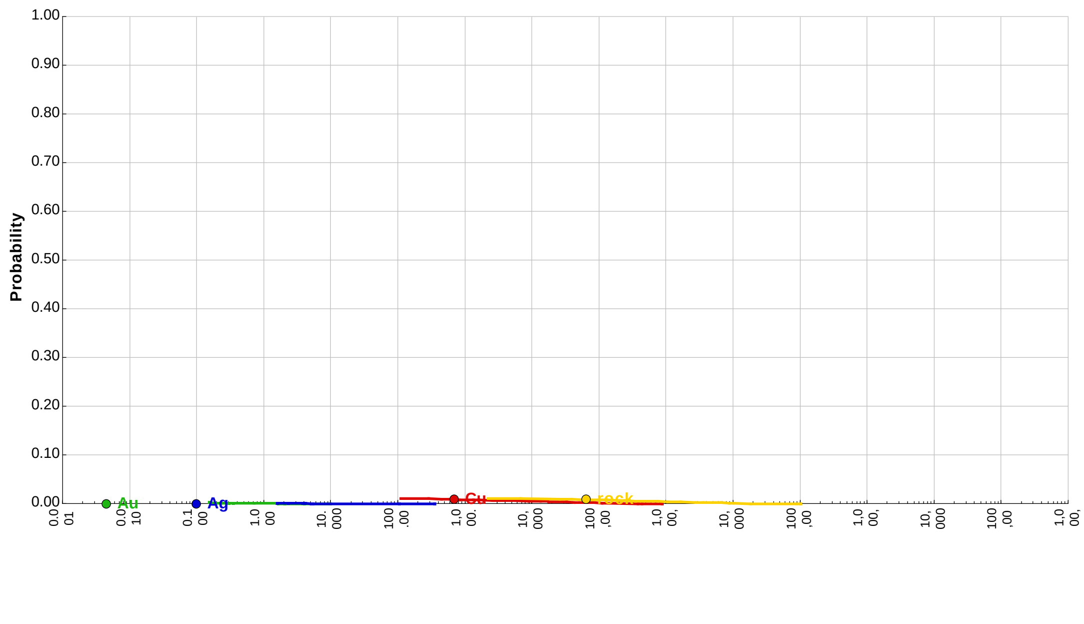
The Mark3 Index is 8: **Skarn Cu**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

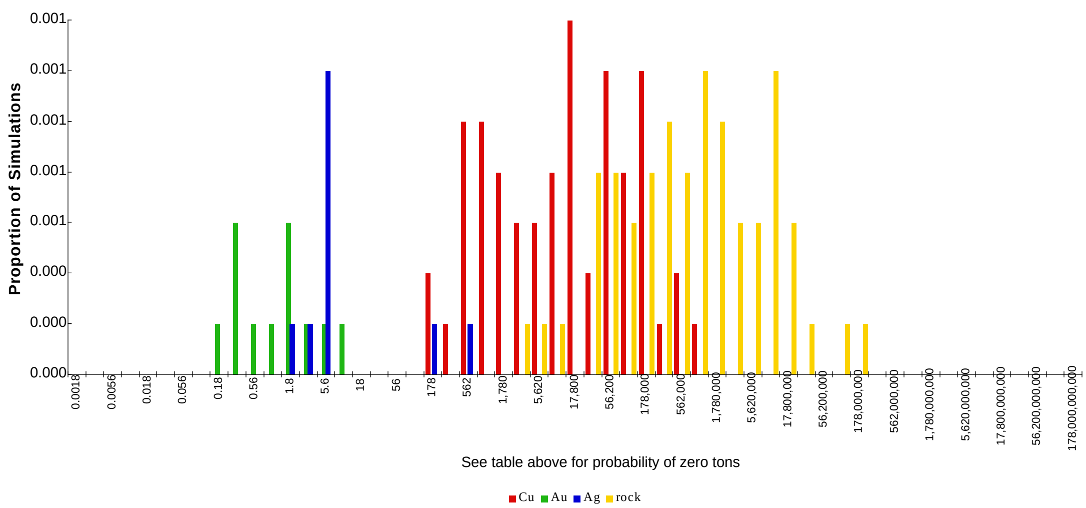
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Ag	rock
0.95	0	0	0	0
0.90	0	0	0	0
0.50	0	0	0	0
0.10	0	0	0	0
0.05	0	0	0	0
mean	**680**	**0**	**0**	**64,000**
Probability of mean	0.01	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W125

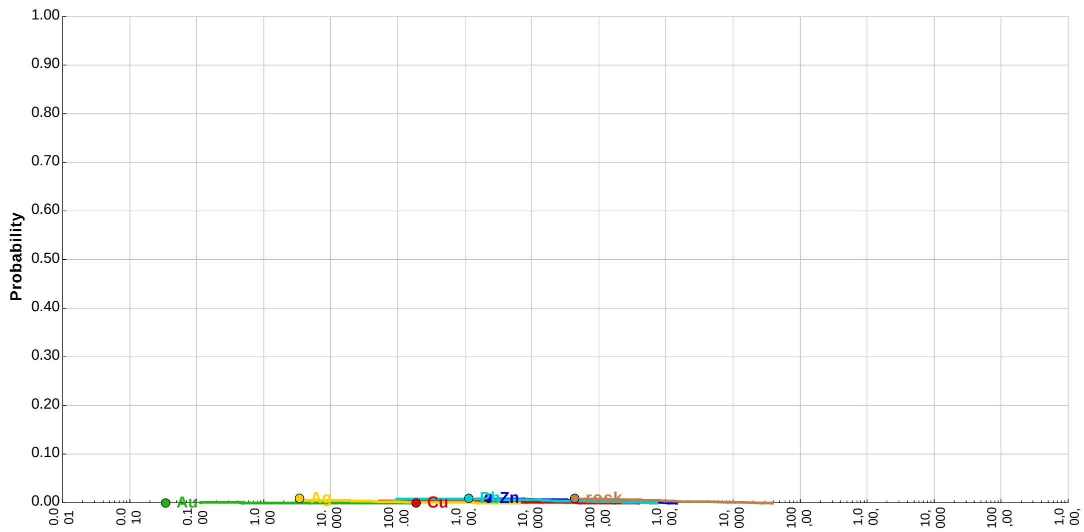
The Mark3 Index is 22: **Skarn Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

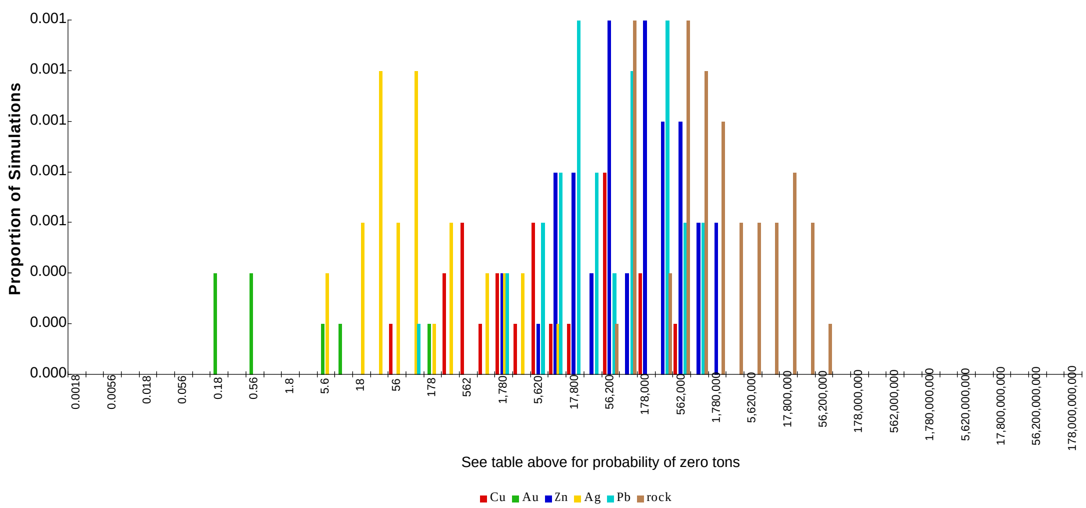
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**180**	**0**	**2,300**	**3**	**1,100**	**43,000**
Probability of mean	0.00	0.00	0.01	0.01	0.01	0.01
Probability of zero	1.00	1.00	0.99	0.99	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

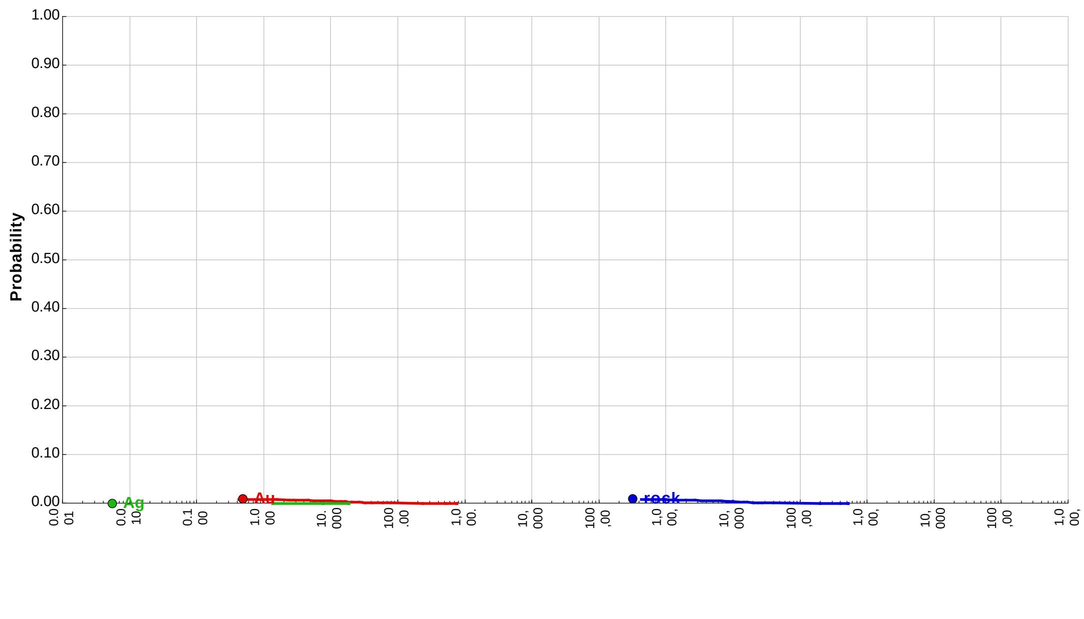
The tract ID is W127

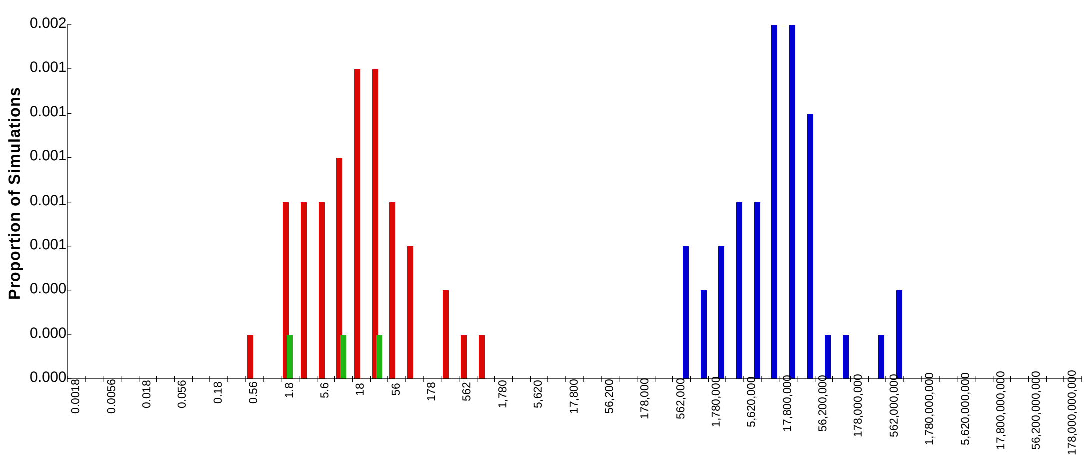
The Mark3 Index is 17: **Sediment-hosted Au**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**1**	**0**	**320,000**
Probability of mean	0.01	0.00	0.01
Probability of zero	0.99	1.00	0.99





The tract ID is W128

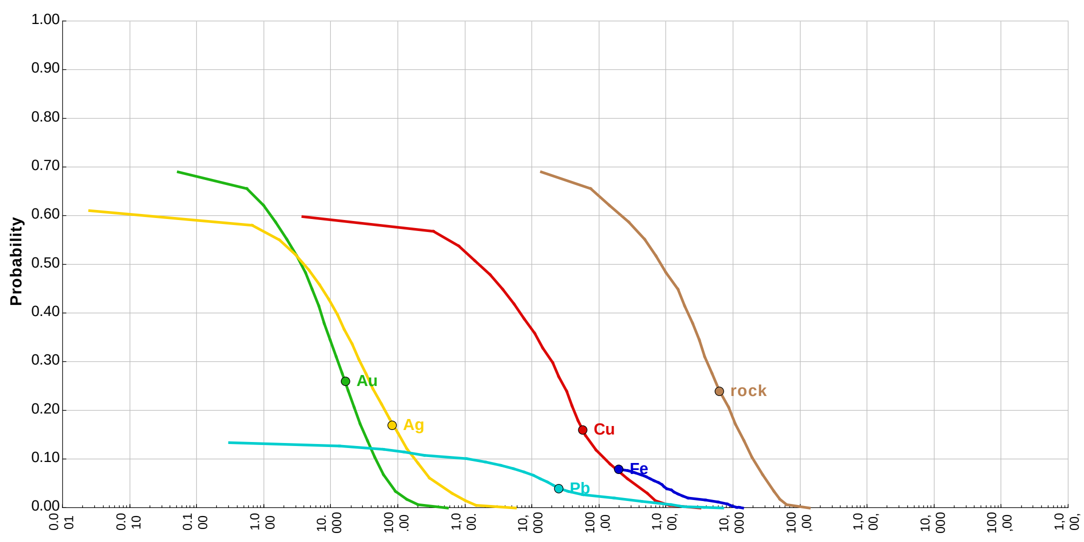
The Mark3 Index is 105: **Skarn Au, truncated**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 3 or more deposits.
There is a 5% or greater chance of 5 or more deposits.
There is a 1% or greater chance of 7 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

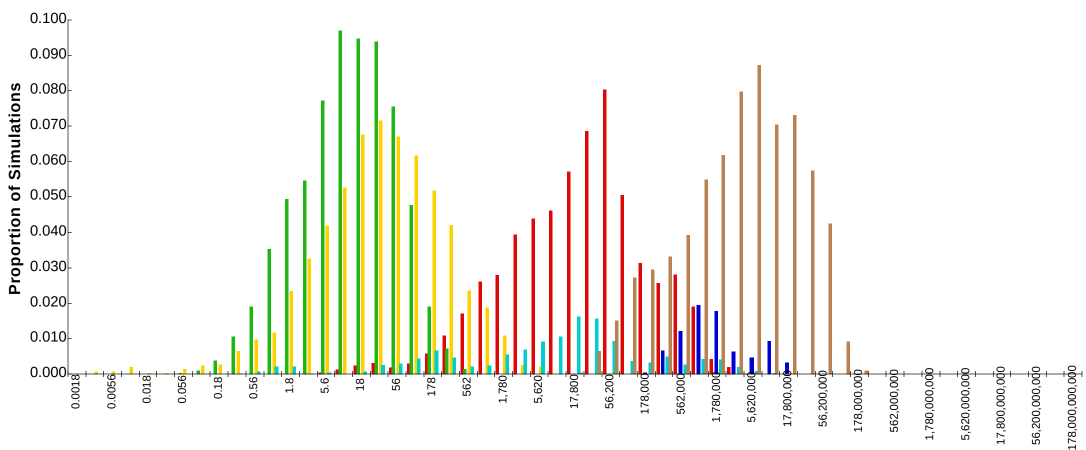
quantile	Cu	Au	Fe	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	1,700	4	0	4	0	850,000
0.10	120,000	45	0	180	1,200	20,000,000
0.05	340,000	74	850,000	380	19,000	33,000,000
mean	**57,000**	**16**	**200,000**	**81**	**25,000**	**6,200,000**
Probability of mean	0.16	0.26	0.08	0.17	0.04	0.24
Probability of zero	0.40	0.31	0.92	0.39	0.87	0.31

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Fe Ag Pb rock

The tract ID is W129

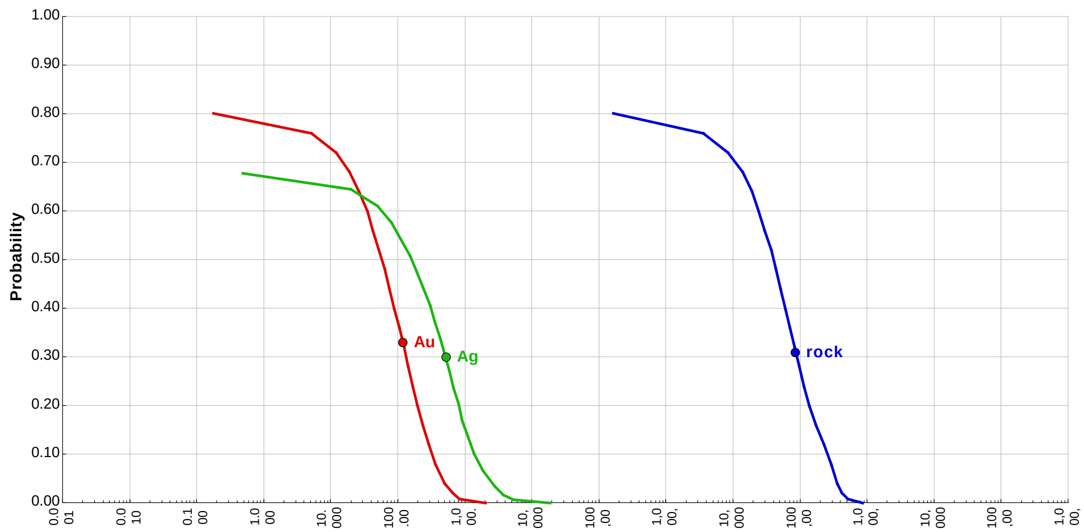
The Mark3 Index is 45: **Hot spring Au-Ag**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 2 or more deposits.
There is a 10% or greater chance of 5 or more deposits.
There is a 5% or greater chance of 7 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

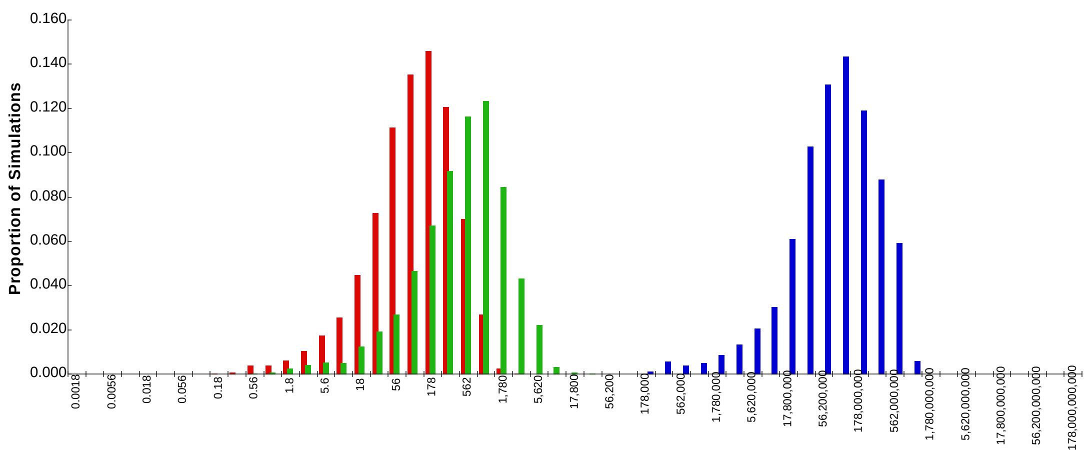
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	57	160	40,000,000
0.10	320	1,400	260,000,000
0.05	450	2,100	340,000,000
mean	**120**	**520**	**84,000,000**
Probability of mean	0.33	0.30	0.31
Probability of zero	0.20	0.32	0.20

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Au Ag rock

The tract ID is W132

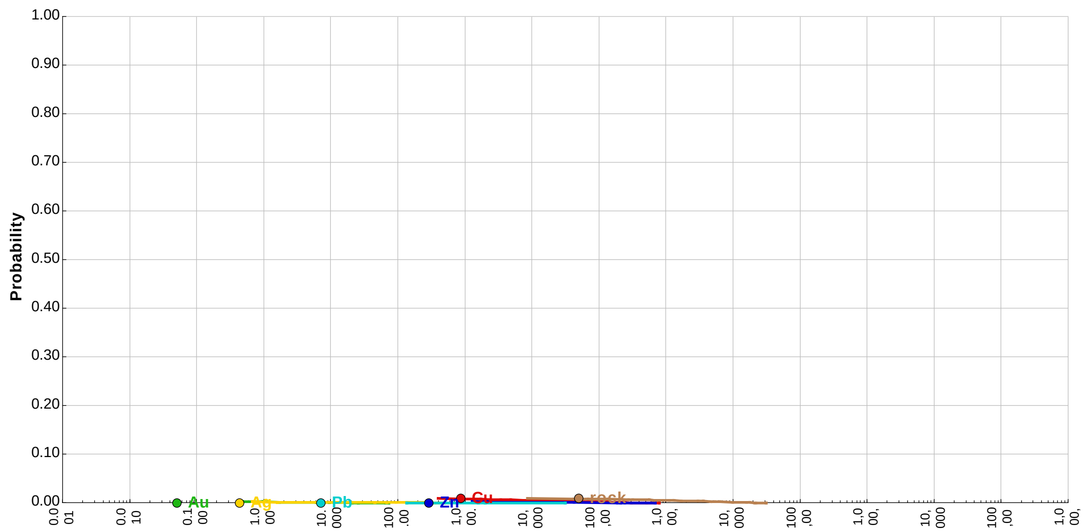
The Mark3 Index is 11: **Massive sulfide, Cyprus**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

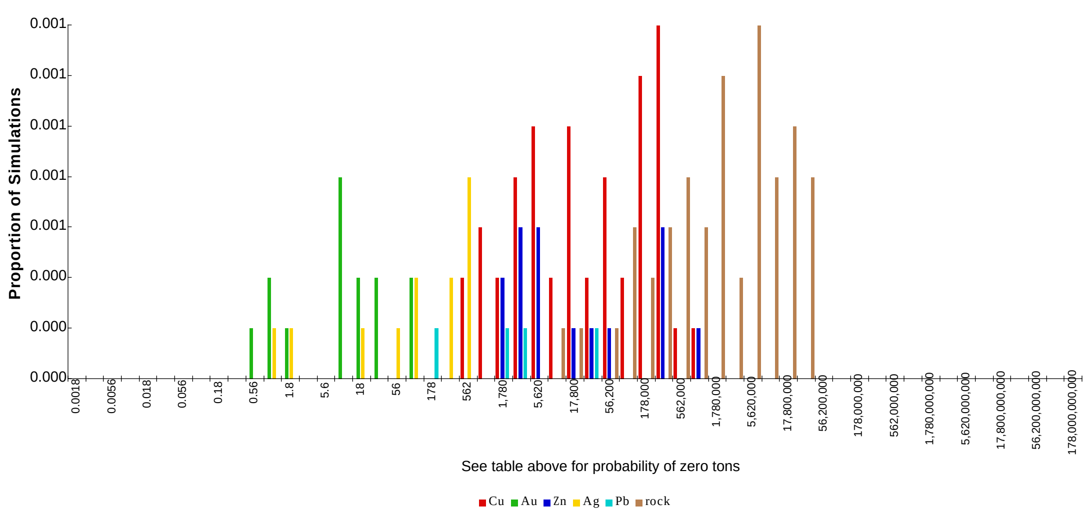
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**850**	**0**	**290**	**0**	**7**	**49,000**
Probability of mean	0.01	0.00	0.00	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	1.00	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W135

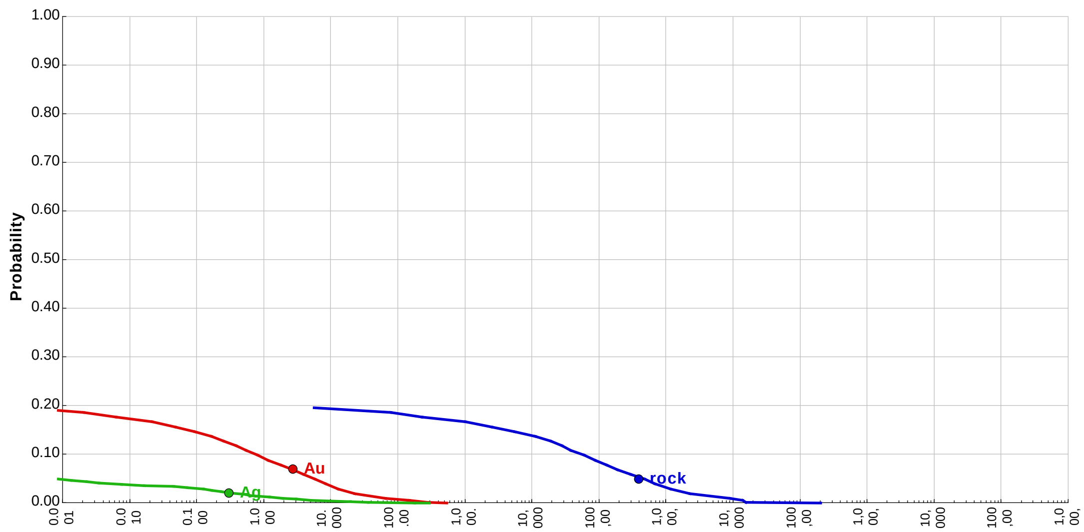
The Mark3 Index is 27: **Low sulfide Au-quartz vein**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 4 or more deposits.
There is a 1% or greater chance of 7 or more deposits.

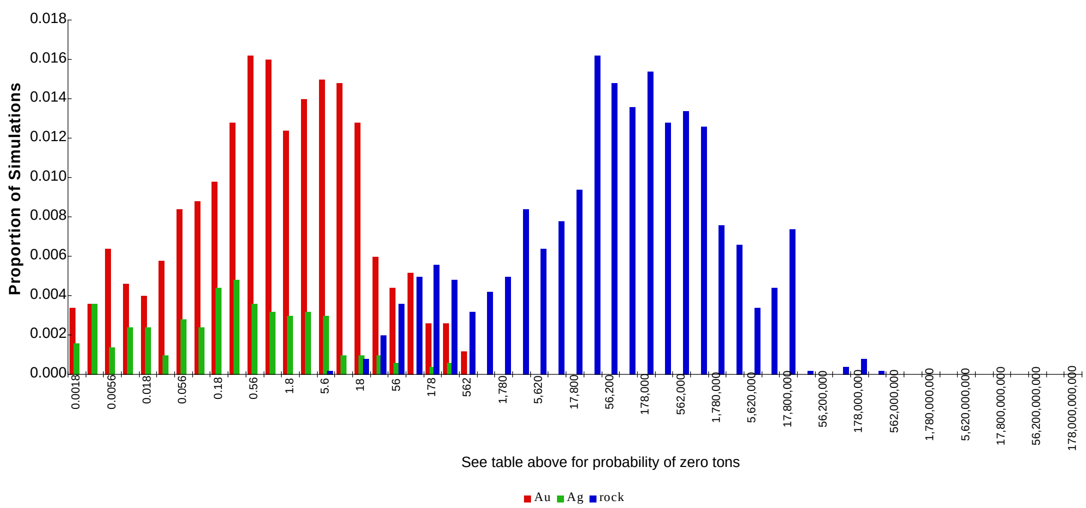
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	1	0	54,000
0.05	6	0	450,000
mean	**3**	**0**	**390,000**
Probability of mean	0.07	0.02	0.05
Probability of zero	0.80	0.95	0.80

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W136

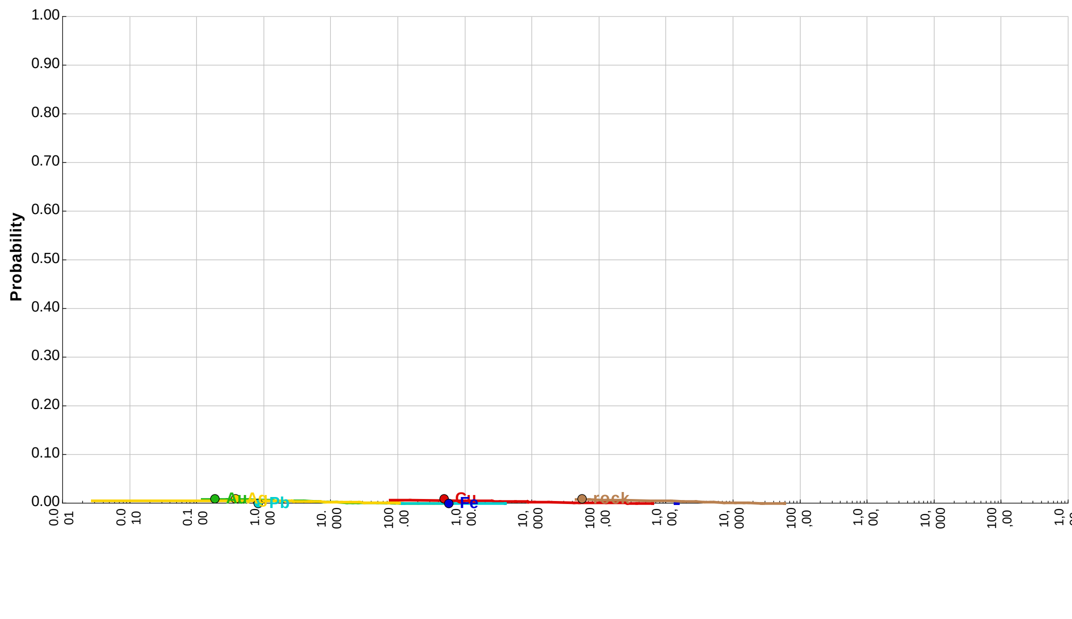
The Mark3 Index is 105: **Skarn Au, truncated**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

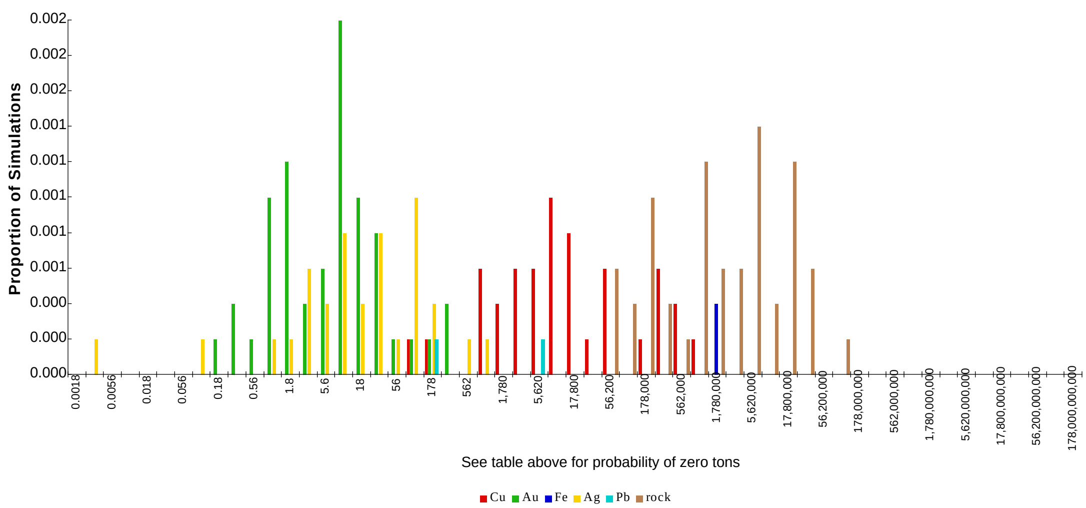
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Fe	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**490**	**0**	**570**	**0**	**1**	**56,000**
Probability of mean	0.01	0.01	0.00	0.01	0.00	0.01
Probability of zero	0.99	0.99	1.00	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W137

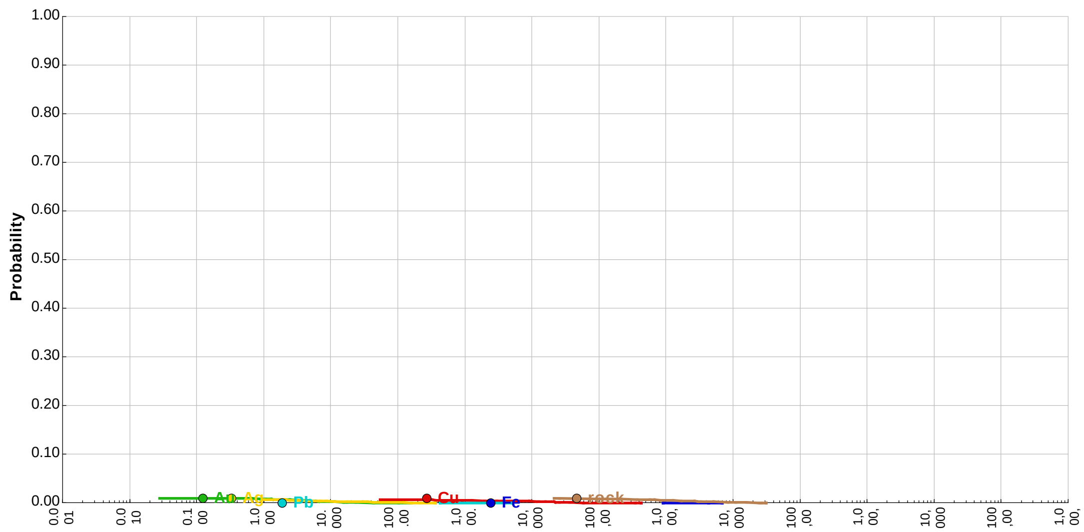
The Mark3 Index is 105: **Skarn Au, truncated**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

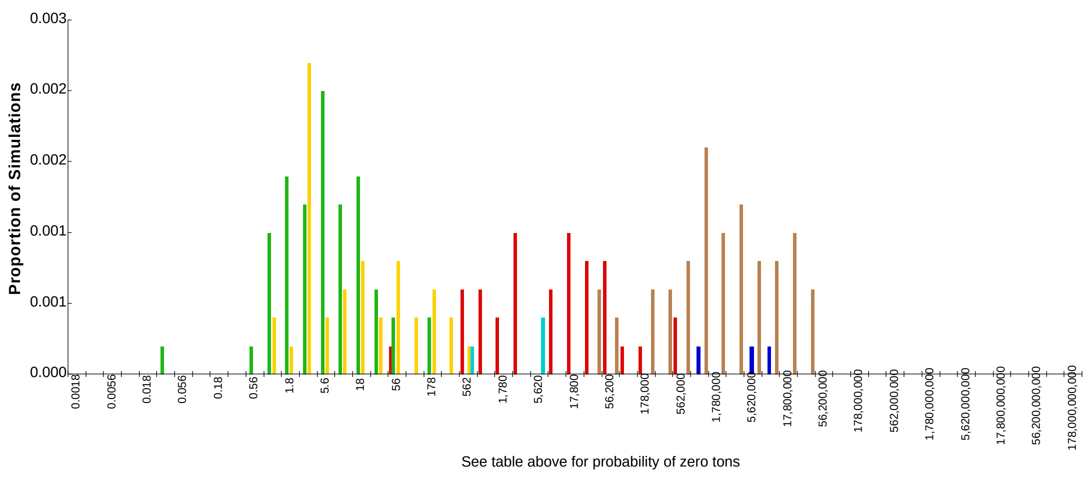
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Cu	Au	Fe	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	0	0	0	0
0.05	0	0	0	0	0	0
mean	**270**	**0**	**2,400**	**0**	**2**	**46,000**
Probability of mean	0.01	0.01	0.00	0.01	0.00	0.01
Probability of zero	0.99	0.99	1.00	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W138 (ICB only)

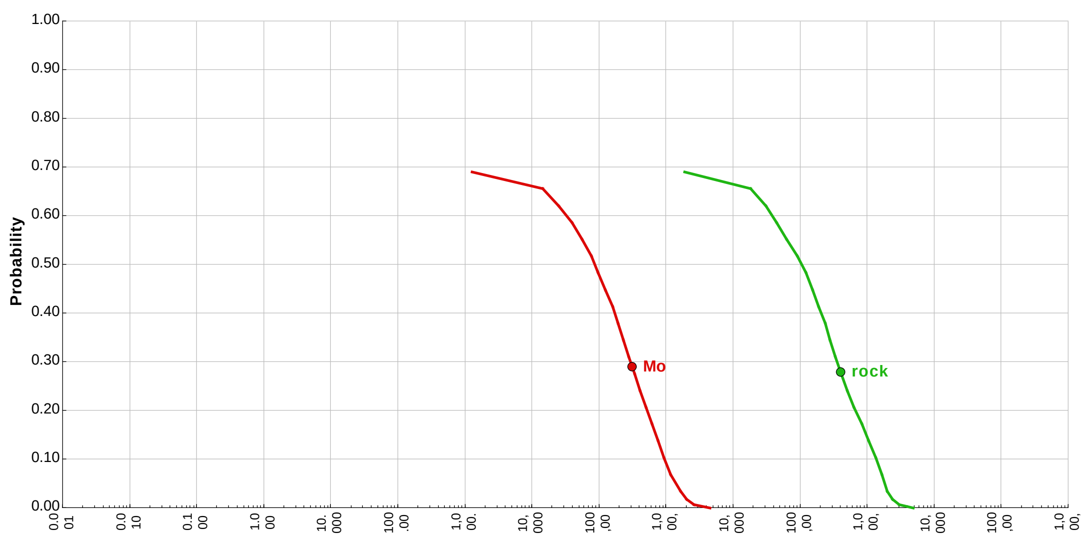
The Mark3 Index is 6: **Porphyry Mo, Low-F**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 1 or more deposits.
There is a 10% or greater chance of 4 or more deposits.
There is a 5% or greater chance of 6 or more deposits.
There is a 1% or greater chance of 8 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

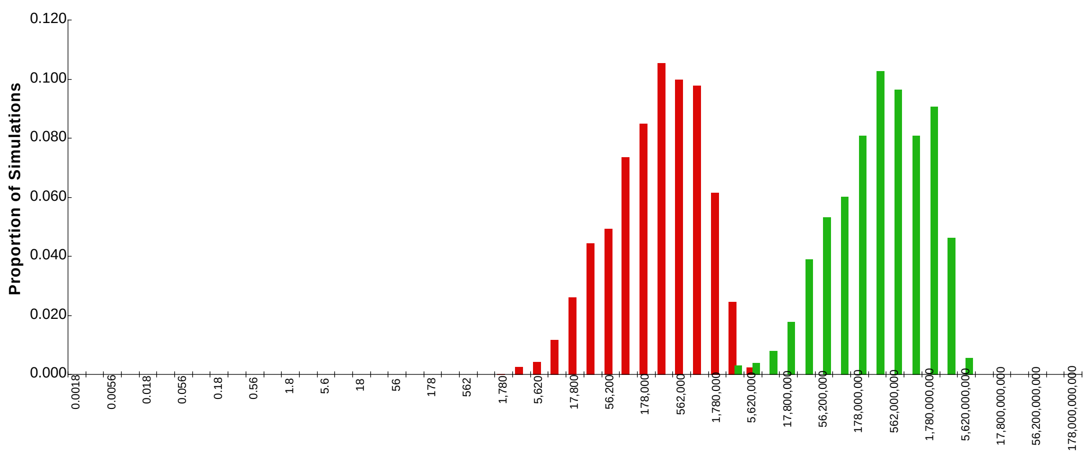
quantile	Mo	rock
0.95	0	0
0.90	0	0
0.50	86,000	100,000,000
0.10	940,000	1,400,000,000
0.05	1,400,000	1,800,000,000
mean	**310,000**	**390,000,000**
Probability of mean	0.29	0.28
Probability of zero	0.31	0.31

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Mo rock

The tract ID is W139

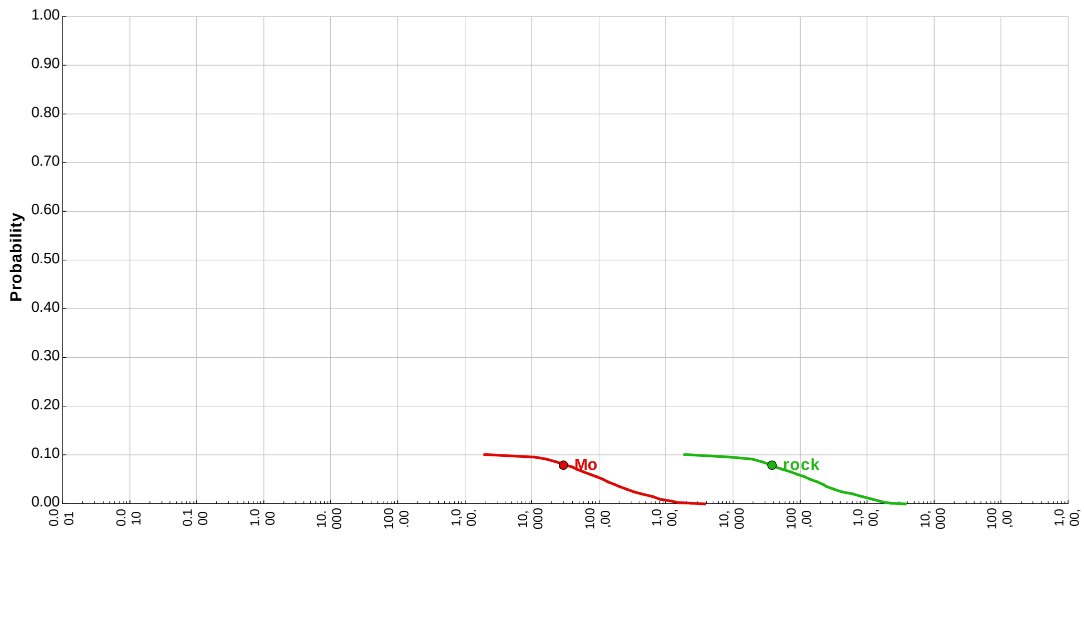
The Mark3 Index is 6: **Porphyry Mo, Low-F**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

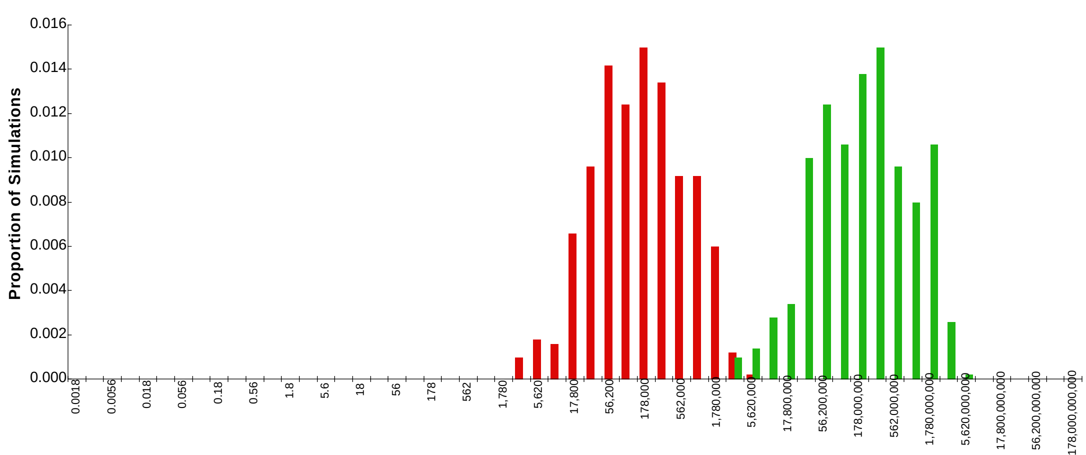
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Mo	rock
0.95	0	0
0.90	0	0
0.50	0	0
0.10	3,800	3,900,000
0.05	120,000	140,000,000
mean	**29,000**	**37,000,000**
Probability of mean	0.08	0.08
Probability of zero	0.90	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Mo rock

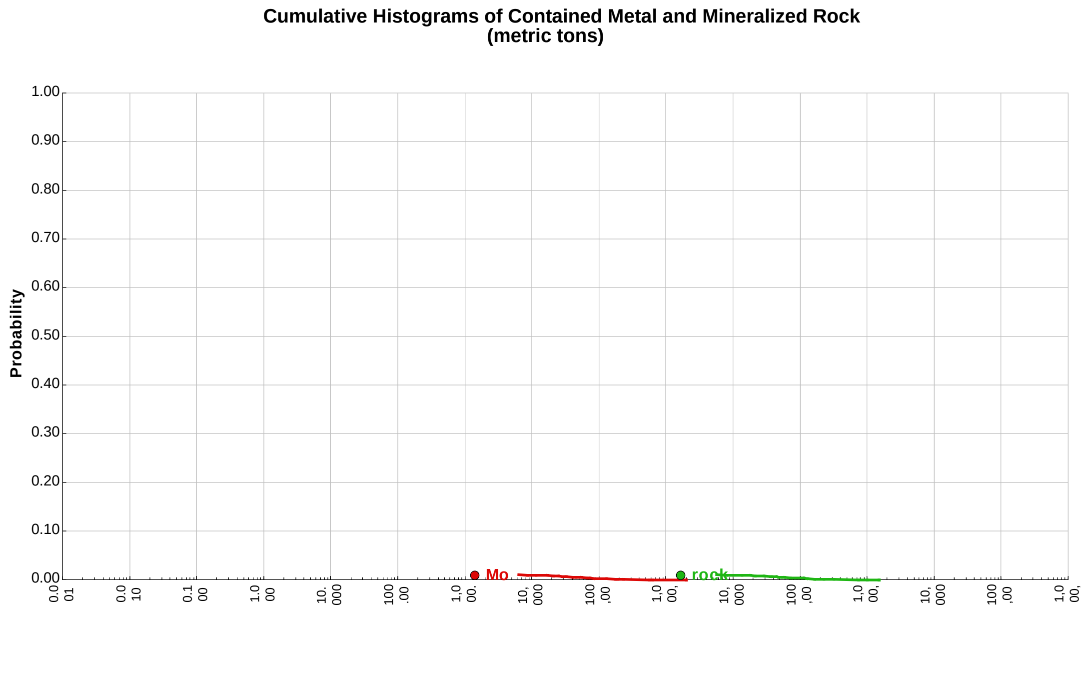
The tract ID is W140

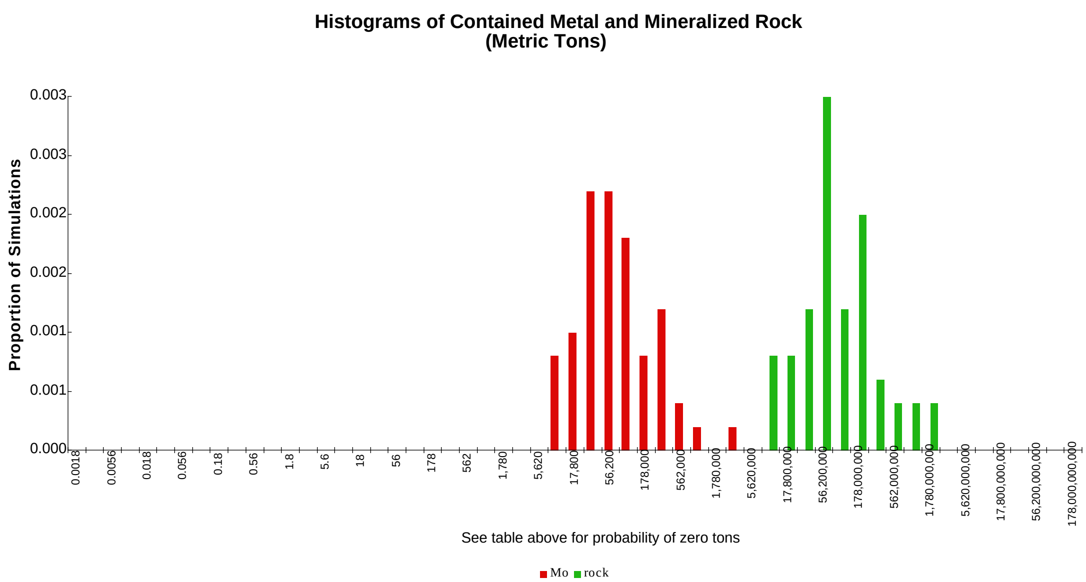
The Mark3 Index is 6: **Porphyry Mo, Low-F**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Mo	rock
0.95	0	0
0.90	0	0
0.50	0	0
0.10	0	0
0.05	0	0
mean	**1,400**	**1,600,000**
Probability of mean	0.01	0.01
Probability of zero	0.99	0.99





The tract ID is W142

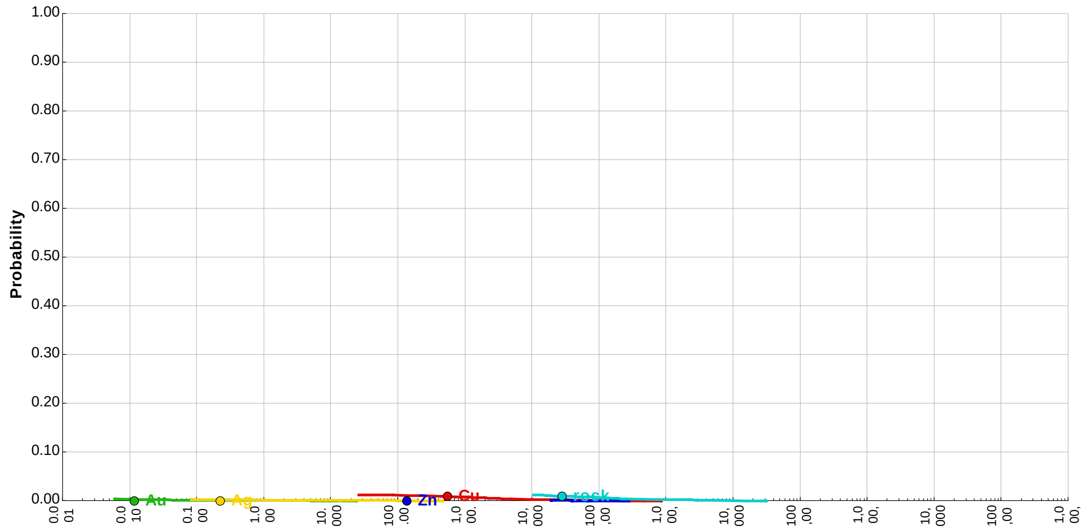
The Mark3 Index is 30: **Massive sulfide, Besshi**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

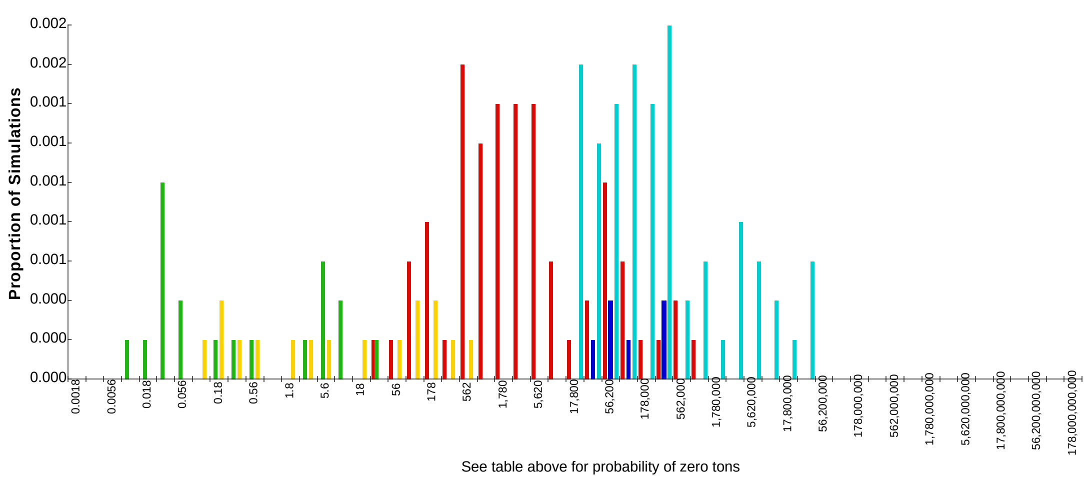
quantile	Cu	Au	Zn	Ag	rock
0.95	0	0	0	0	0
0.90	0	0	0	0	0
0.50	0	0	0	0	0
0.10	0	0	0	0	0
0.05	0	0	0	0	0
mean	**540**	**0**	**130**	**0**	**28,000**
Probability of mean	0.01	0.00	0.00	0.00	0.01
Probability of zero	0.99	1.00	1.00	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



The tract ID is W143

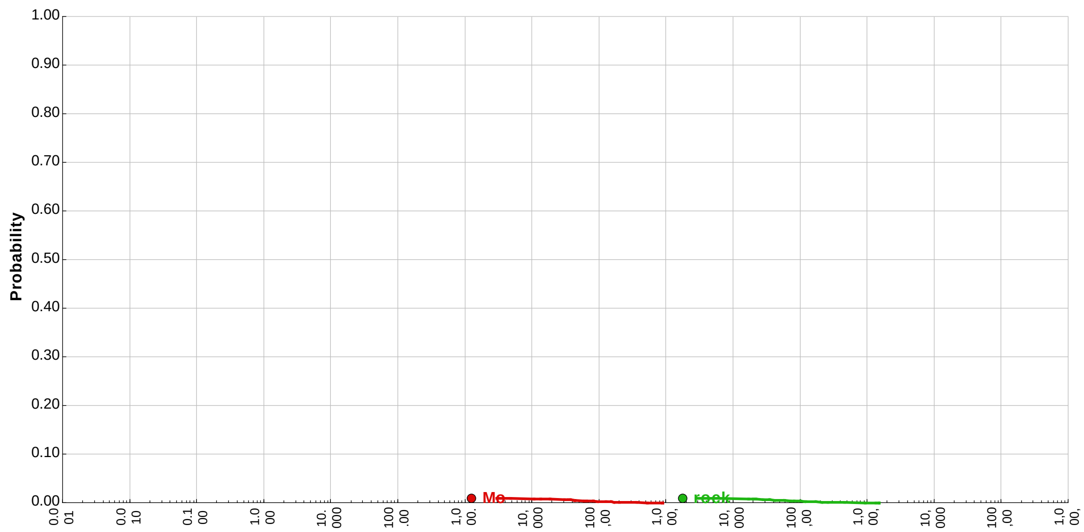
The Mark3 Index is 6: **Porphyry Mo, Low-F**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

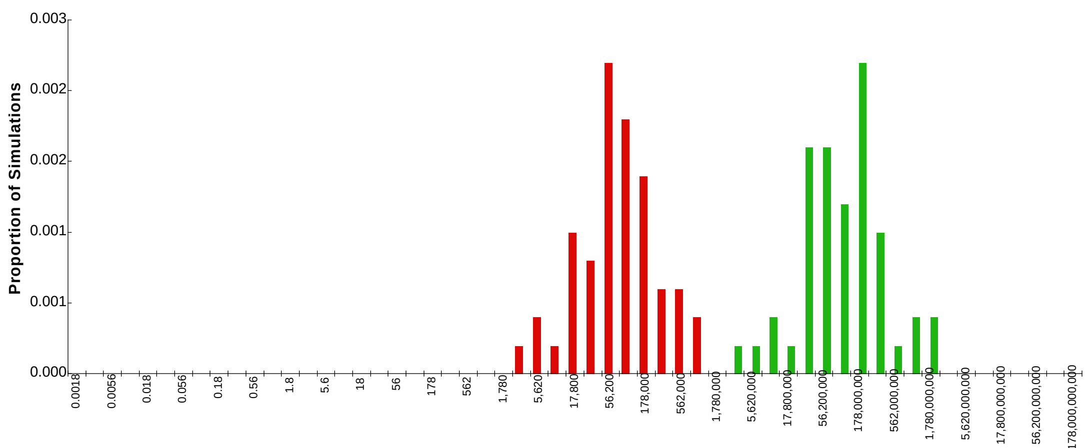
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Mo	rock
0.95	0	0
0.90	0	0
0.50	0	0
0.10	0	0
0.05	0	0
mean	**1,300**	**1,700,000**
Probability of mean	0.01	0.01
Probability of zero	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Mo ■ rock

The tract ID is X3 (ICB only)

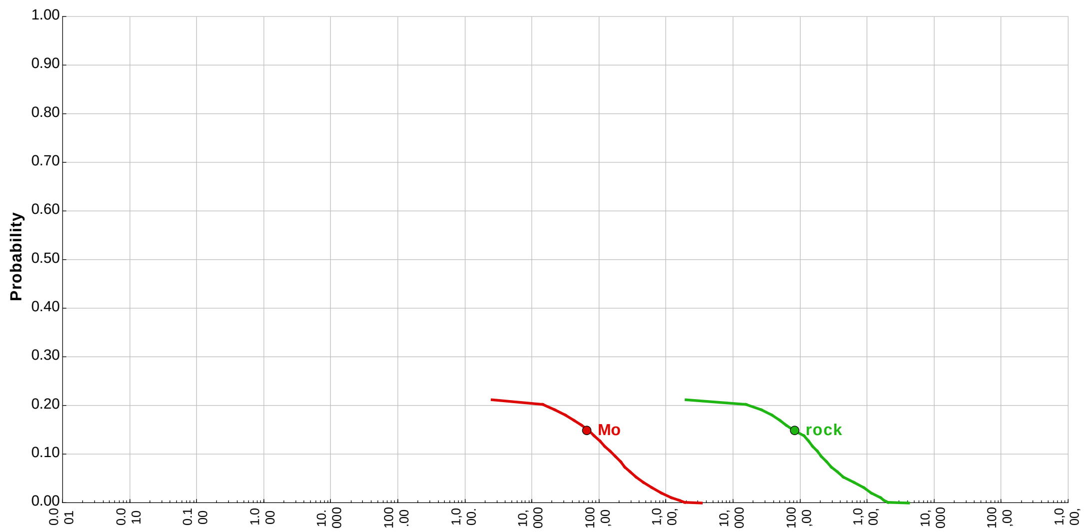
The Mark3 Index is 6: **Porphyry Mo, Low-F**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 2 or more deposits.
There is a 5% or greater chance of 3 or more deposits.
There is a 1% or greater chance of 5 or more deposits.

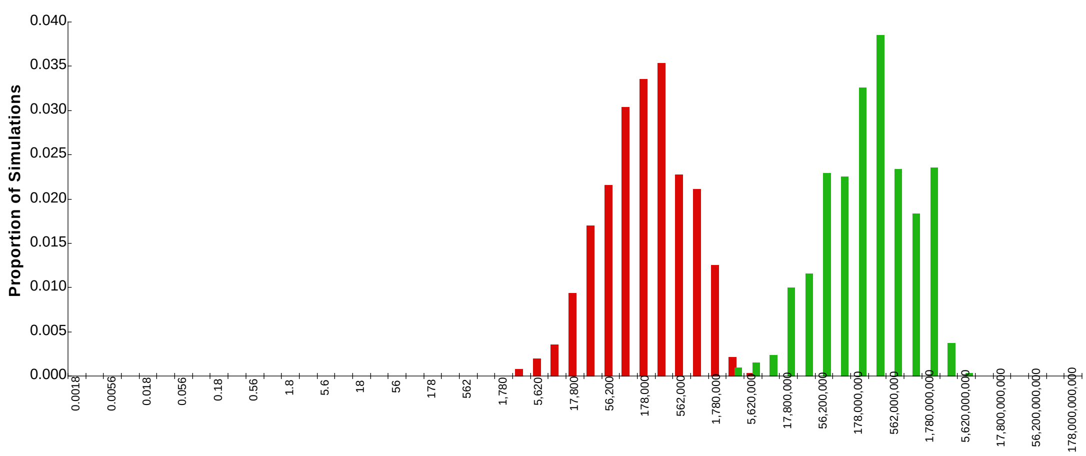
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Mo	rock
0.95	0	0
0.90	0	0
0.50	0	0
0.10	160,000	200,000,000
0.05	390,000	480,000,000
mean	**65,000**	**82,000,000**
Probability of mean	0.15	0.15
Probability of zero	0.79	0.79

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Mo ■ rock

The tract ID is X4 (ICB only)

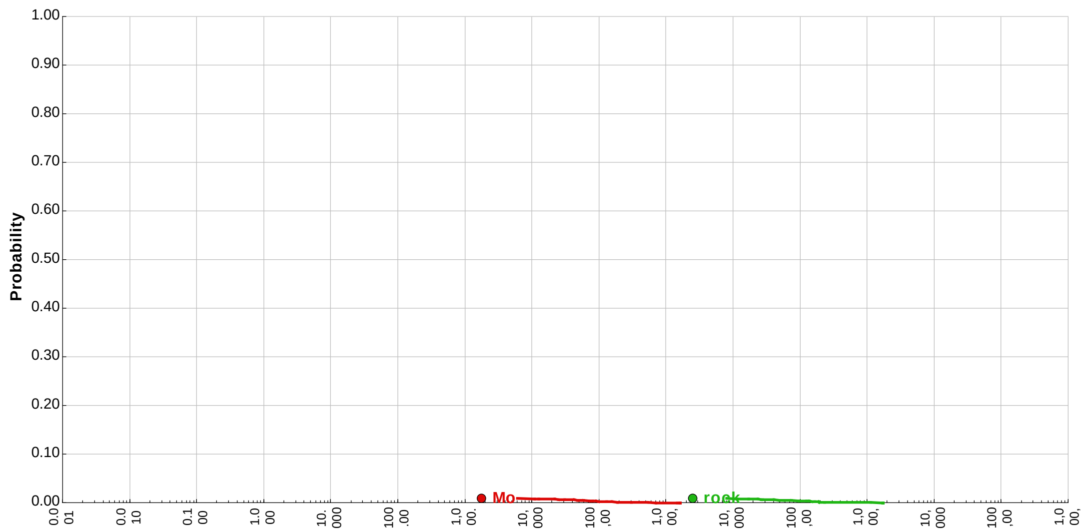
The Mark3 Index is 6: **Porphyry Mo, Low-F**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

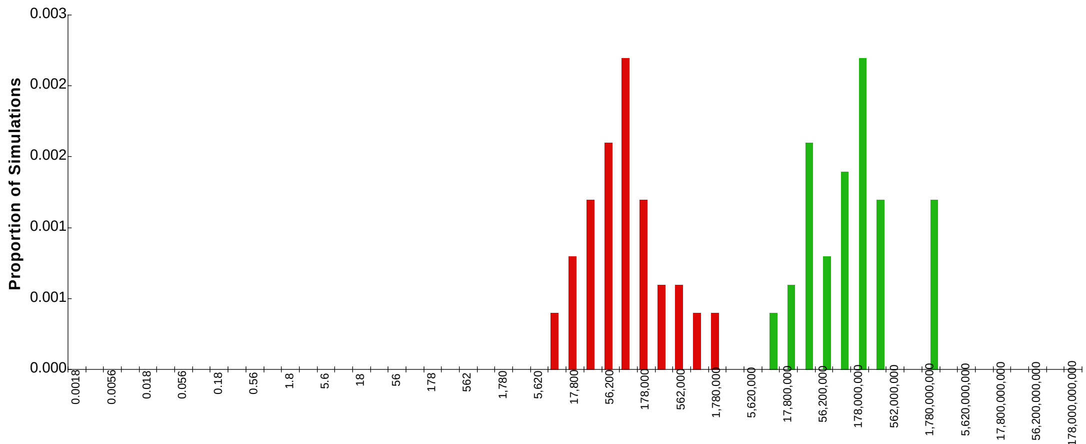
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Mo	rock
0.95	0	0
0.90	0	0
0.50	0	0
0.10	0	0
0.05	0	0
mean	**1,700**	**2,500,000**
Probability of mean	0.01	0.01
Probability of zero	0.99	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Mo ■ rock

The tract ID is X6 (ICB only)

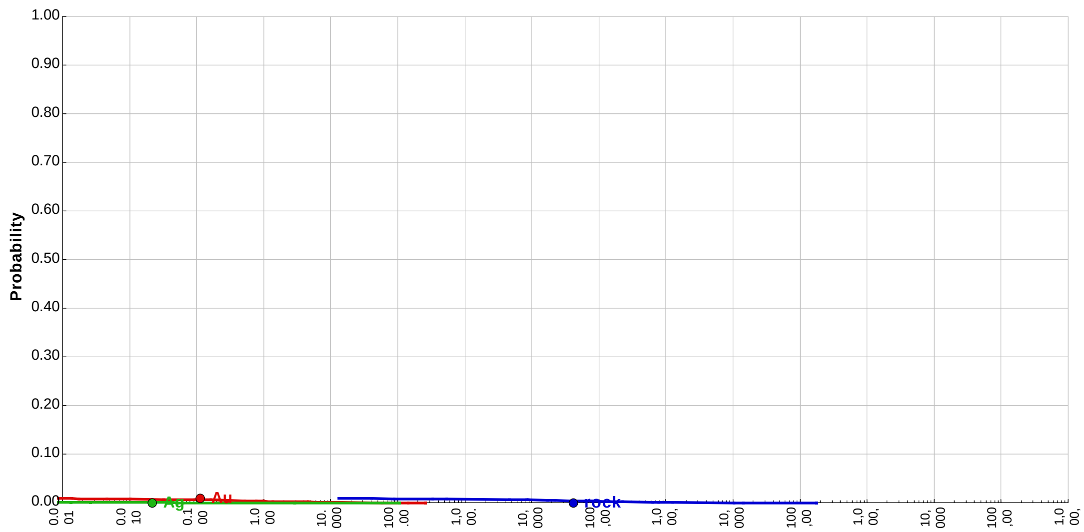
The Mark3 Index is 27: **Low sulfide Au-quartz vein**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 0 or more deposits.
There is a 5% or greater chance of 0 or more deposits.
There is a 1% or greater chance of 1 or more deposits.

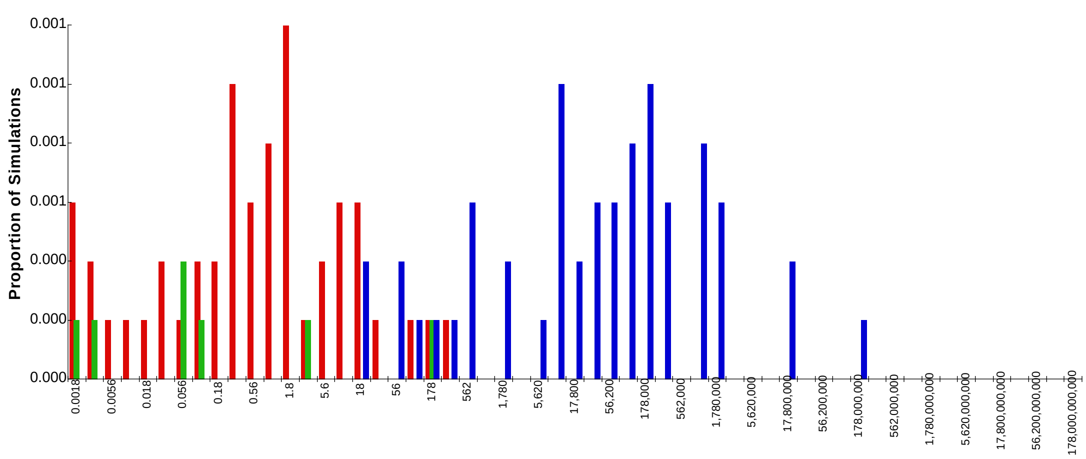
Estimated amounts of contained metal and mineralized rock (metric tons)

quantile	Au	Ag	rock
0.95	0	0	0
0.90	0	0	0
0.50	0	0	0
0.10	0	0	0
0.05	0	0	0
mean	**0**	**0**	**41,000**
Probability of mean	0.01	0.00	0.00
Probability of zero	0.99	1.00	0.99

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

■ Au ■ Ag ■ rock

The tract ID is X14 (ICB only)

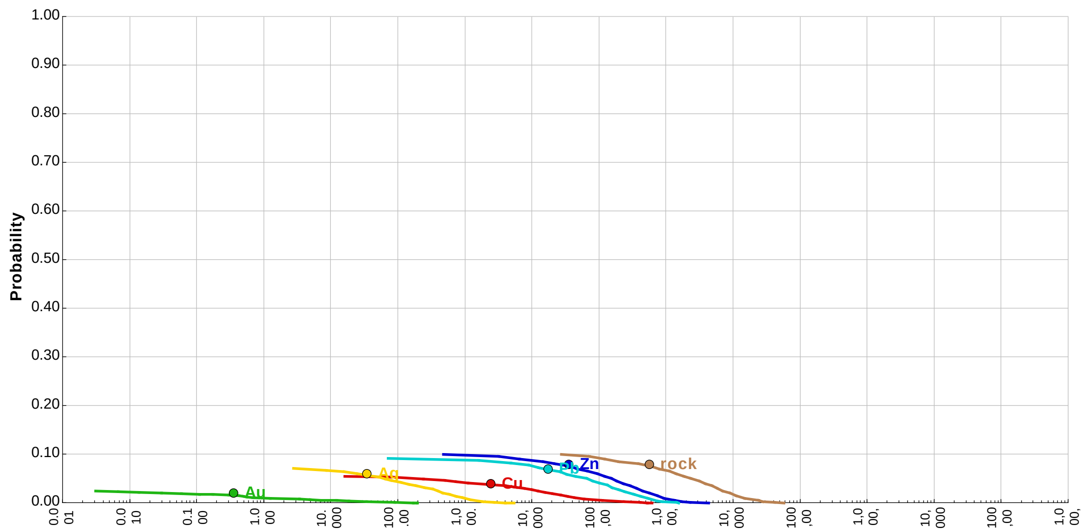
The Mark3 Index is 22: **Skarn Zn-Pb**

There is a 90% or greater chance of 0 or more deposits.
There is a 50% or greater chance of 0 or more deposits.
There is a 10% or greater chance of 1 or more deposits.
There is a 5% or greater chance of 2 or more deposits.
There is a 1% or greater chance of 3 or more deposits.

Estimated amounts of contained metal and mineralized rock (metric tons)

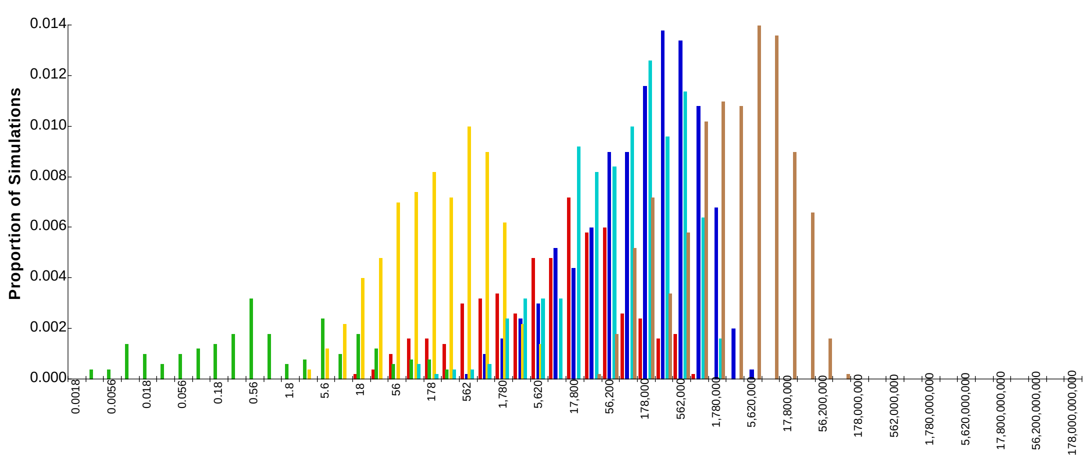
quantile	Cu	Au	Zn	Ag	Pb	rock
0.95	0	0	0	0	0	0
0.90	0	0	0	0	0	0
0.50	0	0	0	0	0	0
0.10	0	0	860	0	0	44,000
0.05	240	0	150,000	65	67,000	2,300,000
mean	**2,400**	**0**	**35,000**	**34**	**17,000**	**560,000**
Probability of mean	0.04	0.02	0.08	0.06	0.07	0.08
Probability of zero	0.94	0.98	0.90	0.93	0.91	0.90

Cumulative Histograms of Contained Metal and Mineralized Rock (metric tons)



Filled circles display mean amounts

Histograms of Contained Metal and Mineralized Rock (Metric Tons)



See table above for probability of zero tons

Cu Au Zn Ag Pb rock

Appendix B

Appendix B presents a two tables of summary information for all the permissive tracts discussed in this report. Appendix B1 presents a table of summary information for all the permissive tracts discussed in this report. Appendix B2 presents the results of the Mark3 numerical simulations of the the estimated mean metal contents of and the estimated number of undiscovered deposits for each whole or partial tract that lies within the ICBEMP study area boundary.
An explanation of the column headings of the tables follows:

Mineral Deposit Type --- Descriptive name for the mineral deposit type; deposit types are listed in the order in which they are discussed in the text.

Permissive Tract ID --- Letter-number combination that identifies a particular tract that encompasses an area in which there exists a non-negligible possibility of the occurrence of undiscovered mineral deposits of the specific type indicated in the first column; areal restriction of the undiscovered deposit estimate is indicated in parentheses after the tract ID ["(ICB only)" indicates estimate is for that part of the tract that falls within the ICBEMP study area; "(OR-WA only)" indicates estimate is for that part of the tract that lies within Oregon and Washington]

Digital Coverage Name --- Name of ARC/INFO polygon coverage export file which illustrates the permissive tracts and favorable areas for this deposit type (see Appendix D for information on how to obtain these digital coverages).

Deposit Model --- Number corresponding to the deposit model for this mineral deposit type in US Geological Survey Bulletin 1693 (see reference under Cox and Singer, 1986); if the deposit model refers to a later publication, that is indicated ("Bul. 2004" refers to US Geological Survey Bulletin 2004; see reference under Bliss, 1992; "OFR-94-250" refers to US Geological Survey Open-File Report 94-250 (see reference under Klein and Day, 1994); "NA" indicates there is no published deposit model.

Mark3 Index --- Identification number of a data file giving the metallic grades (e.g. in grams per metric tonne) and tonnages of a representative suite of mineral deposits of a specific type. In the Mark3 numerical simulation, estimates of grades and tonnages of undiscovered deposits are randomly selected from this data file with probabilities proportional to its frequency in the data file.

Deposit Age --- Age of mineralization of this deposit type either from known deposits within the tract and / or from age of igneous, sedimentary, or structural events with which deposits are inferred to be associated.

State --- State(s) in which the permissive tract occurs; if undiscovered deposit estimate is for part of the tract, only the states of that part of the tract are listed.

90 50 10 5 1 --- Estimates of the numbers of undiscovered deposits at 90% 50%, 10%, 5%, and 1% confidence intervals, made by expert teams at the US Geological Survey as described in text. The estimates can be read as follows: There is a 90% chance of *X* or more deposits with a grade and tonnage distribution similar to that in a given grade and tonnage model, and similarly at 50%, 10%, 5%, and 1%.

Mean no. of deposits --- The mean number of undiscovered deposits given by the Mark3 simulation from the deposit estimates at the five confidence intervals.

p(0) --- Probability of zero deposits in the permissive tract ("0.99" means there is a 99% chance that no undiscovered deposits of this type occur within the permissive tract). Specification of this probability influences the outcome of the Mark3 simulation of the contained metal and mineralized rock in the undiscovered deposits.

Area in ICBEMP --- Relationship of the area of a permissive tract to the ICBEMP study area boundary: 1 = permissive tract is entirely within the ICBEMP study area; 2 = tract is partially within the ICBEMP study area, and the estimate is made for the entire tract; 3 = tract is partially within the ICBEMP study area, but estimate is made only for that part of the tract that is within the ICBEMP study area; 4 = tract is entirely outside the ICBEMP study area.

Text page number --- Page number of the tract description in the body of the text.

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Alkaline Au-Ag-Te vein	**C01**	mralkau	22b	80	Eocene	**MT**	1	6	11	12	20	**6.2**		**4**	21
Alkaline Au-Ag-Te vein	**W100**	mralkau	22b	80	Cretaceous	**WA**	0	0	1	2	4	**0.1**	0.90	**1**	22
Massive sulfide, Besshi type	**PC19 (OR-WA only)**	mrbescu	24b	30	Mesozoic	**OR WA**	0	0	0	0	1	**0.01**	0.99	**4**	28
Massive sulfide, Besshi type	**W47 (ICB only)**	mrbescu	24b	30	Paleozoic	**NV**	0	0	1	2	3	**0.1**	0.90	**3**	28
Massive sulfide, Besshi type	**W142**	mrbescu	24b	30	Mesozoic	**WA**	0	0	0	0	1	**0.01**	0.99	**1**	29
Blackbird Co-Cu	**X7**	mrbirdco	24d	NA	Proterozoic	**ID MT**	No estimate made							**2**	35
Bushveld Cr	**X9**	mrbushcr	2a	NA	Proterozoic	**MT**	No estimate made							**4**	42
Sediment-hosted Au, Carlin-type	**C31 (ICB only)**	mrcarbau	26a	17	Phanerozoic	**UT ID**	0	0	1	1	2	**0.1**	0.90	**3**	51
Sediment-hosted Au, Carlin-type	**W06**	mrcarbau	26a	17	Phanerozoic	**WA**	0	0	0	0	1	**0.01**	0.99	**1**	51
Sediment-hosted Au, Carlin-type	**W27 (ICB only)**	mrcarbau	26a	17	Phanerozoic	**NV ID**	1	2	3	4	6	**2.1**		**3**	52
Sediment-hosted Au, Carlin-type	**W127**	mrcarbau	26a	17	Phanerozoic	**ID**	0	0	0	0	1	**0.01**	0.99	**1**	53

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Coeur d'Alene Pb-Zn-Ag veins	**X1**	mrcdaag	NA	NA	Mesozoic	**ID MT**	No estimate made							**1**	60
Epithermal vein, Comstock type	**C13**	mrcomau	25C + 25D	25	Tertiary	**MT**	1	3	5	6	9	**3.1**		**2**	67
Epithermal vein, Comstock type	**C13 (ICB only)**	mrcomau	25C + 25D	25	Tertiary	**MT**	0	2	2	3	5	**1.5**		**3**	67
Epithermal vein, Comstock type	**C30 (ICB only)**	mrcomau	25C + 25D	25	Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	68
Epithermal vein, Comstock type	**C102**	mrcomau	25c	16	Tertiary	**WY**	0	0	1	4	5	**0.2**	0.90	**2**	68
Epithermal vein, Comstock type	**C102 (ICB only)**	mrcomau	25c	16	Tertiary	**WY**	0	0	0	1	4	**0.1**	0.95	**3**	68
Epithermal vein, Comstock type	**PC03**	mrcomau	25C + 25D	NA	Tertiary	**CA**	No estimate made							**4**	69
Epithermal vein, Comstock type	**PC04**	mrcomau	25C + 25D	NA	Tertiary	**CA NV**	No estimate made							**4**	70
Epithermal vein, Comstock type	**PC101**	mrcomau	25c	16	Tertiary	**WA**	1	3	4	4	4	**2.7**		**1**	70
Epithermal vein, Comstock type	**PW100**	mrcomau	25c	16	Tertiary	**OR**	0	1	3	5	5	**1.4**		**1**	71
Epithermal vein, Comstock type	**W02**	mrcomau	25c	16	Tertiary	**WA**	1	2	4	5	8	**2.4**		**1**	72

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Epithermal vein, Comstock type	**W12**	mrcomau	25c	NA	Tertiary	**ID**	No estimate made							**1**	73
Epithermal vein, Comstock type	**W17 (ICB only)**	mrcomau	25c	16	Tertiary	**NV ID**	0	1	2	3	4	**1.1**		**3**	74
Epithermal vein, Comstock type	**W101**	mrcomau	25c	16	Tertiary	**OR**	2	4	7	11	16	**4.7**		**1**	75
Epithermal vein, Comstock type	**W102**	mrcomau	25c	16	Tertiary	**OR**	2	3	4	6	8	**3.1**		**1**	76
Epithermal vein, Comstock type	**W103**	mrcomau	25c	NA	Tertiary	**ID**	No estimate made							**1**	77
Epithermal vein, Comstock type	**W104**	mrcomau	25c	NA	Tertiary	**ID**	No estimate made							**1**	78
Epithermal vein, Comstock type	**W105**	mrcomau	25c	NA	Tertiary	**ID**	No estimate made							**1**	78
Epithermal vein, Comstock type	**W106**	mrcomau	25c	NA	Tertiary	**ID**	No estimate made							**1**	79
Massive sulfide, Cyprus type	**PC15a (OR only)**	mrcypcu	24a	11	Jurassic	**OR**	0	1	2	2	3	**1.0**		**4**	85
Massive sulfide, Cyprus type	**W19 (ICB only)**	mrcypcu	24a	11	Paleozoic	**NV**	0	0	1	2	3	**0.1**	0.90	**3**	85
Massive sulfide, Cyprus type	**W132**	mrcypcu	24a	11	Paleozoic Mesozoic	**OR ID**	0	0	0	0	1	**0.01**	0.99	**1**	86

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Distal dissem-inated Ag-Au	**W20 (ICB only)**	mrdistau	19c Bul. 2004	18	Mesozoic Tertiary	**NV ID OR**	0	0	2	4	6	**0.4**	0.80	**3**	92
Distal dissem-inated Ag-Au	**W26a (ICB only)**	mrdistau	19c Bul. 2004	18	Mesozoic Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	93
Homestake stratiform Au	**C04**	mrhomeau	OFR 94-250	100	Archean	**MT WY ID**	0	2	4	5	6	**2.1**		**4**	98
Hot-spring Au-Ag	**C05**	mrhsprau	25a	45	Tertiary	**MT**	1	3	5	6	9	**3.1**		**2**	104
Hot-spring Au-Ag	**C05 (ICB only)**	mrhsprau	25a	45	Tertiary	**MT**	0	2	2	3	5	**1.5**		**3**	104
Hot-spring Au-Ag	**C19**	mrhsprau	25a	45	Tertiary	**WY**	0	2	3	4	5	**1.8**		**2**	105
Hot-spring Au-Ag	**C19 (ICB only)**	mrhsprau	25a	45	Tertiary	**WY**	0	1	1	3	4	**0.9**		**3**	105
Hot-spring Au-Ag	**C24 (ICB only)**	mrhsprau	25a	45	Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	105
Hot-spring Au-Ag	**PC10**	mrhsprau	25a	NA	Tertiary	**CA**	No estimate made							**4**	106
Hot-spring Au-Ag	**PW101**	mrhsprau	25a	45	Tertiary	**OR WA**	0	1	3	5	7	**1.5**		**2**	107
Hot-spring Au-Ag	**PW101 (ICB only)**	mrhsprau	25a	45	Tertiary	**OR WA**	0	1	2	3	3	**1.1**		**3**	107

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Hot-spring Au-Ag	**W21 (ICB only)**	mrhsprau	25a	45	Tertiary	**NV ID**	0	1	3	3	4	**1.3**		**3**	108
Hot-spring Au-Ag	**W107**	mrhsprau	25a	45	Tertiary	**OR**	2	6	10	16	30	**6.8**		**1**	110
Hot-spring Au-Ag	**W108**	mrhsprau	25a	45	Tertiary	**OR**	6	12	18	24	30	**12.3**		**1**	110
Hot-spring Au-Ag	**W109**	mrhsprau	25a	45	Tertiary	**ID**	0	1	3	5	5	**1.5**		**1**	111
Hot-spring Au-Ag	**W110**	mrhsprau	25a	NA	Tertiary	**ID**	No estimate made							**1**	112
Hot-spring Au-Ag	**W111**	mrhsprau	25a	NA	Tertiary	**ID**	No estimate made							**1**	113
Hot-spring Au-Ag	**W112**	mrhsprau	25a	45	Tertiary	**ID**	0	0	2	3	4	**0.4**	0.80	**1**	113
Hot-spring Au-Ag	**W129**	mrhsprau	25a	45	Tertiary	**ID**	0	2	5	7	8	**2.5**		**1**	114
Hot-spring Au-Ag	**W130**	mrhsprau	25a	NA	Tertiary	**WA**	No estimate made							**1**	115
Massive sulfide, kuroko type	**C06**	mrkurcu	28a	93	Proterozoic	**MT**	0	0	0	0	1	**0.01**	0.99	**4**	121
Massive sulfide, kuroko-type	**PC14**	mrkurcu	28a	NA	Devonian	**CA**	No estimate made							**4**	121

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Massive sulfide, Sierran kuroko	**PC14a**	mrkurcu	28a.1	NA	Triassic	**CA**	No estimate made							**4**	122
Massive sulfide, Sierran kuroko	**PC15**	mrkurcu	28a.1	NA	Jurassic	**CA OR**	No estimate made							**4**	122
Massive sulfide, Sierran kuroko	**PC16**	mrkurcu	28a.1	44	Mesozoic	**WA**	0	0	1	2	2	**0.1**	0.90	**2**	123
Massive sulfide, Sierran kuroko	**PC16 (ICB only)**	mrkurcu	28a.1	44	Mesozoic	**WA**	0	0	1	2	2	**0.1**	0.90	**3**	123
Massive sulfide, Sierran kuroko	**PC33**	mrkurcu	28a.1	NA	Jurassic	**CA**	No estimate made							**4**	123
Massive sulfide, Sierran kuroko	**W28 (ICB only)**	mrkurcu	28a.1	44	Mesozoic	**OR**	0	0	0	0	1	**0.01**	0.99	**3**	124
Massive sulfide, kuroko type	**W46**	mrkurcu	28a	93	Permian	**OR ID WA**	1	3	6	6	6	**3.3**		**1**	124
Massive sulfide, kuroko type	**W46 ID only**	mrkurcu	28a	93	Permian	**ID**	0	2	2	4	8	**1.7**		**1**	124
Massive sulfide, kuroko type	**W46 OR-WA only**	mrkurcu	28a	93	Permian	**OR WA**	0	2	2	4	6	**1.6**		**1**	124
Massive sulfide, kuroko type	**W113**	mrkurcu	28a	93	Permian Triassic	**WA**	0	0	0	0	1	**0.01**	0.99	**1**	125
Low-sulfide Au-quartz vein	**PC20 (OR only)**	mrlsaqau	36a	27	Mesozoic	**OR**	0	0	0	0	1	**0.01**	0.99	**4**	131

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Low-sulfide Au-quartz vein	**PC21 (OR only)**	mrlsaqau	36a	27	Mesozoic	**OR**	0	0	0	0	1	**0.01**	0.99	**4**	131
Low-sulfide Au-quartz vein	**PC22 (ICB only)**	mrlsaqau	36a	27	Mesozoic	**WA**	0	0	0	0	1	**0.01**	0.99	**3**	132
Low-sulfide Au-quartz vein	**W114**	mrlsaqau	36a	27	Mesozoic	**WA**	0	0	0	0	1	**0.01**	0.99	**1**	133
Low-sulfide Au-quartz vein	**W115**	mrlsaqau	36a	27	Mesozoic	**OR**	0	0	1	3	8	**0.2**	0.90	**1**	133
Low-sulfide Au-quartz vein	**W135**	mrlsaqau	36a	27	Mesozoic	**ID OR WA**	0	0	2	4	7	**0.4**	0.80	**1**	134
Low-sulfide Au-quartz vein	**X6 (ICB only)**	mrlsaqau	36a	27	Mesozoic	**OR**	0	0	0	0	1	**0.01**	0.99	**3**	135
Merensky Reef PGE	**X8**	mrmerepg	2b	NA	Proterozoic	**MT**	No estimate made							**4**	141
Mississippi Valley Pb-Zn, minor	**W08**	mrmvtzn	32a + 32b	94	Paleozoic	**WA**	0	1	1	2	2	**0.8**		**1**	147
Overlook-type Au	**X12**	mroverau	NA	NA	Mesozoic Tertiary	**WA**	No estimate made							**1**	152
Polymetallic Au-Ag, vein & disseminated	**X10**	mrpmvau	NA	NA	Mesozoic	**OR ID**	No estimate made							**1**	159
Polymetallic Au-Ag, vein & disseminated	**X11**	mrpmvau	NA	NA	Mesozoic	**ID MT**	No estimate made							**2**	160

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Polymetallic replacement	**C07**	mrpolypb	19a	47	Mesozoic Tertiary	**MT WY**	1	4	6	8	12	**3.9**		**2**	167
Polymetallic replacement	**C07 (ICB only)**	mrpolypb	19a	47	Mesozoic Tertiary	**MT**	0	1	2	4	7	**1.2**		**3**	167
Polymetallic replacement	**C26 (ICB only)**	mrpolypb	19a	47	Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	168
Polymetallic replacement	**W22 (ICB only)**	mrpolypb	19a	47	Mesozoic Tertiary	**NV OR ID**	0	0	1	2	3	**0.1**	0.90	**3**	169
Polymetallic replacement	**W120**	mrpolypb	19a	47	Mesozoic Tertiary	**ID WA**	0	0	0	0	1	**0.01**	0.99	**1**	170
Porphyry Cu, No. Am. type	**C09**	mrporcu	17	81	Eocene	**MT WY**	1	4	6	7	9	**3.8**		**4**	177
Porphyry Cu, No. Am. type	**C27 (ICB only)**	mrporcu	17	81	mid-Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	178
Porphyry Cu, No. Am. type	**C100**	mrporcu	17	81	Cretaceous Eocene	**MT**	0	1	3	6	7	**1.6**		**2**	179
Porphyry Cu, No. Am. type	**C100 (ICB only)**	mrporcu	17	81	Cretaceous Eocene	**MT**	0	0	2	4	5	**0.8**		**3**	179
Porphyry Cu, BC-AK type	**PC26**	mrporcu	17.1	89	Mesozoic Tertiary	**WA**	3	6	15	15	15	**7.6**		**2**	180
Porphyry Cu, BC-AK type	**PC26 (ICB only)**	mrporcu	17.1	89	Mesozoic Tertiary	**WA**	1	2	8	8	8	**3.5**		**3**	180

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Porphyry Cu, BC-AK type	**PC27**	mrporcu	17.1	89	Tertiary	**OR WA**	1	3	10	10	10	**4.4**		**2**	181
Porphyry Cu, BC-AK type	**PC27 (ICB only)**	mrporcu	17.1	89	Tertiary	**OR WA**	0	1	2	2	2	**1.0**		**3**	181
Porphyry Cu, No. Am. type	**PC30**	mrporcu	17	NA	Mesozoic Tertiary	**CA**	No estimate made							**4**	182
Porphyry Cu, No. Am. type	**PC34**	mrporcu	17	NA	Mesozoic	**CA OR**	No estimate made							**4**	183
Porphyry Cu, BC-AK type	**W11**	mrporcu	17.1	89	Mesozoic Tertiary	**OR ID WA**	0	0	1	2	5	**0.2**	0.90	**1**	184
Porphyry Cu, BC-AK type	**W11 [OR-WA only]**	mrporcu	17.1	89	Mesozoic Tertiary	**OR WA**	0	0	1	1	3	**0.1**	0.90	**1**	184
Porphyry Cu, BC-AK type	**W11 (ID only)**	mrporcu	17.1	89	Mesozoic Tertiary	**ID**	0	0	0	1	2	**0.1**	0.95	**1**	184
Porphyry Cu, No. Am. type	**W25 (ICB only)**	mrporcu	17	81	Mesozoic Tertiary	**NV OR ID**	0	0	2	3	4	**0.4**	0.80	**3**	185
Porphyry Cu, BC-AK type	**W118**	mrporcu	17.1	89	Mesozoic	**WA**	0	0	2	3	4	**0.4**	0.80	**1**	186
Porphyry Cu, No. Am. type	**W119**	mrporcu	17	81	Mesozoic	**ID WA**	0	0	0	0	1	**0.01**	0.99	**1**	186
Porphyry Cu, No. Am. type	**W119a**	mrporcu	17	81	Mesozoic	**ID**	0	0	0	0	1	**0.01**	0.99	**1**	187

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Porphyry Mo, low fluorine	**C105**	mrpormo	21b	6	Mesozoic Tertiary	**MT WY**	0	0	0	0	1	**0.01**	0.99	**4**	193
Porphyry Mo, low fluorine	**PC102**	mrpormo	21b	6	Mesozoic Tertiary	**WA**	0	0	0	0	1	**0.01**	0.99	**2**	193
Porphyry Mo, low fluorine	**PC103**	mrpormo	21b	6	Mesozoic Tertiary	**OR WA**	0	0	0	0	1	**0.01**	0.99	**2**	194
Porphyry Mo, low fluorine	**W138**	mrpormo	21b	6	Mesozoic Tertiary	**ID MT**	0	2	7	8	10	**3.0**		**2**	194
Porphyry Mo, low fluorine	**W138 (ICB only)**	mrpormo	21b	6	Mesozoic Tertiary	**ID MT**	0	1	4	6	8	**1.8**		**3**	194
Porphyry Mo, low fluorine	**W139**	mrpormo	21b	6	Mesozoic Tertiary	**WA ID**	0	0	1	3	5	**0.2**	0.90	**1**	195
Porphyry Mo, low fluorine	**W140**	mrpormo	21b	6	Mesozoic Tertiary	**OR ID WA**	0	0	0	0	1	**0.01**	0.99	**1**	196
Porphyry Mo, low fluorine	**W143**	mrpormo	21b	6	Mesozoic Tertiary	**WA ID MT**	0	0	0	0	1	**0.01**	0.99	**1**	196
Porphyry Mo, low fluorine	**X3 (ICB only)**	mrpormo	21b	6	Mesozoic Tertiary	**NV OR ID**	0	0	2	3	5	**0.4**	0.80	**3**	197
Porphyry Mo, low fluorine	**X4 (ICB only)**	mrpormo	21b	6	Mesozoic Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	198
Porphyry Mo, low fluorine	**X5**	mrpormo	21b	NA	Mesozoic Tertiary	**CA OR**	No estimate made							**4**	198

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Sediment-hosted Cu, Revett type	**W13**	mrrevcu	30B.3	64	Proterozoic	**MT ID WA**	9	10	15	20	30	**11.3**		**2**	205
Sediment-hosted Cu, Revett type	**W13 (ICB only)**	mrrevcu	30B.3	64	Proterozoic	**MT ID WA**	9	10	15	20	30	**11.3**		**3**	205
Sedimentary exhalative Zn-Pb	**C14**	mrsedxzn	31a	13	Late Proterozoic	**MT ID WA**	0	2	4	6	8	**2.2**		**2**	212
Sedimentary exhalative Zn-Pb	**C14 (ICB only)**	mrsedxzn	31a	13	Late Proterozoic	**MT ID WA**	0	1	3	4	7	**1.4**		**3**	212
Sedimentary exhalative Zn-Pb	**W07**	mrsedxzn	31a	13	Paleozoic	**WA**	0	0	1	2	4	**0.1**	0.90	**1**	213
Sedimentary exhalative Zn-Pb	**W16**	mrsedxzn	31a	13	Paleozoic	**ID MT**	0	0	1	2	3	**0.1**	0.90	**1**	214
Sedimentary exhalative Zn-Pb	**W51 (ICB only)**	mrsedxzn	31a	13	Paleozoic	**NV**	0	0	0	0	1	**0.01**	0.99	**3**	215
Skarn Au	**C02**	mrskrnau	Bull. 1930	82	Mesozoic Tertiary	**MT WY**	5	12	20	28	36	**12.8**		**2**	221
Skarn Au	**C02 (ICB only)**	mrskrnau	Bull. 1930	82	Mesozoic Tertiary	**MT**	1	4	6	9	12	**3.9**		**3**	221
Skarn Au, truncated	**C23 (ICB only)**	mrskrnau	Bull. 1930	105	Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	222
Skarn Au	**PC05**	mrskrnau	Bull. 1930	NA	Mesozoic	**CA OR**	No estimate made							**4**	223

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Skarn Au	**PC07**	mrskrnau	Bull. 1930	NA	Mesozoic Tertiary	**CA**	No estimate made							**4**	223
Skarn Au, truncated	**W18 (ICB only)**	mrskrnau	Bull. 1930	105	Mesozoic Tertiary	**NV OR ID**	0	0	2	4	8	**0.4**	0.80	**3**	224
Skarn Au, truncated	**W128**	mrskrnau	Bull. 1930	105	Mesozoic	**WA**	0	1	3	5	7	**1.5**		**1**	225
Skarn Au, truncated	**W136**	mrskrnau	Bull. 1930	105	Mesozoic	**ID WA**	0	0	0	0	1	**0.01**	0.99	**1**	225
Skarn Au, truncated	**W137**	mrskrnau	Bull. 1930	105	Mesozoic	**ID OR WA**	0	0	0	0	1	**0.01**	0.99	**1**	226
Skarn Zn-Pb	**C15**	mrskrnzn	18c	22	Mesozoic Tertiary	**MT WY**	0	0	2	4	6	**0.4**	0.80	**2**	232
Skarn Zn-Pb	**C15 (ICB only)**	mrskrnzn	18c	22	Mesozoic Tertiary	**MT**	0	0	1	2	3	**0.1**	0.90	**3**	232
Skarn Zn-Pb	**C33 (ICB only)**	mrskrnzn	18c	22	Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	233
Skarn Zn-Pb	**W125**	mrskrnzn	18c	22	Mesozoic Tertiary	**ID WA**	0	0	0	0	1	**0.01**	0.99	**1**	233
Skarn Zn-Pb	**X14 (ICB only)**	mrskrnzn	18c	22	Mesozoic Tertiary	**NV OR ID**	0	0	1	2	3	**0.1**	0.90	**3**	234
Stillwater Ni-Cu	**X2**	mrstilni	1	NA	Proterozoic	**MT**	No estimate made							**4**	240

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Polymetallic veins, porphyry -related	**X15**	mrpopmv	22c	NA	Mesozoic Tertiary	**MT ID WA OR CA NV UT WY**	No estimate made							**2**	246
Sediment-hosted Cu, redbed-type	**C92**	mrredbcu	30B.2	NA	Mesozoic	**ID WY UT**	No estimate made							**2**	250
Sediment-hosted Cu, redbed-type	**W05**	mrredbcu	30B.2	NA	Proterozoic	**MT ID WA**	No estimate made							**2**	254
Sediment-hosted Cu, reduced-facies	**W14**	mrreducu	30B.1	96	Proterozoic	**MT ID WA**	0	0	1	3	5	**0.2**	0.90	**2**	254
Sediment-hosted Cu, reduced-facies	**W14 (ICB only)**	mrreducu	30B.1	96	Proterozoic	**MT ID WA**	0	0	1	3	5	**0.2**	0.90	**3**	254
Epithermal vein, Sado type	**PC100**	mrsadoau	25d	28	Tertiary	**OR WA**	0	2	5	8	8	**2.5**		**2**	257
Epithermal vein, Sado type	**PC100 (ICB only)**	mrsadoau	25d	28	Tertiary	**OR WA**	0	0	0	0	1	**0.01**	0.99	**3**	257
Skarn Cu	**C90 (ICB only)**	mrskrncu	18b	8	Tertiary	**UT ID**	0	0	0	0	1	**0.01**	0.99	**3**	261
Skarn Cu	**W52 (ICB only)**	mrskrncu	18b	8	Mesozoic Tertiary	**NV OR ID**	1	1	2	3	3	**1.3**		**3**	261
Skarn Cu	**W122**	mrskrncu	18b	8	Mesozoic Tertiary	**WA**	0	0	0	0	1	**0.01**	0.99	**1**	262
Skarn Cu	**W123**	mrskrncu	18b	8	Mesozoic Tertiary	**ID OR WA**	0	3	5	9	12	**3.1**		**1**	263

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Mineral Deposit Type	Permissive Tract ID	Digital Coverage Name	Deposit Model	Mark3 Index	Deposit Age	State	90	50	10	5	1	Mean no. of deposits	p(0)	Relation to ICBEMP	Text page number
Skarn Cu	**W123 [ID only]**	mrskrncu	18b	8	Mesozoic Tertiary	**ID**	0	2	3	7	10	**2.1**		**1**	263
Skarn Cu	**W123 [OR-WA only]**	mrskrncu	18b	8	Mesozoic Tertiary	**OR WA**	0	0	3	4	5	**1.0**		**1**	263
Skarn Cu	**W124**	mrskrncu	18b	8	Mesozoic Tertiary	**ID WA**	0	0	0	0	1	**0.01**	0.99	**1**	264
Skarn Cu	**X13**	mrskrncu	18b	NA	Mesozoic	**CA OR**	No estimate made							**4**	264

Relation to ICBEMP: 1= entirely within ICB; 2=partially in ICB, estimate for entire tract; 3=partially in ICB, estimate for ICB portion only; 4=entirely outside ICB

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Alkaline Au-Ag-Te vein	**W100**	WA	14	7.4					2,130,000	0.14
Massive sulfide, Besshi type	**W47 (ICB only)**	NV	0.2	7.4	7,980		2,900		473,000	0.14
Massive sulfide, Besshi type	**W142**	WA	0.01	0.2	539		134		28,100	0.01
Sediment-hosted Au, Carlin-type	**C31 (ICB only)**	UT ID	6.4	0.03					2,900,000	0.11
Sediment-hosted Au, Carlin-type	**W06**	WA	2.2	0.003					631,000	0.01
Sediment-hosted Au, Carlin-type	**W27 (ICB only)**	NV ID	133	1.1					59,800,000	2.05
Sediment-hosted Au, Carlin-type	**W127**	ID	0.5	0.01					318,000	0.01
Epithermal vein, Comstock type	**C13 (ICB only)**	MT	29	1,770	675	2	27		4,940,000	1.53
Epithermal vein, Comstock type	**C30 (ICB only)**	UT ID	0.2	5.6	3	0			18,900	0.01
Epithermal vein, Comstock type	**C102 (ICB only)**	WY	2.0	170					354,000	0.10

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Epithermal vein, Comstock type	**PC101**	WA	64	4,680					11,400,000	2.66
Epithermal vein, Comstock type	**PW100**	OR	36	2,270					5,980,000	1.43
Epithermal vein, Comstock type	**W02**	WA	61	4,310					10,800,000	2.41
Epithermal vein, Comstock type	**W17 (ICB only)**	NV ID	28	1,940					4,840,000	1.10
Epithermal vein, Comstock type	**W101**	OR	116	8,440					20,700,000	4.67
Epithermal vein, Comstock type	**W102**	OR	76	5,300					13,500,000	3.09
Massive sulfide, Cyprus type	**W19 (ICB only)**	NV	0.5	6.9	13,200	66	3,240		660,000	0.14
Massive sulfide, Cyprus type	**W132**	OR ID	0.05	0.4	852	7	286		49,400	0.01
Distal disseminated Ag-Au	**W20 (ICB only)**	NV ID OR	7.7	710					8,650,000	0.39
Distal disseminated Ag-Au	**W26a (ICB only)**	UT ID	0.2	25					288,000	0.01

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Hot-spring Au-Ag	C05 (ICB only)	MT	75	310					52,200,000	1.52
Hot-spring Au-Ag	C19 (ICB only)	WY	41	160					28,700,000	0.88
Hot-spring Au-Ag	C24 (ICB only)	UT ID	0.6	1.0					508,000	0.01
Hot-spring Au-Ag	PW101 (ICB only)	OR WA	51	210					35,500,000	1.06
Hot-spring Au-Ag	W21 (ICB only)	NV ID	63	270					44,200,000	1.32
Hot-spring Au-Ag	W107	OR	324	1,330					234,000,000	6.78
Hot-spring Au-Ag	W108	OR	571	2,350					413,000,000	12.26
Hot-spring Au-Ag	W109	ID	71	290					50,100,000	1.49
Hot-spring Au-Ag	W112	ID	17	71					11,800,000	0.37
Hot-spring Au-Ag	W129	ID	118	520					84,400,000	2.47
Massive sulfide, Sierran kuroko	PC16 (ICB only)	WA	0.2	10	1,290	621	3,310		78,700	0.11

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Massive sulfide, Sierran kuroko	**W28 (ICB only)**	OR	0.01	0.7	140	45	273		7,000	0.01
Massive sulfide, kuroko type	**W46**	OR ID WA	20	840	358,000	161,000	807,000		27,400,000	3.26
Massive sulfide, kuroko type	**W46 ID only**	ID	11	430	195,000	87,800	437,000		14,200,000	1.67
Massive sulfide, kuroko type	**W46 OR-WA only**	OR WA	8.8	430	180,000	78,100	425,000		13,100,000	1.62
Massive sulfide, kuroko type	**W113**	WA	0.04	1.7	1,480	222	1,510		48,800	0.01
Low-sulfide Au-quartz vein	**PC22 (ICB only)**	WA	0.02	0.004					1,800	0.01
Low-sulfide Au-quartz vein	**W114**	WA	0.03	0.002					3,100	0.01
Low-sulfide Au-quartz vein	**W115**	OR	1.9	0.6					441,000	0.20
Low-sulfide Au-quartz vein	**W135**	ID OR WA	2.7	0.3					387,000	0.38
Low-sulfide Au-quartz vein	**X6 (ICB only)**	OR	0.1	0.02					41,300	0.01

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Miss. Valley Pb-Zn, minor	**W08**	WA		60		129,000	519,000		8,390,000	0.75
Polymetallic replacement	**C07 (ICB only)**	MT	5.8	1,510	18,700	423,000	433,000		7,560,000	1.21
Polymetallic replacement	**C26 (ICB only)**	UT ID	0.03	5.4	109	1,510	1,660		35,600	0.01
Polymetallic replacement	**W22 (ICB only)**	NV OR ID	0.7	150	2,110	42,500	42,000		793,000	0.14
Polymetallic replacement	**W120**	ID WA	0.1	10	255	2,720	2,760		79,900	0.01
Porphyry Cu, No. America type	**C27 (ICB only)**	UT ID	0.1	3.1	19,500			208	3,360,000	0.01
Porphyry Cu, No. America type	**C100 (ICB only)**	MT	16	500	1,900,000			41,200	340,000,000	0.77
Porphyry Cu, BC-AK type	**PC26 (ICB only)**	WA	127	890	2,350,000			86,500	668,000,000	3.45
Porphyry Cu, BC-AK type	**PC27 (ICB only)**	OR WA	36	250	674,000			24,300	183,000,000	0.97
Porphyry Cu, BC-AK type	**W11**	OR ID WA	4.6	38	100,000			3,650	27,600,000	0.15

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Porphyry Cu, BC-AK type	**W11 OR-WA only**	OR WA	3.7	28	73,000			3,120	20,900,000	0.12
Porphyry Cu, BC-AK type	**W11 ID only**	ID	2.6	18	47,000			1,480	12,500,000	0.07
Porphyry Cu, No. America type	**W25 (ICB only)**	NV OR ID	6.8	200	722,000			16,100	144,000,000	0.35
Porphyry Cu, BC-AK type	**W118**	WA	13	87	231,000			9,460	67,400,000	0.35
Porphyry Cu, No. America type	**W119**	ID WA	0.1	2.9	23,200			354	4,500,000	0.01
Porphyry Cu, No. America type	**W119a**	ID	0.3	9	38,500			776	7,720,000	0.01
Porphyry Mo, low F	**W138 (ICB only)**	ID MT						309,000	395,000,000	1.79
Porphyry Mo, low F	**W139**	WA ID						29,400	37,400,000	0.17
Porphyry Mo, low F	**W140**	OR ID WA						1,380	1,620,000	0.01
Porphyry Mo, low F	**W143**	WA ID MT						1,250	1,740,000	0.01

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Porphyry Mo, low F	**X3 (ICB only)**	NV OR ID						65,200	81,800,000	0.39
Porphyry Mo, low F	**X4 (ICB only)**	UT ID						1,740	2,490,000	0.01
Sediment-hosted Cu, Revett type	**W13 (ICB only)**	MT ID WA		38,300	9,870,000				944,000,000	11.35
Sedimentary exhalative Zn-Pb	**C14 (ICB only)**	MT ID WA		3,920		2,860,000	4,610,000		65,200,000	1.44
Sedimentary exhalative Zn-Pb	**W07**	WA		330		233,000	405,000		6,160,000	0.14
Sedimentary exhalative Zn-Pb	**W16**	ID MT		360		274,000	438,000		6,300,000	0.14
Sedimentary exhalative Zn-Pb	**W51 (ICB only)**	NV		30		24,200	44,000		405,000	0.01
Skarn Au	**C02 (ICB only)**	MT	29	150	103,000	39,300	104,000		11,600,000	3.95
Skarn Au, truncated	**C23 (ICB only)**	UT ID	0.1	0.3	194	89			22,300	0.01
Skarn Au, truncated	**W18 (ICB only)**	NV OR ID	4.8	22	15,200	4,490			1,800,000	0.43

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Skarn Au, truncated	**W128**	WA	16	81	56,700	24,900			6,210,000	1.46
Skarn Au, truncated	**W136**	ID WA	0.2	0.4	489	1			56,000	0.01
Skarn Au, truncated	**W137**	ID OR WA	0.1	0.3	270	2			46,200	0.01
Skarn Zn-Pb	**C15 (ICB only)**	MT	0.5	38	2,970	21,900	38,000		670,000	0.14
Skarn Zn-Pb	**C33 (ICB only)**	UT ID	0.04	1.5	201	1,220	2,290		41,400	0.01
Skarn Zn-Pb	**W125**	ID WA	0.03	3.3	184	1,140	2,250		43,300	0.01
Skarn Zn-Pb	**X14 (ICB only)**	NV OR ID	0.4	34	2,390	17,300	34,900		563,000	0.14
Sediment-hosted Cu, reduced-facies	**W14 (ICB only)**	MT ID WA		710	661,000				29,700,000	0.17
Epithermal vein, Sado type	**PC100 (ICB only)**	OR WA	0.1	2.3	22	0	1		12,100	0.01
Skarn Cu	**C90 (ICB only)**	UT ID	0.003	0.1	538				49,800	0.01

Appendix B2: Estimates of number and mean metal contents (in metric tons) of undiscovered mineral deposits for tracts within ICBEMP study area

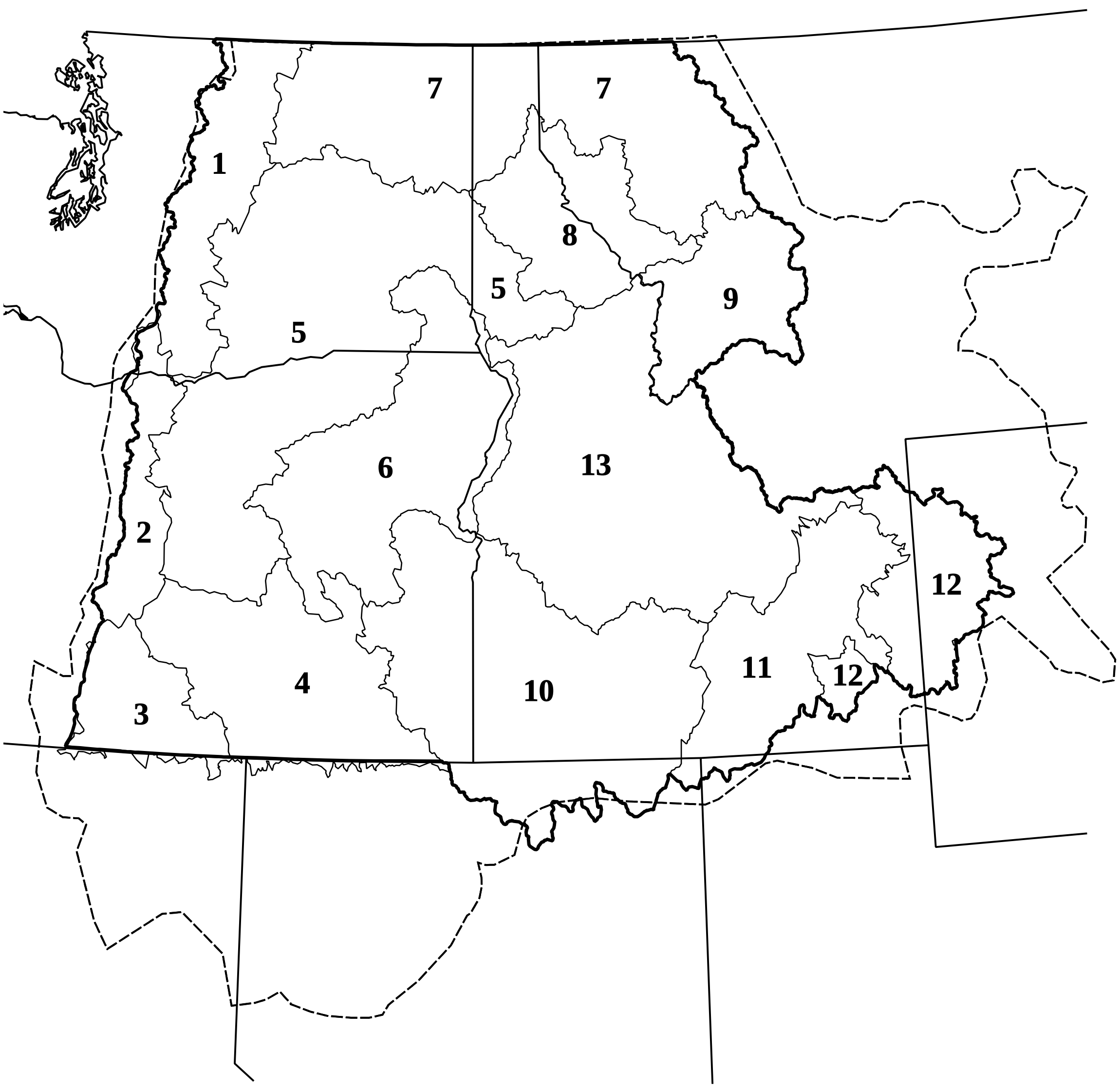
Mineral Deposit Type	Permissive Tract ID	State	Au (t)	Ag (t)	Cu (t)	Pb (t)	Zn (t)	Mo (t)	ore (t)	Mean no. of deposits
Skarn Cu	**W52 (ICB only)**	NV OR ID	1.1	10	75,400				5,550,000	1.31
Skarn Cu	**W122**	WA	0.004	0.1	603				56,400	0.01
Skarn Cu	**W123**	ID OR WA	3.0	25	174,000				12,900,000	3.10
Skarn Cu	**W123 ID only**	ID	1.8	17	124,000				9,160,000	2.10
Skarn Cu	**W123 OR-WA only**	OR WA	0.8	7.4	56,800				4,340,000	1.00
Skarn Cu	**W124**	ID WA	0.004	0.1	682				64,200	0.01
Totals for entire ICBEMP area			**2200**	**84000**	**17,400,000**	**4,260,000**	**7,500,000**	**590,000**	**4,200,000,000**	**86.6**

Appendix C

The ICBEMP study area is subdivided into thirteen Ecological Reporting Units (ERUs), based on similarities in topography, climate, and vegetation. A map showing the ERU boundaries is presented on the following page (figure C1).

Appendix C1 is a table listing each permissive tract discussed in this report, which ERUs the permissive tract is located in, and what percentage of the permissive tract are located in each ERU.

Appendix C2 is a table listing each permissive tract in this report within which favorable areas were delineated, which ERUs any favorable areas within each permissive tract are located in, and what percentage of the favorable areas are located in each ERU.



Legend

ICBEMP Ecologic
Reporting Units

1. Northern Cascades
2. Southern Cascades
3. Upper Kalamath
4. Northern Great Basin
5. Columbia Plateau
6. Blue Mountains
7. Northern Glaciated M
8. Lower Clark Fork
9. Upper Clark Fork
10. Owyhee Uplands
11. Upper Snake
12. Snake Headwaters
13. Central Idaho Mounta

Explanation

Landscape characterization boundary for ICBEMP

Ecological Reporting Unit Boundary

ICBEMP Study

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Alkaline Au-Ag-Te	mralkau	C01	0	Outside CRB Assessment Area	100.0
		W100	7	Northern Glaciated Mountains	90.7
		W100	1	Northern Cascades	9.3
Blackbird Co-Cu	mrbirdco	X7	13	Central Idaho Mountains	62.8
		X7	0	Outside CRB Assessment Area	36.3
		X7	9	Upper Clark Fork	0.9
Bushveld Cr	mrbushcr	X9	0	Outside CRB Assessment Area	100.0
Carlin-type	mrcarbau	C31	0	Outside CRB Assessment Area	94.7
sediment-hosted Au		C31	11	Upper Snake	4.7
		C31	12	Snake Headwaters	0.7
		W06	7	Northern Glaciated Mountains	98.1
		W06	5	Columbia Plateau	1.9
		W127	13	Central Idaho Mountains	96.1
		W127	11	Upper Snake	2.2
		W127	10	Owyhee Uplands	1.7
		W127	0	Outside CRB Assessment Area	0.1
		W27	0	Outside CRB Assessment Area	87.2
		W27	10	Owyhee Uplands	11.1
		W27	11	Upper Snake	1.6
		W27	4	Northern Great Basin	0.2
Coeur d'Alene Ag-Pb-Zn	mrcdaag	X1	8	Lower Clark Fork	70.6

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Coeur d'Alene Ag-Pb-Zn		X1	7	Northern Glaciated Mountains	29.4
(cont'd)		X1	0	Outside CRB Assessment Area	0.0
Epithermal vein,	mrcomau	C102	0	Outside CRB Assessment Area	52.6
Comstock-type		C102	12	Snake Headwaters	47.5
		C13	0	Outside CRB Assessment Area	61.2
		C13	9	Upper Clark Fork	33.5
		C13	7	Northern Glaciated Mountains	3.1
		C13	13	Central Idaho Mountains	1.2
		C13	12	Snake Headwaters	1.1
		C30	0	Outside CRB Assessment Area	83.6
		C30	11	Upper Snake	16.4
		PC03	0	Outside CRB Assessment Area	99.7
		PC03	4	Northern Great Basin	0.3
		PC04	0	Outside CRB Assessment Area	97.7
		PC04	3	Upper Klamath	2.2
		PC04	4	Northern Great Basin	0.1
		PC101	1	Northern Cascades	70.2
		PC101	5	Columbia Plateau	27.5
		PC101	0	Outside CRB Assessment Area	2.3
		PW100	4	Northern Great Basin	32.1
		PW100	5	Columbia Plateau	24.0
		PW100	3	Upper Klamath	18.7
		PW100	2	Southern Cascades	12.2

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Epithermal vein,	mrcomau	PW100	6	Blue Mountains	9.7
Comstock-type (cont'd)		PW100	0	Outside CRB Assessment Area	3.3
		W02	7	Northern Glaciated Mountains	94.4
		W02	1	Northern Cascades	5.6
		W02	0	Outside CRB Assessment Area	0.0
		W101	10	Owyhee Uplands	40.0
		W101	4	Northern Great Basin	35.6
		W101	6	Blue Mountains	24.4
		W102	10	Owyhee Uplands	96.3
		W102	6	Blue Mountains	3.7
		W102	13	Central Idaho Mountains	0.0
		W103	10	Owyhee Uplands	100.0
		W104	10	Owyhee Uplands	100.0
		W105	13	Central Idaho Mountains	83.5
		W105	10	Owyhee Uplands	8.8
		W105	6	Blue Mountains	7.7
		W106	11	Upper Snake	57.9
		W106	12	Snake Headwaters	32.6
		W106	13	Central Idaho Mountains	9.4
		W106	0	Outside CRB Assessment Area	0.1
		W12	13	Central Idaho Mountains	82.2
		W12	10	Owyhee Uplands	17.3
		W12	11	Upper Snake	0.5
		W17	0	Outside CRB Assessment Area	78.9
		W17	10	Owyhee Uplands	14.4

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Epithermal vein,	mrcomau	W17	4	Northern Great Basin	4.9
Comstock-type (cont'd)		W17	11	Upper Snake	1.8
Massive sulfide,	mrcypcu	PC15a	0	Outside CRB Assessment Area	100.0
Cyprus-type		W132	6	Southern Cascades	95.4
		W132	5	Columbia Plateau	2.8
		W132	10	Owyhee Uplands	1.9
		W132	4	Northern Great Basin	0.0
		W19	0	Outside CRB Assessment Area	82.7
		W19	10	Owyhee Uplands	17.3
Homestake Au	mrhomeau	C04	0	Outside CRB Assessment Area	96.4
		C04	12	Snake Headwaters	3.6
		C16	0	Outside CRB Assessment Area	100.0
Hot spring Au-Ag	mrhsprau	C05	0	Outside CRB Assessment Area	60.9
		C05	9	Upper Clark Fork	33.3
		C05	7	Northern Glaciated Mountains	3.6
		C05	13	Central Idaho Mountains	1.2
		C05	12	Snake Headwaters	1.1
		C19	0	Outside CRB Assessment Area	52.6
		C19	12	Snake Headwaters	47.4
		C24	0	Outside CRB Assessment Area	83.6
		C24	11	Upper Snake	16.4
		PC10	0	Outside CRB Assessment Area	100.0

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Hot spring Au-Ag	mrhsprau	PW101	0	Outside CRB Assessment Area	47.1
(cont'd)		PW101	4	Northern Great Basin	14.4
		PW101	5	Columbia Plateau	11.9
		PW101	3	Upper Klamath	8.9
		PW101	2	Southern Cascades	7.3
		PW101	1	Northern Cascades	6.1
		PW101	6	Blue Mountains	4.4
		W107	10	Owyhee Uplands	40.1
		W107	4	Northern Great Basin	35.5
		W107	6	Blue Mountains	24.4
		W108	10	Owyhee Uplands	96.3
		W108	6	Blue Mountains	3.7
		W108	13	Central Idaho Mountains	0.0
		W109	10	Owyhee Uplands	100.0
		W110	10	Owyhee Uplands	100.0
		W111	13	Central Idaho Mountains	83.5
		W111	10	Owyhee Uplands	8.8
		W111	6	Blue Mountains	7.7
		W112	11	Upper Snake	57.9
		W112	12	Snake Headwaters	32.6
		W112	13	Central Idaho Mountains	9.4
		W112	0	Outside CRB Assessment Area	0.1
		W129	13	Central Idaho Mountains	82.1
		W129	10	Owyhee Uplands	17.4
		W129	11	Upper Snake	0.5

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Hot spring Au-Ag	mrhsprau	W130	7	Northern Glaciated Mountains	94.5
(cont'd)		W130	1	Northern Cascades	5.5
		W130	0	Outside CRB Assessment Area	0.0
		W21	0	Outside CRB Assessment Area	79.5
		W21	10	Owyhee Uplands	14.0
		W21	4	Northern Great Basin	4.8
		W21	11	Upper Snake	1.8
Massive sulfide,	mrkurcu	C06	0	Outside CRB Assessment Area	100.0
Kuroko-type		C20	0	Outside CRB Assessment Area	100.0
		PC14	0	Outside CRB Assessment Area	100.0
		PC14a	0	Outside CRB Assessment Area	100.0
		PC15	0	Outside CRB Assessment Area	100.0
		PC16	0	Outside CRB Assessment Area	69.9
		PC16	1	Northern Cascades	30.1
		PC33	0	Outside CRB Assessment Area	100.0
		W113	7	Northern Glaciated Mountains	86.3
		W113	1	Northern Cascades	13.7
		W28	0	Outside CRB Assessment Area	94.0
		W28	4	Northern Great Basin	6.0
		W46	6	Blue Mountains	62.2
		W46	13	Central Idaho Mountains	29.1
		W46	5	Columbia Plateau	8.1
		W46	10	Owyhee Uplands	0.6
		W46	4	Northern Great Basin	0.0

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Low-sulfide	mrlsaqau	PC20	0	Outside CRB Assessment Area	100.0
Au-quartz vein		PC21	0	Outside CRB Assessment Area	100.0
		PC21	3	Upper Klamath	0.0
		PC22	0	Outside CRB Assessment Area	52.4
		PC22	1	Northern Cascades	46.1
		PC22	7	Northern Glaciated Mountains	1.4
		PC22	5	Columbia Plateau	0.1
		W114	7	Northern Glaciated Mountains	93.1
		W114	1	Northern Cascades	6.9
		W115	6	Blue Mountains	93.2
		W115	5	Columbia Plateau	5.4
		W115	10	Owyhee Uplands	1.4
		W115	4	Northern Great Basin	0.0
		W135	13	Central Idaho Mountains	52.5
		W135	6	Blue Mountains	37.2
		W135	5	Columbia Plateau	10.3
		X6	0	Outside CRB Assessment Area	96.2
		X6	4	Northern Great Basin	3.8
Merensky Reef PGE	mrmerepg	X8	0	Outside CRB Assessment Area	100.0
Mississippi Valley Pb-Zn	mrmvtzn	W08	7	Northern Glaciated Mountains	98.1
		W08	5	Columbia Plateau	1.9

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Overlook-type Au	mroverau	X12	7	Northern Glaciated Mountains	85.9
		X12	1	Northern Cascades	13.8
		X12	0	Outside CRB Assessment Area	0.3
Polymetallic Au-Ag, vein	mrpmvau	X10	6	Blue Mountains	79.2
and disseminated		X10	13	Central Idaho Mountains	9.5
		X10	10	Owyhee Uplands	5.2
		X10	5	Columbia Plateau	5.1
		X10	4	Northern Great Basin	1.0
		X11	13	Central Idaho Mountains	67.3
		X11	9	Upper Clark Fork	10.5
		X11	10	Owyhee Uplands	7.9
		X11	5	Columbia Plateau	7.0
		X11	8	Lower Clark Fork	3.5
		X11	0	Outside CRB Assessment Area	3.3
		X11	6	Blue Mountains	0.4
		X11	11	Upper Snake	0.2
Polymetallic replacement	mrpolypb	C07	0	Outside CRB Assessment Area	69.5
		C07	9	Upper Clark Fork	23.7
		C07	8	Lower Clark Fork	6.1
		C07	7	Northern Glaciated Mountains	0.7
		C07	13	Central Idaho Mountains	0.0
		C26	0	Outside CRB Assessment Area	93.2
		C26	11	Upper Snake	6.9

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Polymetallic replacement	mrpolypb	W120	7	Northern Glaciated Mountains	41.5
(cont'd)		W120	13	Central Idaho Mountains	30.3
		W120	8	Lower Clark Fork	22.7
		W120	5	Columbia Plateau	2.3
		W120	12	Snake Headwaters	1.6
		W120	11	Upper Snake	1.6
		W120	0	Outside CRB Assessment Area	0.0
		W22	0	Outside CRB Assessment Area	92.2
		W22	10	Owyhee Uplands	6.2
		W22	4	Northern Great Basin	1.6
		W22	11	Upper Snake	0.1
Polymetallic veins,	mrpopmv	X15	0	Outside CRB Assessment Area	62.7
porphyry-related		X15	7	Northern Glaciated Mountains	11.9
		X15	1	Northern Cascades	9.7
		X15	13	Central Idaho Mountains	7.9
		X15	9	Upper Clark Fork	6.3
		X15	8	Lower Clark Fork	0.5
		X15	4	Northern Great Basin	0.4
		X15	5	Columbia Plateau	0.3
		X15	12	Snake Headwaters	0.2
		X15	2	Southern Cascades	0.1
Porphyry copper	mrporcu	C09	0	Outside CRB Assessment Area	96.5

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Porphyry copper	mrporcu	C09	12	Snake Headwaters	3.5
(cont'd)		C100	0	Outside CRB Assessment Area	54.3
		C100	9	Upper Clark Fork	39.5
		C100	8	Lower Clark Fork	5.1
		C100	7	Northern Glaciated Mountains	1.0
		C100	13	Central Idaho Mountains	0.1
		C27	0	Outside CRB Assessment Area	93.2
		C27	11	Upper Snake	6.8
		PC26	1	Northern Cascades	48.8
		PC26	0	Outside CRB Assessment Area	45.9
		PC26	5	Columbia Plateau	4.3
		PC26	7	Northern Glaciated Mountains	0.9
		PC27	0	Outside CRB Assessment Area	75.1
		PC27	1	Northern Cascades	15.7
		PC27	2	Southern Cascades	7.2
		PC27	5	Columbia Plateau	2.0
		PC30	0	Outside CRB Assessment Area	100.0
		PC34	0	Outside CRB Assessment Area	100.0
		W11	6	Blue Mountains	79.2
		W11	13	Central Idaho Mountains	9.5
		W11	10	Owyhee Uplands	5.2
		W11	5	Columbia Plateau	5.1
		W11	4	Northern Great Basin	1.0
		W118	7	Northern Glaciated Mountains	78.1
		W118	1	Northern Cascades	21.9

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Porphyry copper	mrporcu	W118	0	Outside CRB Assessment Area	0.0
(cont'd)		W119	13	Central Idaho Mountains	59.7
		W119	7	Northern Glaciated Mountains	23.1
		W119	8	Lower Clark Fork	8.3
		W119	10	Owyhee Uplands	4.8
		W119	5	Columbia Plateau	3.1
		W119	11	Upper Snake	0.6
		W119	12	Snake Headwaters	0.4
		W119	9	Upper Clark Fork	0.0
		W119	0	Outside CRB Assessment Area	0.0
		W119a	10	Owyhee Uplands	100.0
		W25	0	Outside CRB Assessment Area	92.7
		W25	10	Owyhee Uplands	6.3
		W25	4	Northern Great Basin	1.0
		W25	11	Upper Snake	0.1
Porphyry molybdenum	mrpormo	C105	0	Outside CRB Assessment Area	96.7
		C105	12	Snake Headwaters	3.3
		PC103	0	Outside CRB Assessment Area	75.1
		PC103	1	Northern Cascades	15.7
		PC103	2	Southern Cascades	7.2
		PC103	5	Columbia Plateau	2.0
		W138	13	Central Idaho Mountains	45.4
		W138	0	Outside CRB Assessment Area	29.0
		W138	9	Upper Clark Fork	15.7

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Porphyry molybdenum	mrpormo	W138	10	Owyhee Uplands	8.8
(cont'd)		W138	11	Upper Snake	0.7
		W138	12	Snake Headwaters	0.4
		W138	7	Northern Glaciated Mountains	0.0
		W139	7	Northern Glaciated Mountains	90.7
		W139	1	Northern Cascades	4.5
		W139	5	Columbia Plateau	3.1
		W139	8	Lower Clark Fork	1.7
		W139	0	Outside CRB Assessment Area	0.0
		W140	6	Blue Mountains	39.0
		W140	1	Northern Cascades	24.9
		W140	0	Outside CRB Assessment Area	23.2
		W140	5	Columbia Plateau	4.6
		W140	13	Central Idaho Mountains	4.6
		W140	10	Owyhee Uplands	2.7
		W140	7	Northern Glaciated Mountains	0.5
		W140	4	Northern Great Basin	0.5
		W142	13	Central Idaho Mountains	49.2
		W142	8	Lower Clark Fork	25.5
		W142	9	Upper Clark Fork	14.9
		W142	5	Columbia Plateau	5.3
		W142	7	Northern Glaciated Mountains	5.0
		X3	0	Outside CRB Assessment Area	92.7
		X3	10	Owyhee Uplands	6.3
		X3	4	Northern Great Basin	1.0

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Porphyry molybdenum	mrpormo	X3	11	Upper Snake	0.1
(cont'd)		X4	0	Outside CRB Assessment Area	93.2
		X4	11	Upper Snake	6.8
		X5	0	Outside CRB Assessment Area	100.0
Sediment-hosted Cu,	mrrevcu	C78	0	Outside CRB Assessment Area	100.0
Revette-type		C78a	0	Outside CRB Assessment Area	100.0
		W13	7	Northern Glaciated Mountains	31.0
		W13	8	Lower Clark Fork	25.0
		W13	13	Central Idaho Mountains	15.8
		W13	9	Upper Clark Fork	12.1
		W13	5	Columbia Plateau	8.4
		W13	0	Outside CRB Assessment Area	7.6
		W13	12	Snake Headwaters	0.1
Epithermal vein, Sado-type	mrsadoau	PC100	0	Outside CRB Assessment Area	78.1
		PC100	1	Northern Cascades	14.2
		PC100	2	Southern Cascades	6.1
		PC100	5	Columbia Plateau	1.6
Sedimentary exhalative	mrsedxzn	C14	7	Northern Glaciated Mountains	36.4
Zn-Pb		C14	8	Lower Clark Fork	26.3
		C14	9	Upper Clark Fork	10.6
		C14	13	Central Idaho Mountains	10.1
		C14	0	Outside CRB Assessment Area	9.2

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Sedimentary exhalative	mrsedxzn	C14	5	Columbia Plateau	7.4
Zn-Pb (cont'd)		W07	7	Northern Glaciated Mountains	100.0
		W16	13	Central Idaho Mountains	94.4
		W16	10	Owyhee Uplands	3.7
		W16	11	Upper Snake	1.9
		W51	0	Outside CRB Assessment Area	80.0
		W51	10	Owyhee Uplands	20.0
Skarn Au	mrskrnau	C02	0	Outside CRB Assessment Area	69.5
		C02	9	Upper Clark Fork	23.7
		C02	8	Lower Clark Fork	6.1
		C02	7	Northern Glaciated Mountains	0.7
		C02	13	Central Idaho Mountains	0.0
		C23	0	Outside CRB Assessment Area	93.2
		C23	11	Upper Snake	6.9
		PC05	0	Outside CRB Assessment Area	100.0
		PC07	0	Outside CRB Assessment Area	100.0
		W128	7	Northern Glaciated Mountains	85.9
		W128	1	Northern Cascades	13.8
		W128	0	Outside CRB Assessment Area	0.3
		W136	7	Northern Glaciated Mountains	41.6
		W136	13	Central Idaho Mountains	30.3
		W136	8	Lower Clark Fork	22.7
		W136	5	Columbia Plateau	2.3
		W136	12	Snake Headwaters	1.6

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Skarn Au (cont'd)	mrskrnau	W136	11	Upper Snake	1.6
		W136	0	Outside CRB Assessment Area	0.0
		W137	6	Blue Mountains	62.2
		W137	13	Central Idaho Mountains	29.1
		W137	5	Columbia Plateau	8.1
		W137	10	Owyhee Uplands	0.6
		W137	4	Northern Great Basin	0.0
		W18	0	Outside CRB Assessment Area	92.2
		W18	10	Owyhee Uplands	6.2
		W18	4	Northern Great Basin	1.6
		W18	11	Upper Snake	0.1
Skarn Cu	mrskrncu	C90	0	Outside CRB Assessment Area	93.2
		C90	11	Upper Snake	6.9
		W122	7	Northern Glaciated Mountains	86.3
		W122	1	Northern Cascades	13.7
		W123	6	Blue Mountains	62.2
		W123	13	Central Idaho Mountains	29.1
		W123	5	Columbia Plateau	8.1
		W123	10	Owyhee Uplands	0.6
		W123	4	Northern Great Basin	0.0
		W124	7	Northern Glaciated Mountains	41.5
		W124	13	Central Idaho Mountains	30.3
		W124	8	Lower Clark Fork	22.7
		W124	5	Columbia Plateau	2.3
		W124	12	Snake Headwaters	1.6

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Skarn Cu (cont'd)	mrskrncu	W124	11	Upper Snake	1.6
		W124	0	Outside CRB Assessment Area	0.0
		W52	0	Outside CRB Assessment Area	92.1
		W52	10	Owyhee Uplands	6.2
		W52	4	Northern Great Basin	1.6
		W52	11	Upper Snake	0.1
		X13	0	Outside CRB Assessment Area	100.0
Skarn Zn-Pb	mrskrnzn	C15	0	Outside CRB Assessment Area	69.5
		C15	9	Upper Clark Fork	23.7
		C15	8	Lower Clark Fork	6.1
		C15	7	Northern Glaciated Mountains	0.7
		C15	13	Central Idaho Mountains	0.0
		C33	0	Outside CRB Assessment Area	93.2
		C33	11	Upper Snake	6.9
		W125	7	Northern Glaciated Mountains	41.5
		W125	13	Central Idaho Mountains	30.3
		W125	8	Lower Clark Fork	22.7
		W125	5	Columbia Plateau	2.3
		W125	12	Snake Headwaters	1.6
		W125	11	Upper Snake	1.6
		W125	0	Outside CRB Assessment Area	0.0
		X14	0	Outside CRB Assessment Area	92.2
		X14	10	Owyhee Uplands	6.2
		X14	4	Northern Great Basin	1.6

Appendix C1: Percentage area of each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Coverage Name	Tract ID	Ecological Reporting Unit (ERU) Number	Ecological Reporting Unit (ERU) Name	Percent of permissive tract in listed ERU
Skarn Zn-Pb (cont'd)	mrskrnzn	X14	11	Upper Snake	0.1
Stillwater Ni-Cu	mrstilni	X2	0	Outside CRB Assessment Area	100.0

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Alkaline Au-Ag-Te	mralkau	C01	0	Outside CRB Assessment Area	100
		W100	7	Northern Glaciated Mountains	100
Blackbird Co-Cu	mrbirdco	X7	0	Outside CRB Assessment Area	73.31
		X7	13	Central Idaho Mountains	26.69
Bushveld Cr	mrbushcr	X9	0	Outside CRB Assessment Area	100
Carlin-type	mrcarbau	C31	0	Outside CRB Assessment Area	92.47
sediment-hosted Au		C31	11	Upper Snake	7.53
		W27	0	Outside CRB Assessment Area	88.5
		W27	10	Owyhee Uplands	11.5
Coeur d'Alene Ag-Pb-Zn	mrcdaag	X1	8	Lower Clark Fork	96.83
		X1	7	Northern Glaciated Mountains	3.17
Epithermal vein,	mrcomau	C13	9	Upper Clark Fork	50.14
Comstock-type		C13	0	Outside CRB Assessment Area	38.73
		C13	7	Northern Glaciated Mountains	11.13
		PC03	0	Outside CRB Assessment Area	100
		PC04	0	Outside CRB Assessment Area	100
		PC101	1	Northern Cascades	95.38
		PC101	5	Columbia Plateau	4.62

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Epithermal vein,	mrcomau	PW100	5	Columbia Plateau	65.93
Comstock-type (cont'd)		PW100	4	Northern Great Basin	34.07
		W02	7	Northern Glaciated Mountains	100
		W101	4	Northern Great Basin	56.88
		W101	6	Blue Mountains	31.73
		W101	10	Owyhee Uplands	11.39
		W102	10	Owyhee Uplands	95.23
		W102	6	Blue Mountains	4.77
		W103	10	Owyhee Uplands	100
		W105	6	Blue Mountains	100
		W17	0	Outside CRB Assessment Area	75.12
		W17	4	Northern Great Basin	14.73
		W17	10	Owyhee Uplands	10.15
Massive sulfide, Cyprus-type	mrcypcu	W19	0	Outside CRB Assessment Area	100
Homestake Au	mrhomeau	C04	0	Outside CRB Assessment Area	100
Hot spring Au-Ag	mrhsprau	C05	9	Upper Clark Fork	50.14
		C05	0	Outside CRB Assessment Area	38.73
		C05	7	Northern Glaciated Mountains	11.13
		PW101	0	Outside CRB Assessment Area	80.96
		PW101	3	Upper Klamath	18.32

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Hot spring Au-Ag	mrhsprau	PW101	4	Northern Great Basin	0.72
(cont'd)		W107	4	Northern Great Basin	56.55
		W107	6	Blue Mountains	31.97
		W107	10	Owyhee Uplands	11.48
		W108	10	Owyhee Uplands	95.23
		W108	6	Blue Mountains	4.77
		W109	10	Owyhee Uplands	100
		W111	13	Central Idaho Mountains	96.79
		W111	6	Blue Mountains	3.19
		W111	10	Owyhee Uplands	0.02
		W112	12	Snake Headwaters	100
		W129	13	Central Idaho Mountains	94.38
		W129	11	Upper Snake	5.62
		W21	0	Outside CRB Assessment Area	81.65
		W21	4	Northern Great Basin	18.35
Massive sulfide,	mrkurcu	W46	6	Blue Mountains	96.55
Kuroko-type		W46	13	Central Idaho Mountains	3.45
Low-sulfide	mrlsaqau	W115	6	Blue Mountains	96.11
Au-quartz vein		W115	10	Owyhee Uplands	3.89
		X6	0	Outside CRB Assessment Area	86.12
		X6	4	Northern Great Basin	13.88

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Merensky Reef PGE	mrmerepg	X8	0	Outside CRB Assessment Area	100
Mississippi Valley Pb-Zn	mrmvtzn	W08	7	Northern Glaciated Mountains	100
Overlook-type Au	mroverau	X12	7	Northern Glaciated Mountains	85.89
		X12	1	Northern Cascades	13.81
		X12	0	Outside CRB Assessment Area	0.3
Polymetallic Au-Ag, vein	mrpmvau	X10	6	Blue Mountains	94.51
and disseminated		X10	10	Owyhee Uplands	5.49
		X11	13	Central Idaho Mountains	80.75
		X11	5	Columbia Plateau	5.8
		X11	9	Upper Clark Fork	4.73
		X11	10	Owyhee Uplands	3.38
		X11	0	Outside CRB Assessment Area	3.35
		X11	8	Lower Clark Fork	2
Polymetallic replacement	mrpolypb	C07	0	Outside CRB Assessment Area	81.04
		C07	9	Upper Clark Fork	18.96
		W22	0	Outside CRB Assessment Area	99.97
		W22	11	Upper Snake	0.03

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Polymetallic veins,	mrpopmv	X15	0	Outside CRB Assessment Area	62.71
porphyry-related		X15	7	Northern Glaciated Mountains	11.93
		X15	1	Northern Cascades	9.67
		X15	13	Central Idaho Mountains	7.9
		X15	9	Upper Clark Fork	6.25
		X15	8	Lower Clark Fork	0.51
		X15	4	Northern Great Basin	0.38
		X15	5	Columbia Plateau	0.29
		X15	12	Snake Headwaters	0.24
		X15	2	Southern Cascades	0.1
Porphyry copper	mrporcu	C09	0	Outside CRB Assessment Area	100
		C100	0	Outside CRB Assessment Area	71.18
		C100	9	Upper Clark Fork	28.82
		PC26	0	Outside CRB Assessment Area	62.09
		PC26	1	Northern Cascades	37.91
		PC27	0	Outside CRB Assessment Area	81.35
		PC27	1	Northern Cascades	18.65
		W118	7	Northern Glaciated Mountains	61.94
		W118	1	Northern Cascades	38.06
		W118	0	Outside CRB Assessment Area	0.01
		W25	0	Outside CRB Assessment Area	100

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Porphyry molybdenum	mrpormo	W138	0	Outside CRB Assessment Area	66.53
		W138	13	Central Idaho Mountains	20.54
		W138	9	Upper Clark Fork	12.93
		W139	7	Northern Glaciated Mountains	97.44
		W139	1	Northern Cascades	2.56
		W142	8	Lower Clark Fork	100
		X3	0	Outside CRB Assessment Area	100
Sediment-hosted Cu,	mrrevcu	W13	8	Lower Clark Fork	73.46
Revette-type		W13	7	Northern Glaciated Mountains	26.54
Epithermal vein, Sado-type	mrsadoau	PC100	0	Outside CRB Assessment Area	100
Sedimentary exhalative Zn-Pb	mrsedxzn	C14	7	Northern Glaciated Mountains	52.33
		C14	0	Outside CRB Assessment Area	24.87
		C14	8	Lower Clark Fork	22.8
Skarn Au	mrskrnau	C02	0	Outside CRB Assessment Area	81.04
		C02	9	Upper Clark Fork	18.96
		W128	7	Northern Glaciated Mountains	75.96
		W128	1	Northern Cascades	23.22
		W128	0	Outside CRB Assessment Area	0.82
		W136	7	Northern Glaciated Mountains	100
		W18	0	Outside CRB Assessment Area	100

Appendix C2: Areal percentage of favorable areas within each permissive tract that lies within Ecological Reporting Units (ERUs)

Mineral Deposit type	Digital Coverage Name	Permissive tract ID	Ecological Reporting Unit Number	Ecological Reporting Unit Name (ERU)	Percent of favorable areas in listed ERU
Skarn Cu	mrskrncu	W123	6	Blue Mountains	100
		W52	0	Outside CRB Assessment Area	91.42
		W52	10	Owyhee Uplands	8.58
Skarn Zn-Pb	mrskrnzn	C15	0	Outside CRB Assessment Area	81.04
		C15	9	Upper Clark Fork	18.96
		X14	0	Outside CRB Assessment Area	100
Stillwater Ni-Cu	mrstilni	X2	0	Outside CRB Assessment Area	100

Appendix D

Geographic Information System (GIS) documentation for digital maps showing permissive tracts and favorable areas for undiscovered metallic mineral deposits in the ICBEMP and surrounding areas

by

Pamela D. Derkey and Bruce R. Johnson

Introduction

Current data describing permissive tracts and favorable areas for potential (undiscovered) metallic mineral deposits were prepared for the Interior Columbia Basin Ecosystem Management Project (ICBEMP) in a GIS-compatible format for digital display, analysis, and distribution. Arc/Info coverages which illustrate permissive and favorable tracts for thirty deposit types are described in this Appendix.

Data Sources, Processing, and Accuracy

The sources of geologic information for the permissive and favorable tract maps are given in the tract descriptions described earlier in this report.

For each type of mineral deposit, an expert team delineated permissive tracts (to 1 km depth) using 1) regional geologic maps, typically at scales ranging from 1:250,000 to 1:500,000, showing mineral deposit occurrences from the U.S. Geological Survey's Mineral Resource Data System (MRDS); 2) maps showing the Department of Energy's National Uranium Resource Evaluation (NURE) stream and rock geochemistry; and 3) regional geophysical maps. Favorable areas are based on known mineral occurrences and exploration activity and occur within permissive tracts.

The permissive tracts were digitized from hand-drawn maps prepared by the expert team typically at scales of 1:250,000 to 1:500,000; favorable tract maps were compiled at 1:1,000,000 before being digitized. Accuracy of line location is variable due to the quality of the data available and to uncertainties of interpretation and of subsurface projections. At best, the accuracy of line locations ranges from 0.5 km to 5 km.

GIS Documentation

Polygon attribute descriptions for permissive and favorable areas for undiscovered metallic mineral deposits, ***cover*.PAT** (where *cover* refers to coverage name) are as follows:

ITEM NAME	START COLUMN	ITEM LENGTH	ATTRIBUTE DESCRIPTIONS
id	17	5	i.e., C01 -- Permissive tract id (alphanumeric identifier) keyed to descriptions in text. No entry indicates tract is not permissive.
cover	22	8	i.e., MRALKAU -- Coverage name, which also identifies mineral deposit type. See list of export files (below) for identification of deposit types. No entry indicates tract is not permissive.
permis	30	3	P -- Area is permissive for occurrence of the indicated deposit type (to 1 km depth). No entry indicates tract is not permissive.
favor	33	3	F -- Area is favorable (and permissive) for occurrence of the indicated deposit type (to 1 km depth). No entry indicates tract is not favorable.

Obtaining Digital Data

The digital files which were used to make the undiscovered metallic mineral deposit permissive and favorable area maps are available as GIS coverages and associated data files. These data and map images are maintained in the map projection used for all ICBEMP products:

Projection: Albers Equal Area

1st Standard Parallel: 43° N

2nd Standard Parallel: 48° N

Central Meridian:	117° W
Origin of Projection:	41° N
Y-offset (false easting):	700,000 meters

Copies of the digital data may be obtained in one of the following ways:

1. Download the digital files from the USGS public access World Wide Web site on the Internet:

URL = http://wrgis.wr.usgs.gov/docs/geologic/northwest_region/ofr95-682.html

or

Anonymous FTP from: **wrgis.wr.usgs.gov**, in the directory:

pub/geologic/northwest_region/min_res/ofr95-682

These Internet sites contain thirty permissive tract and favorable area GIS coverages in Arc/Info Export file format (*cover*.e00). Use of this data requires a GIS that is capable of reading Arc/Info Export formatted files and a computer capable of reading UNIX ASCII files. To use these files on a DOS computer, they must be put through a unix-to-dos filter. Or,

2. Obtain the digital files from the ICBEMP project office from one of the locations listed below:

Interior Columbia Basin Ecosystem Management Project
ATTN: Cindy Dean
112 E. Poplar Street
Walla Walla, WA 99362
(509) 522-4030

or:

Bureau of Land Management
ATTN: Becky Gravenmeier, OR99.2
Oregon - Washington State Office
P.O. Box 2965
Portland, OR 97208
(503) 952-6273

Export File Names

The thirty Arc/Info Export files for permissive tracts and favorable areas for undiscovered metallic mineral deposits by deposit type are identified below:

EXPORT FILE (*cover*.e00)	DEPOSIT TYPE
mralkau.e00	Alkaline Au-Ag-Te
mrbescu.e00	Besshi-type massive sulfide (Cu)
mrbirdco.e00	Blackbird Co-Cu
mrbushcr.e00	Bushveld Cr
mrcarbau.e00	Carlin-type sediment-hosted Au-Ag
mrcdaag.e00	Coeur d'Alene Ag-Pb-Zn
mrcomau.e00	Comstock-type epithermal Au-Ag vein
mrcypcu.e00	Cyprus-type massive sulfide (Cu)
mrdistau.e00	Distal disseminated Ag-Au
mrhomeau.e00	Homestake Au
mrhsprau.e00	Hot spring Au-Ag
mrkurcu.e00	Kuroko-type massive sulfide (Cu-Pb-Zn)
mrlsaqau.e00	Low-sulfide Au-quartz veins
mrmerepg.e00	Merensky Reef PGE
mrmvtzn.e00	Mississippi Valley Pb-Zn
mroverau.e00	Overlook-type Au
mrpmvau.e00	Polymetallic Au-Ag veins & disseminations
mrpolypb.e00	Polymetallic replacement
mrpopmv.e00	Polymetallic vein (porphyry-related)
mrporcu.e00	Porphyry Cu
mrpormo.e00	Porphyry Mo
mrredbcu.e00	Sediment-hosted Cu, Redbed-type
mrreducu.e00	Sediment-hosted Cu, Reduced-facies-type
mrrevcu.e00	Sediment-hosted Cu, Revett-type
mrsadoau.e00	Sado-type epithermal Au-Ag veins
mrsedxzn.e00	Sedimentary exhalative Zn-Pb
mrskarnau.e00	Au skarn
mrskarncu.e00	Cu skarn
mrskarnzn.e00	Zn-Pb skarn
mrstilni.e00	Stillwater Ni-Cu