Stratabound Copper-Silver Deposits of the Mesoproterozoic Revett Formation, Montana and Idaho

By David E. Boleneus, Larry M. Appelgate, John H. Stewart, and Michael L. Zientek

With a section on Databases and Spatial-Data Files for the Geology and Mineral Deposits of the Revett Formation

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Conversion Table

To convert from	To	Multiply by
feet (ft)	meters (m)	0.3048
miles (mi)	kilometers (km)	1.609344
square miles (mi^2)	square kilometers (km^2)	2.5899881
troy ounces (troy oz)	tonnes (t)	3.110348×10^{-5}
tons	tonnes (t)	0.90718474

Stratabound Copper-Silver Deposits of the Mesoproterozoic Revett Formation, Montana and Idaho

By David E. Boleneus, Larry M. Appelgate, John H. Stewart, and Michael L. Zientek

Abstract

The western Montana copper belt in western Montana and northern Idaho contains several large stratabound copper-silver deposits in fine- to medium-grained quartzite beds of the Revett Formation of the Mesoproterozoic (1,470–1,401 Ma) Belt Supergroup. Production from the deposits at the Troy Mine and lesser production from the Snowstorm Mine has yielded 222,237 tons Cu and 1,657.4 tons Ag. Estimates of undeveloped resources, mostly from the world-class Rock Creek-Montanore deposits, as well as lesser amounts at the Troy Mine, total more than 2.9 million tons Cu and 2,600 tons Ag in 406 million tons of ore.

The Rock Creek-Montanore and Troy deposits, which are currently the most significant undeveloped resources identified in the copper belt, are also among the largest stratabound copper-silver deposits in North America and contain about 15 percent of the copper in such deposits in North America. Worldwide, stratabound copper-silver deposits contain 23 percent of all copper resources and are the second-most important global source of the metal after porphyry copper deposits.

The Revett Formation, which consists of subequal amounts of argillite, siltite, and quartzite, is informally divided into lower, middle, and upper members on the basis of the proportions of the dominant rock types. The unit thickness increases from north to south, from 1,700 ft near the Troy Mine, 55 mi north of Wallace, Idaho, to more than 5,300 ft at Wallace, Idaho, in the Coeur d'Alene Trough south of the Osburn Fault, a major right-lateral strike-slip fault.

Mineral deposits in the Revett Formation occur mostly in the A–D beds of the lower member and in the middle quartzite of the upper member. The deposits are concentrated along a preore pyrite/hematite interface in relatively coarse grained, thick quartzite beds that acted as paleoaquifers for ore fluids. The deposits are characterized by mineral zones (alteration-mineral assemblages) that are a useful guide to the locations of mineral deposits. In particular, the gradational zone between the chalcopyrite-ankerite and pyrite-calcite zones is the site of most mineral deposits.

Detailed information on the geology and mineral deposits of the Revett Formation is presented in the accompanying files that include (1) a tab-delimited text file providing details of the geologic and mineral-resource data for 57 Revett-subtype stratabound copper-silver deposits, occurrences, and prospects; (2) the stratigraphic records of 40 diamond-drill cores and 86 measured sections, totaling 150,752 ft of true thickness, which are provided in Excel spreadsheet and Adobe Portable Document Format files; and (3) spatial geologic data consisting of geologic maps of the Revett Formation, the subsurface locations of resources in Revett-subtype stratabound copper-silver deposits based on diamond-drill-core data, and the locations of diamond-drill holes and measured sections. The spatial data are contained in Arc/Info interchange files. Spatial information derived from these data includes the locations of mineral zones, a digital database showing untested exploration areas, and a digital database of permissive tracts for undiscovered mineral deposits.

Introduction

Worldwide, stratabound copper-silver deposits contain 23 percent of all known copper resources and are the second-most important source of the metal (Singer, 1995). These deposits typically consist of disseminated Cu sulfide minerals restricted to a narrow range of mineralized layers within a sedimentary sequence; however, the mineralization does not necessarily follow sedimentary bedding. The deposits are epigenetic and diagenetic; that is, they formed after the host sediment was deposited but mostly before lithification of the host rock (Cox and others, 2003). Two large stratabound copper-silver deposits, the Rock Creek-Montanore and Troy deposits, in the Mesoproterozoic[1] Revett Formation of the western Montana copper belt, contain 15 percent of the known copper from such deposits in North America.

This report describes the regional stratigraphy, lithologic characteristics, and alteration patterns of the Revett Formation in relation to the localization of stratabound copper-silver deposits, along with the exploration potential of the region. The study area covers 4,280 mi^2 of the western Montana cop-

[1]According to the 2004 International Stratigraphic Chart published by the International Commission on Stratigraphy, spanning the period 1,600–1,000 Ma.

per belt and spans 100 mi north-south by 85 mi east-west. The copper belt straddles the Montana-Idaho State line east and southeast of Pend Oreille Lake, Idaho. The study area includes Bonner, Boundary, Kootenai, and Shoshone Counties in northern Idaho and Lincoln, Mineral, Missoula, and Sanders Counties in western Montana. The study area lies east of the cities of Sandpoint and Coeur d'Alene, Idaho; the city of Thompson Falls, Mont., is located near its east edge. One measured section lies west of the copper belt in Stevens County, Wash.

Detailed information on the geology and mineral deposits of the Revett Formation is presented in the accompanying files. Geologic data were compiled from industry exploration records to create six databases: (1) descriptions of 57 Revett-subtype stratabound copper-silver deposits, occurrences, and prospects; (2) subsurface copper-silver resources in the Revett Formation based on diamond-drill-core data; (3) geologic maps of the western Montana copper belt; (4) stratigraphic relations from measured sections; (5) mineral zones in the lower and upper members of the Revett Formation; and (6) permissive and untested exploration areas. Stratigraphic data compiled for the Revett Formation include the geologic logs of 40 diamond-drill cores and 86 measured sections, for a total of 150,752 ft of true thickness.

Geologic Setting

Stratigraphy

The Belt Basin (pl. 1; fig. 1), which covers several thousand square miles in Montana, Idaho, Washington, and British Columbia, Canada, was the site of deposition of more than 60,000 ft of predominantly fine grained sedimentary strata of the Mesoproterozoic Belt Supergroup (fig. 2; Harrison, 1972; Harrison and others, 1974; Winston, 1986a, b; Link and others, 1993; Schieber, 1998; Price and Sears, 2000; Mauk and White, 2004). Argillite, siltite, and carbonates are the most common rock types; lesser amounts of quartzite and coarse-grained clastic rocks are present in some formations.

Rocks of the Belt Supergroup (fig. 2) range in age from 1,401 to 1,470 m.y. (Link and others, 1993; Turner and others, 1995). A concordant sensitive-high-resolution-ion-microprobe (SHRIMP) U-Pb zircon age of 1,467±3 m.y. (Evans and others, 2000) was obtained on a sample from a gabbro sill that intruded the lowermost part of the Aldridge Formation in Canada, strata that are equivalent to the Prichard Formation in the lowest part of the Belt Supergroup. This age sets a minimum date for rifting during deposition of the oldest part of the Belt Supergroup (Turner and others, 1995).

Strata of the Belt Basin can be divided into three main facies (Lydon, 2000): (1) a basinal or rift-fill facies consisting mainly of deep-water turbidites in the main part of the basin and deep-water calcareous argillite and turbidites that shoal upward to midshelf carbonates and siliciclastic rocks in the Helena embayment; (2) a shallow-water platformal and fan-delta facies deposited at the margins of the rift and surrounding shelf, approximately synchronous with turbidite deposition within the rift; and (3) a shallow-water, mudflat, fluvial, lagoonal, alluvial, and playa facies that covers both the rift-fill facies and its adjacent platform and forms the upper part of the Belt Supergroup.

Near the study area (pl. 1; fig. 1), the lower part of the Belt Supergroup consists of the Prichard Formation (fig. 2), locally more than 20,000 ft thick, which consists of pyrite-rich argillite, siltite, and quartzite (Winston and Link, 1993). Overlying the Prichard Formation are rocks of the Ravalli Group, which includes the Burke, Revett, and Empire-St. Regis Formations (fig. 2). The Burke Formation, which is the oldest unit in the Ravalli Group, consists of greenish-gray, purple, reddish-gray, and minor black-and-gray siltite and argillite (Winston and Link, 1993). The Burke Formation thickens from 2,500 to 3,500 ft southward across the region. The overlying Revett Formation contains subequal proportions of quartzite, silty quartzite, siltite, and argillite (Winston and Link, 1993). The grain size of the quartzite very rarely exceeds medium sand. The units thin in all directions from a point of greatest known thickness, estimated at 5,580 ft (Mauk, 2001), in the Coeur d'Alene Trough, 21 mi west of Wallace, Idaho. The overlying St. Regis Formation, which ranges from 1,000 to 3,000 ft in thickness (Harrison and others, 1986), consists of greenish-gray, purple, reddish-gray, and subordinate black-and-gray siltite and argillite. Overlying the Ravalli Group are rocks of the Wallace Formation and Missoula Group. The Wallace Formation, which is about 5,500 ft thick in the Coeur d'Alene Trough, consists mostly of argillite and siltite and a middle part containing dolomitic beds (Winston and Link, 1993). The Missoula Group (not shown in fig. 2), which contains the highest strata in the Belt Supergroup, comprises several formations, with a total thickness of about 15,000 ft in the Coeur d'Alene Trough, consisting of argillite, siltite, sandstone, and, locally, carbonate rock (Winston and Link, 1993).

Structure

Major northwest- and west-northwest-striking faults, including, from north to south, the Hope, Thompson Pass, and Osburn Faults, subdivide the study area into structural domains (pl. 1; fig. 1). The Hope and Osburn Faults were active normal faults during deposition of the Revett Formation, as indicated by major variations in the thickness of strata across them (Harrison and Cressman, 1993; Mauk, 2001). The Coeur d'Alene Trough, lying south of the Osburn Fault, was a depositional center of the Revett Formation. The thick deposits there may owe their origin to syndepositional movement along the Osburn Fault. Movement on the Osburn Fault during deposition of the Revett Formation was down on the south side because the formation thickens southward to at least 5,580 ft (Mauk, 2001), whereas between the Osburn and Hope Faults it thins to only 1,430 ft. Movement on the Hope Fault during deposition of the Revett Formation was down on the northeast side because the formation thickens to 1,750 ft (Hayes, 1983) northeast of the Hope Fault near the Troy Mine.

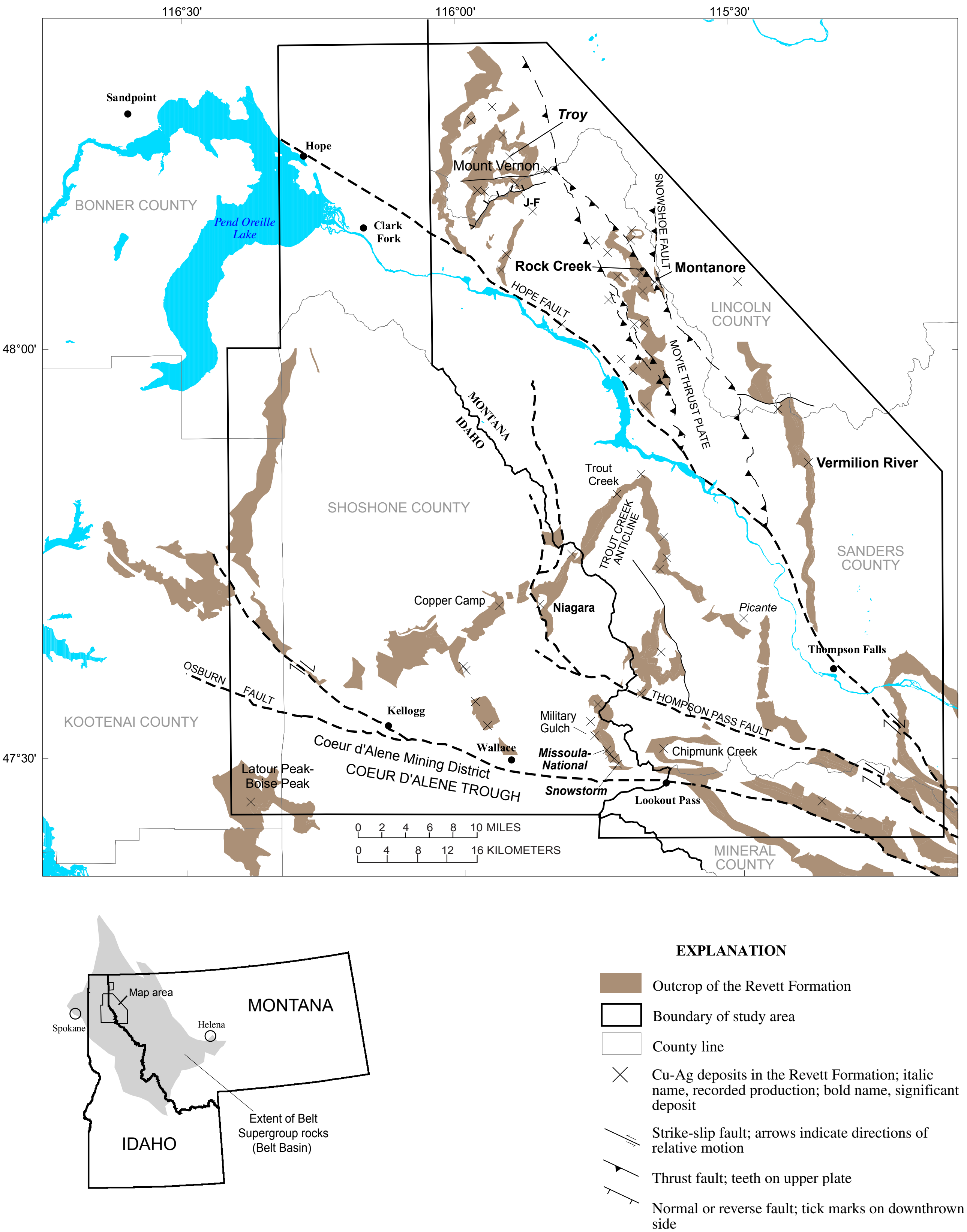

Figure 1. Western Montana and northern Idaho, showing locations of study area, major faults, and stratabound copper-silver deposits in the Revett Formation.

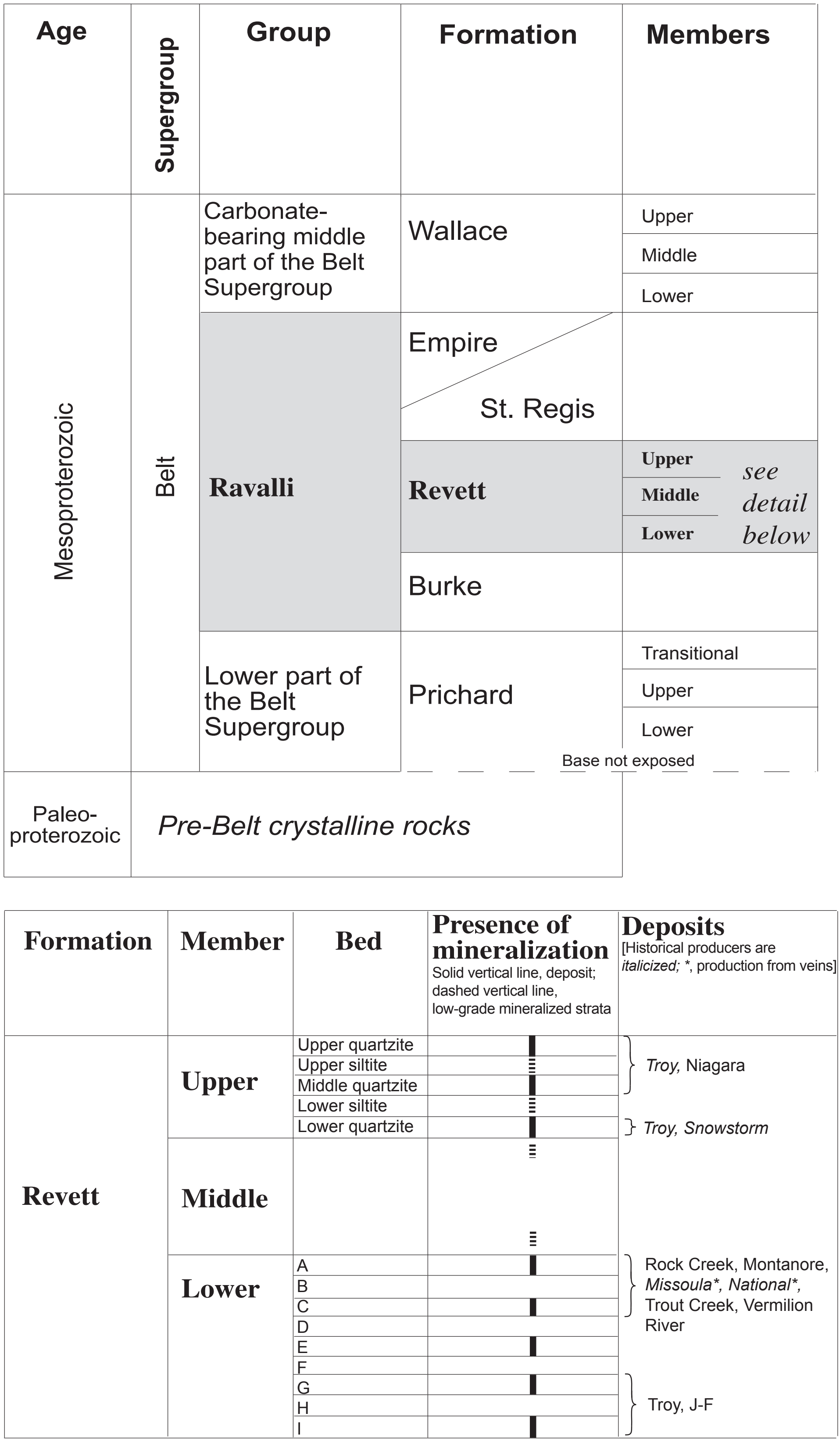

Figure 2. Stratigraphic relations in the lower, middle, and upper members of the Revett Formation of western Montana and northern Idaho (pl. 1; fig. 1). Modified from Harrison and others (1986) and Hayes and Einaudi (1986).

The Hope, Osburn, and Thompson Pass Faults were reactivated as right-lateral strike-slip faults as a consequence of crustal shortening during Laramide time (Harrison and Cressman, 1993). Right-lateral movement is as much as 16 mi on the Hope and Osburn Faults and as much as 2 mi on the Thompson Pass Fault.

The Moyie thrust plate, a listric-fault system consisting of Sevier-Laramide north-trending and eastward-vergent thrust and backslid faults, lies northeast of the Hope Fault (pl. 1; fig. 1). This fault system separates the Troy Mine from the Rock Creek-Montanore deposits. The Rock Creek deposit lies in the upper limb, and the Montanore deposit in the folded lower limb, of the Snowshoe thrust fault, a branch of the Moyie thrust plate. The Vermilion River deposit lies in inverted strata in the folded and faulted lower limb of an unnamed fold of the Moyie thrust plate. Shortening along any single thrust fault in the study area does not exceed 0.5 mi, and apparent total shortening is no more than 12 mi (Harrison and Cressman, 1993). North-south folds like the broad Trout Creek anticline (fig. 1) appear to be related in time with the Moyie thrusting event. The Trout Creek, Eagle Creek, Niagara, and other prospects are located on the northwest limb of this anticline.

Revett Formation

Ransome (1905) named the Revett Formation (his "Revett quartzite") apparently for strata at the Snowstorm Mine, surrounding Lake Revett, and in the eastern part of the Coeur d'Alene Mining District (fig. 1) near the Montana-Idaho State line. As first described by Ransome, the unit consists almost entirely of thick beds of white or gray quartzite interbedded with subordinate micaceous sandstone. Hayes (1983) defined the Revett Formation as that part of the Ravalli Group which includes thick-bedded metasandstone. Hayes' (1983) definition distinguishes thick beds of crossbedded, horizontally laminated and ripple-laminated metasandstone of the Revett Formation from thinner beds of ripple-laminated finer grained rocks of adjacent formations. In the study area (pl. 1; fig. 1), rocks of the Revett Formation have been metamorphosed to subgreenschist (prehnite-pumpellyite; Burchfiel and others, 1992, pl. 9) and, locally, biotite (Hayes and others, 2003) grade, some of the lowest metamorphic grades observed in rocks of the Mesoproterozoic Belt Supergroup. The metamorphic grade increases both westward and southward of the study area. Detrital quartz grains in the rocks are not recrystallized and are easily distinguishable optically in thin section and by the cathodoluminescence of quartz overgrowths and cement (Hayes, 1990).

The terms "quartzite," "silty quartzite," "siltite," and "argillite" are used to describe rocks throughout the region (pl. 1) because of the widespread metamorphic effects; unmetamorphosed equivalents to these rocks are sandstone, silty sandstone, siltstone, and claystone (Harrison and Grimes, 1970). The general field practice for determining the lithology of clastic rocks depends on a scratch test using a steel nail, which will scratch silty argillaceous rocks but not quartzite.

In the Coeur d'Alene Mining District (fig. 1), the Revett Formation is characterized by white, medium-grained, crossbedded quartzite interbedded with white siltite and green laminated argillite (Harrison and others, 1986). Northeastward and eastward from the mining district, the unit contains progressively less quartzite and more siltite and argillite, much of which is purple or purplish gray. Fine-grained strata of the Revett Formation consist of greenish-gray through gray to reddish-gray siltite and argillite, commonly showing centimeter-scale, alternating silt and argillite beds called couplets. The coarsest grained strata are composed of clean, fine- and medium-grained, almost colorless, white, or very light gray to light-greenish-white vitreous quartzite and silty quartzite. These strata commonly exhibit flat laminations, trough crossbedding, and ripple-drift laminations. Sparse incised channels and rare intraclast conglomerate beds probably indicate sediment transport and winnowing by strong currents. The strata occur in both fining- and coarsening-upward sequences, suggesting varying current strength. Beds have continuity on a scale of miles. Thin mud-cracked silty units indicate periods of subaerial exposure. The combination of widespread strata and strata that vary in grain size suggests shallow-water cyclic deposition on a broad, monotonous coastal plain. (Hayes, 1983).

The Revett Formation is informally divided into lower, middle, and upper members (figs. 2, 3; Hayes, 1983). All three members are recognizable at the Troy Mine (Bowden, 1977; Hayes, 1983), in the Wallace 1° by 2° quadrangle (Harrison and others, 1986), and at Flathead Indian Reservation in Lake County, Mont. (Ryan and Buckley, 1998), 50 mi (80 km) east of the study area (pl. 1; fig. 1). The upper and lower members are similar in that they consist of cyclic sequences with abundant quartzite and silty quartzite, along with lesser amounts of siltite and argillite. The middle member is distinct because it consists largely of argillite and siltite. At the Troy Mine, Bowden (1977), Hayes (1983), and Hayes and Einaudi (1986) subdivided the lower and upper members into beds (fig. 2), mainly on the basis of the stratigraphy of fine- and coarse-grained layers. The present study correlates these members and groups of beds within the Revett Formation outward from the Troy Mine, using the stratigraphic terminology of Asarco Inc. (in Hayes, 1983), on the basis of the measured sections shown on plate 1 and included as appendix A.

Lower Member

The base of the lower member of the Revett Formation is located at the base of the lowest thick-bedded quartzite above purple to green argillite and siltite of the Burke Formation. The top of the lower member is defined as the top of the uppermost thick quartzite bed below thick siltite and argillite of the middle member. The lower member is informally subdivided into beds A through I (fig. 3), lettered downward from the top of the lower member (cross sec. *A–B*, pl. 2; Hayes, 1983). Quartzite dominates in the A, C, E, G, and I beds that alternate with the fine-grained B, D, F, and H beds.

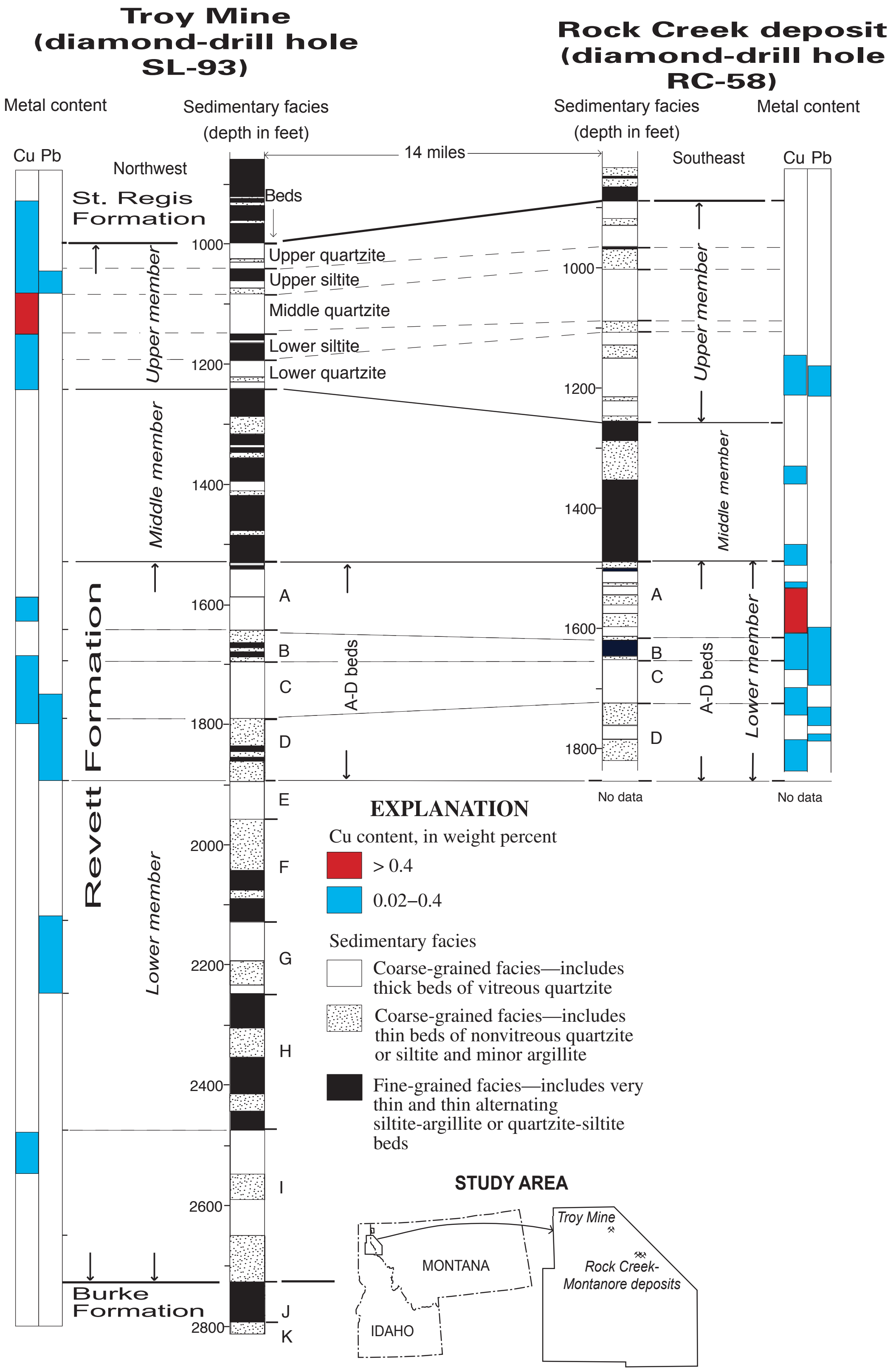

Figure 3. Generalized stratigraphic columns of the Revett Formation at the Troy Mine and Rock Creek deposit, western Montana (pl. 1; fig. 1).

In this report, groups of beds (A–D, E–H, I) are recognized in the lower member and correlated over large areas. The A–D beds are the host rock of the Rock Creek-Montanore deposits. In cross section *A–B* (pl. 2; see section lines on pl. 1), the lower member ranges from 1,170 ft in thickness at the Troy Mine (diamond-drill hole SL–123) down to 990 ft at the West Fork of Crow Creek-Chipmunk Creek 1 composite measured section and then thickens abruptly across the Osburn Fault to more than 2,060 ft at Latour Peak. The lower member probably represents high-energy beach or nearshore deposits.

Middle Member

The middle member of the Revett Formation is dominated by fine-grained clastic rocks. The middle member is undivided and consists mainly of argillite and siltite with only minor quartzite. In cross section *A–B* (pl. 2), the middle member thickens slightly from 275 ft at diamond-drill hole SL–123 on the north to 295 ft at the Chipmunk measured section 1 on the south. The middle member thickens abruptly across the Osburn Fault to 980 ft at the Latour-Boise Peak measured section. The middle member probably represents low-energy mudflat or interdistributary-bay deposits.

Upper Member

The upper member of the Revett Formation is informally subdivided at the Troy Mine (Hayes, 1983) into beds on the basis of the proportion of quartzite relative to argillite and siltite. Upward from the base of the upper member, the beds are named the lower quartzite, lower siltite, middle quartzite (called “ore quartzite” by early workers at the Troy Mine because it contained the main ore deposit), upper siltite, and upper quartzite (figs. 2, 3). The subdivisions of the upper member at the Troy Mine are recognizable with increasing difficulty southwest of the Hope Fault. Hayes (1983) traced the middle quartzite as far southward as Trout Creek and the West Fork of Eagle Creek. Farther south—for example, at Military Gulch—only one quartzite bed is observed in the upper member; this quartzite bed forms the contact between the middle member and the overlying St. Regis Formation. In cross section *A–B* (pl. 2), the upper member thins from 250 ft in diamond-drill hole SL–123 at the Troy Mine to 125 ft in diamond-drill hole MG–6 (Military Gulch), located 6 mi east of Wallace. South of the Osburn Fault, the upper member thickens abruptly to 950 ft at the Latour Peak-Boise Peak measured section. The base of the upper member is located at the contact of the lower quartzite with underlying siltstone and argillite of the middle member. The top of the upper member is characterized by thick quartzite beds below thick purple, greenish-gray, black, or dark-gray argillite and siltite beds of the overlying St. Regis Formation.

Hayes (1983) and Hayes and Einaudi (1986) interpreted the sedimentary layers in the upper member of the Revett Formation in the vicinity of the Troy Mine as coastal deposits. Hayes and Einaudi focused on the lower and middle quartzites of the upper member because of their importance to the Troy deposit.

The lower quartzite consists of coarsening-upward cycles of predominantly quartzite deposited in northeasterly prograding, northwesterly to southeasterly oriented shorelines (Hayes and Einaudi, 1986). The coarsening-upward strata contain various laminated and crossbedded layers, suggesting deposition under high-energy conditions in beach-swash, peritidal, and shallow wave-built nearshore zones. In the lower part of the lower quartzite, southwestwardly oriented foreset beds, composed of megaripple bars, are consistent with postulated shoreward-directed transport in the wave-built nearshore zone. In the upper part of the lower quartzite, coarse-grained, horizontally laminated beds containing abundant heavy-mineral laminae and northeast-dipping foreset beds are interpreted as swash-zone deposits along the shoreface. On this basis, Hayes and Einaudi interpreted the lower quartzite as a barrier-beach deposit influenced by a tidal range of more than 13 ft.

The lower siltite overlies the lower quartzite. The lower siltite is interpreted as channel-fill mud deposits and low-energy mudflat or interdistributary-bay deposits lying landward from barrier-beach deposits of the lower quartzite (Hayes, 1983).

The middle quartzite is the main host rock of the Troy deposit (Hayes, 1983). This medium-grained quartzite is interpreted as tidal-channel deposits in a northeasterly prograding estuarine sequence (Hayes, 1983; Hayes and Einaudi, 1986). In contrast, fining-upward sequences containing significant amounts of argillite and siltite are interpreted as channel-margin deposits. The channel-margin deposits, which have a lower permeability than the tidal-channel sandstone beds, are located outside of the central tidal-channel complex (Hayes and Einaudi, 1986). Together, these channel-margin and tidal-channel strata compose part of the northeasterly prograding estuarine sequence, analogous to those on many modern coastal plains (Reineck and Singh, 1975; Reinson, 1992). Lateral variation in permeability, related to changes from medium sand in the tidal channels to finer sand in the channel margins, impeded permeability and constrained the emplacement of the Troy deposit to the coarser grained sedimentary layers (Hayes and Einaudi, 1986). The highly permeable tidal-channel sand beds served as conduits and host strata for the metal-bearing brines from which the deposit was formed.

The upper siltite is subdivided into three parts (Hayes, 1983): a lower part consisting of a series of 2- to 3-ft-thick ripple- and lenticular-laminated silty quartzite beds and of vitreous quartzite beds; a middle part consisting of 12- to 30-ft-thick quartzite beds, with scoured bases, that grade upward into siltite and argillite; and an upper part consisting of 9- to 18-ft-thick siltite-argillite couplets. The upper siltite is interpreted as subtidal, intertidal-channel, and intertidal mudflat deposits.

The upper quartzite, which is as much as 35 ft thick, consists of a sequence of trough-crossbedded quartzite beds in sets from 1.5 to 2 ft thick that fine upward into siltite (Hayes, 1983). A 1- to 3-ft-thick argillite marker bed, interpreted as supratidal in origin, occurs about 5 ft above the base of the upper quartzite at the Troy Mine. The upper quartzite is interpreted as sabkha to intertidal-channel sand deposits.

Stratabound Copper-Silver Deposits

The western Montana copper belt includes several large stratabound copper-silver deposits in the Revett Formation of the Mesoproterozoic Belt Supergroup (1,401–1,470 m.y.; pl. 1; fig. 1; Harrison, 1972; Hayes, 1983, 1990; Lange and Sherry, 1983; Lange, 1986; Hayes and Einaudi, 1986; Hayes and others, 1989). These deposits, which are referred to as Revett-subtype stratabound copper-silver deposits, are one of the three subtypes of such deposits recognized worldwide (Cox and others, 2003). In the first subtype, the reduced-facies subtype (figs. 4, 5), disseminated native copper and Cu sulfides occur in organic-rich marine or lacustrine fine-grained strata that overlie or are interbedded with red-bed sequences or subaerial basalt flows. In the second subtype, the red-bed subtype, disseminated Cu sulfides occur in white to gray bleached zones in sandstone and (or) black, gray, or green beds of shale and siltstone in a stratigraphic setting that is otherwise dominated by red beds. In the third subtype, the Revett subtype (figs. 4, 5), disseminated Cu, Ag, and Pb-Zn sulfides occur in thick sandstone or quartzite sequences. Mineralization of the rocks along color boundaries is caused by diagenetic alteration of the quartzite.

Exploration of the Revett Formation has found deposits, occurrences, or prospects at 57 sites in the study area (pl. 1; fig. 1) that exhibit characteristics of the Revett-subtype deposit model (Cox and others, 2003). Deposits are sites containing identified resources of stratabound copper-silver. An occurrence is a site containing small amounts of stratabound copper-silver mineralization. Prospects are explored sites with some indication of mineralization that have not been confirmed to be Revett-subtype deposits. Deposits, occurrences, and prospects

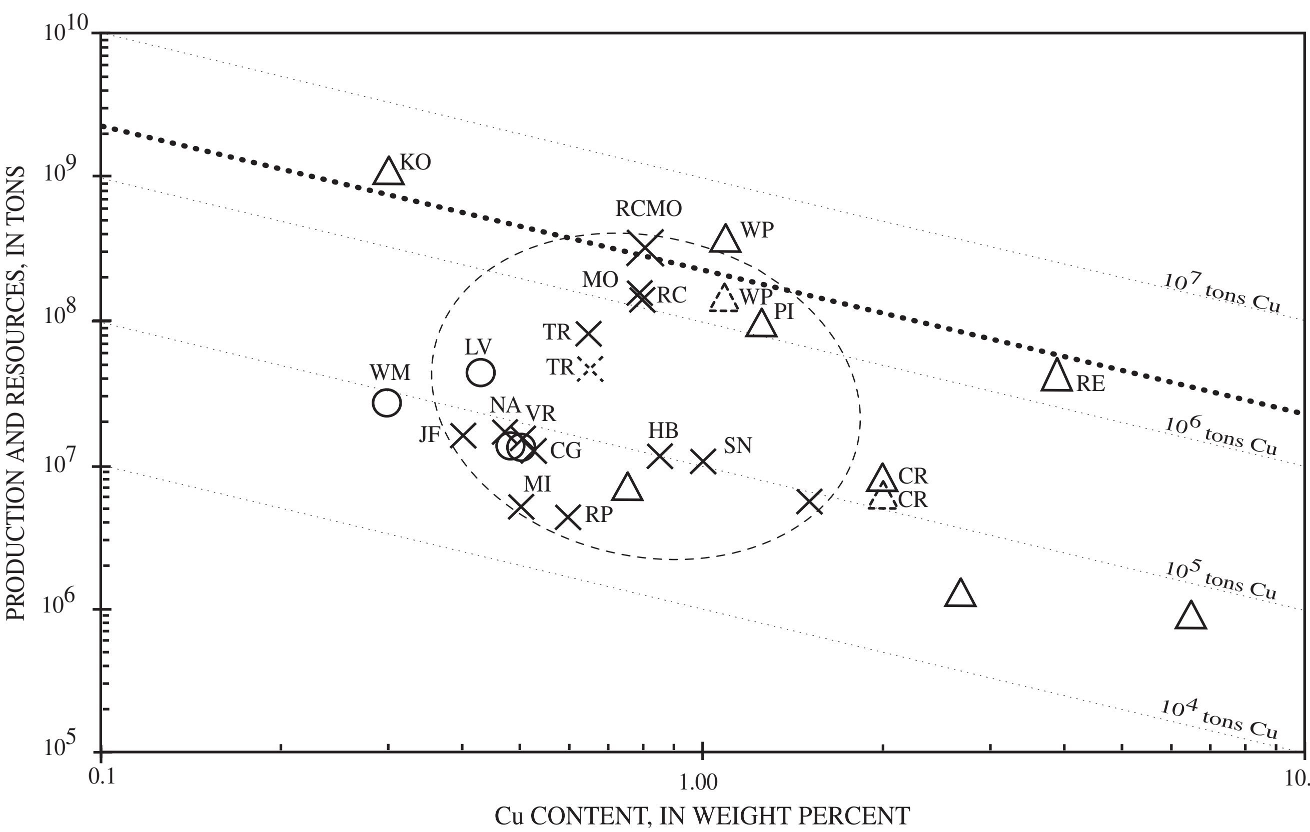

Figure 4. Grade-tonnage diagram for copper in three subtypes of stratabound copper-silver deposits in North America: reduced facies (triangles), red bed (circles), and Revett (Xs). Solid-line symbols, premining resource; dashed-line symbols, postmining resource remaining when mine was closed. Dashed oval, "average" field of Revett-subtype stratabound copper-silver deposits. CG, Copper Gulch, Mont.; CR, Creta, Okla.; HB, Horizon Basin, Mont.; JF, J–F (Ross Creek), Mont.; KO, Kona, Mich.; LV, Lisbon Valley, Utah; MI, Missoula National Mine, Idaho; MO, Montanore, Mont.; NA, Niagara (Eagle Creek), Mont.; PI, Presque Isle, Mich.; RC, Rock Creek, Mont.; RCMO, combined Rock Creek, Montanore, Copper Gulch, Horizon Basin, and Rock Peak, Mont.; RE, Redstone, Canada; RP, Rock Peak, Mont.; SN, Snowstorm Mine, Idaho; VR, Vermilion River, Mont.; WM, White Mesa, Ariz.; WP, White Pine, Mich. Light-dotted diagonal lines show total copper resource available in deposits; deposits above heavy-dotted diagonal line represent largest 10 percent of similar, or "world class," copper deposits.

containing disseminated copper and silver (±lead) in rocks of the Revett Formation are shown on plate 1 and listed in table 1.

Copper and silver production from Revett-subtype stratabound copper-silver deposits in the Revett Formation has been mainly from the Troy Mine, which produced 194,652 tons Cu and 1,516.3 tons Ag (table 2; Long and others, 1998) between 1981 and 1993. The only other copper and silver production from Revett-subtype stratabound copper-silver deposits was from the Snowstorm Mine, which produced 27,585 tons Cu and 141 tons Ag between 1906 and 1912 (table 2; Long and others, 1998). Production of 1,514 tons Cu from the Missoula-National and Picante Mines was from vein deposits in the St. Regis and Revett Formations and not from the stratabound copper-silver deposits described here.

Resources (potentially minable mineralized rock) remaining in stratabound copper-silver deposits of the Revett Formation total more than 2.9 million tons Cu and 25,840 tons Ag in 406 million tons of ore, primarily in the Rock Creek-Montanore and Troy deposits. Mine permitting was ongoing in 2003 at the Rock Creek-Montanore deposits (U.S. Forest Service, 1993, 1995, 2001; Kootenai National Forest, written commun., 2002; Spokesman-Review, 2003a, b). Exploration for additional stratabound copper-silver deposits continues sporadically.

Singer (1995) defined world-class deposits as those that exceed the 90th percentile of discovered metal; world-class copper deposits are those that contain more than 2.2 million tons Cu (heavy dotted line, fig. 4). World-class stratabound copper-silver deposits in North America include the Rock Creek-Montanore deposits, Mont., and the Kona and White Pine deposits, Mich. (Kirkham, 1989; Singer and others, 1993; Long and others, 1998). World-class deposits are significant because production from any of them affects the world's supply-demand relation for the metal.

The Rock Creek-Montanore deposits rank 20th (Singer and others, 1993; D.P. Cox, written commun., 1999) among the world's stratabound copper-silver deposits. Deposits larger than those in the Revett Formation, outside of North America, include the giant reduced-facies deposits of central Asia, the

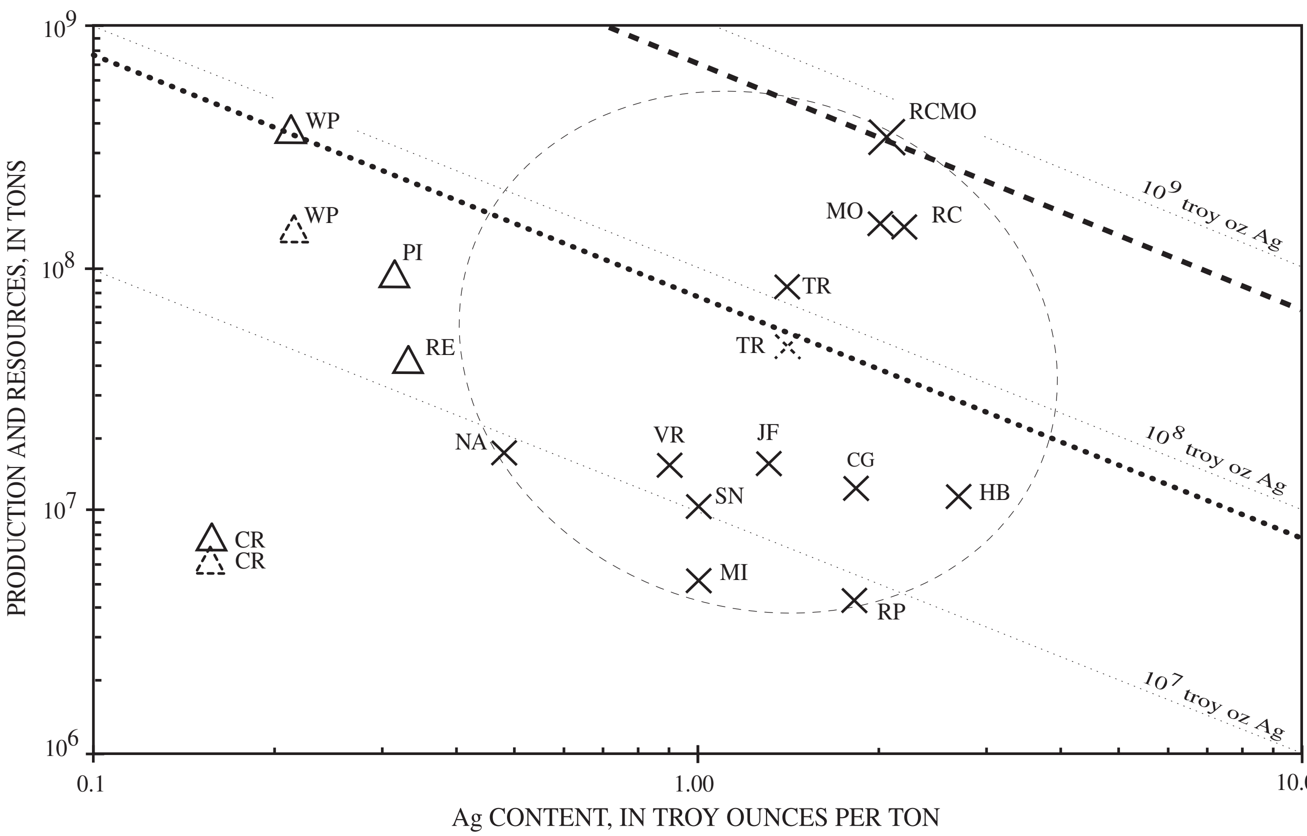

Figure 5. Grade-tonnage diagram for silver in two subtypes of stratabound copper-silver deposits in North America with reported silver production: reduced facies (triangles) and Revett (Xs). Solid-line symbols, premining resource; dashed-line symbols, postmining resource remaining when mine was closed. Dashed oval, "average" field of Revett-subtype stratabound copper-silver deposits. CG, Copper Gulch, Mont.; CR, Creta, Okla.; HB, Horizon Basin, Mont.; JF, J–F (Ross Creek), Mont.; KO, Kona, Mich.; MI, Missoula National Mine, Idaho; MO, Montanore, Mont.; NA, Niagara (Eagle Creek), Mont.; PI, Presque Isle, Mich.; RC, Rock Creek, Mont.; RCMO, combined Rock Creek, Montanore, Copper Gulch, Horizon Basin, and Rock Peak, Mont.; RE, Redstone, Canada; RP, Rock Peak, Mont.; SN, Snowstorm Mine, Idaho; VR, Vermilion River, Mont.; WP, White Pine, Mich. Light-dotted diagonal lines show total silver resource in deposits. Deposits above heavy-dotted diagonal line represent largest 10 percent of similar, or "world class," silver deposits; deposits above heavy-dashed diagonal line represent largest 1 percent of similar, or "supergiant," silver deposits.

Table 1. Summary of 57 stratabound copper-silver deposits, occurrences, and prospects in the Revett Formation, western Montana and northern Idaho.

[Mineralized members: L, lower; M, middle; U, upper. See the file *cuag_deposit.txt* for other details]

Site name	Mineralized member	State
Beaver Creek	U	Idaho
Brooks Mountain[3]	U	Mont.
Bull Lake East	– –	Mont.
Chipmunk Creek[3]	L	Mont.
Clear Peak[3]	L	Mont.
Copper Camp[3]	U	Idaho
Copper Gulch[2,3]	L	Mont.
Copper Rock[3]	U	Mont.
Cub Creek	L, U	Mont.
Devils Club Creek	L	Mont.
Dry Creek	L, U	Mont.
Engle Peak	– –	Mont.
Fairway Creek	L, U	Mont.
GM claims	– –	Mont.
Government Mountain	– –	Mont.
Hayes Ridge	L	Mont.
Hiatt Creek	U	Mont.
Hill Farm[3]	L	Mont.
Horizon Basin[2,3]	L	Mont.
Janstan Group	L, M	Mont.
J–F[2,3]	L	Mont.
Late Group	L	Mont.
Lost Girl	– –	Mont.
Lucky Calumet[3]	U	Idaho
McKay Creek[3]	L	Mont.
Military Gulch[2,3]	L, U	Idaho
Missoula Mine[1,2,3]	U	Idaho
National Mine[3]	U	Idaho
Niagara[2,3]	U	Idaho
Picante[1]	L, U	Mont.
Rabbit Gulch	U	Idaho
Revett Lake	L	Idaho
Ripper Creek[3]	L	Mont.
Rock Creek[2,3]	L	Mont.
Rock Lake (Montanore)[2,3]	L	Mont.
Rock Peak[2,3]	L	Mont.
Ross Point	U	Mont.
Ross Point West[3]	L	Mont.
Sex Peak (Miller Gulch)[3]	L	Mont.
Silver Aurora-Capitol Silver	U	Idaho
Silver Creek[3]	L	Idaho
Sims Creek (Waloven)[3]	L	Mont.
Snake Creek	L, M, U	Mont.
Snowshoe[3]	U	Idaho
Snowstorm[1,2,3]	U	Idaho
Soldier claims	– –	Mont.
Squaw Peak[3]	L, U	Mont.
Standard Creek	U	Mont.
Star Gulch	L	Mont.
Trout Creek[3]	L	Mont.
Troy Mine[1,2,3]	L, U	Mont.
Twilight Creek[3]	L	Mont.
Twomile	L	Idaho
Vermilion River[2,3]	L	Mont.
White Creek	U	Idaho
White Penney	L	Mont.
White Pine Creek[3]	L	Mont.

[1]Site with recorded production.
[2]Site with identified resource.
[3]Site with mineralized domain.

Kupferschiefer of Europe, and a third group in the central African copper belt of Zambia, Zimbabwe, and the Democratic Republic of the Congo (Gustafson and Williams, 1981; Singer and others, 1993).

At least six North American stratabound copper-silver deposits contain more than 1 million tons Cu (fig. 4). The copper grade versus tonnage of the three subtypes of these deposits in North America (D.P. Cox, written commun., 1992, 2002; Spanski, 1992) is plotted in figure 4.

Mineral deposits in the Revett Formation are unusual because they are also rich in silver (heavy dotted line, fig. 5), a characteristic that sets them apart from many other stratabound copper deposits (compare figs. 4 and 5). Considering only Ag content, the resources of the Rock Creek-Montanore deposits, approximately 680 million troy oz Ag (table 2), represent a "supergiant" silver deposit, which Singer (1995) defined as the largest 1 percent of the world's silver deposits (each containing more than 22,000 metric tons Ag; heavy dashed line). Since the 1880s, the nearby Coeur d'Alene Mining District has produced more than 790 million troy oz Ag—more than any other mining district in the world except Cerro Rico de Potosí in Bolivia (Long, 1998). In comparison, the resource contained in stratabound copper-silver deposits of the Revett Formation is equal to 86 percent of the silver produced from veins in the Coeur d'Alene Mining District through 1996 (White, 1998).

The geologic characteristics of Revett-subtype stratabound copper-silver deposits, based on studies at the Troy Mine, are summarized here from the review by Hayes and others (2003). These deposits in the western Montana copper belt are considered to be analogous to the red-bed (hematitic) stratabound copper-silver deposits in Europe and Africa; however, Revett-subtype deposits have undergone metamorphism that has colored any former Revett red beds lavender gray. Before mineralization, northwestward-elongate pyritic sand bodies formed embayments in the Revett red beds. The copper-silver minerals in the Revett Formation were deposited as a large, zoned system of authigenic sulfide and gangue minerals overprinted on the boundary of the reduced pyritic and oxidized hematitic rocks. The appearance, disappearance, and abundance of authigenic sulfide and gangue minerals have been used to establish six mineral zones at Spar Lake (Hayes and Einaudi, 1986) that are named by their dominant sulfide minerals, distinctive nonsulfide minerals, and color: pyrite-calcite (PY–CAL), galena-calcite (GN–CAL), chalcopyrite-calcite (CP–CAL), bornite-calcite (BN–CAL), chalcocite-chlorite (CC–CHL), chalcopyrite-ankerite (CP–ANK), lavender (hematite) with carbonate (LAV), and albite (AB). Mineral-zone boundaries of ore and gangue phases cross stratigraphic units in the Revett Formation. Worldwide, other stratabound copper-silver deposits exhibit similar crosscutting relations (Gustafson and Williams, 1981). The BN–CAL and CC–CHL zones in the middle and upper quartzites constitute ore, and these mineral zones coincide with color changes in the quartzite beds caused by diagenetic alteration. Fluids deposited the copper ore minerals bornite, digenite, and chalcocite as intergranular cements in permeable beds, and as replace-

Table 2. Production and resources of stratabound copper-silver deposits in the Revett Formation, western Montana and northern Idaho.

[Resource values are inplace estimates and do not account for losses due to mining; numbers in columns may not add correctly because of independent rounding. Resources in the Rock Creek deposit include those in the Horizon Basin, Copper Gulch, and Rock Peak deposits that could be mined together. Production from “others” is from the Snowstorm Mine only; resources are in the J–F, Missoula, Snowstorm, and Vermilion River deposits]

Deposit	Production			Remaining resource		
	Ore (10^3 tons)	Copper (tons)	Silver (tons)	Ore (10^3 tons)	Copper (tons)	Silver (tons)
Rock Creek	---	---	---	181,000	1,367,000	13,000
Montanore	---	---	---	150,000	1,170,000	10,300
Troy	33,742.5	194,652	1,516.3	12,000	78,000	580
Others	826.6	27,585	141.1	63,000	342,000	1,960
Total	34,569.1	222,237 (444.5 million lb)	1,657.4 (48.3 million troy oz)	406,000	2,957,000 (5,900 million lb)	25,840 (754 million troy oz)
Total (t)	31,361,600	201,610	1,503.6	368,000,000	2,682,545	23,442

ments of clasts and earlier cements, including preore biogenic pyrite. Most of the silver is in solid solution in copper minerals (~1 weight percent); lesser amounts occur as native silver and in stromeyerite. Local concentrations of ore minerals reflect faults and vertical permeability in the quartzite beds. On the basis of S-isotopic fractionation and fluid-inclusion microthermometry, the ore minerals were deposited at temperatures of 50–125°C in the GN–CAL zone and at 130–180°C in the BN–CAL and CC–CHL zones by fluids that contained 15 to 20 weight percent NaCl equivalent.

Mineralized Domains

Mineralized domains are defined as the surface projection of strata containing copper-silver resources in the Revett Formation identified from surface exposures, mine workings, and diamond-drill holes (fig. 6). Mineralized domains are divided into three categories: identified resources, indicated mineralized rock, and inferred mineralized rock (pl. 1). The locations of mineralized domains, which have been delineated at 30 of the 57 sites listed in table 1, are shown on plate 1 and in figure 6. Detailed definitions and ArcInfo interchange files of mineralized domains are included with this report.

The larger mineralized domains in the lower member of the Revett Formation include, from north to south (pl. 1), Ross Creek, J–F, Rock Creek, Star Gulch, McKay Creek, Sims Creek, Vermilion River, Trout Creek, Miller Gulch, and Clear Peak. Mineralized domains in the upper member of the Revett Formation include, from north to south (pl. 1), Troy, Snowstorm, Brooks Mountain, and Copper Rock. Mineralized domains in both the upper and lower members of the Revett Formation include the greater Troy complex (consisting of Hiatt Creek, Twilight Creek, Cub Creek, and Ross Point), Squaw Peak, and Military Gulch.

Low-Grade Mineralized Strata

In addition to the main ore-bearing units, low-grade mineralized strata occur in the Revett Formation and, at the Troy Mine (fig. 1), extend for hundreds of feet vertically and for miles horizontally beyond ore-bearing units (fig. 7). As used in this report, low-grade mineralized strata include rocks containing any amount of visible copper minerals. For example, low-grade mineralized strata in the A–D beds of the upper member of the Revett Formation extend 9 mi southward from the Troy Mine to subsurface occurrences and outcrops at Dry Creek (diamond-drill holes DC–1, DC–2, pl. 1) and Star Gulch (Grimes and Earhart, 1981), and 10 mi southeastward of the mine to Snake Creek (diamond-drill holes SC–1 through SC–5, pl. 1). Low-grade mineralized strata in the upper member of the Revett Formation extend from outcrops 0.6 mi southward of the Troy Mine to outcrops on Stanley Peak, 5 mi north of the mine (pl. 1).

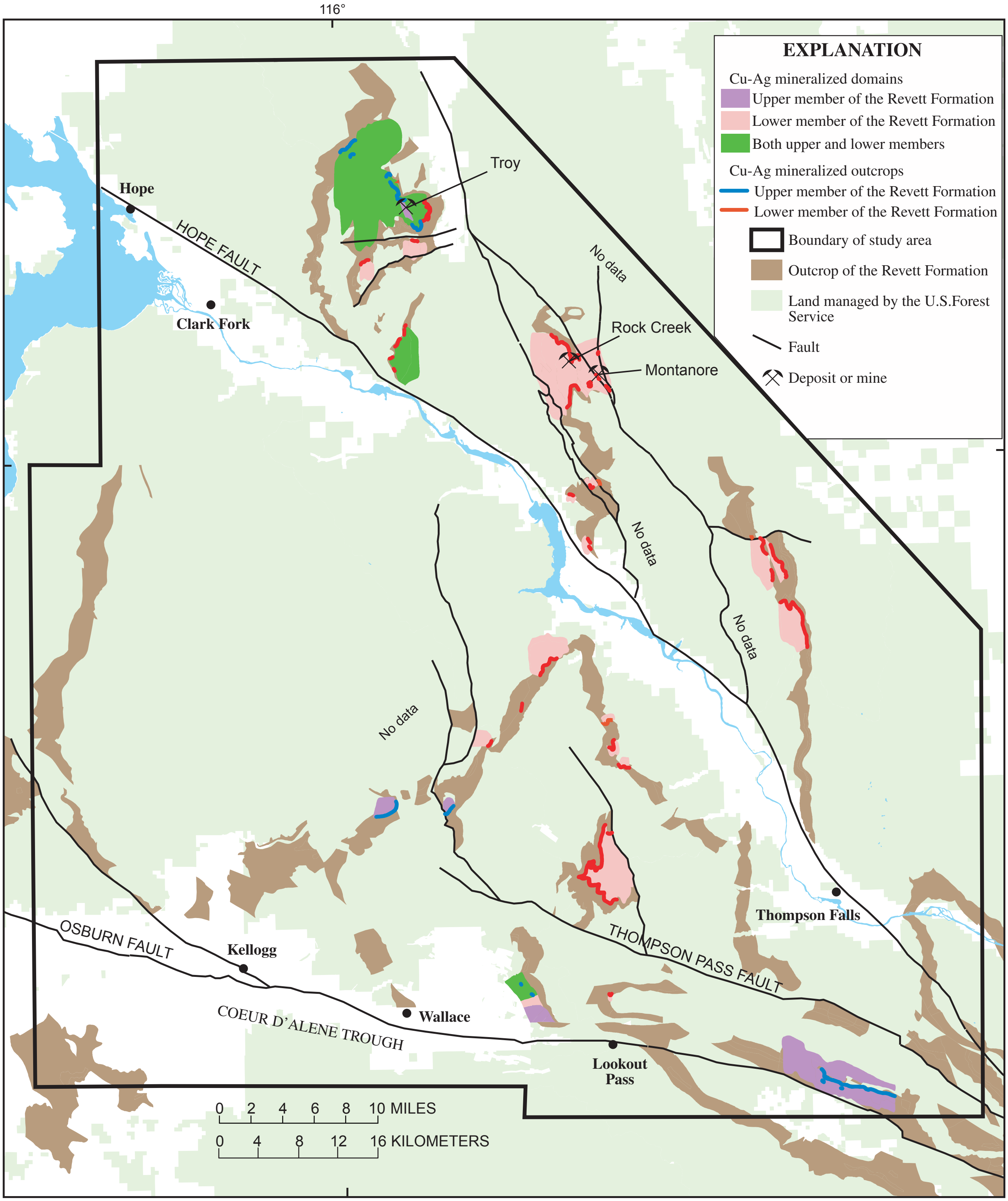

Figure 6. Map of the study area in western Montana and northern Idaho (pl. 1; fig. 1), showing mineralized domains in the western Montana copper belt.

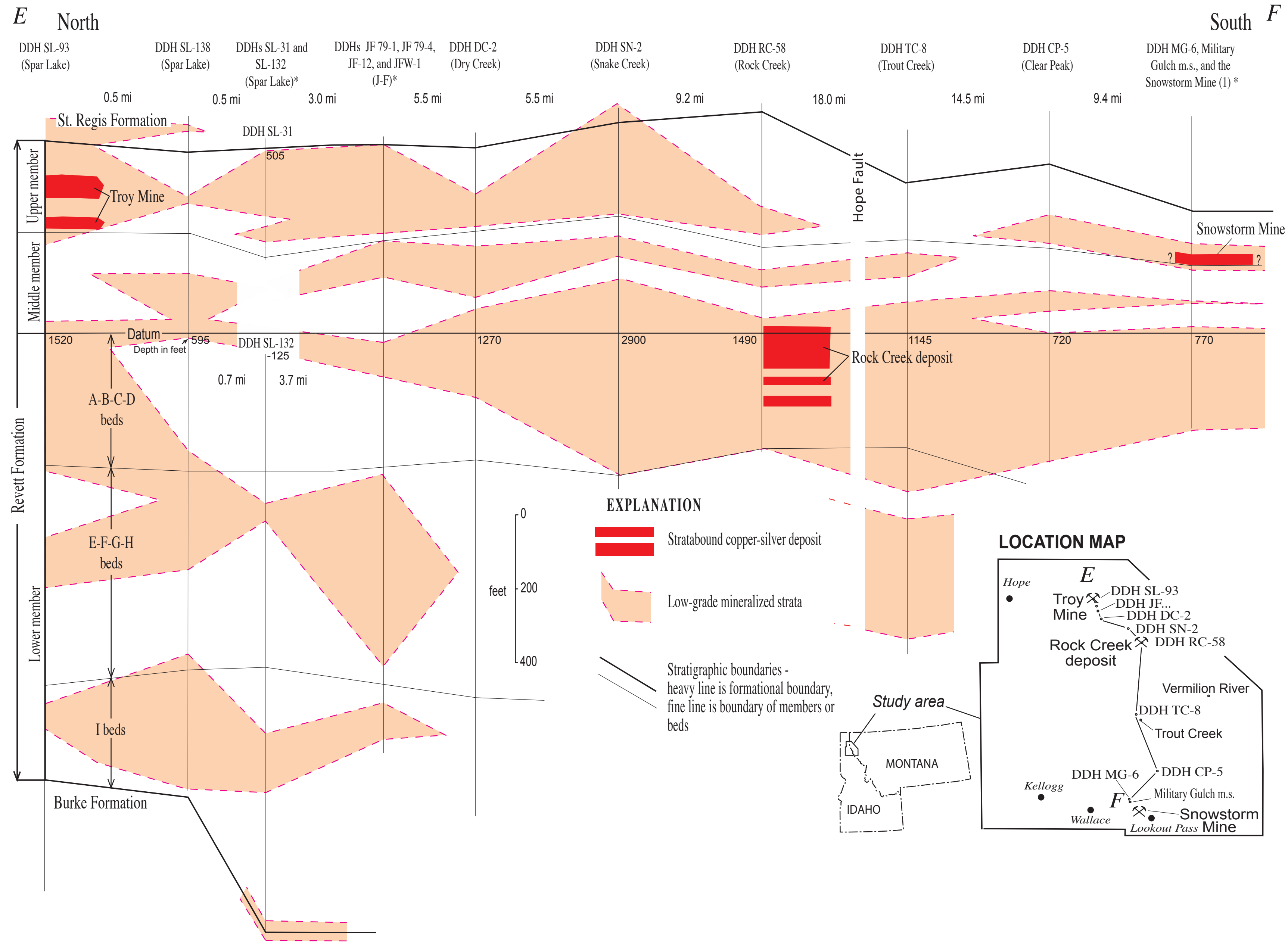

Figure 7. Schematic north-south cross section *E–F* across study area in western Montana and northern Idaho (pl. 1; fig. 1), showing horizontal and vertical extent of low-grade mineralized strata, based on core data from diamond-drill holes (DDHs). (1), unpublished data; *, composite section.

Low-grade mineralized strata containing disseminated copper and silver minerals (fig. 7) occur widely within at least three subparallel, near-horizontal mineralized zones in the Revett Formation. Other hydrothermal minerals—carbonates, pyrite (cubic or framboid), and galena—are ignored because they have different distribution patterns that overlap those of low-grade mineralized strata. Graphical logs (see app. A) show that strata containing visible copper occur over vertical ranges greater than 1,500 ft and horizontal distances exceeding 60 mi. At this regional scale, low-grade mineralized strata are recognized in the following sections of the Revett Formation: (1) the upper member and coarser grained parts of the middle member, (2) the A–D beds of the lower member, and (3) the F–I beds of the lower member. Graphical logs show that low-grade mineralized strata occur predominantly in medium-grained quartzite beds, particularly the white crossbedded vitreous quartzite of Winston (1986b). This occurrence appears to depend on the grain size of strata. Low-grade mineralized strata in the lower and upper members of the Revett Formation generally occur in coarser grained quartzite; the absence of such strata in the middle member may be related to its fine-grained texture. Argillaceous rocks are mineralized locally in the middle member but to a much lesser degree than in coarser grained units and only in the vicinity of a substantial thickness of coarser grained mineralized rocks. Continuous, low-grade mineralized strata cut obliquely across established bed and member boundaries.

The Troy and Snowstorm Mines are located within low-grade mineralized strata in the upper member of the Revett Formation, and the Rock Creek-Montanore, Trout Creek, and Vermilion River deposits occur within low-grade mineralized strata in the A–D beds of the lower member of the Revett Formation. The strongly mineralized F–I beds at the Trout Creek and J–F deposits occur within low-grade mineralized strata in both the lower and middle members of the Revett Formation.

Relation of Stratabound Copper-Silver Deposits to Host Rocks, Stratigraphic Thickness, Grain Size of Ore-Bearing Units, and Mineral Zones

The location of stratabound copper-silver deposits in the Revett Formation in the western part of the Belt Basin (pl. 1; fig. 1) are closely related to the stratigraphic and lithologic setting of the host rocks. Relations considered in detail here are the distribution of host rocks, the thickness of ore-bearing units, the grain size of clastic strata, and mineral zones in the Revett Formation as defined by Hayes (1983). Graphical logs based on core data from diamond-drill holes and on stratigraphic relations in measured sections (see app. A) were used for the construction of isopach maps.

Inverse-distance-squared weighting was used as a contour-map-interpolation method and was adjusted by considering the number of nearest-neighboring control points to obtain a reasonable presentation of the contours. The average number of nearest-neighboring control points used by this method was 12. Isopach and isolith maps were created with the Spatial Analyst extension for ArcView GIS (version 3.2) of the Environmental Systems Research Institute (ESRI), Redlands, Calif.

Host Rocks

Stratabound copper-silver deposits occur in well-sorted, fine- to medium-grained vitreous quartzite beds in the upper and lower members of the Revett Formation. The main ore bodies in the Rock Creek-Montanore deposits are in the A–D beds of the upper part of the lower member of the Revett Formation (fig. 8; U.S. Forest Service, 1993, 2001; Adkins, 1999). The Vermilion River, Trout Creek, Star Gulch, and Squaw Peak deposits (pl. 1) also occur in the upper part of the lower member, whereas copper at the J–F Prospect occurs in the I beds of the lower member. The middle member locally contains low-grade mineralized strata within quartzite beds (see table 1). The upper member hosts the Troy and Snowstorm Mines. Copper and silver at the Troy Mine occur in every bed of the upper member, whereas copper and silver at the Snowstorm Mine occur in a quartzite bed in the upper member, the only quartzite bed in the upper member at this locality. Most of the Troy deposit occurs in the middle quartzite of the upper member of the Revett Formation. The Niagara, Snowshoe, and Missoula-National deposits also occur in the upper member.

In contrast to the stratigraphic position of the ore bodies at the Troy Mine, copper-silver ores of the Snowstorm Mine and nearby Military Gulch deposit are in white vitreous quartzite in the lowermost part of the upper member of the Revett Formation, probably the lower quartzite. Copper-silver occurrences at Military Gulch are also in the A–C beds of the lower member of the Revett Formation (diamond-drill hole MG–6 and Lower and Upper Military Gulch measured sections, pl. 1; Hecla Mining Co., written commun., 1986; B.G. White, written commun., 1999; Mauk, 2001).

A total of 13 correlation diagrams were constructed by using 126 graphical logs of diamond-drill holes and measured sections. Correlations (cross secs. *A–B*, *C–D*, pl. 1; cross sec. *I–J*, fig. 8) were extended outward from the well-defined Troy Mine area, augmented by the data of Bowden (1977), Hayes (1983), Hayes and Einaudi (1986), T.S. Hayes (written commun., 1984, 2001, 2003), Wingerter (1982), and Mauk (2001), and the U.S. Geological Survey (this study). Cross sections were constructed from the data in appendix A.

Stratigraphic correlations were by conventional methods, as described by Tearpock and Bischke (1991). Correlations of members and bed boundaries, as described in appendix A, are shown in the cross sections on plate 2 and in figure 8. Correlations were checked by using adjacent diamond-drill-hole logs. Stratigraphic units are reasonably well defined at the Troy Mine and in other well-studied areas; however, the boundaries become less tenable and increasingly more subjective with increasing distance. North-south cross section *A–B* (pl. 2)

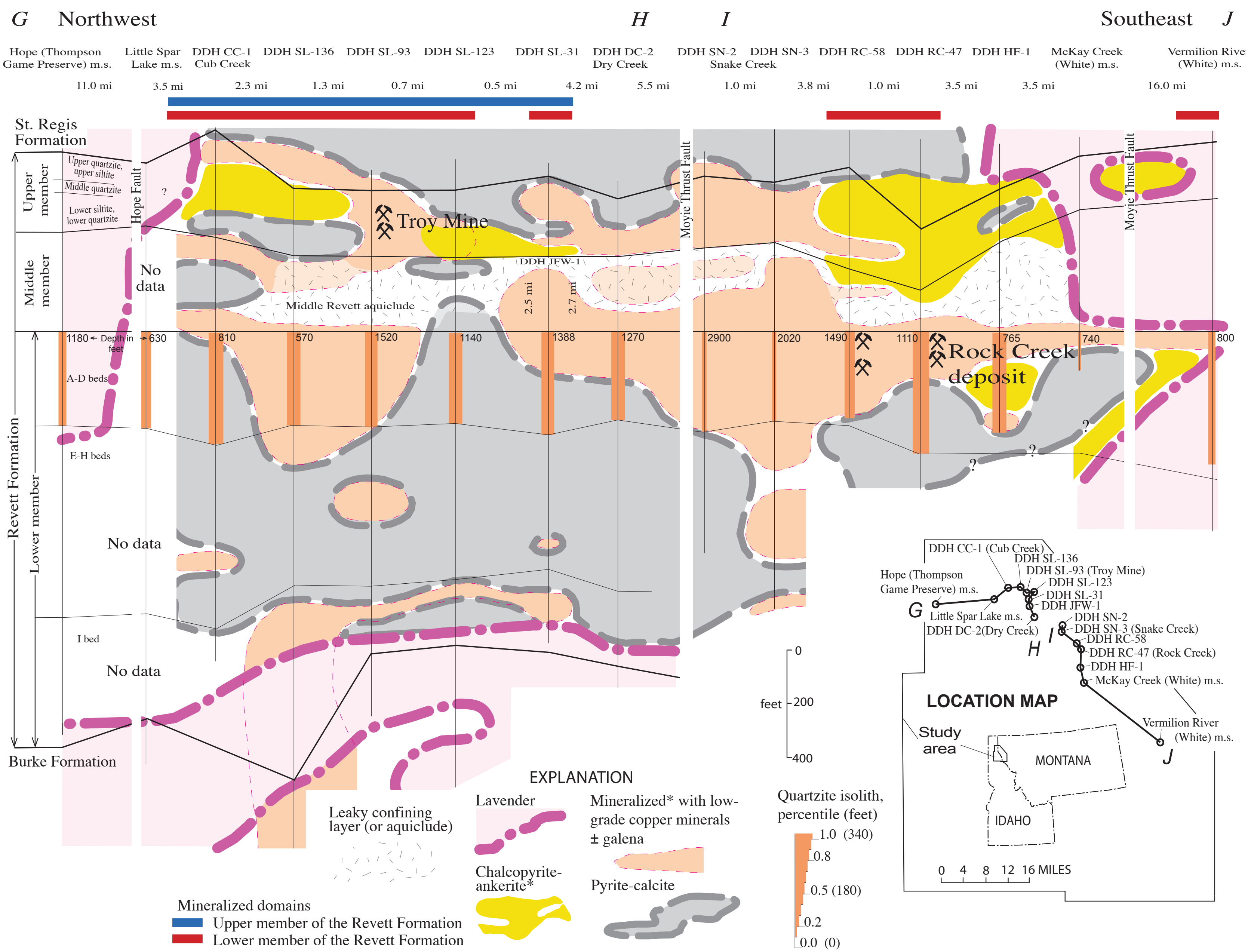

Figure 8. Lithologic cross sections *G–H* and *I–J* across north half of study area in western Montana and northern Idaho (pl. 1; fig. 1), showing stratigraphic setting and mineralized zones of stratabound copper-silver deposits in the Revett Formation, based on core data from diamond-drill holes (DDHs) and stratigraphic relations in measured sections (m.s.). *, ore grade not shown.

shows a continuity of sedimentary units from the Troy Mine (diamond-drill hole SL–123, pl. 1) to the Latour Peak-Boise Peak measured section, a distance of approximately 60 mi. The units can be traced for approximately 57 mi. in an east-west direction (cross secs. *G–H, I–J*, fig. 8).

Isopach Maps

Isopach maps were constructed for three key stratigraphic intervals in the Revett Formation: the A–D beds of the lower member (fig. 9), the middle member (fig. 10), and the upper member (fig. 11). In addition, isopach maps were constructed for the middle quartzite of the upper member (fig. 12) and the combined A–D beds of the lower member and the middle member and upper members (fig. 13). Thickness data for other strata in the lower member were insufficient to construct an isopach map.

The A–D beds of the lower member of the Revett Formation (fig. 9) range from 193 to 490 ft in thickness, with a mean of 339 ft. Southwest of the Hope Fault, the mean thickness of the A–D beds is 318 ft, and northeast of the Hope Fault 355 ft, an increase of 12 percent. The most conspicuous features of the A–D beds on the isopach map are two areas of broad, thick strata northeast of the Hope Fault separated by an area of thinner strata at the Vermilion River. The Rock Creek-Montanore deposits occur in an area where the A–D beds are relatively thick (>400 ft). No deposits are known in the other thick section of the A–D beds east of Thompson Falls (fig. 1).

The middle member of the Revett Formation (fig. 10) ranges from 101 to 466 ft in thickness, with a mean of 270 ft. The most conspicuous features of the middle member on the isopach map are areas of thick strata northeast of the Hope Fault. Two areas of broad, thin strata are present in the central parts of both blocks northeast and southwest of the Hope Fault. The middle member contains sparse Cu-Ag mineralization unrelated to its thickness.

The upper member of the Revett Formation (fig. 11) ranges from 120 to 399 ft in thickness (except for one control point 570 ft thick at the Thompson River), with a mean of 256 ft. The most conspicuous features of the upper member on the isopach map are areas of thick strata northeast of the Hope Fault. Southwest of the Hope Fault, the mean thickness of the upper member is 228 ft, and northeast of the Hope Fault 294 ft, an increase of 29 percent. The Troy deposit occurs in upper strata of the Revett Formation that are approximately 280 ft thick.

In the area northeast of the Hope Fault (fig. 12), the middle quartzite of the upper member of the Revett Formation ranges from 40 to 147 ft in thickness, with a mean of 86 ft. Thicknesses of only 45 to 50 ft were measured at Dry Creek and Goat Rocks, although tectonic attenuation cannot be ruled out. The thickness of the middle quartzite varies consistently with that of the upper member of the Revett Formation. Copper-silver mineralized rocks are more common within thicker parts of the middle quartzite of the upper member, such as at the Troy Mine and Cub Creek.

Isopach maps indicate that syndepositional tectonism in basement rocks significantly controlled sedimentation patterns, influencing the thickness and lithology of potential host rocks for metal deposits in the Belt Basin. The thickness of the combined A–D beds of the lower member and the middle and upper members of the Revett Formation is consistently greater northeast than southwest of the Hope Fault (fig. 13). Southwest of the Hope Fault, the Revett Formation ranges from 643 to 885 ft in thickness, with a mean of 775 ft, and northeast of the Hope Fault from 745 to 1,471 ft, with a mean of 948 ft, an increase of 22 percent, supporting Harrison and Cressman's (1993) observation that the Hope Fault was a down-to-the-north growth fault during deposition of the Revett Formation.

The change in thickness of the Revett Formation in the Coeur d'Alene Mining District in the vicinity of the Osburn Fault (fig. 1, Mauk, 2001) and in the area of the Latour Peak-Boise Peak and Kellogg measured sections (pl. 1) indicates that the Osburn Fault also was a growth fault with down-to-the-south normal movement during deposition of the Revett Formation. The thickness of the combined middle and upper members of the Revett Formations is 300 ft at Military Gulch north of the fault (diamond-drill hole MG–6) and 1,930 ft at the Latour Peak-Boise Peak measured section on the south side of the fault (cross sec. *A–B*, pl. 2), an increase of more than 500 percent. Similarly, the upper member of the Revett Formation thickens southward about 800 percent across the Osburn Fault.

Local basins with anomalously thick strata are scattered throughout the study area (pl. 1; fig. 1), indicating smaller-scale differential subsidence. These basins occur in all the members of the Revett Formation. Two areas of large, thick sedimentary strata are present: one along a northeast-trending belt northeast of the Hope Fault (figs. 9, 10, 11, 13), and the other south of the Osburn Fault in the Coeur d'Alene Trough, outside of the areas of contoured thicknesses shown in figures 9, 10, 11, and 13, suggesting syndepositional faulting or localized flexural subsidence near these faults.

Grain Size and Isoliths of Clastic Strata

In the Revett Formation, grain size provides a reasonable estimate of the effective porosity and permeability (or hydraulic conductivity) before lithification because an aquifer will transmit a volume of fluid proportional to its grain size (Fetter, 2000). The grain-size/permeability relation, which assumes that the sedimentary layers allowed fluid movement before cementation, is an approximation of the permeability before metal deposition. Although the original porosity, permeability, or hydraulic conductivity of the Revett Formation sediment cannot be measured directly because of its current degree of lithification, they can be estimated, as explained below.

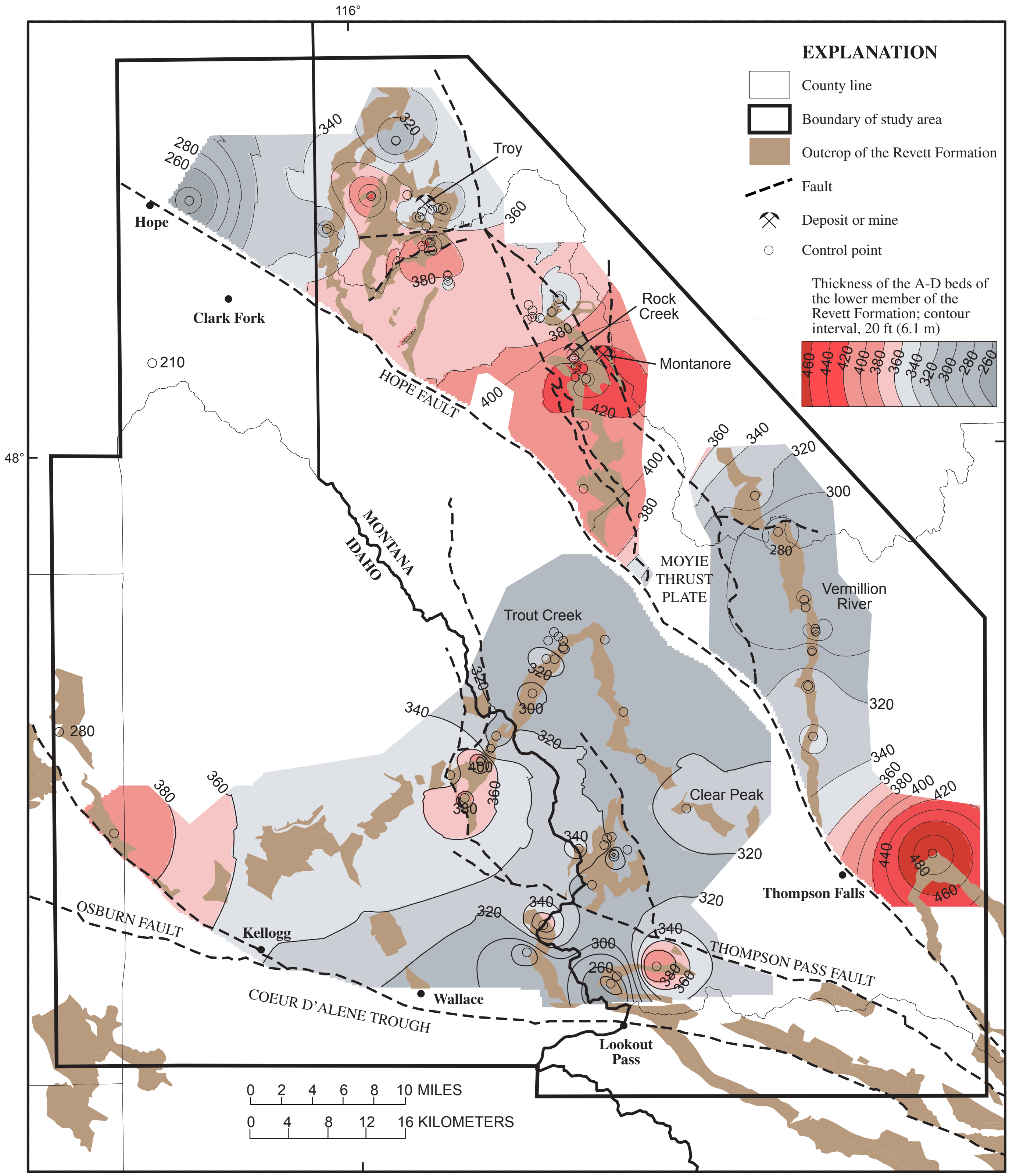

Figure 9. Isopach map of the A–D beds of the lower member of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1).

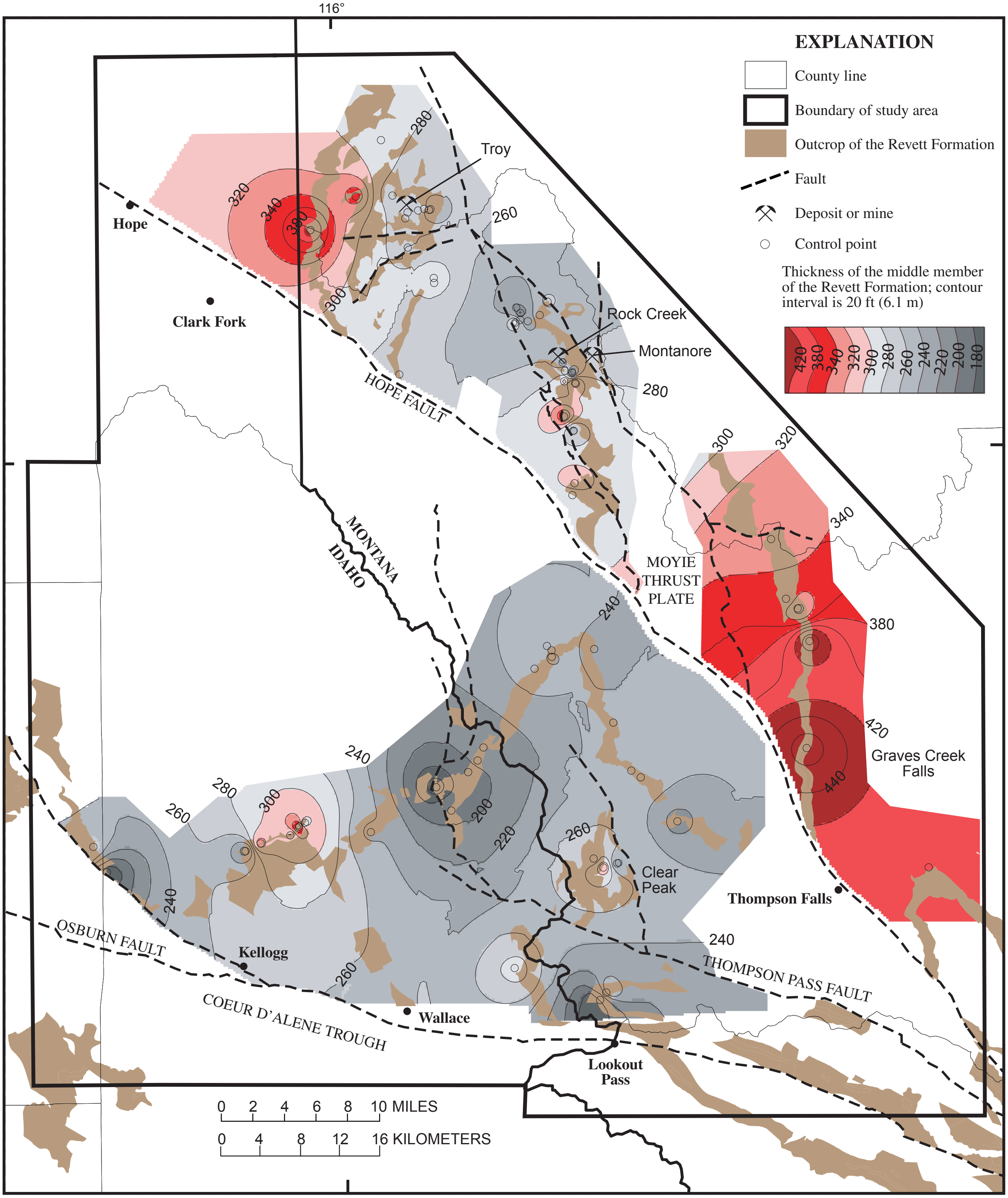

Figure 10. Isopach map of the middle member of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1).

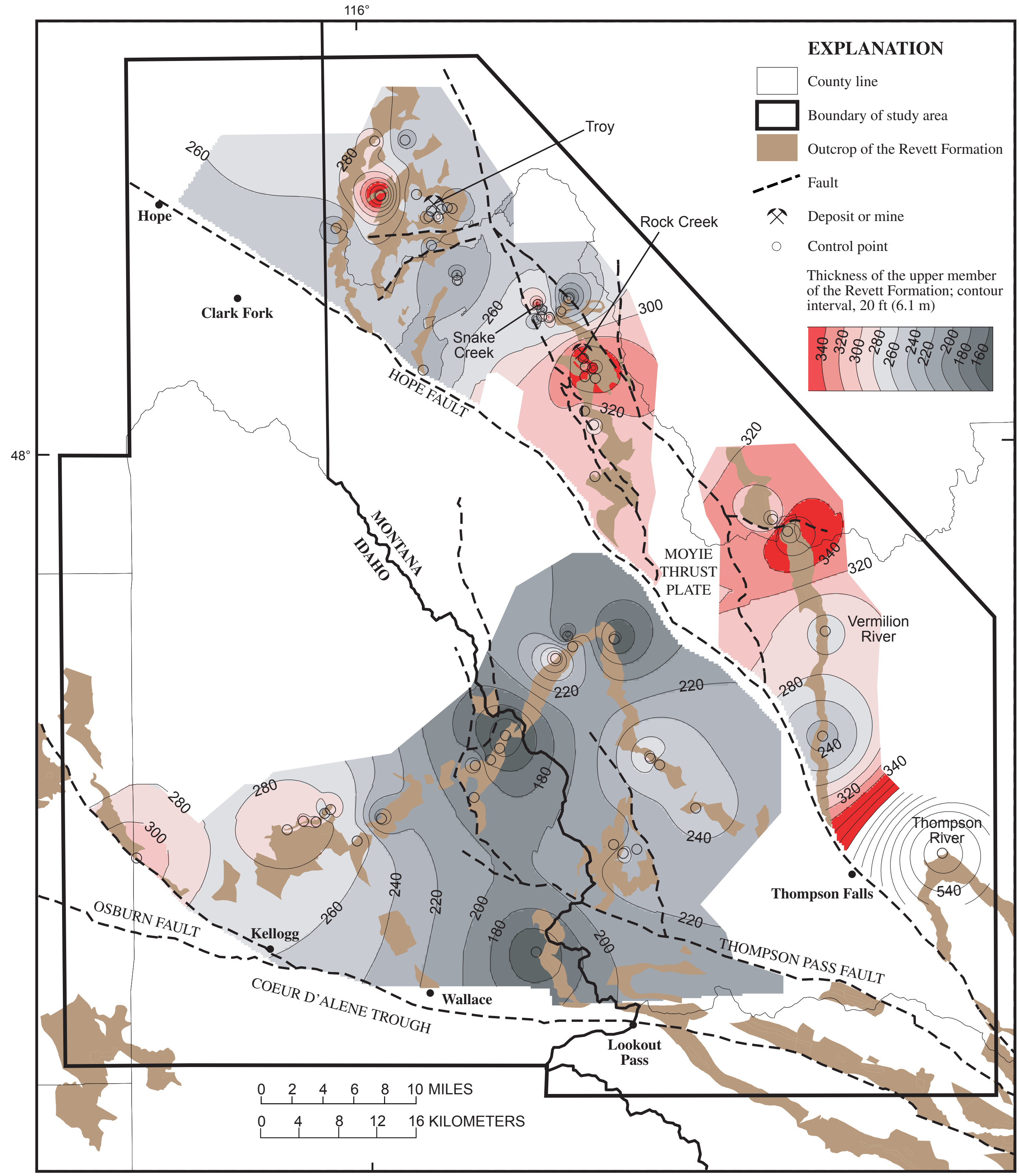

Figure 11. Isopach map of the upper member of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1).

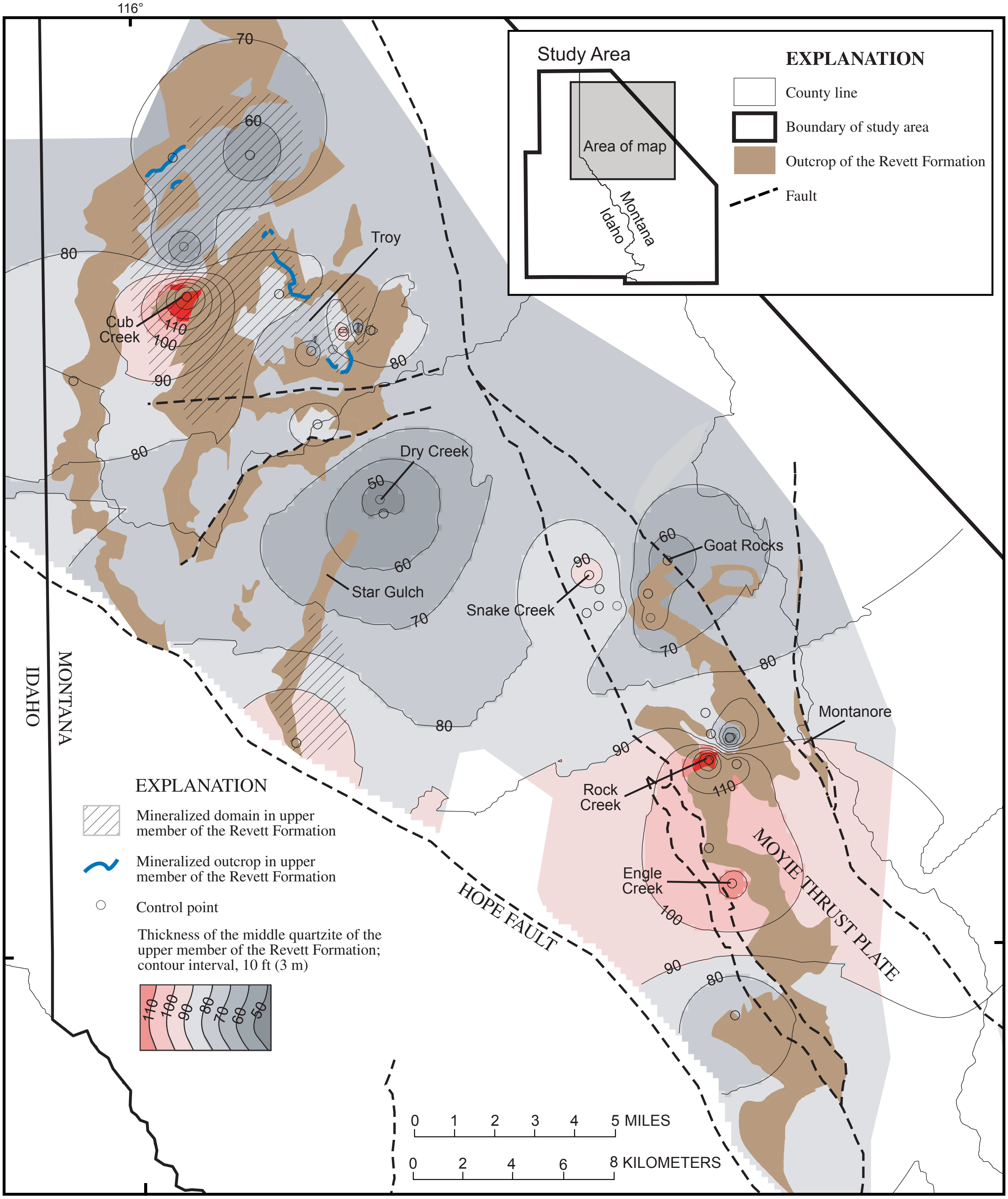

Figure 12. Isopach map of the middle quartzite of the upper member of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1).

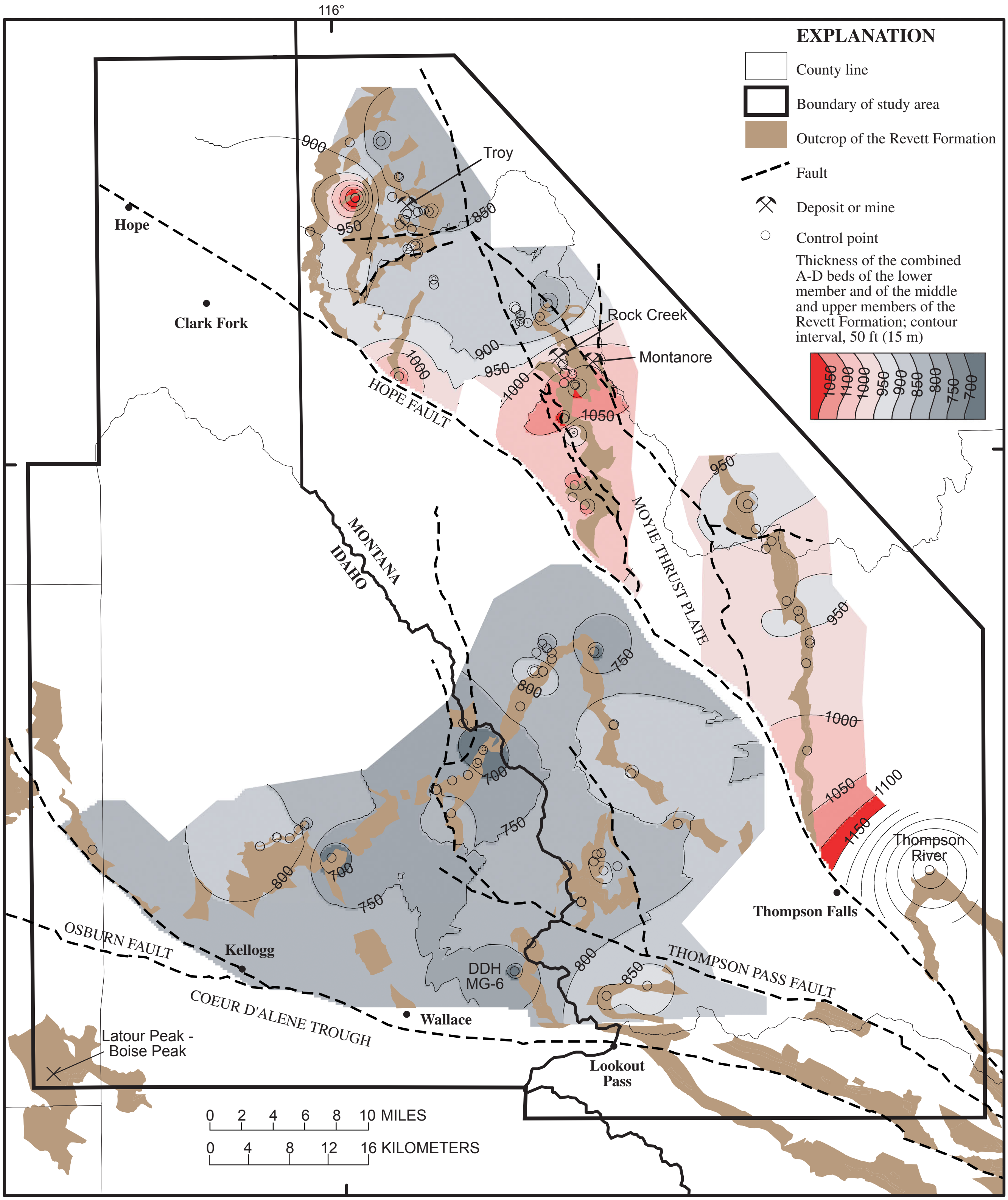

Figure 13. Isopach map of the A–D beds of the lower member and the middle and upper members of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1).

The transmissivity of an aquifer is defined as the volume of water that can be transmitted horizontally through a unit width of the aquifer at a hydraulic gradient of 1 (Fetter, 2000). Hazen (1911) developed a formula for approximate hydraulic conductivity, based on effective grain size and a sorting coefficient, that is commonly used by hydrologists (reviewed by Fetter, 2000). The expression for transmissivity, T, is given by

$$T = hk, \qquad (1)$$

where h is the saturated thickness (in feet) and k is the hydraulic conductivity. The Hazen approximation for hydraulic conductivity, k, is given by

$$k = Cd^2, \qquad (2)$$

where C is the sorting coefficient and d is the effective grain size (dimensionless). Combining equations 1 and 2,

$$T = hCd^2 \text{ (Hazen approximation)}, \qquad (3)$$

which is the basis for equating the transmissivity of an aquifer with accumulated thickness of the coarsest grained rock strata.

The quartzite isoliths (fig. 14; Levorsen, 1958; Krumbein and Sloss, 1963; Low, 1977; Miall, 2000) are the cumulative thicknesses of quartzite in a diamond-drill hole or measured section of the A–D beds of the lower member of the Revett Formation. Except for extremely sparse conglomerate, quartzite is the coarsest grained clastic rock in the Revett Formation. Strata finer grained than quartzite—namely, silty quartzite, slightly silty quartzite, siltite, and argillite—are omitted from the isoliths. Grain-size data were obtained by reference to a grain-size chart. Thickness was determined to the nearest foot with measuring tapes (T.S. Hayes, oral commun., 2003).

A difficulty with preparing isolith maps is that the lithologic descriptions in widely spaced diamond-drill holes and measured sections may not be consistent from locality to locality because of subjectivity in interpretation of the stratigraphic relations. For example, some geologists might describe a rock as quartzite, a rock type included in the isolith, whereas others might describe a similar rock as silty quartzite, a rock type omitted from the isolith. Also, covered intervals along measured sections are not considered. In spite of these shortcomings, we believe that the isolith maps (figs. 14, 15) show the general abundance of quartzite in the A–D beds and provide an approximate measure of regional fluid transmissivity.

Quartzite isoliths demonstrate the high degree of spatial correlation between mineralized domains and the thickness of coarse-grained strata in A–D beds of the Revett Formation (fig. 15). Isoliths range from 0 to 340 ft, with a mean of 180 ft. The A–D beds of the lower member of the Revett Formation that exceed the 180-ft quartzite isolith extend over a broad area that includes stratabound copper-silver deposits, mineralized domains, and low-grade mineralized strata as follows, from north to south: Troy, J–F, Star Gulch, Rock Creek-Montanore, Vermilion River, Trout Creek, Miller Gulch, Clear Peak, and Military Gulch (diamond-drill hole MG–6, pl. 1). A statistical analysis for the A–D beds indicates that the mean-or-greater quartzite isolith has an 87-percent spatial correlation with mineralized domains. Therefore, the area of mean-or-greater thickness (>180 ft) of the A–D beds of the lower member of the Revett Formation, interpreted as a paleoaquifer during or shortly after deposition of the Revett Formation, is highly correlated with the mineralized domains of stratabound copper-silver deposits in the Revett Formation (black-lined pattern, fig. 15).

Mineral Zones

The distribution and extent of mineral zones in the Revett Formation is an important guide for understanding the migration paths of fluids that formed ore deposits and low-grade mineralized strata. Mineral zones associated with stratabound copper-silver deposits in the Revett Formation were described by Hayes (1983, 1990), Hayes and Einaudi (1986), and Hayes and others (1989), as summarized in a preceding section (pl. 2; figs. 8, 16). The mineral zones used in this report are synonymous with Hayes' (1990) diagenetic-cementation sequences and are defined by the appearance, disappearance, and abundance of authigenic sulfide and gangue minerals. Hayes and Einaudi (1986) defined six mineral zones at the Spar Lake deposit. The AB zone, which is outside of the ore-bearing areas and mineral zones described above, may represent source rocks for copper and silver (Hayes, 1990), whereas the other mineral zones, except for the PY–CAL and LAV zones, are alteration assemblages associated with the formation of stratabound copper-silver deposits.

Rocks of the PY–CAL zone are dark green, and rocks of the LAV zone are pink to lavender. Color differences are attributed to the relative abundances of hematite and clay mineral grains in quartzite beds (Hayes, 1990). Coloration of pink-lavender quartzite beds of the LAV zone is derived from early diagenetic hematite-clay dust rims that encircle quartz grains. Such characteristics are absent in unaltered green quartzite beds of the PY–CAL zone.

The PY–CAL/CP–ANK boundary is an important transition because base and precious metals were deposited near it (Hayes and Einaudi, 1986). Hayes (1990) interpreted this boundary to generally correspond to the position of the original contact between red (LAV zone) and green (PY–CAL zone) strata, which is considered to be the boundary between reduced and oxidized rocks. The boundary cuts across stratigraphy and appears to have migrated vertically and horizontally from bed to bed as viewed in profile (Hayes and Einaudi, 1986; Hayes, 1990). The intervening CP–ANK zone is tongue shaped at the Troy Mine, and Hayes (1983) and Hayes and Einaudi (1986) reported that this zone extends several miles southeasterly from the mine.

The CC–CHL, BN–CAL, CP–CAL, and GN–CAL zones form a narrow transition zone between the CP–ANK and PY–CAL zones. The BN–CAL and CC–CHL zones in the middle and upper quartzites of the Revett Formation constitute ore in the Spar Lake deposit (Hayes and Einaudi, 1986). In figures

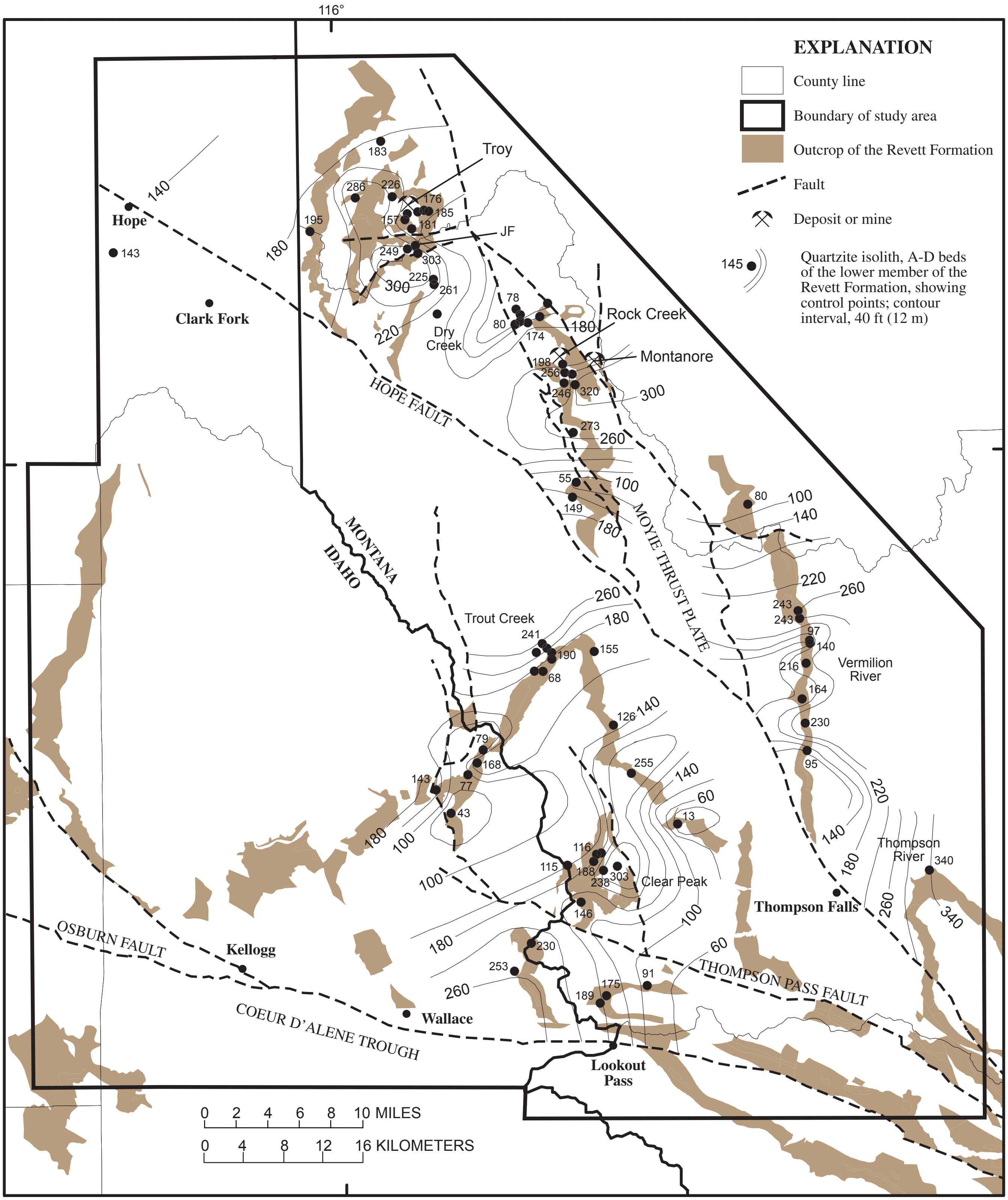

Figure 14. Quartzite isolith map of the A–D beds of the lower member of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1).

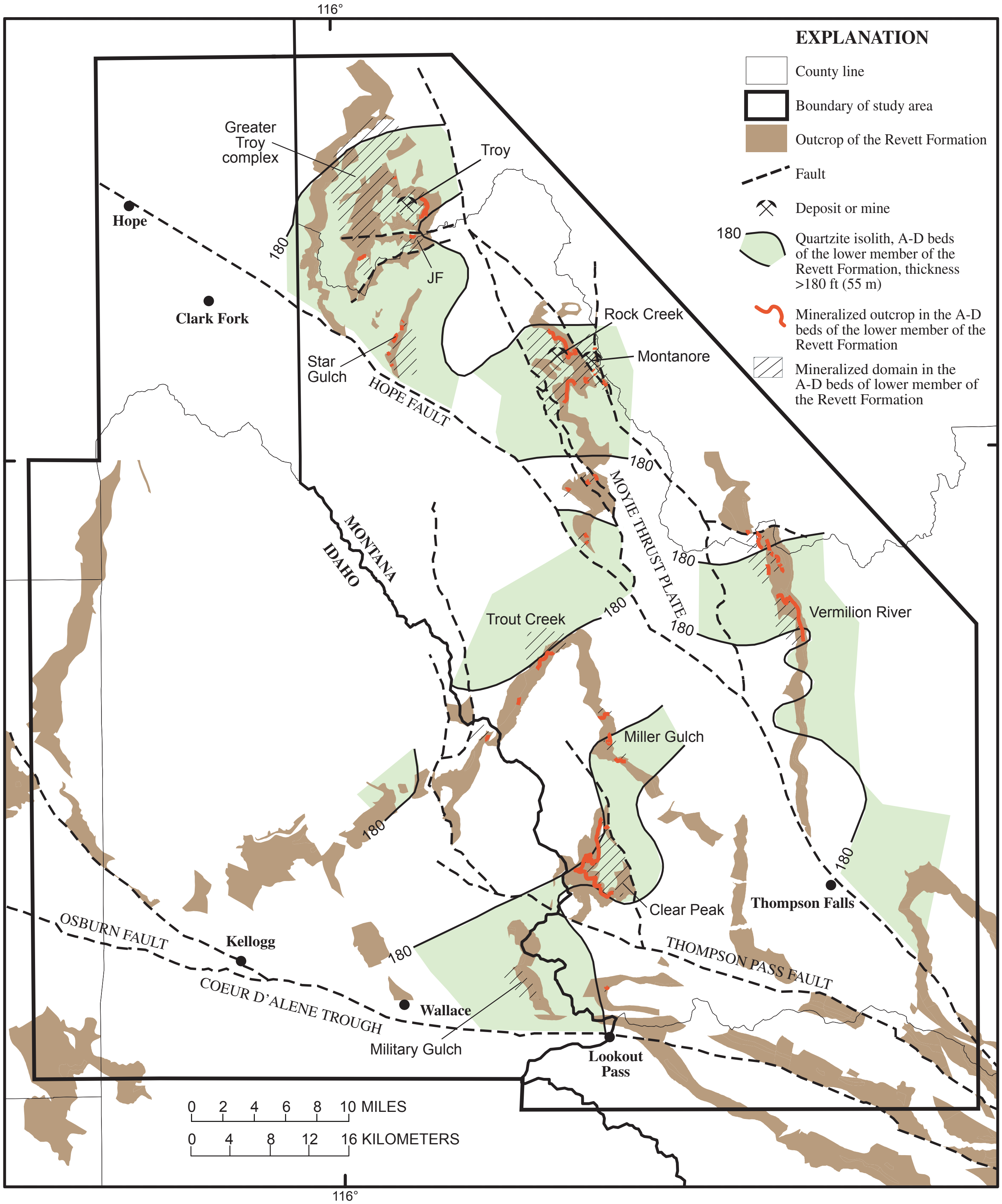

Figure 15. Mean-or-greater (≥180 ft [55 m]) quartzite isolith map of the A–D beds of the lower member of the Revett Formation in study area in western Montana and northern Idaho (pl. 1; fig. 1), in relation to mineralized domains.

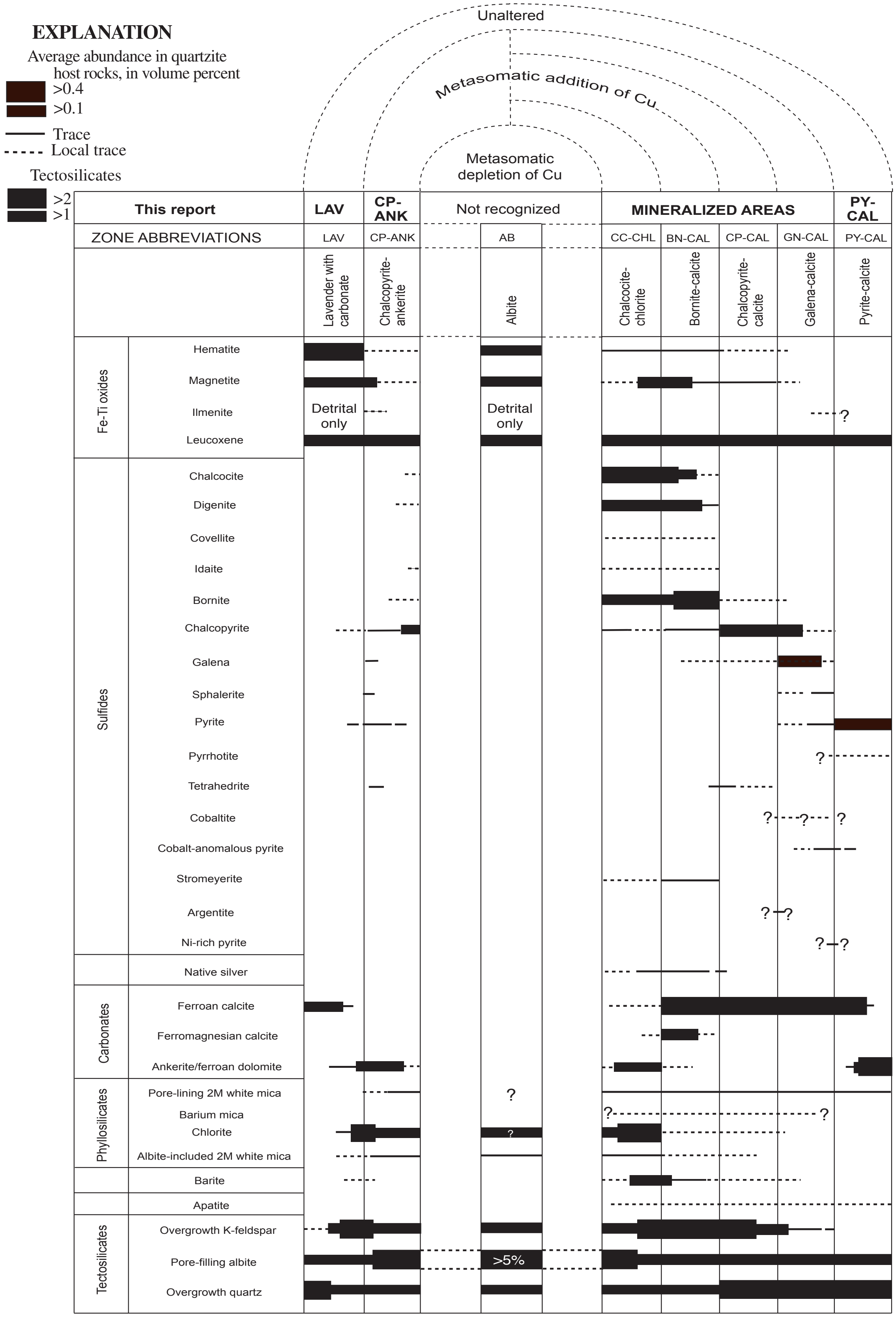

Figure 16. Diagram of mineral zones in Revett-subtype stratabound copper-silver deposits, showing nomenclature based on diagenetic-cementation sequences of Hayes (1983, 1990) and Hayes and Einaudi (1986) used for the Troy Mine in study area in western Montana and northern Idaho (pl. 1; fig. 1). Combined mineral zones used in this report are shown at top.

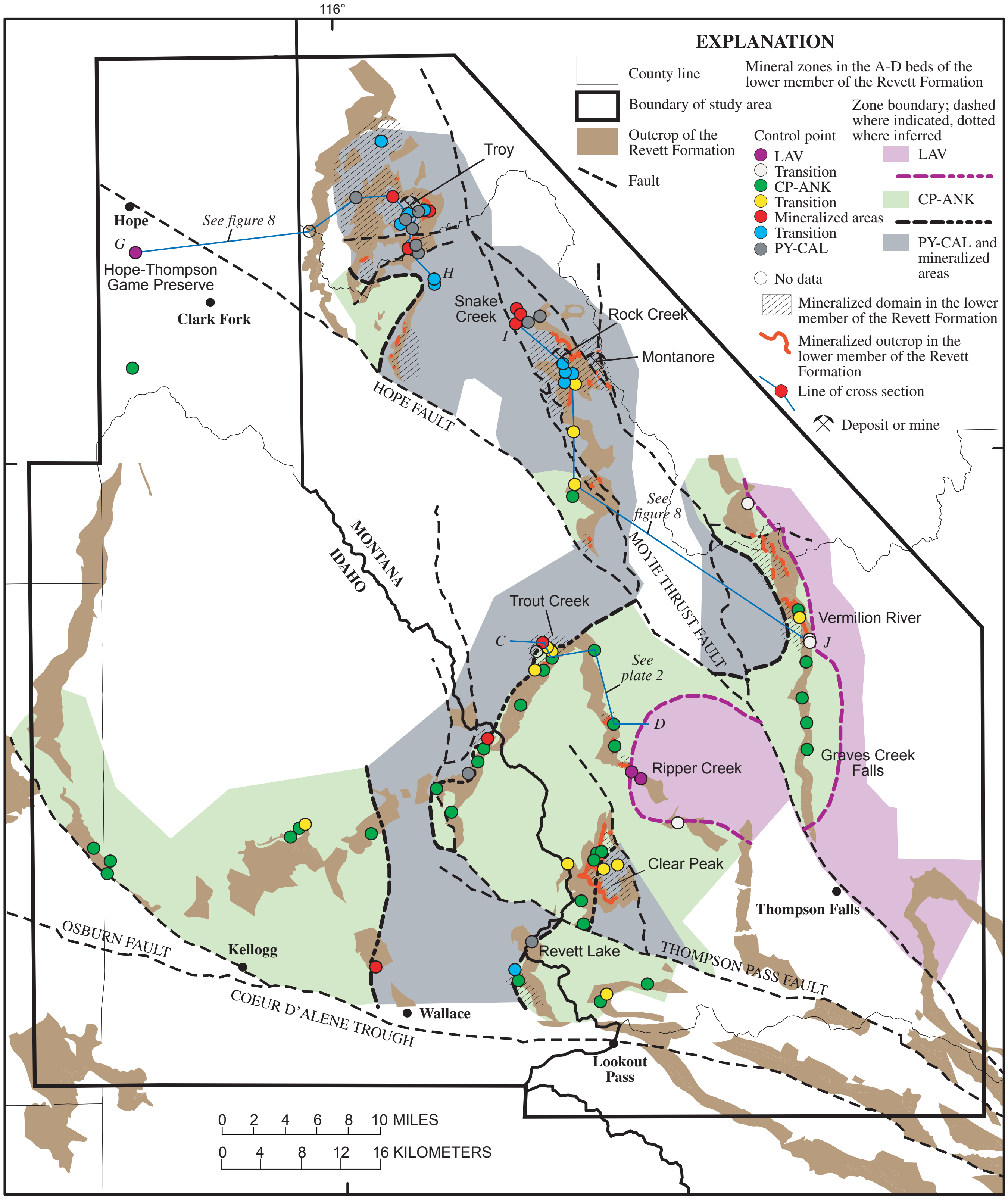

Figure 17. Map of the study area in western Montana and northern Idaho (pl. 1; fig. 1), showing areal extent of mineral zones in the A–D beds of the lower member of the Revett Formation.

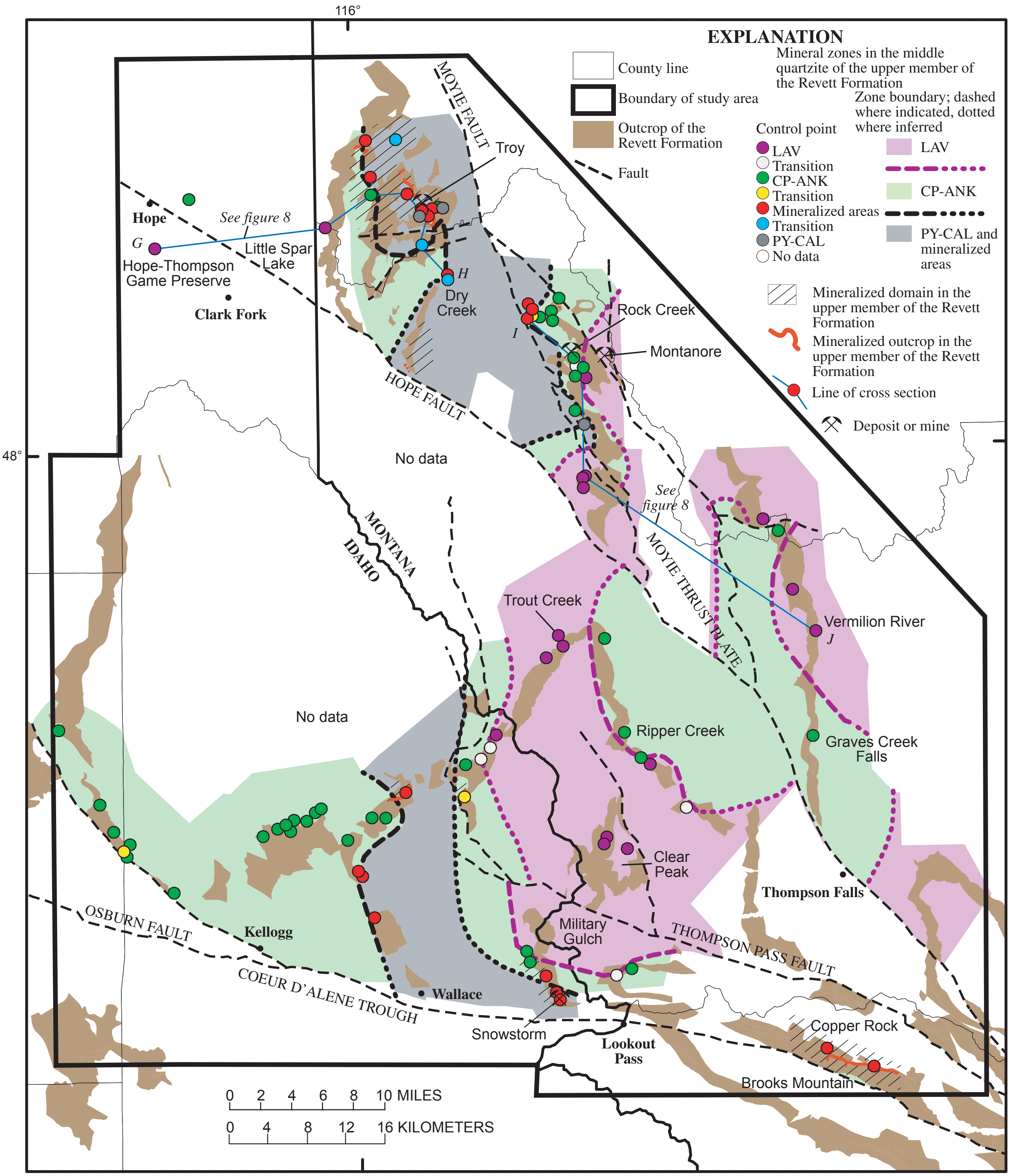

Figure 18. Map of the study area in western Montana and northern Idaho (pl. 1; fig. 1), showing areal extent of mineral zones in the middle quartzite of the upper member of the Revett Formation.

17 and 18, the ore-bearing CC–CHL, BN–CAL, CP–CAL, and GN–CAL zones are grouped together and referred to as "mineralized areas" to show relatively small areas of alteration on the regional maps. Although the distribution of galena was not studied in detail, strata containing abundant galena are spatially distributed between the PY–CAL zone and copper-silver mineralized strata shown in cross sections *A–B* and *C–D* (pl. 2). The other mineral zones shown specifically are the LAV, CP–ANK, and PY–CAL zones, along with transitional areas of alteration.

Grain-size characteristics of strata in the Revett Formation considerably control the stratigraphic positions of the CP–ANK and PY–CAL zones and low-grade mineralized strata (cross secs. *G–H*, *I–J*, fig. 8), although the boundaries between mineral zones are generally indistinct and transitional across stratigraphic units. The importance of grain size is evident where the relatively fine grained middle member of the Revett Formation appears to have acted as an aquiclude (fig. 8) or semipermeable layer that effectively separated low-grade mineralized strata in the upper member above from those in the A–D beds below.

Distribution

Mineral zones are conspicuous in the A–D beds of the lower member and in the middle quartzite of the upper member of the Revett Formation. In the A–D beds (fig. 17), the PY–CAL zone is present in an irregular, generally north-south trending belt in the center of the study area (pl. 1; fig. 1) flanked on each side by CP–ANK zones (cross secs. *G–H*, *I–J*, fig. 8). East of the CP–ANK zone is the LAV zone. In the middle quartzite of the upper member (fig. 18), mineral zones are approximately symmetrical in the northern part of the study area, with a core PY–CAL zone flanked by the CP–ANK zone. The LAV zone lies east of the CP–ANK zone. In the southern part of the study area, the distribution pattern for the middle quartzite of the upper member is more complex, consisting, from west to east, of north-south-trending irregular belts of CP–ANK, PY–CAL, CP–ANK, LAV, CP–ANK, and LAV zones. The core PY–CAL zone is evident on maps of both the A–D beds of the lower member of the Revett Formation (fig. 17) and the middle quartzite of the upper member of the Revett Formation (fig. 18). Mineral zones on the east side of this core PY–CAL zone at Trout Creek are shown on plate 2 (cross sec. *C–D*).

Northeast of the Hope Fault, the relatively well studied mineralized domains at the Troy Mine and Rock Creek (fig. 1) are along both the west and east borders of a broad belt of PY–CAL zones (figs. 17, 18). The belt of PY–CAL zones in the A–D beds of the lower member of the Revett Formation is many miles wider than in the middle quartzite of the upper member (figs. 17, 18). In the A–D beds of the lower member, the core PY–CAL zone extends from near the Idaho-Montana State line southeastward to the Rock Creek deposit. The core PY–CAL zone in the middle quartzite of the upper member extends from west of the Troy Mine to approximately 1 mi west of Rock Creek. The LAV zone in the middle quartzite of the upper member extends from east of Rock Creek to the east boundary of the study area (pl. 1; fig. 1), but is absent in the lower member in the same area. Lavender quartzite is present in the middle and upper members, and in part of the lower member of the Revett Formation in a measured section in Hope-Thompson Game Preserve southwest of the Hope Fault, 14 mi west of the Troy Mine (figs. 17, 18).

Displacement

Sevier-Laramide movements on the major strike-slip and thrust faults (Hope, Thompson Pass, Moyie, and Osburn) in the study area (pl. 1; fig. 1) appear to have displaced mineral-zone boundaries (fig. 17, 18). Mapping shows that the Hope Fault displaces the boundaries between the LAV, CP–ANK, and PY–CAL zones both in the A–D beds of the lower member and in the middle quartzite of the upper member of the Revett Formation. In the middle quartzite, the Hope Fault offsets the LAV zone between Graves Creek Falls and Ripper Creek (fig. 18), where it surrounds an "island" of CP–ANK zone. The Thompson Pass Fault offsets mineral zones in the A–D beds of the lower member between Clear Peak and Revett Lake (fig. 17), creating an "island" of PY–CAL zone around Clear Peak, a pattern further complicated by removal of strata by erosion.

Relations Between Grain Size, Stratigraphic Thickness, and Mineral Zones in Host Rocks at the Trout Creek Prospect

Cross section *C–D* (pl. 2) through the Trout Creek prospect (fig. 1) provides an instructive comparison of the relations between grain size, stratigraphic thickness, and mineral zones in host rocks across rapidly changing sedimentary and alteration facies. Although copper-silver reserves have not been identified, the Trout Creek area contains abundant copper-silver mineralized strata in the A–D and F–I beds of the lower member of the Revett Formation.

Mapping at the Trout Creek prospect (fig. 1) shows that mineralized strata in the Revett Formation are present at or near the PY–CAL/CP–ANK boundary. Copper-silver mineralized strata along this boundary form a broad zone where the alteration changes from PY–CAL to CP–ANK in the northwestern part of the prospect (bold gray line, cross sec. *C–D*, pl. 2), and from CP–ANK to LAV in the southeastern part (bold purple line, cross sec. *C–D*). In diamond-drill holes TC–8 and TC–9 (pl. 1), the PY–CAL zone and rocks containing galena, chalcopyrite, and calcite occur in the lower member of the Revett Formation and in proximity to thick intervals of mineralized strata. Rocks containing galena, chalcopyrite, and calcite occur between and irregularly overlap the PY–CAL zone and mineralized strata. Eastward in diamond-drill hole TC–7A, the vertical extent of the PY–CAL zone and mineralized strata diminishes; instead, the CP–ANK zone is predominant in these strata. Farther east,

Table 3. Thicknesses and isoliths in the A–D beds of the lower member of the Revett Formation in the Trout Creek Prospect area, western Montana

Diamond-drill hole (DDH) or measured section	Thickness of the A-D beds (ft [m])	Quartzite isolith: cumulative thickness of quartzite in the A–D beds (ft [m])
White Pine Creek 2, 3, 4	310 (94)	126 (38)
Trout Creek 1 and 2[1]	315 (96)	155 (47)
Trout Creek (White)	280 (85)	190 (58)
DDH TC–7A	322 (98)	252 (77)
DDH TC–8	308 (94)	264 (80)
DDH TC–9	314 (96)	241 (73)

[1]Part of this measured section is covered; covered strata are omitted from reported thickness.

LAV strata gradually replace CP–ANK strata. The distribution of these mineral zones suggests that the area around and west of diamond-drill holes TC–7A, TC–8, and TC–9 (also west of a north-south line connecting diamond-drill holes C–5, TC–9, and TC–10) is favorable for the occurrence of copper-silver mineralized strata.

Cross section *C–D* (pl. 2) is useful in predicting proximity to mineralized strata. Along a northwest-trending line from the White Pine Creek measured section northwestward to diamond-drill hole TC–9 (pl. 1), we note that (1) the A–D beds of the lower member of the Revett Formation thicken from 310 to 314 ft, (2) the quartzite isolith of the lower member of the Revett Formation increases from 126 to 241 ft (table 3), and (3) an increase in the thickness of the PY–CAL zone corresponds to a decrease in the thickness of the LAV and CP–ANK zones.

Permissive Tracts

Permissive tracts for undiscovered Revett-subtype stratabound copper-silver deposits may be defined on the basis of the descriptive model for this subtype (D.P. Cox, written commun., 2002; Cox and others, 2003). The permissive tracts lie within untested exploration areas—areas that have not yet been explored by drilling (pl. 3). The recognition of permissive tracts is based on the presence or absence of various geologic characteristics and indicators of Revett-subtype stratabound copper-silver deposits. Other workers (Box and others, 1996; Spanski, 1992) defined tracts as permissive or favorable for the occurrence of a specific mineral-deposit type, or used numeric methods to predict the probability of a deposit, given the characteristics of the area (Singer, 1993; Boleneus and others, 2001b). Criteria used here to define permissive tracts for Revett-subtype stratabound copper-silver deposits require that the area (1) is underlain by the Revett Formation to a depth of 8,000 ft (pl. 3c), (2) contains alteration minerals indicative of proximity to the PY–CAL/CP–ANK boundary (pls. 3a, 3b), and (3) is near stratabound copper-silver deposits or occurrences in the Revett Formation.

Permissive tracts (area, ~556 mi^2) are mostly cospatial with untested exploration areas (pls. 3c, 3d), except on the east side of the Trout Creek anticline and in Lincoln and Sanders Counties from Waloven Creek to Graves Creek Falls (pl. 1). The west side of both these areas is considered permissive because mineral deposits occur near the PY–CAL/CP–ANK boundary, a position that is favorable for mineral deposits, whereas the east side of these areas is associated with the LAV/CP–ANK boundary, a position that is generally unfavorable for mineral deposits.

Conclusions

Analyses of the settings of stratabound copper-silver deposits in the Mesoproterozoic Revett Formation, based on stratigraphic thicknesses, mineral deposits and occurrences, and gangue and ore-mineral distribution (mineral zones), reveal the following relations:

- The upper, middle, and lower members hosting stratabound copper-silver deposits are traceable, with reasonable certainty, across the study area (pl. 1; fig. 1). The A–D beds, which contain the Rock Creek-Montanore deposits, in addition to the E–H and I beds of the lower member, are traceable across the study area. The middle quartzite of the upper member, which contains the Troy deposit, is most confidently recognized in the area northeast of the Hope Fault.
- Differences in the thickness of the stratigraphic succession indicate that the Hope and Osburn Faults were active during deposition of the Revett Formation.

Syndepositional normal-fault movements were down on the northeast side of the Hope Fault and down on the south side of the Osburn Fault. In comparison, the area between the Hope and Osburn Faults either subsided less or was subjected to periodic erosion during deposition of the Revett Formation, or both, because the thickness of the Revett Formation is substantially less in this area.

- An irregular, north-south-trending PY–CAL zone occupies a core area in the center of the western Montana copper belt. This core PY–CAL zone is flanked by a CP–ANK zone and by an oxidized LAV zone that extends eastward of the study area (pl. 1; fig. 1). Regionally, these mineral zones strongly correlate with the distribution of stratabound copper-silver deposits in the Revett Formation. On the basis of the mineral zones, an area of ~556 mi^2 is classified as permissive for the occurrence of undiscovered stratabound copper-silver deposits. On the basis of the deposit model for the Troy Mine (Cox and others, 2003), the permissive tracts lie near the PY–CAL/CP–ANK boundary in the A–D beds of the lower member and in the middle quartzite of the upper member of the Revett Formation.
- Areas of high-transmissivity paleoaquifers, as indicated by quartzite isoliths, are spatially correlated with the distribution of mineral zones and stratabound copper-silver deposits.
- Stratabound copper-silver deposits are likely to occur in thick, coarse-grained units within the upper member of the Revett Formation, in minor sandstone beds of the middle member of the Revett Formation, and in the A–D and F–I beds of the lower member of the Revett Formation.

Databases and Spatial-Data Files for the Geology and Mineral Deposits of the Revett Formation

By David E. Boleneus, Larry M. Appelgate, Mary H. Carlson, Derrick W. Chase, and Michael L. Zientek

Introduction

This section presents databases and spatial-data files for the geology and mineral deposits of the Revett Formation (table 4). Records of 40 diamond-drill cores and 86 measured sections, for a total of 150,752 ft of true thickness, include field data compiled into Microsoft Excel spreadsheets and graphical logs in Adobe Portable Document Format (PDF) that summarize the observations. The text file *cuag_deposit.txt* provides detailed descriptions of the 57 Revett-subtype stratabound copper-silver deposits, occurrences, and prospects in the western Montana copper belt. Spatial databases (ArcInfo coverages) contain location data from the diamond-drill cores (*rev_ddh*) and measured sections (*rev_msec*). The spatial data also include files for the regional geology of the Revett Formation (*rev48k*); copper-silver mineralized domains, unexplored areas, and permissive tracts (*rev_cuag*); and mineral zones for the upper (*urevzone*) and lower (*lrevzone*) members of the Revett Formation. Explanation of the methods and format used to compile the databases and spatial-data files is given, including the metadata required for files that contain spatial information.

Nomenclature in the databases varies in places from that used in the rest of this report; for example, "lower Revett", middle Revett", and "upper Revett" in several parts of the databases are, respectively, "lower member", "middle member", and "upper member of the Revett Formation" in the text; and "sediment-hosted deposits" in the databases are "stratabound deposits" in the text.

Diamond-Drill-Core and Measured-Section Data

Stratigraphic relations and mineral zones associated with stratabound copper-silver mineralization in the Revett Formation are based on the descriptions of 40 diamond-drill cores and 86 measured sections in the Revett Formation and adjacent strata (pl. 1; table 5). Most of this descriptive information was collected in the field by Asarco Inc. and Kennecott Exploration Co. geologists, although five sections were measured and compiled by USGS personnel. Rock type and sedimentary structures was recorded to understand the stratigraphy and depositional environment of the Revett Formation. The amount of sulfide, oxide, and silicate minerals in synsedimentary cements was also described in order to determine whether the distribution of these minerals could be used to predict the occurrence of stratabound copper-silver mineralization. The observations were systematically collected on forms; colored or black-and-white paper copies of this data were provided to the USGS for this study. The information on the forms was compiled into Microsoft Excel spreadsheets, which were then used to create graphical logs of the data for each diamond-drill core and measured section. The following sections describe the data collected in the field, the spreadsheets used to compile the data, and the graphical logs summarizing the observations.

Field-Data Forms

Data recorded in the header of the field-data forms (figs. 19, 20) include the name of the section ("location"), an identifier number ("no.") to indicate recording of data in two or more parts, the direction (up or down) of measurement traverse ("direction"), the author ("by"), pages ("page"), and the date ("date"). Detailed rock and mineralogic descriptions for diamond-drill cores and measured sections are recorded in the columns "footage", "graphic section", "sulfide", "oxide", "carbonate", "silicate", "supergene", "structure", and "lithology, grain-size, bedform, and comments" (figs. 19, 20). Numbered notes appearing in superscripted parentheses [( )] refer to the example field-data forms in figure 19 or 20. The first is an example lithologic field-data form of a measured section (fig. 19), and the second is an example lithologic field-data form from a diamond-drill core (fig. 20). "Footage" is a linear scale indicating hole depth or apparent stratigraphic position. The most commonly used vertical scale (footage) was 1 in. for every 20 ft of strata[(2)]. The column "graphic section" graphically displays information on rock type, sedimentary structures, and inclination of strata[(1)]. Colors are used to identify rock type (figs. 19, 20), as follows: "green" is argillite, "brown-green" is siltite-argillite couplets, "brown" is siltite, "blue" is silty quartzite, "orange" is slightly silty quartzite, and "yellow" is quartzite. A blank area in the graphic section at a particular depth indicates an interval of missing core or nonoutcropping strata[(2,3)]. Penciled lines to the left of the footage column indicate division of strata into stratigraphic intervals, members, or beds[(6,7)].

The columns "sulfide", "oxide", "carbonate", and "silicate" qualitatively illustrate the distribution of these miner-

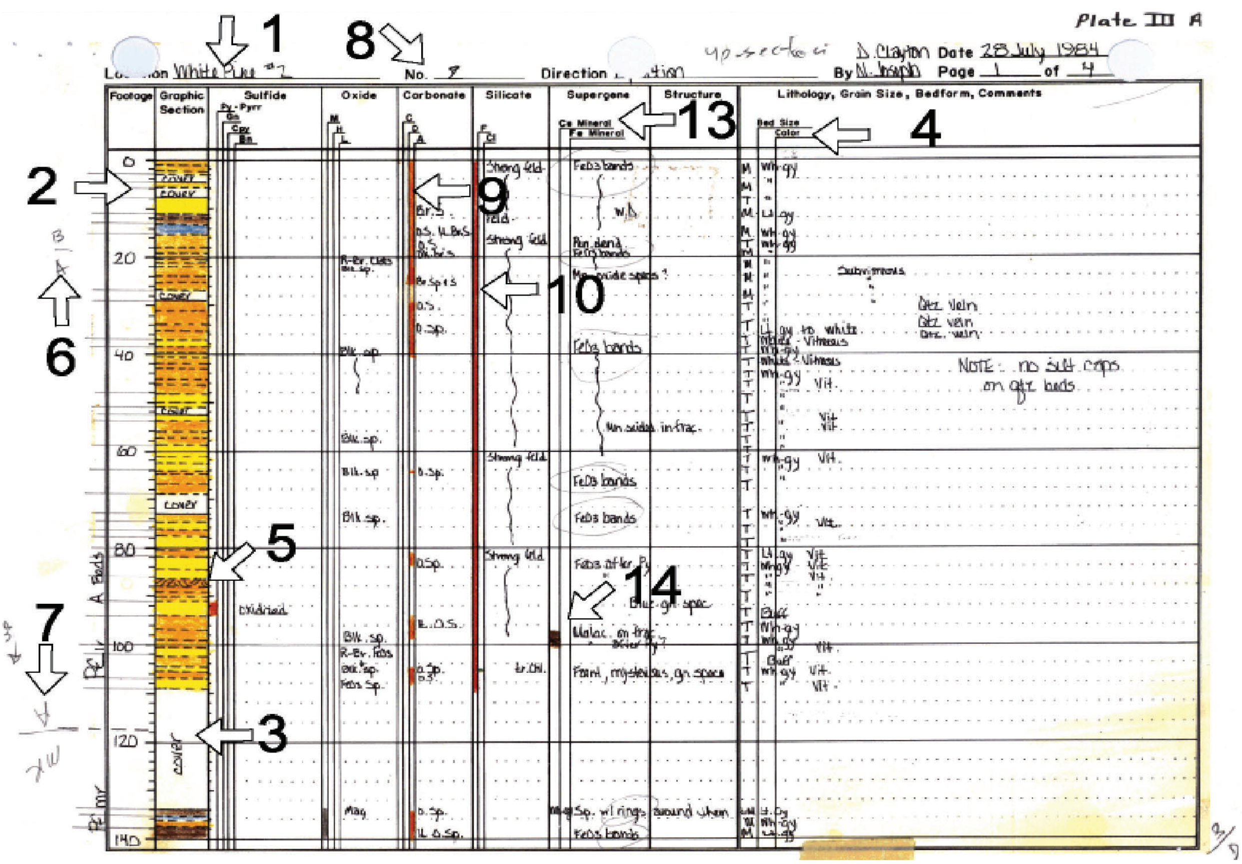

Figure 19. Scanned image of field-data form for White Pine Creek #2–#3 measured section. See text for explanation of numbers.

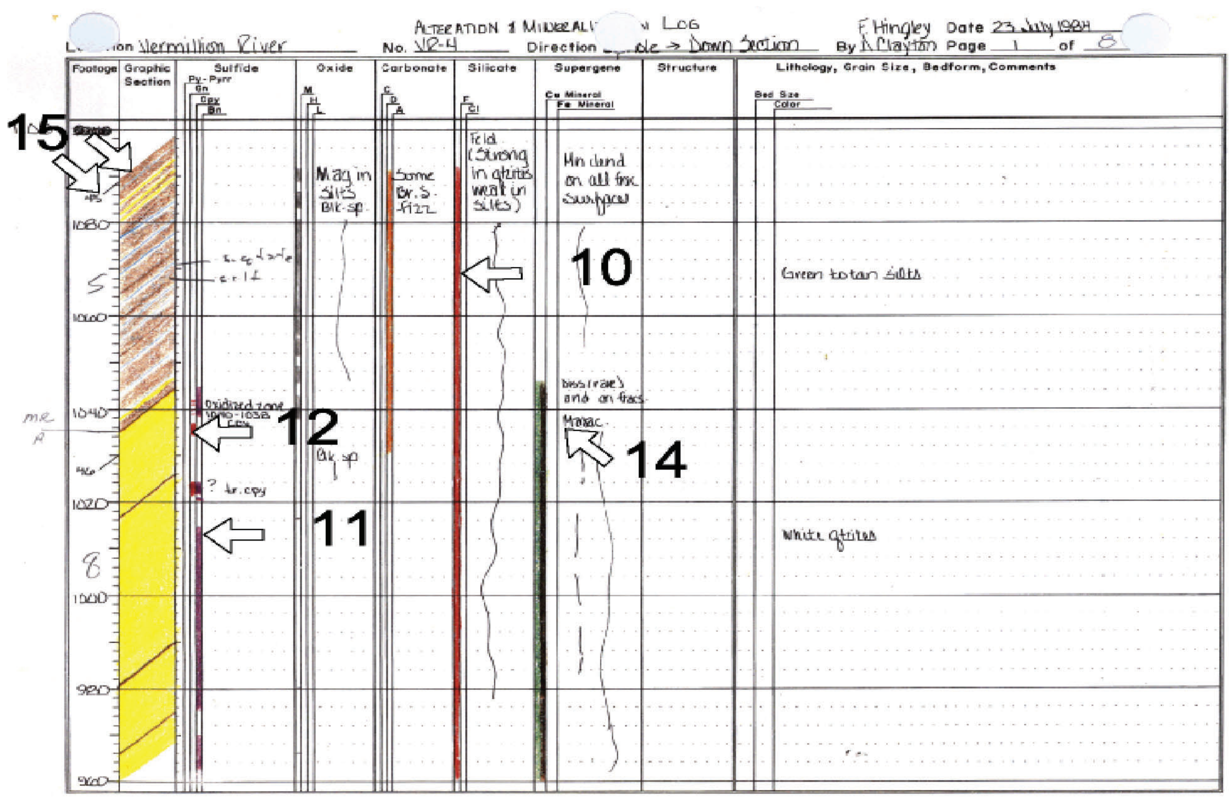

Figure 20. Scanned image of field-data form for diamond-drill hole VR–4. See text for explanation of numbers.

Table 4. List of databases, graphical logs, and spatial-data files.

File name	Description
Data and graphical logs summarizing the location, stratigraphy, lithology, and mineralogy for diamond-drill cores and measured sections through the Revett Formation and nearby units Microsoft Excel 2003 workbook (*.xls) and Adobe Portable Document Format files (*.pdf)	
Beaver Creek Road	Beaver Creek Road measured section.
Beaver Lake 1, 2	Beaver Lake 1, 2 measured section.
Beaver Peak North	Beaver Peak North measured section.
Bloom Peak	Bloom Peak measured section.
Bobtail Creek	Bobtail Creek measured section.
Browns Gulch	Browns Gulch measured section.
Bumblebee Road	Bumblebee Road measured section.
Castle Rock	Castle Rock measured section.
Cedar Creek	Cedar Creek measured section.
Chicago Peak (White)	Chicago Peak (White) measured section.
Chipmunk 1	Chipmunk 1 measured section.
Chipmunk 2	Chipmunk 2 measured section.
Clark Fork	Clark Fork measured section.
Clear Peak (Asarco)	Clear Peak (Asarco) measured section.
Clear Peak (White)	Clear Peak (White) measured section.
Coal Creek	Coal Creek measured section.
Coeur d'Alene River 3	Coeur d'Alene River 3 measured section.
Cottonwood	Cottonwood measured section.
County Creek	County Creek measured section.
DDH CC–1 (Cub Creek)	DDH CC–1 (Cub Creek) diamond-drill-hole section.
DDH CP–4 (Clear Peak)	DDH CP–4 (Clear Peak) diamond-drill-hole section.
DDH CP–5 (Clear Peak)	DDH CP–5 (Clear Peak) diamond-drill-hole section.
DDH DC–2 (Dry Creek)	DDH DC–2 (Dry Creek) diamond-drill-hole section.
DDH DC–3 (Dry Creek)	DDH DC–3 (Dry Creek) diamond-drill-hole section.
DDH FC–4 (Fairway Creek)	DDH FC–4 (Fairway Creek) diamond-drill-hole section.
DDH HC–4 (Hiatt Creek)	DDH HC–4 (Hiatt Creek) diamond-drill-hole section.
DDH HF–1 (Hereford)	DDH HF–1 (Hereford) diamond-drill-hole section.
DDH JF–12 (JF)	DDH JF–12 (J–F) diamond-drill-hole section.
DDH JF–79–1 (JF)	DDH JF–79–1 (J–F) diamond-drill-hole section.
DDH JF–79–4 (JF)	DDH JF–79–4 (J–F) diamond-drill-hole section.
DDH JFW–1 (JF West)	DDH JFW–1 (J–F West) diamond-drill-hole section.
DDH MG–6 (Military Gulch)	DDH MG–6 (Military Gulch) diamond-drill-hole section.
DDH RC–43 (Rock Creek)	DDH RC–43 (Rock Creek) diamond-drill-hole section.
DDH RC–47 (Rock Creek)	DDH RC–47 (Rock Creek) diamond-drill-hole section.
DDH RC–49 (Rock Creek)	DDH RC–49 (Rock Creek) diamond-drill-hole section.
DDH RC–58 (Rock Creek)	DDH RC–58 (Rock Creek) diamond-drill-hole section.
DDH SL–106 (Spar Lake)	DDH SL–106 (Spar Lake) diamond-drill-hole section.
DDH SL–122 (Spar Lake)	DDH SL–122 (Spar Lake) diamond-drill-hole section.
DDH SL–123 (Spar Lake)	DDH SL–123 (Spar Lake) diamond-drill-hole section.
DDH SL–130 (Spar Lake)	DDH SL–130 (Spar Lake) diamond-drill-hole section.
DDH SL–132 (Spar Lake)	DDH SL–132 (Spar Lake) diamond-drill-hole section.
DDH SL–136 (Spar Lake)	DDH SL–136 (Spar Lake) diamond-drill-hole section.
DDH SL–138 (Spar Lake)	DDH SL–138 (Spar Lake) diamond-drill-hole section.
DDH SL–139 (Spar Lake)	DDH SL–139 (Spar Lake) diamond-drill-hole section.
DDH SL–31 (Spar Lake)	DDH SL–31 (Spar Lake) diamond-drill-hole section.
DDH SL–60 (Spar Lake)	DDH SL–60 (Spar Lake) diamond-drill-hole section.
DDH SL–93 (Spar Lake)	DDH SL–93 (Spar Lake) diamond-drill-hole section.
DDH SN–1 (Snake Creek)	DDH SN–1 (Snake Creek) diamond-drill-hole section.
DDH SN–2 (Snake Creek)	DDH SN–2 (Snake Creek) diamond-drill-hole section.
DDH SN–3 (Snake Creek)	DDH SN–3 (Snake Creek) diamond-drill-hole section.
DDH SN–4 (Snake Creek)	DDH SN–4 (Snake Creek) diamond-drill-hole section.
DDH SN–5 (Snake Creek)	DDH SN–5 (Snake Creek) diamond-drill-hole section.
DDH TC–10 (Trout Creek)	DDH TC–10 (Trout Creek) diamond-drill-hole section.
DDH TC–5A (Trout Creek)	DDH TC–5A (Trout Creek) diamond-drill-hole section.
DDH TC–7A (Trout Creek)	DDH TC–7A (Trout Creek) diamond-drill-hole section.
DDH TC–8 (Trout Creek)	DDH TC–8 (Trout Creek) diamond-drill-hole section.
DDH TC–9 (Trout Creek)	DDH TC–9 (Trout Creek) diamond-drill-hole section.
DDH VR–11 (Vermilion River)	DDH VR–11 (Vermilion River) diamond-drill-hole section.

Table 4. List of databases, graphical logs, and spatial-data files—Continued

File name	Description
Data and graphical logs summarizing the location, stratigraphy, lithology, and mineralogy for diamond-drill cores and measured sections through the Revett Formation and nearby units Microsoft Excel 2003 workbook (*.xls) and Adobe Portable Document Format files (*.pdf)	
DDH VR–4 (Vermilion River)	DDH VR–4 (Vermilion River) diamond-drill-hole section.
Deep Creek	Deep Creek measured section.
East Fork Bull River 1, 2, 3	East Fork Bull River 1, 2, 3 measured section.
East Lake	East Lake measured section.
Goat Rocks	Goat Rocks measured section.
Goat Rocks Lower	Goat Rocks (Lower) measured section.
Graham Creek	Graham Creek measured section.
Granite Creek	Granite Creek measured section.
Graves Creek Falls	Graves Creek Falls measured section.
Graves Peak	Graves Peak measured section.
Green Mtn	Green Mountain measured section.
Grizzly Creek	Grizzly Creek measured section.
Gunsight Mtn	Gunsight Mountain measured section.
Hope (David Thompson Game Preserve)	Hope (David Thompson Game Preserve) measured section.
Horseshoe Lake	Horseshoe Lake measured section.
Janstan	Janstan measured section.
Kellogg	Kellogg measured section.
Kilbrennan Creek	Kilbrennan Creek measured section.
Latour Peak-Boise Peak	Latour Peak–Boise Peak measured section.
Little Beaver Creek	Little Beaver Creek measured section.
Little Grizzly Creek	Little Grizzly Creek measured section.
Little Spar Lake	Little Spar Lake measured section.
Little Tepee Creek 1, 2	Little Tepee Creek 1, 2 measured section.
Lower Glidden Lake	Lower Glidden Lake measured section.
Maple Cliffs	Maple Cliffs measured section.
McKay Creek (White)	McKay Creek (White) measured section.
McKay Creek, North	McKay Creek, North measured section.
McKay Creek, South	McKay Creek, South measured section.
Military Gulch (lower)	Military Gulch (lower) measured section.
Military Gulch (upper)	Military Gulch (upper) measured section.
Miller Gulch (Sex Peak)	Miller Gulch (Sex Peak) measured section.
Miners Gulch (Vermilion R.)	Miners Gulch (Vermilion R.) measured section.
Mount Vernon	Mount Vernon measured section.
Niagara	Niagara measured section.
North Fork Coeur d'Alene Section 20	North Fork Coeur d'Alene Section 20 measured section.
North Fork Coeur d'Alene Section 25	North Fork Coeur d'Alene Section 25 measured section.
Obemeyer Mtn	Obemeyer Mountain measured section.
Prado Creek, North of	North of Prado Creek measured section.
Prichard Creek	Prichard Creek measured section.
Revett Lake	Revett Lake measured section.
Ripper Creek	Ripper Creek measured section.
Rock Creek (East Fork)	Rock Creek (East Fork) measured section.
Rush Lake	Rush Lake measured section.
Silver Creek	Silver Creek measured section.
Sims Creek (west slope)	Sims Creek (west slope) measured section.
Sims Creek 1, 2 (east slope)	Sims Creek 1, 2 (east slope) measured section.
Slide Rock Mtn	Slide Rock Mountain measured section.
Spokane Creek	Spokane Creek measured section.
Spokane-Chipmunk Ridge 3	Spokane-Chipmunk Ridge 3 measured section.
Squaw Peak	Squaw Peak measured section.
Stanley Peak	Stanley Peak measured section.
Thompson River	Thompson River measured section.
Timmies Section	Timmies Section measured section.
Trout Creek (White)	Trout Creek (White) measured section.

Table 4. List of databases, graphical logs, and spatial-data files—Continued

File name	Description
Data and graphical logs summarizing the location, stratigraphy, lithology, and mineralogy for diamond-drill cores and measured sections through the Revett Formation and nearby units Microsoft Excel 2003 workbook (*.xls) and Adobe Portable Document Format files (*.pdf)	
Trout Creek 1, 2	Trout Creek 1, 2 measured section.
Twentyfour Mile Creek (Clear Peak 1)	Twentyfour Mile Creek (Clear Peak 1) measured section.
Vermilion River (White)	Vermilion River (White) measured section.
Waloven Creek (lower)	Waloven Creek (lower) measured section.
Waloven Creek (upper)	Waloven Creek (upper) measured section.
Wee Lake 1, 2	Wee Lake 1, 2 measured section.
West Fork Crow Creek	West Fork Crow Creek measured section.
West Fork Eagle Creek 1–2	West Fork Eagle Creek 1–2 measured section.
West Fork Eagle Creek 3	West Fork Eagle Creek 3 measured section.
West Fork Eagle Creek 5	West Fork Eagle Creek 5 measured section.
West Fork Trout Creek 1	West Fork Trout Creek 1 measured section.
West Fork Trout Creek 2	West Fork Trout Creek 2 measured section.
White Pine Creek 2, 3, 4	White Pine Creek 2, 3, 4 measured section.
Windfall Peak	Windfall Peak measured section.
Tab-delimited text file	
cuag_deposit	Description of 57 Revett-subtype copper-silver deposits, occurrences, and prospects.
Spatial databases in export format ESRI interchange format files (*.e00)	
lrevzone	Polygons showing the extent of mineral zones in the lower member of the Revett Formation; arcs (lines) showing the boundaries between the zones.
rev_48k	Polygons showing the extent of the Revett Formation and nearby units; arcs (lines) showing contacts, faults, and outcrops with copper-silver mineralization.
rev_cuag	Polygons showing copper-silver mineralized domains, untested exploration areas, and permissive tracts for Revett-subtype stratabound copper-silver deposits.
rev_ddh	Collar locations of 40 diamond-drill holes.
rev_msec	Traverse lines for 87 measured sections.
urevzone	Polygons showing the extent of mineral zones in the upper member of the Revett Formation; arcs for the boundaries between the zones.
Metadata files providing information about the spatial datasets Hypertext markup language format files (*.htm)	
cuag_deposit	Metadata for the tab-delimited text file, cuag_deposit.txt, describing copper-silver deposits, occurrences, and prospects in the Revett Formation.
lith_log	Metadata for the Microsoft Excel spreadsheets summarized diamond-drill cores and measured sections.
lrevzone	Metadata for the spatial database lrevzone.
rev_48k	Metadata for the spatial database rev48k.
rev_cuag	Metadata for the spatial database rev_cuag.
rev_ddh	Metadata for the spatial database rev_ddh.
rev_msec	Metadata for the spatial database rev_msec.
revett	Metadata providing overview for all spatial datasets.
urevzone	Metadata for the spatial database urevzone.

als in synsedimentary cements. The "sulfide" column has separate subcolumns for pyrite-pyrrhotite (py-pyrr), galena (ga), chalcopyrite (cpy), and bornite (bn). If these minerals are present within the strata, the appropriate footage intervals within the columns are colored. Solid, dashed, or dotted lines are used to indicate the amount of mineral present. Bornite[(11)] is indicated by a purple line, and chalcopyrite[(12)] by a red line. Additional data about the texture, amount, or degree of oxidation of sulfide minerals (see abbreviations in sulfide column, fig. 19) includes cubic or disseminated pyrite (pyc); clots, clusters, balls, or framboids of pyrite (pyf); pyrrhotite (pyrr or po); galena (gn or ga); bornite (bn; includes chalcocite and digenite); and chalcopyrite (cpy). The "oxide" column has separate subcolumns for magnetite (M), hematite (H), and leucoxene (L), which are colored in appropriate footage intervals if these minerals are present within the strata. Information (abbreviated) in the "oxide" column includes magnetite (m), leucoxene (l or leu), hematite and specularite (h), and limonite (l or lim). Occasionally, features called black spots[(8)] (blk sp.), believed to be oxides, are recorded. The "carbonate" column has separate subcolumns for calcite (C), dolomite (D), and ankerite (A), which are colored in appropriate footage intervals if these minerals are present within the strata. Information (abbreviated) in the "carbonate" column includes calcite-disseminated (c or cal), calcite occurring along bedding or bedform (bf), dolomite (d), and ankerite (a or ank). The "silicate" column has separate subcolumns for feldspar (F), and chlorite (Cl), which are colored in appropriate footage intervals if these minerals are present within the strata. Information (abbreviated) in the "silicate" column include feldspar (f), chlorite (cl or chl), and biotite. The "supergene" column is used to record the effects of weathering. This column includes separate subcolumns for Cu mineral and Fe mineral, which are colored in appropriate footage intervals if these minerals are present within the strata. Information (abbreviated) in the "supergene" column includes Cu oxide (C, CuOx), Fe oxides (F, FeOx), and pyrolusite (MnOx, dendrite, or penetrative dendrite). In the "supergene" column, notes about Cu mineral (green)[(13)] or "malac"[(14)] indicate the content of Cu oxides. Data about liesegang banding (banding, bands, stripes, or lies.) are recorded where possible.

The information in the "structure" column describes features related to deformation of the rocks; the column "lithology, grain-size, bedform, and comments" includes notes on bed thickness ("bed size"), color, grain-size, sedimentary structures, and luster (for example, vitreous or subvitreous). Bed-thickness abbreviations (VT, T, M, t) indicate very thick (>4 ft), thick (1–4 ft), medium (1 in.–1 ft), and thin (<1 in.)[(4)]. Colors of strata include white, green, greenish gray, gray (includes buff, cream, yellow, brown), and lavender. A determination of grain size by geologists was consistently made by reference to a grain-size chart. Primary sedimentary structures (bedform) recorded include ripple-drift lamination (rdl, includes flaser bedding), crossbeds (cb, includes megaripples and channels),[(5)] horizontal lamination (hl, includes lenticular bedding), ripup clasts (ru), soft-sediment-deformation structures (ssd; includes ball-and-pillow, convolute, and pinch-and-swell structures), mud chips (mc), graded beds (grb), and water-release structures (wrs).

Spreadsheets and Graphical Logs

The information recorded on the field-data forms was transcribed into Microsoft Excel spreadsheets in order to use charting software to create graphical logs of the diamond-drill cores and measured sections. The data recorded on the spreadsheets are sufficiently detailed that few or no geologic data recorded on field-data forms were lost. Considerable effort was expended to retain the integrity of the information recorded on the field-data forms upon transfer to the spreadsheets. Some data may be recorded as notes or comments in the spreadsheets that could not be shown in the graphical logs. We note that in some cases, stratigraphic boundaries established by Asarco Inc. or other geologists (for example, formation, member, and bed) may have been changed by USGS personnel during the interpretations made for this report or to maintain consistent terminology in text, illustrations, and correlated sections of this report. Nonetheless, the original data from field-data forms were retained in the spreadsheet's worksheets and graphical logs. Adjustments of apparent to true thickness, inversion of overturned strata, or other corrections were also made in the spreadsheets, and so the completed graphical logs show true, undeformed stratigraphic thicknesses. The thickness of covered intervals along measured outcrop traverses is also shown. Although the effects of faulting or intrusions of igneous rocks could not be determined or removed, the locations of faults are listed on the spreadsheets and logs.

Graphical lithologic logs based on the spreadsheets of each measured section or diamond-drill core were constructed with Interdex or CoreView software (Surpac Minex Group, Perth, Australia, http://www.surpac.com/) and saved as Adobe Portable Document Format (PDF) files. The graphical logs specifically emphasize the characteristics of Revett-subtype stratabound copper-silver deposits: lithology and stratigraphic terminology are listed in the center, ore and related minerals on the right, and gangue minerals, structures, and related data on the left. The colored rock type and grain-size histograms are the same data presented in two ways. The columns to the right of center on the graphical logs show ore minerals arranged in order, from left to right, corresponding to the mineral-zone sequence at the Troy deposit (Hayes, 1983; Hayes and Einaudi, 1986). Amounts of ore and gangue minerals are listed in histogram form at three levels of relative abundance: trace (t), present (p), and abundant (a).

Data-entry steps were checked at several stages. After completing data entry, each worksheet of a core or measured section was checked against the field-data form by two persons. As the data entry proceeded, changes in format of the worksheets required review of all field-data forms to maintain consistent data-entry practices. If corrections were needed, they were checked a second time after reentering the data. Following these steps, the graphical log was produced by using

Table 5. Summary of data from diamond-drill cores and measured sections

[Name of diamond-drill core or measured section is the same as the name of the graphical logs in appendix A and Microsoft Excel files; true thickness, true stratigraphic thickness corrected from diamond-drill core, measured section, or transect length of underground section; ms, measured-section traverse on outcrop; core, core from diamond-drill hole. NA, not applicable]

Figure (app. A)	Name of diamond-drill core or measured section	Latitude (° N.)	Longitude (° W.)	Thickness (ft)	True thickness (ft)	Type	Azimuth (°)	Dip (°)	Elevation (ft)	Author
1	Obemeyer Mtn	48.9753	115.809	751	751	ms	NA	NA	NA	Asarco Inc.
2	Wee Lake 1, 2	48.6123	115.804	1,218	1,218	ms	NA	NA	6,000	Asarco Inc.
3	Gunsight Mtn	48.6096	115.832	254	254	ms	NA	NA	5,000	Asarco Inc.
4	Kilbrennan Creek	48.59	115.898	858	858	ms	NA	NA	2,850	Asarco Inc.
5	Horseshoe Lake	48.2575	117.612	1,570	1,570	ms	NA	NA	NA	D.E. Boleneus
6	Granite Creek	48.0843	116.28	840	840	ms	NA	NA	NA	Asarco Inc.
7	DDH FC–4 (Fairway Creek)	48.2919	115.9349	3,225	3,154	core	NA	–90	3,800	Asarco Inc.
8	Stanley Peak	48.2899	115.977	355	355	ms	NA	NA	NA	B.G. White
9	DDH SL–130 (Spar Lake)	48.2599	115.9085	635	585	core	NA	–90	4,420	Asarco Inc.
10	DDH HC–4 (Hiatt Creek)	48.2575	115.9712	1,307	1,262	core	NA	–90	4,900	Asarco Inc.
11	DDH SL–136 (Spar Lake)	48.2423	115.9207	2,559	2,520	core	NA	–90	5,220	Asarco Inc.
12	DDH CC–1 (Cub Creek)	48.2409	115.9708	2,049	2,018	core	NA	–90	3,550	Asarco Inc.
13	Clark Fork	48.2381	116.215	925	925	ms	NA	NA	NA	Asarco Inc.
14	DDH SL–122 (Spar Lake)	48.2287	115.8776	2,321	2,286	core	NA	–90	5,100	Asarco Inc.
15	Mount Vernon	48.2283	115.871	2,040	2,040	ms	NA	NA	NA	B.G. White
16	DDH SL–60 (Spar Lake)	48.227	115.9006	1,215	1,211	core	NA	–90	5,460	T.S. Hayes
17	DDH SL–123 (Spar Lake)	48.2276	115.8858	2,852	2,831	core	NA	–90	5,200	Asarco Inc.
18	DDH SL–93 (Spar Lake)	48.2274	115.8998	2,990	2,990	core	NA	–90	5,360	Asarco Inc.
19	DDH SL–106 (Spar Lake)	48.2256	115.9035	1,015	1,015	core	NA	–90	5,060	T.S. Hayes
20	DDH SL–138 (Spar Lake)	48.2202	115.9038	1,844	1,844	core	NA	–90	4,440	Asarco Inc.
21	DDH SL–31 (Spar Lake)	48.2204	115.8907	941	920	core	NA	–90	4,638	T.S. Hayes
22	DDH SL–139 (Spar Lake)	48.216	115.9108	1,109	1,109	core	NA	–90	3,540	Asarco Inc.
23	DDH SL–132 (Spar Lake)	48.2115	115.8944	1,614	1,590	core	NA	–90	3,280	Asarco Inc.
24	Little Spar Lake	48.211	116.031	2,310	2,310	ms	NA	NA	NA	T.D. Bowden
25	DDH JF–79–1 (JF)	48.2001	115.8906	935	714	core	001	–55	3,529	Asarco Inc.
26	DDH JF–79–4 (JF)	48.1965	115.8895	1,605	1,229	core	310	–45	4,120	Asarco Inc.
27	DDH JFW–1 (JF West)	48.1935	115.9003	2,705	2,705	core	NA	–90	4,900	Asarco Inc.
28	DDH JF–12 (JF)	48.1892	115.8867	1,596	1,129	core	000	–80	4,100	Asarco Inc.
29	DDH DC–3 (Dry Creek)	48.1662	115.8646	2,392	1,832	core	NA	–90	2,350	Kennecott
30	DDH DC–2 (Dry Creek)	48.1605	115.8662	2,903	2,549	core	NA	–90	2,350	Kennecott
31	Squaw Peak	48.0772	115.916	765	765	ms	NA	NA	NA	B.G. White
32	Goat Rocks	48.1404	115.709	1,160	1,160	ms	NA	NA	4,800	Asarco Inc.
33	DDH SN–2 (Snake Creek)	48.1369	115.7528	3,519	3,415	core	NA	–90	3,390	Kennecott
34	DDH SN–5 (Snake Creek)	48.1319	115.7473	2,509	2,478	core	NA	–90	3,070	Kennecott
35	East Fork Bull River 1, 2, 3	48.1224	115.723	1,400	1,400	ms	NA	NA	4,400	Asarco Inc.
36	DDH SN–1 (Snake Creek)	48.1261	115.7486	1,853	1,806	core	NA	–90	2,800	Kennecott
37	DDH SN–4 (Snake Creek)	48.1243	115.7377	1,329	1,249	core	NA	–90	2,680	Kennecott
38	DDH SN–3 (Snake Creek)	48.1233	115.7551	2,466	2,412	core	NA	–90	2,600	Kennecott
39	Goat Rocks Lower	48.1294	115.723	140	140	ms	NA	NA	3,600	Asarco Inc.
40	DDH RC–58 (Rock Creek)	48.0861	115.692	1,861	1,820	core	NA	–90	6,503	Asarco Inc.
41	DDH RC–49 (Rock Creek)	48.0778	115.6887	1,081	1,023	core	260	–80	5,968	Asarco Inc.
42	DDH RC–47 (Rock Creek)	48.0766	115.6784	2,052	1,660	core	030	–80	7,119	Asarco Inc.
43	DDH RC–43 (Rock Creek)	48.069	115.6898	1,375	1,292	core	347	–80	6,523	Asarco Inc.

Table 5. Summary of data from diamond-drill cores and measured sections—Continued

[Name of diamond-drill core or measured section is the same as the name of the graphical logs in appendix A and Microsoft Excel files; true thickness, true stratigraphic thickness corrected from diamond-drill core, measured section, or transect length of underground section; ms, measured-section traverse on outcrop; core, core from diamond-drill hole. NA, not applicable]

Figure (app. A)	Name of diamond-drill core or measured section	Latitude (° N.)	Longitude (° W.)	Thickness (ft)	True thickness (ft)	Type	Azimuth (°)	Dip (°)	Elevation (ft)	Author
44	Chicago Peak (White)	48.068	115.676	1,505	1,505	ms	NA	NA	NA	B.G. White
45	Rock Creek (East Fork)	48.0378	115.69	728	728	ms	NA	NA	3,472	Asarco Inc.
46	DDH HF–1 (Hereford)	48.0239	115.6764	1,382	1,119	core	NA	–90	4,950	Kennecott
47	McKay Creek (White)	47.9756	115.678	895	895	ms	NA	NA	NA	B.G. White
48	McKay Creek, North	47.9739	115.68	228	228	ms	NA	NA	3,200	Asarco Inc.
49	McKay Creek, South	47.9665	115.68	900	900	ms	NA	NA	3,600	Asarco Inc.
50	Green Mtn	47.9572	115.664	202	202	ms	NA	NA	4,800	Asarco Inc.
51	Waloven Creek (lower)	47.9555	115.441	504	504	ms	NA	NA	NA	Asarco Inc.
52	Waloven Creek (upper)	47.9328	115.432	613	613	ms	NA	NA	5,200	Asarco Inc.
53	Sims Creek (west slope)	47.9145	115.42	376	376	ms	NA	NA	5,000	Asarco Inc.
54	Sims Creek 1, 2 (east slope)	47.9216	115.414	1,154	1,154	ms	NA	NA	5,400	Asarco Inc.
55	Miners Gulch (Vermilion R.)	47.8672	115.392	570	570	ms	NA	NA	3,600	Asarco Inc.
56	DDH VR–11 (Vermilion River)	47.8562	115.3771	883	705	core	NA	–90	6,000	Asarco Inc.
57	DDH VR–4 (Vermilion River)	47.8504	115.374	1,089	770	core	NA	–90	5,550	Asarco Inc.
58	Rush Lake	47.8294	115.363	670	670	ms	NA	NA	6,160	Asarco Inc.
59	Vermilion River (White)	47.8267	115.362	1,300	1,300	ms	NA	NA	NA	B.G. White
60	Slide Rock Mtn	47.8087	115.364	1,183	1,183	ms	NA	NA	6,400	Asarco Inc.
61	Deep Creek	47.7743	115.38	1,076	1,076	ms	NA	NA	5,300	Asarco Inc.
62	Graves Peak	47.7538	115.367	1,235	1,235	ms	NA	NA	6,950	Asarco Inc.
63	Graves Creek Falls	47.7265	115.374	1,435	1,435	ms	NA	NA	NA	Asarco Inc.
64	Thompson River	47.6122	115.206	2,100	2,100	ms	NA	NA	4,075	Asarco Inc.
65	DDH TC–9 (Trout Creek)	47.831	115.7245	2,203	2,069	core	NA	–90	3,200	Asarco Inc.
66	DDH TC–8 (Trout Creek)	47.8266	115.7184	2,238	1,976	core	NA	–90	3,760	Asarco Inc.
67	DDH TC–10 (Trout Creek)	47.8229	115.7336	2,249	2,113	core	NA	–90	4,000	Asarco Inc.
68	Trout Creek 1, 2	47.8222	115.66	1,015	1,015	ms	NA	NA	NA	Asarco Inc.
69	DDH TC–7A (Trout Creek)	47.8227	115.7129	992	899	core	NA	–90	3,700	Asarco Inc.
70	Trout Creek (White)	47.8164	115.713	2,035	2,035	ms	NA	NA	NA	B.G. White
71	DDH TC–5A (Trout Creek)	47.8059	115.736	1,276	1,214	core	NA	–90	4,400	Asarco Inc.
72	West Fork Trout Creek 1	47.8062	115.725	700	700	ms	NA	NA	NA	Asarco Inc.
73	West Fork Trout Creek 2	47.8005	115.735	808	808	ms	NA	NA	NA	Asarco Inc.
74	Windfall Peak	47.7742	115.757	883	883	ms	NA	NA	NA	Asarco Inc.
75	White Pine Creek 2, 3, 4	47.7536	115.632	706	706	ms	NA	NA	NA	Asarco Inc.
76	Ripper Creek	47.7353	115.632	956	956	ms	NA	NA	4,800	Asarco Inc.
77	Miller Gulch (Sex Peak)	47.7127	115.606	1,173	1,173	ms	NA	NA	NA	Asarco Inc.
78	Beaver Creek Road	47.7054	115.595	1,383	1,383	ms	NA	NA	NA	Asarco Inc.
79	Little Beaver Creek	47.6645	115.545	939	939	ms	NA	NA	NA	Asarco Inc.
80	Clear Peak (Asarco)	47.6385	115.651	885	885	ms	NA	NA	NA	Asarco Inc.
81	Beaver Peak North	47.6365	115.656	567	567	ms	NA	NA	NA	Asarco Inc.
82	Clear Peak (White)	47.6309	115.661	410	410	ms	NA	NA	NA	B.G. White
83	Beaver Lake 1, 2	47.6276	115.694	1,585	1,585	ms	NA	NA	NA	Asarco Inc.
84	DDH CP–5 (Clear Peak)	47.6268	115.6285	1,100	1,062	core	NA	–90	5,200	Asarco Inc.
85	DDH CP–4 (Clear Peak)	47.6237	115.6479	1,260	1,260	core	NA	–90	6,400	Asarco Inc.

Table 5. Summary of data from diamond-drill cores and measured sections—Continued

[Name of diamond-drill core or measured section is the same as the name of the graphical logs in appendix A and Microsoft Excel files; true thickness, true stratigraphic thickness corrected from diamond-drill core, measured section, or transect length of underground section; ms, measured-section traverse on outcrop; core, core from diamond-drill hole. NA, not applicable]

Figure (app. A)	Name of diamond-drill core or measured section	Latitude (° N.)	Longitude (° W.)	Thickness (ft)	True thickness (ft)	Type	Azimuth (°)	Dip (°)	Elevation (ft)	Author
86	Twentyfour Mile Creek (Clear Peak1)	47.5954	115.677	690	690	ms	NA	NA	NA	Asarco Inc.
87	Janstan	47.5717	115.674	182	182	ms	NA	NA	NA	Asarco Inc.
88	West Fork Crow Creek	47.5174	115.586	1,098	1,098	ms	NA	NA	4,400	Asarco Inc.
89	Spokane Creek	47.5145	115.626	337	337	ms	NA	NA	NA	Asarco Inc.
90	Spokane-Chipmunk Ridge 3	47.5136	115.634	292	292	ms	NA	NA	4,000	Asarco Inc.
91	Chipmunk 1	47.5083	115.646	990	990	ms	NA	NA	3,780	Asarco Inc.
92	Chipmunk 2	47.5016	115.653	562	562	ms	NA	NA	5,900	Asarco Inc.
93	Bloom Peak	47.7607	115.834	700	700	ms	NA	NA	NA	Asarco Inc.
94	East Lake	47.7388	115.778	396	396	ms	NA	NA	NA	Asarco Inc.
95	West Fork Eagle Creek 3	47.7356	115.808	1,215	1,215	ms	NA	NA	NA	Asarco Inc.
96	West Fork Eagle Creek 1–2	47.7244	115.811	1,755	1,755	ms	NA	NA	NA	Asarco Inc.
97	West Fork Eagle Creek 5	47.7134	115.829	1,372	1,372	ms	NA	NA	NA	Asarco Inc.
98	Cottonwood	47.708	115.851	604	604	ms	NA	NA	NA	Asarco Inc.
99	Bobtail Creek	47.6987	115.872	822	822	ms	NA	NA	NA	Asarco Inc.
100	Niagara	47.6771	115.851	1,235	1,235	ms	NA	NA	NA	Asarco Inc.
101	Revett Lake	47.5573	115.747	870	870	ms	NA	NA	NA	Asarco Inc.
102	DDH MG–6 (Military Gulch)	47.532	115.7695	1,139	1,032	core	NA	–90	4,640	US Borax
103	Prichard Creek	47.6584	115.961	698	698	ms	NA	NA	3,400	Asarco Inc.
104	Coeur d'Alene River 3	47.6586	115.98	620	620	ms	NA	NA	3,300	Asarco Inc.
105	Cedar Creek	47.6383	116.013	481	481	ms	NA	NA	3,200	Asarco Inc.
106	Little Grizzly Creek	47.6677	116.05	954	954	ms	NA	NA	NA	Asarco Inc.
107	Grizzly Creek	47.6643	116.058	998	998	ms	NA	NA	2,340	Asarco Inc.
108	Timmies Section	47.6565	116.07	873	873	ms	NA	NA	2,900	Asarco Inc.
109	Maple Cliffs	47.6566	116.087	674	674	ms	NA	NA	3,100	Asarco Inc.
110	Graham Creek	47.6473	116.092	214	214	ms	NA	NA	NA	Asarco Inc.
111	Silver Creek	47.6531	116.098	397	397	ms	NA	NA	2,700	Asarco Inc.
112	Castle Rock	47.6493	116.112	693	693	ms	NA	NA	2,900	Asarco Inc.
113	Coal Creek	47.6429	116.132	354	354	ms	NA	NA	NA	Asarco Inc.
114	Kellogg	47.5155	116.1498	4,110	4,110	ms	NA	NA	NA	B.G. White
115	Latour Peak-Boise Peak	47.4439	116.386	4,400	4,400	ms	NA	NA	NA	Unknown
116	Prado Creek, North of	47.5908	116.254	268	268	ms	NA	NA	2,100	Asarco Inc.
117	Bumblebee Road	47.6314	116.319	1,936	1,936	ms	NA	NA	2,400	Asarco Inc.
118	Browns Gulch	47.6252	116.317	526	526	ms	NA	NA	2,800	Asarco Inc.
119	County Creek	47.6357	116.316	185	185	ms	NA	NA	2,400	Asarco Inc.
120	Little Tepee Creek 1, 2	47.6443	116.338	1,807	1,807	ms	NA	NA	3,200	Asarco Inc.
121	North Fork Coeur d'Alene Section 20	47.6736	116.357	662	662	ms	NA	NA	NA	Asarco Inc.
122	North Fork Coeur d'Alene Section 25	47.741	116.41	280	280	ms	NA	NA	NA	Asarco Inc.
123	Hope (David Thompson Game Preserve)	48.1967	116.2875	2,701	2,701	ms	NA	NA	NA	D.E. Boleneus
124	Military Gulch (upper)	47.5083	115.7467	646	646	ms	NA	NA	5,591	D.E. Boleneus
125	Military Gulch (lower)	47.5189	115.7647	595	595	ms	NA	NA	6,000	D.E. Boleneus
126	Lower Glidden Lake	47.5108	115.7294	389	389	ms	NA	NA	6,400	D.E. Boleneus

the Interdex or CoreView log-plotting software. After plotting, the graphical logs were again checked by two persons, and additional changes made if necessary. The final labeling was completed by using Adobe Illustrator software, and the result saved as a PDF file.

Each Microsoft Excel file for a diamond-drill core or measured section consists of four worksheets named “lithology”, “formation”, “mineralogy”, and “collar”. Four worksheets are required because depth intervals differ substantially for the different categories of information recorded on the field-data forms (table 6). The following sections of this report describe how the field-data forms were transcribed into worksheets, using examples of original diamond-drill-hole and measured-section logs (figs. 19, 20).

Collar Worksheet

Collar worksheets generally contain location and descriptive data about the site. They include the following columns: “section”, “easting”, “northing”, “elevation”, “depth”, “depth_corr”, “azimuth”, “dip”, “GPS_lat”, and “GPS_long” (table 7). The “easting” and “northing” give map coordinates (in meters) in a Universal Transverse Mercator (North American datum of 1927) map projection. “Elevation” is the height above sea level of the collar of the core (in feet) or the elevation of the start of the measured section (in feet). “Depth” is the total length (in feet) of the core or measured section. “Azimuth” and “dip” give the direction and inclination of a diamond-drill hole if drilled in an orientation other than vertical (–90º).

Formation Worksheet

The formation worksheet stores data about formations, members, and beds in the core or measured section. A formation worksheet generally contains the following columns: “section”, “section logged”, “orientation”, “formation”, “member”, “bed”, “ave_core_angle”, “from”, “to”, “from_corr”, “to_corr”, “app_thick”, “thickness”, “GPS_lat”, “GPS_long”, and “comments” (table 8). Stratigraphic names, which were taken from the margin of the field-data forms[6,7], include such formation names as Wallace, St. Regis, Revett, and Burke. The Revett Formation has been informally divided into three members: upper, middle, and lower. The lower member of the Revett Formation is further subdivided, from the top downward, into beds A through J. Members of the Revett Formation were further subdivided, from the top downward, into beds in the upper member of the Revett Formation designated the upper quartzite, upper siltite, middle quartzite, lower siltite, and lower quartzite.

Lithology Worksheet

The lithology worksheet includes columns for lithology, grain size, bed thickness, color, luster (vitreous or nonvitreous), and sedimentary structures described in diamond-drill cores or measured sections. All lithology worksheets contain the following columns: “section”, “section_logged”, “orientation”, “from”, “to”, “app_thick”, “ave_core_angle”, “from_corr” (if corrected), “to_corr”, “lithology”, “thickness”, “grain_size”, “bed_thickness”, “color” (a number to indicate color), “white_beds”, “green_beds”, “gray-green_beds”, “gray_beds”, “lavender_beds”, “vitreous”, “structures”, “horizontal_laminations”, “ripup_clasts”, “soft-sediment_deformation”, “cross-beds”, “ripple_drift_lamination”, “mud_chips”, “graded_beds”, “dewatering_structures”, and “comments” (table 9). The depth intervals in the diamond-drill core or measured sections are listed in “to” and “from” columns if no correction was required. If any correction to depth was required, corrected depths are reported as “to_corr” and “from_corr” and uncorrected depth values are not reported.

All other log intervals (faults, covered) or rock types (quartzite, intrusive, and so on) were assigned a unique number to distinguish them in the log-plotting software. The “lithology” and “grain-size” columns in this worksheet contain identical information, but two columns were required to accommodate the log-plotting software. Their equivalency is quartzite (q)=“5”, slightly silty quartzite (ssq)=“4”, silty quartzite (sq)=“3”, siltite (s)=“2”, silt-argillite couplet (sac)=“1.5”, and argillite (a)=“1”. The bed thickness of each lithologic interval was assigned a numeric value or letter abbreviation as follows: thin (t) bedded (<1 in.)=“1”, medium (m) bedded (1–12 in.)=“2”, thick (Th) bedded (1–4 ft)=“3”, and very thick (vTh) bedded (>4 ft)=“4”. Color was entered by name in the “color” column and duplicated as a “1” in a corresponding column that describes this color. Color of the lithologic intervals was assigned to one of six of the most frequently occurring colors: black, white, green, green-gray (includes gray-green), gray, and lavender. The text column is the color given by the geologist, which was found to vary between logging practices and from log to log. For example, “light green-gray” is “green-gray”, and “light olive green” is “green”. The various shades of gray are all grouped together as “gray” (no separation between “light gray”, “dark gray”, and so on). Colors other than the six designated were assigned to “gray”, and in unusual circumstances, these colors might include cream, buff, orange, brown, and yellow. Structures were listed by name in the “structures” column and by a “1” in the column that describes them. The “vitreous” column represents intervals having a vitreous luster (vitreous=“1”; absent, subvitreous, or nonvitreous=blank). Bedform structures are noted as text in the “structures” column. Sedimentary structures are also listed in following columns as a “1” to denote their presence in an interval. The “comments” column contains relevant notes and remarks.

Data for determining the grain size and thickness of units used for stratigraphic mapping were taken from the “lithology” table. Grain-size and thickness data were needed for the sand isolith mapping method. Thickness was determined by subtracting the “from” depth from the “to” depth. If only corrected depths were provided, thickness was obtained by subtracting “from_corr” from the “to_corr” to obtain true

Table 6. Contents of each spreadsheet

Worksheet name	Data
Collar -------------	Location and orientation (cores).
Formation --------	Depth intervals (rows) (in feet), showing stratigraphic tops of formations, members, and beds.
Lithology---------	Depth intervals (rows) (in feet), showing lithologic data, such as rock type, color, sedimentary structures, bed thickness, and grain size.
Mineralogy-------	Depth intervals (rows) (in feet), showing mineralogic data on gangue minerals (calcite, hematite, biotite, feldspar, pyrite, and so on) and ore minerals (bornite [includes digenite and chalcocite], chalcopyrite, Cu oxide, and galena).

Table 7. Definitions of item names in the collar worksheet

Item name	Definition
section	Name of the diamond-drill hole or measured section. Diamond-drill holes have "DDH" as the first three letters in the name.
easting	Easting values represented in a UTM map projection (in meters).
northing	Northing values represented in a UTM map projection (in meters).
elevation	Elevation (in feet) of the collar of the diamond-drill hole or elevation at the beginning of the measured section. NA or No entry, no information available.
depth	Total depth (in feet) of the diamond-drill hole or the length of the measured section.
depth_corr	Total true stratigraphic penetration (in feet) of a diamond-drill hole calculated from the total length of the hole (depth) and the core axis to bedding angle (ave_core_angle), or the total stratigraphic thickness of a measured section, whether its beds are actually upright or overturned.
azimuth	A positive value, ranging from 0 to 360 measured in the clockwise direction beginning at North, that indicates the compass direction (in degrees) of in-clined diamond-drill holes. No entry, no data provided.
dip	Inclination of diamond-drill hole (in degrees from horizontal). Positive values indicate that the hole was drilled in an upward direction; negative values indicate that the hole was drilled in a downward direction.
gps_lat	Latitude (in degrees), obtained using GPS equipment.
gps_long	Longitude (in degrees), obtained using GPS equipment.

thickness. The lithology (quartzite="5", slightly silty quartzite="4", * * * argillite="1") assigned by the geologist completing the diamond-drill-hole or measured-section log was made by reference to a grain-size chart for consistent naming. Data in the "grain_size" column (numbered equivalent to the "lithology" column) was used to compile sand isolith data. The sand (quartzite) isolith was determined by accumulating only the thickness (in feet) of quartzite (grain-size class="5") from rows of an interval of interest in the spreadsheet (table 10). Covered intervals were not considered.

Mineralogy Worksheet

Mineralogic data are listed on the mineralogy worksheet. Data were obtained from columns on the field-data forms[8] labeled "sulfide", "oxide", "carbonate", "silicate", and "supergene". Notes about rock-forming and accessory minerals are included here. The data listed in the mineralogy worksheet are defined in table 11.

Mineralogy worksheets contain the columns "section", "section_logged", "orientation", "from", "to", "from_corr", "to_corr", "ave_core_angle", "thickness", "app_thick" (apparent thickness), "py-cube" (cubic pyrite), "py_fram" (framboids, clusters, balls, or clots of pyrite), "pyrrhotite", "galena", "chalcopyrite", "bornite", "magnetite", "hematite" (includes limonite or specularite), "leucoxene", "mnox" (MnO_2 and dendrites), "calcite", "calcite_bedform" (carbonates conformable to bedding, but nearly always calcite), "dolomite", "ankerite", "feldspar", "chlorite", "biotite", "cuox" (Cu oxide), "feox" (Fe oxide), "banding", "orange/brown spots", and "comments" (table 11). The quantity and intensity of color shading in the "mineral" columns indicates the relative amount of a mineral present. Written comments or fill color (solid line, dashed line, or dotted line) in the "mineral" columns are used to

Table 8. Definitions of item names in the formation worksheet

Item name	Definition
section	Name of the diamond-drill hole or measured section. Drill holes will have “DDH” as the first three letters in the name.
section_logged	For measured sections, if the item is attributed, then the measured section is a composite of multiple segments. The attribute is the name of the various measured sections used to make the composite. For diamond-drill holes, the attribute is the name of an extended area where several diamond-drill holes are located, for example, Spar Lake, Rock Creek.
orientation	Direction in which the section was measured, for example, upsection stratigraphically or downsection stratigraphically. No data, data unavailable for the section.
formation	Formation name, for example, Wallace, St. Regis, Revett, or Burke. No entry, no information provided.
member	Informal member name of the Revett Formation, for example, upper, middle, and lower. No entry, no information provided.
bed	Informal bed name, for example, A, B, C, D, E, F, G, H, I, J, and K of the lower member of the Revett Formation or upper quartzite, upper siltite, middle quartzite, lower siltite, and lower quartzite beds of the upper member of the Revett Formation. The locations of faults, fault zone, overburden, and fault gouge are indicated where present. No entry, no information provided.
from	Depth (in feet) measured at the beginning of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. No data, data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction and holes were drilled at an angle not requiring a correction) so that the “from_corr” value (item name) will not be attributed.
to	Depth (in feet) measured at the end of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. No data, data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction and holes were drilled at an angle not requiring a correction) so that the “to_corr” value (item name) will not be attributed.
app_thick	Thickness (in feet) of a stratigraphic interval, measured parallel to the core axis of a diamond-drill hole. Not yet corrected to true stratigraphic thickness for diamond-drill holes.
ave_core_angle	Average angle (in degrees) of the bedding inclination, measured from the core axis. A value of –90° means that strata are horizontal. No data, data unavailable for the section.
from_corr	Corrected depth derived from the “down” value (item name). Corrected to true stratigraphic thickness in the downsection direction for diamond-drill holes and for overturned beds in diamond-drill holes and measured sections. No data, data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where a correction was needed so that the “from” value (item name) will not be attributed.
to_corr	Corrected depth derived from the “to” value (item name). Corrected to true stratigraphic thickness in the downsection direction for diamond-drill holes and for overturned beds in diamond-drill holes and measured sections. No data, data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where a correction was needed so that the “to” value (item name) will not be attributed.
thickness	Calculated true thickness (in feet) of the sample interval. Thickness = (to – from, or to_corr – from_corr if a correction was needed).
gps_lat	Latitude (in degrees) obtained using GPS equipment.
gps_long	Longitude (in degrees) obtained using GPS equipment.
comments	Additional comments about the interval.

Table 9. Definitions of item names in the lithology worksheet

Item name	Definition
section	Name of the measured section or drill hole. Diamond-drill holes have "DDH" as the first three letters in the name.
section_logged	For measured sections, if the item is attributed, then the measured section is a composite of multiple segments, and the attribute is the name of the various measured sections used to make up the composite. For diamond-drill holes, the attribute is the name of the extended area where several diamond-drill holes are located, for example, Spar Lake, Rock Creek.
orientation	Direction in which the section was measured, for example, upsection stratigraphically or downsection stratigraphically. No data, data unavailable for the section.
from	Depth (in feet), measured at the beginning of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. Item contains "no data" if data were unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction, and holes were drilled at an angle not requiring a correction) so that the "from_corr" value (item name) will not be attributed.
to	Depth (in feet), measured at the end of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. Item contains "no data" if data were unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction, and holes were drilled at an angle not requiring a correction) so that the "to_corr" value (item name) will not be attributed.
ave_core_angle	Average angle (in degrees) of the bedding inclination, measured from the core axis. A value of −90º means that strata are horizontal perpendicular to the core axis. No data, data unavailable for the section.
from_corr	Corrected depth derived from the "from" value (item name). Corrected to true stratigraphic thickness in the downsection direction for diamond-drill holes and for overturned beds in diamond-drill holes and measured sections. Item contains "no data" if data were unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where a correction was needed so that the "from" value (item name) will not be attributed.
to_corr	Corrected depth derived from the "to" value (item name). Corrected to true stratigraphic thickness in the downsection direction for diamond-drill holes and for overturned beds in diamond-drill holes and measured sections. Item contains "no data" if data were unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where a correction was needed so that the "to" value (item name) will not be attributed.
lithology	Abbreviation for rock type: a, argillite; q, quartzite; s, siltite; sac, silt-argillite couplet; sq, silty quartzite; ssq, slightly silty quartzite. Cover or covered, interval covered by unconsolidated sedimentary material; fault gouge or fault, zone of fault gouge; missing, information not provided; no recovery, core not recovered.
grain_size	Numeric value indicating grain size based on rock type "lithology" value (item name): 0 or covered, interval covered by unconsolidated sedimentary material; 0.01, fault; 0.03, biotite schist; 1, argillite (a); 1.5, silt-argillite couplet (sac); 2, siltite (s); 3, silty quartzite (sq); 4, slightly silty quartzite (ssq); 5, quartzite (q); blank, no information available; int or intrusive, intrusive rocks.
bed_thickness	Numeric value based on a description of bed thickness; smaller values indicate thinner beds, and larger values indicate thicker beds: 1, thin bedded (<1 in.); 2, medium bedded (1–12 in.); 3, thick bedded (1–4 ft); 4, very thick bedded (>4 ft); no entry, information not provided.
color	Color of rocks noted by the field geologist. The following "rules" were used to attribute the six dominant color items (white_beds, green_beds, gray-green_beds, gray_beds, black_beds, and lavender_beds). Lavender and lavender-like colors take precedence over gray and green. When one of the six dominant colors (white, green, gray-green, gray, black, and lavender) is combined with a graylike color (cream, orange, buff, yellow, or brown), the dominant color is used. Gray takes precedence over white. No entry, no information provided, but if the "lithology" value is attributed with a rock type, then gray is the attributed color.
white_beds	1, white if white is only in "color" item; no entry, color is not white.
green_beds	1, green if green is in "color" item; no entry, color is not green.
gray-green_beds	1, grayish-green and (or) greenish-gray beds if gray-green or green-gray is in "color" item. No entry, color is not grayish green or greenish gray.

Table 9. Definitions of item names in the lithology worksheet—Continued

Item name	Definition
gray_beds	1, gray if cream, orange, buff, yellow, and brown is in "color" item; or, if no entry and "lithology" value is attributed with a rock type, then gray is the attributed color. No entry, color is not one of these colors.
black_beds	1, black if black is in "color" item; no entry, color is not black.
lavender_beds	1, lavender if lavender, pink, red, or maroon is in "color" item; no entry, color is not lavender.
vitreous	1, vitreous or subvitreous if luster of rocks is described as such; no entry, luster is nonvitreous (not described)
structures	Abbreviations or terms describing sedimentary structures noted in the section. Many of the more frequently noted structures correspond to another item in the spreadsheet; others, less frequently noted, are listed only here. This item may also include bedding descriptions, faults, or general comments. Sedimentary structures: cb or x-beds, crossbedded (includes megaripple and channel); chnl or chnls, channel, climbing ripples, f-l, flat laminations; gdb, grb, or grdb, graded beds; hl, horizontal laminations (includes lenticular bedding); inclined, inclined bedding; lam, laminations; massive, massive bedding; mc, mudchips; rdl or ripple, ripple-drift laminae (includes flaser bedding); ru or rc, ripup clasts; ssd or deformed slump, slump block, ball/pillow, or pinch/swell, soft-sediment deformation (includes ball and pillow, convoluted beds, and pinch and swell); wrs, water release, or dewatering structures, water-release structures; no entry, sedimentary structures not described.
horizontal_laminations	1, horizontal laminations (or flat laminations includes lenticular bedding) if hl is in "structures" item; no entry, horizontal laminations are absent.
ripup_clasts	1, ripup clasts if ru or rc is in "structures" item; no entry, ripup clasts are absent.
soft-sediment_deformation	1, soft-sediment deformation (also ball and pillow, convolute beds, and pinch and swell) if ssd, deformed slump, ball/pillow, or pinch/swell is in "structures" item; no entry, soft-sediment deformation is absent.
cross-beds	1, crossbeds if cb or x-beds is in "structures" item (also megaripple or channel); no entry, crossbeds are absent.
ripple_drift_laminae	1, ripple-drift laminae (includes flaser bedding) if rdl is in "structures" item; no entry, ripple-drift laminae are absent.
mud_chips	1, mudchips if mc is in "structures" item; no entry, mudchips are absent.
graded_beds	1, graded beds if gdb, grb, or grdb is in "structures" item; no entry, graded beds are absent.
dewatering_structures	1, dewatering structures (includes water-release structures) if wrs or water release is in "structures" item; no entry, dewatering structures are absent.
comments	Additional comments about interval.
thickness	Calculated true thickness of the sample interval (in feet). Thickness = (to – from, or to_corr – from_corr if a correction was needed).
app_thick	Thickness (in feet) of a stratigraphic interval, measured parallel to the core axis of a diamond-drill hole. Not yet corrected to the true stratigraphic thickness for diamond-drill holes.

determine the relative abundance of a mineral, as "abundant", "present", or "trace". For example, a solid red-filled color[9] in the "carbonate" column indicates that ankerite was present in large amounts and would have been recorded in the mineralogy worksheet, discussed below, as "abundant" (A). An "abundant" amount would be interpreted for the red coloring for feldspar ("f")[10] in the "silicate" column as well. A single narrow, solid or dashed color line that does not fill the column was interpreted as "present" (P), which indicates that the mineral is present in moderate amounts but less than abundant and more than a trace. A dotted line or occasional dots in the column were interpreted as a "trace" (T) amount. A number appearing in any of the spreadsheet columns describes the relative amount of a mineral: abundant="3", present="2", and trace="1". The data on logs did not permit a precise estimation of mineral proportions.

Thickness and Other Corrections

After data entry was completed, a correction was made in the spreadsheet to the depth intervals of the diamond-drill-hole data to account for inclination of strata with respect to the core axis of the hole. Thickness intervals of measured sections are always recorded in feet of true thickness, and so no thickness correction was necessary.

Table 10. Example of spreadsheet calculation of sand isolith

[Bold, data from spreadsheet; bold italic, grain-size data used to sort data in columns 1 to 4 of spreadsheet in ascending order; roman, temporary column of data containing thickness calculated using from_corr and to_corr. Lithologies: q, quartzite; s, siltite; sa, silt-argillite; sq, silty quartzite. Gray-shaded area, sand isolith calculated from thickness of cells above with grain_size=5]

from_corr	to_corr	lithology	*grain_size*	Thickness (ft)
687.0	**690.6**	**sa**	***1.5***	3.6
690.6	**695.1**	**s**	***2***	4.5
695.1	**698.8**	**s**	***2***	3.6
676.1	**680.6**	**sq**	***3***	4.5
670.7	**676.1**	**q**	***5***	5.4
680.6	**683.4**	**q**	***5***	2.7
683.4	**685.2**	**q**	***5***	1.8
685.2	**687.0**	**q**	***5***	1.8
698.8	**703.3**	**s**	***2***	4.5
Sand isolith---------------------------------------				11.8

A correction was also applied so that the footage is always reported as increasing with stratigraphic depth. Measured-section data collected in the downsection direction required no correction; however, depth intervals of diamond-drill holes or measured sections logged in the upsection direction were inverted for display in the downsection direction. The inversion was done by subtracting the deepest interval from depths (“from”, “to”) on each row of the spreadsheet.

The White Pine Creek 2, 3, 4 measured section is unusual because data are recorded in five parts, with sections measured in both “up” and “down” directions (fig. 19) consisting of 2, 2a, 3, 3a, and 4. Each part was corrected individually and then combined. White Pine Creek 4 required no correction, but White Pine Creek 3 had to be corrected by inverting the data. If no correction was needed in the spreadsheet, the top and bottom of the intervals are shown as “from” and “to”. If a correction was needed in the spreadsheet, the from-to intervals of the downsection direction are shown in the “from_corr” and “to_corr” columns.

Entry of diamond-drill-hole data, such as for diamond-drill hole VR–4 (fig. 20), differs somewhat from that of a measured section. In diamond-drill hole VR–4 and others, the bedding orientation of the strata relative to the core axis must be considered to correct apparent thickness to true thickness. For diamond-drill hole VR–4, the average angle is 45º[(15)]. A correction for the average core angle for entire diamond-drill core was applied to each from-to depth interval (row) in the worksheet for cores to estimate the true thickness of the strata. Diamond-drill hole VR–4 was logged in the “up” direction because of overturned strata, and so a correction was made for diamond-drill-hole inclination, followed by inversion of the overturned strata to obtain true thickness and orientation of strata. The true stratigraphic thickness in proper orientation is listed in the spreadsheets in the “from_corr” and “to_corr” columns.

Revett-Subtype Stratabound Copper-Silver Deposits, Occurrences, and Prospects

Exploration of the Revett Formation has disclosed copper-silver deposits, occurrences, or prospects at 57 sites in the study area (pl. 1; fig. 1). Deposits, occurrences, and prospects containing disseminated copper and silver (±lead) in rocks of the Revett Formation are shown on plate 1 and listed in table 1. They exhibit characteristics of the Revett-subtype deposit model (Cox and others, 2003). Most sites were recognized previously (Lange and Sherry, 1983; Spanski, 1992); the accompanying tab-delimited text file *cuag_deposit.txt* provides added details. A total of 4 of these sites have recorded production, 12 have identified resources, and 30 have mineralized domains (see next section). Deposits are sites containing identified resources of stratabound copper. An occurrence is a site containing small amounts of stratabound copper. Prospects are explored sites with characteristics that have not been confirmed to be Revett-subtype deposits but are recorded because of their historical value.

The tab-delimited text file *cuag_deposit.txt* contains more than 55 data fields describing each of the 57 sites, including location (legal land description and latitude-longitude coordinates), county, State, mining district, references, exploration history, nature and stratigraphic position of mineralization, nature of alteration and host horizon, local structures present, production history, and resources. The data structure of fields in the file *cuag_deposit.txt* is explained in table 12.

Spatial Databases

Between 1977 and 1984, Larry Appelgate and other Asarco Inc. geologists explored for stratabound copper-silver mineralization associated with the Revett Formation in northern Idaho and western Montana. Some results of their work were compiled on 11 topographic base maps at 1:48,000 scale and on 2 maps at 1:12,000 scale that were assembled on photographically produced scale-stable media of 7½- or 15-minute USGS quadrangle maps. Paper versions of these maps printed from scale-stable media were hand-colored, scanned, georeferenced for GIS use and published separately as 13 raster (tiff) images (Boleneus and others, 2001a).

Selected features from copies of these maps were converted into ArcInfo coverages by the USGS and include the datasets *rev48k* (geology of the Revett Formation), *rev_ddh* (location of diamond-drill cores), *rev_msec* (location of measured sections), and *rev_cuag* (copper-silver mineralized domains, unexplored areas, and permissive tracts). New or interpreted data added to complete the databases include domain type and mineralized unit (*rev_cuag*) and mineralized outcrops and the nature of fault contacts (*rev48k*). New information and interpretations were used to create spatial data-

Table 11. Definition of item names in the mineralogy worksheet

Item name	Definition
section	Name of the measured section or drill hole. Drill holes have "DDH" as the first three letters in the name.
section_logged	For measured sections, if the item is attributed, then the measured section is a composite of multiple segments. The attribute is the name of the various measured sections used to make the composite. For diamond-drill holes, the attribute is the name of an extended area where several diamond-drill holes are located, for example, Spar Lake, Rock Creek.
orientation	Direction in which the section was measured, for example, upsection stratigraphically or downsection stratigraphically. "no data," data unavailable for the section.
from	Depth (in feet) measured at the beginning of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. "no data," data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction, and holes were drilled at an angle not requiring a correction) so that the "from_corr" value (item name) will not be attributed.
to	Depth (in feet) measured at the end of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. "no data," data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction, and holes were drilled at an angle not requiring a correction) so that the "to_corr" value (item name) will not be attributed.
ave_core_angle	Average angle (in degrees) of the bedding inclination, measured from the core axis. A value of −90º means that strata are horizontal perpendicular to the core axis. "no data," data unavailable for the section.
from_corr	Depth (in feet) measured at the beginning of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. "no data," data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction, and holes were drilled at an angle not requiring a correction) so that the "from_corr" value (item name) will not be attributed.
to_corr	Depth (in feet) measured at the end of a stratigraphic interval for diamond-drill holes and measured sections in the stratigraphic down direction. "no data," data unavailable for the section. This item is attributed for diamond-drill holes and measured sections only where no correction is needed (they are already in stratigraphic down direction, and holes were drilled at an angle not requiring a correction) so that the "to_corr" value (item name) will not be attributed.
py-cube	Numeric value indicating relative rank (amount) of pyrite with a non-framboidal habit (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
py-fram	Numeric value indicating relative rank (amount) of pyrite with a framboidal, clustered, balled, or clotted habit (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
pyrrhotite	Numeric value indicating relative rank (amount) of pyrrhotite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
galena	Numeric value indicating relative rank (amount) of galena (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
chalcopyrite	Numeric value indicating relative rank (amount) of chalcopyrite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
bornite	Numeric value indicating relative rank (amount) of bornite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
magnetite	Numeric value indicating relative rank (amount) of magnetite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
hematite	Numeric value indicating relative rank (amount) of hematite (including specularite) (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
leucoxene	Numeric value indicating relative rank (amount) of leucoxene (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
mnox	Numeric value indicating relative rank (amount) of MnO_2 (including dendrites) (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
calcite	Numeric value indicating relative rank (amount) of calcite with disseminated habit (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
calcite_bedform	Numeric value indicating relative rank (amount) of calcite with bedform habit (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
dolomite	Numeric value indicating relative rank (amount) of dolomite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
ankerite	Numeric value indicating relative rank (amount) of ankerite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.

Table 11. Definition of item names in the mineralogy worksheet—Continued

Item name	Definition
feldspar	Numeric value indicating relative rank (amount) of feldspar (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
chlorite	Numeric value indicating relative rank (amount) of chlorite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
biotite	Numeric value indicating relative rank (amount) of biotite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
cuox	Numeric value indicating relative rank (amount) of Cu oxide (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
feox	Numeric value indicating relative rank (amount) of Fe oxide as limonite (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
banding	Numeric value indicating relative rank (amount) of color banding or liesegang banding (higher numbers indicate more): 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
comments	Additional comments about the interval.
orange/brown_spots	Numeric value indicating relative rank (amount) of unidentified orange/brown spots (higher numbers indicate more) suspected to be dolomite, ferroan calcite, or ankerite: 3, abundant; 2, moderate; 1, trace; no entry, "0", or "no data," information not provided.
thickness	Calculated true thickness (in feet) of the sample interval. Thickness = (to − from, or to_corr − from_corr if a correction was needed).
app_thick	Thickness (in feet) of a stratigraphic interval, measured parallel to the core axis of a diamond-drill hole. Not yet corrected to true stratigraphic thickness for diamond-drill holes.

bases of mineral zones in the A–D beds of the lower member of the Revett Formation (*lrevzone*) and in the middle quartzite of the upper member of the Revett Formation (*urevzone*). The UTM zone 11 coordinate system is used to represent the geographic features in all the spatial datasets. The overall accuracy (with respect to the location of lines and points) of spatial databases ranges from 72 to 192 m when comparing the digital data with the locations shown on USGS raster topographic maps. Refer to metadata for the accuracy of each dataset. These digital databases are not meant for use or display at a scale larger than 1:48,000 (for example, 1:24,000 or 1:12,000).

Geologic Databases

The geologic dataset, *rev48k*, consists of two parts: (1) geology of the Revett and other formations and (2) outcrops of the upper and lower members of the Revett Formation containing disseminated copper-silver mineralization (pl. 1). The geologic dataset is based on the exploration mapping conducted by Asarco Inc. (Boleneus and others, 2001a). Polygons in the ArcInfo coverage *rev48k* show the extent of the Revett Formation and parts of the underlying Burke and overlying St. Regis and Wallace Formations. The lower, middle, and upper members of the Revett Formations are shown if they were located during field mapping; however, these rocks crop out over less than 10 percent of the study area (pl. 1; fig. 1), a factor that limited field identification of stratigraphic units. Arcs in the coverage *rev48k* indicate whether the boundaries between polygons are contacts, faults, or scratch boundaries.

The surface trace of outcropping strata with disseminated copper-silver mineralization shown on the maps compiled by one of the authors (L.M. Appelgate) and others at Asarco Inc. are represented as arcs (lines) in the ArcInfo coverage *rev48k*. The trace of copper-bearing horizons can be followed continuously for distances ranging from several hundred feet to several tens of thousands of feet. Outcrops of mineralized horizons are scattered widely throughout the western Montana copper belt but are particularly common in the upper and lower members of the Revett Formation near the Troy and Rock Creek deposits. The mineralized outcrops are weathered and characterized by Cu oxides consisting of light-green to light-blue blooms (or disseminations), or heavy Fe oxide coatings along fractures and rock surfaces. The trace of outcrops with visible disseminated copper (Cu oxide or sulfide) in the Revett Formation, referred to as *mineralized outcrop* on plate 1, commonly are associated with identified resources or mineralized domains and, in some places, ore-grade copper mineralization.

Table 12. Definition of item names in the file cuag_deposit.txt

[File contains geologic data on mines, mineral deposits, occurrences, and prospects of stratabound copper-silver deposits in the Revett Formation (Mesoproterozoic) in the western part of the Belt Basin, western Montana and northern Idaho]

Item name	Description of field
No	Number designation.
Site name	Name of the site.
Abbrev	Abbreviation of site name.
Project name	Other project name used.
Other names	Alternate names.
MILS number	Mineral Industry Location System number.
MRDS number	Mineral Resources Data System number.
District name	Mining-district name.
County	County name.
State	State name.
Quad 250K	Name of 1:250,000-scale quadrangle.
Township	Township number and direction for site.
Range	Range number and direction for site.
Section	Sections to locate site.
Latitude	Latitude (in degrees, yy.zzzz).
Longitude	Longitude (in degrees, –xxx.zzzz).
TRSMER_ST	Concatenated form of township, range, section, and State for site.
Location comments	Comments concerning location of the site.
Size	Type of property described (large, medium, small, occurrence); Revett-subtype stratabound mineralization has not been established to occur at sites labeled "prospects."
Ore minerals	Ore minerals present.
Gangue minerals	Gangue minerals present.
Degree of supergene oxidation	Degree of supergene oxidation.
Major commodities	List of major commodities.
Minor commodities	List of minor commodities.
Reference 1	First reference.
Reference 2	Second reference.
Reference 3	Third reference.
Deposit type	Type of mineral deposit.
Form and shape	Form and shape of mineral deposit.
Thickness of mineralized interval	Thickness of interval.
Grade of mineralized interval	Grade of mineralized interval.
Alteration	Alteration of interval.
Significant local structure	Significant local structure affecting stratabound deposits.
Ore control	Ore controls affecting stratabound deposits.
Host rock unit	Host rock within the Revett Formation.
Stratigraphic sub-unit hosting mineralization	Stratigraphic unit within the Revett Formation.
Host-rock type	Host-rock type.
Discovery year	Year of discovery.
Nature of discovery	Nature of discovery methods used.
Exploration and development history	Chronology of exploration and development.
Geochemistry	Geochemistry methods used in exploration.
Geophysics	Geophysics methods used in exploration.
Drilling and trenching	Drilling and trenching used in exploration.
Description of mine workings	Description of mine workings.
Production dates	Production dates.
Production,short tons	Amount of production.
Production Silver, troy ounces	Silver grade of production.
Copper production lbs	Copper grade of production.
PRODUCTION-reference	Reference for production data.
Resource short tons	Resources of stratabound mineralization known.
RESOURCE-Grade Ag troy ounces/short ton	Silver grade of resources.
RESOURCE-Grade Cu (%)	Copper grade of resources.
RESOURCE-References	Reference for resources.
Comments	Comments.
Owner or operator	Owner or operator of the site.

Documentation for the ArcInfo Coverage rev48k.e00

Linear Features

REV48K.AAT

Descriptions of the user-defined items identifying linear features, such as contacts, boundaries (for example, map boundaries), and structures in the arc (or line)-attribute table, REV48K.AAT, are as follows:

REV48K.AAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
linecode	Number used by the USGS to manage attribute information on lines. Linecodes <100 are used for contacts and boundaries Linecodes >100 and <600 represent structural features. Linecodes >800 represent linear geologic units.
str_name	Name of fault.
source	Number used to identify the data source for the linear features. See the lookup table **REV48K.REF** for complete reference.
line_type1	General classification of the linear features.
line_type2	Qualified classification of the linear features.
line_type3	Complete description of the linear features, which may also include a description of the line pattern.

0Areal Features

REV48K.PAT

Descriptions of the user-defined items identifying geologic units in the polygon-attribute table, REV48K.PAT, are as follows:

REV48K.PAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
unit	Number used by the USGS to manage attribute information for each rock unit.
source	Number used to identify the data source for the unit. See the lookup table **REV48K.REF** for complete reference.
label-alpha	Map symbol, represented by alpha characters, used to label map units.
unit_name	Formal or informal map unit name.
lith	Major type of lithostratigraphic unit, for example, metasedimentary rocks, intrusive rocks.
minage	Minimum stratigraphic age of the unit.
maxage	Maximum stratigraphic age of the unit.

Source Attributes

REV48K.REF

Source or reference information for the REV48K ArcInfo dataset is stored in the REV48K.REF file. Attribute descriptions for items in this file are as follows:

REV48K.REF	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source. (This is the keyfield that relates to the **REV48K.AAT** and **REV48K.PAT** files.)
scale	Scale of source map, given as the denominator of the proportional fraction.
authors	Names of author(s), entered as last name, first name or initial, and middle initial.
year	Source (map) publication date.
reference1	The first 250 characters of the reference in USGS reference format.
reference2	The second set of 250 characters of the reference in USGS reference format.

Measured-Section and Diamond-Drill-Core Datasets

The spatial dataset for measured sections, *rev_msec,* is an ArcInfo coverage in which arcs represent the traverse lines for the measured sections. The spatial dataset for diamond-drill cores, *rev_ddh,* is an ArcInfo point coverage showing the collar locations of the drillsites (pl. 1). All diamond-drill cores or measured sections occur at a single site or traverse line, respectively. Measured sections were assembled from observations on a series of outcrops occurring along a traverse line, a few of which were assembled from two or more separate traverses that recorded a series of continuous strata.

Documentation for the ArcInfo Coverage rev_ddh.e00

Point Features

REV_DDH.PAT

Descriptions of the items identifying diamond-drill holes and one measured section are given in the point-attribute table, REV_DDH.PAT, which is defined as follows:

REV_DDH.PAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source for the diamond-drill holes. See the lookup table **REV_DDH.REF** for complete reference.
name	Name of drill hole. One measured section, Kellogg, is included because it incorporated diamond-drill-core information.

The composite measured section contained in this coverage, Kellogg, consists of stratigraphic data assembled from a combination of diamond-drill cores and underground and surface measured sections. Data from the upper part of the Revett Formation were assembled from diamond-drill cores and measured sections at the Bunker Hill Mine; data for the middle part of the Revett Formation were assembled from a measured section at a rock quarry in Big Creek; and data from the lower Revett Formation were assembled from a measured section north of the quarry (above) in Big Creek (B.G. White, written commun., 2003). This third section contains about 3,700 ft of the upper, middle, and lower members of the Revett Formation. The section starts in the lower member of the Revett Formation and continues into the overlying St. Regis Formation. The lower member of the Revett Formation is 1,600 ft thick but is incomplete.

Source Attributes

REV_DDH.REF

Source or reference information for the REV_DDH ArcInfo dataset is stored in the REV_DDH.REF file. Attribute descriptions for items in the REV_DDH.REF data-source file are as follows:

REV_DDH.REF	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source. (This is the keyfield that relates to the **REV_DDH.PAT** file.)
scale	Scale of source map, given as the denominator of the proportional fraction.
authors	Names of author(s), entered as last name, first name or initial, and middle initial.
year	Source (map) publication date.
reference1	The first 250 characters of the reference in USGS reference format.
reference2	The second set of 250 characters of the reference in USGS reference format.

Documentation for the ArcInfo Coverage rev_msec.e00

Linear Features

REV_MSEC.AAT

Descriptions of the items identifying linear features, such as measured sections (trace of the outcrops examined) in the arc (or line)-attribute table, REV_MSEC.AAT, are as follows:

REV_MSEC.AAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source for the measured section. See the lookup table **REV_MSEC.REF** for complete reference.
msec_name	Name of measured section.

Source Attributes

REV_MSEC.REF

Source or reference information for the REV_MSEC ArcInfo dataset is stored in the REV_MSEC.REF file. Attribute descriptions for items in the REV_MSEC.REF data-source file are as follows:

REV_MSEC.REF	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source. (This is the keyfield that relates to the **REV_MSEC.AAT** file.)
scale	Scale of source map, given as the denominator of the proportional fraction.
authors	Names of author(s), entered as last name, first name or initial, and middle initial.
year	Source (map) publication date.
reference1	The first 250 characters of the reference in USGS reference format.
reference2	The second set of 250 characters of the reference in USGS reference format.

Mineral-Zone Datasets

The mineral-zone datasets, *lrevzone* and *urevzone*, show the geographic extent of mineral zones in the lower A–D beds of the lower member of the Revett Formation and in the middle quartzite of the upper member of the Revett Formation, respectively. They show the interpreted area of three mineral zones: chalcopyrite-ankerite (CP–ANK), pyrite-calcite (PY–CAL), and lavender (LAV). The boundary between the PY–CAL and CP–ANK zones is the locus of mineralization in the Revett Formation. The nature of these zones was defined by Hayes (1983, 1990) and Hayes and Einaudi (1986). The locations of mineral zones were individually determined during analysis of other data for both the lower member of the Revett Formation, the A–D beds (*lrevzone*) (fig. 16), and the middle quartzite of the upper member of the Revett Formation (*urevzone*) (fig. 17).

Documentation for the ArcInfo Coverages lrevzone.e00 and urevzone.e00

Linear Features

LREVZONE.AAT and UREVZONE.AAT

Descriptions of the items identifying mineral-zone boundaries with respect to the lower member of the Revett Formation in the arc-attribute table, LREVZONE.AAT, and descriptions of the items identifying mineral-zone boundaries with respect to the upper member of the Revett Formation in the arc-attribute table, UREVZONE.AAT, are as follows:

LREVZONE.AAT and UREVZONE.AAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
type	Linear features that form the boundaries between areas characterized by a mineral zone. The chalcopyrite-ankerite/lavender (CP–ANK/LAV boundary) linear feature is the boundary between the chalcopyrite-ankerite and lavender zones. Likewise, the pyrite-calcite/chalcopyrite-ankerite (PY–CAL/CP–ANK boundary) linear feature is the boundary between the chalcopyrite-ankerite and pyrite-calcite zones as defined by Hayes and Einaudi (1986). *fault:* A line corresponding to a known fault. *scratch:* A boundary that indicates either (1) a limit of data, (2) extent of study area, or (3) a contact estimated by the USGS from existing data. *CP–ANK/LAV:* Boundary between chalcopyrite-ankerite and lavender zones. *PY–CAL/CP–ANK:* Boundary between pyrite-calcite and chalcopyrite-ankerite zones.
accuracy	Line-type modifier indicating degree of accuracy, for example, known, indicated, inferred. No entry indicates accuracy not needed for type of line. (For all records where accuracy is blank, type="scratch".)
source	Number used to identify the data source for the mineral-zone boundaries. See the lookup tables **LREVZONE.REF** or **UREVZONE.REF** for complete reference.

Areal Features

LREVZONE.PAT and UREVZONE.PAT

Descriptions of the items identifying mineral zones within the lower member of the Revett Formation in the polygon-attribute table, LREVZONE.PAT, and descriptions of the items identifying mineral zones in the middle quartzite bed of the upper member of the Revett Formation in the polygon-attribute table, UREVZONE.PAT, are as follows:

LREVZONE.PAT and UREVZONE.PAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
alter_zone	Mineral zone in which alteration occurs. The chalcopyrite-ankerite (CP–ANK), pyrite-calcite (PY–CAL), and lavender (LAV) zones are defined by Hayes and Einaudi (1986) from work at the Troy deposit. The mineral zones define a volume of rock in which this alteration-mineral assemblage dominates. *CP–ANK:* Indicates presence of the CP–ANK zone (Hayes, 1983; Hayes and Einaudi, 1986). *LAV:* Indicates presence of the LAV zone (Hayes, 1983; Hayes and Einaudi, 1986). *PY–CAL:* Indicates presence of the PY–CAL zone.
source	Number used to identify the data source identifying mineral-zone areas. See the lookup tables **LREVZONE.REF** or **UREVZONE.REF** for complete reference.

Source Attributes

LREVZONE.REF and UREVZONE.REF

Source or reference information for the LREVZONE and UREVZONE ArcInfo datasets is stored in the LREVZONE.REF or UREVZONE.REF files. Attribute descriptions for items in the LREVZONE.REF or UREVZONE.REF data-source file are as follows:

LREVZONE.REF and UREVZONE.REF	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source. (This is the keyfield that relates to the **LREVZONE.AAT** and **LREVZONE.PAT** or the **UREVZONE.AAT** and **UREVZONE.PAT** files.)
scale	Scale of source map, given as the denominator of the proportional fraction.
authors	Names of author(s), entered as last name, first name or initial, and middle initial.
year	Source (map) publication date.
reference1	The first 250 characters of the reference in USGS reference format.
reference2	The second set of 250 characters of the reference in USGS reference format.

Copper-Silver-Mineralized-Domain, Untested-Exploration-Area, and Permissive-Tract Dataset

The copper-silver mineralized-domain dataset, *rev_cuag*, contains three types of data: mineralized domain, untested exploration area, and permissive tracts.

Mineralized Domains

Mineralized domains (pl. 1) are the areas underlain by stratabound copper-silver mineralization that are delimited by surface exposures and diamond-drill-hole information. Mineralized domains occur at 30 of the 57 sites listed in table 1. Mineralized domains are divided for the purposes of this report into three categories: identified resources, indicated mineralized rock, and inferred mineralized rock. These categories are partly based on the U.S. Bureau of Mines (USBM) and USGS mineral-resource classification (U.S. Geological Survey, 1980).

Identified resources of copper-silver are concentrations of earth materials whose economic extraction is potentially feasible on the basis of location, tonnage, and copper-silver grade. Identified copper-silver resources occur at 12 sites, including Troy, Rock Creek, Rock Lake (Montanore), Rock Peak, Copper Gulch, and Horizon Basin. *Indicated mineralized rock* is used in this report rather than the term “indicated resources” of the USBM and USGS (U.S. Geological Survey, 1980; Long and others, 1998). This category is copper-silver-mineralized rock determined by visual examination of diamond-drill core or outcrop and, locally, assay but for which grade and tonnage of deposits are absent. *Inferred mineralized rock* is used here rather than the term “inferred resources” of the USBM and USGS (USGS, 1980; Long and others, 1998). *Inferred mineralized rock* means that mineralized bodies are assumed to exist beyond areas of *identified resources* or *indicated mineralized rock* on the basis of geologic evidence favorable for the presence of ore deposits. Areas of inferred mineralized rock may or may not be supported by samples or measurements.

The color shading on plate 1 (see figs. 8, 15, 17, 18) denotes the mineralized-domain limits. The member of the Revett Formation containing the mineralized domain identified on plate 1 is further defined in the *rev_cuag* dataset, the file *cuag_deposit.txt*, and table 1. Boundaries of identified resource areas (T. Henricksen, written commun., 1998; Hayes and others, 1989; U.S. Forest Service, 1993, 1995, 2001) may be indefinite or gradational because they depend on varying factors, such as metal prices and mining costs.

Untested Exploration Area and Permissive Tracts

The untested exploration area represents surface and subsurface areas of the Revett Formation to a depth of 8,000 ft (pl. 3). The subsurface extent of the Revett Formation was estimated from the extent of surface outcrops (Boleneus and others, 2001a), from the amount of dip of strata of the Revett Formation, and from the presence of known or inferred faults that could truncate the formation at depth.

The mineral-resource assessment described earlier in this report defined permissive and nonpermissive tracts on the basis of an analysis of the untested-exploration-area and mineral-zone datasets.

Documentation for the ArcInfo Coverage rev_cuag.e00

Areal Features

REV_CUAG.PAT

Descriptions of the items identifying copper-silver mineralized domains (with respect to the Revett Formation) in the polygon-attribute table, REV_CUAG.PAT, are as follows:

REV_CUAG.PAT	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source for the areal extent of the mineralized domain. See the lookup table **REV_CUAG.REF** for complete reference.
asses_rank	Mineral-resource-assessment rank with respect to undiscovered copper deposits in the Revett Formation (stratabound copper-silver deposits or occurrences in the Revett Formation): *not evaluated:* Area not evaluated. *non-permissive*: Domains in which undiscovered copper deposits in the Revett Formation cannot occur (based on not fitting the criteria listed below for "permissive"). *permissive:* Domains in which undiscovered copper deposits in the Revett Formation may occur. A permissive domain must contain the Revett Formation, either at the surface or at depth (where dom_type=*untested exploration area*, AND it must either (1) contain alteration characteristics that suggest proximity to copper deposits in the Revett Formation OR (2) occur at or near identified copper-silver resources or copper-silver-mineralized rock (where dom_type="*identified resource*", "*mineralized rock—indicated*", or "*mineralized rock—inferred*").
dom_name	Revett Formation mineralized domain name (for example, Chipmunk, Missoula-National, Rock Creek West). A mineralized domain is the known surface and subsurface extent of identified resources or mineralized rock. No entry indicates no name. (For all records where dom_name is blank, dom_type="*untested exploration area*" or "*unknown*".)
dom_type	Type of mineralized domain: *unknown:* Area was not evaluated. *identified resource:* A concentration of copper-silver minerals in the Revett Formation in such a form and amount that economic extraction from the concentration is currently or potentially feasible AND whose location, quality, and quantity are known or estimated from specific geologic evidence (see Long and others, 1998, p. 33, for complete definitions of "resource" and "identified resources"). Delineation of these identified resources is based on published data (Adkins, 1993; Boleneus and others, 2001a; U.S. Forest Service, written commun., 2001); however, data were insufficient to determine whether the identified resource could be more specifically classified as measured, indicated, or inferred according to the USGS mineral-resource-classification system of Long and others (1998). *mineralized rock—indicated:* Substantial copper-silver-mineralized rock in the Revett Formation, as indicated from physical evidence, such as diamond-drill core or outcrop. Overburden and grade were also taken into consideration but were not quantified. The low grade, a lack of continuity of the mineralized rock OR lack of data precluded an identified resource designation. *mineralized rock—inferred:* Believed to contain copper-silver-mineralized rock in the Revett Formation, on the basis of geologic inference. The low grade AND/OR lack of continuity of the mineralized rock AND/OR lack of data precluded an identified resource designation. *untested exploration area:* Area believed to warrant further exploration. These areas are underlain by the Revett Formation to a depth of 8,000 ft or less, and they do not include areas designated as identified resource, mineralized rock—indicated, or mineralized rock—inferred.
min_unit	Stratigraphic unit(s) in which identified copper-silver resources or copper-silver-mineralized rock occurs, on the basis of lithologic descriptions from diamond-drill cores logs and/or measured sections and/or other data: *both upper and lower Revett:* Identified copper-silver resources or mineralized rock occurs in both the upper and lower members of the Revett Formation. *lower Revett:* Identified copper-silver resources or mineralized rock occurs in the lower member of the Revett Formation. *upper Revett:* Identified copper-silver resources or mineralized rock occurs in the upper member of the Revett Formation. No entry indicates that min_unit is unknown. (For all records where min_unit is blank, dom_type="untested exploration area" or "unknown".) Also, attributes for "min_unit" may be more detailed than those for the "desc" item in the **REV48K.PAT** file.

Source Attributes

REV_CUAG.REF

Source or reference information for the REV_CUAG ArcInfo dataset is stored in the REV_CUAG.REF file. Attribute descriptions for items in the REV_CUAG.REF data-source file are as follows:

REV_CUAG.REF	
ITEM NAME	**ATTRIBUTE DESCRIPTION**
source	Number used to identify the data source. (This is the keyfield that relates to the **REV_CUAG.PAT** file.)
scale	Scale of source map, given as the denominator of the proportional fraction.
authors	Names of author(s), entered as last name, first name or initial, and middle initial.
year	Source (map) publication date.
reference1	The first 250 characters of the reference in USGS reference format.
reference2	The second set of 250 characters of the reference in USGS reference format.

How to Obtain Data

To obtain copies of the digital data, download the digital files from the USGS public-access Web site at URL *http://pubs.usgs.gov/sir/2005/5231/,* which contains the spatial digital databases and metadata for diamond-drill-core, measured-section, geologic, resource, and mineral-zone maps of the Revett Formation as ArcInfo interchange-format files (see app. A). Formatted metadata (Federal Geographic Data Committee compliant) are included in this report.

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Appendix A. Graphical Logs of Measured Sections and Diamond-Drill Cores

Figure A–1. Obemeyer Mountain measured section
Figure A–2. Wee Lake 1, 2 measured section
Figure A–3. Gunsight Mountain measured section
Figure A–4. Kilbrennan Creek measured section
Figure A–5. Horseshoe Lake measured section
Figure A–6. Granite Creek measured section
Figure A–7. DDH FC–4 (Fairway Creek) diamond-drill-hole section
Figure A–8. Stanley Peak measured section
Figure A–9. DDH SL–130 (Spar Lake) diamond-drill-hole section
Figure A–10. DDH HC–4 (Hiatt Creek) diamond-drill-hole section
Figure A–11. DDH SL–136 (Spar Lake) diamond-drill-hole section
Figure A–12. DDH CC–1 (Cub Creek) diamond-drill-hole section
Figure A–13. Clark Fork measured section
Figure A–14. DDH SL–122 (Spar Lake) diamond-drill-hole section
Figure A–15. Mount Vernon measured section
Figure A–16. DDH SL–60 (Spar Lake) diamond-drill-hole section
Figure A–17. DDH SL–123 (Spar Lake) diamond-drill-hole section
Figure A–18. DDH SL–93 (Spar Lake) diamond-drill-hole section
Figure A–19. DDH SL–106 (Spar Lake) diamond-drill-hole section
Figure A–20. DDH SL–138 (Spar Lake) diamond-drill-hole section
Figure A–21. DDH SL–31 (Spar Lake) diamond-drill-hole section
Figure A–22. DDH SL–139 (Spar Lake) diamond-drill-hole section
Figure A–23. DDH SL–132 (Spar Lake) diamond-drill-hole section
Figure A–24. Little Spar Lake measured section
Figure A–25. DDH JF–79–1 (J–F) diamond-drill-hole section
Figure A–26. DDH JF–79–4 (J–F) diamond-drill-hole section
Figure A–27. DDH JFW–1 (J–F West) diamond-drill-hole section
Figure A–28. DDH JF–12 (J–F) diamond-drill-hole section
Figure A–29. DDH DC–3 (Dry Creek) diamond-drill-hole section
Figure A–30. DDH DC–2 (Dry Creek) diamond-drill-hole section
Figure A–31. Squaw Peak measured section
Figure A–32. Goat Rocks measured section
Figure A–33. DDH SN–2 (Snake Creek) diamond-drill-hole section
Figure A–34. DDH SN–5 (Snake Creek) diamond-drill-hole section
Figure A–35. East Fork of Bull River 1, 2, 3 measured section
Figure A–36. DDH SN–1 (Snake Creek) diamond-drill-hole section
Figure A–37. DDH SN–4 (Snake Creek) diamond-drill-hole section
Figure A–38. DDH SN–3 (Snake Creek) diamond-drill-hole section
Figure A–39. Goat Rocks (lower) measured section
Figure A–40. DDH RC–58 (Rock Creek) diamond-drill-hole section
Figure A–41. DDH RC–49 (Rock Creek) diamond-drill-hole section
Figure A–42. DDH RC–47 (Rock Creek) diamond-drill-hole section
Figure A–43. DDH RC–43 (Rock Creek) diamond-drill-hole section
Figure A–44. Chicago Peak (White) measured section
Figure A–45. Rock Creek (East Fork) measured section
Figure A–46. DDH HF–1 (Hereford) diamond-drill-hole section
Figure A–47. McKay Creek (White) measured section
Figure A–48. McKay Creek North measured section
Figure A–49. McKay Creek South measured section
Figure A–50. Green Mountain measured section
Figure A–51. Waloven Creek (lower) measured section
Figure A–52. Waloven Creek (upper) measured section
Figure A–53. Sims Creek (west slope) measured section
Figure A–54. Sims Creek 1, 2 (east slope) measured section
Figure A–55. Miners Gulch (Vermilion River) measured section
Figure A–56. DDH VR–11 (Vermilion River) diamond-drill-hole section
Figure A–57. DDH VR–4 (Vermilion River) diamond-drill-hole section
Figure A–58. Rush Lake measured section
Figure A–59. Vermilion River (White) measured section
Figure A–60. Slide Rock Mountain measured section
Figure A–61. Deep Creek measured section
Figure A–62. Graves Peak measured section
Figure A–63. Graves Creek Falls measured section
Figure A–64. Thompson River measured section
Figure A–65. DDH TC–9 (Trout Creek) diamond-drill-hole section
Figure A–66. DDH TC–8 (Trout Creek) diamond-drill-hole section
Figure A–67. DDH TC–10 (Trout Creek) diamond-drill-hole section
Figure A–68. Trout Creek 1, 2 measured section
Figure A–69. DDH TC–7A (Trout Creek) diamond-drill-hole section
Figure A–70. Trout Creek (White) measured section

Figure A–71. DDH TC–5A (Trout Creek) diamond-drill-hole section
Figure A–72. West Fork of Trout Creek 1 measured section
Figure A–73. West Fork of Trout Creek 2 measured section
Figure A–74. Windfall Peak measured section
Figure A–75. White Pine Creek 2, 3, 4 measured section
Figure A–76. Ripper Creek measured section
Figure A–77. Miller Gulch (Sex Peak) measured section
Figure A–78. Beaver Creek Road measured section
Figure A–79. Little Beaver Creek measured section
Figure A–80. Clear Peak (Asarco) measured section
Figure A–81. Beaver Peak North measured section
Figure A–82. Clear Peak (White) measured section
Figure A–83. Beaver Lake 1, 2 measured section
Figure A–84. DDH CP–5 (Clear Peak) diamond-drill-hole section
Figure A–85. DDH CP–4 (Clear Peak) diamond-drill-hole section
Figure A–86. Twentyfour Mile Creek (Clear Peak 1) measured section
Figure A–87. Janstan measured section
Figure A–88. West Fork of Crow Creek measured section
Figure A–89. Spokane Creek measured section
Figure A–90. Spokane-Chipmunk Ridge 3 measured section
Figure A–91. Chipmunk 1 measured section
Figure A–92. Chipmunk 2 measured section
Figure A–93. Bloom Peak measured section
Figure A–94. East Lake measured section
Figure A–95. West Fork of Eagle Creek 3 measured section
Figure A–96. West Fork of Eagle Creek 1–2 measured section
Figure A–97. West Fork of Eagle Creek 5 measured section
Figure A–98. Cottonwood measured section
Figure A–99. Bobtail Creek measured section
Figure A–100. Niagara measured section
Figure A–101. Revett Lake measured section
Figure A–102. DDH MG–6 (Military Gulch) diamond-drill-hole section
Figure A–103. Prichard Creek measured section
Figure A–104. Coeur d'Alene River 3 measured section
Figure A–105. Cedar Creek measured section
Figure A–106. Little Grizzly Creek measured section
Figure A–107. Grizzly Creek measured section
Figure A–108. Timmies Section measured section
Figure A–109. Maple Cliffs measured section
Figure A–110. Graham Creek measured section
Figure A–111. Silver Creek measured section
Figure A–112. Castle Rock measured section
Figure A–113. Coal Creek measured section
Figure A–114. Kellogg measured section
Figure A–115. Latour Peak-Boise Peak measured section
Figure A–116. North of Prado Creek measured section
Figure A–117. Bumblebee Road measured section
Figure A–118. Browns Gulch measured section
Figure A–119. County Creek measured section
Figure A–120. Little Tepee Creek 1, 2 measured section
Figure A–121. North Fork of Coeur d'Alene Section 20 measured section
Figure A–122. North Fork of Coeur d'Alene Section 25 measured section
Figure A–123. Hope (David Thompson Game Preserve) measured section
Figure A–124. Military Gulch (upper) measured section
Figure A–125. Military Gulch (lower) measured section
Figure A–126. Lower Glidden Lake measured section