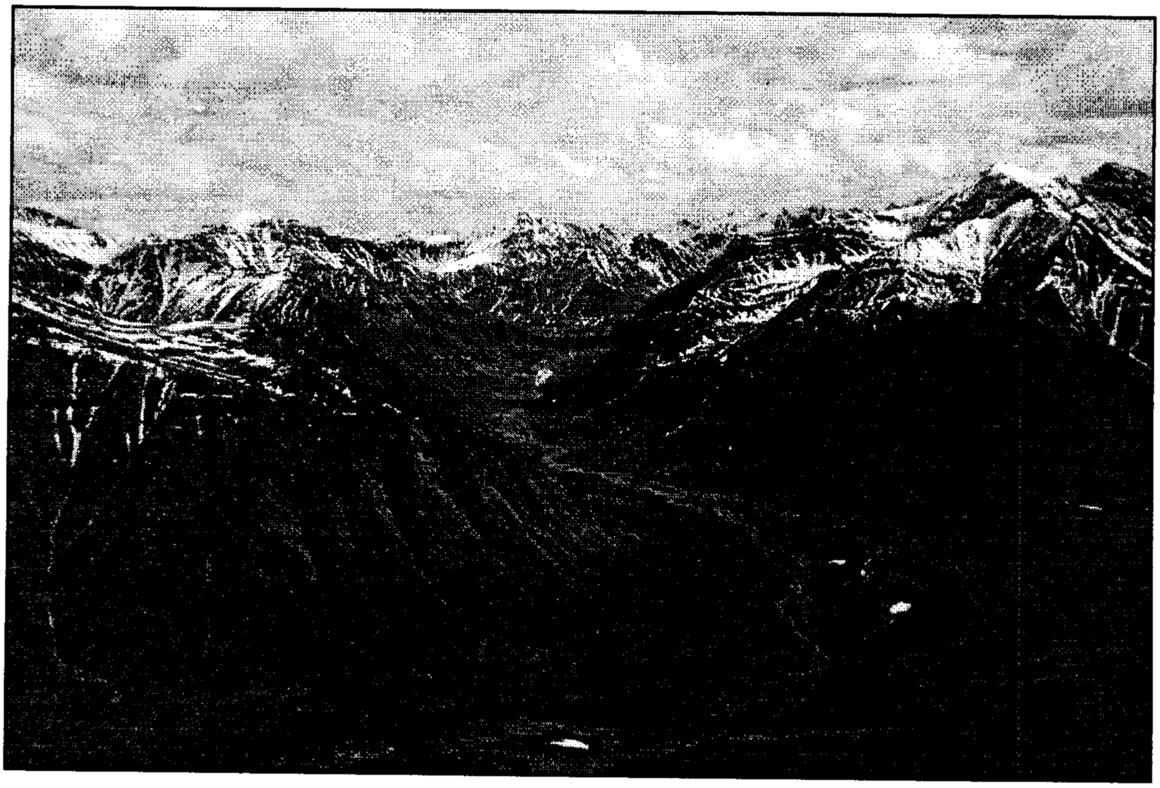
MINERAL INVESTIGATIONS IN THE COLVILLE MINING DISTRICT AND SOUTHERN NATIONAL PETROLEUM RESERVE IN ALASKA

By Joseph M. Kurtak, Russell W. Hicks, Melanie B. Werdon, Mark P. Meyer, and Charles G. Mull



Itkillik River Area, Endicott Mountains

United States Department of the Interior
U.S. Bureau of Mines

OFR 8-95

CONTENTS

CONTENTS CONT.

ILLUSTRATIONS

CONT.

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

%	percent
C	degree celsius
cm	centimeter
m	meter
km	kilometer
g/mt	grams per metric ton
ppb	parts per billion
ppm	parts per million
mt	metric tons
mmt	million metric tons
deg	degrees
fluoro	fluorometric analysis
mtpd	metric tons per day

MINERAL INVESTIGATIONS IN THE COLVILLE MINING DISTRICT AND SOUTHERN NATIONAL PETROLEUM RESERVE IN ALASKA

By Joseph M. Kurtak[1], Russell W. Hicks[2], Melanie B. Werdon[3], Mark P. Meyer[4], and Charles G. Mull[5]

ABSTRACT

The U.S Bureau of Mines conducted a five-year mineral resource assessment of the 16.6 million acre Colville Mining District in northern Alaska, which includes part of the National Petroleum Reserve in Alaska. The study was initiated at the request of the Bureau of Land Management, which administers the majority of the region. The study was done in cooperation with the Alaskan Division of Geological and Geophysical Surveys, the U.S. Geological Survey, and the University of Alaska.

During fieldwork, 1593 rock, soil, and stream sediment samples were collected and four bulk samples taken for beneficiation studies. A total of 40 mineral occurrences were documented, including 27 which were previously undescribed.

No mining has occurred within the district. Mississippian carbonaceous shale and siliceous mudstone contain stratiform exhalative lead-zinc-silver occurrences. Grades average 8.0% combined lead/zinc and 51 gm/mt silver. Upper Devonian to Lower Mississippian sandstones host breccia veins, containing up to 29% combined lead/zinc and 274 gm/mt silver. Mineralized quartzites of similar age have potential for disseminated-type lead-zinc deposits. Samples from Lower Cretaceous mudstone and shale beds up to 6.5 meters thick, contain as much up to 12% manganese. Upper Mississippian carbonaceous shale and limestone beds contain up to 23% phosphate. Stratiform barite deposits hosted by cherts, are up to 27 meters thick with an average specific gravity of 4.16. Vein-type fluorite occurrences are associated with Mississippian limestone.

Moderate potential exists for development of zinc-lead-silver, barite, and phosphate deposits.

[1]Geologist, Alaska Field Operations Center, Anchorage, Alaska

[2]Geologist, ARCO Alaska, Anchorage, Alaska

[3]Graduate student, University of Alaska, Fairbanks, Alaska

[4]Physical Scientist, Alaska Field Operations Center, Anchorage, Alaska

[5]Geologist, Alaska Division of Geological and Geophysical Surveys, Fairbanks, Alaska

INTRODUCTION

In 1990 the U.S. Bureau of Mines initiated a five-year assessment of the mineral resources of the Colville Mining District, which includes a portion of the National Petroleum Reserve in Alaska (Fig. 1). The ultimate objectives of this evaluation were to: 1) identify the mineral resources of the area; 2) study the application of modern beneficiation technologies on known mineral deposits; 3) perform mining feasibility studies, using hypothetical mine models, on mineral deposits that have potential for being economic; and 4) perform a probablisitic mineral resource and economic assessment of the mining district.

This study is part of the Bureau's ongoing mining district evaluation program and was a cooperative effort, involving the Bureau, the Alaska Division of Geological and Geophysical Surveys (ADGGS), the U.S. Geological Survey (USGS), the University of Alaska, and the Bureau of Land Management (BLM). The Bureau funded the ADGGS to map the geology of a belt of Upper Devonian to Lower Mississippian rocks, which extends through the southern portion of the study area and contains known sulfide occurrences (plate I). The ADGGS also evaluated the the coal and industrial mineral resources of the district (171)[6].

The USGS collected numerous stream sediment samples and mapped geology in the study area as part of the Alaska Mineral Resource Assessment Program AMRAP) of the Howard Pass Quadrangle. Cooperative field work by the Bureau and USGS led to the discovery of several large barite occurrences in the area and the USGS conducted magnetic and gravity surveys over over one sulfide occurrence and gravity surveys over several of the barite occurrences (128)(177).

The Bureau gave logistical and analytical support to a geology graduate student with the University of Alaska Fairbanks who mapped the geology of several of the sulfide occurrences in the study area. The BLM, which manages the majority of the land in the district, gave logistical support to the Bureau during the field work portion of the study.

This report evaluates the mineral resources of the Colville Mining District and includes the results of the application of beneficiation technologies to several of the deposits. During the course of the study yearly results were reported in a series of Bureau open file reports (172)(173). The complete geochemical results for all samples collected during the study have been compiled in a separate open file report (174). The results of a study evaluating the feasibility of mining zinc-lead-silver, barite, and coal deposits within the district will be published as a separate Bureau open file report(43). The entire study is summarized in an executive summary (171).

[6]Underlined numbers in parenthesis refer to references in the bibliography section preceeding the appendices.

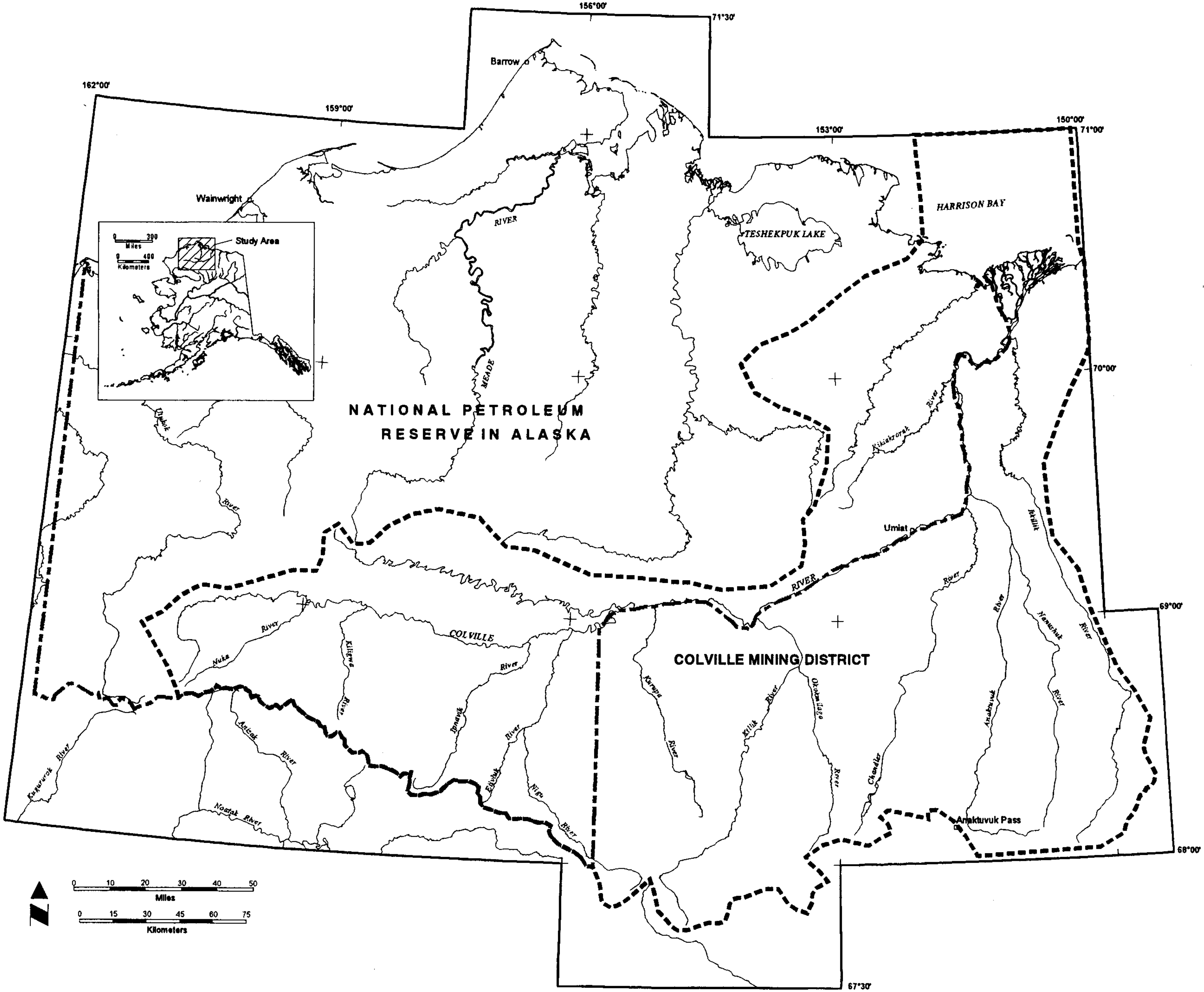


Figure 1. - Location map of the Colville Mining District, Alaska.

ACKNOWLEDGEMENTS

Completion of this study would not have been possible without the assistance and support of many individuals, a few of whom are mentioned here. The authors would like to thank Bureau Research Division personnel Frank Oliver, Bill O'Conner and Jeff Vandel for their geologic expertise in sulfides and industrial minerals. Uldis Jansons, now with the Bureau Intermountain Field Operations Center, passed on considerable information concerning his pioneering work in the district during the 1970's. Field assistants Nick Enos, Dan Graham, Ed Klimasauskas, Allen Nakanishi, Matt Nelson, and Steve Oswald made tireless and enthusiastic efforts in the field through all kinds of weather. Camp cooks Jennifer Claxton and Lori Indendi provided excellent meals and moral support. Jim Clough and Dianne Pinney (ADGGS), contributed their knowledge of coal and industrial minerals respectively. Irv Tailleur (USGS emeritus) and John Kelley (USGS) guided the Bureau to several of the barite occurrences within the study area. Lorne Young with Cominco Alaska, was very helpful in interpreting lead isotope data for the district. Don Keil (BLM) helped considerably with logistical coordination. Helicopter pilots Mike Arlene, Jim Spraggins, Michael Wilton, and Bill Murphy brought everyone home safely each day. Mechanics Chuck Crowl and Ole Olsen kept all the aircraft, as well as the camps running smoothly.

GEOGRAPHY AND CLIMATE

The Colville Mining District totals 6.7 million hectacres (16.6 million acres) and comprises the Colville River drainage basin which is located on the northwestern side of the Brooks Range (231). The southern portion of the study area is bounded by the crests of the Endicott and De Long Mountains. The Endicott Mountains are high, glaciated and very rugged, with peaks rising to nearly 2300 m (fig. 2). Low broad glaciated valleys form passes through the mountains on the Anaktuvuk, Chandler River, and Etivluk River drainages. Small cirque glaciers are common among the higher peaks. The De Long Mountains are glaciated, though less rugged, with peaks rising to 1500 m.

The northern portion of the study area consists of the Arctic Foothills. The southern portion of the foothills consists of irregular buttes, knobs, mesas, and east-trending ridges, with intervening tundra plains (fig.3) The foothills become more gentle towards the northern border of the district (299). There are no roads or trails in the district, other than a few trails, useable only during the winter months when the ground is frozen. The largest permanent settlement in the area is Anaktuvuk Pass (elevation 670 m), a Nunamiut (people of the land) Eskimo village of 250 people (232). The only other year-round settlement is at Umiat (elevation 80 m), located on the Colville River. It is occuppied by a small number of residents who operate a lodge, flight service station, and take weather observations (206).

The area is host to abundant wildlife. The western arctic

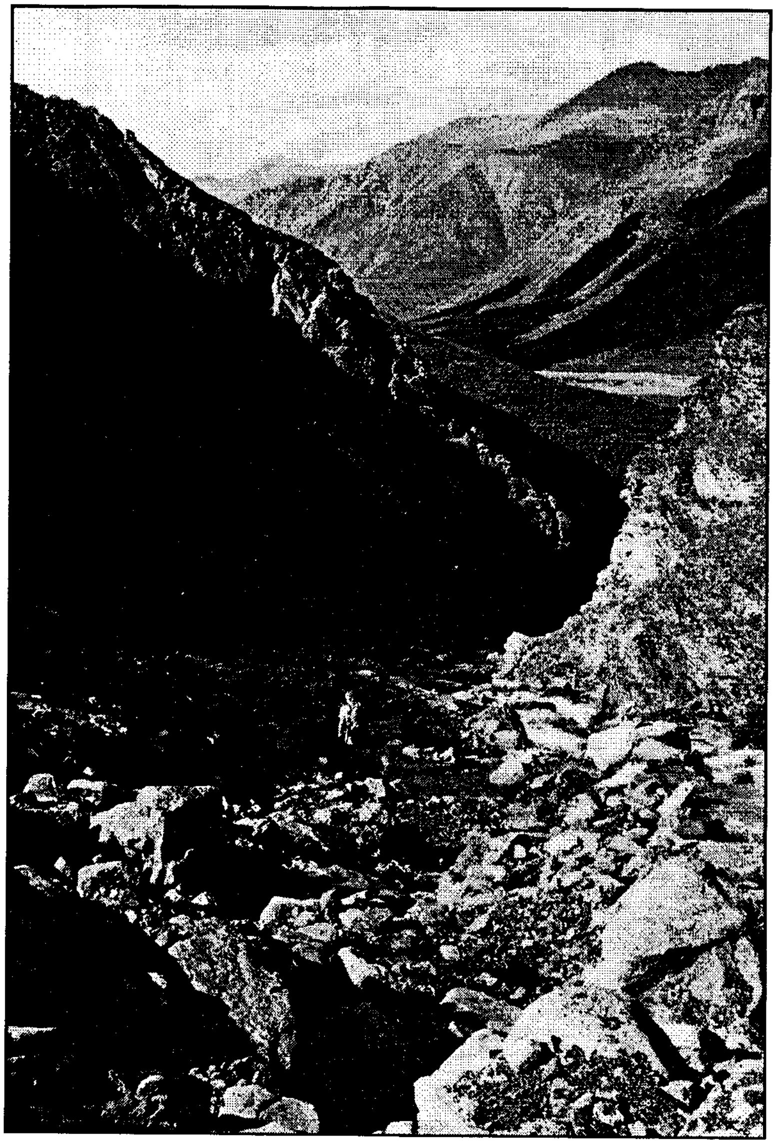


Figure 2. - Itkillik River tributary in the Endicott Mountains, looking northwest.

Figure 3. - Lisburne Ridge area in the Arctic Foothills, looking east.

caribou herd, consiting of an estimated 400,000 animals, migrates through the area during the summer. Barren ground grizzly bears, Dall sheep, wolverine, wolf, gray fox, and small number of muskox and moose also inhabit the region.

The area has an arctic climate with long cold winters and short summers. Anaktuvuk Pass, located in the Endicott Mountains on the southern boundary of the study area, has an average July temperature of 11 degrees C. and an average February temperature of - 22 degrees C. Mean annual precipitation is 25.7 cm with a mean snowfall of 145 cm (146). Drifts of wind-compacted snow will remain on lee slopes, and many of the lakes will stay frozen until early July. Umiat, on the lower Colville River, has a mean winter temperature of -31 degrees C., which is the lowest anywhere in the United States (285). Afternoon thunder and lightening storms with accompanying precipitation occur during the summer months. These storms can at times be very intense. One such storm deposited 4.3 cm of precipitation, in the form of rain and hail, within a 30 minute period, on a Bureau camp near Galbraith Lake. During mid to late summer moist winds blowing in off the Arctic Ocean will cause fog to form in the lower valleys for days at a time.

Weather observations were taken on 141 days from mid June to mid August during the course of field work. The lowest temperature recorded was -2 degrees C. and the high 32 degrees C. Skies were cloudy 57% of those days and precipitation fell during 45% of the days. Snow can fall during any month of the year. The area is subject to strong winds, expecially in the foothills, north of the range front (138).

In the Arctic foothills vegetation consists of tundra meadow plants with some willow growth along watercourses. The dry, rocky mountain slopes support little vegetation, other than Dryas, which also occurs on moraines and alluvial fans. The entire region is underlain by permafrost, which in summer thaws to a depth of several inches in the valley floors to more than 3 ft in well-drained gravelly places (232).

LAND STATUS

The Bureau of Land Management manages the majority of the land within the Colville Mining District. This includes the National Petroleum Reserve in Alaska, located in the western portion of the district. It is open to oil and gas exploration, but closed to other mineral development (fig. 4). The National Park Service manages the Gates of the Arctic National Park, in the eastern portion of the area, which is closed to oil, gas, and mineral development.

The State of Alaska has selected lands in the area as have native village and regional corporations. These lands may eventually be available for mineral exploration and development.

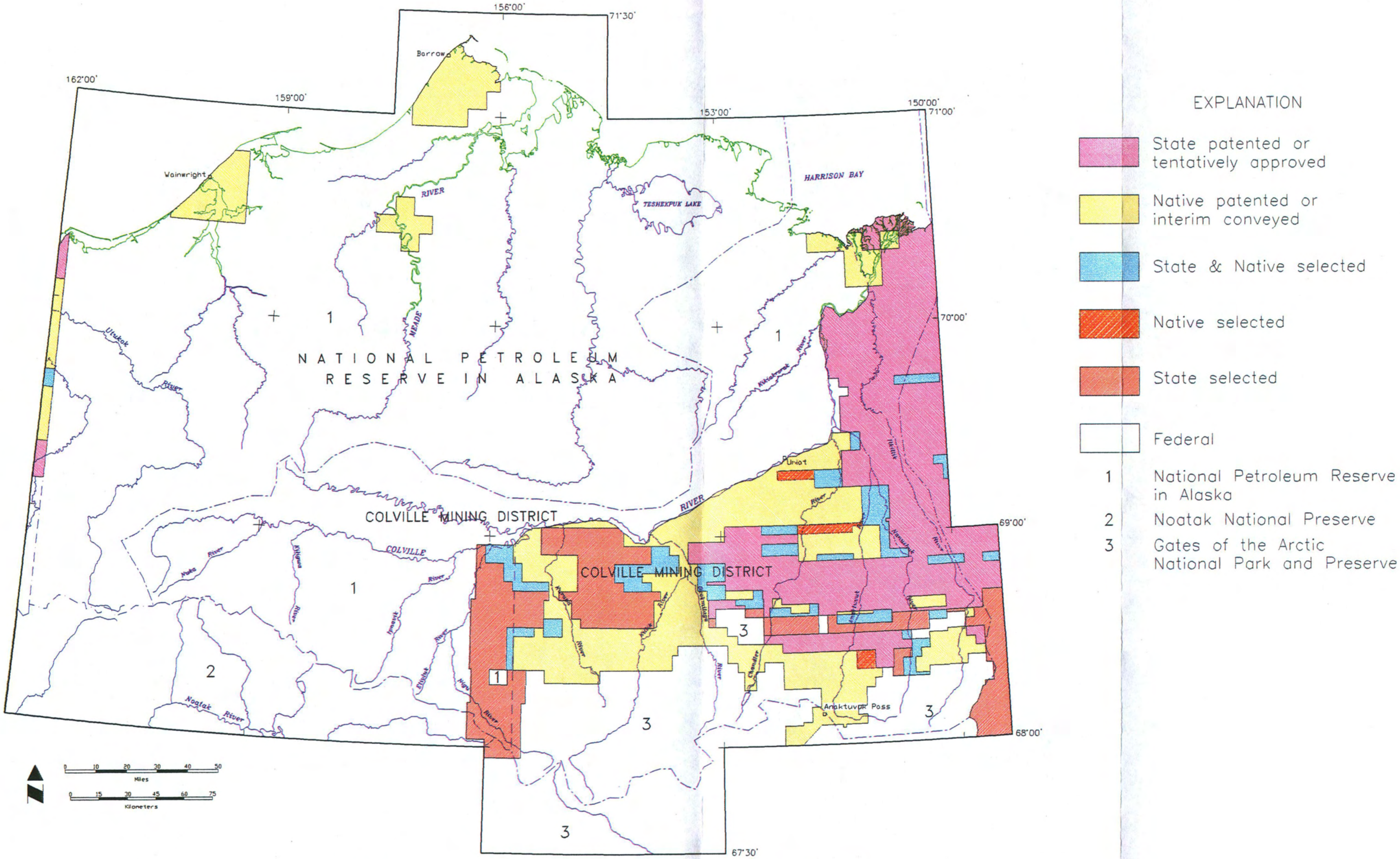


Figure 4. – Land status map of the Colville Mining District.

PREVIOUS STUDIES

The first published accounts of explorations in the Colville Mining District area were made by U.S. Navy personnel. In 1886 Lt. G.M. Stoney explored the upper Alatna River drainage and reached Chandler Lake on the southern boundary of the study area The same year Ensign Howard, with one companion and occasional native guides, crossed from the Noatak to the headwaters of the Colville and down that river, eventually reaching Barrow after a portage to the Ikpikpuk River (265). The first recorded observations of the geology and mineral deposits of the Colville Mining District area were made by USGS geologists. The interest stimulated by gold discovered on the south side of the Brooks Range lead to the dispatching of geological survey parties. The first of these was a group led by F.C. Schrader, who along with a group of geologists and topographers, ascended the John River in 1901, crossed the divide at Anaktuvuk Pass and descended to the north coast via the Anaktuvuk and Colville Rivers (255).

Systematic geological surveys of the area began in earnest when the petroleum potential of the area was realized. Oil seeps were first reported on the northern coast in the Cape Simpson area in 1908 (9). This led to the establishment of the Naval Petroleum Reserve no. 4 in 1923 which includes the western portion of the mining district. These boundaries were defined by the Director of the Bureau of Mines and administration of the area added to the duties of the Supervising Mining Engineer. In 1925 adiministration of the NPRA was turned over to the USGS from the Bureau (190). A series of geologic investigations in the area were made by the USGS from 1923-1926 (261) (fig. 5).

Some topographic features in the southeast portion of the study area were named by Robert Marshall. He made several expolorations into the area with local prospectors and gold miners from 1929 to 1932 in both summer and winter (153).

Renewed interest in the petroleum potential of the area began during World War II due to the fuel demands of the war effort. In 1943 the Bureau investigated the known petroleum seepages and checked on the existence of other reported seepages, including some near Umiat (233). A series of geologic investigations by the USGS followed from 1944-1953 some of which covered the study area (28)(53)(215). During this period phosphate occurrences were first investigated (214) and iron oxide-stained rocks were noted, but not sampled. Also the presence of barite was first noted (271).

A third phase of petroleum exploration began in 1975 when the Department of the Navy transfered management of the Naval Petroleum Reserve No. 4 to the Department of the Interior to be ultimately overseen by the Bureau of Land Management. The name was changed to the National Petroleum Reserve in Alaska (NPRA). This phase resulted in the drilling of several petroleum exploration holes within the upper Colville River drainage (92). At this time a joint study by the Bureau and the USGS of the mineral resources of

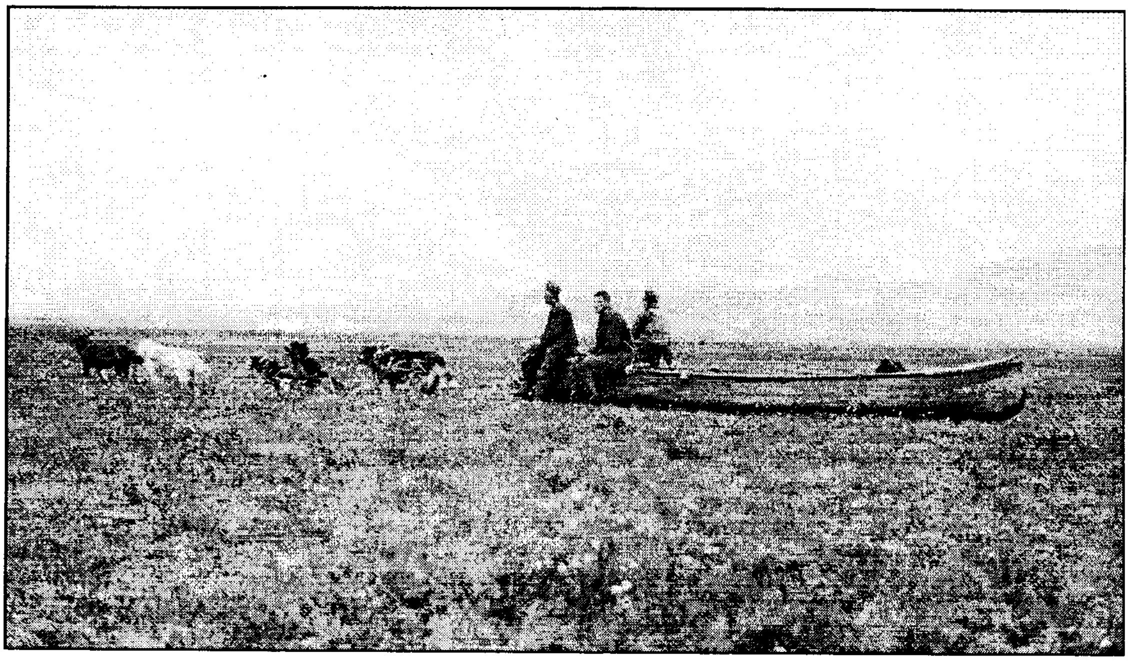


Figure 5. - U. S. Geological Survey party portage canoe in the Howard Pass area, 1924. (courtesy of U.S. Geological Survey).

the of the Petroleum Reserve was mandated by the Naval Petroleum Reserves Production Act of 1976. This led to the discovery of several zinc and lead occurrences and to the conclusion that more undiscovered occurrences may exist in the area (76)(111)(115)(201). A bedrock geologic map of the southern half of NPRA was compiled at this time (164) and considerable geochemical sampling done by the USGS (283)(284). The pioneering work by these geologists provided impetuous for the present study.

The USGS Alaskan Mineral Resource Appraisal Program (AMRAP) has completed work on the Philip Smith Mountains Quadrangle (14)(, and the Chandler Lake Quadrangle (125)(132)(133)(134). A preliminary geologic map has been published on the Killik River Quadrangle (186) and a geologic map has been compiled for the southern part of the Howard Pass Quadrangle (plate I). The USGS is currently conducting an AMRAP study of the Howard Pass Quadrangle. As part of an AMRAP study in progress of the Howard Pass Quadrangle, the USGS has published the results of preliminary sampling of the barite occurrences examined during the present study (128).

PROSPECTING AND EXPLORATION HISTORY

There are no records of any hardrock or placer mining within the Colville Mining District and there is little written information on any early prospecting that might have been done. Discoveries of placer gold on the south side of the Brooks Range in the Koyukuk drainage, brought a rush of prospectors to that area in 1898. Prospectors penetrated the area just east of the mining district during the summer of 1900, when a party of men ascended the Dietrich River and crossed the Brooks Range divide, in the vicinity of Oolah Pass. They then proceeded north to the Arctic slope, probably via the Itkillik River valley. There is no mention of what they found, other than the country was passable by pack train. In 1903 a prospecting party, of which James Reed and Walter Lucas were members, traveled up the Alatna to the divide and down the killik River to the Colville, which they descended to its mouth. They found coal, which they burned in their camp fires, but no gold (255). Any prospectors who may have ventured across the divide, noted the lack of placer gold on the Colville drainage and abandoned any further efforts in this extremely remote area.

The establishment of the Naval Petroleum Reserve and subsequent closure to mineral development did not encourage mineral exploration in the area. The realization, in 1975, that the Red Dog zinc-lead-silver deposit was a world-class discovery, spurred interest in the area. The same belt of rocks that host the Red Dog deposit extend into the NPRA which led several companies including the Comminco, Anaconda, and Kennecott companies to evaluate some of the mineral occurrences within the district (44)(64). Also Arctic Slope Regional Corporation evaluated the mineral potential of the area in preparation for making possible land selections. (1).

BUREAU INVESTIGATIONS

The fieldwork portion of the Colville Mining District study began in 1990, with an eight day reconnaissance trip to the study area (Meyer, 1990). A total of 168 days of field work were conducted during the summers of 1991-1993. Field work was helicopter supported, out of base camps at the Ivotuk, Eagle, and Galbraith Lake airstrips. Spike camps were set up for short periods at Drenchwater Creek, Story Creek, Kivliktort Mountain, Monotis Creek, Skimo Creek, Cobblestone Creek, and the Itkillik River to conduct more detailed studies at those sites. Field investigations were based on a literature search of all previous geological work done in the area, by both the Bureau and other agencies. All previously documented sites were evaluated as well as new ones that were discovered during field work. At each site samples were collected and the geology mapped if warranted. Depending on the amount of data available, an attempt was made to determine mineral resources and/or mineral development potential at each site.

Areas with no previously known mineralization were also investigated. These areas were prioritized, using regional stream geochemical sampling and geology. The results of that work as well as the analytical results for all samples collected during the study have been published in a separate Bureau Open File Report (171)

Field work concentrated on the northern flank of the Brooks Range and the Arctic Foothills area. Oil and gas resources were not evaluated. Coal and aggregate resources were evaluated by the ADGGS under contract to the Bureau. A total of 40 mineral occurrences[7] were examined during the study. This included 26 previously undescribed occurrences. There are no known prospects[8] or mines[9] within the mining district.

SAMPLING

During the study 1593 samples were collected, consisting of rock, soil, stream sediment, and bulk-types. Rock samples were of seven types: 1) continuous chip-small rock fragments broken in a continuous line for a measured distance across an exposure; 2) chip channel-collected along a channel of uniform width and depth across the exposure of mineralized rock; 3) random chip-collected at random points from an apparently homogeneous mineralized exposure; 4) spaced chip-collected in a continuous line at designated intervals across an exposure; 5) representive chip-sample volume

[7] Mineralization exists, but no sign of development.
[8] Development work done, but no ore shipped.
[9] Ore shipments made over a period of several years or production confirmed.

collected in proportion to volumes of different rock types observed at a specific locality; 6) select-collected from the highest grade portion of a mineralized zone; and 7) grab-collected more or less at random from outcrop or float.

Soil samples were collected from the thin C horizon characteristic of arctic soils (fig. 6). Samples collected near the surface were obtained with a plastic hand trowel and stainless steel hand augers were used to sample the horizon beneath a 0.3 to 0.8 m-thick tundra cover. Stream sediment samples were collected of silt-sized material from the active portion of stream beds. Bulk samples, ranging from 90 to 200 kg, were collected at Drenchwater and Story Creeks and from the phosphate occurrences on the Tiglukpuk River and the Ivotuk Hills. The samples were analyzed by Bureau research centers at Salt Lake City, Utah and Albany, Oregon to determine optimum mineral recovery techniques.

ANALYTICAL PROCEDURES

All rock, soil, and stream sediment samples were analyzed by Bondar Clegg and Company[10] of Vancouver, Canada. Rock samples were ground to -140 mesh and analyzed by ICP spectroscopy. Any samples suspected of containing elevated levels of lead, zinc, silver, copper, or PGM minerals were fire assayed or analyzed by atomic absorption spectroscopy. Soil and stream sediment samples were sieved through a -80 mesh screen prior to analysis. The detection limits for the elements that were analyzed by atomic emission spectroscopy (ICP), Fire Assay - directly coupled plasma (DCP) and quantitative analysis - fire assay (FA) varied each year of the study. These are listed in (174). Fluorometric analysis was used to analyze for uranium. Specific gravity values for barite were determined by both Bondar Clegg and the USGS (128). The USGS values were consistantly higher.

REGIONAL GEOLOGY

The geologic history of the Brooks Range is quite complicated and a select group of both government and private sector geologists have spent nearly their entire careers attempting to decipher it. The Brooks Range and the adjacent Arctic Coastal Plain, situated at the northern end of the Cordilleran orogenic belt of North America comprise two major tectonostratigraphic terranes (fig. 7). These include the continentaly-derived Arctic Alaska terrane to the north

[10] Use of Bondar Clegg does not signify Bureau of Mines endorsement.

Figure 6. - Soil sampling with hand auger, Drenchwater Creek.

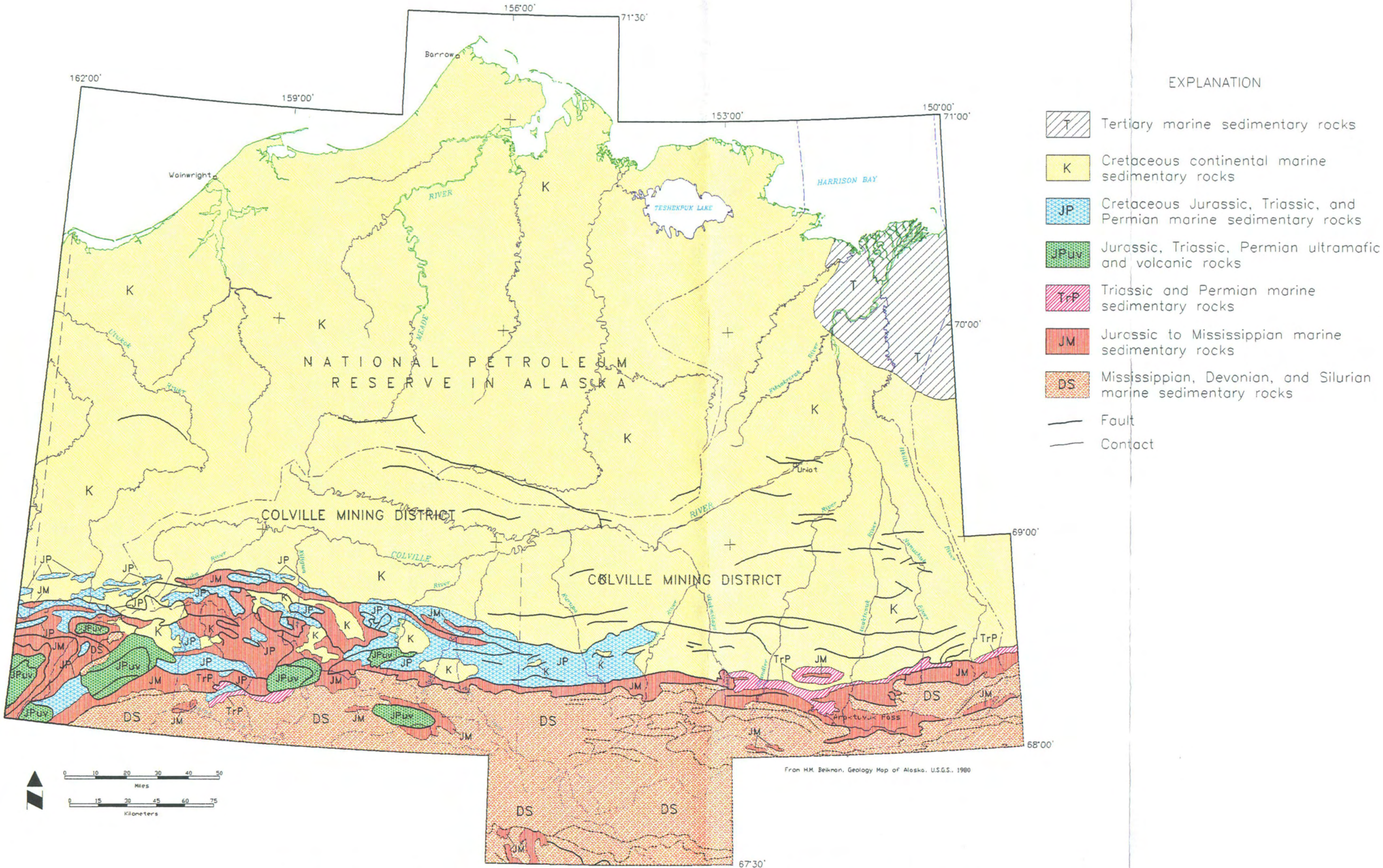


Figure 7. – Generalized geologic map of the Colville Mining District, Alaska.

and the oceanically-derived Angayucham terrane to the south. The rocks in the Colville Mining District are part of the Arctic Alaska terrane, which in the northern Brooks Range consists dominatly of Devonian through Lower Cretaceous shelf sediments. These rocks consist mostly of sandstone, conglomerate, shale, limestone, and lesser amounts of chert and siliceous sediments. Intercalated with some of the sediments are relatively minor amounts of dominantly mafic igneous rocks, including basalt and andesite, and some areas of tuff and other volcanoclastic rocks. In one locality, tuffand andesite are associated with basinal sediments of the Mississippian Lisburne Group, which contain an significant stratiform zinc-lead-silver occurrence in the district. Elsewhere carbonate rocks of the upper Lisburne Group host sedimentary phosphate deposits. Significant barite deposits that may be structurally controlled, are associated with chert and siliceous sediments that range from Mississippian to Triassic in age.

Rocks of the Arctic Alaska terrane are part of the western North American cordilleran belt. They have been deformed by a series of major thrust faults of regional extent (fig. 8). Several major allochthons have been mapped in the northern Brooks Range thrust belt that constitutes the southern part of the Colville Mining District. This thrust belt developed in Late Jurassic through Early Cretaceous time during the early stages of the Brooks Range orogeny. This resulted from the collision and subduction of tectonic plates along the margin of the Arctic Alaska plate.
A north-vergent thrust belt formed as oceanic crust of the Angayucham terrane was obducted over the continental crust of the Arctic Alaska terrane. In the process, large allochthonous slices of crust were peeled off the Arctic Alaska terrane. In the central Brooks Range the telescoping of these allochthons represents crustal shortening of over 180 km.

During the middle and probably extending into Late Cretaceous, northern Alaska apparently rotated counterclockwise, away from the Canadian Arctic Islands to form the Canada Basic and Arctic Ocean. This event, following the initial major orogeny, resulted in the development of the present east-west trend of the Brooks Range. Additional uplift and deformation also occurred at this time. Fractures in brittle sediment and thrust faults, developed during the orogeny, may have provided avenues for migration of metal-rich fluids. This may have resulted in the formation of zinc-lead-silver-bearing vein breccia and associated disseninated occurrences in rocks of the Upper Devonian through Lower Mississippian Endicott Group.

Eight folded, stacked allochthons have been mapped in the central and western Brooks Range. Portions of all these allochthons are present in parts of the Colville Mining District. Recognition of these allochthons is important because certain types of mineralization are confined to specific allochthons or thrust sequences within them. Numerous fensters and klippen have been formed as erosion has cut differentiately through the allochthons. Mafic and ultramafic rocks that are parts of a dismembered

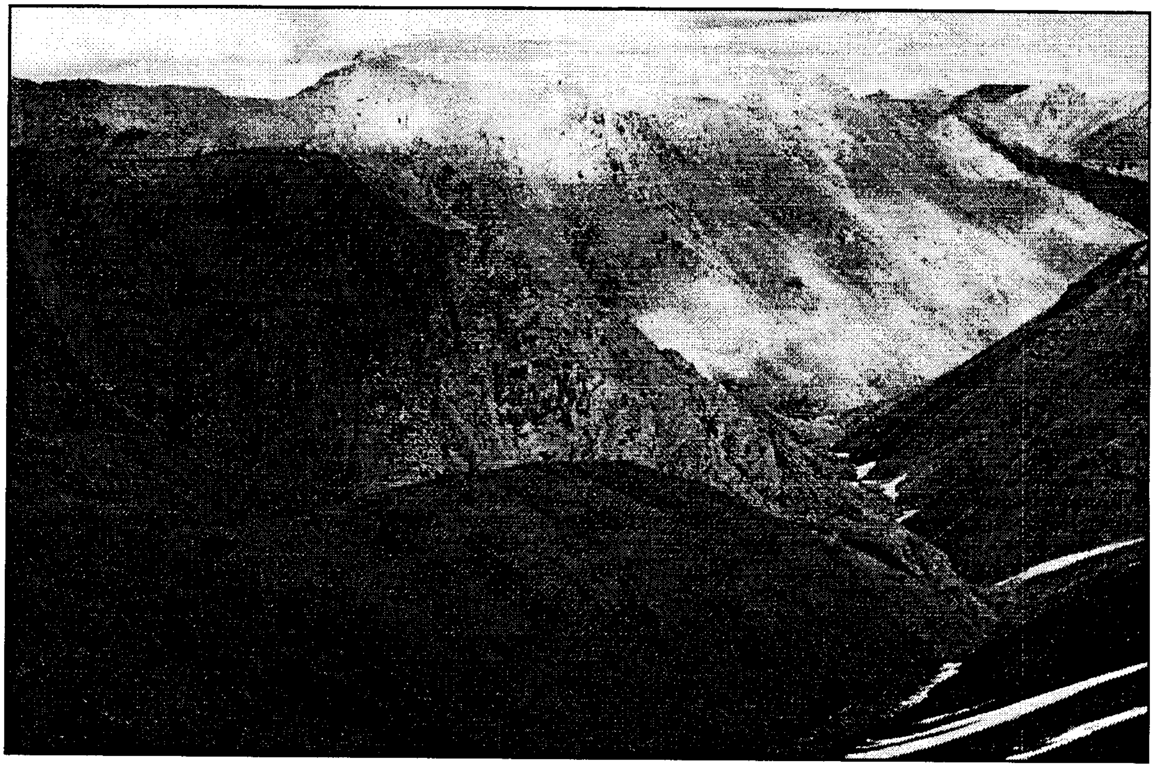


Figure 8. - Thrust fault contact between dark gray Upper Devonian Hunt Fork Shale (left) and light gray Mississippian Lisburne Group Limestone. Cobblestone Creek area, looking north.

ophiolite are present in klippen within the structurally highest allochthon. Just outside the study area boundary, these rocks host chrome, platinum group metals, and minor copper mineralization (75). Most of the other mineralization in the district is found in rocks of the lower allochthons.

Beginning in Late Tertiary and extending through the Pleistocene, a series of glacial advances occurred in the Brooks Range. Glacial retreats left U-shaped valleys in many of the drainages and a veneer of surficial deposits on the foothills to the north of the range (100).

MINERAL OCCURRENCES

A variety of metallic and nonmetallic mineral occurrence types are located within the Colville Mining District. These include sediment-hosted zinc-lead-silver, vein-breccia zinc-lead-silver, quartz-carbonate veins, metalliferous black shales, stratiform barite, sedimentary phosphate, sedimentary manganese, and fluorite veins. Additional industrial minerals and energy fuels include clay, limestone, sand and gravel, coal, oil sands and oil shale. Other commodities occurring in the study area as accessories to other deposit types include copper, cadmium, uranium, vanadium, chromium, lanthanum, scandium, and yttrium.

The mineral occurrence locations are indexed in figure 9 and shown in figures 10-12. Detailed descriptions of the occurrences are listed alphabetically by quadrangle in appendices A through C. Appendix D is an alphabetical summary of all occurrences in the district.

SEDIMENT-HOSTED STRATIFORM ZINC-LEAD-SILVER OCCURRENCES

Sediment-hosted zinc-lead-silver occurrencess consist of two types: black shale-hosted massive and disseminated sulfides and sandstone-hosted disseminated sulfides. The shale-hosted types have the greatest potential in the district for mineral development.

Shale-hosted Occurrences

The shale-hosted occurrences are hosted by black carbonaceous shales, and gray-black chert or siliceous mudstone of the Mississippian Kuna Formation in the northwestern portion of the Howard Pass Quadrangle (fig. 10). This sequence is intercalated with minor felsic and intermediate volcanic rocks, and is exposed in the Drenchwater Fenster through the Endicott Mountains allochthon. The rocks are cut by northwest-trending, south-dipping, thrust faults and north-south trending high-angle faults.

Drenchwater Creek is the only substantiated example of shale-hosted mineralization within the district. Iron oxide-stained rocks were noticed by USGS geologists along Drenchwater Creek in 1951, but it was not until 1975 that zinc and lead sulfides were identified (115)(271).

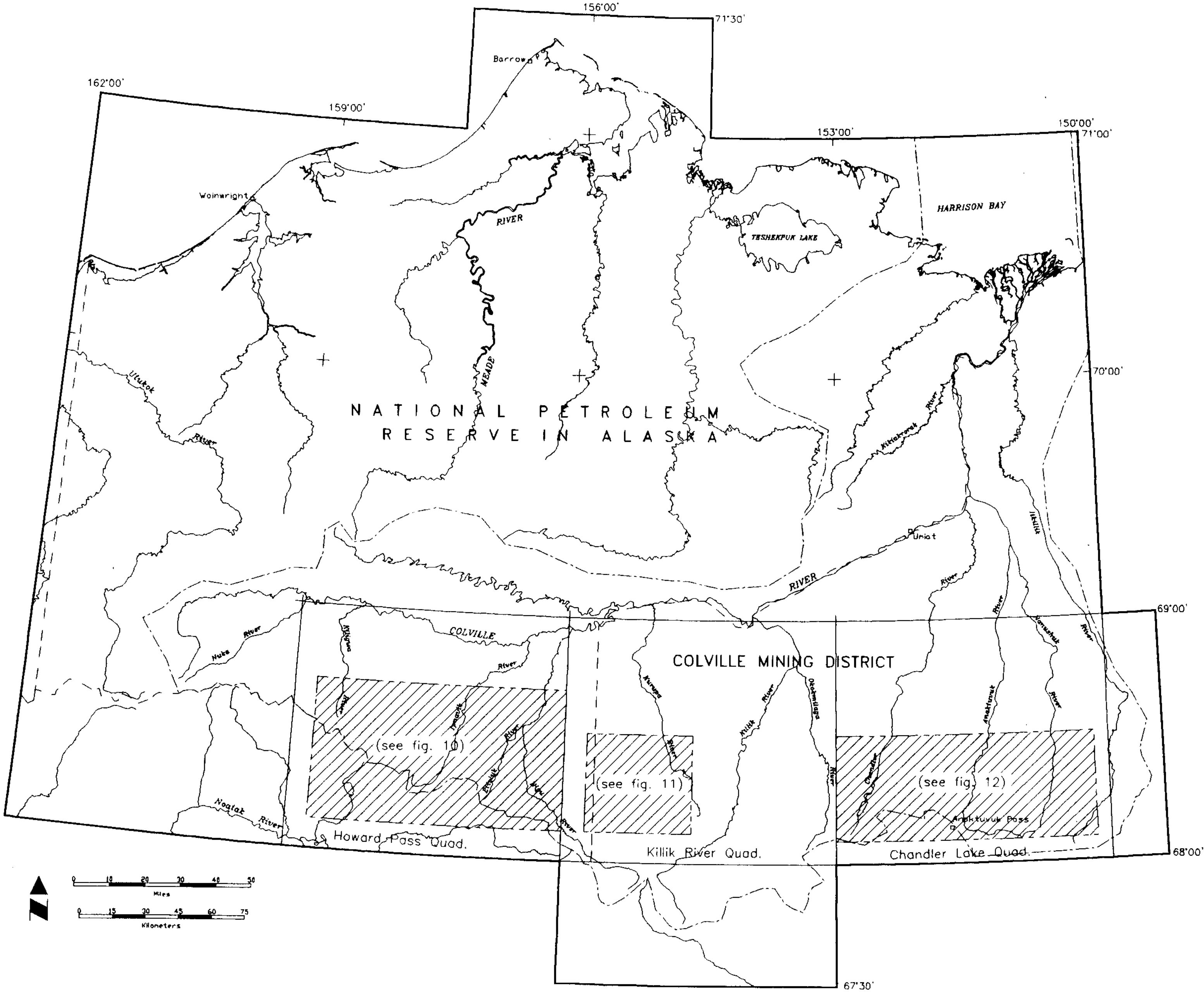


Figure 9. – Mineral occurrence index maps – Colville Mining District.

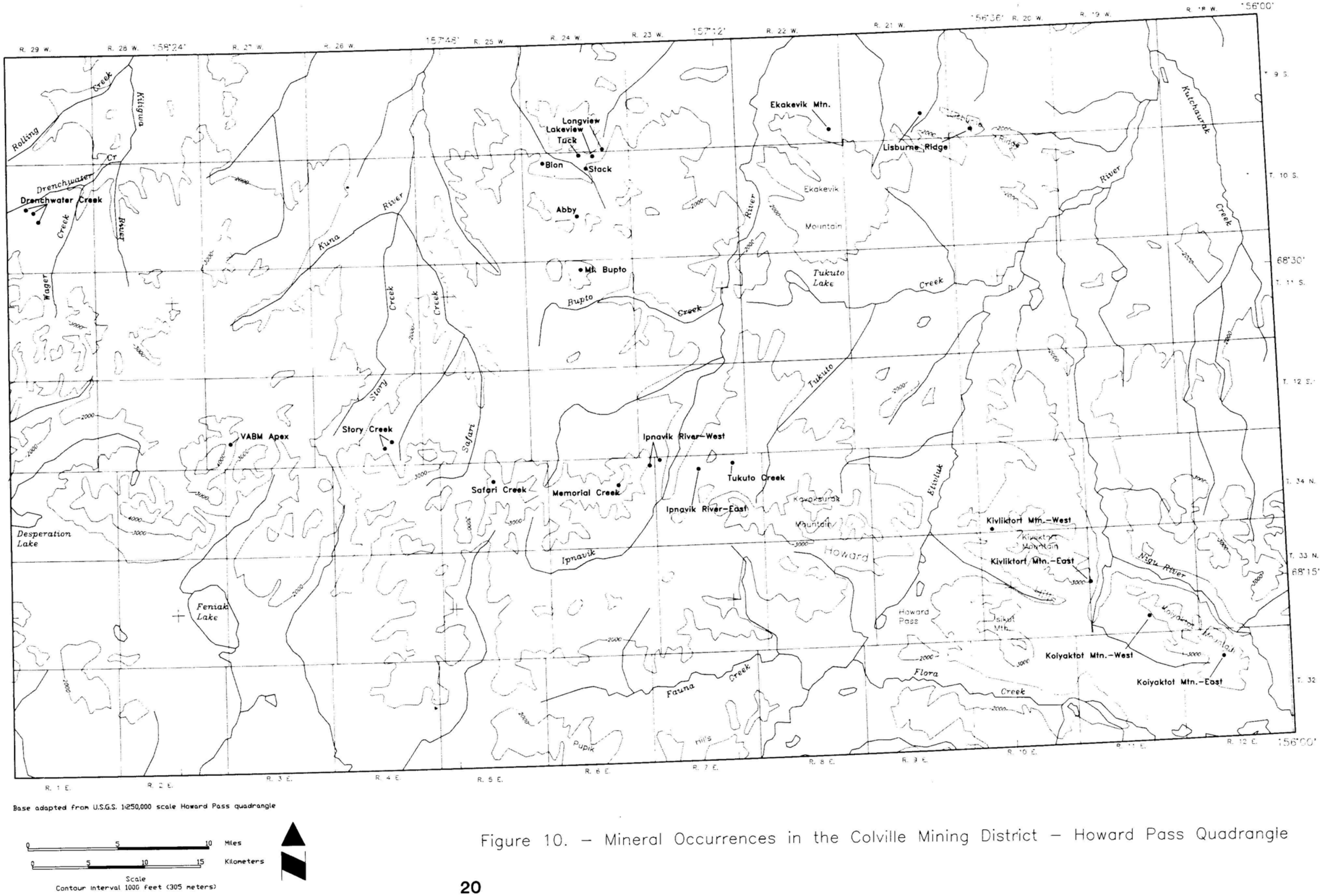
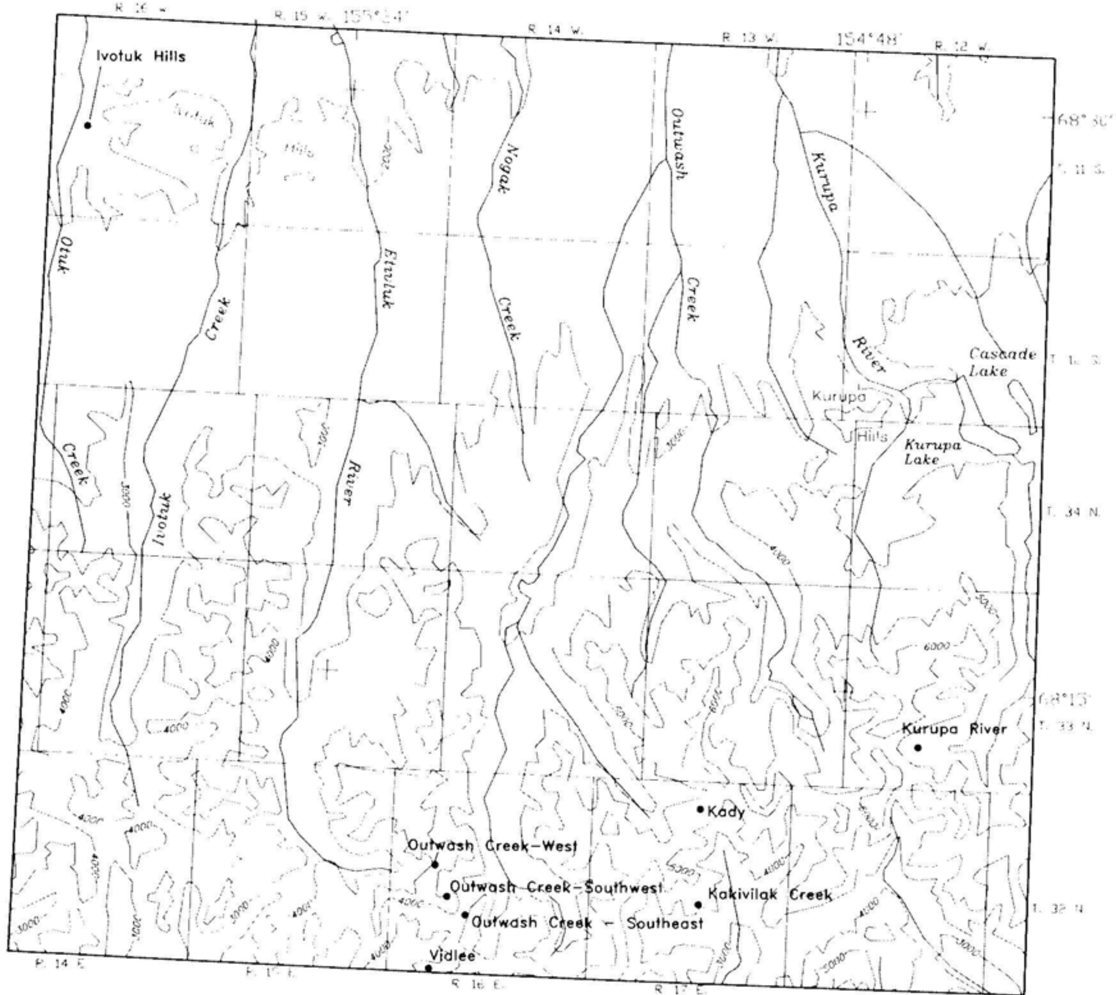
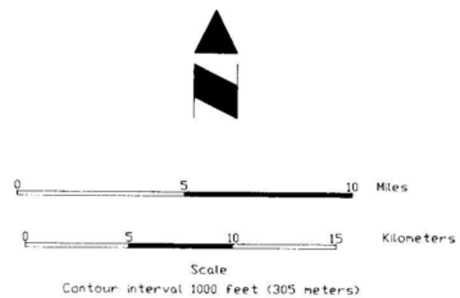


Figure 10. – Mineral Occurrences in the Colville Mining District – Howard Pass Quadrangle





Base map adapted from U.S.G.S. 1:250,000 scale Killik River quadrangle

Figure 11. - Mineral Occurrences in the Colville Mining District - Killik River Quadrangle.

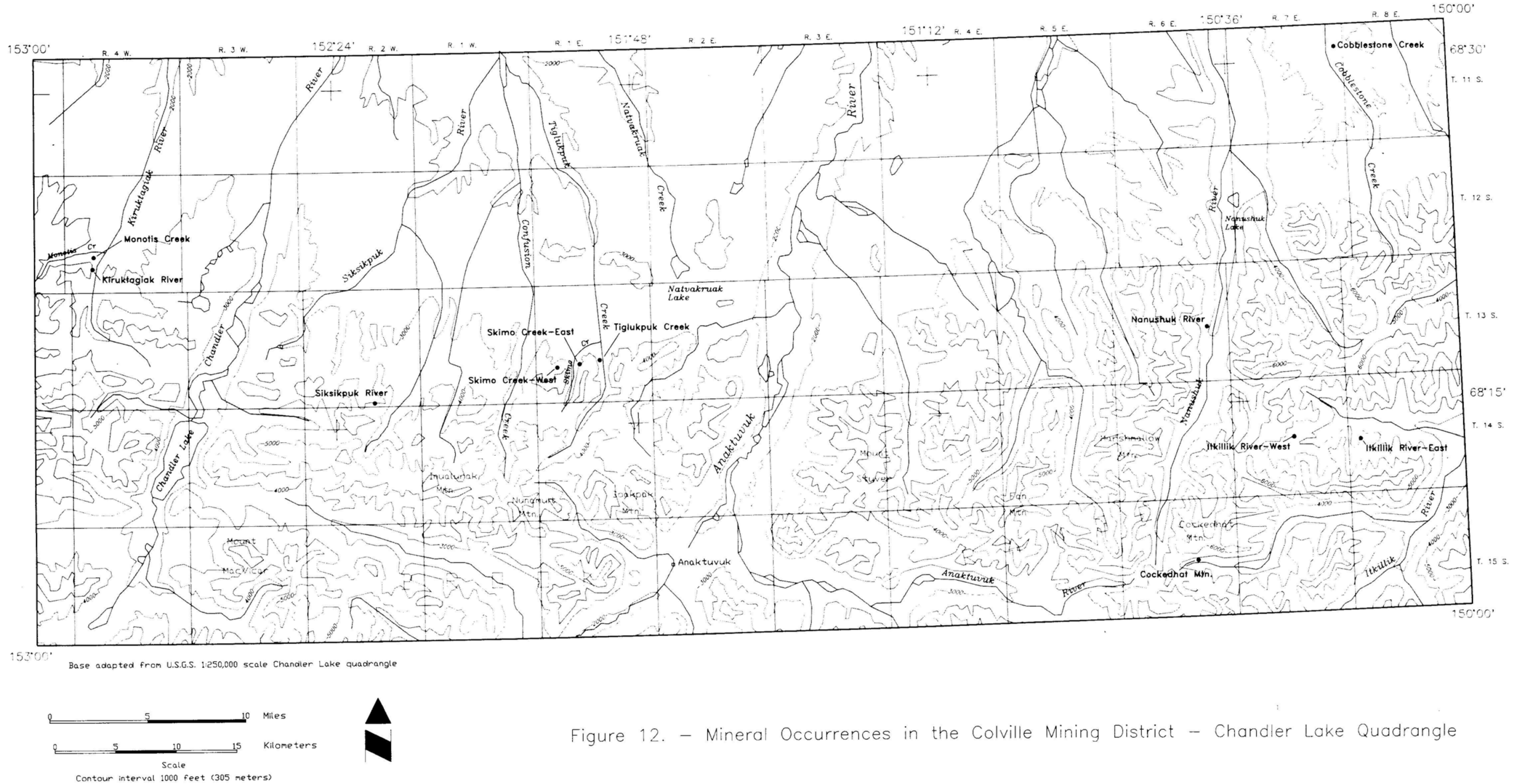


Figure 12. – Mineral Occurrences in the Colville Mining District – Chandler Lake Quadrangle

Mineralization is associated with hydrothermal silicification of the carbonaceous shale, mudstone, and local volcanic breccia. Sphalerite and galena occur both as fracture fillings and disseminations within chert and shale and as small massive stratiform bodies within the siliceous mudstones near the top of the volcanic section (fig. 13).

A northwest-trending zone of sulfide-bearing rocks is intermittently exposed for nearly 3.2 km along strike in the Drenchwater Creek area. Samples from deeply-weathered outcrops average 6.8% zinc, 6.7% lead, and 43.6 gmt silver (fig. 14). The results of a soil survey, conducted to test the possible extension of exposed mineralized zones under tundra cover, delineated a 150 x 920 m zinc and lead anomaly. Soil samples contained up to 5500 ppm zinc and 10,000 ppm lead (172). A gravity survey conducted by the USGS delineated an anomaly in approximately the same area as the geochemical anomaly (Morin, 1991). The results of these surveys and the exposure length of mineralized rocks, indicate potential at Drenchwater for a large undiscovered zinc-lead-silver deposit. Both volcanogenic and sedimentary exhalative processes may have been involved in the mineraliztion process, but a sedimentary exhalative process may have been dominant. A resource estimate could not be determined due to the intermittant nature of the exposures, structural complexity of the area, and unknown total thickness of the mineralized rocks (fig. 14).

The host rocks at Drenchwater Creek are similar to those found at the Red Dog zinc-lead-silver Mine, which lies 158 km to the southwest. Reserves at Red Dog total 70.5 mmt at 22.0% combined lead-zinc and 70 g/mt silver (136).

Two other sites in the district have potential for similiar types of deposits. At Twistem Creek, 10 km southeast of Drenchwater, silicified mudstone of the Kuna Formation also outcrop (fig. 10). Stream sediment samples collected by the Bureau from this drainage contain up to 1,895 ppm zinc , but no zinc or lead sulfides have been located (134)(173). A sample collected from lithic tuff, intercalated with sandstone on Tukuto Creek, contained 1838 ppm zinc and 1686 ppm lead (fig. 10). No sulfides were identified in the field.

Sandstone-hosted Occurrences

Sandstone-hosted lead-zinc is confined to the Upper Devonian through Lower Mississippian Noatak Sandstone and Kanayut Conglomerate of the Endicott Group. Sphalerite and galena occur as fine-grained disseminations and fracture fillings in silica-altered, recrystallized sandstone. It appears quartzitic and weathered surfaces have a bleached appearence (fig. 15). These occurrences vary widely in metal content, ranging from 572 to >20,000 ppm zinc and 379-1920 ppm lead. They are generally much lower grade than other base-metal types in the study area, but potential exists for large tonnages due to extensive host rocks.

The origin of the sulfides is unclear. Epigenetic, metal-bearing solutions may have permeated the sandstones, precipitating

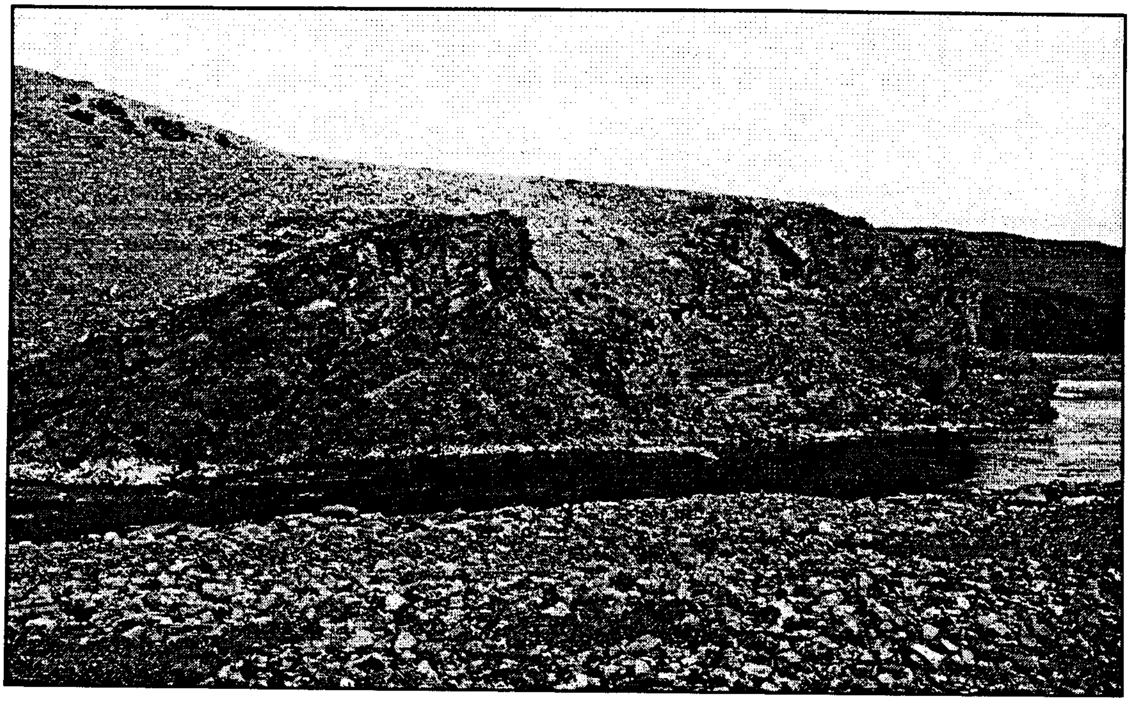


Figure 13. - Sulfide-bearing, resistant, silicified mudstone of the Mississippian Kuna Formation. Dreanchwater Creek narrows, looking west.

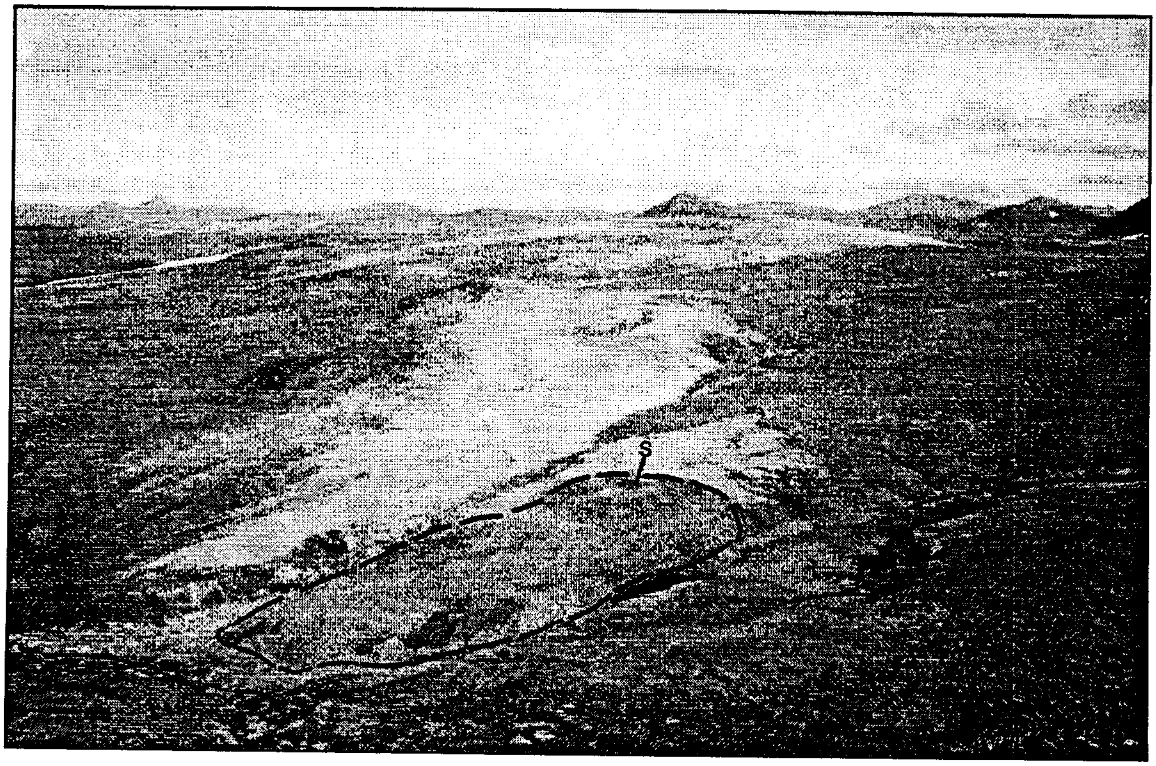


Figure 14. - Rubblecrop and float exposure of sulfide-bearing Kuna Formation (s). Drenchwater Creek occurrence, looking east. Discovery Creek in foreground.

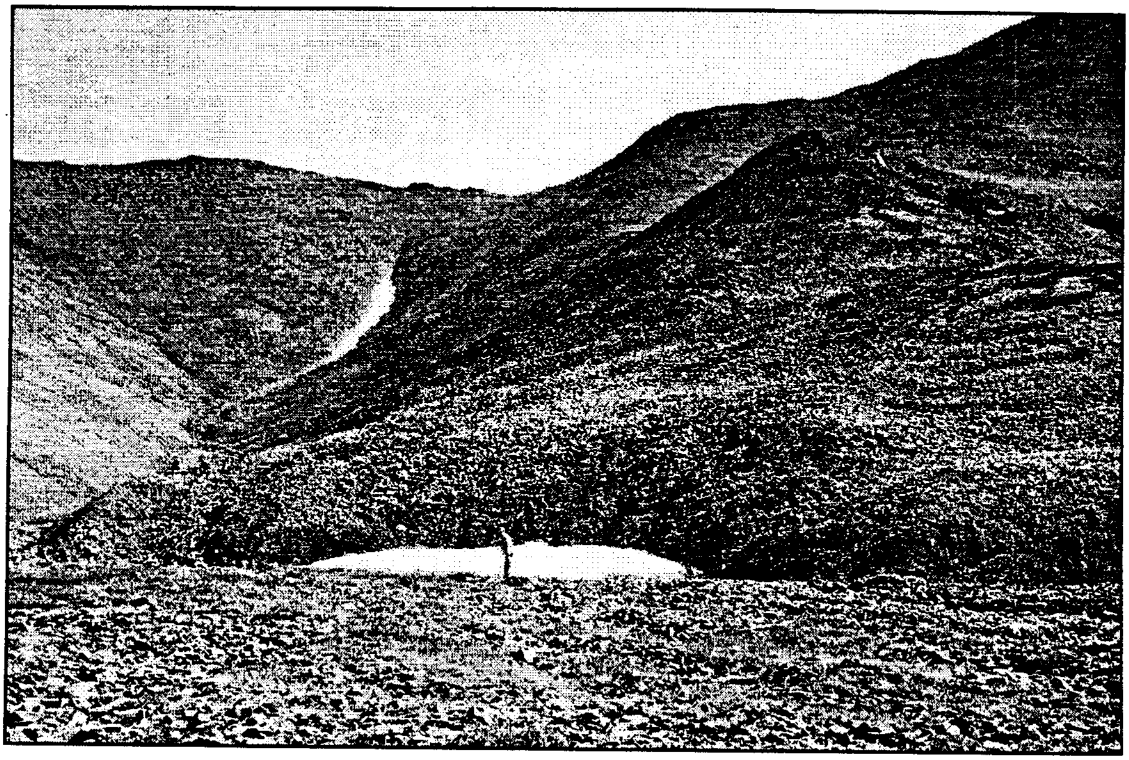


Figure 15. - Light-colored, silicified sandstone of the Upper Devonian Noatak Sandstone (behind figure) anomalous in zinc and lead. Upper Safari Creek, looking east.

sulfides when encountering sulfidic waters. Later orogenic events such as the Brooks Range Orogeny, may have produced hydrothermal fluids which remobilized sulfides into fractures. An origin of this type has been postulated for Swedish sandstone lead-zinc deposits (235). Occurrences with this type of mineralization occur along a 60 km belt in the southern Howard Pass Quadrangle (fig. 10). Examples are located at Ipnavik River East, Safari Creek , Kivliktort West, and potentially Memorial Creek. In the study area, these occurrences are concentrated along the north edge of the Endicott Mountains Allochthon and are often associated with vein breccia-type occurrences. Potential for similar undiscovered occurrences exists along that thrust fault contact.

VEIN BRECCIA LEAD-ZINC-SILVER

Vein breccias are small, high-grade occurrences, hosted by Endicott Group rocks, consisting of Upper Devonian to Lower Mississippian Kanayut Conglomerate, Noatak Sandstone, Kayak Shale, and Isikut Formation. Galena, sphalerite, and chalcopyrite, occur in quartz veins and quartz-cemented breccia zones. The occurrences are concentrated within a 150 km-long belt in the district, in the southern Howard Pass and southwestern Killik River Quadrangles (figs.10-11). The majoity are concentrated near the northern edge of the Endicott Mountains allochthon. Sulfides occur as breccia fragments, stringers, and are locally massive. Mineralization can be found in quartz veinlets less than 0.5 cm-wide as well as in breccia zones up to 36 m-wide.

The Story Creek occurrence, first discovered in 1978 by Bureau geologists is the most extensive example of this deposit type (115). Here a zone of sulfide-bearing quartz veins and quartz-cemented siltstone breccia, hosted in siltstone members of the Isikut Formation, is up to 36 m-wide and extends intermittantly for 1570 m along strike (fig. 16). Samples average 18% combined lead-zinc, and 159 g/mt silver. Select samples contain as much as 30% lead, 55.6% zinc, and 696 g/mt silver. A geochemical survey over the occurrence delineated a 284 x 424 m zone, anomalous in lead and zinc. The zones appear steeply dipping and lense-like, with unknown vertical extent.

Other, less extensive examples of this type occur at Safari Creek (fig. 17), Ipnavik River, Kivliktort Mountain, and the Kady Occurrence on Outwash Creek (fig. 18). At the Kady Occurrence select samples contained > 2.0% copper. At Safari Creek, Kivliktort West, and Ipnavik River the vein breccias are associated with sandstone-hosted, disseminated mineralization. The vein breccias were probably formed during the Late Jurassic through Early Createous Brooks Range orogeny. Hydrothermal fluids associated with the orogeny may have remobilized metals from disseminated sources within the Endicott Group and emplaced them in the brecciated and fractured sandstone, resulting from deformation during the orogeny. It is also possible that the original source of the metals may have been the Kayak Shale, which is anomalous in

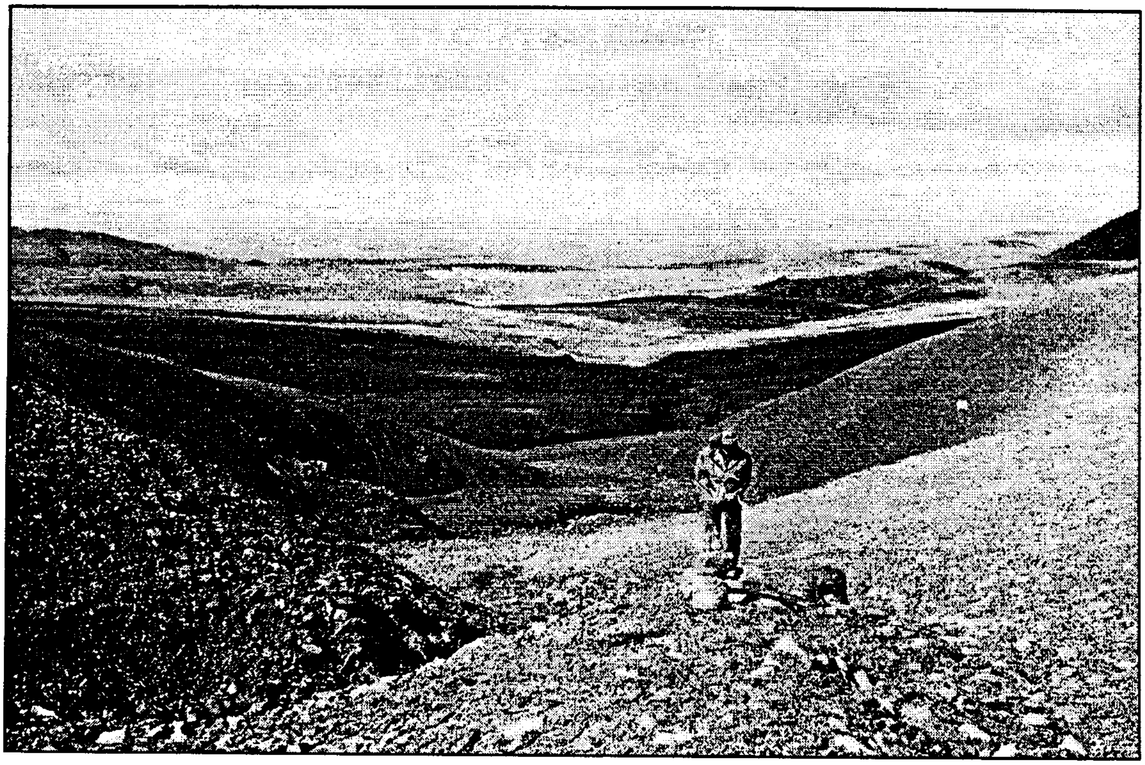


Figure 16. - Sulfide-bearing rubblecrop, Isikut Formation (left of figures). Story Creek occurrences, looking north.

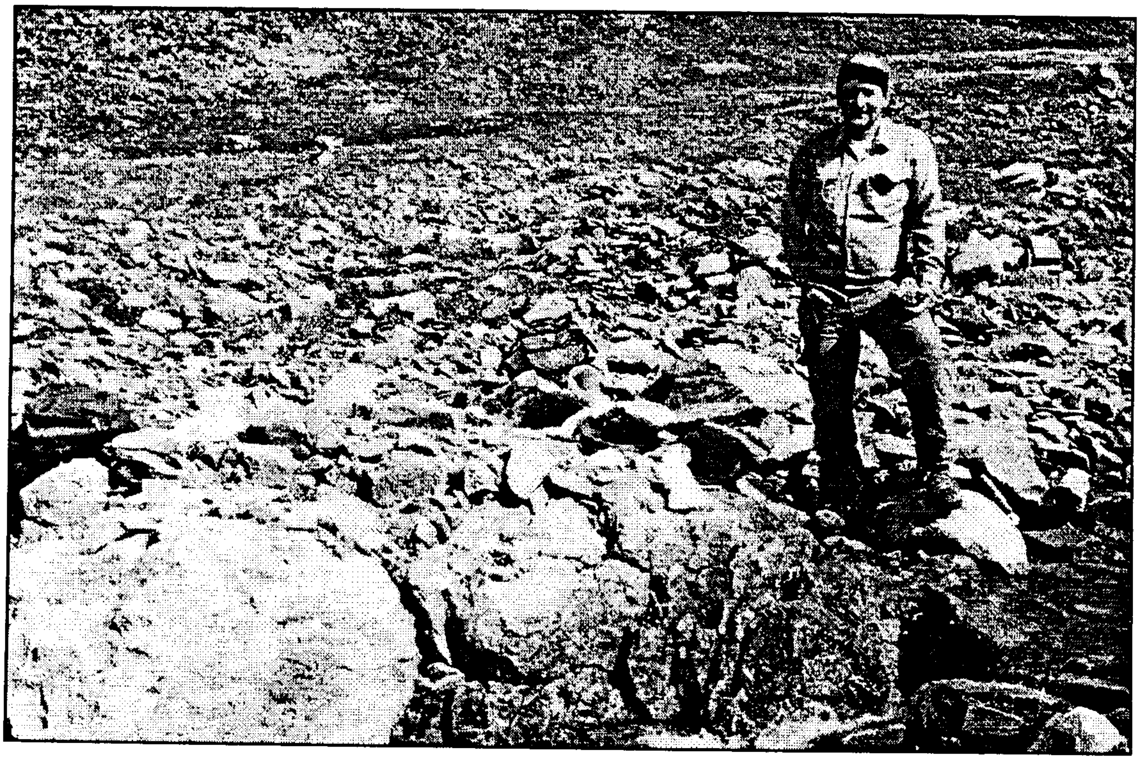


Figure 17. - Massive sulfide exposure containing sphalerite and galena. Located in stream bed on upper Safari Creek.

Figure 18. - Sulfide-bearing breccia vein at the Kady Occurrence, Outwash Creek.

zinc (72). Vein breccia occurrences represent a high grade, but low tonnage resource in the district.

QUARTZ-CARBONATE VEINS

Interbedded siltstone and shale of the the Lower Devonian Hunt Fork Shale hosts numerous narrow quartz veins, most of which are barren. At a few isolated locations in the Itkillik and Nanushuk River drainages in the Chandler Lake Quadrangle (Fig. 12), quartz carbonate veins up to 30 cm wide contained calcite, siderite, barite along with minor chalcopyrite and galena. Samples from the Itkillik River West occurrence contained up to 62% barium, 0.67% lead, 1.71 g/mt silver, and 735 ppm copper. The veins are low grade, small, and not considered to be a significant resource.

METALLIFEROUS BLACK SHALES

The Lower Mississippian 300 m-thick Kayak Shale is intermittently exposed on an east-west trend for 467 km along the southern portion of the Colville Mining District. The 43 m-thick upper black shale member of the formation is anomalous in zinc. Near Cockedhat Mountain in the Chandler Lake Quadrangle (fig. 12), grab samples of the shale contained up to 284 ppm zinc, which is over twice the average crustal abundance of zinc in similar rock types (147).

Siltstone and mudstone septarian concretions occurring within the shales contain sphalerite, barite, and minor galena (Fig. 19). Select samples of concretions from the Confusion Creek area contained up to 16,172 ppm zinc and 104 ppm lead (fig. 12) (174). The sulfide-bearing concretions appear prevalent throughout the extent of the formation and were also found in the Itkillik River, Siksikpuk River, Encampment Creek, and Safari Creek draingaes.

The Kayak Shale represents an extremely low grade, large tonnage, zinc resource. Though not economic, it may have been one of the sources from which metals were remobilized during orogenic events to form the higher grade vein breccia and disseminated occurrences (72).

SEDIMENTARY MANGANESE

In the Cobblestone Creek area (Fig.12) the Lower Cretaceous Torok Formation contains anomalous amounts of manganese. Samples collected across a 6.4 m-thick section of silty mudstone and shale contain up to 12% manganese. Specific manganese minerals have not been identified (63). These manganese-bearing beds are known to extend for at least 3.3 km along strike. Potential exists in the area for large tonnage sedimentary manganese deposits.

STRATIFORM BARITE

Minor barite occurrences consisting of thin beds, nodules, and

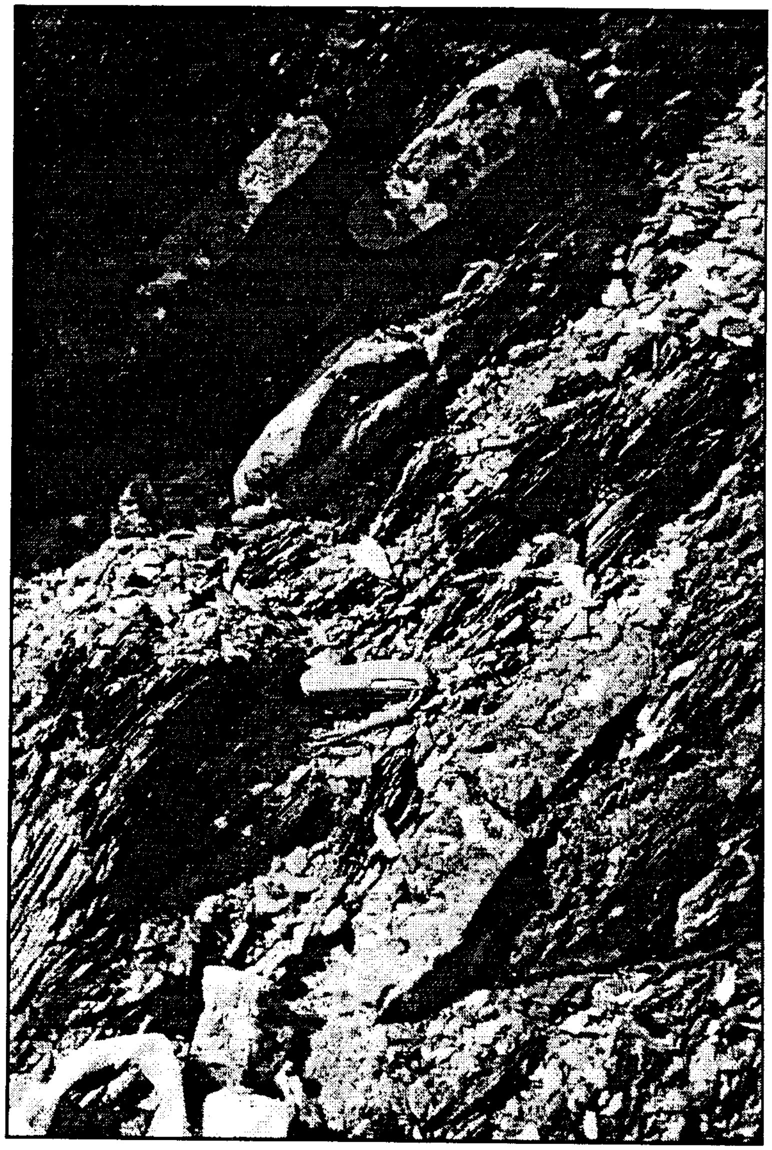


Figure 19. - Sulfide-bearing concretions in the upper black shale member of the Lower Mississippian Kayak Shale. South of Cockedhat Mountain.

fracture fillings within the Permian Siksikpuk Formation occur throughout the Colville Mining District. Larger and higher grade stratiform occurrences are mostly concentrated in the Cutaway Basin area in the central Howard Pass Quadrangle (fig. 10). Seven barite occurrences were discovered by Bureau and USGS personnel in this area during the Colville Mining District study. The barite is hosted dominantly by shale, chert, and siliceous sediments that range from Mississippian to Triassic in age. The occurrences may be structurally controlled, as they lie along allochthon boundaries or lineaments that represent high-angle faults. The largest is the Longview occurrence, which consists of a tabular bed of barite that averages 22 m-thick and can be traced for 686 m along strike (fig. 20). This bed may be continuous between the Longview and the nearby Lakeview occurrence resulting in a potential strike length at least 2 km. The Bion, Stack, Tuck, and Ekakevik Mountain are similar, but smaller occurrences.

The occurrences have a total inferred-indicated resource totalling 49.2 mmt with grades of up to 97% $BaSO_4$ and specific gravities as high as 4.3. Besides barite, one occurrence contains minor amounts of witherite ($BaCO_3$). The barite at the majority of the occurrences has specific gravity that meets the minimum requirements for drilling mud grade barite (128)(209). The potential for additional barite deposits exists along allochthon boundaries in the Cutaway Basin area.

SEDIMENTARY PHOSPHATE

Phosphate-bearing, oolitic, shaley, limestone and mudstone beds are concentrated in the Upper Mississippian Lisburne Group and to a lesser extent the Triassic Otuk Formation. These formations extend for 240 km across the Colville Mining District and phosphate has been noted along this trend in numerous localities. The Bureau sampled these phosphatic rocks at Lisburne Ridge (fig. 10), the Ivotuk Hills (fig.11), and Skimo and Monotis Creek (Fig. 12)

The largest resources are to be found in the Skimo, Tiglukpuk, and Monotis Creek areas where stratigraphic sections were measured and detailed sampling done. In the Skimo Creek area a sequence including phosphate rock, and phosphatic shale and limestone has an average thickness of 11.2 m (fig. 21). This sequence is intermittantly exposed for 4.2 km along strike. Samples average 6.7% phosphate. At Monotis Creek a 6.7-thick, less continuous, sequence of similiar rocks averages 23.0% phosphate. Individual 0.6 m-thick beds contain up to 30% phosphate.

Bulk samples of the phosphate rock were collected at the Ivotuk Hills and Monotis Creek. Examination of the material indicates that the phosphate mineral fluorapatite makes up approximately 60% of the phosphate rock with the remainder as carbonate material (205)(298). Samples of the phosphate rock also contain up to 2,000 ppm vanadium, 1353 ppm zinc, and 150 ppm uranium. A minimum indicated resource of 14.2 mmt has been delineated in the Skimo Creek area and the potential exists for additional phosphate resources within Lisburne Group rocks

Figure 20. - Longview barite occurrence (light-colored ridge in photo center). Looking north across Cutaway Basin.

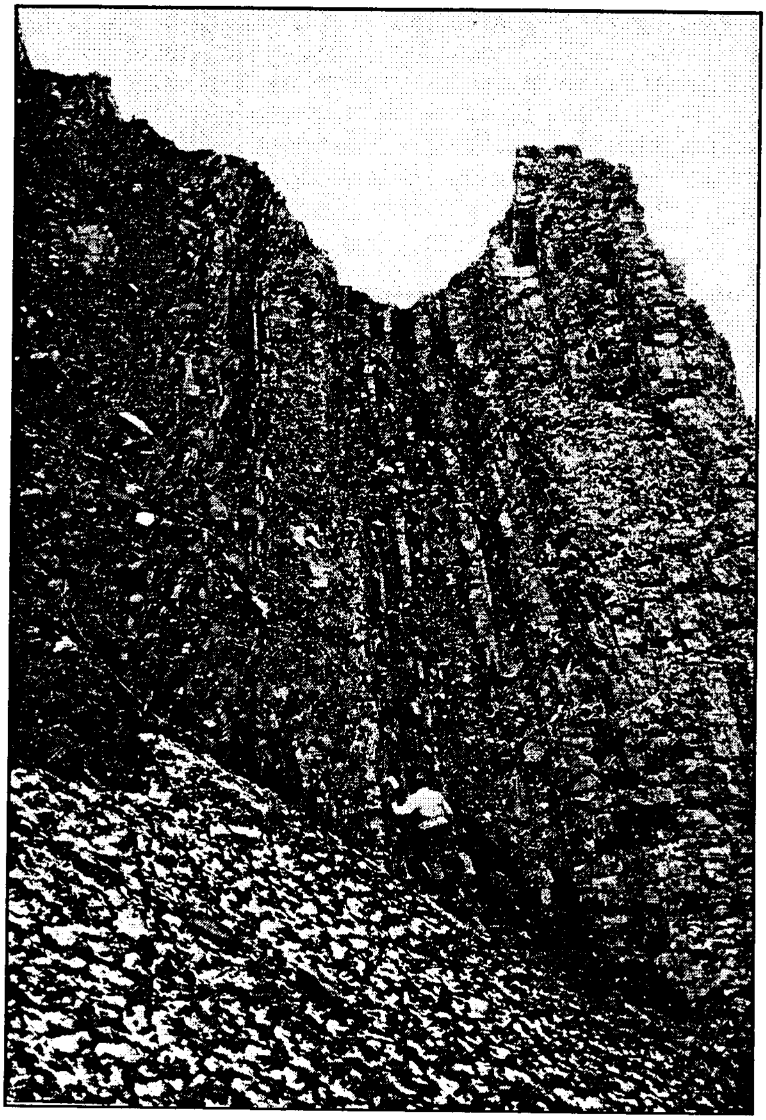


Figure 21. - Steeply-dipping interbedded phosphatic shale and limestone. Upper Mississippian Lisburne Group, Skimo Creek.

throughout the district.

FLUORITE

Fluorite occurs in the Upper Mississippian Lisburne Group on the north side of Mt. Bupto in the central Howard Pass Quadrangle (fig. 10). Fluorite occurs with calcite, in narrow lenses and fracture fillings within brecciated crinoidal limestone. Select samples contain up to 73.2% fluorite. The fluorite-bearing rocks are intermittantly exposed for 200 m along strike. The potential for large-tonnage resources in the area is low.

MINERAL PRODUCTION AND RESOURCES

There has been no recorded mineral production from the Colville Mining District. Resources were classified using the following criteria developed by the Bureau and the USGS (296).

"Measured - Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and/or quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well-defined that size, shape, depth, and mineral content of the resource are well established.

Indicated - Quantity and grade and/or quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are further apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observations.

Inferred - Estimates are based on an assumed continuity beyond measured and/or indicated resources, for which there is geologic evidence. Inferred resources may or may not be supported by samples or measurements."

Resources were calculated where enough information concerning the continuity and grade of occurrences was available to do so. Tonnages were calculated using the average length, width and depth of a tabular mineralized body. Where depth could not be determined, an assumed half-strike-length depth projection was used. Tonnage factors were obtained from standard tables or calculated using specific gravities (166).

Resources were not calculated for the stratiform zinc-lead-silver deposits due poor exposures and lack of continuity of mineralization. Inferred resources calulated for the Story Creek vein breccia occurrence total 2.9 mmt and average 14.2% zinc, 3.9% lead, and 159 g/mt silver.

In the Skimo Creek area a minimum indicated resource totaling 14.2 mmt, averaging 6.7% phosphate in an average 11.2 m-thick zone exists. In the Cutaway Basin area seven barite occurrences have a combined inferred-indicated resource totalling 49.2 mmt. The Longview is the largest individual barite occurrence, containing an indicated resource totalling 29.5 mmt, with an average specific gravity of 4.13.

MINERAL DEVELOPMENT POTENTIAL

Based on resources and grades of mineralization, all the occurrences within the Colville Mining District were classified according to the following criteria (83):

High Mineral Development Potential - High grades and probable continuity of mineralization exist. The occurrence is likely to have economically minable resources under current economic conditions. A high potential exists for developing tonnage or volume with reasonable geologic support for continuity or grade.

Moderate Mineral Development Potential - Either high grades or continuity of mineralizations exists, but not both. Mineralization has limited extent as shown by geology, dimensions, and/or grades are low and tend to stay low. The occurrence is not economically minable (i.e., due to low tonnages and/or grades) under existing conditions(economical, political, technological). It could serve as a material source if economics were not a factor.

Low Mineral Development Potentia - The occurrence exhibits uneconomic grades and/or little evidence of continuity of mineralization. There is little or no potential for developing ore resources or it is an insignificant source of the material of interest.

Unevaluated - This category includes all occurrences not located or visited in the field. Data are only available from previous reports.

Unknown - Insufficient work was done at the occurrence for an evaluation.

None of the occurrences in the district have a high mineral development potential at present, due to either small size, low grades and/or lack of accessibility.

The Drenchwater occurrence has moderate potential as a stratiform zinc-lead deposit due to grades, continuity of mineralization over a long exposure length, and host rocks similar to those at the Red Dog deposit. An economic feasibility study was done by the Bureau for a Drenchwater-type deposit model. The results indicate that gross revenues for a surface mining operation, ranging in size from 25-130 mmt varies from $140/mt for a 17,000 mtpd mine to $200/mt for a 5,000 mtpd operation (43). The Story Creek and Kady Occurrences have moderate potential for small high-grade lead-zinc-silver veins. The Safari Creek, Ipnavik River, and Kivliktort Mountain West Occurrences have moderate potential for similar veins, but lack good exposure.

The combined Abby, Bion, Lakeview, Longview, Stack, Tuck, and Ekakevik barite occurrences have moderate potential as a source of drilling mud-grade barite due to high specific gravities and potential for large tonnages. An economic feasibility study by the Bureau for a barite mining operation resulted in subeconomic operations for three seasonal mines modeled (43).

The sedimentary phosphate occurences in the Skimo Creek area have moderate potential as a source material for the production of phosphoric acid due to grades, bed thicknesses, and exposure length. Rocks in the Cobblestone Creek area have low potential for large sedimentary manganese deposits. Fluorite-bearing limestone in the Mt. Bupto area has low potential as a source of fluorspar.

SUMMARY

The Bureau of Mines has identified and evaluated 40 mineral occurrences in the Colville Mining District and southern National Petroleum Reserve in Alaska. A total of 27 were previously undescribed. Detailed evaluations were made of 19 of the occurrences, which included rock and soil sampling, geologic mapping, geophysics, and bulk sampling for beneficiation studies. Major mineral commodities occurring in the district include zinc, lead, silver, barite, and phosphate. Minor commodities include copper, manganese, fluorite, cadmium, vanadium , and uranium.

Mineralized rocks are exposed within a 3.2 km-long trend in the Drenchwater Creek area. Samples from selected sites average 6.8% zinc, 6.7% lead, and 43.6 g/mt silver. Beneficiation studies indicate that extremely fine grinding would be needed to liberate the sulfides. Potential exists in the area for a large stratiform shale-hosted zinc-lead-silver deposit. Anomalous geochemical samples collected from Twistem Creek indicate the potential for shale-hosted mineralization in that drainage. Samples of tuffaceous volcanic rocks, collected in the Tukuto Creek drainage are anomalous in zinc and lead.

Small high-grade zinc-lead-silver breccia veins occur in the Story Creek, Safari Creek, Ipnavik River, Kivliktort Mountain, Koiyaktot Mountain, and Outwash Creek Areas. Inferred resources at Story Creek total 2.9 mmt, averaging 14.2% zinc, 3.9% lead, and 159 g/mt silver. Beneficiation studies indicate that the mineralized rocks are ameneable to standard recovery techniques. Potential exists for low grade, large tonnage, disseminated zinc-lead deposits in the Safari Creek, Ipnavik River, Memorial Creek and kivliktort Mountain areas. Bedded barite occurrences in the Cutaway Basin area are of high enough quality to meet drilling mud specifications. Inferred and indicated resources total 49.2 mmt. Sedimentary Phosphates are extensively exposed in the Monotis and Skimo Creek areas. Inferred resources at Skimo Creek total 14.2

mmt, averaging 6.7% phosphate. Potential for sedimentary manganese deposits exists in the Cobblestone Creek area. Small fluorite occurrences are associated with limestones in the Mt. Bupto area, but potential for development is low.

BIBLIOGRAPHY

1. Barnwell, C.E., Arctic Slope Consulting Engineers, written communication, July, 1990.

2. Barnwell, C.E., S. Simpson, and S. E. Church. Analytical Results and Sample Locality Maps of Stream-Sediment and Rock Samples From the Cobblestone Creek Area, Southeastern Chandler Lake Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 89-540, 1989, 26 pp.

3. Barton, H. N., S. K. Odland, R. M. O'Leary, and G. W. Day. Geochemical Data for the Killik River and Chandler Lake Quadrangles, Alaska. U.S. Geol. Surv. Open-file Rep. OF 82-1026, 1982, 53 pp.

4. Bates, R.L., Geology of the Industrial Minerals. Dover Publications Inc., New York, 1969, 459 p.

5. Beikman, H. M., and E. F. Lathram. Preliminary Geologic Map of Northern Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-789, 1976.

6. Bjorlykee, A., and D.F. Sangster, An Overview of Sandstone Lead Deposits and Their Relation to Red-Bed Copper and Carbonate-Hosted Lead-Zinc Deposits. Econ. Geol. 75th anniv. Vol., 1981, pp. 179-213.

7. Bowsher, A. L., and J. T. Dutro, Jr. Stratigraphy and Paleontology of the Mississippian Rocks in the Central Part of the Brooks Range, Alaska (abstr.). Geol. Soc. America Bull., v. 61, No. 12, pt. 2, 1950, p. 1445.

8. _____. The Paleozoic Section in the Shainin Lake Area, Central Brooks Range, Alaska: Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, Pt. 3, Areal Geology. U.S. Geol. Surv. Prof. Paper 303-A, 1957, pp. vii, 1-39.

9. Brooks, A.L., and others, Mineral Resources of Alaska, U.S.Geol. Surv. Bull. no. 379, 1909, p.61.

10. Brosgé, W. P., T. H. Nilsen, T. E. Moore, and J. T. Dutro, Jr. Geology of the Upper Devonian and Lower Mississippian (?) Kanayut Conglomerate in the Central and Eastern Brooks Range. Ch. in Geology and Exploration of the National Petroleum Reserve in Alaska, 1974 to 1982. U.S. Geol. Surv. Prof. Paper 1399, 1988, pp. 299-316.

11. Brosgé, W. P., and G. H. Pessel. Preliminary Reconnaissance Geologic Map of Survey Pass Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-27, 1977.

12. Brosgé, W. P., H. N. Reiser, J. T. Dutro, Jr., and R. L. Detterman. Generalized Geologic Map of Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-430, 1977. (Superseded by: USGS Misc. Field Studies Map MF 879-B).

13. _____. Bedrock Geologic Map of the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF 879-B, 1979.

14. Brosgé, W. P., H. N. Reiser, J. T. Dutro, Jr., and T. H. Nilsen. Geologic Map of Devonian Rocks in Parts of the Chandler Lake and Killik River Quadrangles, Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-1224, 1979.

15. Brosgę, W. P., H. N. Reiser, W. W. Patton, Jr., and M. D. Mangus. Geologic Map of the Killik-Anaktuvuk Rivers Region, Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 60-21 (198), 1960.

16. Brosgé, W. P., and I. L. Tailleur. Isopach Maps of Upper Paleozoic and Mesozoic Rocks, Northern Alaska. U.S. Geol. Surv. Open-file Rep. OF 69-26 (364), 1969, 17 pp.

17. _____. Inorganic Chemical Analysis of Black Shale From Wells in the National Petroleum Reserve in Alaska. U.S. Geol. Surv. Open-file Rep. OF 84-641, 1984, 25 pp.

18. Cady, J. W. Aeromagnetic Map and Interpretation of the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-879-E, 1978.

19. Cady, J. W., and S. W. Hackett. Map Showing Aeromagnetic Survey and Interpretation of the Survey Pass Quadrangle, Brooks Range, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1176-G, 1982, 13 pp.

20. Cathrall, J. B. Evidence From Stream-Sediment Geochemical and Biogeochemical Data, Mineral Occurrences, and Landsat Images for Potential Mineralized Target Areas in the Brooks Range, Alaska. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1980. U.S. Geol. Surv. Circ. 844, 1982, p. 41.

21. Cathrall J. B., E. F. Cooley, D. E. Detra, and T. M. Billings. A Listing and Statistical Summary of Spectrographic Analysis of Heavy-Mineral Concentrate Samples for the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-426, 1977, 70 pp.

22. Cathrall, J. B., E. F. Cooley, S. K. McDanal, and T. M. Billings. A Listing and Statistical Summary of Spectrographic Analysis of Heavy-Mineral Concentrates for the Survey Pass Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-837-B, 1979, 52 pp.

23. Cathrall, J. B., E. F. Cooley, R. M. O'Leary, T. M. Billings, and S. K. McDanal. A Listing and Statistical Summary of Spectrographic and Chemical Analyses of Stream-Sediment Samples From the Survey Pass Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-837-A, 1979, 56 pp.

24. Cathrall, J. B., D. E. Detra, and E. F. Cooley. Geochemical Maps Showing the Distribution and Abundance of Copper in the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-879G, 1978.

25. _____. Geochemical Maps Showing the Distribution and Abundance of Lead in the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-879H, 1978.

26. _____. Geochemical Maps Showing the Distribution and Abundance of Antimony, Arsenic, Bismuth, Cadmium, Molybdenum, and Tin in the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-879L, 1978.

27. Catherall, J. B., D. E. Detra, and R. M. O'Leary. Geochemical Maps Showing the Distribution and Abundance of Zinc in the Philip Smith Mountains, Alaska. U.S. Geol. Surv. Misc. Fields Studies Map MF-879I, 1978.

28. Chapman, R. M., R. L. Detterman, and M. D. Mangus. Geology of the Killik-Etivluk Rivers Region, Alaska: Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, Pt. 3, Areal Geology. U.S. Geol. Surv. Prof. Paper 303-F, 1964, pp. 325-407.

29. Chapman, R.M., and E.G. Sable,. Geology of the Utukok-Corwin Region, Northwestern Alaska: Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, Pt. 3, Areal Geology. U.S. Geol. Surv. Prof. Paper 303-C, 1960, pp. 47-167.

30. Christofferson, H.C., B. Wallin, S. Selkman, and D. T. Rickard. Mineralization Controls in the Sandstone Lead-Zinc Deposits at Vassbo, Sweden. Econ. Geol. Vol. 74, 1979, pp. 1239-1249.

31. Church, S.E., M.H. Delevaux, and J.E. Gray, Pb-Isotope Data Base for Sulfides from Alaska. USGS Open File Report 87-259, 1987, 44 p.

32. Churkin, M., Jr., C. Huie, C. F. Mayfield, and W. J. Nokleberg. Geologic Investigations of Metallic Mineral Resources of Southern NPRA. Ch. in The United States Geologic Survey in Alaska: Accomplishments During 1977. U.S. Geol. Surv. Circ. 772-B, 1978, pp. B15-B17.

33. Churkin, M., Jr., C. F. Mayfield, P. K. Theobald, H. Barton, W. J. Nokleberg, G. R. Winkler, and C. Huie. Geological and Geochemical Appraisal of Metallic Mineral Resources, Southern National Petroleum Reserve in Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-70-A, 1978, 85 pp.

34. Churkin, M., Jr., W. J. Nokleberg, and C. Huie. Collision-Deformed Paleozoic Continental Margin, Western Brooks Range, Alaska. Geology, v. 7, No. 8, 1979, pp. 379-383.

35. Clough, J. G., and J. T. Roe. Coal Resources of Northwest Alaska: Final Report. AK Div. Geol. and Geophys. Surv. Public Data File PDF 90-17, 1990, 65 pp.

36. Cobb, E. H. Summary of References to Mineral Occurrences (Other Than Mineral Fuels and Construction Materials) in Northern Alaska. U.S. Geol. Surv. Open-file Rep. OF 75-628, 1975, 106 pp.

37. _____. Selected Geological Survey, U.S. Bureau of Mines, and Alaska Division of Geological and Geophysical Surveys Reports and Maps on Alaska Released During 1976, Indexed by Quadrangle. U.S. Geol. Surv. Open-file Rep. OF 77-177, 1977, 115 pp.

38. _____. Alaskan Papers and Abstracts Published by the Geological Society of America, 1890-1978, Indexed by Quadrangle. U.S. Geol. Surv. Open-file Rep. OF 79-1640, 1979, 201 pp.

39. _____. Selected Geological Survey, U.S. Bureau of Mines, and Alaska Division of Geological and Geophysical Surveys Reports and Maps on Alaska Released During 1979, Indexed by Quadrangle. U.S. Geol. Surv. Open-file Rep. OF 80-291, 1980, 103 pp.

40. Cobb, E. H., and R. Kachadoorian. Index of Metallic and Nonmetallic Mineral Deposits of Alaska Compiled From Published Reports of Federal and State Agencies Through 1959. U.S. Geol. Surv. Bull. 1139, 1961, pp. 49-50, 121, 192, 296-297.

41. Cobb, E. H., C. F. Mayfield, and W. P. Brosgé. Summaries of Data On and Lists of References to Metallic and Selected Nonmetallic Mineral Occurrences in Arctic, Baird Mountains, Chandler Lake, De Long Mountains, Demarcation Point, Howard Pass, Misheguk Mountain, Mt. Michelson, Noatak, Point Lay, and Table Mountain Quadrangles in Northern Alaska. Supplement to Open-file Rep. OF 75-628, Part A - Summaries of Data to January 1, 1981. U.S. Geol. Surv. Open-file Rep. OF 81-767-A, 1981, 25 pp.

42. _____. Summaries of Data On and Lists of References to Metallic and Selected Nonmetallic Mineral Occurrences in Arctic, Baird Mountains, Chandler Lake, De Long Mountains, Demarcation Point, Howard Pass, Misheguk Mountain, Mt. Michelson, Noätak, Point Lay, and Table Mountain Quadrangles in Northern Alaska. Supplement to Open-file Rep. OF 75-628, Part B - Lists of References to January 1, 1981. U.S. Geol. Surv. Open-file Rep. OF 81-767-B, 1981, 15 pp.

43. Coldwell, J.R., and E.C. Gensler, Economic Feasibility of Mining in the Colville Mining District, Alaska. BuMines Open File Report in progess.

44. Cook Inlet Region Inc., Anchorage, Alaska, written communication, Oct. 1991.

45. Crane, R. C. Cretaceous Olistostrome Model, Brooks Range, Alaska. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 1., 1987, pp. 433-440.

46. Crane, R. C., and C. G. Mull. Structural Style - Brooks Range Mountain Front, Alaska. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 2, 1987, pp. 631-638.

47. Crane, R. C., and V. D. Wiggins. The Ipewik Formation, A Significant Jurassic-Neocomian Map Unit in the Northern Brooks Range Fold Belt (abstr.). Am. Assoc. Petroleum Geol. Pacific Sec. Annu. Meeting, 51st., San Francisco, CA, April 22, 1967, 1976, pp. 25-26.

48. Curtis, S. M., I. Ellersieck, C. F. Mayfield, and I. L. Tailleur. Silver, Copper, Lead and Zinc Stream-Sediment Geochemical Anomalies in Misheguk Mountain Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 80-315, 1980.

49. _____. Reconnaissance Geologic Map of Southwestern Misheguk Mountain Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 82-611, 1982, 42 pp.

50. _____. Reconnaissance Geologic Map of the Southwestern Misheguk Mountain Quadrangle, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1502, 1984.

51. Curtis, S. M., R. Rossiter, I. F. Ellersieck, C. F. Mayfield, and I. L. Tailleur. Gamma-Ray Values in the Misheguk Mountain Region, Northwestern Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-1086, 1979.

52. Detterman, R. L. Geology of the Central Part of the Northern Foothills, Arctic Slope, Alaska (abstr.). Geophysics, v. 24, No. 5, 1959, p. 1138.

53. Detterman, R. L., R. S. Bickel, and G. Gryc. Geology of the Chandler River Region, Alaska: Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, Pt. 3, Areal Geology. U.S. Geol. Surv. Prof. Paper 303-E, 1963, pp. 223-324.

54. Dillon, J. T., G. H. Pessel, J. H. Chen, and N. C. Veach. Tectonic and Economic Significance of Late Devonian and Late Proterozoic U-Pb Zircon Ages From the Brooks Range, Alaska. AK Div. Geol. and Geophys. Surv. Geol. Rep. 61, 1979, pp. 36-41.

55. Dillon, J. T., G. R. Tilton, J. Decker, and M. J. Kelly. Resource Implications of Magmatic and Metamorphic Ages for Devonian Igneous Rocks in the Brooks Range. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 2, 1987, pp. 713-723.

56. Dover, J., U.S. Geol. Surv., Banch of Alaskan Geology, personal communication, July, 1992.

57. Dutro, J. T., Jr. Stratigraphy and Paleontology of the Noatak and Associated Formations, Brooks Range, Alaska (abstr.). Geol. Soc. America Bull., v. 64, No. 12, pt. 2, 1953, p. 1415.

58. _____. Stratigraphy and Paleontology of the Noatak and Associated Formations, Brooks Range, Alaska (abstr.). Dissert. Abstr., Sec. B, Sci. and Eng., v. 28, No. 3, 1967, p. 939B.

59. _____. Revised Megafossil Biostratigraphic Zonation for the Carboniferous of Northern Alaska. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 1., 1987, pp. 359-364.

60. Dutro, J. T., Jr., and A. K. Armstrong. Biostratigraphy of Carboniferous of Northern Alaska (abstr.). Am. Assoc. Petroleum Geol. Bull., v. 54, No. 12, 1970, p. 2478.

61. Duttweiler, K. A. Sulfide Occurrences in the Itkillik River Region, Southeast Chandler Lake Quadrangle, Brooks Range. U.S. Geol. Surv. Circ. 978, 1986, pp. 10-13.

62. _____. Use of Factor Analysis in Locating Base Metal Mineralization in the Killik River Quadrangle, Alaska. U.S. Geol. Surv. Circ. 998, 1987, pp. 27-30.

63. Edwards, D.L., Bureau of Mines Research Center, Albany, Oregon, written communication, February, 1994.

64. Ebisch, J., Kennecott Exploration, Spokane, Washington, written communication, 1993.

65. Einaudi, M. T., and M. W. Hitzman. Mineral Deposits in Northern Alaska: Introduction. Econ. Geol., v. 81, No. 7, 1986, pp. 1583-1591.

66. _____. Mineral Deposits in Northern Alaska: Introduction. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc. Book 50, vol. 1, 1987, pp. 255-262.

67. Ellersieck, I. F., S. M. Curtis, C. F. Mayfield, and I. L. Tailleur. Explanation to Accompany Reconnaissance Geologic Map of South-Central Misheguk Mountain Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 82-612, 1982, 37 pp.

68. _____. Reconnaissance Geologic Map of South-Central Misheguk Mountain Quadrangle, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1504, 1984.

69. Ellersieck, I. F., U. Jansons, C. F. Mayfield, and I. F. Tailleur. The Story Creek and Whoopee Creek Lead-Zinc-Silver Occurrences, Western Brooks Range, Alaska. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1980. U.S. Geol. Surv. Circ. 844, 1981, pp. 35-38.

70. Ellersieck, I. F., C. F. Mayfield, I. L. Tailleur, and S. M. Curtis. Thrust Sequences in the Misheguk Mountain Quadrangle, Brooks Range, Alaska. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1978. U.S. Geol. Surv. Circ. 804-B, 1979, pp. B8-B9.

71. Ellersieck, I. F., and I. L. Tailleur. The Strategic and Critical Mineral Resources of the Southern Part of the National Petroleum Reserve in Alaska. U.S. Geol. Surv. Open-file Rep. OF 86-158, 1986, 12 pp.

72. Ellersieck, I, I.L. Tailleur, and C.G. Mull, Reconnaissance Geologic Map of the Story Creek Area, National Petroleum Reserve, Alaska. USGS Open-File Report 90-533, 1990, 13 p.

73. Emmel, K. S. Geological Literature on the North Slope of Alaska, 1974-1980. AK Div. Geol. and Geophys. Surv. Spec. Rep. 29, 1982, 127 pp.

74. Erlich, O., J. M. Motooka, S. E. Church, E. A. Bailey, B. F. Arbogast, and W. R. Wilson. Analytical Data and Sample Locality Map for Aqua-Regia Leachates of Stream Sediments Analyzed by ICP, and Emission Spectrographic Results for Both Stream Sediments and Panned Concentrates Collected in 1985 From the Chandler Lake Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 88-530, 1988, 38 pp.

75. Foley, J.Y., D.C. Dahlin, C.L. Mardock, and W.K. O'Connor. Reconnaissance Investigations of Chromite Deposits and Platinum-Group Metals in the Western Brooks Range, Northwestern Alaska. BuMines OFR-80-92, 1992, 68 p.

76. Force, E.R., and W.F. Cannon, Depositional Model for Shallow-Marine Manganese Deposits around Black Shale Basins. Econ. Geol., Vol. 83, 1988, pp. 93-117.

77. Foster, D. S. Quaternary Acoustic Stratigraphy Between the Colville River and Prudhoe Bay, Beaufort Sea Shelf, Alaska. U.S. Geol. Surv. Open-file Rep. OF 88-276, 1988, 108 pp.

78. Foran, W. T. Geology of Alaska Naval (Petroleum) Reserve (No.4). Oil Weekly, v. 121, No. 10, Int. Sec., 1946, pp. 35-36, 48.

79. Forrest, K. Geologic and Isotopic Studies of the Lik Deposit and the Surrounding Mineral District, De Long Mountains, Western Brooks Range, Alaska. Ph.D. Thesis, Univ. MN, Minneapolis, MN, 1983, 161 pp.

80. Forrest, K., and F. J. Sawkins. Geologic Setting and Mineralization of the Lik Deposit: Implications for the Tectonic History of the Western Brooks Range. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 1, 1987, pp. 295-305.

81. Fraser, D. C. Contouring of VLF-EM Data. Geophysics, v. 34, No. 6, 1969, pp. 958-967.

82. Galloway, J. P. A Bibliography of Selected Geologic and Engineering-Geologic Literature of Northern Alaska (Arctic Coastal Plain and Northern Foothills). U.S. Geol. Surv. Open-file Rep. OF 88-395, 1988, 34 pp.

83. Goudarzi, G.H., Guide to Preparation of Mineral Survey Reports on Public Lands. USGS Open-file report 84-787, 1984, 51 p.

84. Govier, R.D., Bureau of Mines, Research Center, Salt Lake City, Utah, written communication, Jan. 1994.

85. Grybeck, D. Maps Showing Known Mineral Deposits of the Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-166-C, 1977.

86. _____. Maps Showing Geochemical Anomalies in the Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-166-D, 1977.

87. Grybeck, D., H. M. Beikman, W. P. Brosgé, I. L. Tailleur, and C. G. Mull. Geological Map of the Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-166-B, 1977.

88. Grybeck, D. J., J. B. Cathrall, J. R. LeCompte, and J. W. Cady. Buried Felsic Plutons in Upper Devonian Redbeds, Central Brooks Range. Ch. in United States Geological Survey in Alaska: Accomplishments During 1983. U.S. Geol. Surv. Circ. C-945, 1985, pp. 8-10.

89. Grybeck, D., and J. H. De Young, Jr. Map and Tables Describing Mineral Resource Potential of the Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-1-B, 1978.

90. Grybeck, D., and W. J. Nokleberg. Metallogeny of the Brooks Range, Alaska. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1978. U.S. Geol Surv. Circ. 804-B, 1979, pp. B19-B22.

91. Gryc, G. Introduction and Summary. Ch. in Mesozoic Sequence in Colville River Region, in Northern Alaska. Am. Assoc. Petroleum Geol. Bull., v. 40, No. 2, 1956, pp. 209-213.

92. _____. The National Petroleum Reserve in Alaska. U.S. Geol. Surv. Prof. Paper 1240C, 1985, 94 pp.

93. _____. (ed.). Geology and Exploration of the National Petroleum Reserve in Alaska, 1974 to 1982. U.S. Geol. Surv. Prof. Paper 1399, 1988, 940 pp.

94. Gryc, G., and others. Mesozoic Sequence in Colville River Region, Northern Alaska. Am. Assoc. Petroleum Geol. Bull., v. 40, No. 2, 1956, pp. 209-254.

95. Gryc, G., I. L. Tailleur, and W. P. Brosgé. Geologic Framework of the "North Slope" Petroleum Provence. U.S. Geol. Surv. Open-file Rep. OF 69-115 (390), 1969, 15 pp.

96. Hamilton, T. D. Surficial Geologic Map of the Chandler Lake Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1121, 1979.

97. _____. A Late Pleistocene Glacial Chronology for the Southern Brooks Range: Stratigraphic Record and Regional Significance. Geol. Soc. America Bull., v. 93, No. 8, 1982, pp. 700-716.

98. _____. Quaternary Stratigraphic Sections With Radiocarbon Dates, Killik River Quadrangle, Alaska. U.S. Geol Surv. Open-file Rep. OF 82-606, 1982, 31 pp.

99. _____. Surficial Geologic Map of Howard Pass Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1677, 1984.

100. _____. Glacial Geology of the Brooks Range. in Dalton Highway, Yukon River to Prudhue Bay, ADGGS Guidebook no. 7, 1989, pp.23-26.

101. Hamilton, T. D., and D. P. Bauer. Engineering-Geologic Maps of Northern Alaska; Howard Pass Quadrangle. U.S. Geol. Surv. Open-file Rep. OF 84-401, 1984.

102. Hamilton, T. D., and J. H. Trexler, Jr. Analyses of Surficial Deposits, Central Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-228, 1979, 95 pp.

103. Harben, P.W., Geology of the Nonmetallics. Metal Bulletin Inc., New York, 1984, 392 p.

104. Heiner, L. E., and E. N. Wolff. Final Report - Mineral Resources of Northern Alaska. Miner. Ind. Res. Lab (MIRL) Rep. No. 16, 1968, 306 pp., (reprinted 1969).

105. Hill, P. L. Bibliographies and Location Maps of Aeromagnetic and Aeroradiometric Publications for Alaska and Hawaii. U.S. Geol. Surv. Open-file Rep. OF 86-525-E, 1986, 26 pp.

106. Hillhouse, J. W., and S. Grommé. Cretaceous Overprint Revealed by Paleomagnetic Study in the Northern Brooks Range. Ch. in The United States Geologic Survey in Alaska: Accomplishments During 1980. U.S. Geol. Surv. Circ. 844, 1982, pp. 43-46.

107. Hittelman, A. M. Catalog of Geological and Geophysical Data for the National Petroleum Reserve in Alaska. Natl. Geophys. and Solar-Terrestrial Data Center, Boulder, CO, 1982.

108. Hoekzema, R. B. Alaska's National Petroleum Reserve: Explore it Before Locking the Door. BuMines Minerals and Materials. A Bimonthly Survey, April-May 1989, pp. 7-14.

109. Huffman, A. C., Jr. Introduction to the Geology of the Nanushuk Group and Related Rocks, North Slope, Alaska. Ch. in Geology of the Nanushuk Group and Related Rocks, North Slope, Alaska. U.S. Geol. Surv. Bull. 1614, 1985, pp. 1-6.

110. _____. Uranium Potential of the Cretaceous Nanushuk Group, North Slope, Alaska. Ch. in Geology of the Nanushuk Group and Related Rocks, North Slope, Alaska. U.S. Geol. Surv. Bull 1614, 1985, pp. 121-123.

111. Jansons, U. Zinc-Lead Occurrences In and Near the National Petroleum Reserve in Alaska. BuMines MLA 121-82, 1982, 55 pp.

112. Jansons, U., and D. W. Baggs. Mineral Investigations of the Misheguk Mountain and Howard Pass Quadrangles, National Petroleum Reserve-Alaska. BuMines OFR 38-80, 1980, 76 pp.

113. Jansons, U., and T. C. Mowatt. U.S. Bureau of Mines 1977 Field Investigations - NPR-A. Mineral Investigations 1977-1978 Southern NPR-A, National Petroleum Reserve in Alaska, Field Study 5 Part 2, pp. 47-86. Prepared for National Petroleum Reserve in Alaska 105(c) Field Studies Under Authority of the National Petroleum Reserve Production Act 1976.; Available upon request from U.S. Bureau of Land Management, NPR-A, Anchorage, Alaska.

114. _____. Resource Evaluation of the Western Brooks Range 17(d)(2) Lands. BuMines Situation Rep., 1976, 40 pp.

115. Jansons, U., and M. A. Parke. 1978 Mineral Investigation in the Misheguk Mountain and Howard Pass Quadrangles. BuMines OFR 26-81, 1981, 195 pp.

116. Johnson, K. M. Map Showing Slopes and Selected Geomorphic Features, National Petroleum Reserve, Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-206, 1978.

117. Jones, D. L., N. J. Silberling, H. C. Berg, and G. Plafker. Map Showing Tectonostratigraphic Terranes of Alaska, Columnar Sections, and Summary Descriptions of Terranes. U.S. Geol. Surv. Open-file Rep. OF 81-792, 1981, 20 pp.

118. Jones, R. W. Overthrusting in the Central Brooks Range, Arctic Alaska (abstr.). Geol Soc. America Spec. Paper 121, 1969, p. 519.

119. Kachadoorian, R., and F. E. Crory. Engineering Geology Studies in the National Petroleum Reserve, Alaska. U.S. Geol. Surv. Open-file Rep. OF 83-6, 1983, 37 pp.

120. Kaiser Engineers, Inc. Technical and Economic Feasibility Surface Mining Coal Deposits North Slope of Alaska (contract J0265051). BuMines OFR 153-77, 1977, 158 pp.

121. Keller, F., Jr., and J. R. Henderson. Aeromagnetic Survey of Naval Petroleum Reserve No. 4 and Adjacent Areas. U.S. Geol. Surv. Aeromagnetic and Aeroradiometric Maps Rep. RR10, 1947, 15 pp.

122. Kelley, J. S. Geologic Map and Geologic Sections of a Portion of the Chandler Lake B-1 Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 84-77, 1984.

123. _____. Geologic Map and Sections of a Portion of the Chandler Lake A-1 and A-2 Quadrangles, Alaska. U.S. Geol. Surv. Open-file Rep. OF 84-555, 1984.

124. _____. U.S. Geol. Surv., Anchorage, Alaska, written communmication, Oct. 1993.

125. _____. Generalized Geologic Map of the Chandler Lake Quadrangle, North-Central Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-2144-A, 1990.

126. Kelley, J. S., and D. Bohn. Decollements in the Endicott Mountains Allochthon, North-Central Brooks Range. Ch. in Geologic Studies in Alaska by the U.S. Geologic Survey during 1987. U.S. Geol. Surv. Circ. 1016, 1988, pp. 44-47.

127. Kelley, J. S., and D. M. Peterson. Bibliography of Geologic Literature on the Killik River and Chandler Lake Quadrangles and Parts of Neighboring Quadrangles, North-Central Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 83-232, 1983, 30 pp.

128. Kelley, J. S., I. L. Tailleur, R. L. Morin, K. M. Reed, A. G. Harris, J. M. Schmidt, F. M. Brown, and J. M. Kurtak. Barite Deposits in the Howard Pass Quadrangle and Possible Relations to Barite Elsewhere in the Northwestern Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. 93-215, 1993, 13 pp.

129. Kelley, J.S., Phosphate and Whole Rock Chemical Analyses From Upper Paleozoic and Lower Mesozoic Strata in the Chandler Lake and Killik River Quadrangles, Alaska. USGS unpublished report, 1982.

130. Kelley, K.D., USGS, Branch of Geochemistry, unpublished geochemical data for the Howard Pass Quadrangle, Alaska, 1992.

131. Kelley, K. D., S.J. Sutley, and J.G. Frisken, Maps Showing Geochemistry and Mineralogy of Nonmetalic Heavy-mineral-concentrate Samples from the Southern Part of the Chandler Lake Quadrangle, Alaska. U.S. Geol. Surv., Misc. Field Studies Map MF-2144-B, 1993.

132. Kelley, K. D., H. N. Barton, S.J. Sutley, and R.M. O'Leary, Maps Showing Geochemistry of Stream Sediment Samples from the Southern Part of the Chandler Lake Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-2144-C, 1993.

133. Kelley, K. D., and S. J. Sutley. Maps Showing Geochemistry of Stream Sediment Samples from the Northern Part of the Chandler Lake Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-2144-D, 1993.

134. Kelley, K.D., J.C. Borden, E.A. Bailey, D.L. Fey, J.M. Motooka, and B.H. Roushey. Geochemically Anomalous Areas in the West-Central Part of the Howard Pass Quadrangle, National Petroleum Reserve, Alaska: Evidence for Sediment-Hosted Zn-Pb-Ag-Ba Mineralization. USGS Bull. 2041, 1992, pp. 60-69.

135. Kelley, K.D., and C.G. Mull, Maps showing Areas of Potential for Mineral Resources in the Killik River 1 deg.x3 deg. Quadrangle, Brooks Range, Alaska. USGS Miscellaneous Field Investigations Map MF 225-A, 1994.

136. Kulas, J., Cominco Alaska, written communication, March, 1993

137. Kurtak, J. M. U.S. Bureau of Mines Mineral Investigations in the Colville Mining District. The Alaska Miner, v. 21, No. 4, April, 1993, p. 12-15.

138. _____ Searching for Minerals Above the Arctic Circle. Minerals Today, August, 1992, p.6-10.

139. Lange, I. M., and W. J. Nokleberg. Geologic Setting, Petrology, and Geochemistry of Stratiform Sphalerite-Galena-Barite Deposits, Red Dog Creek and Drenchwater Creek Areas, Northwestern Brooks Range, Alaska - A Reply. Econ. Geol. v. 82, 1987, pp. 1079-1084.

140. Lange, I. M., W. J. Nokleberg, J. T. Plahuta, H. R. Krouse, and B. R. Doe. Geologic Setting, Petrology, and Geochemistry of Stratiform Sphalerite-Galena-Barite Deposits, Red Dog Creek and Drenchwater Creek Areas, Northwestern Brooks Range, Alaska. Econ. Geol., v. 80, No. 7, 1985, pp. 1896-1926.

141. Lange, I. M., W. J. Nokleberg, J. T. Plahuta, H. R. Krouse, B. R. Doe, and U. Jansons. Isotopic Geochemistry of Stratiform Zinc-Lead-Barium Deposits, Red Dog and Drenchwater Creek Areas, Northwestern Brooks Range, Alaska. Ch. in Proc. of the Symp. on Miner. Deposits of the Pacific Northwest, Geol. Soc. America, Cordilleran Sec. Meeting at Corvallis, R, March 20-21, 1980. U.S. Geol. Surv. Open-file Rep. OF 81-355, 1981, pp. 2-16.

142. Lathram, E. H. Preliminary Geologic Map of Northern Alaska. U.S. Geol. Surv. Open-file Rep. OF 254, 1965.

143. _____. Tectonic Framework of Northern and Central Alaska (abstr.), Ch. in International Symposium on Arctic Geology, 2nd, San Francisco, CA, 1971. Am. Assoc. Petroleum Geol. Bull., v. 54, No. 12, 1970, p. 2493.

144. Le Compte, J. R. Map Showing Interpretation of Landsat Imagery of the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF 879-F, 1979.

145. LeFond, S.J., Ed., Industrial Minerals and Rocks. Society of Mining Engineers, 2 vols., 1983, 1433 p.

146. Leslie, L.D., Alaska Climate Summaries. Alaska Climate Tech. Rep. no. 3, 1986, 200 p.

147. Levinson, A.A., Introduction to Exploration Geochemistry, Applied Publishing Inc., Wilmette, Ill. USA, 1974, 924 p.

148. Liss, S. A., and M. A. Wiltse. United States Geological Survey Alaska Mineral Resources Appraisal Program (AMRAP), Geochemical Data, Alaska (i. Chandler Lake Quadrangle, p. Killik River Quadrangle, and v. Philip Smith Mountains Quadrangle). AK Div. Geol. and Geophys. Surv. Public Data File PDF 93-39, 1993, 6 pp.

149. Lueck, L. Lead Isotope Ratios From the Red Dog and Drenchwater Creek Lead-Zinc Deposits, De Long Mountains, Brooks Range, Alaska. Ch. in Short Notes on Alaskan Geology 1979-1980. AK Div. Geol. and Geophys. Surv. Geol. Rep. 63, 1980, pp. 1-5.

150. _____. Petrologic and Geochemical Characterization of the Red Dog and Other Base-Metal Sulfide and Barite Deposits in the De Long Mountains, Western Brooks Range, Alaska. Miner. Ind. Res. Lab (MIRL) Rep. 71, 1986, 105 pp.

151. MacNamara, E. E. Soils of the Howard Pass Area, Northern Alaska (abstr.). Dissert. Abstr., v. 26, No. 12, pt. 1, 1966, p. 7260.

152. Malone, J., A close look at a faraway place. BLM Alaska Frontiers, Issue no. 49, July/August, 1994, p. 4-5.

153. Marshall, R., Alaska Wilderness: Exploring the Central Brooks Range. Univ. of Calif. Press, 1970, p.

154. Martin, A. J. Structure and Tectonic History of the Western Brooks Range, De Long Mountains, and Lisburne Hills, Northern Alaska. Geol. Soc. America Bull., v. 81, No. 12, 1970, pp. 3605-3622.

155. Martin, G. C. Geology and Mineral Resources of the Controller Bay Region, Alaska. U.S. Geol. Surv. Bull. 335, 1908, p. 110.

156. Martin, G. C., and J. E. Callahan. Preliminary Report on the Coal Resources of the National Petroleum Reserve in Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-1033, 1978, 29 pp.

157. Matzko, J. J. Phosphate Rock from the Brooks Range, Northern Alaska - A Preliminary Mineralogic Report (abstr.). Geol. Soc. America Bull., v. 66, No. 12, pt. 2, 1959, p. 1705.

158. _____. Phosphate Rock from the Brooks Range, Northern Alaska - A Preliminary Mineralogic Report (abstr.). AK Sci. Conf., 6th-7th, 1955-56, Proc., 1959, pp. 85-86.

159. Mayfield, C. F., S. M. Curtis, I. R. Ellersieck, and I. L. Tailleur. Reconnaissance Geology of the Ginny Creek Zinc-Lead-Silver and Nimiuktuk Barite Deposits Northwestern Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-1092, 1979, 20 pp.

160. _____. Reconnaissance Geologic Map of the Southeastern Misheguk Mountain Quadrangle, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1503, 1984.

161. Mayfield, C. F., I. L. Tailleur, and I. Ellersieck. Stratigraphy, Structure, and Palinspastic Synthesis of the Western Brooks Range, Northwestern Alaska. U.S. Geol. Surv. OFR 83-779, 1983, 58 pp.

162. _____. Stratigraphy, Structure, and Palinspastic Synthesis of the Western Brooks Range, Northwestern Alaska. Ch. in Geology and Exploration of the National Petroleum Reserve in Alaska, 1974 to 1982. U.S. Geol. Surv. Prof. Paper 1399, 1988, pp. 143-186.

163. Mayfield, C. F., I. L. Tailleur, and C. E. Kirschner. Bedrock Geologic Map of the National Petroleum Reserve in Alaska. Ch. in Geology and Exploration of the National Petroleum Reserve in Alaska, 1974 to 1982, U.S. Geol. Surv. Prof. Paper 1399, 1988, pp. 187-190.

164. Mayfield, C. F., I. L. Tailleur, C. G. Mull, and E. G. Sable. Bedrock Geologic Map of the South Half of the National Petroleum Reserve in Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-70-B, 1978.

165. Mayfield, C. F., I. L. Tailleur, C. G. Mull, and M. L. Silberman. Granitic Clasts From Upper Cretaceous Conglomerate in the Northwestern Brooks Range. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1977. U.S. Geol. Surv. Circ. 772-B, 1978, pp. B11-B13.

166. McKinstry, H.E., Mining Geology. Prentice-Hall, Inc., 1948, 680 p.

167. Menzie, W. D., H. N. Reiser, W. P. Brosgé and R. L. Detterman. Map Showing Distribution of Mineral Resources (Excepting Oil & Gas) in the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-879-C, 1985.

168. Metz, P. A. Baseline Geochemical Investigations of the Red Dog and Drenchwater Creek Mineral Occurrences (BuMines contract G0177176). Miner. Ind. Res. Lab (MIRL), 1979, 21 pp.

169. Metz, P. A., and M. S. Robinson. Mineral Investigations of D-2 Lands in the Philip Smith Mountains and Chandler Lake Quadrangles. Miner. Ind. Res. Lab (MIRL) Open-file Rep. OFR 79-4, 1979, 77 pp.

170. Metz, P. A., M. S. Robinson, and L. Lueck. Baseline Geochemical Studies for Resource Evaluation of D-2 Lands - Geophysical and Geochemical Investigations of the Red Dog and Drenchwater Creek Mineral Occurrences. Miner. Ind. Res. Lab (MIRL) Open-file Rep. OFR 79-3, 1979, 117 pp.

171. Meyer, M. P., and others, Executive Summary of the U.S. Bureau of Mines Investigations in the Colville Mining District, Alaska, BuMines Open File report, proposed, 1994.

172. Meyer, M. P., and J. M. Kurtak. Results of the 1991 U.S. Bureau of Mines Colville Mining District Study. BuMines OFR 75-92, 1992, 101 pp.

173. Meyer, M. P., J. M. Kurtak, and R. W. Hicks. Results of the 1992 U.S. Bureau of Mines Colville Mining District Study. BuMines OFR 12-93, 1993, 35 pp.

174. Meyer, M. P., Analytical Results From U.S. Bureau of Mines Investigations in the in the Colville Mining District, Alaska. BuMines OFR 34-94, 1994, 137 p.

175. Molenaar, C. M., K. J. Bird, and T. S. Collett. Regional Correlation Sections Across the North Slope of Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1907, 1986.

176. Moore, T. E., and T. H. Nilsen. Regional Variations in the Fluvial Upper Devonian and Lower Mississippian(?) Kanayut Conglomerate, Brooks Range, Alaska. Sed. Geol., v. 38, 1984, pp. 465-497.

177. Morin, R. L. USGS Geophysics Branch, Written Communication, December, 1991. 178. Morris, R. H. Heavy Mineral Analysis of Sedimentary Rocks of Northern Alaska. U.S. Geol. Surv. Open-file Rep. OF 52-102 (85), 1952, 68 pp.

179. Morrissey, L. A., and R. A. Ennis. Vegetation of the National Petroleum Reserve in Alaska Using Landsat Digital Data. U.S. Geol. Surv. Open-file Rep. OF 81-315, 1981, 27 pp.

180. Motooka, J. M., B. M. Adrian, S. E. Church, C. M. McDougal, and J. B. Fife. Analytical Data and Sample Locality Map for Aqua-Regia Leachates of Stream Sediments Analyzed by ICP, and Emission Spectrographic Results for Many NURE Stream Sediments From the Killik River Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 89-12, 1989, 77 pp.

181. Mowatt, T. C., J. A. Dygas, C. Gibson, and A. L. Seidlitz. Mineral Resources of Western Arctic Alaska. U.S. BLM Open File Rep. 39, 1991, 27 pp.

182. Mull, C.G., The Tectonic Evolution and Structural Style of the Brooks Range, Alaska: An Illustrated Summary. Ch. in Geological Studies of the Cordilleran Thrust Belt. Rocky Mountain Assoc. of Geol., Denver, CO, v. 1, 1982, pp. 1-45.

183. Mull, C.G., Alaska Div. of Geol. and Geophys. Surv., written communication
, Nov. 1992.

184. Mull, C.G., and K.E. Adams (eds.) Dalton Highway, Yukon River to Prudhoe Bay, Alaska. Alaska Div. of Geol. and Geophys. Surv. Guidebook no. 7, 2 vols. 1989, 309 p.

185. Mull, C. G., R. K. Crowder, J. P. Siok, K. E. Adams, D. A. Bodnar, E. E. Harris, and R. A. Alexander. A Summary of the Stratigraphy and Structural Setting of the Picnic Creek Allochthon, Killik River Quadrangle, Central Brooks Range, Alaska. AK Div. Geol. and Geophys. Surv. Public Data File PDF 86-33b, 1986, 31 pp.

186. Mull, C. G, T.E. Moore, E. E. Harris, and I. L. Tailleur, Preliminary Geologic Map of the Killik River Quadrangle. U.S. Geol. Surv., Open-File Report in progress.

187. Mull, C. G., D. H. Roeder, I. L. Tailleur, G. H. Pessel, A. Grantz, and S. D. May. Geologic Sections and Maps Across the Brooks Range and Arctic Slope to Beaufort Sea, Alaska. Geol. Soc. America Map and Chart Series MC 28-S, 1987.

188. Mull, C. G., I. L. Tailleur, C. F. Mayfield, I. Ellersieck, and S. Curtis. New Upper Paleozoic and Lower Mesozoic Stratigraphic Units, Central and Western Brooks Range, Alaska. Am. Assoc. Petroleum Geol. Bull., v. 66, No. 7, 1982, pp. 348-362.

189. Mull, C. G., I. L. Tailleur, C. F. Mayfield, and G. H. Pessel. New Structural and Stratigraphic Interpretations, Central and Western Brooks Range and Arctic Slope. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1975. U.S. Geol. Surv. Circ. 733, 1976, pp. 24-26.

190. Mulligan, J. J. Bureau of Mines in Alaska, 1910 to 1970, The History of the Bureau of Mines in Alaska. BuMines, Unpub. Rep., 1986?, 7 pp. Available from Librarian Alaska Field Operations Center, Juneau, Alaska.

191. Nelson, S. W., and W. H. Nelson. Geology of the Siniktanneyak Mountain Ophiolite, Howard Pass Quadrangle, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1441, 1982.

192. Nilsen, T. H., W. P. Brosgé, T. E. Moore, J. T. Dutro, Jr., and D. F. Balin. Significance of the Endicott Group for Tectonic Models of the Brooks Range. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1980. U.S. Geol. Surv. Circ. 844, 1982, pp. 28-32.

193. Nilsen, T. H., and T. E. Moore. Sedimentology and Stratigraphy of the Kanayuk Conglomerate, Central and Western Brooks Range, Alaska--Report of the 1981 Field Season. U.S. Geol. Surv. Open-file Rep. OF 82-674, 1982, 64 pp.

194. _____. Stratigraphic Nomenclature for the Upper Devonian and Lower Mississippian(?) Kanayut Conglomerate, Brooks Range, Alaska. U.S. Geol. Surv. Bull. 1529-A, 1984, pp. A1-A64.

195. Nilsen, T. H., T. E. Moore, D. F. Balin, and S. Y. Johnson. Sedimentology and Stratigraphy of the Kanayut Conglomerate, Central Brooks Range, Alaska--Report of 1980 Field Season. U.S. Geol. Surv. Open-file Rep. OF 82-199, 1982, 81 pp.

196. Nilsen, T. H., T. E. Moore, W. P. Brosgé, and J. T. Dutro, Jr. Sedimentology and Stratigraphy of the Kanayut Conglomerate and Associated Units, Brooks Range, Alaska: Report of the 1981 Field Season. U.S. Geol. Surv. Open-file Rep. OF 81-506, 1981, 39 pp.

197. Nilsen, T. H., T. E. Moore, J. T. Dutro, W. P. Brosgé, and D. M. Orchard. Sedimentology and Stratigraphy of the Kanayuk Conglomerate and Associated Units, Central and Eastern Brooks Range, Alaska: Report of the 1978 Field Season. U.S. Geol. Surv. Open-file Rep. OF 80-888, 1980, 40 pp.

198. Nokelberg, W. J., T. K. Bundtzen, H. C. Berg, D. A. Brew, D. Grybeck, M. S. Robinson, T. E. Smith, and W. Yeend. Significant Metalliferous Lode Deposits and Placer Districts of Alaska. U.S. Geol. Surv. Bull. 1786, 1987, 104 pp.

199. Nokleberg, W. J., J. T. Plahuta, I. M. Lange, and D. Grybeck. Volcanogenic Zinc-Lead Mineralization in Pelagic Sedimentary Rocks of Late Paleozoic Age, Northwestern Brooks Range, Alaska (abstr.). Geol. Assoc. Canada Abstr. with Programs, v. 4, 1979, p. 21.

200. _____. Volcanogenic Zinc-Lead-Barite Deposits in Pelagic Rocks of Late Paleozoic and Early Mesozoic Age, Northwestern Brooks Range, Alaska (abstr.). Geol. Assoc. Canada Abstr. with Programs, v. 11, No. 7, 1979, pp. 487-488.

201. Nokleberg, W. J., and G. R. Winkler. Geologic Setting of the Lead and Zinc Deposits, Drenchwater Creek Area, Howard Pass Quadrangle, Western Brooks Range, Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-70-C, 1978, 17 pp.

202. _____. Geologic Setting of Stratiform Zinc-Lead Mineralization, Drenchwater Creek Area, Howard Pass Quadrangle, Western Brooks Range, Alaska (abstr.). Geol. Soc. America Abstr. with Programs, v. 10, No. 3, 1978, p. 139.

203. _____. Stratiform Zinc-Lead Deposits in the Drenchwater Creek Area, Howard Pass Quadrangle, Northwestern Brooks Range, Alaska. U.S. Geol. Surv. Prof. Paper 1209, 1982, 22 pp.

204. _____. Stratiform Zinc-Lead Mineralization, Drenchwater Creek Area, Howard Pass Quadrangle, Western Brooks Range, Alaska. Ch. in The United States Geological Survey: Accomplishments During 1977. U.S. Geol. Surv. Circ. 772-B, 1978, pp. B17-B19.

205. O'Conner, W.K., BuMines Research Center, Salt Lake City, Utah, written communication, November, 1992.

206. O'Harra, D., Anchorage Daily News, We Alaskans. Feb. 9, 1992.

207. Olhoeft, G. R., R. Watts, F. Frischkenecht, F. Bradley, and D. Dansereau. Electromagnetic Geophysical Exploration in the National Petroleum Reserve in Alaska. Paper in Proceedings of Symposium on Permafrost Field Methods, Saskatoon, Saskatchewan, Canada. Ottawa, Natl. Res. Council of Canada, Tech. Memo., 1978.

208. Oliver, F.S., BuMines Research Center, Salt Lake City, Utah, written communication, October, 1992. Available from J. M. Kurtak, BuMines, Alaska Field Operations Center, Anchorage, Alaska.

209. Oyler, H., Baroid Corp. Houston, Texas, personal communication, Dec. 1993.

210. Paige, S., W. T. Foran, and J. Gilluly. A Reconnaissance of the Point Barrow Region, Alaska. U.S. Geol. Surv. Bull. 772, 1925, 33 pp.

211. Patton, W. W., Jr. Phosphate Deposits in Northern Alaska (abstr.). Geol. Soc. America Bull., v. 66, No. 12, pt. 2, 1955, p. 1707.

212. _____. A New Upper Paleozoic Formation, Central Brooks Range, Alaska Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, Areal Geology, Pt. 3. U.S. Geol. Surv. Prof. Paper 303-B, 1957, pp. iv, 41-45.

213. _____. Geology of the Upper Killik-Itkillik Region, Alaska (abstr.). Dissert. Abstr., v. 20, No. 8, 1960, pp. 3261-3262.

214. Patton, W. W., Jr., and J. J. Matzko. Phosphate Deposits in Northern Alaska: Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-59, Pt. 4, Regional Studies. U.S. Geol. Surv. Prof. Paper 302-A, 1959, pp. 1-17.

215. Patton, W. W., Jr., and I. L. Tailleur. Geology of the Killik-Itkillik Region, Alaska. Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, Pt. 3, Areal Geology. U.S. Geol. Surv. Prof. Paper 303-G, 1964, pp. 409-500.

216. Patton, W. W., Jr., I. L. Tailleur, W. P. Brosgé, and M. A. Lanphere. Preliminary Report on the Ophiolites of Northern and Western Alaska. Ch. in North American Ophiolites. Oregon Dept. Geol. and Miner. Ind. Bull. 95, 1978, pp. 51-58.

217. Payne, T. G., and others. Geology of the Arctic Slope of Alaska. U.S. Geol. Surv. Oil & gas Invest. Map OM-126, 1952.

218. _____. Generalized Isopach Map of Jurassic and Possibly Lower Cretaceous Shale, Including Kingak Shale, Eastern North Slope Petroleum Province, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-928-K, 1978.

219. Perkins, W., J.R. Simplot Co., Afton, Wyoming, Written Communication, April, 1994.

220. Pessel, G. H., I. L. Tailleur, and K. J. Bird. Generalized Structure Map of Top of the Colville Group, Eastern North Slope Petroleum Province, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-928-C, 1978.

221. Pettijohn, F.J., Sedimentary Rocks, Harper and Row, Publishers, New York,1957, 718 p.

222. Péwé, T. L. Quaternary Geology of Alaska. U.S. Geol. Surv. Prof. Paper 835, 1975, 145 pp.

223. Péwé, T. L., and others. Multiple Glàciation in Alaska, A Progress Report. U.S. Geol. Surv. Circ. 289, 1953, 13 pp.

224. Porter, S. C. Glacial Stratigraphy and Chronology of Anaktuvuk Valley, Arctic Slope of Alaska (abstr.). Geol. Soc. America Spec. Paper 73, 1963, pp. 216-217.

225. _____. Stratigraphy and Deformation of Paleozoic Section at Anaktuvuk Pass, Central Brooks Range, Alaska. American Assoc. of Pet. Geol. Bull. vol. 50 no. 5, May, 1966, pp. 952-980.

226. _____. Geology of Anaktuvuk Pass, Central Brooks Range, Alaska. Dissertation, Yale Univ., 1962.

227. _____. Antiquity of Man at Anaktuvuk Pass, Alaska. Am. Antiquity, v. 29, No. 4, 1964, pp. 493-496.

228. _____. Pleistocene Geology of Anaktuvuk Pass, Central Brooks Range, Alaska. Arctic Inst. North Am. Tech. Paper 18, 1966, 100 pp.

229. _____. Stratigraphy and Deformation of Paleozoic Section at Anaktuvuk Pass, Central Brooks Range, Alaska. Am. Assoc. Petroleum Geol. Bull., v. 50, No. 5, 1966, pp. 952-980.

230. Quaide, W. Enquiry Into the Paleontologic and Geologic History of the Naval Petroleum Reserve No. 4 and Adjoining Areas. Report Prepared for Arctic Institute of North America Under Office of Naval Research Project ONR-118, 1955, 26 pp., unpublished.

231. Ransome, A.L., and W.H. Kerns, Names and Definitions of Regions, Districts, and Subdistricts in Alaska, BuMines Info. Circ., no. 7679, 1954, 91 p.

232. Raush, R., Notes on the Nunamiut Eskimo and Mammals of the Anaktuvuk Pass Region, Brooks Range, Alaska. Arctic, Vol. 4, no. 3, 1951, pp. 147-195.

233. Reed, J. C. Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53; Part I, History of the Exploration. U.S. Geol. Surv. Prof. Paper 301, 1958, 192 pp.

234. _____. Naval Petroleum Reserve No. 4; Then and Now (abstr.). Geophysics, v. 34, No. 6, 1969, p. 1006.

235. Rickard, D.T., M.Y. Willden, N.E. Marinder, and T.H. Donnelly, Studies on the Genesis of the Laisval Sandstone Lead-Zinc Deposit, Sweden. Econ. Geol. Vol. 74. 1979, pp. 1255-1285.

236. Robinson, M. S. Kerogen Microscopy of Coal and Shales From the North Slope of Alaska. AK Div. Geol. and Geophys. Surv. Public Data File PDF 89-22, 1989, 19 pp.

237. Robinson, M. S., and M. D. Myers. Colville River Geologic Transect: Vitrinite Reflectance, Palynology, Tai, and Fussion Track Data, Central North Slope, Alaska. AK Div. Geol. and Geophys. Surv. Public Data File PDF 90-12, 1990, 5 pp.

238. Roeder, D. H., and C. G. Mull. Tectonics of Brooks Range Ophiolites, Alaska. Am. Assoc. Petroleum Geol. Bull., v. 62, No. 9, 1978, pp. 1696-1702.

239. Roehler, H. W. Depositional Environments of Coal-Bearing and Associated Formations of Cretaceous Age in the National Petroleum Reserve in Alaska. U.S. Geol. Surv. Bull. 1575, 1987, 16 pp.

240. Roehler, H. W., and G. D. Stricker. Stratigraphy and Sedimentation of the Torok, Kukpowruk and Corwin Formations of Cretaceous Age in the Kokolik-Utukok River Region, National Petroleum Reserve in Alaska. U.S. Geol. Surv. Open-file Rep. OF 79-995, 1979, 80 pp.

241. Rossman, D. L. Sample Aeromagnetic Surveys of Iron County, Michigan, Mangun, Oklahoma Area, and Naval Petroleum Reserve No. 4, Alaska. U.S. Geol. Surv. Geophys. Inv. Prelim. Map 3, 1946, Accompanying Prelim. Rep. 3, Maps and Data Compiled by D. L. Rossman, M. E. Hill, F. M. Byers, Jr., M. S. Walton, Jr., J. R. Balsey, Jr., R. Thurwood, L. P. Barrett, F. G. Pardee, W. Osgood, H. Jensen, J. P. Fitzsimmons, and V. S. Neuschel.

242. Sable, E. G., R. M. Chapman, and I. L. Tailleur. Geologic Map of the Western Kukpowruk-Nuka Rivers Region, Northwestern Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1668, 1984.

243. Sable, E. G., and J. T. Dutro, Jr. New Devonian and Mississippian Formations in De Long Mountains, Northern Alaska. Am. Assoc. Petroleum Geol. Bull., v. 45, No. 5, 1961, pp. 585-593.

244. Sable, E. G., J. T. Dutro, Jr., M. D. Mangus, and R. H. Morris. Geology of the Kukpowruk-Nuka Rivers Region, Northwestern Alaska. U.S. Geol. Surv. Open-file Rep. OF 81-1078, 1981, 240 pp.

245. Sable, E. G., J. T. Dutro, Jr., R. H. Morris, and I. L. Tailleur. Geologic Map of the Eastern Kukpowruk-Nuka Rivers Region, Northwestern Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1671, 1984.

246. Sable, E. G., and M. D. Mangus. Stratigraphy and Structure of the Upper Utukok-Kokolik Rivers Area, Alaska. U.S. Geol. Surv. Inv. Naval Petroleum Reserve No. 4, Rep. No. 45, OFR:PR45, 1951, 19 pp.

247. _____. Geologic Map of the West-Central Kukpowruk-Nuka Rivers Region, Northwestern Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1669, 1984.

248. Sable, E. G., M. D. Mangus, R. H. Morris, and J. T. Dutro, Jr. Geologic map of the East-Central Kukpowruk-Nuka Rivers Region, Northwestern Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1670, 1984.

249. Sable, E. G., and G. D. Stricker. Coal in the National Petroleum Reserve in Alaska (NPRA): Framework Geology and Resources. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 1, 1987, pp. 195-215.

250. Sanford, R. S., and H. C. Pierce. Exploration of Coal Deposits of the Point Barrow and Wainwright Areas, Northern Alaska. BuMines RI 3934, 1946, 17 pp.

251. Schmidt, J. M., D. Bohn, K. D. Kelly, J. A. Dumoulin, R. L. Morin, M. D. Krohn, D. C. Bradley, S. M. Karl, J. S. Kelly, and H. A. Pohn. Compilation of Geologic, Geochemical and Geophysical Data for the Misheguk Mountain, Howard Pass, and Western Killik River Quadrangles, Alaska, with Special Emphasis on the Southern National Petroleum Reserve in Alaska (NPRA). U.S. Geol. Surv. Admin. Rep., 1991, 250 pp.

252. Schoennagel, F. H. Mississippian Unconformities in Northern Alaska Related to Antler Tectonic Pulses. Am. Assoc. Petroleum Geol. Bull., v. 61, No. 3, 1977, pp. 435-442.

253. Schrader, F. C. Geological Section of the Rocky Mountains in Northern Alaska. Geol. Soc. America Bull., v. 13, 1902, pp. 233-252.

254. _____. Geological Section of the Rocky Mountains in Northern Alaska. Science, v. 15, 1902, pp. 665-666.

255. _____. A Reconnaissance in Northern Alaska Across the Rocky Mountains, Along the Koyukuk, John, Anaktuvuk, and Colville Rivers, and the Arctic Coast to Cape Lisburne, in 1901. U.S. Geol. Surv. Prof. Paper 20, 1904, 139 pp.

256. Siok, J. P. Geologic History of the Siksikpuk Formation on the Endicott Mountains and Picnic Creek Allochthons, North Central Brooks Range, Alaska. M.S. Thesis, Univ. AK Fairbanks, Fairbanks, AK, 1985, 253 pp.

257. Siok, J. P., and C. G. Mull. Glauconitic Phosphatic Sandstone and Oncolite Deposition at the Base of the Etivluk Group (Carboniferous) Picnic Creek Allochthon, North-Central Brooks Range, Alaska. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 1, 1987, pp. 367-370.

258. Sloan, C., D. Trabant, and W. Glude. Reconnaissance Snow Surveys of the National Petroleum Reserve in Alaska, April 1977 and April-May 1977. U.S. Geol. Surv. Open-file Rep. OF 79-1342, 1979, 42 pp.

259. Smith, P. S. Geologic Investigations in Northern Alaska. U.S. Geol. Surv. Bull. 792-C, 1927, pp. 111-120.

260. _____. Surveys in Northwestern Alaska in 1926. U.S. Geol. Surv. Bull. 797-D, 1929, pp. 125-142.

261. Smith, P. S., and J. B. Mertie, Jr. Geology and Mineral Resources of Northwestern Alaska. U.S. Geol. Surv. Bull. 815, 1930, 351 pp.

262. Smith, P. S., J. B. Mertie, Jr., and W. T. Foran. Summary of Recent Surveys in Northern Alaska. U.S. Geol. Surv. Bull. 783-E, 1926, pp. 151-166.

263. Snelson, S., and I. L. Tailleur. Large-Scale Thrusting and Migrating Cretaceous Foredeeps in the Western Brooks Range and Adjacent Regions of Northwestern Alaska (abstr.). Am. Assoc. Petroleum Geol. Bull., v. 52, 1968, p. 567.

264. Spicer, R. A., and B. A. Thomas. A Mississippian Alaska-Siberian Connection: Evidence From Plant Fossils. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologist and Mineralogists and AK Geol. Soc., Book 50, v. 1, 1987, pp. 355-358.

265. Stoney, G.M., Naval Explorations in Alaska. U.S. Naval Inst. Annapolis, Maryland, 1900, 105 p.

266. Summers, C. A. Mineralogy of the Ivotuk Hills Phosphate Occurrence, Colville Mining District, Alaska. BuMines, Unpub. Rep., 1992, 6 pp. Available from M. P. Meyer, U.S. BuMines, Alaska Field Operations Center, Anchorage, Alaska.

267. Summers, C. A., D. E. Larson, and M. B. Werdon. Lead and Zinc Mineralization at Story Creek, Colville Mining District, Alaska. Preprint no. 93-124, Presented at SME 1993 Annual Meeting, Reno, NV, Feb. 16, 1993.

268. Sutley, S. J., K. A. Duttweiler, and R. T. Hopkins. Analytical Results and Sample Locality Map of Stream-Sediment and Panned Concentrate Samples From the Killik River 1° x 3° Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 84-406, 1984.

269. _____. Analytical Results and Sample Locality Map of Stream-Sediment and Panned Concentrate Samples From the Chandler Lake 1° x 3° Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 84-412, 1984.

270. Tailleur, I. L. Speculations on North Slope Geology. Oil and Gas J., v. 67, No. 38, 1969, pp. 128-130, 215-216, 225-226.

271. _____. U.S. Geol. Surv., Emeritus, written communication, Oct., 1992.

272. _____. Brooks Range Orogen, Arctic Alaska (abstr.). Geol. Soc. America Abstr., v. 3, No. 6, 1971, p. 415.

273. Tailleur, I. L., and W. P. Brosgé. Tectonic History of Northern Alaska. Geol. Seminar on the North Slope of Alaska, Palo Alto, CA, 1970 Proc., Los Angeles, CA. Am. Assoc. Petroleum Geol. Pacific Sec., 1970, pp. E1-E20.

274. Tailleur, I. L., I. F. Ellersieck, and C. F. Mayfield. Mineral Resources of the Western Brooks Range. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1976. U.S. Geol. Surv. Circ. 751-B, 1977, pp. B24-B25.

275. Tailleur, I. L., and S. E. Engwicht. Structure Maps of Top of Sadlerochit Group and Cross Sections of Sadlerochit Reservoir, Eastern North Slope Petroleum Province, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-928-O, 1978.

276. Tailleur, I. L., B. H. Kent, and H. N. Reiser. Outcrop/Geologic Maps of the Nuka-Etivluk Region, Northern Alaska. U.S. Geol. Surv. Open-file Rep. OF 66-128 (226), 1966.

277. Tailleur, I. L., B. L. Mamet, and J. T. Dutro, Jr. Revised Age and Structural Interpretation of Nuka Formation at Nuka Ridge, Northwestern Alaska. Am. Assoc. Petroleum Geol. Bull., v. 57, 1973, pp. 1348-1352.

278. Tailleur, I. L., G. H. Pessel, W. P. Brosgé, and C. F. Mayfield. Informal Cooperation Between U.S. Geological Survey and State of Alaska, Division of Geological and Geophysical Surveys, in the Brooks Range. Ch. in The United States Geological Survey in Alaska: Accomplishments During 1975. U.S. Geol. Surv. Circ. 733, 1976, pp. 27-30.

279. Tailleur, I. L., and S. Snelson. Large-Scale Thrusts in the Brooks Range Orogen, Northern Alaska (abstr.). Geol. Soc. America Spec. Paper 101, 1968, p. 217.

280. Tailleur, I. L., and P. Weimer. (eds.). Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc. Book 50, v. 1, 1987, 542 pp.

281. ______. Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc. Book 50 v. 2, 1987, pp. 545-874.

282. Templeman-Kluit, D. J. Yukon Mineral Exploration Highlighted by New Zinc-Lead Deposit Discoveries. Western Miner, v. 51, No. 2, 1978, pp. 12-14,16.

283. Theobald, P. K., and H. N. Barton. Basic Data for the Geochemical Evaluation of National Petroleum Reserve, Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-70-D, 1978, 15 pp.

284. Theobald, P. K., H. N. Barton, T. M. Billings, J. G. Frisken, R. L. Turner, and G. Van Trump, Jr. Geochemical Distribution of Elements in Stream Sediments and Heavy-Mineral Concentrate Samples in the Southern Half of the National Petroleum Reserve, Alaska. U.S. Geol. Surv. Open-file Rep. OF 78-517, 1978.

285. Thoman, R.L. Jr., The Lowest Average Winter Temperature in the United States - Umiat Alaska. National Weather Digest, Vol. 11 no. 4, 1986, pp.33-36.

286. Till, A. B. Proterozoic Rocks of the Western Brooks Range. Ch. in Geological Studies in Alaska by the U.S. Geological Survey, 1988. U.S. Geol. Surv. Bull. 1903, 1989, pp. 20-25.

287. Toenges, A. L., and T. R. Jolley. Investigation of Coal Deposits for Local Use in the Arctic Regions of Alaska and Proposed Mine Development. BuMines RI 4150, 1947, 19 pp.

288. Tourtelot, H. A., and I. L. Tailleur. Mineral Resource Assessment, National Petroleum Reserve, Alaska. BuMines, Interim Rep., Submitted to NPR-A Planning Team, Nov. 15, 1977, 51 pp.

289. Union Carbide Corp. Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Killik River Quadrangle, Alaska. Oak Ridge Gaseous Diffusion Plant, Oak Ridge, TN, 1981, 73 pp.

290. U.S. Bureau of Mines. Alaska Mineral Find Reported by Mines Bureau. AK Div. Geol. and Geophys. Surv., Mines and Geol. Bull., v. 24, No. 6, 1975, p. 3.

291. _____. Mineral Appraisal of the Proposed Gates of the Arctic Wilderness National Park, Alaska: A Preliminary Comment. BuMines OFR 109-78, 1978, 22 pp.

292. _____. A Mineral Appraisal of the Areas Traversed by the Kobuk, Killik, Alatna, and John Rivers and the North Fork of the Koyukuk River, Brooks Range, Alaska: A Summary Report. BuMines OFR 36-79, 1979, 23 pp.

293. _____. Mineral Appraisal of the Proposed Utukok and Colville Wild and Scenic Rivers: A Summary Report. BuMines OFR 37-80, 1980, pp. 1, 6-8.

294. U.S. Geological Survey. Aeromagnetic Data from SW Naval Petroleum Reserve, Alaska. U.S. Geol. Surv. Open-file Rep. OF 72-383, 1972.

295. _____. Aeromagnetic Map of the Philip Smith Mountains Quadrangle, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-572, 1977.

296. _____. Principles of a Resource/Reserve Classification for Minerals. U.S. Geol. Surv. Circ. 831, 1980, 5 pp.

297. _____. Aeromagnetic Map of the Killik River and Chandler Lake 1° x 2° Quadrangles, Alaska. U.S. Geol. Surv. Open-file Rep. OF 84-77, 1983.

298. Vandel, J., BuMines Salt Lake City Research Center, written Communication, Dec. 1993 and May, 1994.

299. Wahrhaftig, C. Physiographic Divisions of Alaska. U.S. Geol. Surv. Prof. Paper 482, 1965 (1966), 52 pp.

300. Walker, H. J. Guidebook to Permafrost and Related Features of the Colville River Delta. AK Div. Geol. and Geophys. Surv. Guidebook GB-2, 1983, 34 pp.

301. Walker, H. J., and L. Arnborg. Nature of the Colville River During the Late Winter and Breakup Periods, 1962 (abstr.). Geol. Soc. America Spec. Paper 73, 1963, p. 290.

302. Walton, M. S., Jr., and others. Magnetic Survey of Naval Petroleum Reserve No. 4 by Airborne Magnetometer. U.S. Geol. Surv. Aeromagnetic and Aeroradiometric Maps Rep. RR2, 1954.

303. Whittington, C. L., and E. G. Sable. Preliminary Geologic Report of Sadlerochit River Area, Alaska. U.S. Geol. Surv. Inv. Naval Petroleum Reserve No. 4, Rep. No. 20, OFR:PR20, 1948, 18 pp.

304. Whittington, C. L., and M. L. Troyer. Stratigraphy and Structure of the Area of the Kigalik and Awuna Rivers, Alaska. U.S. Geol. Surv. Inv. Naval Petroleum Reserve No. 4, Rep. No. 17, OFR:PR17, 1948, 7 pp.

305. Wilber, S. C., J. P. Siok, and C. G. Mull. A Comparison of Two Petrographic Suites of the Okpikruak Formation: A Point Count Analysis. Ch. in Alaskan North Slope Geology. Pacific Sec. Soc. Econ. Paleontologists and Mineralogists and AK Geol. Soc., Book 50, v. 1, 1987, pp. 441-447.

306. Williams, J. R., W. E. Yeend, L. D. Carter, and T. D. Hamilton. Preliminary Surficial Deposits Map of National Petroleum Reserve, Alaska. U.S. Geol. Surv. Open-file Rep. OF 77-868, 1977.

307. Woolson, J. R. Geology and Geophysics of Northern Alaska (abstr.). Houston Geol. Soc. Bull., v. 1, No. 6, 1959, unpaged.

308. _____. Geology and Geophysics of Northern Alaska (abstr.). Geophys. Soc. Tulsa Proc. 1959-60 (or 1958-59), v. 6, 1959, pp. 51-52.

309. Woolson, J. R., and others. Seismic and Gravity Surveys of Naval Petroleum Reserve No. 4 and Adjoining Areas, Alaska. Exploration of Naval Petroleum Reserve No. 4 and Adjacent Areas, Northern Alaska, 1944-53, pt. 4, Geophysics. U.S. Geol. Surv. Prof. Paper 304-A, 1962, pp. 1-25.

310. Yeend, W. Surficial Geology of the Foothills and Mountains of NPRA. Ch in The United States Geological Survey: Accomplishments During 1977. U.S. Geol. Surv. Circ. 772-B, 1978, pp. B19-B20.

311. _____. Engineering-Geologic Maps of Northern Alaska, Lookout Ridge Quadrangle. U.S. Geol. Surv. Open-file Rep. OF 83-279, 1983.

312. _____. Engineering-Geologic Maps of the Northern Alaska, Utukok River Quadrangle. U.S. Geol. Surv. Open-file Rep. OF 84-682, 1984.

313. Young, L.E., Cominco Alaska, written communication, Nov. 1993.

314. Young, L. E., and D. W. Moore. Geologic Setting, Petrology, and Geochemistry of Stratiform Sphalerite-Galena-Barite Deposits, Red Dog Creek and Drenchwater Creek Areas, Northwestern Brooks Range, Alaska - A Discussion. Econ. Geol. v. 82, 1989, pp. 1077-1079.

APPENDIX A - ALPHABETICAL LISTING OF MINERAL OCCURRENCES IN THE CHANDLER LAKE QUADRANGLE

PROPERTY SUMMARY

NAME: Cobblestone Creek MAS NO. 0020220011

DEPOSIT TYPE: Sedimentary
COMMODITIES: Manganese

LOCATION:

Quadrangle: Chandler Lake C1
NW 1/4, Sec.12, T.11S, R.7E, Meridian: Kateel River,
Lat.68deg.30'35"N.,Long.150deg.23'30"W.
Geographic: On west side Cobblestone Creek, 15.7 km south of Arc Mountain.
Elevation: 1380 m

GEOLOGIC SETTING:

Folded shale and silty mudstone of the lower Cretaceous Torok Formation occur in cutbank exposures along Cobblestone Creek. These exposures locally contain intense manganese staining (125).

BUREAU INVESTIGATION:

In 1993 investigation of anomalous geochemical samples resulted in location of manganese-bearing mudstone and shale. Several exposures were sampled for manganese. A bluff on the east side of the creek contained staining which appears to be concordant with bedding. The stained zone has a true thickness of approximately 6.5 m. Four samples collected at spaced intervals across the zone (4450-4453) contained from 2.4%-11.7% manganese (table A1).

Another exposure, located 175 m west of the one previously described is located on the west side of the creek. Staining is exposed for 4.5 m across an east-facing outcrop. A sample from this site (4454) contained 5.5% manganese. A true thickness for the bedding could not be determined. Two other manganese stained exposures located on a Cobblestone Creek tributary 2.3 km to the northeast were also sampled. Two samples (4442,4455) contained 2.5% and 1.3% manganese respectively.

A sample collected by the USGS (124) from the Torok Formation in the same area was examined by the Bureau's Albany, Oregon Research Center. The material consisted of interbedded iron-stained siltstone and shale. Analysis of the sample showed it to contain 61.9% iron, 15.2% silica, 7.4% aluminum, 5.8% calcium, 4.8% manganese, and 4.0% phosphorous. The primary material in the sample is the iron-carbonate mineral siderite. Manganese may be substituting for iron in the siderite and phosphorous occurs in a hydroxylapatite compound. No specific manganese minerals were identified (84).

MINERAL DEVELOPMENT POTENTIAL:

Anomalous manganese values occur in manganese-stained rocks collected along a 2.3 km-long northeast-trending zone in the Torok Formation. Low development potential for large tonnage, low grade sedimentary manganese deposits.

RECOMMENDATIONS:

Further sampling of the Torok Formation along this trend is recommmended as well as examination of other manganese anomalies reported in the area.

REFERENCES:

1, 2, 76, 84, 124, 125

Table A1 - Analytical Results - Cobblestone Creek Occurrence

Sample no.	Basic rock type	Sample site	Sample type	Mn %	Ag ppm	As ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Mn ppm	Ni ppm	Pb ppm	Sb ppm	V ppm	Zn ppm
4441	Shale	Outcrop	Select		1.6	1229	329	<2.0	48	36	2138	101	57	87	302	74
4442	Shale	Outcrop	Grab	2.54	2.0	106	668	<2.0	62	62	>20000	168	27	<5	286	297
4443	Shale	Outcrop	Repr chip		2.1	411	610	<2.0	203	59	2483	44	43	37	613	117
4444	Shale	Outcrop	Repr chip	0.65	0.8	81	1061	<2.0	92	72	6392	125	24	<5	361	240
4445	Shale	Outcrop	Select		<0.5	28	651	<2.0	53	36	13130	74	29	<5	135	152
4446	Shale	Outcrop	Select	0.68	0.6	106	>2000	<2.0	147	47	6615	41	27	<5	494	181
4447	Shale	Outcrop	Grab	0.51	0.8	135	742	<2.0	269	57	5215	37	30	<5	607	101
4448	Shale	Outcrop	Grab		4.2	1780	338	15	49	51	1014	13	17	11	150	79
4449	Quartz vein	Outcrop	Select	1.32	0.9	65	356	<2.0	128	53	12462	45	25	10	166	120
4450	Shale	Outcrop	Select	10.00	7.3	489	670	<2.0	50	36	>20000	168	24	24	163	201
4451	Shale	Outcrop	Select	2.37	2.6	438	543	<2.0	270	74	>20000	71	27	<5	632	170
4452	Shale	Outcrop	Select	11.69	8.5	87	700	<2.0	49	29	>20000	153	12	<5	158	206
4453	Shale	Outcrop	Select	3.43	2.5	146	903	<2.0	72	58	>20000	157	16	<5	318	350
4454	Shale	Outcrop	Select	5.54	2.6	44	782	<2.0	33	26	>20000	46	16	<5	130	199
4455	Shale	Outcrop	Select	1.34	1.1	102	667	<2.0	116	91	12644	203	42	8	384	374

PROPERTY SUMMARY

NAME: Cockedhat Mountain MAS NO. 0020220012

DEPOSIT TYPE: Metalliferous black shales
COMMODITIES: Zinc, lead

LOCATION:

Quadrangle: Chandler Lake A2
NW 1/4, Sec. 22 , T. 15S , R. 6E , Meridian: Umiat,
Lat. 68 deg. 07' 47" N., Long. 150 deg. 42' 50" W.
Geographic: 2.1 km southwest of Cockedhat Mountain
Elevation: 1560 m

GEOLOGIC SETTING:

The Kayak Shale forms the basal unit of the Mississippian section in the north-central Brooks Range. It is exposed along an east-west trend, throughout the eastern portion of the Colville Mining District. The 293 m-thick type section, exposed near Shainin Lake, has been divided into five informal members (8). In the Anaktuvuk Pass area the shale is 323 m thick, indicating that the Kayak thickens to the south (225).

The upper fissile, carbonacous, black shale member is overlain by a ferruginous bioclastic limestone member, containing abundant fossils (225). The section is repeated in some areas due to thrusting and folding (125). Included within the upper black shale member are red-brown weathering, cherty ironstone-type nodules or concretions containing septarian structures (221). The concretions range from 4.0 cm rounded forms to 7.5 x 38 cm flattened, elongate forms. One to two-inch thick sedimentary beds of similar composition also occur (see Siksikpuk River Occurrence). The concretions are filled with quartz, calcite, barite, siderite, and pyrite along wih minor sphalerite and trace galena.

Sulfide-bearing concretions have been noted along and east-west trend at least 347 km from the eastern study area boundary, just east of the Itkillik River to Safari Creek on the western end (125) (135). A carbonaceous shale, similiar to the Kayak, occurs in the western portion of the district, but lacks the sulfide-bearing concretions. It may be a laterial facies of the Kayak and has been tenatively been given the names Isikut Formation (183) and False Kayak (56).

BUREAU INVESTIGATION:

The Kayak Shale was examined in numerous locations along the 128 km trend of the shale through the central Chandler Lake Quadrangle (174). At most sites the sulfide-bearing concretions were found as rubblecrop or float, weathering out of the upper black shale member. At Cockedhat Mountain they were located in outcrop interbedded with the fissile shales. At this site a 19 m-thick section of the shale was measured and detailed sampling done to determine the extent of the mineralization through the upper shale member (fig. A1 and table A2). Samples of concretion-bearing zones up to 11 cm thick contained up to 8443 ppm zinc and 27 ppm lead (4605).

The weighted average value for continuous chip samples (4603-4611, 4701-4703) collected across a 7.9 m-thick portion of the measured section is 487 ppm zinc. The shale may be intensely folded at this site, resulting in possible repetition of the section and exaggerated thickness. Select samples of concretions collected at Confusion Creek (fig. 12), contained up to 16,172 zinc and 104 ppm lead (4759). A sample of the fissile shale at Cockedhat Mountain contained 284 ppm zinc (4604). The average of six samples of shale collected at several locations along the strike length of the Kayak was 208 ppm zinc and 11 ppm lead. The average crustal abundance in shales is reported to be 100 ppm zinc and 20 ppm lead (147).

The metals and sulfur which combined to form sulfides in the concretions may be originally from the enclosing shales. The metals may have been leached out of water-saturated black muds during diagenesis and precipitated as fillings in the septarian-type cracks in the concretions along with quartz, calcite, and barite. The cracks probably formed during chemical desiccation of the concretions as a result of dewatering of the enclosing sedimentary pile (221). The carbonate content of the concretions may have acted as a catalyst in causing sulfide precipitation.

The shales and concretions, anomalous in zinc and although not economic, may be the source of the sulfides in vein breccias found in the nearby Kanayut conglomerate. The conglomerate is in thrust fault contact with the Kayak in many sites and both are included in the Endicott Mountains Allochthon. The hydrothermal fluids which permeated the breccias formed in the Kanayut could have leached zinc, lead, and sulfur from the Kayak and precipitated the resulting sulfides along with quartz in the breccia zones.

The lead isotope ratios determined from a sample of galena from a Kayak concretion (31) were close to those for some of the vein breccia occurrences within the Kanayut Conglomerate. This would indicate a possible recycling of dominantly sulfide lead and subordinate non-sulfide lead from the Kayak Shale (313).

RESOURCE ESTIMATE: none

MINERAL DEVELOPMENT POTENTIAL:

Low development potential for shale-hosted zinc deposits, due to extremely low grades.

RECOMMENDATIONS: None

REFERENCES:

31, 56, 125, 135, 147, 183, 221, 225, 313

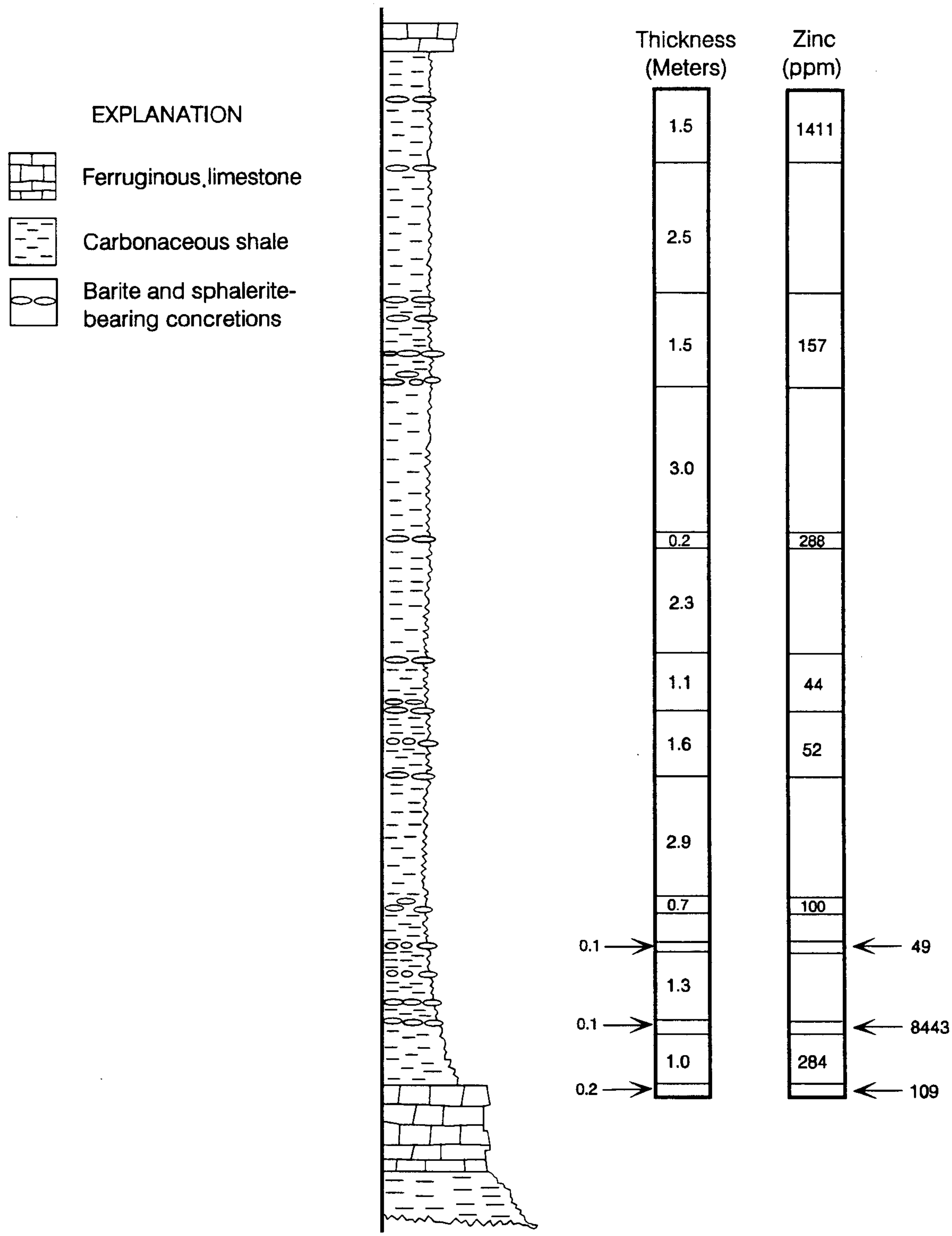


Figure A1. Cockedhat Mountain - Measured Section of the Kayak Formation, upper black shale member.

Table A2 - Analytical Results - Cockedhat Mountain Occurrence.

Sample no.	Basic rock type	Sample site	Sample type	Ag ppm	As ppm	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	Sb ppm	V ppm	Zn ppm
4603	Limestone	Outcrop	Select	<0.5	<5	82	<2.0	11	2648	7	<5	57	109
4604	Shale	Outcrop	Contin chip	<0.5	80	>2000	<2.0	36	744	5	<5	211	284
4605	Chert	Outcrop	Select	<0.5	<5	251	<2.0	83	3464	27	<5	23	8443
4606	Chert	Outcrop	Select	<0.5	<5	641	<2.0	12	4286	21	<5	30	49
4607	Chert	Outcrop	Select	<0.5	<5	847	<2.0	14	3434	21	<5	27	100
4608	Chert	Outcrop	Select	<0.5	<5	217	<2.0	15	4552	18	<5	27	52
4609	Shale	Outcrop	Contin chip	<0.5	13	696	<2.0	39	556	5	<5	223	156
4610	Chert	Outcrop	Select	<0.5	36	>2000	<2.0	21	4524	34	<5	33	44
4611	Chert	Outcrop	Select	<0.5	<5	305	<2.0	18	5057	75	<5	36	288
4628	Chert	Outcrop	Select	<0.5	<5	198	<2.0	19	4398	50	<5	28	781
4629	Chert	Outcrop	Select	<0.5	<5	328	<2.0	23	4598	78	<5	28	11962
4631	Limestone	Outcrop	Select	<0.5	<5	280	<2.0	8	2411	30	14	37	160
4701	Chert	Outcrop	Select	<0.5	<5	884	<2.0	21	5078	43	<5	30	157
4702	Chert	Outcrop	Select	<0.5	<5	267	<2.0	27	4204	47	<5	24	1411
4703	Shale	Outcrop	Contin chip	<0.5	46	1154	<2.0	49	608	25	<5	230	204
4759	Chert	Rubblecrop	Select	<0.5	<5	253	<2.0	19	4745	104	<5	31	161

PROPERTY SUMMARY

NAME: Itkillik River East MAS NO. 0020220013

DEPOSIT TYPE: Quartz veins
COMMODITIES: Zinc copper

LOCATION:

Quadrangle: Chandler Lake A1
NW1/4, Sec. 19 , T. 14S , R. 8E , Meridian: Kateel River,
Lat. 68deg.12'03"N.,Long. 150deg.22'00"W.
Geographic: On east side of southern tributary to Itkillik River, 14.8 km southeast of Thibodeaux Mountain.
Elevation: 1079 m

GEOLOGIC SETTING:

Quartz-carbonate veins cutting the wacke member of the Hunt Fork Shale. (Kelley, 1990).

BUREAU INVESTIGATION:

Investigation of anomalous geochemical samples led to the discovery of quartz-carbonate vein float containing minor sulfides was found in a 3x3 m area in talus slopes on the east side of the drainage bottom (131)(269). Minor chalcopyrite was observed. Samples contained up to 352 ppm copper (4708). A float sample collected in the stream bottom 1600 meters upstream from the talus site contained 673 ppm zinc (4706), but no zinc minerals were observed. (Table A3). The veins were not located in place, but examination of float indicates that the veins are probably only a few cm wide.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for base metal-bearing veins, due to low grades and small sizes.

RECOMMENDATIONS: None

REFERENCES:

131, 132, 269

Table A3 - Analytical Results - Itkillik River West and East Occurrences

Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Ba %	Pb %	Zn %	Ag ppm	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
				Itkillik River East											
4649	Conglomerate	Float	Grab					<0.5	106	2.8	11	1023	15	15	191
4650	Sandstone	Outcrop	Select					<0.5	558	<2.0	35	1485	38	51	240
4705	Sandstone	Float	Select					<0.5	327	<2.0	13	1442	5	35	39
4706	Sandstone	Float	Select					<0.5	98	<2.0	24	3578	<2	31	673
4707	Sandstone	Outcrop	Select					<0.5	259	<2.0	144	151	15	66	38
4708	Sandstone	Float	Select					<0.5	206	<2.0	352	7927	11	31	27
4709	Sandstone	Float	Select					<0.5	177	<2.0	140	256	<2	40	45
4710	Shale	Float	Grab					<0.5	761	<2.0	59	1578	29	131	144
4711			Stream sed					<0.5	385	<2.0	45	581	20	89	103
				Itkillik River West											
4552	Barite	Float	Select	1.71	62	0.67	<0.01	1.5		<2.0	12	20	6653	<2	3
4553	Barite	Float	Select	25.00	60	0.10	0.01	<0.5		<2.0	25	<5	848	<2	<2
4576	Sandstone	Float	Select					<0.5	188	<2.0	174	1809	27	65	41
4577			Stream sed					<0.5	421	<2.0	42	573	16	113	84
4578	Sandstone	Float	Select					1.1	895	19	33	3945	24	83	3910
4579	Shale	Outcrop	Random chip					<0.5	546	<2.0	53	628	32	142	131
4580	Sandstone	Outcrop	Random chip					0.9	170	<2.0	188	5482	11	76	26
4592	Shale	Outcrop	Select					1.0	785	<2.0	33	7326	39	82	118
4618	Sandstone	Float	Select					<0.5	368	<2.0	8	1525	118	63	68
4619	Sandstone	Rubblecrop	Select					<0.5	204	<2.0	735	1525	6	66	97
4620	Sandstone	Float	Select					<0.5	183	<2.0	17	8063	17	56	37

PROPERTY SUMMARY

NAME: Itkillik River West MAS NO. 0020220007

DEPOSIT TYPE: Quartz-carbonate veins veins
COMMODITIES: Lead, silver, copper, barium

LOCATION:

Quadrangle: Chandler Lake A1
SE1/4 Sec.16 and S1/2 Sec 15, T14S, R.7E
, Meridian: Umiat
Lat. 68deg.13'28"N., Long. 150deg.30'05"W.
Geographic: West tributary of the Itkillik River, 18.8 km southwest of Thibodeaux Mountain
Elevation: 1460 meters

GEOLOGIC SETTING:

Bedrock in the area consists of folded and faulted Upper Devonian Hunt Fork Shale, Wacke member which includes interbedded shale and sandstone wacke, 500 m north of the Itkillik Thrust contact with the Kanayut Conglomerate (125).

The Hunt Fork rocks are locally cut by quartz and sulfide-bearing quartz-carbonate veins and veinlets, at no particular orientation.

BUREAU INVESTIGATION:

Investigation of sulfide-bearing float described by the USGS (61) led to the location of minor sulfide mineralization both in-place and as float.

Cobble-sized pieces of rounded massive white barite, containing streaks and blebs of galena, were found as float in a gully bottom in the SE 1/4 of Section 16. Samples contain up to 62% barium, 0.67% lead, and 1.71 g/mt silver (4552-4553) (Table A3). The source of the float was never located, but probably comes from veins of unknown size.

In another gully, located 800 m to the northeast, lense-like quartz-calcite-siderite veins trend parallel to bedding. The veins are confined to a 50 cm-wide zone with individual veins occurring up to 5 cm wide. The zone trends N. 60 deg. W., dips 65 deg. S., and can be traced for at least 50 m along strike. The veins weather a distinctive orange color due to the formation of iron carbonate (siderite?). Minor chalcopyrite, malachite stain, and trace galena were noted. One sample (4619) contained 735 ppm copper. A sample of quartz vein float collected 1000 m downstream from this site contained 3900 ppm zinc (4578), though no zinc minerals were observed.

These veins are cut by a set of barren quartz veinlets, trending N.40 deg.E. with a variety of dip orientations. This occurrence is similar to that found in the Nanushuk River drainage.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low development potential for silver-bearing veins, due to probable small size.

RECOMMENDATIONS:

Locate source of barite-galena vein float.

REFERENCES:

61, 125

PROPERTY SUMMARY

NAME: Kiruktagiak River MAS NO. 0020220014

DEPOSIT TYPE: Sedimentary

COMMODITIES: Phosphate, vanadium, uranium, zinc

LOCATION:
Quadrangle: Chandler lake B4
NW 1/4, Sec. 28, T. 12S, R. 4W, Meridian: Umiat
Lat. 68 deg. 22' 46" N., Long. 152 deg. 51' 10"W.
Geographic: On west side of upper Kiruktagiak River, 450 m-1200 m above mouth of Monotis Creek.
Elevation: 793 m

GEOLOGIC SETTING:

The upper Kiruktagiak River (fig. 12) is underlain by a thick sequence of highly deformed sedimentary rocks. These include the Alapah Limestone member of the Upper Mississippian Lisburne Group, Permian Siksikpuk Formation, Triassic to Jurassic Otuk Formation, and the Lower Cretaceous Okpikruak Formation.

Phosphate occurrences are confined to the black chert and shale member of the Alapah Limestone, near the top of the Lisburne Group. The Alapah ranges from 12 m to 30 m thick and consists mainly of dark shaley limestone, mudstone, phosphorite and phosphate rock (214).

BUREAU INVESTIGATION:

Occurrences of sedimentary phosphate were first identified in the Colville Mining District by USGS geologists working in the area from 1944 to 1953 (214). The Bureau examined the occurrence in 1993. Stratigraphic sections were measured and samples collected at two sites on the west bank of the Kiruktagiak River (figs. A2, A3, and A7) (table A4). The measured sections are located on the limbs of a broad syncline. A 0.7 m-thick phosphorite bed contained 20.6% phosphate (fig. A3). Continuous chip samples collected across a 9.7 m stratigraphic thickness averaged 5.2% phosphate. Samples also contained up to 1528 ppm vanadium (4506), 1464 ppm zinc (4506), and 68 ppm uranium (4511) (Meyer, 1994).

The highest concentrations of phosphate are in oolitic material with sizes ranging from <1 mm ooids to >35 mm flattened pellets. This is probably the same phosphatic zone that was sampled on Monotis Creek, 500 m to the northwest (see Monotis Creek occurrence). Columnar sections were constructed, indicating possible correlations between sites (Fig. A8).

A 45 kg bulk sample of phosphatic material was collected at the Kiruktagiak River sample site KR1 (4507) and analyzed by the Bureau's Salt Lake City, Utah Research Center. It was found to be composed of 60% fluorapatite ($Ca_5(PO_4,CO_3)_3F$) and 40% calcite

(CaCO3) intergrown with each other. Minor amounts of quartz, pyrite, and sphalerite were also observed. The rocks grades from matrix-supported fluorapatite pellets to massive fluorapatite. Fluorapatite occurs in aggregate fomr in the pellets, along with a small amount of calcite and quartz inclusions. The matrix is composed of calcite with minor grains of fluorapatite.

The material was ground to various size fractions and analyzed with the scanning electron microscope in an effort to determine the optimum liberation size for the fluorapatite particles. At -200 mesh size 59% of the material was liberated apatite, 26% liberated calcite, and a remaining 14% nonliberated grains. A grain was considered liberated if approximately 90% of it was just one mineral phase. The percentage of nonliberated grains decreased in the finer mesh sizes. The sample had a specific gravity ranging from 2.9-3.0 (298). These results indicate that the material would need some upgrading before it could be used as a source of commercial phosphate.

A sample was sent to the J.R. Simplot Company in Afton, Wyoming which operates the nearby Smoky Canyon Phosphate Mine. A size analysis to finer grain sizes than those done by the Bureau indicate that 94% of the phosphate is recovered at +325 mesh. This indicates that significant comminution equipment would be needed to liberate the phosphate and that a "scavenger" floatation circuit would be needed to reclaim high phosphate losses in the tailings. The test also indicated that the diluent contents were extremely low which is acceptable for recovery of a clean product (219).

RESOURCE ESTIMATE:

The phosphate beds were too folded and irregular to make a realistic resource estimate.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as a source of industrial-grade phosphate, due to grades and bed thicknesses.

RECOMMENDATIONS:

Drilling to determine extent of phosphate along strike and at depth.

REFERENCES:

103, 125, 145, 174, 214, 219, 298

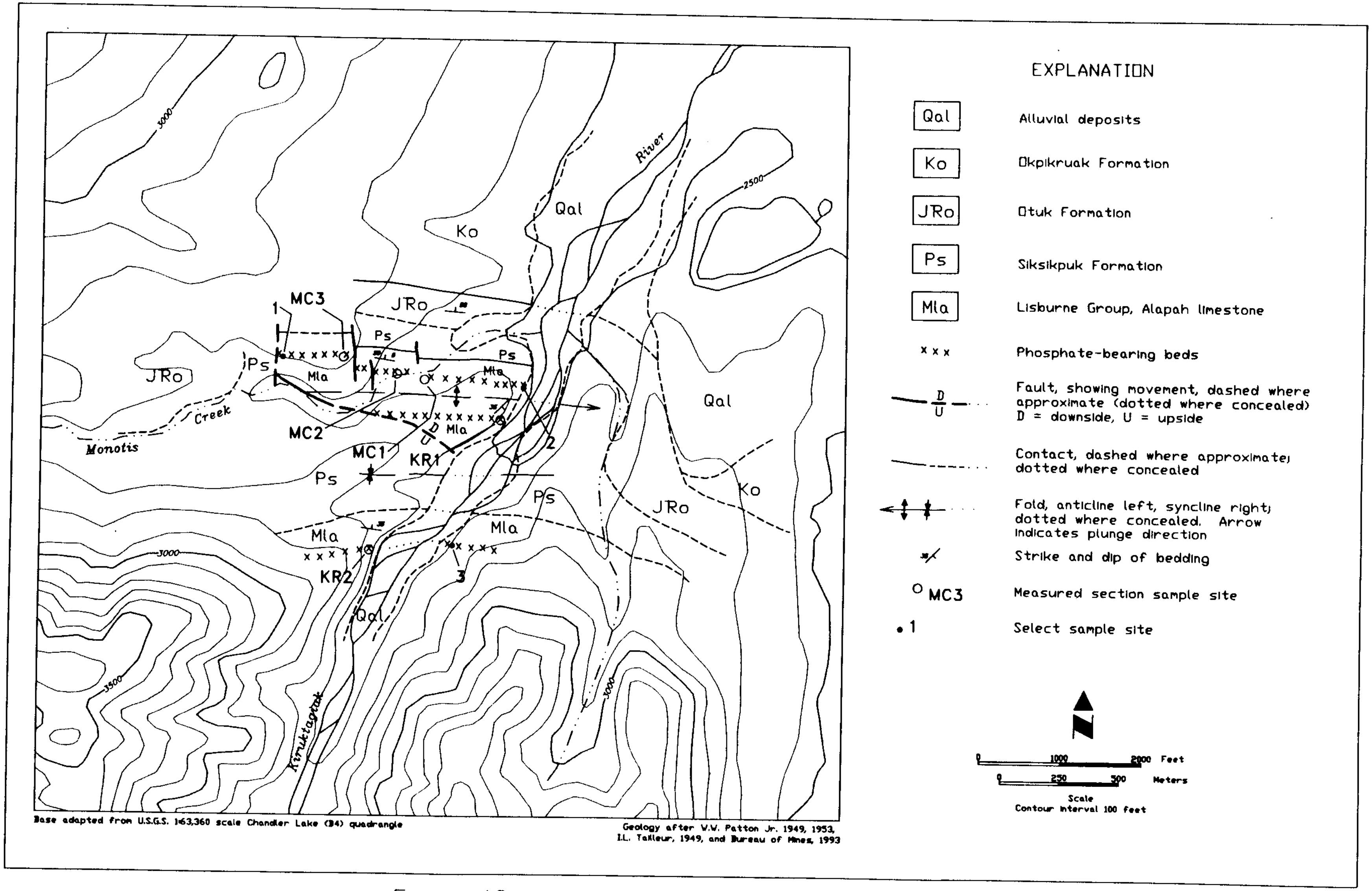


Figure A2. -- Monotis Creek - Kiruktagiak River Area, geology and sample sites.

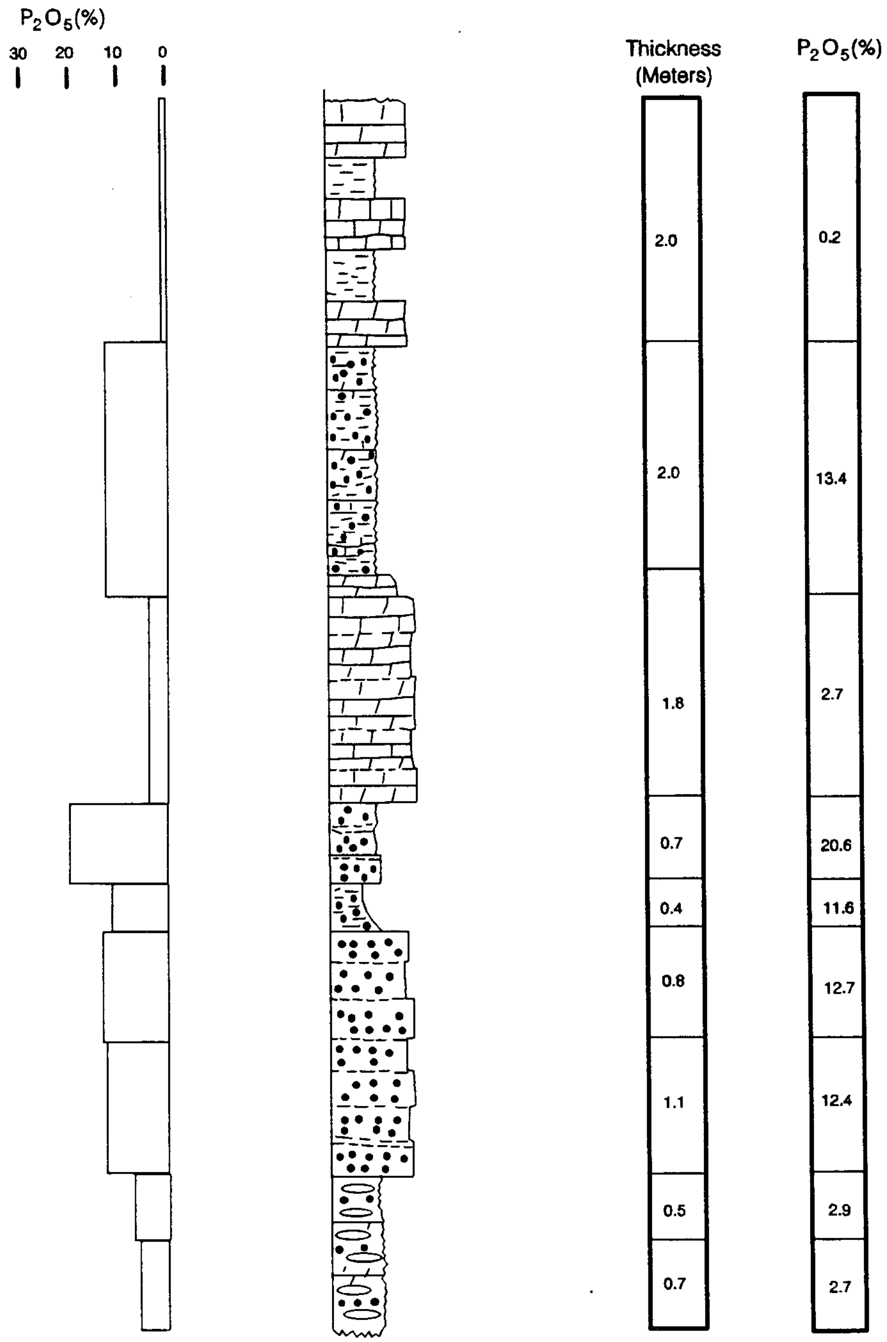


Figure A3. - Columnar section of phosphatic zone Kiruktagiak River measured section no.1.(see figure A5 for lithologic descriptions.

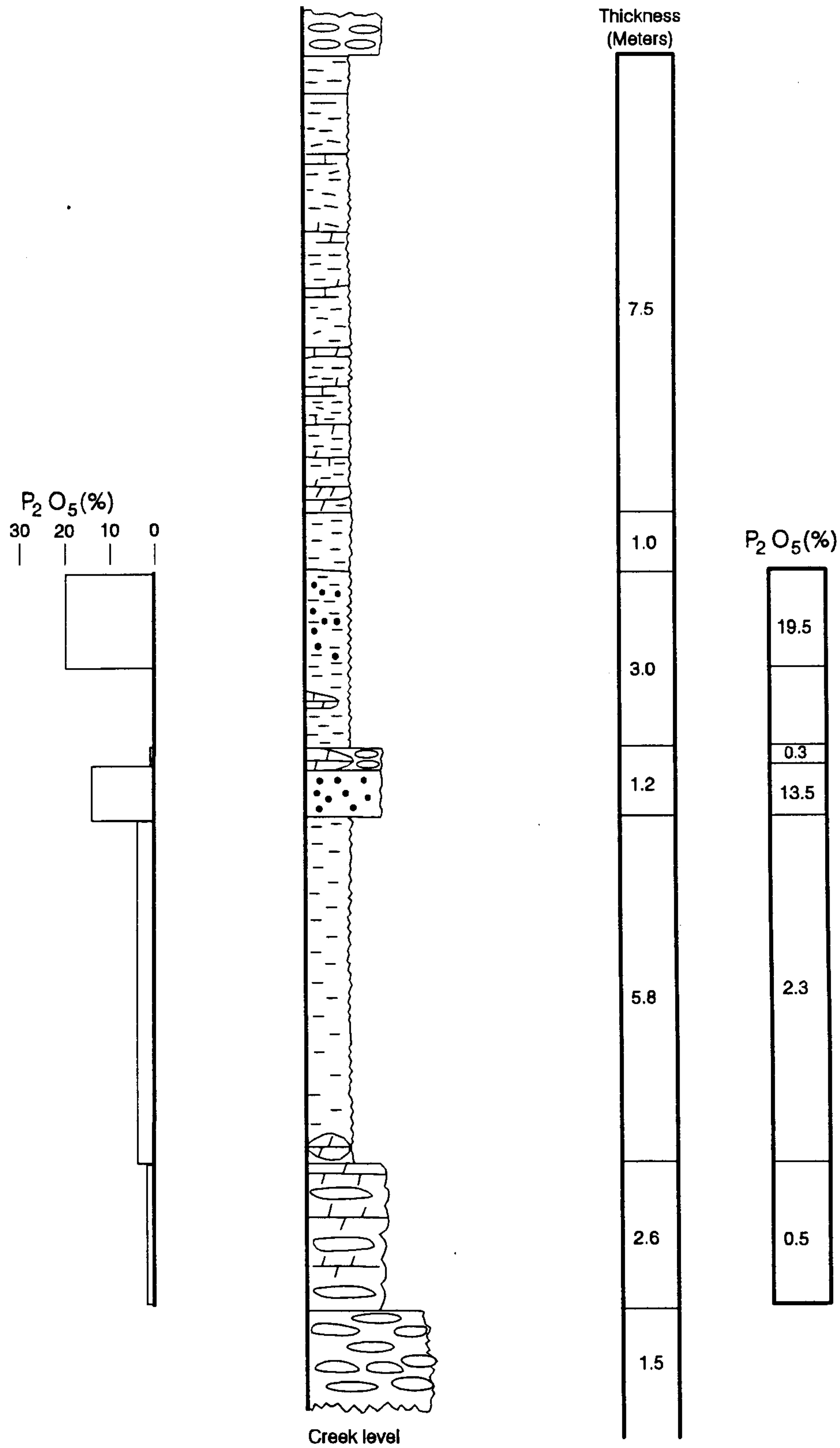


Figure A4. -- Columnar section of phosphatic zone Kiruktagiak River measured section no.2.

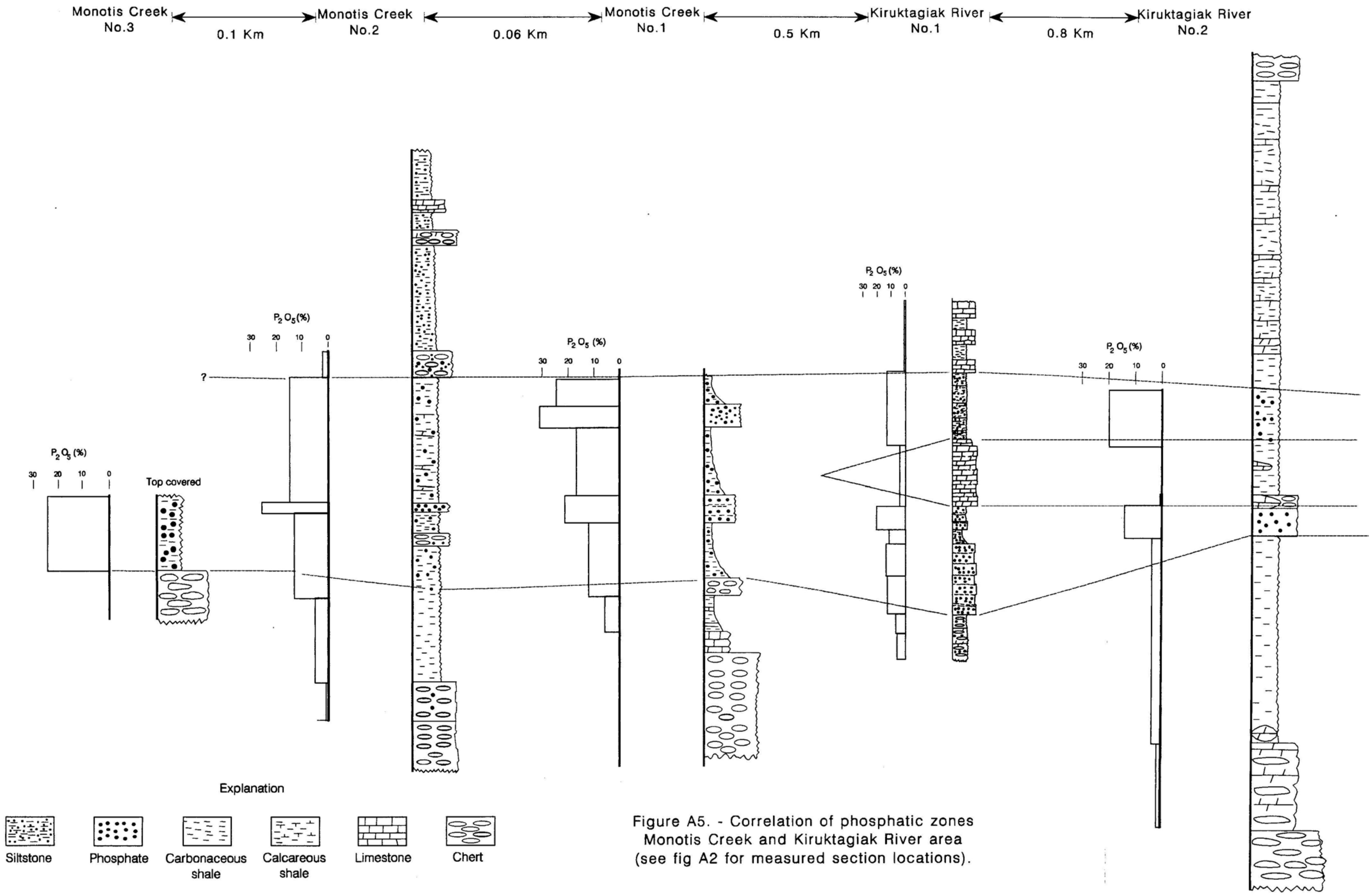


Figure A5. - Correlation of phosphatic zones Monotis Creek and Kiruktagiak River area (see fig A2 for measured section locations).

Table A4 - Analytical Results - Monotis Creek and Kiruktagiak River Areas, Excluding Measured Sections

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag ppm	Al %	Ba ppm	Cu ppm	Fe %	Mg %	Mn ppm	P2O5 %	Pb ppm	V ppm	U (flou ppm	Zn ppm
					Monotis Creek											
1	4524	Limestone	Float	Select	2.0	0.11	248	19	0.11	0.15	31	22.42	14	298	82	76
					Kiruktagiak River											
2	4512	Shale	Outcrop	Contin chip	<0.5	2.64	278	44	2	0.98	299	0.34	<2	111	2	171
2	4513	Shale	Outcrop	Grab	<0.5	2.59	275	31	1.49	0.70	129	0.16	<2	89	3	108
3	4530	Limestone	Float	Select	2.5	0.31	139	22	0.34	0.12	61	5.94	7	157	17	66

PROPERTY SUMMARY

NAME: Monotis Creek MAS NO. 0020220015

DEPOSIT TYPE: Sedimentary

COMMODITIES: Phosphate, vanadium, zinc, uranium

LOCATION:
Quadrangle: Chandler Lake B5
SE 1/4, Sec. 20, T. 12S, R. 4W, Meridian: Umiat
Lat. 68 deg. 22' 50" N., Long. 152 deg. 52' 35"W.
Geographic: Along both sides of Monotis Creek, 600 m above junction with Kiruktagiak River
Elevation: 777 m

GEOLOGIC SETTING:

The Monotis Creek area is underlain by a thick sequence of highly deformed sedimentary rocks. These include the upper Mississippian Lisburne Group Alapah Limestone, Permian Siksikpuk Formation, Triassic-Jurassic Otuk Formation, and the lower Cretaceous Okpikruak Formation.

Phosphate occurrences are confined to the black chert and shale member of the Alapah limestone, near the top of the lisburne Group. The Alapah ranges from 12 m to 30 m thick and consists mainly of dark shaley limestone, mudstone, phosphorite, and phosphate rock (214).

BUREAU INVESTIGATION:

Occurrences of sedimentary phosphate were first identified by USGS geologists working in the area between 1944 and 1953. The Bureau first examined the occurrences in 1993, during the present study. Stratigraphic sections were measured and samples collected at three sites on Monotis Creek (Figs. A6-A8 and Table A4. A chart was also constructed indicating correlations of phosphates between the sites (Fig. A5).

Interbedded phosphorite and phosphate rock occur in sections up to 11.3 m thick. Individual phosphorites up to 0.6 m thick contain up to 30% P2O5 (Fig. A6). One 6.7 m-thick section averaged 23% P2O5. Samples also contained up to 2000 ppm vanadium, 119 ppm uranium, and 1258 ppm zinc (174). The phosphate-bearing mineral consists of Fluorapatite, which is concentrated in oolites, pellets, and matrix. Purple fluorite occurs locally (298). The phosphatic rocks could be traced for 1.5 km along strike.

RESOURCE ESTIMATE:

The phosphatic rocks appear to be confined to one bed that has been folded into broad anticlines and synclines. It was sampled at several locations for 1.5 km across fold axes.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as source of phosphate. Grades and thicknesses are similar to those of the Phosphoria Formation that is currently being mined in eastern Idaho (219).

RECOMMENDATIONS:

Drilling to test phosphatic bed along strike and at depth.

REFERENCES:

103, 125, 145, 174, 214, 219, 298

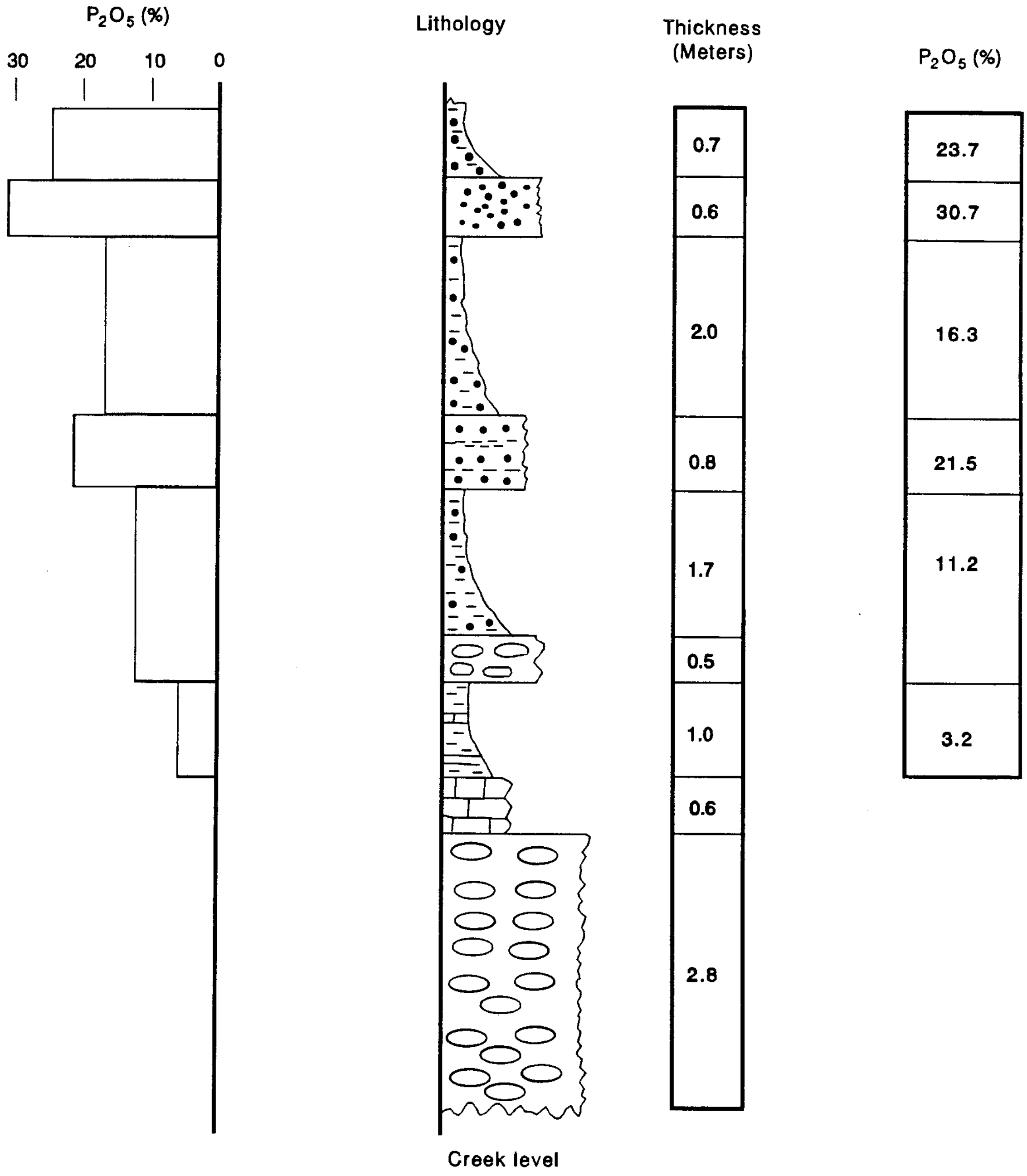


Figure A6. - Columnar section of phosphatic zone Monotis Creek measured section no.1(see figure A5 for lithologic description).

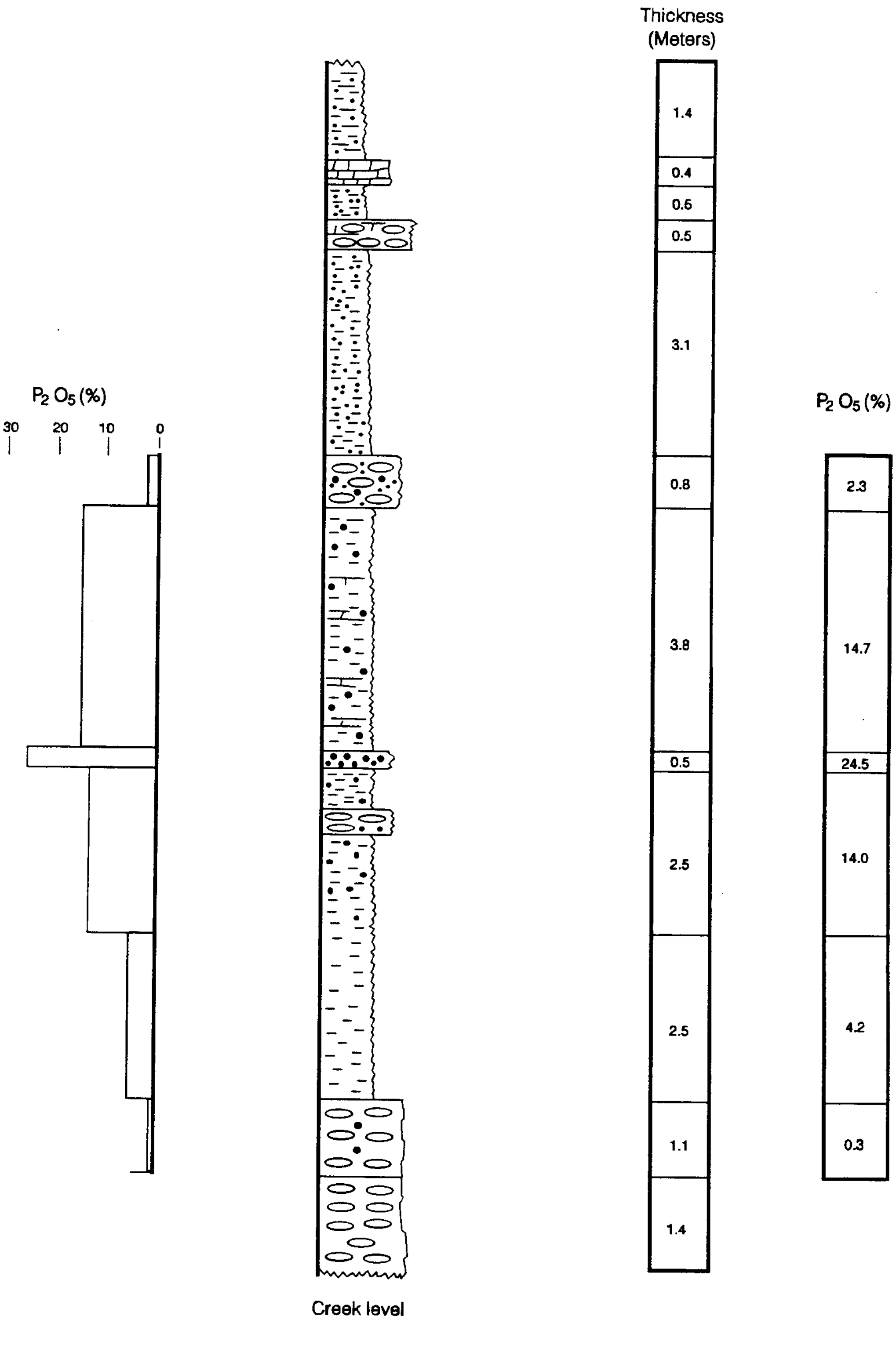


Figure A7. -- Columnar section of phosphatic zone Monotis Creek measured section no.2.

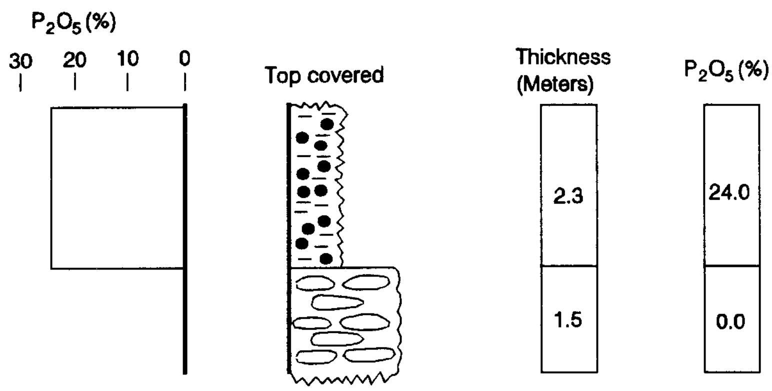


Figure A8. -- Columnar section of phosphatic zone Monotis Creek measured section no.3.

PROPERTY SUMMARY

NAME: Nanushuk River | MAS no. 0020220016

DEPOSIT TYPE: Quartz-carbonate veins
COMMODITIES: copper, zinc

LOCATION:

Quadrangle: Chandler Lake B2
NE1/4, Sec. 23 , T.13S, R.6E, Meridian: Kateel River,
Lat.68 deg.18'25"N.,Long. 150 deg.39'45"W.
Geographic: West tributary to Nanushuk River, 10 km south of Nanushuk Lake.
Elevation: 1006 m

GEOLOGIC SETTING:

In 1993 investigation of anomalous stream sediment and heavy mineral concentrate geochemical samples anomalous in lead and barium (131) (269), led to the discovery of at least three parallel quartz-carbonate veins. The veins are exposed in a zone 15 m wide along the south canyon wall and cut interbedded siltstone and shale of the Hunt Fork Shale, and . The veins are up to 30 cm wide and can be traced for at least 8 m along strike.

Gangue minerals consist of quartz, calcite, ankerite? and barite. The barite is mainly concentrated along the vein margins which locally contain breccia and slickensides. The vein margins also contain minor chalcopyrite and galena. It appears that the veins were originally emplaced along a fault and subsequent movement resulted in slickensides and brecciation of the vein margins.

BUREAU INVESTIGATION:

A series of samples were collected from the veins (table A5). These contained up to 420 ppm copper, (4819), 54 ppm lead, 343 ppm zinc, and >2,000 ppm barium.

MINERAL DEVELOPMENT POTENTIAL:

Low potential for base metal-bearing veins due to low metal content.

RECOMMENDATIONS:

Only a short time was spent at the site. Further work in the area may lead to the discovery of more veins.

REFERENCES:

131, 269

Table A5 - Analytical Results - Nanushuk River Occurrence

Sample no.	Basic rock	Sample site	Sample type	Ag ppm	As ppm	Ba ppm	Cd ppm	Cr ppm	Cu ppm	Mn ppm	Ni ppm	Pb ppm	Sb ppm	V ppm	Zn ppm
4815			Stream sed	<0.5	20	444	<2.0	101	44	705	52	17	<5	120	102
4816	Siltstone	Float	Select	<0.5	30	>2000	<2.0	22	190	10835	11	20	6	44	47
4817	Siltstone	Float	Select	<0.5	40	408	<2.0	121	31	3149	39	50	15	65	75
4818	Siltstone/sh	Outcrop	Random chip	<0.5	30	331	<2.0	80	55	3088	26	22	<5	77	103
4819	Breccia vei	Outcrop	Random chip	<0.5	<5	1224	<2.0	70	420	3122	50	5	17	47	67
4834	Siltstone	Float	Select	<0.5	30	>2000	<2.0	143	83	3908	57	54	15	93	84
4835	Siltstone	Outcrop	Repr chip	<0.5	12	1233	<2.0	25	238	4960	23	22	8	40	343

PROPERTY SUMMARY

NAME: Siksikpuk River MAS NO. 0020220017

DEPOSIT TYPE: Metalliferous black shales

COMMODITIES: Zinc

LOCATION:

Quadrangle: Chandler Lake B4
SE 1/4, Sec.34, T.13S, R.2W, Meridian: Umiat
Lat. 68 deg. 16' 13" N.,Long.151 deg. 13' 30" W.
Geographic: Headwaters of Siksikpuk River, 8.7 km northwest of Inualuruk Mountain.
Elevation: 1195 m

GEOLOGIC SETTING:

The Kayak Shale forms the basal unit of the Mississippian section in the north-central Brooks Range. It is exposed along an east-west trend across the entire 467 km length of the study area. The 293 m-thick type section is exposed near Shainin Lake and has been divided into five informal members (8). In the Anaktuvuk Pass area the shale is 323 m-thick, indicating the the formation thickens to the south (225). There is structural repetition of members in some areas due to thrusting and folding (125).

The 42.9 m-thick fissile, carbonaceous upper Black Shale Member is situated between lower argillaceous and upper Red Limestone Member (8). .Included within the shale are concentrations of red-brown, cherty, ironstone nodules or concretions containing septarian structures. The concretions range from 4.0 cm rounded forms to 7.5 x 38 cm flattened, elongate forms. The concretions contain quartz, calcite, barite, siderite, and pyrite (marcasite?) as septarian fracture fillings along with minor sphalerite and trace galena. Also 2.5 - 5 cm thick sulfide-bearing beds of similar compositions have been observedinterbedded with the shale.

Sulfide-bearing concretions and beds have been noted and sampled along the trend of the shale for at least 347 km from the eastern boundary of the study area to Safari Creek on the West. A carbonaceous shale similiar to the Kayak, occurs in the western portion of the district, but lacks the sulfide-bearing concretions. It may be a lateral facies of the Kayak and has been tenatively given the names Ikikut Formation (183) and False Kayak (56) (125)(133)(135)(plate I).

BUREAU INVESTIGATION:

A series of select float samples were collected of the sulfide-bearing concretions which appear to be confined to an approximately 6 m-thick section of the black shale member (table A6). Samples contained up to 13,152 ppm zinc (4829), >2000 ppm barium, and 52 ppm lead (4830). At the structural base of the shale member, a 10 cm-thick red-brown cherty ironstone bed of similar composition as the concretions, contains minor sphalerite. A select sample of a the ironstone bed, eposed for 6 m along strike contained 1357 ppm zinc and 809 ppm zinc, and 809 ppm barium (4801). The bed overlies an orange-weathering ferruginous limestone bed approximately 80 cm thick, similar to that described at Cockedhat Mountain. This limestone member normally lies at the top of the formation (Porter, 1966) which indicates that the section may be overturned at this site due to intense recumbant folding.

A sample of the black shale contained 216 ppm zinc (4800).

Similiar sulfide-bearing concretions and beds along the trend of the Kayak Shale were sampled at numerous sites, including 1.5 km northeast of Fan Mountain and 2.2 km southwest of Cockedhat Mountain.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for shale-hosted zinc deposits

RECOMMENDATIONS: None

REFERENCES:

8, 125, 133, 135, 225

Table A6 - Analytical Results - Siksikpuk River Occurrence

Sample no.	Basic rock	Sample site	Sample type	Pb %	Zn %	As ppm	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	Sb ppm	V ppm	Zn ppm
4782	Chert	Float	Select			<5	370	<2.0	17	3743	39	<5	30	753
4783	Chert	Float	Select			<5	333	<2.0	12	3782	152	<5	30	736
4796	Shale	Rubblecrop	Random chip			19	547	<2.0	5	348	3	<5	139	130
4797	Chert	Float	Select	0.01	0.37	<5	>2000	<2.0	<1	4867	73	7	11	3403
4798			Stream sed			24	296	<2.0	36	271	22	<5	82	114
4799	Mudstone	Float	Select	<0.01	0.54	<5	>2000	<2.0	<1	5786	42	<5	9	4770
4800	Shale	Outcrop	Random chip			<5	897	<2.0	3	671	5	<5	196	216
4801	Mudstone	Outcrop	Select			<5	809	<2.0	37	4446	37	<5	132	1357
4802			Stream sed			15	349	<2.0	26	354	21	<5	99	116
4817	Siltstone	Float	Select			40	408	<2.0	31	3149	50	<5	65	75
4818	Siltstone/sh	Outcrop	Random chip			30	331	<2.0	55	3088	22	15	77	103
4825	Chert	Outcrop	Select			63	505	<2.0	50	3166	50	32	53	7107
4826	Chert	Outcrop	Select			<5	1218	<2.0	16	3233	22	<5	29	33
4829	Chert	Rubblecrop	Select			41	303	<2.0	18	6878	47	24	34	13152
4830	Chert	Outcrop	Select			40	>2000	<2.0	16	5756	52	<5	34	375

PROPERTY SUMMARY

NAME: Skimo Creek East MAS NO. 0020220005

DEPOSIT TYPE: Sedimentary phosphate

COMMODITIES: Phosphate, vanadium

LOCATION:

Quadrangle: Chandler Lake B2
SW 1/4, Sec. 21, T. 13S, R. 1E, Meridian: Umiat
Lat. 68 deg. 17' 08" N., Long. 151 deg. 54' 50"W.
Geographic: East side Skimo Creek, 4.5 km above junction with Tiglukpuk Creek.
Elevation: 854 m

GEOLOGIC SETTING:

Rocks in the Skimo Creek area lie along the north flank of a broad east-west trending anticline, the axis of which lies about 1.5 km south of the mountain front. Sedimentary rocks on the northern limb of the anticline are steeply dipping to vertical and relatively undeformed. Phosphatic rocks are confined to the middle and upper parts of the black chert and shale member of the Upper Mississippian Lisburne Group Alapah Limestone. This member ranges from 12 m to 30 m thick and consists of a mixture of phosphatic mineral, calcium carbonate, silt and clay (215). More recently the USGS has sampled other formations in the area to test their phosphate content (129).

BUREAU INVESTIGATION:

Occurrences of sedimentary phosphate were first identified by USGS geologists working in the area between 1944 and 1953 (215). The Bureau first examined the occurrences in 1993. The Bureau measured a stratigraphic section and collected samples at an exposure 250 m east of Skimo Creek (Fig A9, table A7).

Phosphate occurs in a 12.1 m-thick section of interbedded oolitic shales and pisolitic phosphorites containing oblate pellets up to 3 cm in size. Continuous chip samples across individual phosphorites up to 30 cm thick contained up to 23.7% phosphate. Two higher grade zones occur within the section. One 2.2 m-thick zone averaged 20.6% phosphate and a second 0.9 m-thick zone averaged 13.0% phosphate. The phosphate content averaged 7.2% across a 12.1 m stratigraphic thickness.

The phosphatic rocks were found to be relatively continuous for a minimum to 4.2 km along strike. They were also sampled at the Skimo Creek West occurrence, 2.2 km to the west and at Tiglukpuk Creek, 2.5 km to the east. Columnar sections were constructed and correlations made between the three sites (Fig. A11). Samples also contained up to 874 ppm vanadium (4655) and

2047 ppm zinc (4662) (174).

Analysis of a sample collected from the same formation at the Kiruktagiak River phosphate occurrence, showed the phosphorites to be an intergrown mixture of 60% fluoroapatite and 40% calcite with minor amounts of quartz, fluorite, and pyrite (298). See that occurrence summary for a more detailed mineralogic description.

RESOURCE ESTIMATE:

A minimum indicated resource totalling 14.2 mmt, averaging 6.7% phosphate and an average phosphatic zone thickness of 11.2 m.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as a source of industrial-grade phosphate.

RECOMMENDATIONS:

Drilling to determine thickness and extent of phosphates.

REFERENCES:

103, 129, 145, 174, 215, 298

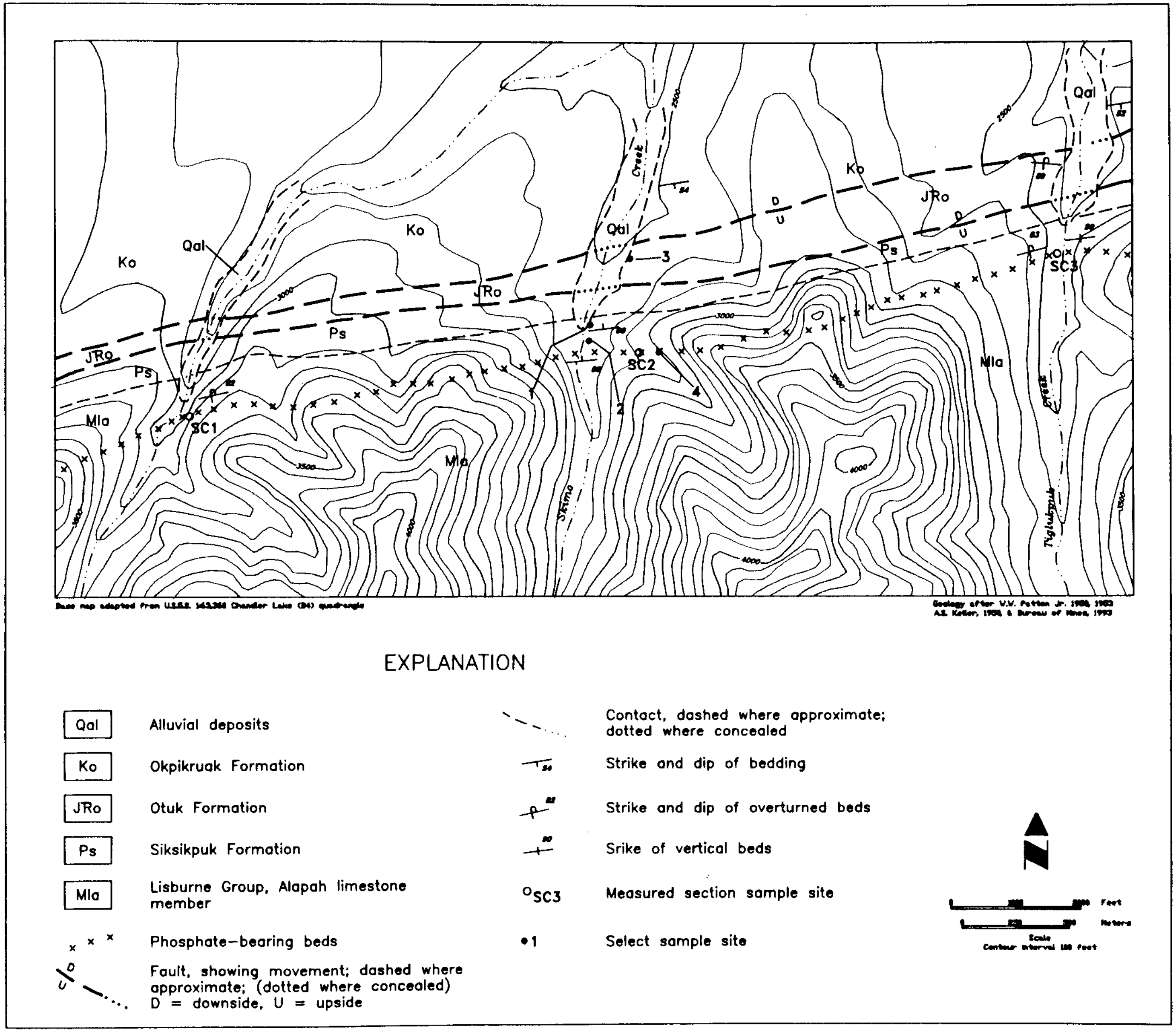


Figure A9. –– Skimo Creek West/East and Tiglukpuk Creek – geology and sample sites.

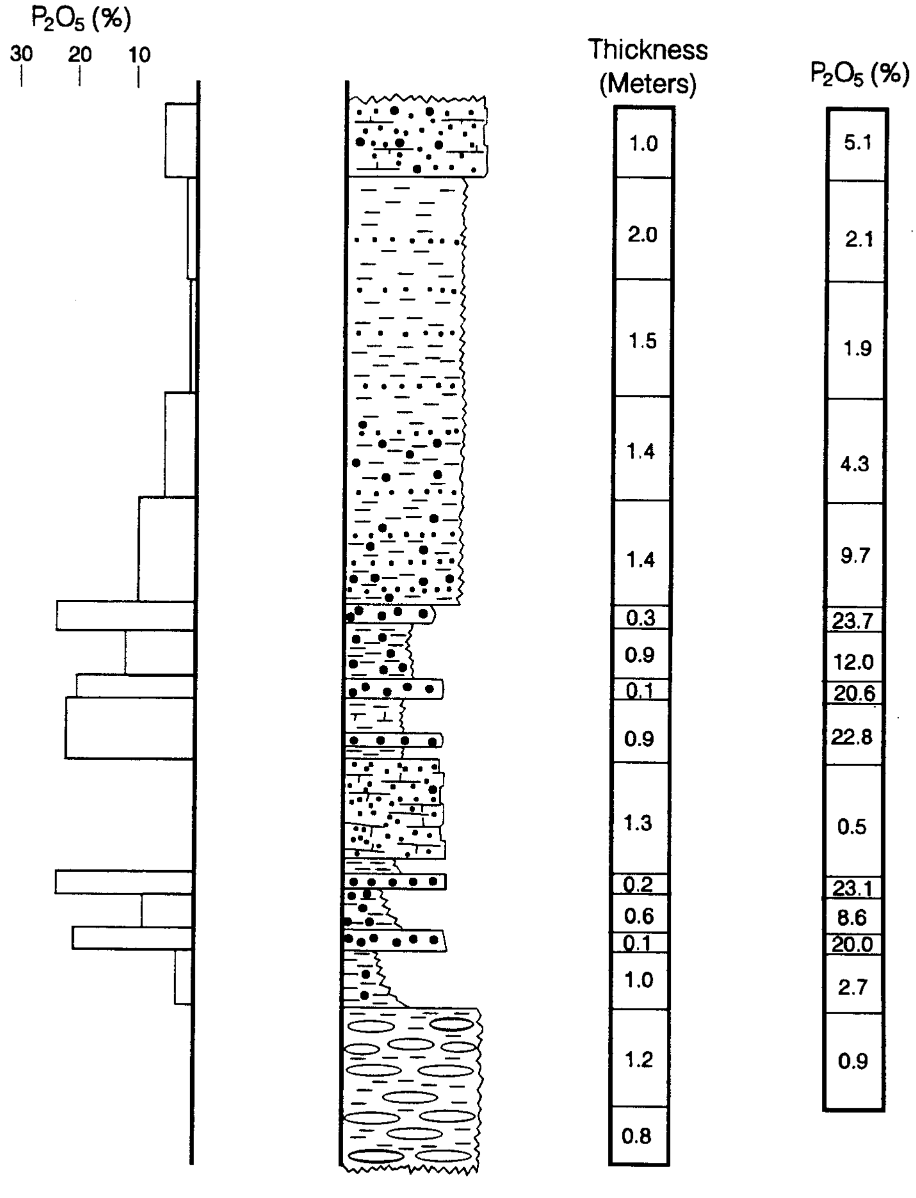


Figure A10. -- Columnar section of phosphatic zone Skimo Creek East (SC2) measured section (see figure A11 for lithologic descriptions).

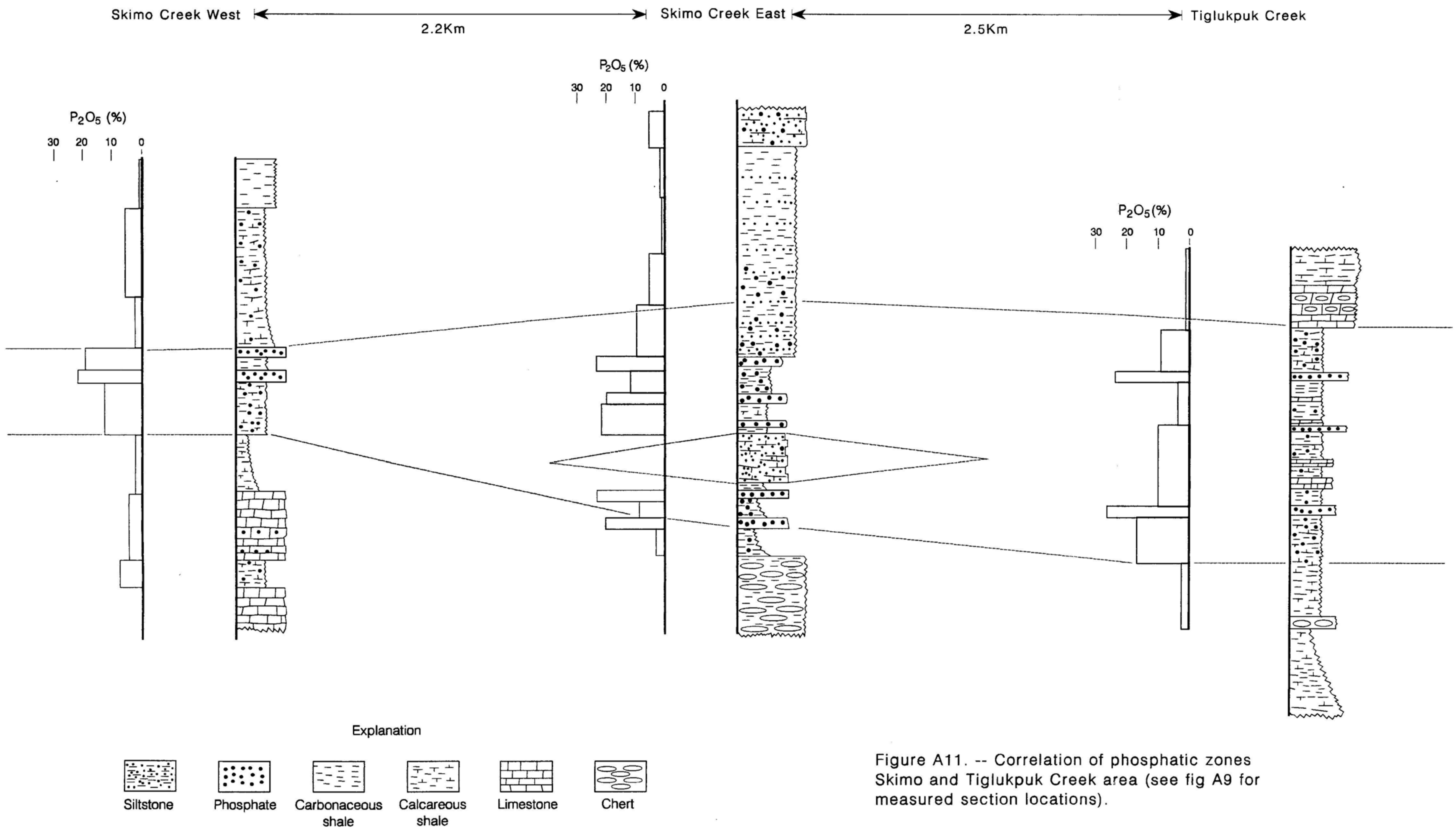


Figure A11. -- Correlation of phosphatic zones Skimo and Tiglukpuk Creek area (see fig A9 for measured section locations).

Table A7 - Analytical Results - Skimo Creek Area, Excluding Measured Sections

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag ppm	Al %	Ba ppm	Cu ppm	Fe %	Mg %	Mn ppm	Ni ppm	Pb ppm	P205 %	U (flouro) ppm	V ppm	Zn ppm
1	4593	Limestone	Outcrop	Select	<0.5	2.04	621	30	4.14	0.89	227	39	12	0.52	<9.0	115	141
1	4594	Shale	Outcrop	Contin chip	<0.5	1.62	496	40	0.98	0.41	142	94	12	0.23	<9.0	78	162
1	4597	Shale	Outcrop	Contin chip	<0.5	2.61	1298	41	2.59	0.74	184	71	7	0.24	<9.0	122	198
2	4582	Shale	Outcrop	Contin chip	0.8	2.09	264	62	1.41	0.52	104	110	8	1.49	<9.0	105	270
2	4667	Shale	Outcrop	Contin chip	1.4	0.24	54	32	0.23	0.52	32	62	<2	1.95	<9.0	186	251
2	4668	Shale	Outcrop	Contin chip	1.6	0.23	58	32	0.12	0.34	27	60	4	2.20	<9.0	152	262
3	4583	Chert	Outcrop	Contin chip	<0.5	2.61	>2000	45	2	0.45	202	49	9	0.03	<9.0	74	92
4	4581	Chert	Float	Select	<0.5	0.20	82	31	0.31	0.36	61	55	18	0.09	<9.0	37	157

PROPERTY SUMMARY

NAME: Skimo Creek West MAS NO. 0020220019

DEPOSIT TYPE: Sedimentary

COMMODITIES: Phosphate, vanadium, zinc

LOCATION:
Quadrangle: Chandler Lake B2
NW 1/4, Sec. 29, T. 13S , R. 1E , Meridian: Umiat
Lat. 68 deg. 17' 38" N., Long. 151 deg. 57' 40"W.
Geographic: East side of western tributary to Skimo Creek, 3 km above junction.
Elevation: 976 m

GEOLOGIC SETTING:

Rocks in the Skimo Creek area lie along the north limb of a broad east-west trending anticline, the axis of which lies about 1.5 km south of the mountain front. Sedimentary rocks on the north limb of the anticline are steeply dipping to vertical and relatively undeformed. Phosphatic rocks are confined to the Alapah Limestone memberof the Upper Mississippian Lisburne Group. This member is composed predominantly of dark soft shale, shaly limestone, phosphate rock, and phosphorite which form a discrete lithologic unit within the light-colored massive, fossiliferous clastic limestone that characterizes the rest of the Alapah Limestone. It ranges from 12 to 30 m thick (215).

BUREAU INVESTIGATION:

Occurrences of sedimentary phosphate were first identified by USGS geologists working in the area between 1944 and 1953. The Bureau exammined the occurrences in 1993. A stratigraphic section was measured and continuous chip samples collected from an exposure 90 m above and on the steep, rocky west wall of the stream valley (fig. A12.

Phosphate rock and phosphorites occur within a 11 m-thick section of interbedded oolitic to pisolitic limestone and calcareous shale. Flattened pellets up to 3 cm in size were observed in the phosphorites. A continuous chip sample collected across a 0.3 m-thick phosphorite contained 22.5% phosphate. Samples collected across a 2.3 m-thick section averaged 16.4% phosphate, and the entire 11 m-thick phosphatic section averaged 5.7% phosphate.

This phosphatic zone has been correlated with sites at Skimo Creek East and Tiglukpuk Creek, 2.2 and 4.7 km to the east respectively (fig. A11). Samples also contained up to 733 ppm vanadium (4644) and 1133 ppm zinc (4639) (174).

RESOURCE ESTIMATE:

This occurrence lies at the western of an indicated resource totaling 14.2 mmt, averaging 6.7% phosphate, with an average thickness of 11.2 m. This zone is traceable along strike from Skimo Creek West to Tiglukpuk Creek for a minimum of 4.7 km.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as a resource of industrial-grade phosphate.

RECOMMENDATIONS:

Drilling to determine continuity of phosphates.

REFERENCES:

129, 174, 215

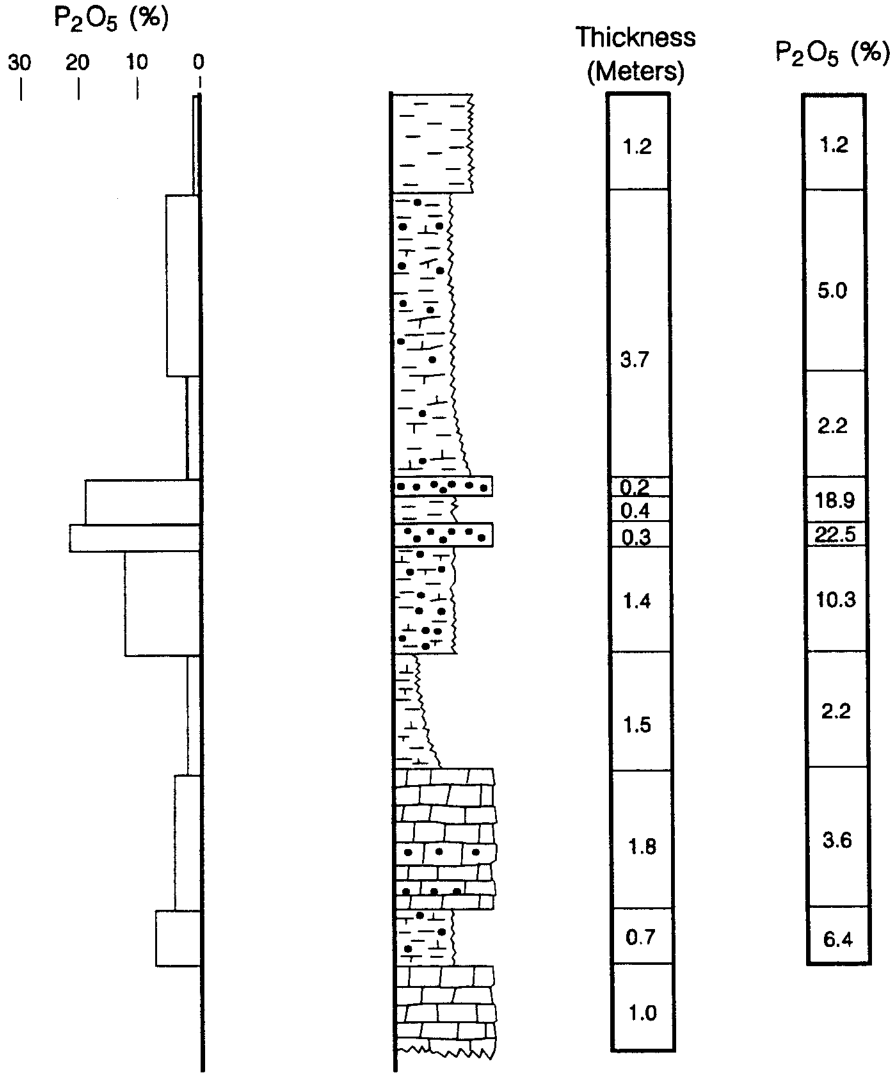


Figure A12. -- Columnar section of phosphatic zone Skimo Creek West (SC1) measured section.

PROPERTY SUMMARY

NAME: Tiglukpuk Creek MAS NO. 0020220005

DEPOSIT TYPE: Sedimentary

COMMODITIES: Phosphate

LOCATION

Quadrangle: Chandler Lake B2
SE 1/4, Sec. 22, T. 13S, R. 1E, Meridian: Umiat
Lat. 68 deg. 17' 58" N., Long. 151 deg. 51' 55" W.
Geographic: West side of Tiglukpuk Creek, 2.6 km above junction with Firestone Creek.
Elevation: 747 m

GEOLOGIC SETTING:

Sedimentary rocks in the Tiglukpuk Creek area lie on the north limb of a broad eastward-trending anticline. The axis of the fold lies 1.5 km south of the mountain front. The rocks are dipping near vertically and are relatively undeformed. Phosphates are confined to the middle and upper parts of the black chert and shale member of the Upper Mississippian Lisburne Group Alapah Limestone.

This member is composed predominantly of dark soft shale, shaly limestone, and phosphate rock which form a discrete lithologic unit within the light-colored massive fossiliferous clastic limestone that characterizes the rest of the Alapah Limestone. It ranges from 12 to 30 m thick and consists of a mixture of phosphatic mineral, calcium carbonate, silt and clay (215).

BUREAU INVESTIGATION:

Occurrences of sedimentary phosphate were first identified by USGS geologists working in the area between 1944 and 1953. The Bureau examined the occurrences in 1993. The Bureau measured a stratigraphic section and collected samples at an exposure 150 m west of Tiglukpuk Creek (fig. A9, A13).

Phosphate rock and phosphorites occur within a 10.5 m-thick section of interbedded oolitic to pisolitic limestone, chert, and shale. Flattened pellelts up to 2 cm in size were observed in the phosphorites. A continuous chip samples taken across 0.7m-thick phosphorite, contained 23% phosphate. A series of continuous chip samples collected across a 10.5 m-thick zone averaged 7.2% phosphate. A 3.3 m-thick high grade zone within this section averaged 13.1% phosphate. Samples also contained up to 1035 ppm vanadium and 2044 ppm zinc (4613), but no detectable uranium (174). See Kiruktagiak River Occurrence for a complete mineralogic description.

What appears to be the same continuous phosphatic zone was also sampled at the Skimo Creek and Skimo Creek West occurrences, 2.5 km and 4.7 km respectively to the west. The correlation with these sites is shown in Fig. A11. Detailed analysis was done on a sample collected from similar material at the Kiruktagiak River phosphate occurrence, 44 km to the west. This showed the phosphorites to consist of an intergrown mixture of 60% fluoroapatite and 40% calcite with minor amounts of quartz, fluorite, and pyrite. See that occurrence summary for a complete mineralogic description.

The USGS has sampled other formations in the area to test for phosphate content, but all have lower values than the Alapah Limestone (129).

RESOURCE ESTIMATE:

This occurrence lies at the eastern end of a continuous zone with an indicated resource totaling totaling 14.2 mmt, averaging 6.7% phosphate. The average phosphatic zone thickness is 11.2 m. This zone is traceable along strike from Tiglukpuk Creek west to the Skimo Creek West occurrence a minimum of 4.7 km.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as a source of industrial-grade phosphate.

RECOMMENDATIONS:

Drilling to determine continuity of phosphates.

REFERENCES:

129, 174, 215

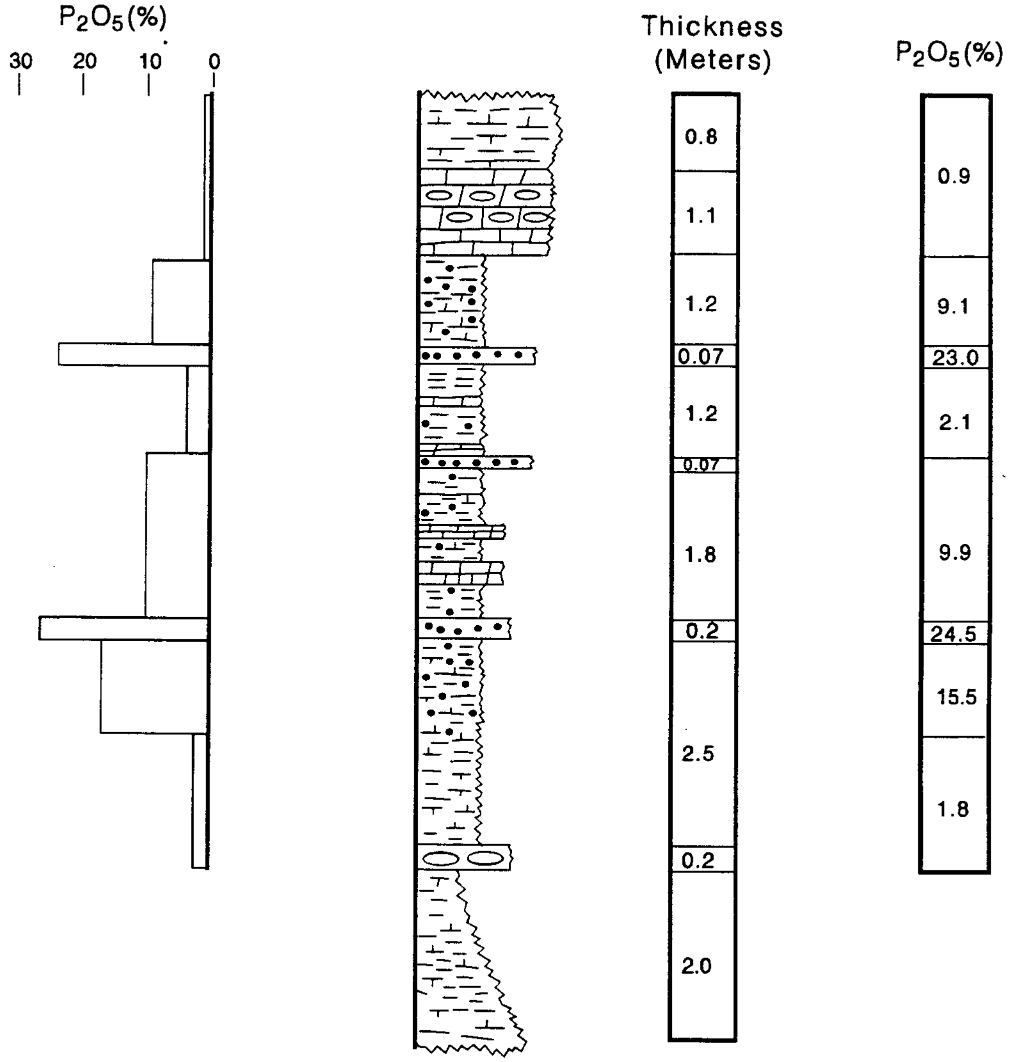


Figure A13. -- Columnar section of phosphatic zone Tiglukpuk Creek (SC3) measured section.

APPENDIX B - ALPHABETICAL LISTING OF MINERAL OCCURRENCES IN THE HOWARD PASS QUADRANGLE

PROPERTY SUMMARY

NAME: Abby MAS NO. 0020200019

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:
Quadrangle: Howard Pass C3
NE 1/4, Sec. 21, T. 10S, R. 24W, Meridian: Umiat
Lat. 68 deg. 33' 45" N., Long. 157 deg. 31' 20" W.
Geographic: Cutaway Basin, 5.2 km north of Mt. Bupto
Elevation: 683 m

GEOLOGIC SETTING:

The Abby stratiform barite occurrence is hosted in sedimentary rocks of the Endicott Mountains Allochthon and lies adjacent to the thrust contact with overlying rocks of the Picnic Creek Allochthon (fig. B2). Barite occurs in a series of rubblecrop mounds over a 64 x 155 m area interbedded with black siliceous mudstone or chert of Mississippian age. One of a series of thrust faults that repeat cherts in the Cutaway Creek area, cuts the base of the Abby occurrence. Lower Cretaceous sandstone of the Okpikruak Formation occurs in the footwall of the fault along the base of the barite body (128).

BUREAU INVESTIGATION:

The Abby occurrence was discovered in 1990 by the USGS (128). The Bureau mapped the geology of and sampled the occurrence. Rubblecrop exposures indicate a barite body with a possible average thickness of 30 m. Rubblecrop grab samples (5843-5849) averaged 95.7% $BaSO_4$ (table B1). Determinations by the USGS indicate an average specific gravity of 4.25 These specific gravity numbers are higher than those determined for the Bureau by Bondar Clegg Labs Inc. A gravity survey by the USGS revealed a 1 mGal gravity anomaly associated with the occurrence (128). None of the samples contained anomalous amounts of metals.

RESOURCE ESTIMATE:

Indicated resource: 406,000 mt at 95.1% $BaSO_4$ and a specific gravity of 4.21.

MINERAL DEVELOPMENT POTENTIAL:

Low potential as source of drilling mud, due to small size of occurrence.

RECOMMENDATIONS:

Test drill gravity anomaly to determine thickness and extent of barite bed.

REFERENCES:

128, 164

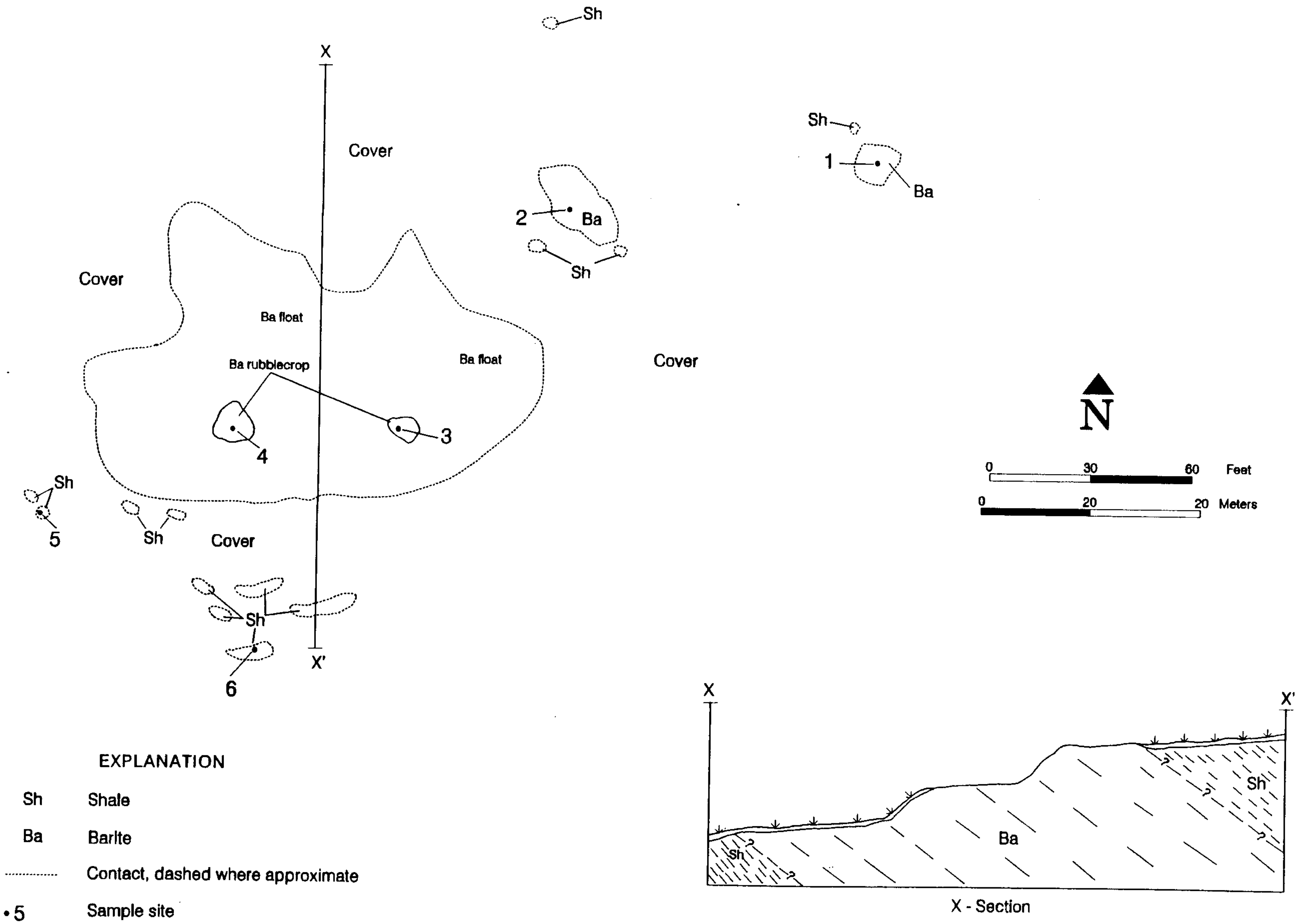


Figure B1. -- Abby Creek barite occurrence - geology and sample sites.

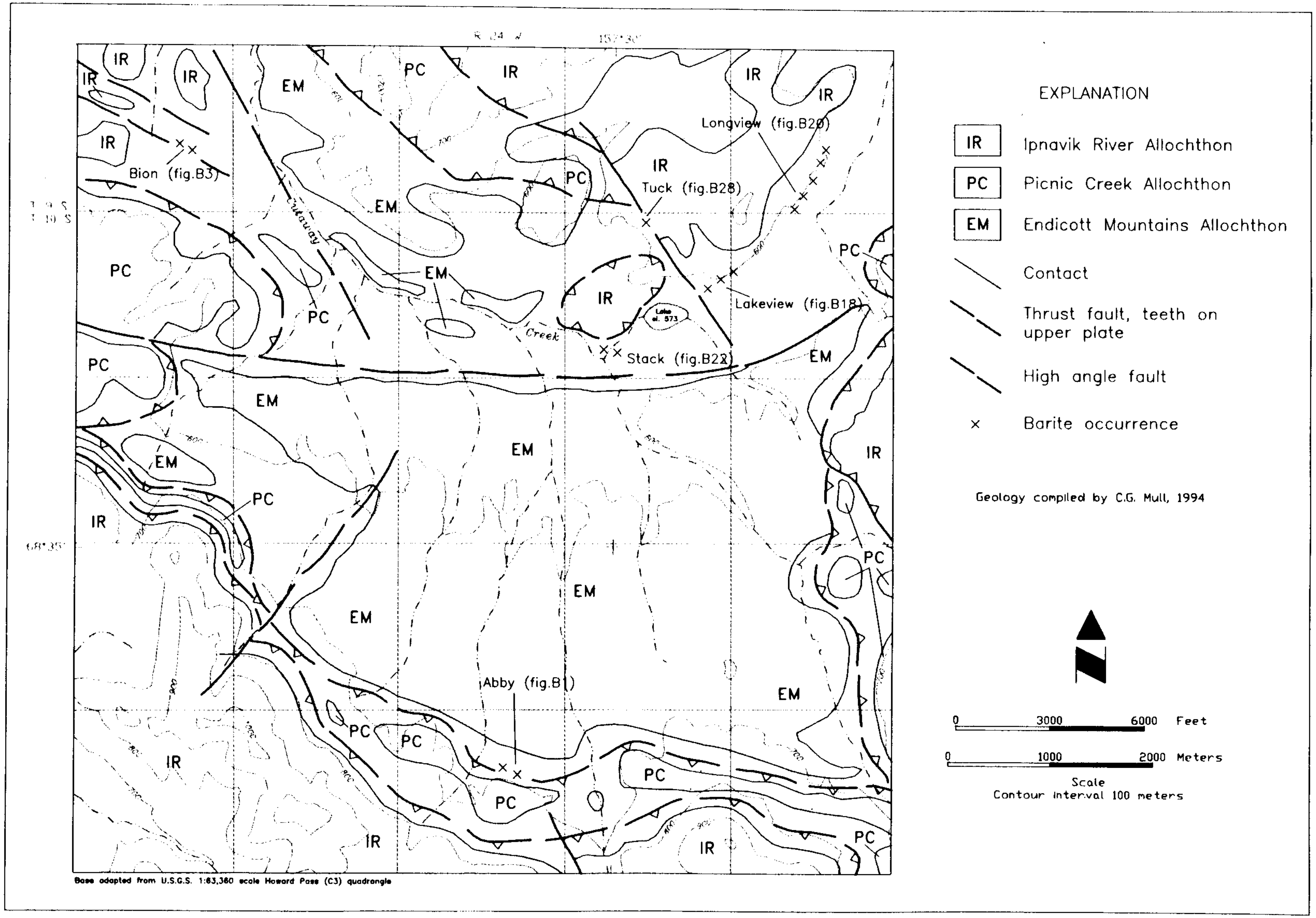


Figure B2. — Cutaway Basin area — geology and barite occurrences

Table B1 – Analytical Results – Cutaway Basin and Ekakevik Mountain Area

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Cd ppm	Mn ppm	Ba ppm	V ppm	U (fluoro) ppm	P205 %	BaSO4 %	Specific Gravity
							Abby Occurrence									
1	5846	Barite	Rubblecrop	Grab	<0.5	15	9	19	<2.0	77	401	34			93.15	3.9
2	5845	Barite	Rubblecrop	Grab	<0.5	<1	<2	9	<2.0	914	1828	16			87.18	3.6
3	5844	Barite	Rubblecrop	Grab	<0.5	<1	<2	4	<2.0	<5	693	7			96.24	3.8
4	5843	Barite	Rubblecrop	Grab	<0.5	<1	<2	14	<2.0	14	484	11			95.84	3.6
5	5847	Black Mudstone	Float	Grab	<0.5	30	14	16	<2.0	58	123	81			1.09	2.5
6	5848	Black Mudstone	Float	Grab	0.8	38	14	18	<2.0	55	107	91			0.88	2.5
							Bion Occurrence									
1	5852	Barite	Rubblecrop	Grab	<0.5	33	34	15	3.1	658	>2000	25			92.33	3.9
2	5853	Barite	Rubblecrop	Grab	<0.5	14	16	3	2.7	20	406	30			96.01	4.2
3	5854	Barite/Chert	Float	Grab	<0.5	20	18	8	<2.0	56	683	27			73.13	3.4
4	5850	Barite	Rubblecrop	Grab	<0.5	14	11	4	<2.0	38	<5	9			99.94	3.7
5	5851	Black Shale	Rubblecrop	Grab	9.4	197	15	91	<2.0	56	286	324			1.46	1.4
6	5855	Barite	Rubblecrop	Grab	<0.5	10	11	4	<2.0	18	1658	15			95.88	3.8
7	5858	Barite	Rubblecrop	Grab	<0.5	5	3	6	<2.0	41	>2000	6			96.35	4.0
8	5857	Black Shale	Float	Grab	1.0	20	13	21	<2.0	23	880	107			1.48	2.2
9	5856	Barite	Float	Grab	<0.5	8	10	<2	<2.0	14	796	11			96.49	4.0
10	5859	Barite	Float	Grab	<0.5	9	5	16	<2.0	101	974	17			93.12	4.0
11	5860	Black Chert	Float	Grab	<0.5	41	10	20	<2.0	48	209	53			1.60	2.5
							Ekakevik Mountains Occurrence									
1	5879	Black Shale	Float	Grab	1.0	9	5	54	<2.0	2137	645	47	3.3	0.05	2.27	2.5
2	5875	Sil. Mudstone	Float	Grab	1.0	10	8	11	<2.0	20	251	142	1.2	0.04	1.06	2.3
3	5876	Barite	Rubblecrop	Grab	<0.5	79	<2	11	<2.0	48	1001	8	0.2	0.01	94.69	3.9
4	5877	Witherite	Rubblecrop	Grab	0.8	<1	<2	7	2.5	<5	>2000	<2	0.8	0.03	99.90	4.0
5	5878	Barite	Outcrop	Rep chip	<0.5	3	2	8	<2.0	103	>2000	7	0.5	0.01	96.67	3.9
							Lakeview Occurrence									
1	5864	Barite	Float	Grab	<0.5	7	<2	21	<2.0	146	304	10			95.08	4.0
2	5865	Barite	Rubblecrop	Grab	<0.5	6	<2	53	<2.0	364	589	5			95.82	4.0
3	5866	Barite	Rubblecrop	Grab	<0.5	4	<2	17	<2.0	232	1453	2			96.65	4.0
4	5867	Barite	Rubblecrop	Grab	<0.5	4	<2	7	<2.0	8	501	13	25.0	0.42	96.42	4.2

Table B1 - Analytical Results---Cutaway Basin and Ekakevik Mountain Area (continued)

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Cd ppm	Mn ppm	Ba ppm	V ppm	U (fluoro) ppm	P205 %	BaSO4 %	Specific Gravity
					Longview Occurrence											
1	5747	Barite	Float	Grab	<0.5	3	6	4	<2.0	142	783	8			96.64	3.9
2	5748	Barite	Outcrop	Contin chip	<0.5	3	<2	7	<2.0	35	378	14			94.66	3.9
3	5746	Barite	Outcrop	Contin chip	<0.5	<1	<2	11	<2.0	49	408	11			94.69	3.9
4	5745	Cherty Mudstone	Outcrop	Random chip	1.6	41	4	47	<2.0	75	243	44	10.3	0.38	0.49	2.5
5	5744	Diabase	Outcrop	Random chip	<0.5	20	11	71	<2.0	878	>2000	95	0.2	0.10	0.29	2.6
6	5743	Barite	Outcrop	Spaced chip	<0.5	<1	<2	7	<2.0	42	1989	3			97.11	4.0
7	5742	Chert/Mudstone	Outcrop	Contin Chip	3.0	38	12	40	<2.0	65	324	92	61.0	1.56	0.67	2.5
8	5750	Sil. Mudstone	Outcrop	Random chip	<0.5	10	4	56	<2.0	134	517	19	<0.2	0.04	19.78	2.6
9	5861	Barite	Outcrop	Random chip	<0.5	13	<2	29	<2.0	839	1557	19			94.06	3.9
10	5862	Barite	Rubblecrop	Grab	<0.5	7	<2	7	<2.0	43	599	22			94.46	3.9
11	5749	Chert	Outcrop	Contin chip	2.5	24	6	11	<2.0	42	519	57	25.0	0.42	1.60	2.5
					Stack Occurrence											
1	5870	Barite	Rubblecrop	Grab	<0.5	<1	<2	<2	<2.0	42	>2000	8	0.2	0.02	96.33	3.6
2	5871	Carb. Shale	Outcrop	Contin chip	4.7	65	13	41	<2.0	29	234	143	18.9	0.54	1.35	1.5
3	5868	Barite	Rubblecrop	Grab	<0.5	2	7	3	<2.0	49	>2000	9	0.2	0.02	93.70	2.8
4	5751	Carb. Limestone	Float	Grab	<0.5	7	<2	90	<2.0	1118	96	18	4.0	0.05	0.77	2.2
5	5869	Barite	Rubblecrop	Grab	<0.5	<1	<2	<2	<2.0	8	428	4	0.5	0.01	97.36	3.7
					Tuck Occurrence											
1	5872	Barite	Outcrop	Rep chip	<0.5	<1	<2	4	<2.0	101	528	6	0.5	0.02	95.02	4.1
2	5873	Barite	Rubblecrop	Grab	<0.5	<1	<2	5	<2.0	36	633	5	0.2	0.01	96.78	3.7

PROPERTY SUMMARY

NAME: VABM Apex MAS NO. 0020200033

DEPOSIT TYPE: Ultramafic

COMMODITIES: Copper

LOCATION:
Quadrangle: Howard Pass B4
SW 1/4, Sec. 20, T. 12S, R. 27W, Meridian: Umiat
Lat. 68 deg. 23' 05" N., Long. 157 deg. 17' 20"W.
Geographic: 1.1 km northeast of Apex benchmark
Elevation: 1250 m

GEOLOGIC SETTING:

The occurrence lies near the north end of the Misheguk Mountain Allochthon, composed of Jurassic olivine gabbro (92)(75).

BUREAU INVESTIGATION:

During a brief stop in the area, located 2 km south of the study area boundary, malachite stain was noticed coating some olivine gabbro float. A select float sample (5797) contained 6943 ppm copper, 15 ppb platinum, 8 ppb palladium, and 24 ppm nickel (173). No copper sulfide minerals were identified. The nearby Siniktanneyak Mountain area, containing similar rocks, was examined by the Bureau in a separate study (75).

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL: Unknown

RECOMMENDATIONS:

Prospect surrounding area for further signs of copper mineralization.

REFERENCES:

75, 93, 173,

PROPERTY SUMMARY

NAME: Bion MAS NO. 0020200020

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:
Quadrangle: Howard Pass C3
SW 1/4, Sec. 05, T. 10S, R. 24W, Meridian: Umiat
Lat. 68 deg. 36' 17" N., Long. 157 deg. 35' 20" W.
Geographic: Cutaway Basin, 3.8 km west of lake 573.
Elevation: 524 m

GEOLOGIC SETTING:

The Bion stratiform barite occurrence is hosted by chert, organic shale, and petroliferous limestone turbidites of Late Mississippian to Early Pennsylvanian age. These rocks, which are part of the Endicott Mountains allochthon, are exposed through the Cutaway Fenster (93)(128).

The Bion occurrence consists of a series of rubblecrop mounds up to 70 x 130 m in size, surrounded by tundra cover. At the largest exposure, shale, chert, and limestone are interbedded with barite in a sequence that strikes northwest
.

BUREAU INVESTIGATION:

Barite was noted in the Cutaway Basin area by USGS geologists while geologic mapping in 1950 (271). Further prospecting in the area by the USGS during the present study led to the discovery of the Bion Occurrence (128). The Bureau mapped the occurrence and collected samples (fig. 3, table B1). Grab samples of rubblecrop contain up to 99.9% barite (5850) and specific gravities of up to 4.2 (5853). Using rubblecrop width and assuming that the barite is conformable with the enclosing sediments, a bed of at least 41 m thickness is estimated to exist. It is intermittantly exposed for 343 m along strike. A poorer exposure of barite rubble, occurs 274 m to the northwest. This may represent a separate barite bed, or a repetition of the southerly one due to thrust faulting. Ten samples collected at the occurrence averaged 95.7% barite. Determinations by the USGS resulted in an average specific gravity of 4.25 which meets specifications for drilling mud (209). The USGS also conducted a gravity survey over the two largest outcrops of the occurrence. This resulted in a gravity anomaly of 1.2 mGal which overlies the western most of the two outcrops (128). None of the samples were anomalous in base metals.

RESOURCE ESTIMATE:

Indicated resource: 10,100,000 mt, averaging 95.7% barite and a specific gravity of 4.25.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as source of drilling mud.

RECOMMENDATIONS:

Drilling to test gravity anomaly.

REFERENCES:

93, 128, 209, 271

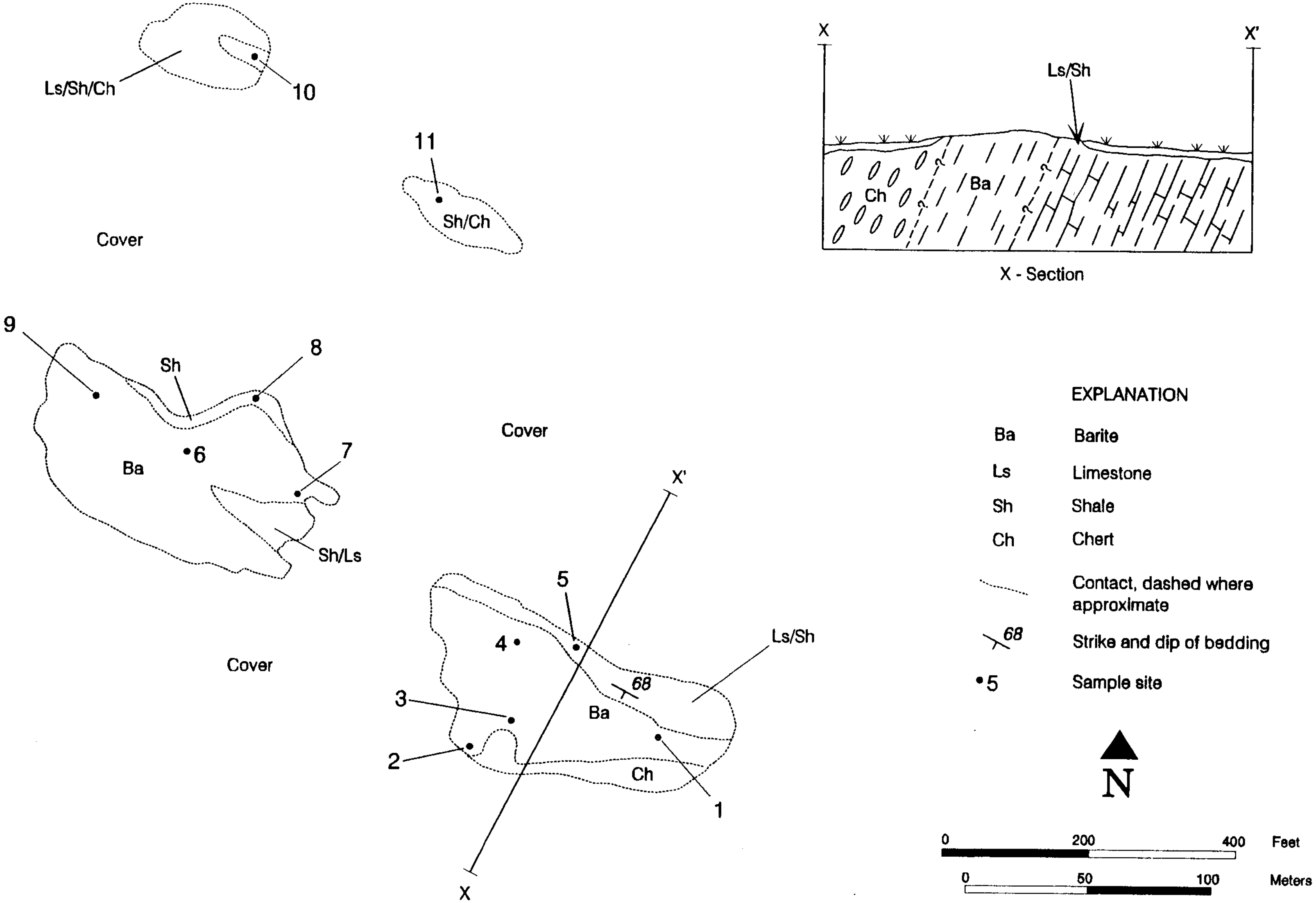


Figure B3. -- Bion Barite occurrence - geology and sample sites.

PROPERTY SUMMARY

NAME: Mt. Bupto MAS NO. 0020200005

DEPOSIT TYPE: Vein

COMMODITIES: Fluorite

LOCATION:

Quadrangle: Howard Pass C3
NE1/4, Sec. 04 , T. 11S , R. 24W , Meridian: Umiat
Lat. 68 deg. 31'11" N., Long. 157 deg. 31" 15"W.
Geographic: 0.5 km north of the summit of Mt Bupto
Elevation: 1010 m

GEOLOGIC SETTING:

Mt. Bupto is composed of Lisburne Group massive, light gray, crinoidal limestone that has been folded into a large northwest-trending anticline. On the north side of the mountain fluorite occurs associated with calcite in lenses and fracture fillings within brecciated limestone. The fluorite is clear, green, or purple in color (112).

BUREAU INVESTIGATION:

During a visit to the area in 1977, the Bureau found minor amounts of green and purple fluorite in float, associated with quartz and calcite. These minerals occurred as cement in fractured chert and limestone. A float sample contained 5.34%[1] fluorite (112).

In 1991, three samples were collected by the Bureau from fluorite-bearing outcrop and rubblecrop (table B2). Select sample (4053), collected from rubblecrop, contained 73.2% fluorite. A random chip sample (4052), collected from outcrop, contained 16.0% fluorite. A fluorite-bearing zone was traced for 200 m along the strike of the limestone bed.

RESOURCE ESTIMATE: Unknown

MINERAL DEVELOPMENT POTENTIAL:

Low potential for large tonnage vein-type fluorite deposits due to spotty exposures. To be of commercial value fluorspar ore must contain at least 30% fluorite (4).

RECOMMENDATIONS:

Further prospecting in area to determine extent of fluorite-bearing rocks.

REFERENCES:

4, 112, 115

[1] All values originally reported as percent fluorine. These values have been converted to fluorite, using a factor of (x 4.11).

Table B2 - Analytical Results - Mt. Bupto

Sample no.	Basic rock type	Sample site	Sample type	F %	As ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Fe %	Mg %	Mn ppm	Pb ppm	Sb ppm	V ppm	Zn ppm
4051	Dolomite	Outcrop	Select	0.28	12	4	46	<2.0	4	0.43	>10.00	332	10	7	73	121
4052	Dolomite	Outcrop	Random chip	3.96	13	3	74	<2.0	3	0.17	0.90	423	<2	<5	32	55
4053	Dolomite	Rubblecrop	Select	17.76	17	2	78	<2.0	4	0.17	1.77	111	<2	<5	28	63

PROPERTY SUMMARY

NAME: Drenchwater Creek MAS NO. 0020200002

DEPOSIT TYPE: Shale-hosted stratiform

COMMODITIES: zinc-lead-silver

LOCATION:

Quadrangle: Howard Pass C5
S 1/2, Sec. 16, T. 10S , R. 29W , Meridian: Umiat
Lat. 68 deg. 34' 20"N., Long. 158 deg. 41' 50"W.
Geographic: On Drenchwater Creek, 6.5 km south ofjunction with Wager Creek.
Elevation: 670 m

EXPLORATION HISTORY

1951

Drenchwater was named by a USGS field party for the excessive rains and high winds that struck their camp on the upper part of the creek. During the early 1950's USGS geologists observed iron-oxide staining near the narrows along Drenchwater Creek, 6.5 km south of its junction with Wager Creek (271).

1975

Discovery of lead and zinc minerals associated with iron-oxide stained rocks on Red Dog Creek prompted the USGS to go back and sample similar rocks observed years earlier on the north side of the Brooks Range. Several samples from Drenchwater Creek contained anomalous concentrations of barium and up to 3000 ppm lead. These samples probably came from the resistant siliceous mudstone outcrops which form the narrows on Drenchwater Creek (112).

1977

Joint field work by the USGS and the Bureau led to the discovery of sphalerite within silicified carbonaceous shales, just dowstream of the Drenchwater Creek narrows. Subsequent field work that same year by the Bureau, led to the discovery of galena and spahlerite in rubblecrop at a site on Discovery Creek, 900 m east of the Drenchwater Creek narrows (111). At this the USGS mapped the geology of the area at a scale of 1:20,000 (203).

1979

Under contract with the Bureau, the University of Alaska, Mineral Industry Research Lab conducted wide-spaced soil grid geochemical sampling in the area of Discovery Creek. Samples were also collected for lead isotope and petrographic analysis (149)(150)(168).

1980

Area evaluated by Anaconda Exploration. The geology was mapped, soil grid geochemical sampling done, and geophysical surveys conducted. The results are unpublished (44).

1987

Arctic Slope Regional Corporation evaluated Drenchwater Creek. Wide-spaced soil grid geochemial sampling conducted and some geologic mapping done. The results are unpublished (1).

1991

The Bureau surveyed a grid betwee Drenchwater Creek ad False Wager Creek prior to conducting geochemical samplig and geological mapping (172). USGS conducted gravity and magetic surveys on grid (177). Two bulk sample collected for beneificiation studies (172).

1992

The Bureau conducted reconnaissance sampling in Drenchwater Creek area ad a VLF survey using the 1991 grid. Kennecott Exploration in association with Arctic Slope Regional Corp. conducted detailed geologic studies at Drenchwater, including soil geochemical sampling, geologic mapping, and geophysics (64) (173).

1993

Arctic Slope Regional Corp. in conjuction with Kennecott Exploration applied for a permit to conduct drilling at Drenchwater Creek. Permit is denied by the BLM as the National Petroleum Reserve is closed to claim staking and drilling of hard rock minerals (64).

<u>GEOLOGIC SETTING</u>:

Mineralization in the Drenchwater Creek area is confined to the Key Creek Sequence which is exposed in the Drenchwater Fenster. This sequence includes Mississippian through Cretaceous rocks, consisting of the Kuna, Siksikpuk, Otuk, and Okpikruak Formations. The window may have formed as a result of late broad scale folding. The rocks within the window occur as a series of individual south-dipping thrust sheets with stratigraphic tops also generally to the south. The thrust faulting, has intensely deformed the rocks and resulted in repetition of the section. Mesozoic deformation occurred during emplacement of the Endicott Mountains Allochthon and during subsequent broad scale folding and arching. This deformation was likely superimposed on pre-existing Devonian to Mississippian extensional structures. Several north-south trending high-angle faults, which are probably postthrust, also exist in the area. Original spatial and stratigraphic relationships between the different thrust plates in the Drenchwater area are poorly understood. Individual thrust plates show different facies within the Mississippian units. These units are compositionally variable and show a myriad of different facies. This may indicate closely juxtaposed basinal to shallow water facies such as in a graben-horst environment. It is also possible that different thrust plates originally had considerable spatial distance between them. Although the area is structurally complex, metamorphic effects are minimal. Metamorphic grade in the area is lower greenschist. Incompetent units have developed slately cleavage and most rocks have undergone slight isochemical recrystallization.

The mineralized Drenchwater plate is distinguished by the presence of stratiform mineralization, altered volcanic rocks, and a high proportion of carbonaceous shale and laminated silicified shale (Fig. B4). The mineralization is dominately hosted by black carbonaceous shale and chert and is spatially associated with trachyte, trachyandesite, and lesser alkali basalt and basanite nephelinite. Volcanic units outcrop over a distance of 5 km and dominately consist of submarine, felsic tuffaceous material with volumetrically minor mafic tuffs occurring east of the Drenchwater occurrence. A number of small, porphyritic trachyte and trachyandesite domes intrude the volcanic pile. Black shale and a volcanic breccia unit outcrop to the north of the isolated intrusive and again to the north of the main volcanic pile. Clay alteration minerals (Kaolinite, dickite, and illite) within the dominantly felsic tuffaceous rocks increase in crystallinity toward porphyritic intrusives. Primary sedimentary, volcanic and mineralization textures are well preserved.

Mineralization is directly associated with hydrothermal silicification of the black carbonaceous shale and silicified mudstone host rocks , as well as local silicification of volcanic breccia units. Bleaching and silicification are useful guides for locating higher sulfide concentrations within the carbonaceous host rocks. Sphalerite, the predominant sulfide mineral, occurs with variable amounts of pyrite, marcasite, and galena, trace amounts of fluorite and barite, and anomalous amounts of silver, arsenic, and antimony. Metal zoning is poorly developed, but the relative proportion of sphalerite to galena is higher distal to the inferred vent area.

Sulfide minerals are very fine grained and exhibit a wide variety of textures. Four types of mineralization have been defined on the basis of texture and spatial distribution. These include semi-massive, disseminated, layered/diagenetic, and breccia cement. Semi-massive sulfides have mottled, diffusely layered, and/or brecciated textures, and formed proximal to the hydrothermal source. This type is also coarser grained and contains more galena than the others. Disseminated type mineralization consists of fine-grained sulfide crystals, sparsely distributed within bleached, gray silicified shales. This type is the most common form of mineralization and occurs laterally for at least 3.3 km. Layered/diagenetic type mineralization consists of thin laminations of alternating sulfide minerals and black carbonaceous shale. In breccia type mineralization, volcanic breccia clasts are cemented and/or replaced by quartz, sphalerite, pyrite, galena, and fluorite.

The spatial association of mineralization with volcanic rocks and alteration patterns centered about intrusions is consistent with volcanogenic massive sulfide models. The lack of copper and stringer type mineralization, the small percentage of high temperature alteration minerals, laterally extensive silicification, and the zinc-iron-lead-fluorine-barium-silver metal assemblage point to a dominantly basinal fluid source, similar to that of a sedimentary exhalative type model.

Both volcanogenic and sedimentary exhalative processes may have been involved in the mineralizing process, but a dominantly sedimentary exhalative interpretation for Drenchwater is supported by numerous similarities (i.e., timing, host rocks, metal ratios) to the sediment-hosted Red Dog deposit, 158 km to the southwest. Alkaline volcanism supports an extensional continental setting and elevated geothermal gradient during Mississippian to Pennsylvanian time for the northwestern Brooks Range.

BUREAU INVESTIGATION:

The Bureau first examined the mineralization at Drenchwater Creek in 1977, collecting samples and making a reconnaissance geologic map (111). In 1991 the Bureau extensively sampled known mineralized exposures, made a series of geologic maps of the mineralized areas, and conduct systematic soil sampling to delineate extensions of known mineralization under tundra-covered areas (figs. B4-B8)(172)(173).

Mineralized rocks are intermittantly exposed within a 3200-long zone, trending approximately N60 deg. W. This zone extends from False Wager Creek on the east to the divide west of Drenchwater Creek (fig. B5). Mineralized rocks are best exposed near the narrows on Drenchwater Creek and at the head of Discovery Creek. On the east side of Drenchwater Creek (fig. B6) a 76 cm thick zone of siliceous mudstone containing semi-massive and disseminated stratiform sulfides is exposed in a small outcrop. Samples from the outcrop averaged 6.0% zinc, 1.9% lead, and 13.7 g/mt silver (5392-5394) (table B3). The exposure appears to lie close to the boundary between the top of the Kuna Formation and overlying tuffaceous rocks. A small, outcrop of stratiform, pyrite-rich semi-massive sulfides is poorly exposed 50 m west at creek level on west side of Drenchwater Creek (5266-5267). It is probably a lateral equivalent. Samples from this exposure averaged 9.3% zinc, 0.36% lead, 18.2 g/mt silver, and 291 ppm cadmium.

Mineralized siliceous mudstone rubblecrop and float can be traced for 812 m up the hillside west of Drenchwater Creek. A series of samples collected from deeply-weathered disseminated mineralization rubblecrop at the head of Discovery Creek averaged 6.8% zinc, 6.7% lead, 43.6 g/mt silver, and 211 ppm cadmium (5247-5249, 5326, 5328) (fig. B7). Due to the rubbly nature of the exposure, a thickness for this mineralized zone could not be determined.
Massive sulfide float was found in frost boils, located between two forks of False Wager Creek, 430 m southeast of the end of the geochemical grid (5731) (Ebisch, 1992). It occurs along with siliceous mudstone breccia and lies adjacent to and apparently stratigraphically above an exposure of felsic tuff. A select sample contained 12.6% zinc, 1.9% lead, and 204 g/mt silver. Near the top of the ridge separating False Wager and Wager Creeks, iron stained siliceous mudstones contain what appear to be sphalerite boxworks (5827-5828). Samples of this material did not contain anomalous sphalerite, but did contain up to 225 ppm lead.

A total of 6860 m of grid lines were surveyed along a 2000 m northwest trend between False Wager and Drenchwater Creeks. The area was selected because it contains the greatest concentration of sites with mineralized rubblecrop, interspaced with extensive areas of tundra cover. When possible, both soil and rock samples were collected at 30 m intervals along the grid. Soil samples contained up to 5525 ppm zinc (5084), 10,000 ppm lead (5220, 5327), and 2,000 ppm barium (5041, 5106) (172). The lead, zinc, and barium values were contoured (Figs. B11-B13).

Anomalous lead and zinc concentrations extend for up to 976 m along an approximate N. 60 deg. W trend through the eastern portion of the grid. Soil lead anomalies are concentrated mainly in areas underlain by siliceous mudstone and shale and to a lesser extent the volcanic breccias. High zinc values are concentrated in the siliceous mudstone and shale, but the tuffaceous and porphyritic volcanic rocks also contain zinc anomalies. Barium values are concentrated in areas underlain by siliceous mudstone and chert. The chert is part of the Siksikpuk Formation which is regionally anomalous in barium (212). A soil geochemical lead anomaly extends for 2185 m along the length of the Drenchwater gid.

A gravity and magnetic survey was conducted by the USGS, using the grid for control (177). No significant magnetic anomalies were detected, but a gravity anomaly was delineated (fig. B9). It is highest in the Discovery Creek outcrop area, offset across a north-south trending fault, then slowly weakens across the 732 m length of the grid.

The Bureau conducted a very low frequencey (VLF) survey, which delineated a series of subparallel anomalies across the southern portion of the grid (fig. B10). These may represent underlying conductive carbonaceous shales. The conductors are offset across the same north-south fault as the gravity anomaly.

A 102 kg select bulk sample of semi-massive and disseminated mineralization was collected from the head of Discovery Creek and at the Drenchwater Creek narrows. The disseminated material exhibited boxworks textures due to deep weathering of the sphalerite. The two types were assayed separately. The dissseminated type had head assays of 15.2% zinc, 3.23% lead, and 60 g/mt silver. The semi-massive type contained a high percent of pyrite and head assays contained 10.5% zinc, 0.91% lead, and 30.2 g/mt silver. A standard floatation test proved unsuccessful as the sulfides are very fine grained and poorly liberated. The material would have to be ground to at least -400 mesh to maximize recovery In comparison, the ore at the Red Dog Mine has to be ground to -600 mesh for optimum recovery (208).

A feasibility study concerning the mining of stratiform sulfide deposits in the Colville Mining District was conducted the Bureau. The study indicates that gross revenues for a surface mining operation, ranging in size from 25-30 mmt, varies from $140/mt for a 17,000 mtpd mines to $220/mt for a 5,000 mtpd operation (43).

RESOURCE ESTIMATE:

Mineralized rocks are intermittantly exposed in a 3200 m-long trend between False Wager and Drenchwater Creeks. Metals values vary, but samples from one of the better exposures average 6.8% zinc, 6.7% lead, and 43.6 gmt silver.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential for stratiform zinc-lead deposit, due to extensive exposures and grades.

RECOMMENDATIONS:

Test drilling of soil geochemical anomlies. Trenching of mineralized float and rubblecrop to obtain unweathered samples.

REFERENCES:

1, 32, 33, 44, 64, 81, 111, 112, 140, 141, 149, 150, 168, 172, 177, 181, 201, 202, 203, 204, 208, 212, 271, 314

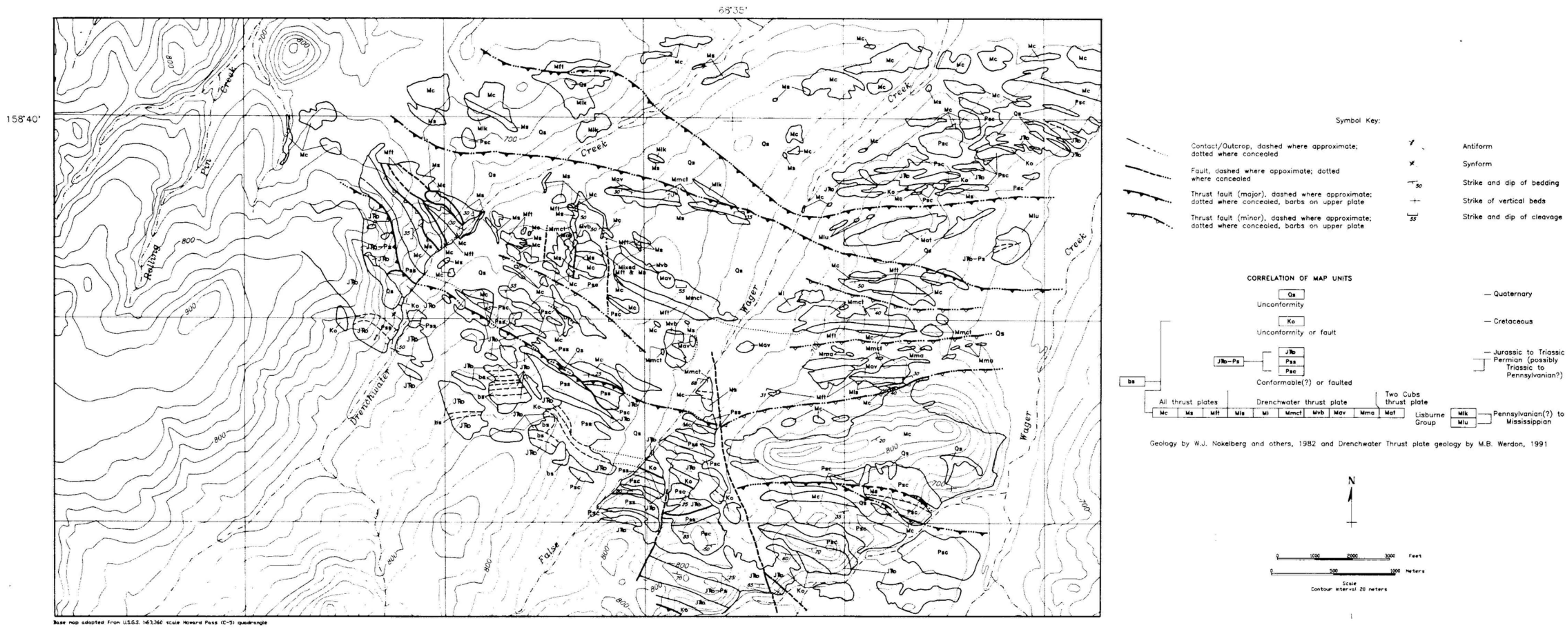


Figure B4. – Drenchwater Creek Area – Geology.

Legend

Drencnwater Symbol Key:
(Modified from Nokleberg and Winkler, 1982)

Rock Units

Qs - SURFICIAL DEPOSITS (Quaternary) - Undifferentiated alluvium, colluvium, glacial deposits, talus, and gravel.

The following units have been correlated to those of Mull and others, 1982.

Ko - OKPIKRUAK FORMATION (Cretaceous) - Lithic sandstone, siltstone, and mudstone. Occurs as strongly deformed and partly fault bounded units several tens to several hundreds of meters thick. Sandstone and siltstone weather dark brown, mudstone weathers dark gray to black. Major clasts in the sandstone are plagioclase, dark chert, quartz, and unidentified lithic fragments. Coarse-ribbed *Buchia* and plant fragments occur along partings. Abundant cleavage; lenses formed from disrupted isoclinal folds.

JTRo - OTUK FORMATION (Jurassic to Triassic) - Predominantly medium-bedded chert, with lesser amounts of black paper shale and thin limestone. Chert weathers gray and yellow, with distinctive mottled green surfaces. Fresh surfaces are medium gray. Contains abundant *Monotis* on limestone partings. Commonly thinner than 50 m. Intricately folded and faulted.

SIKSIKPUK FORMATION (Permian; may range from Triassic to Pennsylvanian) Mull and others, 1982.

Pss - Red and green siliceous shale - Strongly cleaved and locally intensely folded and faulted.

Psc - Yellow, green and gray chert - Medium bedded, with dark-gray fresh surfaces. Contains scattered radiolarians and sparse barite concretions or disseminations.

JTRo-Ps - OTUK AND SIKSIKPUK FORMATIONS, UNDIVIDED - (Triassic to Permian; possibly as old as Pennsylvanian) Undifferentiated chert.

KUNA FORMATION and VOLCANIC UNITS - (Mississippian; possibly extends into Pennsylvanian) Specific units are restricted to certain thrust plates. See correlation of map units. Original stratigraphic position of the following units unknown.

Mc - Black chert and black to light gray silicified mudstone/shale - Silicified mudstone/shale contains variable amounts of pyrite, marcasite, sphalerite, galena, and barite. Black chert contains radiolarians.

Ms - Black shale - Approximately 100 m thick (Tailleur and others, 1966). Intensely faulted and sheared; commonly serving as a detachment surface for minor thrust faults. Locally contains galena, sphalerite and barite in veins and concretions.

Ml - Light gray limestone - bedded limestone with disseminated pyrite, no apparent fossil debris. Appears to be laterally transitional into medium to coarse-grained tuffaceous material.

Mls - Crinoidal and coralline limestone - As much as 35m thick. Light to medium gray. Partially to completely silicified. Grades into fine-grained felsic tuff to the north.

Mft - Fine-grained felsic tuff - Maximum thickness 80 m. Weathers bright orange, with light-gray fresh surfaces. Contains sparse microphenocrysts of biotite and feldspar, angular fragments of black chert, and disseminated pyrite.

Mmct - Medium- to coarse-grained felsic tuff - As much as 250 m thick. Weathers brown where carbonate altered, and light greenish-gray where chlorite altered. Fresh surfaces are typically light gray. Contains abundant medium to large feldspar phenocrysts and sparse fine biotite phenocrysts in a fine-grained matrix. Locally grades into sandstone composed of tuff grains.

Mav - Porphyritic massive alkaline volcanic units - As much as 80 m thick. Contains coarse-grained phenocrysts of feldspar and fine-grained biotite phenocrysts in a fine-grained trachytic groundmass. Occurs as sills/flows or as small domes. Radiometric age of 319 ± 17 m.y. by K-Ar method on biotite (Tailleur and others, 1966).

Mvb - Volcanic breccia - As much as 50 m thick. Angular, porphyritic volcanic clasts in a matrix of fine tuff. Locally silicified, clasts occasionally cemented and/or replaced by quartz, sphalerite, and galena.

Mms - Mafic tuff - As much as 30 m thick. Mottled dark-green tuff. Foliated, poorly exposed, dominantly altered to chlorite.

Mat - Medium-grained pyroxene andesite and fine-grained andesitic tuff - Occurs only in the Two Cubs thrust plate. Pyroxene andesite weathers dark brown, with black fresh surfaces. Andesitic tuff weathers medium brown, with pale-olive-gray fresh surfaces. Mainly massive calcareous crystal-lithic tuff, with sparse pyroxene and plagioclase phenocrysts. Locally, unit consists of alternating sills, flows, and tuff. Radiometric age of 330 m.y. by K-Ar method on biotite.

bs - Undifferentiated black shale of the Okpikruak, Otuk, Siksikpuk, and Kuna Formations.

LISBURNE GROUP

Mlk - KOGRUK FORMATION (Upper to Lower Mississippian) - Light- to medium-gray crinoidal limestone and calcareous shale. Several tens of meters thick; thick bedded (Tailleur and others, 1966).

Mlu - UTUKOK FORMATION (Lower Mississippian) - Purplish-gray thin-bedded limestone, dolomite, and sparse calcareous siltstone. Several tens of meters thick. Sparse fossils including proetid trilobite, fenestrate bryozoan, brachiopoda *Leptagonia analoga*, brachiopod comparative to *Brachythyris suborbicularis*, schuchertellid brachiopod, and zaphrentoid coral. Occurs only in the Two Cubs thrust plate.

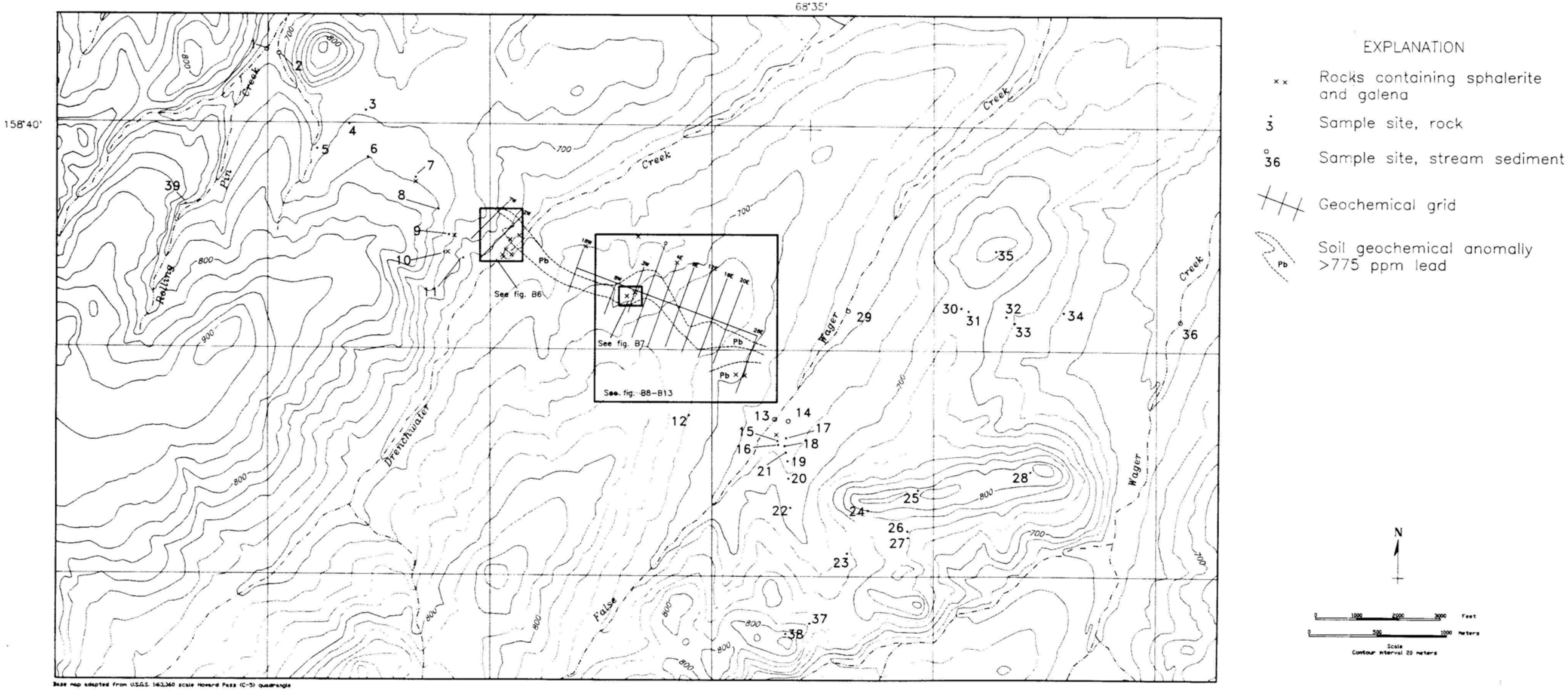
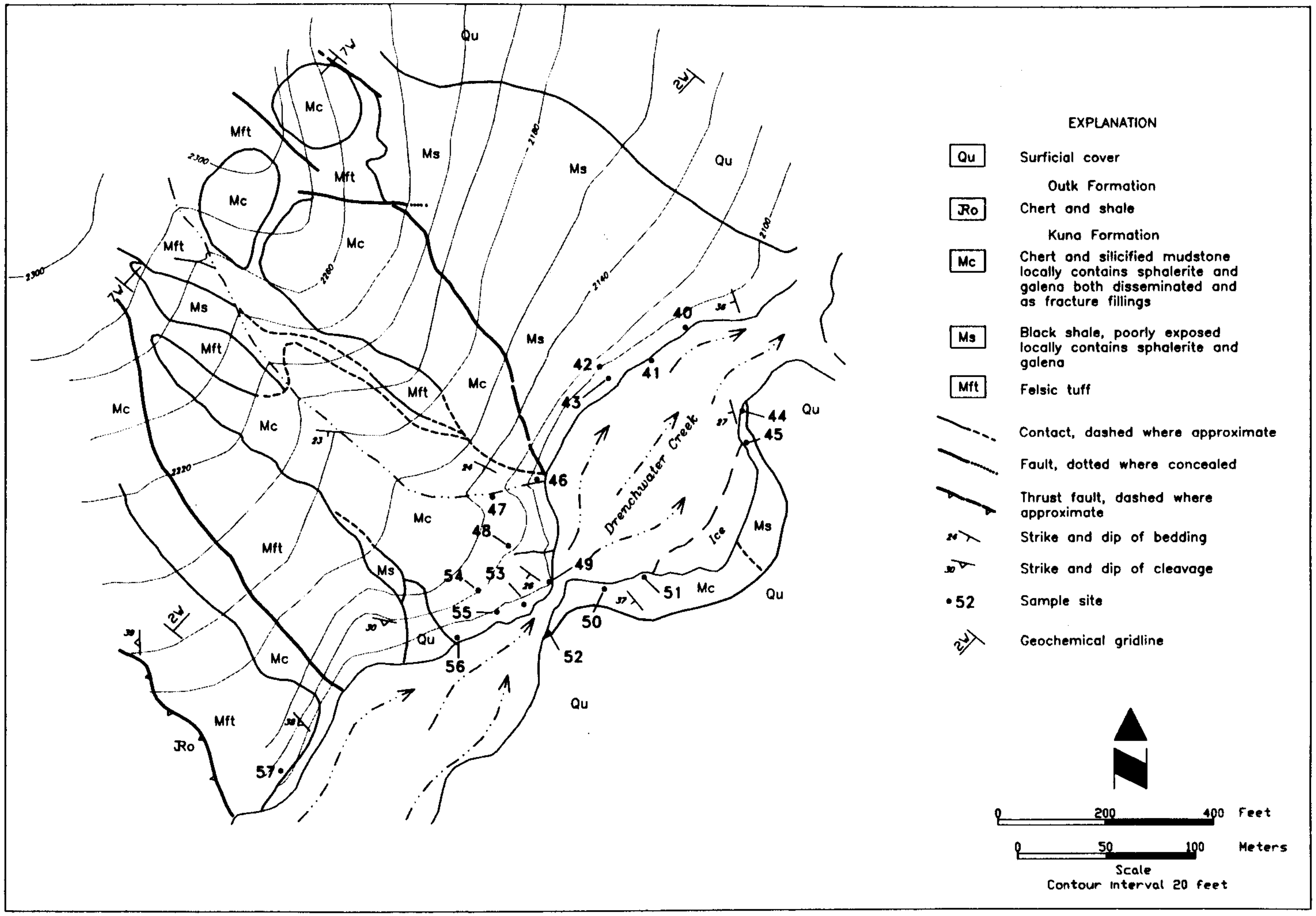


Figure B5. — Drenchwater Creek area — sample sites.



Geology by M.B. Werdon, 1991

Figure B6. – Drenchwater Creek narrows – geology and sample sites.

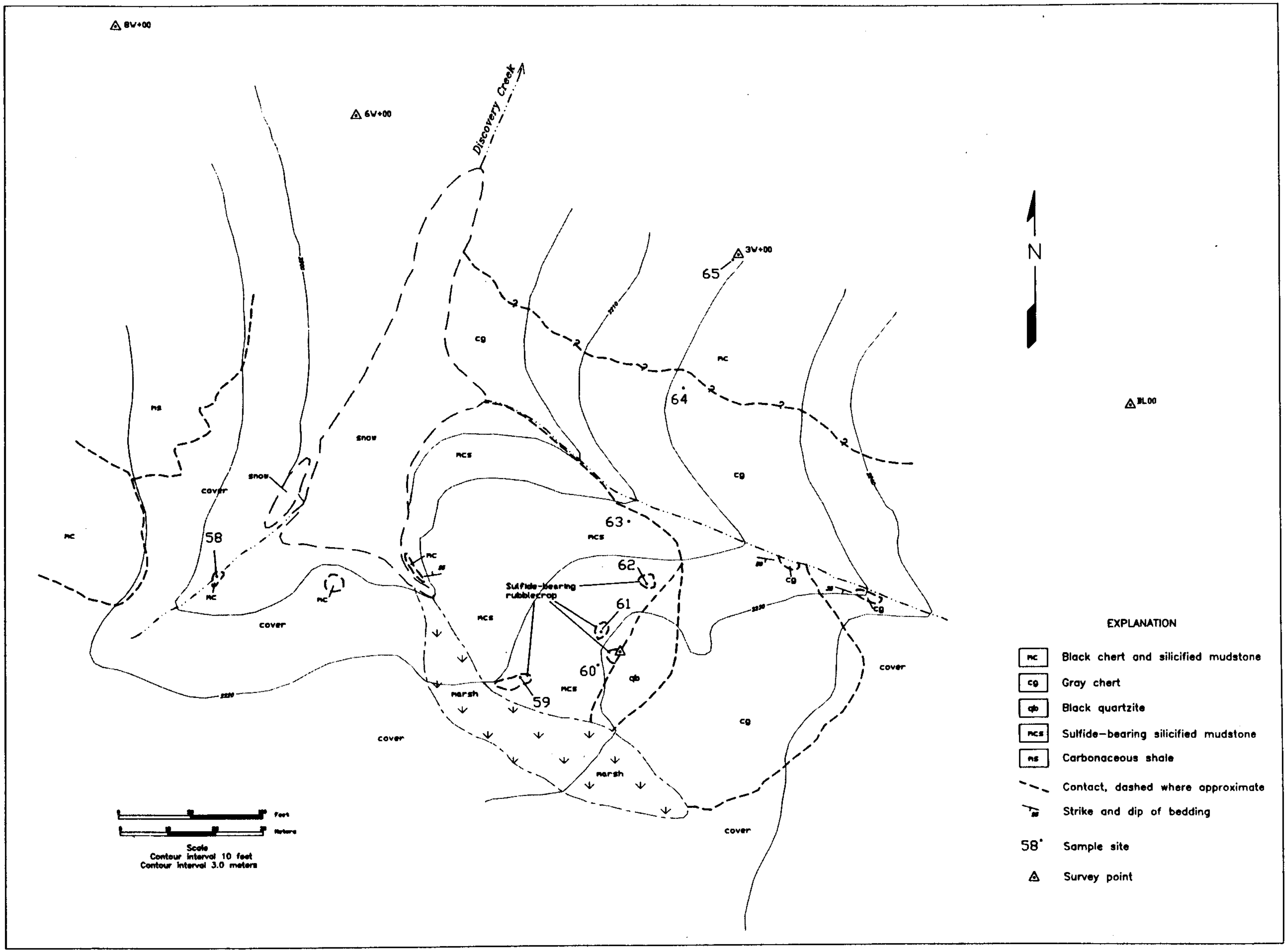
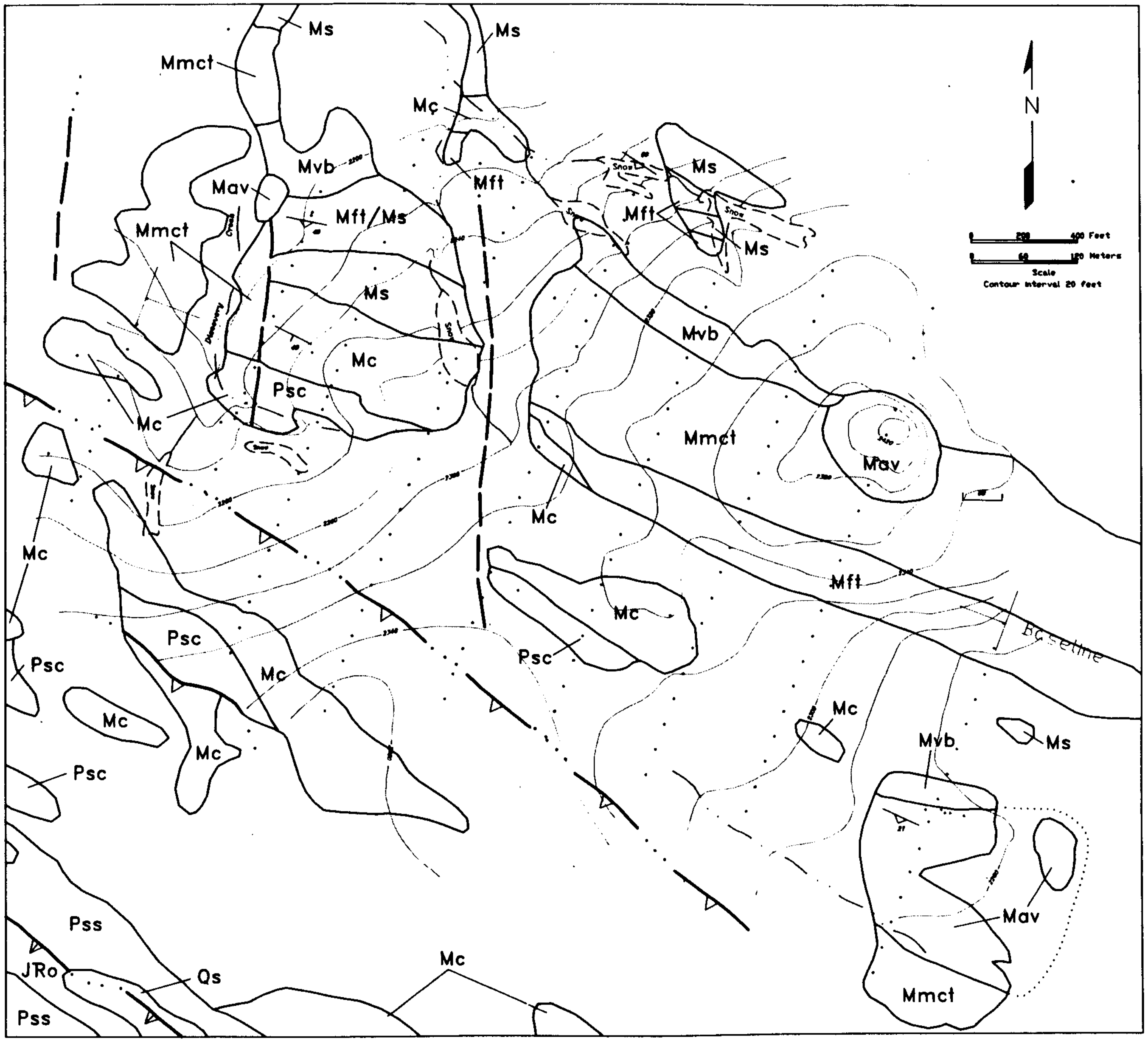


Figure B7. -- Drenchwater Creek area - Upper Discovery Creek, geology and sample sites.



Geology by V. B. Verdon, 1991

Figure B8. – Drenchwater Grid – Geology

Note: See figure B4 for map legend.

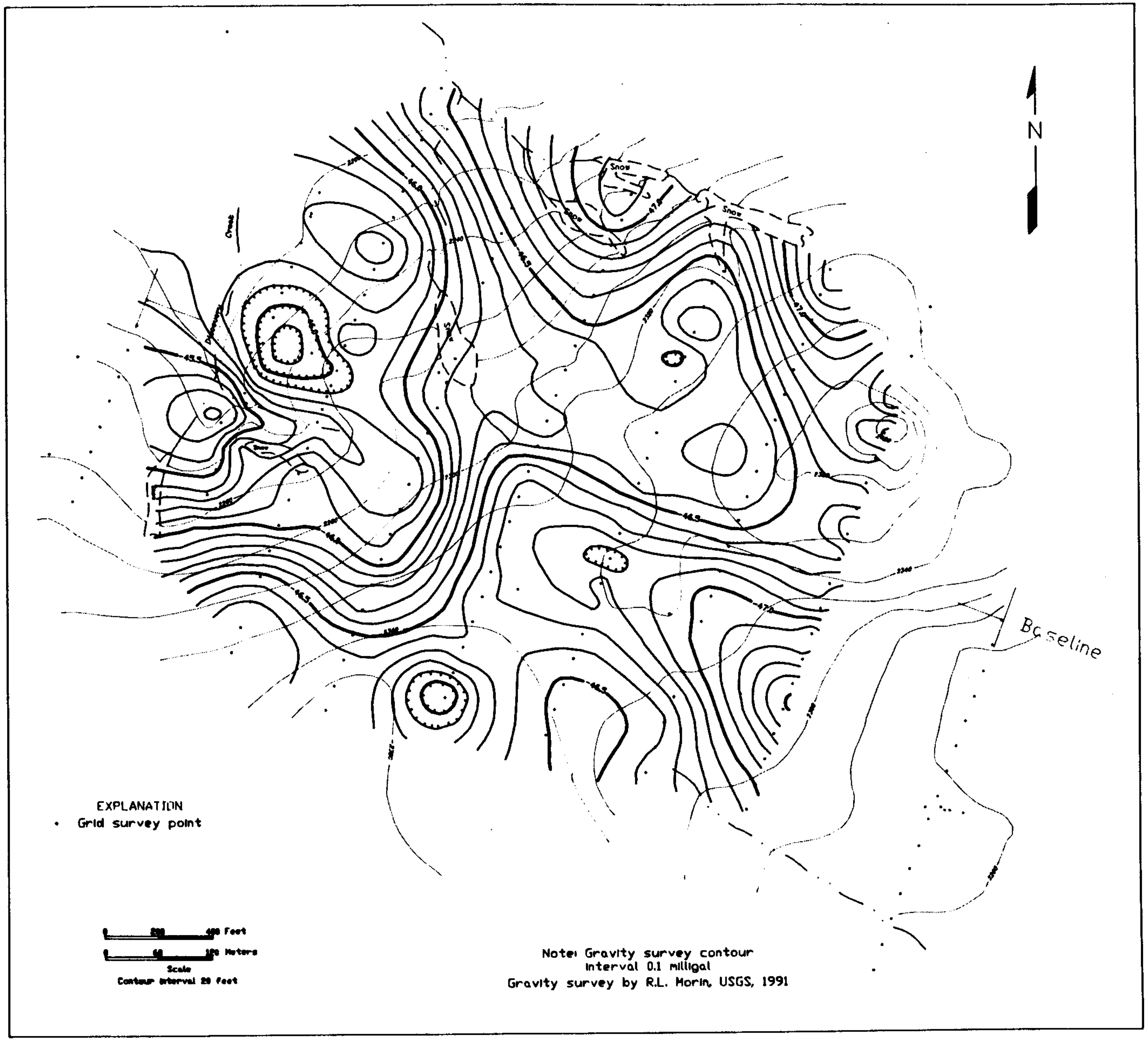


Figure B9. — Complete Bouguer Anomaly Map, Drenchwater Grid, Alaska

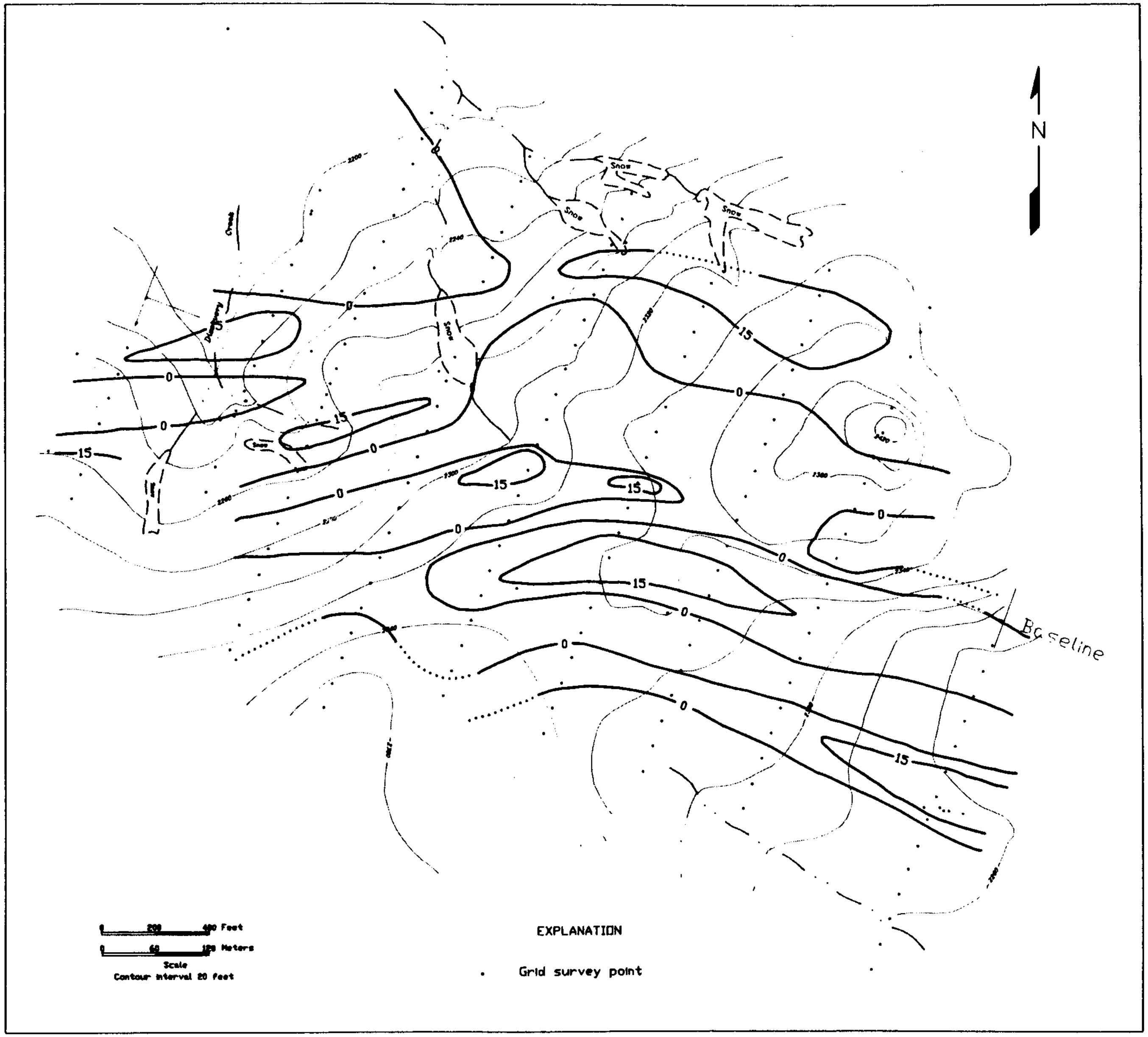


Figure B10. - Drenchwater Grid VLF Fraser Filter

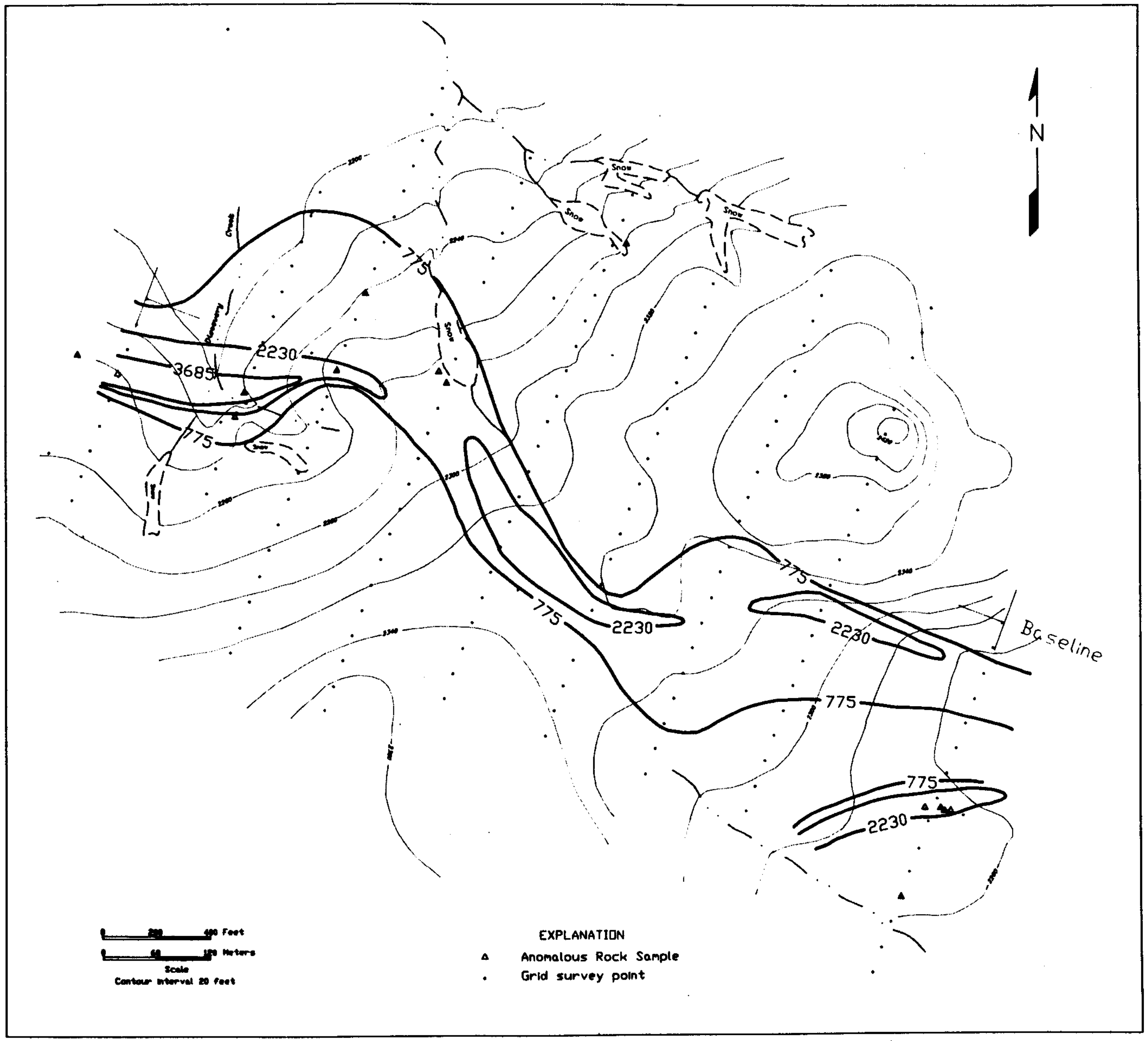


Figure B11. - Drenchwater Grid, Soil Geochem - Lead

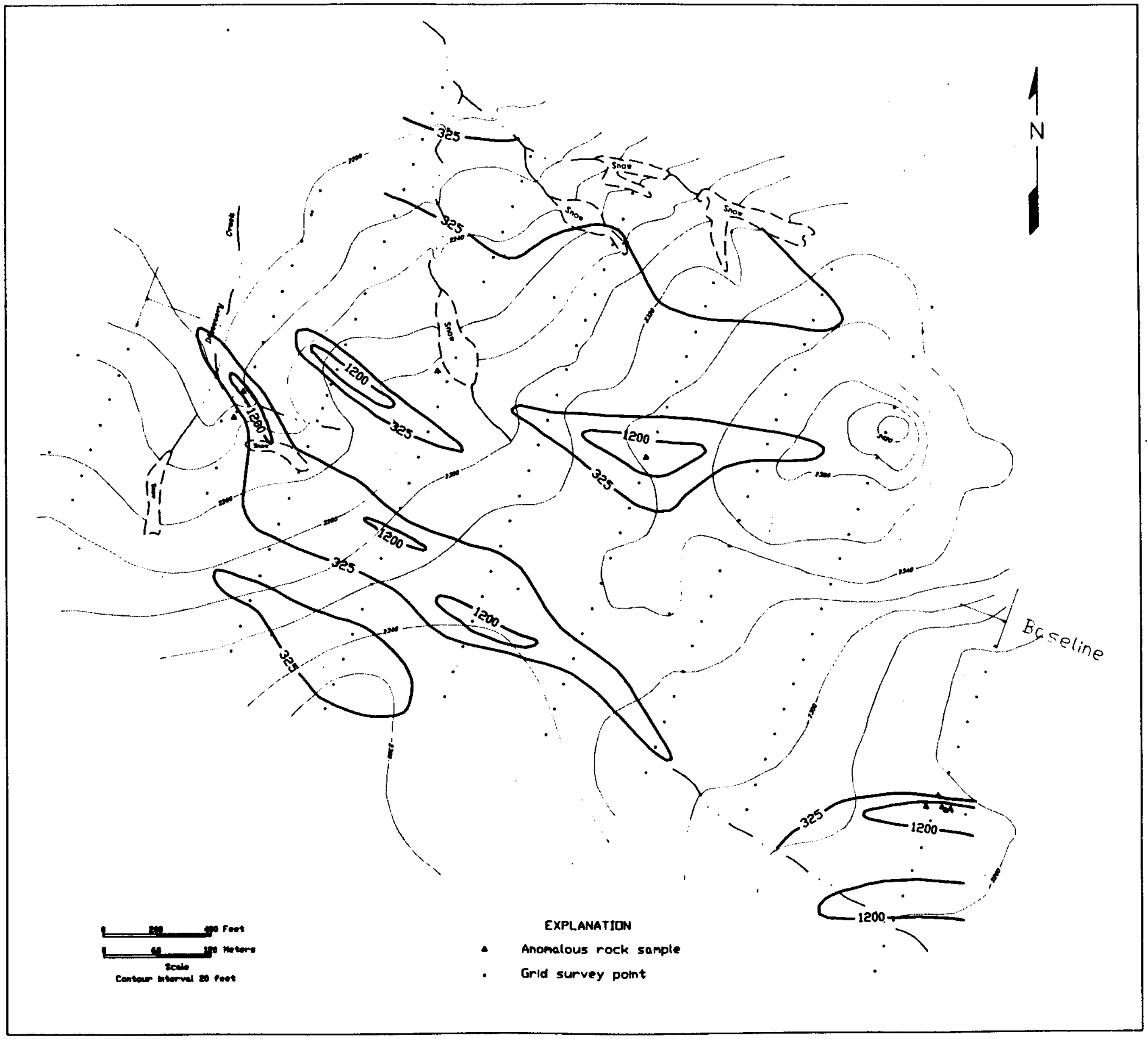


Figure B12. - Drenchwater Grid, Soil Geochem-Zinc

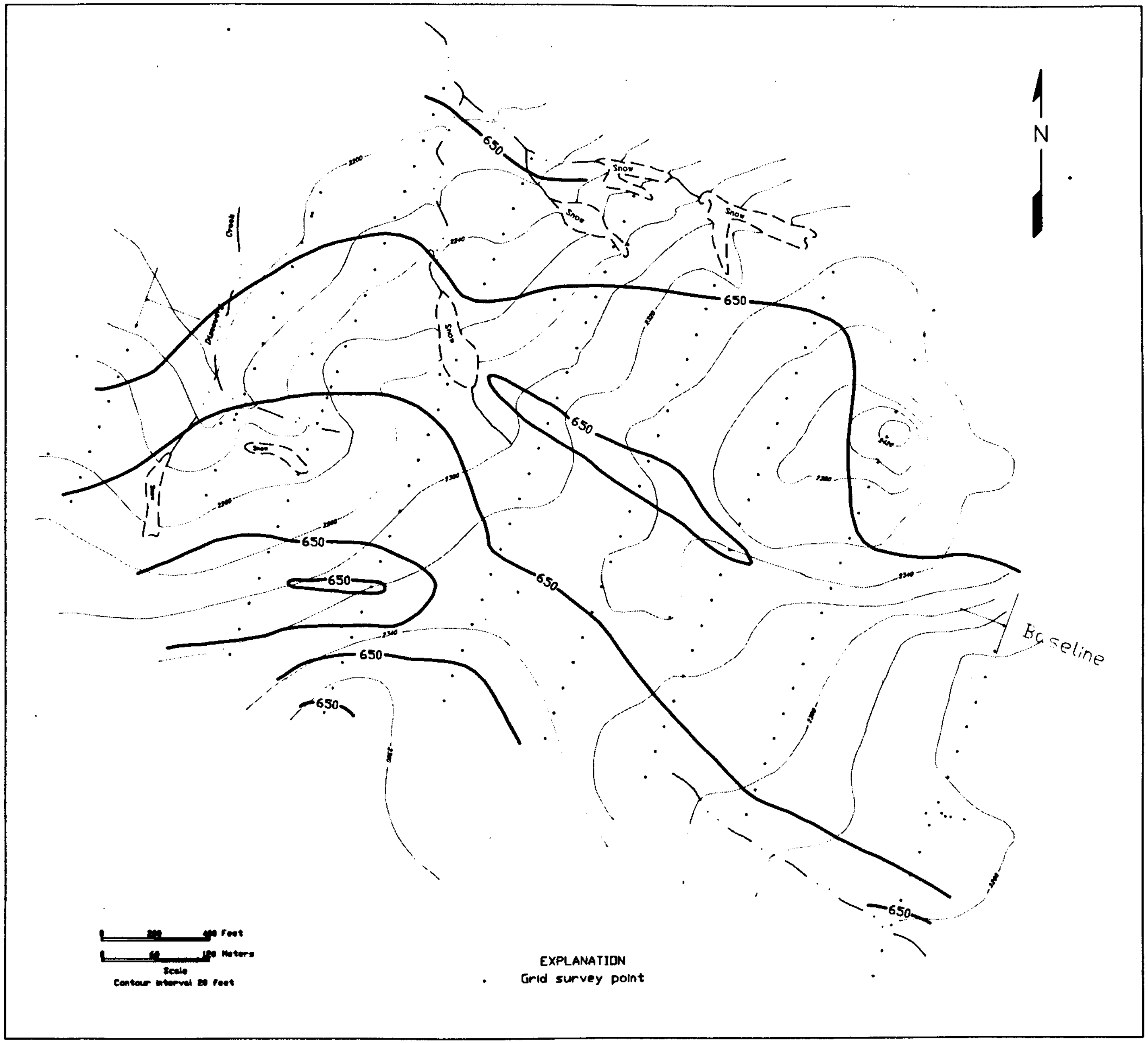


Figure B13. - Drenchwater Grid, Soil Geochem-Barium

Table B3 - Analytical Results - Drenchwater Creek Area, Excluding Geochemical Grid Samples

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
1	5824	Stream sed		Stream sed				<0.5	9	525	<2.0	180	6077	32	240	450
2	5823	Stream sed		Stream sed				<0.5	9	533	<2.0	146	5321	29	218	260
3	5821	Chert brec	Float	Select				<0.5	3	643	<2.0	6	124	6	16	113
4	5820	Chert brec	Float	Select				<0.5	2	719	<2.0	18	686	24	28	50
5	5822	Chert	Outcrop	Repr chip				0.9	11	107	2.7	109	449	9	307	260
6	5722	Chert/mudstone	Rubblecrop	Repr chip				<0.5	2	333	<2.0	35	179	13	17	51
6	5819	Chert	Float	Select				<0.5	6	169	<2.0	33	57	23	106	65
7	5818	Mudstone	Float	Select				8.5	7	101	<2.0	29	28	4815	35	645
8	5815	Chert	Rubblecrop	Select				2.9	7	78	<2.0	<1	19	786	21	16
8	5816	Chert	Rubblecrop	Select				1.3	6	463	<2.0	3	15	458	25	16
8	5817	Chert	Float	Grab				1.9	4	401	<2.0	5	33	451	18	53
9	5709	Mudstone	Outcrop	Select		0.32	0.26	9.8	12	55	11.1	49	74	3261	29	2708
10	5720	Chert	Outcrop	Repr chip		0.02	0.02	1.4	5	27	<2.0	16	75	200	21	181
11	5721	Shale	Rubblecrop	Grab				8.1	10	63	<2.0	14	123	573	104	56
12	5719	Mudstone/chert	Outcrop	Grab				0.9	7	337	<2.0	10	32	74	21	12
13	5734	Stream sed		Stream sed				<0.5	7	81	<2.0	49	373	42	333	131
14	5735	Stream sed		Stream sed				<0.5	12	539	<2.0	168	>20000	37	108	2158
15	5731	Mudstone	Float	Select	203.97	1.89	12.64	>50.0	76	7	292.3	94	424	>10000	11	>20000
16	5733	Shale/chert	Float	Grab				1.9	7	162	<2.0	35	76	80	60	250
17	5732	Felsic volcanic	Outcrop	Repr chip				0.7	2	120	<2.0	6	258	67	41	214
18	5730	Shale	Rubblecrop	Grab				12.2	14	74	<2.0	134	58	12	142	137
19	5728	Chert	Float	Select				<0.5	19	<5	<2.0	28	83	34	19	17
20	5727	Shale	Float	Grab				1.5	6	407	<2.0	45	37	10	83	84
21	5729	Shale	Float	Grab				2.5	8	134	<2.0	14	32	<2	112	34
22	5726	Chert	Float	Grab				2.3	7	618	2.4	53	115	4	39	56
23	5725	Mudstone	Float	Grab				1.1	9	336	<2.0	15	37	10	74	11
24	5825	Chert	Float	Select				3.9	6	177	<2.0	229	145	10	176	397
25	5826	Chert	Float	Select				2.7	7	82	<2.0	51	63	10	104	31
26	5723	Shale	Float	Grab				<0.5	3	953	<2.0	11	44	12	72	17
27	5724	Chert	Float	Grab				0.6	5	1161	<2.0	12	58	6	26	12
28	4042	Arkose/tuff	Outcrop	Grab				<0.5	<1	130	<2.0	11	149	15	36	587
29	5835	Stream sed		Stream sed				<0.5	9	59	<2.0	51	353	33	298	131
30	5834	Siliceous brec	Float	Select				<0.5	3	125	<2.0	<1	46	31	4	233
31	5833	Mudstone	Float	Select				6.3	7	40	<2.0	15	26	55	91	9
32	5832	Mudstone/chert	Float	Select				<0.5	4	118	<2.0	<1	33	139	<2	<2
33	5827	Chert (?)	Float	Select				<0.5	3	74	<2.0	5	37	130	17	7
33	5828	Chert (?)	Float	Select				<0.5	4	189	<2.0	<1	34	27	2	22
33	5829	Stream sed		Soil				12.4	7	98	<2.0	10	26	225	140	12
34	5830	Mudstone	Float	Select				<0.5	2	126	<2.0	8	38	40	3	94
35	4043	Mafic intrusive	Outcrop	Grab				0.5	3	1046	<2.0	95	1146	13	276	132

Table B3 - Analytical Results - Drenchwater Creek Area, Excluding Geochemical Grid Samples (continued)

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
36	5831	Stream sed		Stream sed				<0.5	44	1411	<2.0	77	1863	30	184	386
37	4041	Chert	Outcrop	Grab				<0.5	3	>2000	<2.0	9	276	<2	31	28
38	4039	Felsic intrusive	Float	Grab				<0.5	3	1537	<2.0	9	20	<2	16	13
38	4040	Chert	Rubblecrop	Grab				<0.5	3	>2000	<2.0	24	654	<2	18	51
39	4049	Chert	Outcrop	Random chip				<0.5	2	>2000	<2.0	47	2435	<2	21	150
40	5271	Mudstone	Outcrop	Contin chip		0.03	<0.01	4.3	8	106	<2.0	5	20	254	270	66
41	5241	Mudstone	Outcrop	Select		0.16	5.18	26.5	11	61	179.5	122	103	1726	39	>20000
41	5400	Mudstone	Outcrop	Contin chip		0.20	3.05	14.3	14	47	66.7	35	58	2017	38	>20000
42	5270	Mudstone	Rubblecrop	Random chip		0.11	0.01	3.8	4	45	<2.0	6	15	1099	25	128
43	5242	Mudstone	Rubblecrop	Grab		0.01	0.01	3.0	9	136	<2.0	8	208	98	33	204
44	5243	Mudstone	Outcrop	Contin chip		0.03	0.02	3.2	8	182	<2.0	6	<5	301	43	119
45	5273	Chert	Outcrop	Contin chip		0.05	0.26	4.1	3	154	3	14	103	414	36	2850
46	5272	Mudstone/chert	Rubblecrop	Random chip		0.04	0.03	4.3	6	55	<2.0	16	132	357	207	211
47	5398	Chert	Outcrop	Contin chip		0.08	0.09	4.2	6	147	3.6	22	82	701	53	724
48	5369			Soil				1.4	6	784	<2.0	25	292	121	123	37
49	5399	Chert	Outcrop	Contin chip	335.60	9.66	0.08	>50.0	13	93	<2.0	35	85	>10000	60	770
50	5224			Soil				1.1	5	893	<2.0	37	229	95	116	468
51	5274	Chert	Outcrop	Random chip				4.2	6	180	<2.0	35	51	271	58	51
52	5392	Chert/quartz	Outcrop	Select		2.62	5.14	28.6	6	160	120	39	164	10000	69	20000
52	5393	Quartzite	Outcrop	Contin chip		2.88	10.08	43.2	14	180	258.2	70	258	10000	90	20000
52	5394	Quartzite	Outcrop	Contin chip		0.29	2.79	11.5	8	602	73.8	38	117	3045	157	20000
53	5397	Chert	Outcrop	Contin chip		0.15	0.28	5.8	5	68	8.3	40	35	1355	67	2965
54	5395	Chert	Outcrop	Random chip		0.18	0.60	8.8	8	78	22.7	30	66	1752	64	6635
55	5268	Chert	Outcrop	Contin chip		0.15	0.12	6.4	6	292	4.8	35	49	1534	85	1439
56	5266	Sulfides	Outcrop	Select		0.33	10.04	22.9	18	96	333.8	102	22	3026	20	>20000
56	5267	Sulfides	Outcrop	Contin chip		0.39	8.58	13.5	14	112	247.9	88	90	3761	36	>20000
57	5245	Chert	Outcrop	Random chip		<0.01	0.04	1.1	2	56	<2.0	5	285	4	9	68
58	5250	Chert	Outcrop	Contin chip		0.16	0.14	5.8	6	176	7.6	14	40	1655	35	1630
59	5248	Quartzite	Outcrop	Random chip	181.34	5.46	12.95	>50.0	17	130	679.4	162	120	>10000	21	>20000
60	5328	Quartzite	Rubblecrop	Select	134.72	2.19	4.69	>50.0	12	113	152.9	36	59	>10000	8	>20000
61	5249	Quartzite	Rubblecrop	Random chip	101.47	3.16	2.97	>50.0	15	432	63	35	94	>10000	17	>20000
62	5247	Quartzite	Rubblecrop	Random chip		1.90	9.23	26.4	13	234	130.7	12	16	>10000	11	>20000
63	5326	Quartzite	Float	Grab		1.55	1.97	41.7	15	180	29.3	8	50	>10000	11	19403
64	5324	Chert/quartz	Float	Grab				1.9	3	>2000	<2.0	16	58	346	43	70
65	5322	Chert	Float	Grab				3.8	4	661	<2.0	9	35	349	41	32

PROPERTY SUMMARY

NAME: Ekakevik MAS NO. 0020200023

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:

Quadrangle: Howard Pass C3
NW 1/4, Sec. 36, T. 9S, R. 22W, Meridian: Umiat
Lat. 68 deg. 37' 13" N., Long. 156 deg. 57' 46" W.
Geographic: Ipnavik River drainage, 5.0 km northwest of Ekakevik Mountain.
Elevation: 518 m

GEOLOGIC SETTING:

The Ekakevik occurrence consists of barite and minor witherite, interbedded with Mississippian (?) Lisburne Group chert, shale, and minor limestone (128). These rocks are part of a sequence that strikes northwest and dips south (271).

BUREAU INVESTIGATION:

The Ekakevik occurrence was discovered by the USGS while mapping in the area during the 1950's (276). The Bureau mapped and sampled the occurrence (fig. B14). Since no bedding is exposed at the occurrence, the attitudes used for cross section construction were projected from nearby outcrops (271). Mapping indicates a single barite bed, containing scattered lenses of witherite. The barite bed is estimated to be 20 m-thick and extend for 165 m along strike. Rubblecrop grab samples (5875-5879) averaged 97.1% $BaSO4$ (table B1). Determinations by the USGS indicate an average specific gravity of 3.9 (128). The specific gravitites determined by Bondar Clegg Inc. for the Bureau are lower. A specific gravity of 4.2 is the minimum required for drilling mud. The witherite is probably a secondary product resulting from alteration of the barite. The samples contained no anomalous metal values.

RESOURCE ESTIMATE:

Indicated resource: 2,300,000 mt at 97.1% barite and a specific gravity of 3.9.

MINERAL DEVELOPMENT POTENTIAL:

Low potential as a source of drilling mud, due to the low specific gravity.

RECOMMENDATIONS: None

REFERENCES:

128, 271, 276

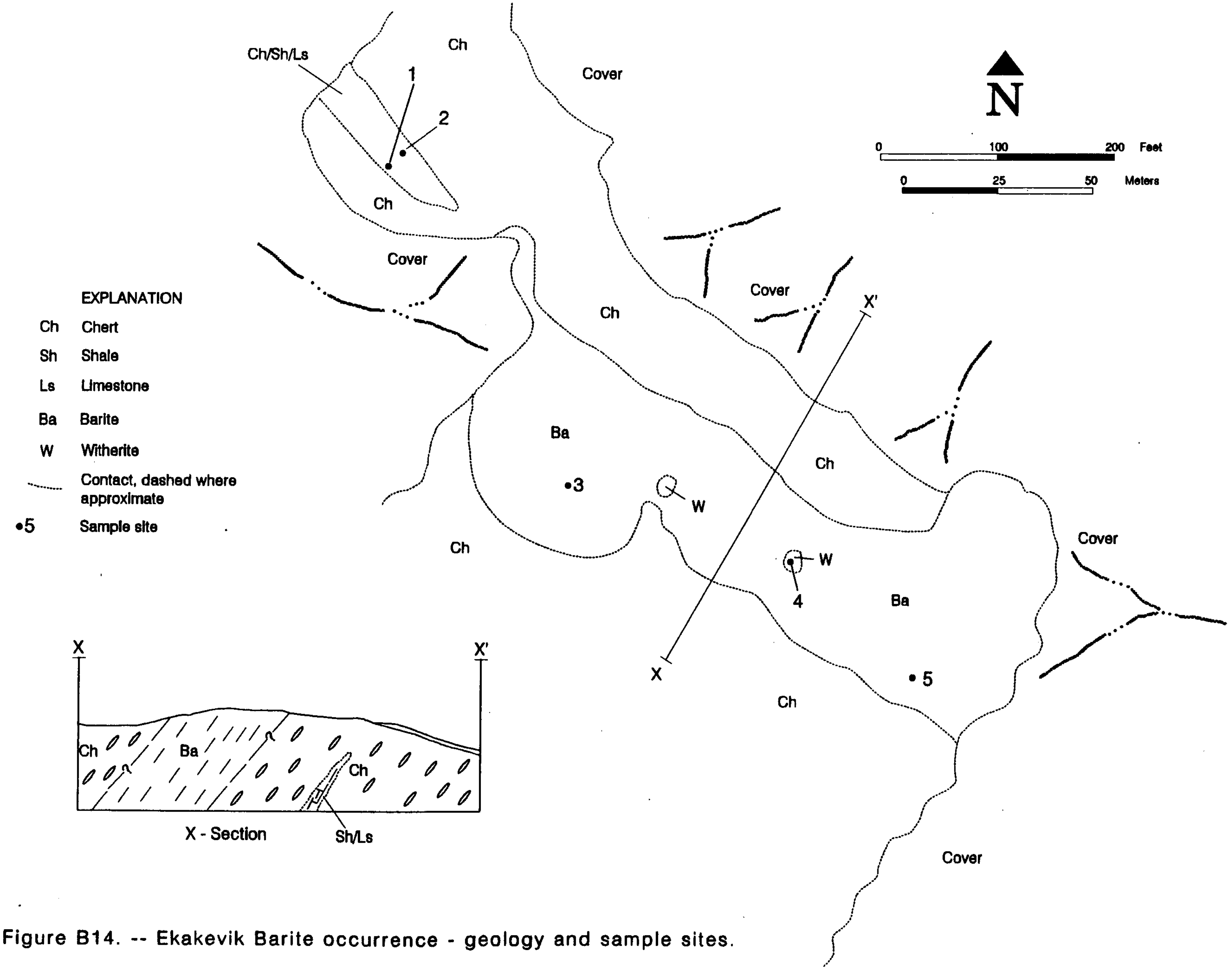


Figure B14. -- Ekakevik Barite occurrence - geology and sample sites.

PROPERTY SUMMARY

NAME: Ipnavik River East MAS NO. 0020200010

DEPOSIT TYPE: Disseminated

COMMODITIES: Zinc, lead, silver

LOCATION:

Quadrangle: Howard Pass B3
SW 1/4, Sec. 9, T. 34N , R. 7E , Meridian: Kateel River
Lat. 68 deg. 21' 20 " N.,Long. 157 deg. 15' 5"W.
Geographic: East side of the Ipnavik River, 0.7 km northeast of Peak 909 m.
Elevation: 670-790 m.

GEOLOGIC SETTING:

Rocks in the area consist of Endicott Group interbedded Kanayut Conglomerate, Noatak Sandstone, Kayak Shale, and mafic igneous rocks. The contact between the other rocks and the Kayak Shale may be faulted. Mineralization occurs in sandstone float and rubblecrop through a saddle which appears to lie on or near the contact between the sandstone and shale (fig. B15).

BUREAU INVESTIGATION:

The Bureau first investigated the Ipnavik River area in 1978, during followup of anomalous stream sediment samples. No signs of mineralization were located at this time (115).
the Bureau returned to the area in 1993 to followup anomalous stream sediment samples collected since the first visit (130). This led to the discovery of scattered occurrences of disseminated sulfides. Sulfides were found at four sites along a 1000 m-long trend through a saddle which appears to lie near the contact between the sandstone and shale (fig. B15). Sulfides consist of disseminated grains of sphalerite with minor galena and pyrite. These occur in gossaneous silicified sandstones that locally contain sphalerite boxworks textures. Select samples of float contained 3,4% zinc and 1920 ppm lead (6005, 6042) (table B4). Sulfide-bearing float was scattered over areas up to 30x30 m.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for sandstone-type lead and zinc deposits, due to low metal content. .

RECOMMENDATIONS:

Drilling to determine lateral and vertical extent of disseminated sulfides. Further prospecting of Endicott Group rocks in the area near the north edge of the Endicott Mountains allochthon.

REFERENCES:

115, 130

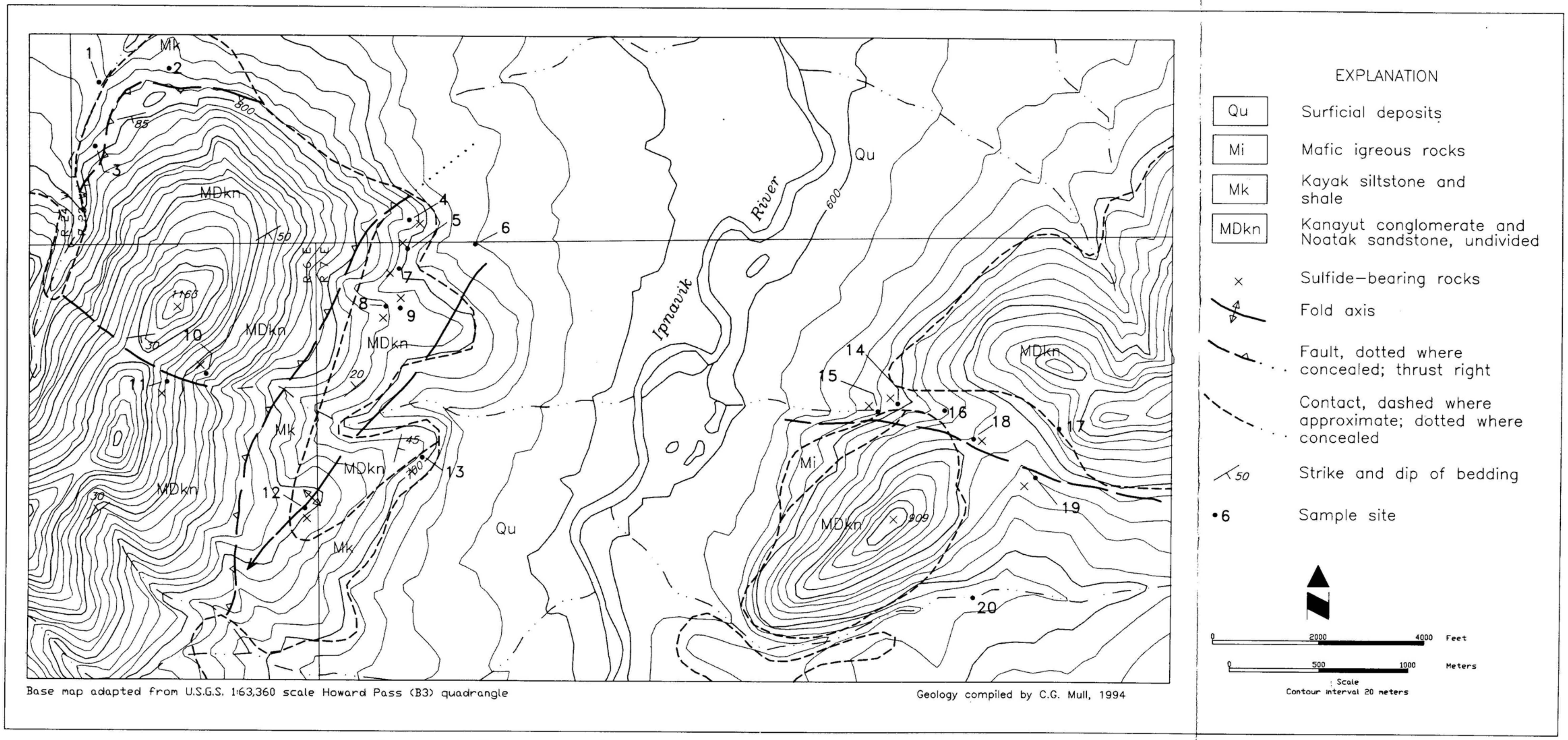


Figure B15. – Ipnavik River East and West – geology and sample sites.

Table B4 - Analytical Results - Ipnavik River and Memorial Creek Occurrences

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
						Memorial Creek									
	6008	Siltstone	Rubblecrop	Grab				0.5	1122	18.8	74	9335	41	79	9423
						Ipnavik River West									
1	6039			Stream sed				<0.5	320	<2.0	30	1460	114	81	415
2	6038	Chert	Float	Select				<0.5	142	<2.0	20	9969	547	17	618
3	6040	Chert	Float	Select				<0.5	216	<2.0	25	8722	166	33	603
4	6036	Sandstone	Rubblecrop	Select	379	32.6	0.03	50.0	29	5.7	138	65	>10000	14	288
5	6035	Sandstone	Float	Select	25	2.7	1.67	25.4	102	66.5	63	43	>10000	22	16334
6	6037			Stream sed				<0.5	384	4.6	30	1157	104	98	783
7	6033	Sandstone	Float	Select	23	2.17	0.26	23.2	263	2.8	81	1198	>10000	46	2640
7	6034	Sandstone	Float	Select				10.4	86	<2.0	13	58	6712	21	86
8	6027	Sandstone	Rubblecrop	Select	8	0.15	2.31	7.3	74	73.8	83	207	1442	22	>20000
9	6028	Sandstone	Rubblecrop	Select	439	36.44	0.02	50.0	37	2.1	99	39	>10000	17	112
9	6029	Sandstone	Float	Select	245	19.26	0.02	50.0	101	<2.0	49	64	>10000	31	128
9	6030	Sandstone	Rubblecrop	Grab				3.5	114	5	14	39	1466	22	1526
9	6031	Sandstone	Float	Select	30	1.84	3.99	29.6	108	167	108	143	>10000	17	>20000
9	6032	Sandstone	Rubblecrop	Contin chip	140	9.46	0.04	50.0	177	<2.0	29	501	>10000	39	438
10	6026	Sandstone	Float	Select				<0.5	182	<2.0	46	309	55	72	2693
11	6001	Ss/conglomerate	Float	Grab				<0.5	264	<2.0	30	494	60	96	2991
12	6002	Ss/conglomerate	Rubblecrop	Select				5.8	105	9.2	3688	428	287	17	3456
13	6003	Shale	Rubblecrop	Grab				<0.5	272	<2.0	53	3814	138	41	761
						Ipnavik River East									
14	6007	Sandstone	Float	Grab				<0.5	890	5.7	673	681	39	76	149
15	6004	Sandstone	Float	Grab				<0.5	764	<2.0	22	68	10	132	455
16	6006	Sandstone	Float	Grab				<0.5	540	<2.0	40	598	29	68	148
17	6045	Shale	Float	Select	1	0.03	0.07	<0.5	141	<2.0	30	815	177	52	471
18	6005	Sandstone	Rubblecrop	Grab			2.74	25.0	68	137.1	104	47	1920	17	>20000
19	6041	Sandstone	Float	Select				0.8	420	<2.0	20	75	418	54	56
19	6042	Sandstone	Float	Select			3.39	19.2	55	84.6	102	461	662	37	>20000
19	6043	Sandstone	Float	Select	9	0.1	0.73	9.5	163	19.3	45	104	918	43	7323
19	6044	Sandstone	Float	Select	2	0.1	<0.01	2.0	237	<2.0	13	38	1012	19	56
20	6046			Stream sed				<0.5	775	<2.0	29	725	32	119	197

PROPERTY SUMMARY

NAME: Ipnavik River West MAS NO. 0020200024

DEPOSIT TYPE: Breccia veins, disseminated

COMMODITIES: Lead, zinc, silver

LOCATION:

Quadrangle: Howard Pass B3
NW 1/4, Sec. 7 , T. 34N , R. 7E , Meridian: Kateel River
Lat. 68 deg. 21' 50" N., Long. 157 deg. 21' 10" W.
Geographic: West side of the Ipnavik River, 1.2 km east of Peak 1163.
Elevation: 726 m

GEOLOGIC SETTING:

Rocks on the west side of the Ipnavik River consist of interbedded Upper Devonian through Lower Mississippian Kanayut Conglomerate, Noatak Sandstone, and Kayak Shale. The sandstone units and the shale appear to be in both stratigraphic and fault contact. Mineralization is associated brecciated, silicified sandstone, which is in stratigraphic contact with tan through brown siltstone and shale of the Kayak Shale. The silicification gives the sandstone a bleached appearence, noticeable from a distance. These rocks have been folded into a southwest-plunging anticline , exposed in an erosional window through an overthrust of Noatak Sandstone and Kanayut Conglomerate. Northwest of the fenster, the conglomerate and sandstone, comprising the Endicott Mountains allochthon, have been thrust over the shale (plate I)(fig. B15).

BUREAU INVESTIGATION:

The Bureau first investigated the Ipnavik River in 1978, but located no mineralization. Sulfide-bearing rocks were discovered by the Bureau in 1993 during followup of stream sediment samples collected since the first visit. Those samples contained up to 1200 ppm zinc and 380 ppm lead (130). Massive, stringer, and disseminated galena along with minor sphalerite and trace chalcopyrite occur in light gray recrystallized and least partially brecciated Noatak? Sandstone. Sulfides are concentrated near a contact with underlying siltstone of what appears to be Kayak Shale. The siltstone may also just be interbeds within the Noatak Sandstone. Select samples from a 3x92 m area of high grade rubblecrop and float contained up to 36% lead, 4% zinc and 439 g/mt silver (6028, 6031) (table B4). A representative chip sample (6032) collected from a 2 m-wide zone of rubblecrop, extending for 6 m along strike, contained 9.5% lead and 140 g/mt silver. A sample of what appeared to be unmineralized silicifed sandstone collected 30 m away from the mineralized area contained 1466 ppm lead and 1526 ppm zinc (6030). This indicates the presence of finely disseminated mineralization in the sandstone.

Less significant shows of sulfides were noted at several other sites within the fenster. These were lower grade and mostly confined to quartz veinlet and fracture fillings in sandstone. A select sample of brecciated sandstone (6002) contained 3688 ppm copper which is the highest copper value for this occurrence. The occurrences within the fenster lie within a 1.8 km-long northeast-trending zone (fig. B15). Sulfides were also found in quartz veinlet-bearing, brecciated, ferruginuous sandstone lying along the projection of a northwest-trending fault west of the main occurrence. Select samples contain up to 2693 ppm zinc (6026). A sample from the shale adjacent to the Kanayut contact contained 761 ppm zinc (6003).

A sample (6028) collected and analyzed for lead isotope ratios produced the following values: Pb206/204 = 18.482, Pb207/204 = 15.586, Pb208/204 = 38.233. These ratios are typical of those for the north half of the western Brooks Range. The model lead age is Mississippian. These values are comparable with Mississippian shale-hosted deposits such as Red Dog, and most other vein occurrences hosted by Devonian conglomerate and sandstone. If the galena at this occurrence was emplaced in Mesozoic time, the pre-existing (Mississippian) sulfide lead is the probable source (314). Lack of outcrop make it difficult to determine the configuration of the sulfide-bearing zones. It appears that the highest concentration of galena and sphalerite are in silicified Kanayut Conglomerate near the contact with underlying siltstone. Sulfides also occur in the Kanayut away from the thrust contact, as fracture fillings and associated with quartz veinlets.

<u>RESOURCE ESTIMATE</u>: None

<u>MINERAL DEVELOPMENT POTENTIAL</u>:

Moderate potential for small high-grade lead, zinc, and silver veins. Low Potential for sandstone-type disseminated lead-zinc deposits.

<u>RECOMMENDATIONS</u>:

Drilling of occurrence to test downward and lateral extension of massive sulfides. Further prospecting of thrusted Kanayut Conglomerate and Kayak Shale contacts in the Endicott Mountains Allochthon for other vein occurrences. Prospecting of Kanayut Conglomerate for sandstone-type lead-zinc deposits.

<u>REFERENCES</u>:

115, 130, 314

PROPERTY SUMMARY

NAME: Kivliktort East MAS NO. 0020200013

DEPOSIT TYPE: Vein breccia

COMMODITIES: zinc, lead, silver

LOCATION:

Quadrangle: Howard Pass A1

SE 1/4, Sec. 13 , T. 33N , R. 10E , Meridian:
Lat. 68 deg. 15' 28" N., Long. 156 deg. 26' 40"W.
Geographic: Southeast side of Kivliktort Mountain, 4 km from the summit.
Elevation: 808 m

GEOLOGIC SETTING:

Sedimentary rocks in the southern Kivliktort Mountain area consist of Devonian Noatak Sandstone overlain by the Kanayut Conglomerate. In some areas the Noatak has been thrust over the Kanayut. Sulfide-bearing quartz vein and quartz-cemented sandstone breccia are associated with one of the thrust fault contacts (plate I).

BUREAU INVESTIGATION:

The area was first examined by the Bureau in 1978 during followup of anomalous geochemical samples. Pyritiferous graphitic quartzite was found in and unamed drainage, but samples, contained no significant metal values (115). In 1990, mineralized quartz-cemented sandstone breccia float was found in the stream bottom. A select sample (4015) contained 19.6% zinc, 1062 ppm cadmium, and 394 ppm copper (table B5). Quartz veinlet-bearing sandstone and quartz-cemented sandstone breccia were also located in rubblecrop and float at the 808 m-level on the west side of a small southerly tributary to the main drainage. A select sample (5433) contained 4.3% lead, and 82.6 gm/mt silver. The sulfide-bearing rubblecrop and float are confined to a 5x15 m area. In a saddle at the head of the anomalous drainage, a grab sample of iron-stained conglomerate rubblecrop contained 0.4% zinc (4007)

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for zinc, lead and silver-bearing vein breccias. Unknown potential for disseminated sulfide deposits.

RECOMMENDATIONS:

The vein breccia portions of this occurrence are small and low grade with little potential for large tonnage resources. Further work is recommended to determine significance and extent of sulfide-bearing sandstone.

REFERENCES:

115

Table B5 - Analytical Results - Kivliktort Mountain East and West Occurrences

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
Kivliktort East																
	4007	Conglomerate	Rubblecrop	Grab		0.03	0.44	2.5	6.0	288	<1.0	23	6500		88.0	
	4008	Alluvium	Stream	Placer		0.04	0.06	1.9	4.0	396	<1.0	38	4500		127.0	
	4015	Massive sulfides	Float	Grab	14.7	0.07	19.57	15.7	220.0	132	1062	394	200		25.0	
	5433	Sandstone	Float	Select	82.6	4.31	0.12	>50.0		184	2.4	168	69	>10000	34.0	518
Kivliktort West																
1	5434	Sandstone	Float	Select	360.0	0.25	14.03	>50.0	35	336	888.5	243	20	2300	16	>20000
1	5551	Sandstone	Outcrop	Select	54.5	3.22	0.09	43.1	17	>2000	4.2	26	72	>10000	14	1255
2	5436	Sandstone	Float	Select	2.4	0.11	0.16	2.5	3	>2000	5.8	4	48	733	12	1467
3	5438	Sulfides	Float	Select	143.0	0.06	54.71	>50.0	96	90	>2000	535	10	607	3	>20000
4	5437	Sandstone	Float	Select	94.0	0.69	15.13	>50.0	50	311	946.4	138	19	7486	7	>20000
4	5552	Sandstone	Float	Grab	45.9	1.07	2.74	42.5	29	1620	147.8	46	25	>10000	15	>20000
5	5440	Sandstone	Outcrop	Select	2.4	0.09	0.20	2.5	3	>2000	9.9	6	154	817	16	2311
6	5602	Massive barite	Float	select	0.7	0.03	0.07	0.6	1	>2000	2.6	36	29	166	10	1036
7	4012	Massive sulfides	Rubblecrop	Grab	206.1	2.08	15.82	>50.0	131	172	730.0	171	<100		21	
7	4013	Massive sulfides	Rubblecrop	Select	149.2	2.76	31.50	>50.0		87	1712	328	<100		13	
7	4014	Massive sulfides	Float	Grab	58.3	1.58	7.36	>50.0	94	358	394.0	100	<100		24	
8	5441	Sandstone	Float	Select	102.2	1.54	9.34	>50.0	65	378	582.9	160	22	>10000	13	>20000
9	5442	Sandstone	Float	Select	117.3	1.14	12.99	>50.0	124	267	798.9	284	19	>10000	8	>20000
10	5555	Sandstone	Float	Select	56.2	1.31	4.11	49.7	53	895	188.6	105	14	>10000	20	>20000
11	5553	Sandstone	Float	Select	7.5	0.41	4.34	6.9	17	921	187.6	77	30	4328	14	>20000
12	5601	Sandstone	Rubblecrop	Select	203.7	0.49	31.42	>50.0	13	510	1009.3	30	24	4949	11	>20000
13	5554	Sandstone	Float	Select	12.0	0.20	0.38	9.0	17	>2000	15.1	90	28	1814	14	3830
14	5435	Sandstone	Float	Select	346.7	0.10	23.50	>50.0	10	179	999.7	71	18	867	15	>20000
15	5439	Sulfides	Float	Select	261.6	0.72	34.60	>50.0	35	141	1594.6	165	21	7996	<2	>20000

PROPERTY SUMMARY

NAME: Kivliktort Mountain West   MAS NO. 0020200003

DEPOSIT TYPE: Vein breccia, disseminated

COMMODITIES: Zinc, lead, silver

LOCATION:

Quadrangle: Howard Pass B2
E 1/2, Sec. 31, T. 34N, R. 10E, Meridian: Kateel River
Lat. 68 deg. 17' 48"N., Long. 156 deg. 38' 15" W.
Geographic: 5 km northwest of Kivliktort Mountain.
Elevation: 640-730 m

GEOLOGIC SETTING:

Clastic units of the Upper Devonian to Lower Mississippian Endicott Group comprise the stratigraphic section in the Kivliktork Mountain area (plate I). Mineralizations is concentrated mainly within gray, fine to medium grained, massive to crossbedded sandstone of the Kanayut Conglomerate which locally contains minor shale and coal-bearing beds. Minor amounts of mineralization also occur within red-brown, fine grained, carbonate cemented, interbedded sandstones, siltstones, and phyllitic shales. These rocks were originally mapped as Kayak Shale, but in reality may be a lateral facies equivalent. This equivalent has been tenatively termed the Isikut Formation (183) or False Kayak Shale (56). This new unit is also characteritized by mudchip conglomerates and limonite concretions. To save confusion, the name Kayak Formation will be used here.

Mineralization is concentrated within a structurally disturbed zone at the base of Kivliktort Mountain (fig. B16). This zone marks the position of a major, southeast-dipping, low angle thrust fault or detachment surface. The surface separates Endicott Group rocks in both the upper and lower thrust plates. A northwest-trending creek flows through the mineralized area and the structural style is different on opossite sides of the creek. Therefore, the creek may be the surface expression of a high-angle fault, perpendicular to the thrust fault. On the east side of the creek, numerous bedding-plane type thrust faults occur along incompetent shale and coal interbeds within the Kanayut Conglomerate. Numerous repeated sections of the Kayak Shale and Kanayut Conglomerate are present as well. On the west side of the creek, a large thrust plate of gray sandstone of the Kanayut Conglomerate structurally overlies red-brown siltstone and sandstone of the Kayak Formation (fig. B17). The gray sandstone units on both sides of the creek have been extensively silicified, faulted, and brecciated.

Mineralization occurs in four different textural varieties. These include breccia, vein, replacement, and disseminated type sulfides. Mineralized sandstone and siltstone breccia are readily recognizable in the field by their distinctive bleached appearance on weathered surfaces. These breccias are spatially related to thrust fault surfaces both on the east and west sides of the creek. They are composed of large (up to 5 cm) angular clasts of sandstone, siltstone, and locally sphalerite in a matrix of small sandstone fragments and sand, derived from ground up host rock. The matrix is cemented mainly by quartz along with sphalerite and galena locally. Where grinding of the host rocks is less intense, there is no matrix component and the breccia is cemented by quartz.

The mineralized breccias take on a vuggy appeanence where voids are left after dissolution of clasts of sphalerite during weathering. Barite is present in later veins which cut the thrust-related breccias. Vein type sphalerite occurs in Kanayut sandstone rubblecrop along the banks of the creek near the contact between the Kanayut and underlying Kayak siltstone. Locally up to fist-sized pieces of sphalerite can be found. In some of the thrusted sandstones containing organic material, sphalerite appears to have replaced some of the organic material. Disseminated sphalerite occurs locally in pore spaces within the Kanayut sandstone.

Although the float and rubblecrop nature of the occurrence limits the interpretation of the genesis of the mineralization, reconstruction of partial cross-cutting relationships of different textures can be noted. The presence of disseminated sphalerite mineralization in mixed continental-marine rocks suggests a sandstone-type lead mineralizing environment. Organic material in the section is present as coal and as an unidentified species disseminated in the Kanayut sandstone as a cement. Sulfides are found replacing coaly beds and other organic and other organic material throughout the section. This suggests that organic material acted as a reductant for mineralizing fluids. In the sandstone lead deposits of Sweden, there is a strong concentration of galena around shale fragments, indicating that galena was nucleated on clays and/or organic material (6).

Structural deformation may have remobilized metals from the metal-enriched sandstone lead-type of deposit and deposited them in structural breccias and along faults and fractures. The rocks in the region as a whole are cut by numerous barren quartz veinlets. These were later followed by veins with quartz and the sulfides remobilized from the sandstone. The brittle fracturing of the Kanayut resulted in the formation of host rock breccias. The timing of the brecciation postdates both these veining events as shown by the fact that breccia clasts contain quartz veinlets and clasts of vein-type sphalerite.

Late barite mineralization crosscuts all previous deformation and sulfide textures. The lead isotope ratios of the breccia mineralization may have been altered by contamination with fluids migrating up from the underlying detachment surface. Carbonate minerals are present in some fractures, but any relationship to mineralization is unknown.

A sample of quartz-cemented silstone breccia, containing sphalerite fragments and fine-grained galena in the matrix was analyzed for lead isotopic ratios (4013). Lead isotope values are; Pb 206/204 = 18.632, Pb 207/204 = 15.617, and Pb 208/204 = 38.353. These ratios are roughly compatible with a three-stage Brooks Range growth curve, though more radiogenic than those previously previously published (31). This would indicate a remobilized nature for the breccia-type mineralization.

Using Comminco Alaska 206/204 and 207/204 plots, a Mississippian to Pennsylvanian model lead age is indicated. This states the age of the lead and not necessarily the age of the mineralization. A detailed comparison shows the lead isotope ratios to be more radiogenic than other samples from the north side of the western Brooks Range, but closest in composition to the galena-bearing Kayak Shale concretions (see Cockedhat Mountain Occurrence). A possible explanation of the values would involve recycling of dominantly sulfide lead and subordinate non-sulfide lead from the Kayak Shale (314).

BUREAU INVESTIGATION:

The area was first examined by the Bureau in 1978 during followup of an anomalous stream silt sample collected from the northwest-southeast-trending stream that cuts through the middle of the map area. Highly mineralized cobbles containing up to 30.5% zinc were found in the stream bottom, but no bedrock source was located at that time.

In 1990, continued followup led to the discovery of sulfide-bearing bleached, vuggy sandstone and siltstone breccia in frost boils and rubblecrop at the base of a small fenster of Kanayut sandstone overlying Kayak siltstone 500 m southwest of the creek (fig. B17). Select rubblecrop samples contain up to 31.5% zinc, 2.8% lead, and 206.1 g/mt silver (4012-4013) (table B5). Sphalerite occurs as breccia fragments up to 1 cm in size and as fine grained matrix with minor galena fragments. The sulfides appear to be centered around the overturned nose of an antiform within the klippe. This site forms the southwest end of a northeast-trending 760 x 1280 m area that contains sulfide mineralization and straddles both sides of the creek, expressed in part by the bleached appearence of the rocks.

Rubblecrop along the sides of the creek contained massive vein type occurrences of sphalerite. Select samples contained up to 34.6% zinc, 0.72% lead, 1594 ppm cadmium, and 261.6 g/mt silver (5439). Samples of breccia from frost boils found 400 m northeast of the creek contained up to 54.7% zinc, 0.06% lead, 535 ppm copper, >2000 ppm cadmium, and 143 g/mt silver (5438).

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential for zinc-lead-silver deposits in vein breccias.

Low potential for sandstone-type, disseminated lead and zinc deposits.

RECOMMENDATIONS:

Prospecting of Kanayut Conglomerate, Noatak Sandstone, and Kayak contacts near the north edge of the Endicott Mountains allochthon for vein breccia and disseminated occurrences.

REFERENCES:

6, 30, 31, 56, 115, 235, 314

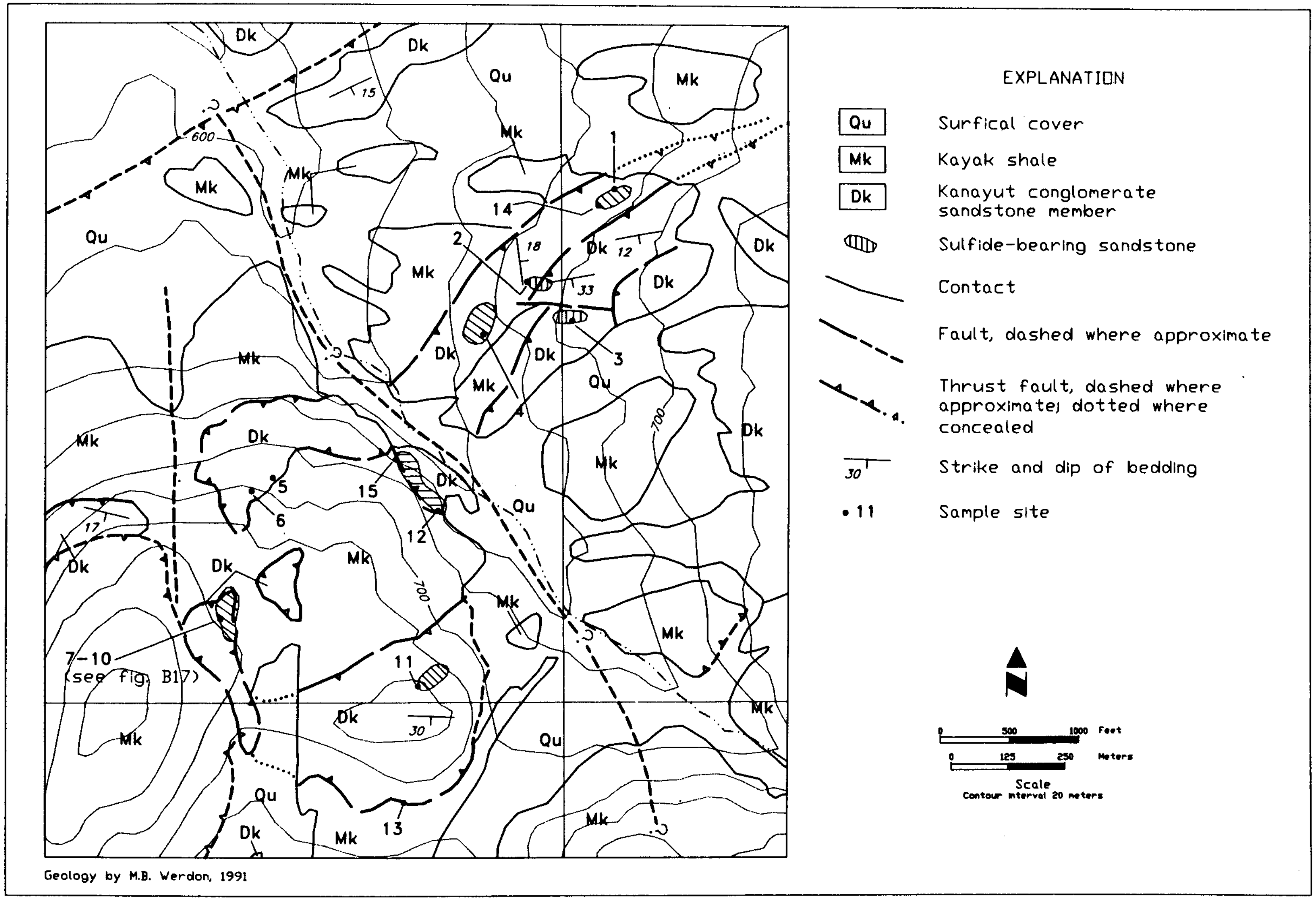


Figure B16. - Kivliktort Mountain west - geology and sample sites.

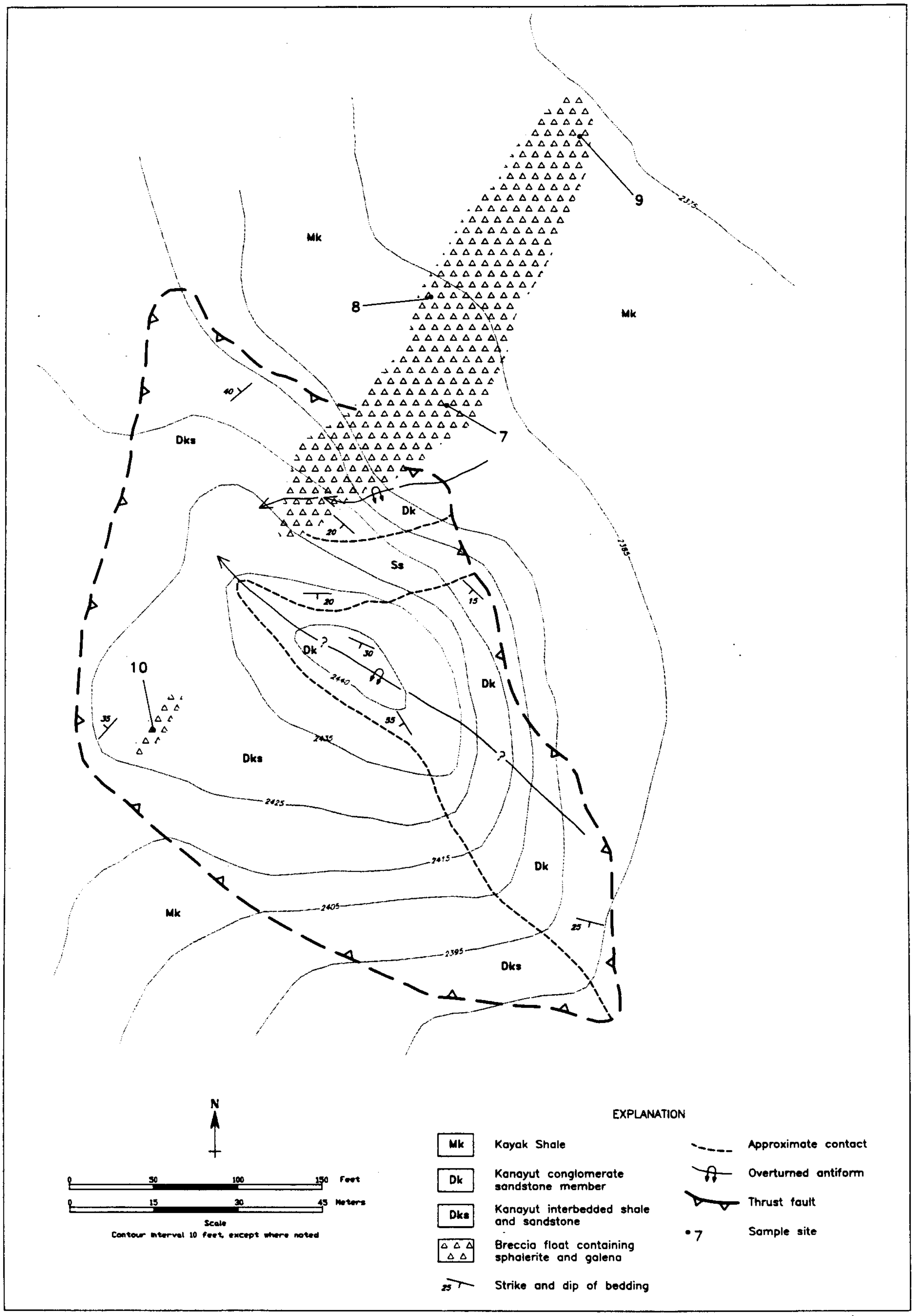


Figure B17. — Detail—Kivliktort Mountain West occurrence.
(see figure B16 for location)

PROPERTY SUMMARY

NAME: Koiyaktot Mountain East **MAS NO.** 0020200014

DEPOSIT TYPE: Vein breccia

COMMODITIES: Lead, zinc, silver

LOCATION:

Quadrangle: Howard Pass A1
NE 1/4, Sec. 9, T. 32N, R. 12E, Meridian: Kateel River
Lat. 68 deg. 11' 20" N., Long. 156 deg. 8' 15" W.
Geographic: Northeast side of Koiyaktot Mountain, 7 km north of Etivluk Lake.
Elevation: 800-860 m

GEOLOGIC SETTING:

Sedimentary rocks in the Koiyaktot Mountain area consist of a repetitive sequence of northwest-trending, southwest dipping interbedded Devonian Kanayut Conglomerate and Noatak Sandstone. The repetitive section is the result of a series of thrust faults that cut the sequence (plate I). Sulfide-bearing quartz veins and quartz cemented breccia are hosted in siltstone within Noatak Sandstone, which is in stratigraphic contact with overlying Kanayut Conglomerate.

BUREAU INVESTIGATION:

The Bureau first investigated the area in 1978, finding galena as fracture fillings and disseminations in sandstone float during followup of an anomalous stream silt sample (115). In 1991 sulfide-bearing quartz veinlets and quartz cemented sandstone breccia were found as rubblecrop and float in frost boils in a north-south trending zone. Pieces of massive sphalerite and galena were found locally (172). Samples of massive sulfide rubblecrop contained up to 39.9% lead (4128) 23.9% zinc, 1404 ppm cadmium, and 1838 g/mt silver (4116). Iron-stained water seeps were observed in the gully bottom at this site. A sample of quartz-cemented siltstone breccia float contained 1376 ppm copper (5565) and a sample of massive sulfides contained >2000 ppm antimony (4059) (table B6). The extent of the float and rubblecrop is unknown.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low development potential for lead, zinc, and silver veins, due to small size of occurrence.

RECOMMENDATIONS:

Prospect surrounding area for more and possibly larger vein breccia occurrences.

REFERENCES:

115, 172

Table B6 – Analytical Results – Koiyaktot Mountain East and West Occurrences

Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	Sb ppm	V ppm	Zn ppm
							Koiyaktot East									
4059	Massive sulfides	Rubblecrop	Grab	1163	37.04	21.86	>50.0	4	24	1131	389	24	>10000	>2000	<2	>20000
4060	Massive sulfides	Rubblecrop	Select	537	15.32	16.35	>50.0	5	22	856	503	28	>10000	507	8	>20000
4061	Massive sulfides	Rubblecrop	Select	345	14.78	9.31	>50.0	2	17	614	382	28	>10000	446	4	>20000
4062	Massive sulfides	Rubblecrop	Select		3.38	0.22	47.8	84	74	11	818	402	>10000	57	34	2323
4115	Sandstone	Float	Select		<0.01	0.07	6.1	3	158	<2.0	13	6465	153	<5	88	637
4116	Massive sulfides	Rubblecrop	Select	1838	31.40	23.94	>50.0	81	11	1404	430	161	>10000	1344	3	>20000
4118	Sandstone	Float	Grab				1.3	1	74	<2.0	4	30	105	<5	26	87
4128	Massive sulfides	Float	Grab	960	39.89	0.10	>50.0	109	45	7.0	875	50	>10000	290	15	906
4129	Massive sulfides	Float	Grab	142	6.65	0.03	>50.0	58	118	2.3	437	51	>10000	66	25	300
5565	Quartz vein	Float	Grab	127	7.49	0.55	>50.0	101	69	25	1376	242	>10000	20	29	6015
							Koiyaktot West									
4009	Massive sulfides	Rubblecrop	Grab	256	0.79	49.91	>50.0		8	1679	204	<100		404	2	
4010	Massive sulfides	Outcrop	Select		0.83	0.53	10.5	12	200	13	6	6300		<5	103	
4025	Massive sulfides	Rubblecrop	Select	105	0.25	13.19	>50.0		167	687	531	<100		147	12	
4026	Massive sulfides	Rubblecrop	Select	19.2	1.55	2.41	21.0	52	400	81	41	<100		16	28	
4119	Sandstone	Outcrop	Grab				<0.5	<1	179	<2.0	7	752	<2	<5	36	37
4120	Sandstone	Outcrop	Grab				<0.5	1	65	<2.0	2	7370	<2	<5	33	35
5459	Sulfides	Float	Select	245	3.27	43.90	>50.0	108	11	1274	404	20	>10000	402	<2	>20000
5460	Quartz vein	Float	Select	23.7	0.41	0.07	19.3	72	106	2.5	140	38	3764	34	19	1136
5461	Quartz vein	Float	Select	6.52	0.22	0.24	7.1	16	169	6.1	55	230	2071	24	29	2428
5462	Sandstone	Float	Select	4.80	0.07	0.13	3.8	6	198	7.4	21	13	502	25	33	868
5464	Gossan	Float	Select	64.5	0.03	16.24	>50.0	336	219	782	652	35	377	144	11	>20000
5605	Quartz veins	Float	Select	24.3	1.56	1.19	22.1	11	200	47	131	269	>10000	36	46	12029

PROPERTY SUMMARY

NAME: Koiyaktot West MAS NO. 0020200015

DEPOSIT TYPE: Vein breccia

COMMODITIES: Zinc, lead, silver

LOCATION:

Quadrangle: Howard Pass A1
NW 1/4, Sec. 34 , SW1/4 Sec. 35, T. 33N , R. 11E , Meridian:
Lat. 68 deg. 13'00" N.,Long. 156 deg. 17' 30" W.
Geographic: North end of Koiyaktot Mountain, 6.8 km northeast of Inyorurak Pass.
Elevation: 896 m

GEOLOGIC SETTING:

Rocks in the Koiyaktot Mountain area consist of a repetitive sequence of northwest-trending, southwest-dipping interbedded Devonian Kanayut Conglomerate and Noatak Sandstone. The repetition of the section is the result of a series of thrust faults that cut the sequence (plate I). Sulfide-bearing quartz vein stockworks and quartz-cemented sandstone breccia occur within the Noatak Sandstone near the projected trend of one of the thrust faults.

BUREAU INVESTIGATION:

The area was initially investigated by the Bureau in 1978. At that time followup of an anomalous stream silt sample led to the discovery of galena-bearing float in a northwest draining canyon (Jansons and Parke, 1981).

In 1990, at the head of the drainage investigated, the Bureau located a 2x9 m northwest trending zone of quartz-cemented sandstone breccia float and rubblecrop that contained sphalerite and galena. Fist-size pieces of solid sphalerite cut by quartz and galena
veinlets were found in float. Select samples contained up to 49.9% zinc, 0.72 % lead, and 256 g/mt silver (4009) (table B6). Further examination by the Bureau in 1991 enlarged the area of sulfide-bearing float to 15x90 m. A select sample contained 43.9% sphalerite, 3.27% lead, and 404 ppm copper (5459). A single piece of sulfide-bearing float was located 400 m south of this site (5460).

An area of sulfide-bearing rubblecrop and float similiar in size to that at (5459) was located 950 m to the north across a gully and sampled (5605). A 15x152 m quartz vein stockwork and quartz-cemented sandstone breccia zone was located 320 n north of (5605). It trends northeast, crossing the divide to the East side of Koiyaktot Mountain and probably represents a mineralized fault or shear zone. Sphalerite and sphalerite boxworks were found associated with the quartz and locally fist-sized pieces of massive sphalerite were found in float. Select samples of float (5464) contained up to 16.2 % zinc, 64.4 g/mt silver, and 336 ppb gold.

These four separate mineralized sites all lie within a 1.2 km-long, north-south trending, intermittant mineralized zone. The breccias that contain the quartz and sulfides probably formed faulting.

RESOURCE ESTIMATE:

These mineralized areas are small and isolated, having little potential for large scale resources.

MINERAL DEVELOPMENT POTENTIAL:

Low development potential for zinc and silver, due to small size of occurrences.

RECOMMENDATIONS:

Prospect extensions of the mineralized zone for larger vein breccia occurrences in sandstones of the Endicott Group.

REFERENCES:

115

PROPERTY SUMMARY

NAME: Lakeview MAS NO. 0020200028

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:

Quadrangle: Howard Pass C3
NE 1/4, Sec. 3, T. 10S, R. 24W, Meridian: Umiat
Lat. 68 deg. 36' 23" N., Long. 157 deg. 28' 40" W.
Geographic: Cutaway Basin, 200 m northeast of lake 573 m
Elevation: 590 m

GEOLOGIC SETTING:

Stratiform barite deposits in the Cutaway Basin area are hosted by Middle Osagean to Early Meramecian (early to late Mississippian) sedimentary rocks of the Endicott Mountains allochthon, exposed in the Cutaway Fenster (fig. B2) (93) (128). The Lakeview occurrence consists of a single barite bed, from 7.6 m to 18.3 m thick and traceable for 427 m along a northeast trend. The barite is interbedded with black cherts and minor tuffaceous volcanics? with an average dip of 66 deg. southeast.

BUREAU INVESTIGATION:

Barite was noted in the Cutaway Basin area by USGS geologists while geologic mapping during the 1950's (271). Continued prospecting in the area by both USGS and Bureau geologists led to the joint discovery of several barite bodies, including the Lakeview occurrence. During a brief visit, a brunton and pace map was made and samples collected (fig. B18). A grab sample (5865) of rubblecrop across a barite exposure with a 7.6 m stratigraphic thickness contained 95.8% barite at a specific gravity of 4.0. A minimal specific gravity of 4.2 is required for use as drilling mud (209). Grab samples contained up to 96.7% barite (5866) ((table B1). This occurrence could be part of the same barite bed exposed at the Longview Occurrence, 800 m to the northeast. The rocks between the two are mostly tundra-covered. This indicates that a continuous barite bed up to 2 km long, could be present in the area.

RESOURCE ESTIMATE:

Inferred resources: 3,800,000 tonnes with an average specific gravity of 4.13.

MINERAL DEVELOPMENT POTENTIAL:

low potential for use as drilling mud, as the specific gravity is below industry requirements.

RECOMMENDATIONS:

Gravity survey to determine extent of barite under tundra-covered areas, followed by test drilling.

REFERENCES:

93, 128, 209, 271

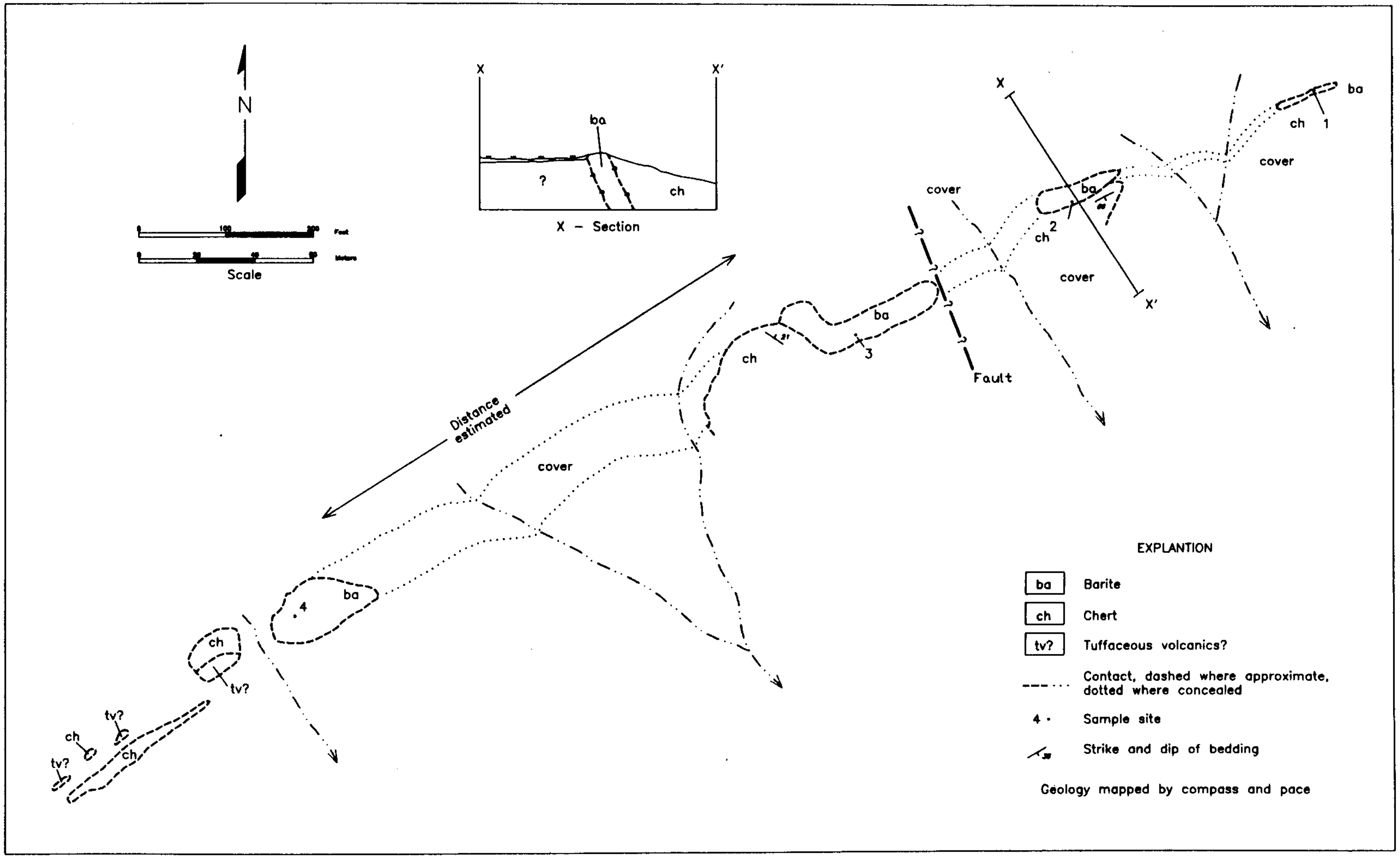


Figure B18. –– Lakeview barite occurrence – geology and sample sites.

PROPERTY SUMMARY

NAME: Lisburne Ridge MAS NO. 002020004

DEPOSIT TYPE: Sedimentary phosphate

COMMODITIES: Phosphate, uranium, vanadium, zinc

LOCATION:
Quadrangle: Howard Pass C2
N 1/2, Sec. 26 and NW1/4 Sec.32, T.9S, R.21W , Meridian:
Lat. 68 deg. 38' 06" N.,Long. 156 deg. 05' 45" W.
Geographic: Near headwaters of Blankenship Creek, near west end of Lisburne Ridge.
Elevation: 500-760 m

GEOLOGIC SETTING:

The core of Lisburne Ridge is made up of interbedded chert and dolomite of the Upper Mississippian Lisburne Group. Overlying the Lisburne and poorly exposed on both sides of the ridge are shales and siliceous beds of the Permian Siksikpuk and mid Triassic through Jurassic Otuk Formation. This sequence is folded into an anticline which is overturned to the north (Fig. B19). Phosphate in concentrated in oolite and Pellet-bearing phosphorite beds from 2.5 to 15.5 cm thick, interbeded within poorly exposed carbonaceous black shale on the south side of the ridge at the stratigraphic top of the Lisburne Group. The pellets range from <1 to at least 6 mm in diameter (214).

BUREAU INVESTIGATION:

The Bureau examined the area in 1978, 1990, and again in 1992 before locating phosphatic rocks. This was due to the poorly exposed nature of the phosphorites. They are detectable with a scintillometer, due to an anomalous uranium content. This instrument proved a very useful tool for prospecting as with it phosphorites could be located in and/or traced through areas of tundra cover. The Phosphorites range from 2.5 to 15.5 cm thick and occur mostly as rubblecrop and float, associated with carbonaceous shale. The phosphorites and adjacent rocks are often stained by a characteristic blue-gray oxide coating (phosphate bloom). The higher-grade beds are located on the south side of Lisburne Ridge, and traceable in limited exposures for up to 5 km along a northwest strike direction.Select samples of the phosphorites contained up to 29.2% phosphate (5806) (table B7) and a series of five samples averaged 24.3% phosphate. Samples of the shale adjacent to the phosphorites, contained >2,000 ppm vanadium and 1695 ppm zinc (5805). Samples of the phosphorite contained up to 94 ppm uranium (5806).

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential as source of commercial phosphate. Grades are high, but phosphorite beds are too thin.

RECOMMENDATIONS:

Using a scintillometer, prospect for phosphorites on south side of Lisburne Ridge. Also follow eastern extension of Lisburne Group rocks. Thicker beds than those previously located, may exist.

REFERENCES:

215, 271

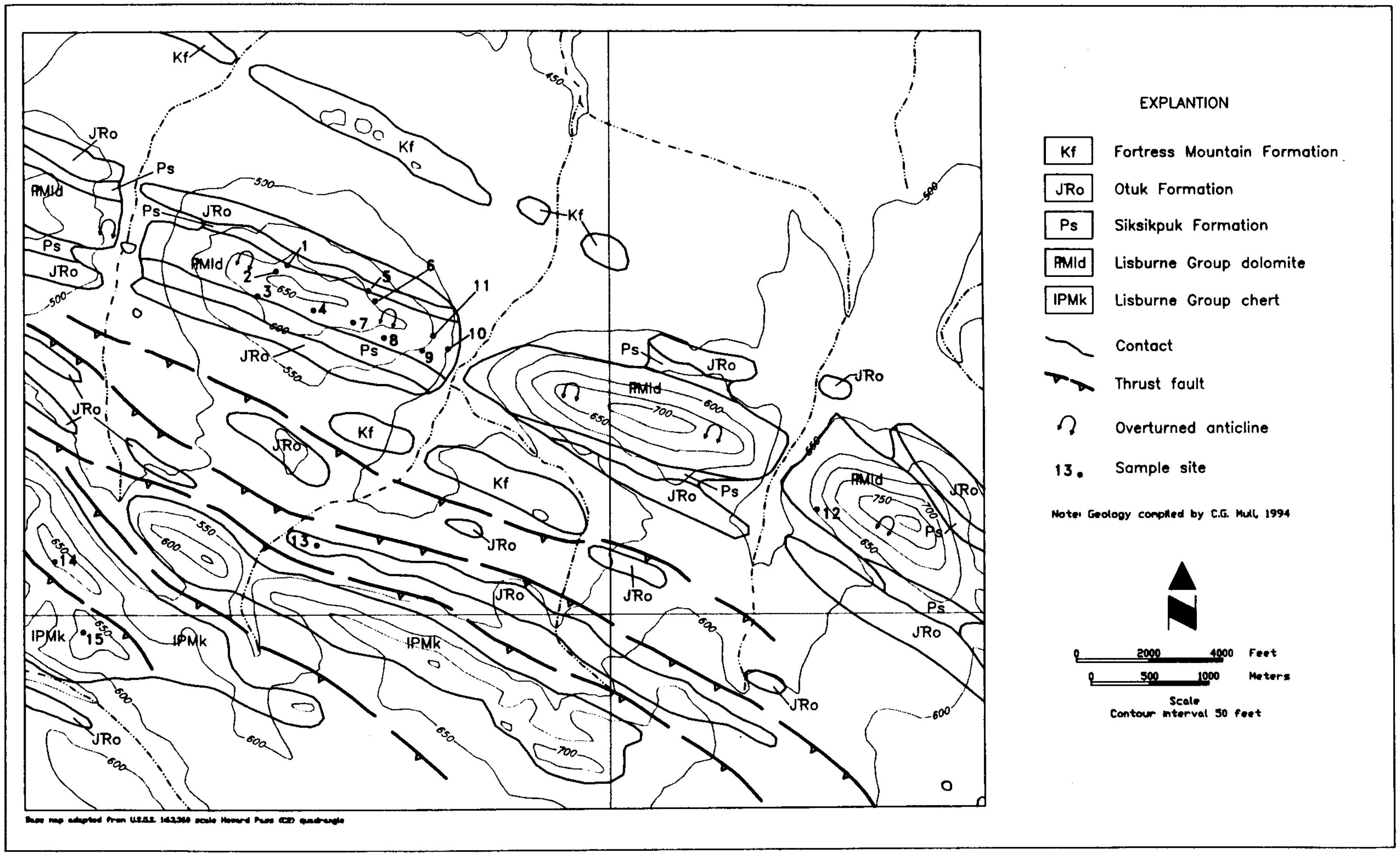


Figure B19. - Lisburne Ridge area - geology and sample sites.

Table B7 – Analytical Results – Lisburne Ridge Area

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag ppm	Al %	Ba ppm	Cu ppm	Fe %	Mg %	Pb ppm	P205 %	U (flouro) ppm	V ppm	Zn ppm
1	5702	Chert	Rubblecrop	Grab	<0.5	1.43	>2000	38	1.32	0.55	14	0.02	0.3	30	48
1	5703	Chert	Rubblecrop	Grab	<0.5	1.10	1642	34	2.08	0.37	8	0.02	0.3	28	62
2	5701	Limestone (?)	Outcrop	Spaced chip	0.6	0.21	53	11	0.21	9.44	7	0.05	1.1	26	38
3	5808	Shale	Rubblecrop	Select	7.8	2.28	662	68	0.86	6.25	13	0.78	8.8	364	333
4	5807	Pelletal limestone	Rubblecrop	Repr chip	1.4	0.33	735	25	0.25	3.43	12	23.56	78.0	397	371
5	5810	Shale	Float	Select	3.0	3.04	1678	234	1.26	0.53	5	1.06	33.0	1547	806
6	5809	Chert	Outcrop	Repr chip	0.8	0.20	157	12	0.44	3.83	4	0.30	2.4	29	56
7	5704	Siltstone	Rubblecrop	Grab	3.6	1.64	330	62	0.61	8.75	7	0.66	9.9	145	384
7	5803	Limestone	Rubblecrop	Select	1.8	0.29	658	23	0.38	3.03	7	22.49	65.0	435	459
7	5804	Limestone	Outcrop	Repr chip	1.3	0.28	964	27	0.3	2.54	15	25.48	84.0	406	425
7	5805	Shale	Outcrop	Repr chip	7.5	3.88	713	101	1.77	4.35	20	4.16	36.0	>2000	1695
7	5806	Pellet phosphate	Float	Grab	2.0	0.27	595	23	0.27	1.34	4	29.20	94.0	317	465
8	5812	Pelletal limestone	Float	Repr chip	2.7	0.37	849	29	0.36	4.08	12	20.29	62.0	426	297
9	5811	Pelletal limestone	Float	Repr chip	1.3	0.37	313	21	0.3	6.09	10	3.67	11.6	144	126
10	5814	Pelletal limestone	Float	Grab	3.7	0.25	303	24	0.25	2.96	10	24.70	56.0	474	444
11	5813	Chert/siltstone	Rubblecrop	Select	1.1	0.14	86	11	0.47	2.51	4	0.14	1.8	22	29
12	5796	Mudstone	Float	Select	1.8	0.21	163	14	0.25	1.87	28	20.23	53.0	316	337
13	5794	Mudstone	Float	Select	<0.5	1.34	859	17	0.74	0.22	120	0.01	<0.2	20	97
14	5924	Mudstone	Float	Select	1.6	0.35	192	20	0.42	1.73	67	0.26	1.7	91	86
15	5795	Shale	Rubblecrop	Grab	4.0	0.81	374	34	0.39	3.59	52	0.41	3.7	148	174

PROPERTY SUMMARY

NAME: Longview MAS NO. 0020200030

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:
Quadrangle: Howard Pass C3
SW 1/4, Sec. 35, T. 9S , R. 24W , Meridian: Umiat
Lat. 68 deg. 36' 55" N.,Long. 157 deg. 27' 15" W.
Geographic: Cutaway Basin, 2.0 km northeast of lake 573 m
Elevation:610 m

GEOLOGIC SETTING:

Stratiform barite deposits in the Cutaway Basin area are hosted by Middle Osagean to Early Meramecian (early to late Mississippian) sedimentary rocks of the Endicott Mountains allochthon, exposed in the Cutaway Fenster (fig. B2) (93)(128) . At the Longview occurrence the barite bed lies above orange-weathering siliceous mudstone and is overlain by interbedded light gray, green, and black chert. The barite body is tabular in nature and appears to lie along fault structures associated with imbricate thrust sheets . Diabase is poorly exposed just northwest of the barite bed.

BUREAU INVESTIGATION:

Barite was noted in the Cutaway Basin area by USGS geologists while geologic mapping during the 1950's (271). Further prospecting in the area in 1991 by both USGS and Bureau geologists , led to the joint discovery of several larger barite bodies, including the Longview occurrence. The barite is resistant to weathering and forms a low northeast-trending ridge. The Bureau mapped the extent of the body, measured sections across it, and collected a series of samples (fig. B20 and table B1). The bed has an average strike of N35E, dips 65 deg. southeast, and varies from 15-30 m thick. It is intermittantly exposed for 686 m along strike. The barite varies from white to light gray in color.

A 3-m long Spaced chip sample (5743), collected from outcrop within an estimated 27 m-thick barite bed, contained 97.1% barite ($BaSO_4$). The bed has a vertical exposure of 47 m. Its projected depth beneath ground level is unknown, but may be cut off by a low-angle thrust fault. The samples contained no significant amounts of base metals. Dark gray chert beds overlying the barite bed produced scintillometer readings up to 7 times background value. A 0.6 m-thick continuous chip sample contained (5742) contained 61 ppm uranium.

The Lakeview barite occurrence, 800 m to the southwest, lies along strike with the Longview Occurrence. Both occurrences may lie along one continuous, poorly exposed barite bed.

Economic modeling by the Bureau for a barite mining operation was subeconomic for three different seasonal mines modeled (43).

RESOURCE ESTIMATE:

Indicated resources: 29,500,000 tonnes of barite with an average specifc gravity of 4.13. Resource estimates were made using a projected depth of one-half strike length. The Longview occurrence may occur within imbricate thrust sheets and possibly cut off by faulting at shallow depths. A 2.3 kilogram sample of material, analyzed by Baroid Corp. of Houston, Texas, had a specific gravity of 4.2. This meets the requirements for use as drilling mud (209).

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential for use as drilling mud-grade barite.

RECOMMENDATIONS:

Gravity survey to determine the extent of the barite under tundra cover. Drilling to determine total length, depth, and thickness of barite bed.

REFERENCES:

4, 93, 128, 209

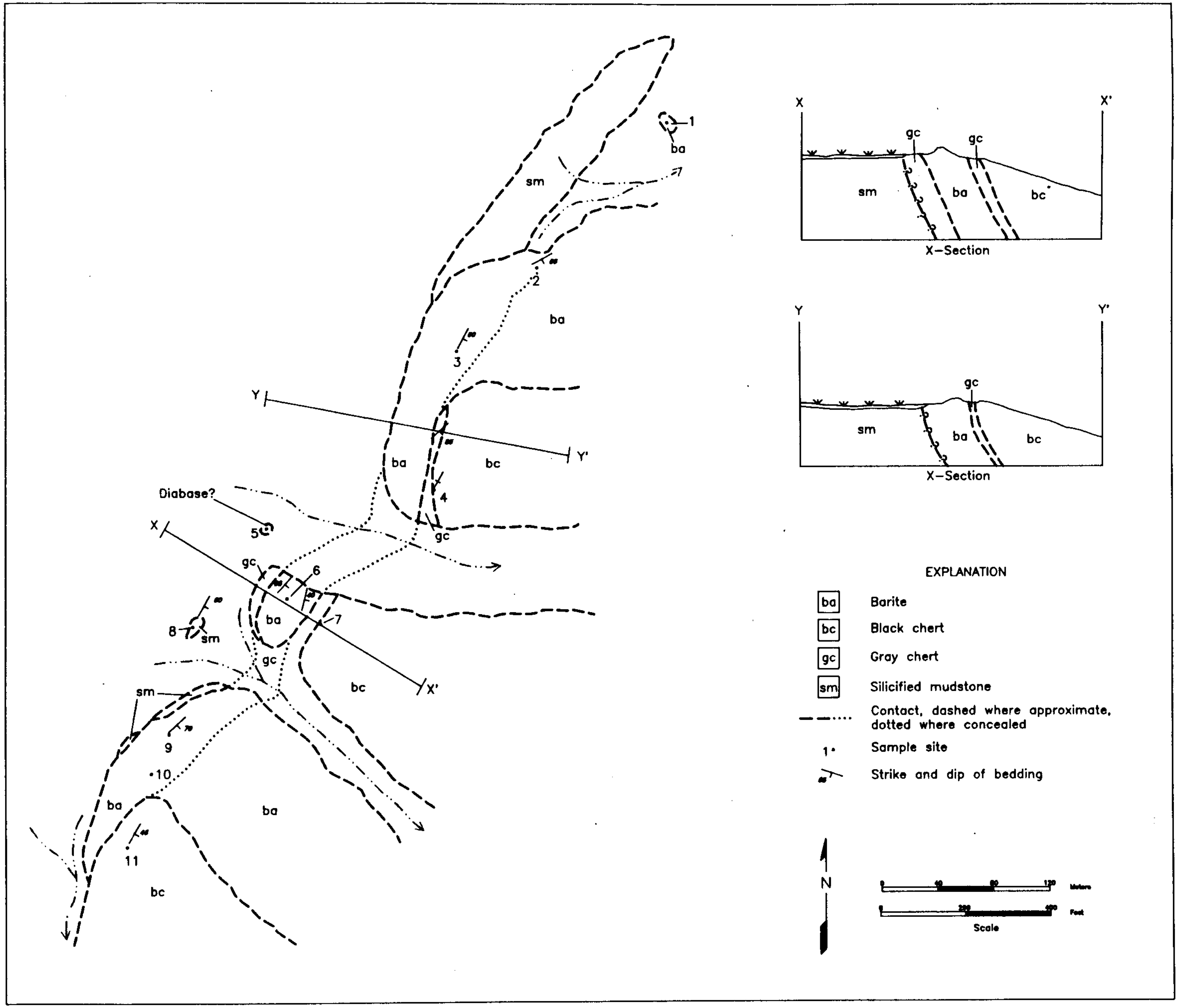


Figure B20. –– Longview barite occurrence – geology and sample sites.

PROPERTY SUMMARY

NAME: Memorial Creek MAS NO. 0020200016

DEPOSIT TYPE: Disseminated

COMMODITIES: Zinc

LOCATION:

Quadrangle: Howard Pass B3
NE 1/4, Sec. 15 , T. 34N , R. 6E , Meridian: Kateel River
Lat. 68 deg. 20' 43"N., Long. 157 deg. 26' 25"W.
Geographic: Headwaters of Memorial Creek, 1.2 km northwest of Peak 1347m.
Elevation: 1060 m

GEOLOGIC SETTING:

Rocks in the area consist of interbedded sandstone, siltstone, and shale of the Kanayut Conglomerate. This sequence dips to the north as it lies on the north limb of a large east-west trending anticline (plate I).

BUREAU INVESTIGATION:

An examination was initially made of the area in 1978. Anomalous stream silt samples were investigated and samples collected from an interbedded sequence of stained sandstone, pyritiferous conglomerate, and shale. Samples of sandstone contained up to 720 ppm lead (115). During the present study, investigation of a 210 ppm zinc stream silt anomaly heavy, led to the discovery of red-brown siltstone rubblecrop near the headwaters of Memorial Creek (130). A grab sample contained 9423 ppm zinc, 1122 ppm barium, and >2000 ppm strontium (6008)(table B4). No sulfides were noted, but the high values are probably due to the occurrence of fine-grained sphalerite and barite in the sample. The extent of the rubblecrop is unknown.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL: unknown

RECOMMENDATIONS:

Further prospecting is recommended in the area to determine the extent of heavy red-brown siltstones which may contain sphalerite.

REFERENCES:

115, 130

PROPERTY SUMMARY

NAME: Safari Creek MAS NO. 0020200021None

DEPOSIT TYPE: Breccia vein, disseminated

COMMODITIES: Lead, zinc, silver

LOCATION:

Quadrangle: Howard Pass B3
NE 1/4, Sec. 16, T. 34N, R. 5E, Meridian: Kateel River
Lat. 68 deg. 20' 58" N., Long. 157 deg. 43' 20" W.
Geographic: Eastern tributary near headwaters of Safari Creek, 4 km northeast of Peak 1122 m
Elevation: 726 m

GEOLOGIC SETTING:

Near the headwaters of Safari Creek Upper Devonian Endicott Group Kanayut Conglomerate and Noatak Sandstone have been thrust over younger Endicott Group rocks, including Lower Mississippian Kayak Shale as well as the Lisburne and Etivluk Groups (72). The younger rocks are exposed in the Safari Creek Window. The Safari Creek Occurrence is exposed on the eastern margin of the window where Kayak Shale is in thrust contact with overlying Noatak Sandstone (plate I) Here the Kayak consists of interbedded, red-brown siltstone and carbonaceous shale. It has been deformed into a series of broad folds and cut by quartz veinlets and minor quartz-cemented siltstone breccia veinlets. The Noatak Sandstone in the vicinity of the occurrence is thick bedded, light gray to white in color, and contains numerous quartz veinlets. This gives the sandstone a bleached appearence, conspicuous from a distance. Microscopic examination shows that the sandstone grains to be very angular and interlocked with triple junctions, indicating the rock probably underwent recrystallization at some point. The low-angle fault contact between the Noatak Sandstone and Kayak Shale is covered by float making its location approximate. The sandstone hosts massive, stringer, and disseminated sulfides consisting of galena, sphalerite, and minor chalcopyrite.

BUREAU INVESTIGATION:

The Bureau initially examined the area in 1978, while investigating an anomalous stream silt sample. A stream silt sample collected by the Bureau at this time from the stream that drains the occurrence contained 415 ppm lead, but the anomaly was not followed-up (115).

Investigations in 1992 led to the discovery of sulfides in outcrop in a stream bed at an elevation of 726 m (fig. B21). Sulfide-bearing rocks, concentrated in the Noatak Sandstone, can be traced for 350 m in float and rubblecrop along the south stream bank. A 3-m-wide zone of bedrock containing massive pods and lenses of galena and sphalerite, along with minor chalcopyrite is exposed through gravels in the stream bottom. The sulfides are contained within a medium gray recrystallized, silificed sandstone that is locally brecciated and cut by abundant quartz veinlets. A 1.1-m-wide continuous chip sample taken across this zone contained 25.2% lead, 8.5% zinc, 278 g/mt silver, and 925 ppm copper (5900) (table B8) The exposure can be traced intermittantly for for 12.2 m along strike. The massive sulfide zone has a crude foliation and slickenslided surfaces were observed. This indicates the possible presence of an east-west trending fault or shear zone, dipping steeply to the south. An east-west trending fault has been projected along the trend of the stream (plate I). The textures observed may be the result of postmineralization movement along that fault. Select samples of massive sulfides exposed on the stream bank nearby contain up to 46% lead, 12% zinc, and 685 g/mt silver (5770) . It is possible that these exposures are all part of the same sulfide-bearing zone which could be up to 15.5 m wide. Adjacent to the massive zone are stringer and disseminated sulfides, exposed on the south side of the stream in a 7.8 m-wide zone. Select samples from this zone averaged 22% lead, 7% zinc, and 274 g/mt silver (5769-5770, 5903, 5908). A sample of quartz veinlets and quartz-cemented siltstone breccia, hosted by the Kayak Shale contained 459 ppm zinc and 270 ppm lead (6049). A sample of what appeared to be unmineralized, recrystallized Noatak Sandstone contained 572 ppm zinc, and 379 ppm lead (6051).

A VLF survey line was run normal to the massive sulfide zone to check for conductor responses, but none were noted.
The sulfides are concentrated in the recrystallized Noatak Sandstone,just above the thrust contact with the underlying Kayak. The Kayak is cut by quartz veinlets, but samples contained only minor amounts of metal. Lead isotope ratios for a galena sample collected from the massive sulfides are; Pb 206/204 = 18.281, Pb 207/204 = 15.608, Pb 208/204 = 38.152. This sample represents the least radiogenic lead from north of the Brooks Range. Comparision with the pb206/204 and 207/204 plots of Cominco Alaska correlates with a Cambro-Ordovician model lead age is. This indicates the lead age not necessarily that of the mineralization. These isotopic ratios are directly comparable to the more non-radiogenic leads of the Seward Peninsula. If the galena at the sampled site was remobilized in post-Devonian time, then pre-existing sulfide lead is the source. The isotope ratios of the proposed older sulfide lead could be reconciled by upper crustal lead mixed with Ambler District-type (Devonian volcanogenic massive sulfide) lead (314).

The source of the sulfides may be hydrothermal fluids which flowed along the low angle fault and fracture zones developed at thrust contacts during the Brooks Range Orogeny. The fluids may have leached lead and zinc from disseminated mineralization in the Noatak Sandstone, and the zinc-bearing Kayak Shale. Sulides were precipitated when metal-bearing fluids combining with sulfur associated with carbonaceous material found both in the Noatak

Formation and Kayak Shale (72)(314). The sandstones may have provided a better host for mineralization than the shale by being more susceptible to brittle fracture during deformation.

RESOURCE ESTIMATE

The extent of exposed mineralization is small, but there is considerable cover in the area.

MINERAL DEVELOPMENT POTENTIAL:

Moderate Potential for small, high-grade lead, zinc, silver veins. Low potential for disseinated sulfides in sandstone.

RECOMMENDATIONS:

Drilling to determine the vertical and lateral extent of the sulfides. Prospecting for similar bleached rocks along north edge of Endicott Mountains Allochthon.

REFERENCES:

72, 115, 314

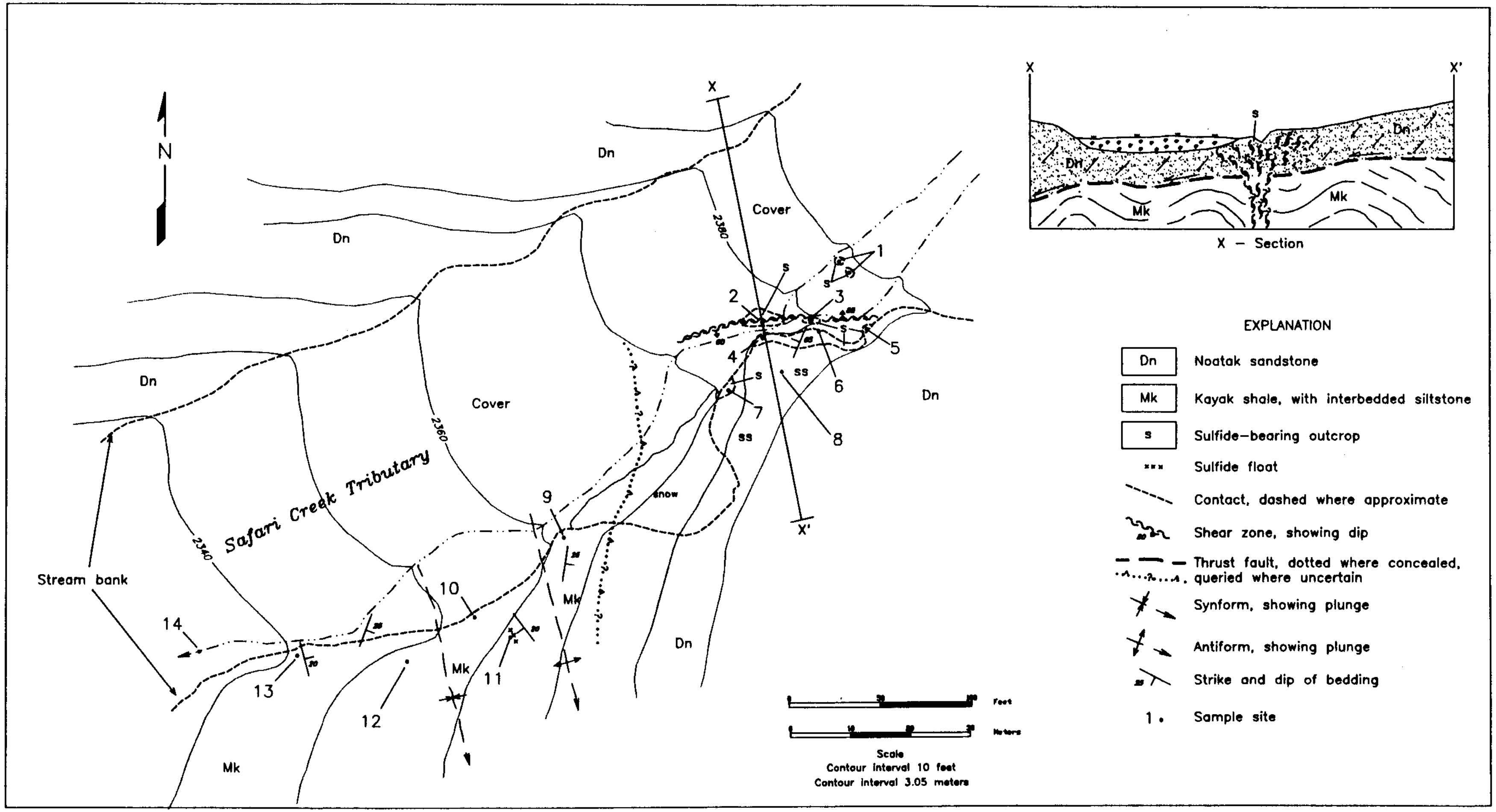


Figure B21. -- Safari Creek occurrence - geology and sample sites

Table B8 - Analytical Results - Safari Creek Occurrence

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
1	5902	Sandstone	Outcrop	Repr chip		2.15		13.8	8	89	61	74	142	>10000	20	14685
2	5900	Sandstone	Outcrop	Chip channel	279	25.21	8.47	>50.0	67	8	347	925	50	>10000	15	>20000
3	5901	Sandstone	Outcrop	Chip channel		2.87		15.9	14	44	70	92	189	>10000	18	18390
4	5770	Sandstone	Outcrop	Select	672	45.89	6.42	>50.0	34	<5	356	1156	29	>10000	5	>20000
4	5908	Sandstone	Outcrop	Repr chip	163	13.82	6.33	>50.0	61	12	270	523	101	>10000	16	>20000
5	5907	Sandstone	Outcrop	Repr chip	171	23.38	4.60	>50.0	33	13	170	315	126	>10000	21	>20000
6	5769	Sandstone	Outcrop	Repr chip	58.0	5.83	8.47	>50.0	39	203	311	334	440	>10000	19	>20000
6	5903	Sandstone	Outcrop	Repr chip		3.75	4.41	34.7	22	102	179	185	227	>10000	26	>20000
7	5913	Sandstone	Outcrop	Select	204	27.00	11.93	>50.0	59	<5	433	2629	21	>10000	8	>20000
7	6047	Sandstone	Outcrop	Select	311	53.36	2.05	50.0		17	90	507	33	>10000	9	19573
8	6051	Sandstone	Rubblecrop	Select				<0.5		280	<2.0	13	289	379	23	572
9	5904	Sandstone	Float	Grab				<0.5	6	562	<2.0	34	4502	225	110	519
10	5905	Volcanic (?)	Rubblecrop	Grab				<0.5	4	172	<2.0	44	1995	174	243	434
11	5771	Sandstone	Float	Select	53.8	6.93	2.27	>50.0	101	58	100	171	244	>10000	24	>20000
12	6048	Shale	Outcrop	Repr chip				<0.5		557	<2.0	33	687	661	57	281
13	5906	Shale	Outcrop	Repr chip				<0.5	5	160	<2.0	18	2952	78	59	285
13	6049	Shale	Rubblecrop	Select				<0.5		372	<2.0	21	1405	270	63	459
14	6050			Stream sed				<0.5		493	<2.0	32	702	82	102	229

PROPERTY SUMMARY

NAME: Stack MAS NO. 0020200032

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:
Quadrangle: Howard Pass C3
SW 1/4, Sec. 03, T. 10S, R. 24W, Meridian: Umiat
Lat. 68 deg. 36' 01" N., Long. 157 deg. 30' 07" W.
Geographic: Cutaway Basin, 400 m southwest of lake 573.
Elevation: 543 m

GEOLOGIC SETTING:

In the Cutaway Basin area, sedimentary rocks included within the Endicott Mountains allochthon are exposed through the Picnic Creek Allochthon, through the Cutaway Fenster (93). The Stack barite occurrence lies near an approximately 7 m-high limestone monolith, just east of Cutaway Creek (fig. B2). Barite is exposed in a series of rubblecrop mounds and interbedded with petroliferous limestone, chert, sandstone, and carbonaceous shale. The limestones contain Meramecian (early Late Mississippian) conodonts (128). Bedding strikes in a northwesterly direction, parallel to regional structure in the area, and dipping steeply to the southwest.

BUREAU INVESTIGATION:

The Stack occurrence was discovered by USGS geologists in 1991 (128). The Bureau sampled the occurrence and made a determination of possible resources (fig. B22, table B1). Rubblecrop exposures indicate a possible barite bed thickness of 30 m, intermittantly exposed for 136 m along strike. Grab samples of rubblecrop (5868-5871) averaged 95.8% $BaSO_4$. Determinations by the USGS produced an average specific gravity of 4.21 which is higher than the determinations made by Bondar Clegg Inc. for the Bureau (128). Samples contained no anomalous base metal values. The carbonaceous shales produced a 3 times background total count radioactivity reading on a scintillometer. A sample (5871) contained 18.9 ppm uranium and 143 ppm vanadium.

RESOURCE ESTIMATE:

Indicated resources: 2,900,000 mt at 95.8% $BaSO_4$. A specific gravity of 4.21 meets the requirements for use as drilling mud.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential as a source for drilling mud.

RECOMMENDATIONS:

Drilling to test thickness and extent of barite bed.

REFERENCES:

93, 128

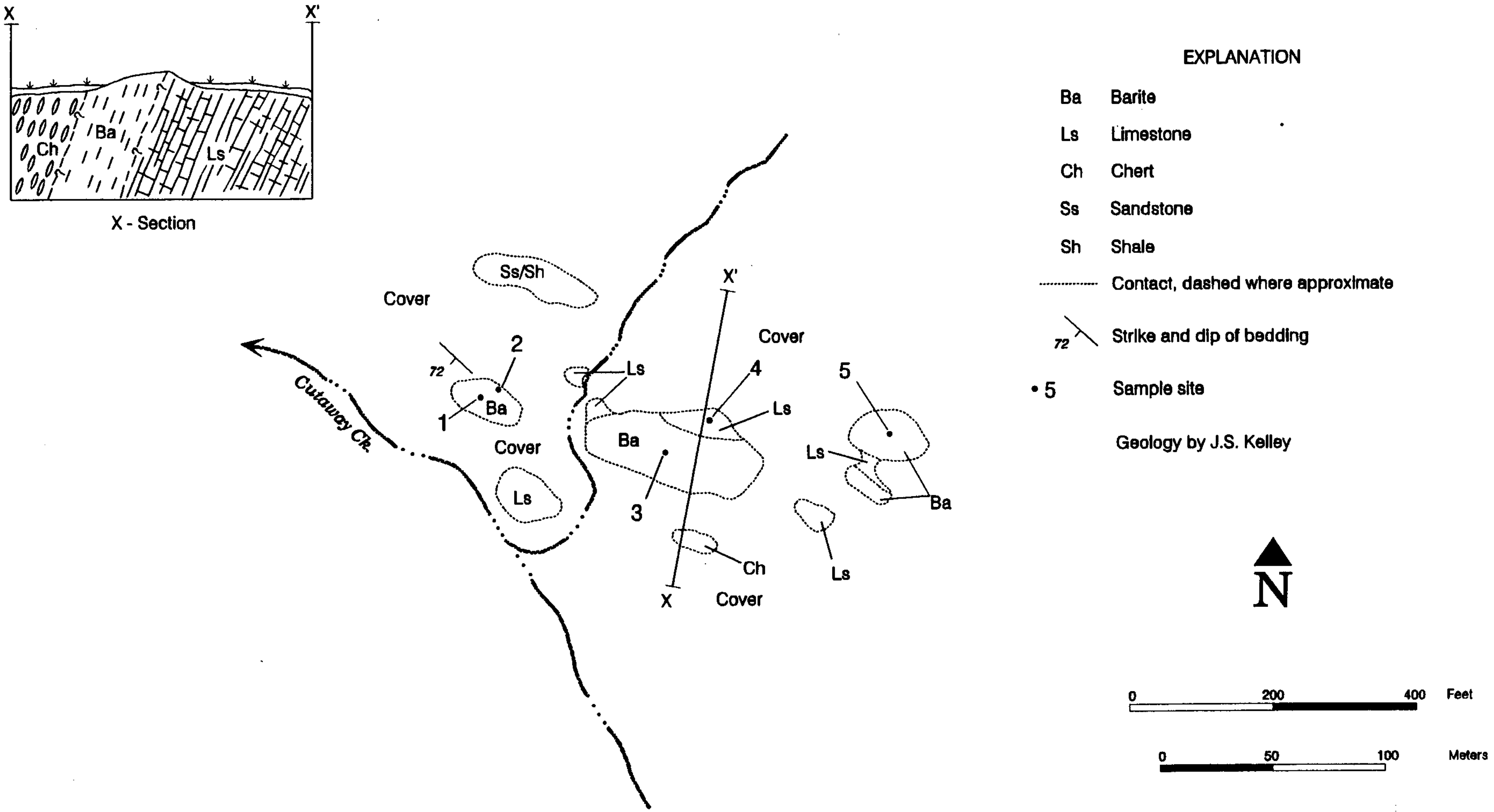


Figure B22. -- Stack barite occurrence - geology and sample sites.

PROPERTY SUMMARY

NAME: Story Creek MAS NO. 0020200022

DEPOSIT TYPE: Breccia vein

COMMODITIES: Lead, zinc, silver

LOCATION:

Quadrangle: Howard Pass B4
SW 1/4, Sec. 23, T. 12S, R. 26W, Meridian: Umiat
Lat. 68 deg. 22' 56" N., Long. 157 deg. 55' 55"W.
Geographic: Eastern tributary to Story Creek, 2.5 km north of Peak 1272 m.
Elevation: 811 m

EXPLORATION HISTORY

1977 - Stream sediment samples collected by USGS from streams in area prove to be anomalous in zinc and lead (115).

1978 - Follow-up of anomalous samples by the Bureau leads to the discovery of massive sulfides near head of stream (115).

1979 - The USGS maps the regional geology of the area surrounding the Story Creek occurrence (72).

1980 - Anaconda Minerals did reconnaissance in area. Max/min and gravity geophysical surveys failed to define any anomalies (64).

1987 - Arctic Slope Consulting Group, under contract to Arctic Slope Regional Corporation examined the occurrence. Two anomalies were identified using EM geophysics (64).

1991 - The Bureau conducts detailed sampling, mapping, and soil geochemical sampling to determine extent of mineralization. Bulk sample collected for beneficiation studies (172).

1992 - Kennecott Exploration mapped geology and sampled the occurrence (64).

GEOLOGIC SETTING:

Clastic sedimentary rocks in the Story Creek area are included within the Key Creek Sequence which makes up the Endicott Mountains (Brooks Range Allochthon). This sequence is intensely folded and thrust faulted and is exposed along the Brooks Range mountain front. The Lower Mississippian Isikut Formation is the host for mineralization at Story Creek. It has been thrust over younger rocks of the Endicott Mountains Allochthon. As a result of this thrusting, it has been intensely deformed into an imbricate stack of overturned folds whose axial planes strike northeast and dip at various angles to the south (fig. B23)(plate I). Numerous minor thrust faults occur between the individual folds.

To the south of the occurrence the Isikut Formation is in stratigraphic contact with overlying sandstone of the Kanayut Conglomerate. The contact is reported to be overturned and may be locally faulted (72). The Isikut Formation forms a topographic bench north of the Kanayut contact as the shale and siltstone weathers more rapidly than the sandstone. The Kayak Shale has a distinctive red-brown weathering color and is composed of laminated siltstones and fine-grained sandstones with shaley partings and interbeds. It is characterized by the presence of ripplemarks, crossbeds, mudchips, limonite, and carbonate concretions, thin calcareous interbeds and minor amounts of coal (267). It is thought to be a lateral facies of the Kayak Shale (183).

Mineralization is confined to a series of parallel approximately N55 deg.E trending discontinous sulfide-bearing vein/breccia zones. These zones strike roughly parallel to fold axes and thrust faults within the Isikut Formation. Zones vary from 5 to 60 meters in width and are intermittantly exposed in an en-echelon-like pattern for up to 2000 m along strike. The zones are exposed mainly as float with some rubblecrop and minor outcrop. This outcrop pattern may have resulted through offset of a single vein breccia zone by northwest-trending high-angle faults.

Sulfides occur in quartz veinlets, crosscutting the Isikut Formation, in banded massive sulfide veins, and in siltstone breccias with sulfide-quartz cement. Sulfides consist mainly of sphalerite and galena along with trace chalcopyrite and pyrite. Other minerals present include barite, calcite, hematite, cerrusite, anglesite, and hydrozincite (?). Silicification is the most prominent evident form of alteraton.

Sulfide veins consist mostly of massive sphalerite with lesser amounts of galena and quartz. Breccia-type mineralization consists of sphalerite and galena occurring as fragmental components and as interstitial cement. In some breccias sphalerite occurs as clasts (?) rimmed with galena in a sphalerite-rich matrix. Sulfides are covered by or terminate against a thrust fault on the south side of the mineralized zone.

Brecciation of the host rock is interpreted to be contemporaneous with silica mineralization. Sulfide minerals were deposited in a single, final-filling episode, but the paragenetic sequence of sphalerite and galena is unclear. In general, the breccias represent a paragenetic history which begins with host rock brecciation, followed by quartz deposition, to sulfide and quartz deposition. Open-space filling textures and the low degree of alteration indicate the mineralization to be epigenetic.

The linear trend of the quartz and sulfide-bearing zones indicates that mineralization may have initially taken place along steeply-dipping fault structures as opposed to low-angle thrust faults cutting the Kayak Shale. The numerous quartz veinlets in the host rocks probably represent at least two pulses of emplacement. An earlier, iron-stained sulfide-bearing set is cut by a later stage, white, barren set of veinlets. Quartz, may have been emplaced along axial plane cleavage in the intensely folded rock. The breccias, which provided open space for quartz and sulfide deposition, may have formed as a result of fault movement and/or as crush breccias in the axial areas of folds (267). The banded massive sulfide veins may have been emplaced in dilation zones formed near fold axes.

Lead isotope ratios determined from galena samples collected at Story Creek indicate a late Mississippian lead model age of approximately 310-320 million years (150). This is the age of the lead and not necessarily the age of the Story Creek mineralization.

Sulfide veins and breccias are best exposed as float and rubblecrop on the banks of a north-flowing, tributary stream to Story Creek just below a topographic bench (fig. B24). Sulfide-bearing rubblecrop and float are exposed in a 36 m-wide zone along the west stream bank. High concentrations of sulfides are confined to a 12 m-width on the southern side of this zone. It extends for 1295 m to the southwest and 274 m to the northeast through intermittant exposures of float and rubblecrop. To the east this zone is offset by a northwest-trending fault (267). The sulfide-bearing breccias are very similar to those located at the Whoopee Creek Occurrence, 18 km to the south.

The source of the metals may be from within the Isikut Formation or the zinc-bearing Kayak Shale. During the late stages of the Brooks Range Orogeny, hydrothermal fluids may have recycled lead and zinc out of these two formations and redposited them in the open spaces formed by fracturing of the more brittle siltstone in the Isikut Formation. It is thought that dewatering of the synorogenic Okpikruak Formation may have been a source of fluid. The Story Creek occurrence may also represent the feeder system to a sedimentary exhalative deposit of Mississippian age (72).

BUREAU INVESTIGATION:

The Bureau first examined the area in 1978, while investigating anomalous stream sediment samples. At that time lead and zinc sulfide mineralization were discovered near the heads of several north-flowing tributaries to Story Creek (112). In 1991 a total of 1433 m of grid line were surveyed over the greatest concentration of mineralization and used as a base for detailed geologic mapping and soil geochemical sampling. (figs. B23-B24). Detailed sampling was done on all known mineralized exposures and the surrounding area was prospected to find extensions of known mineralization.

Soil and/or rock samples were collected at 100 foot intervals along the grid on lines which were run normal to the trend of the mineralized zone. Soil samples contained up to 3400 ppm lead, 2400 ppm zinc, and 1500 ppm barium (172). The lead, zinc, and barium values were contoured (figs. B25-B27). Zinc values show a broad 284 m x 424 m anomaly containing several higher anomalies within it. The anomaly terminates to the northeast, but is open to the southwest. Lead values produce an anomaly less than half the width of zinc, but of similar lateral extent. This is probably due to the fact that lead is much less mobile in the geochemical environment than zinc. These anomalies probably represent the surface expressions of partially concealed vein and breccia-hosted mineralization.

Select samples (table B9) of banded vein-type sulfide float contain up to 30% lead, 696 g/mt silver, 55.6% zinc, and 775 ppb gold (5294, 5432). A series of continuous chip samples taken across 8.5 m of rubblecrop (5426-30) averaged 14.2% zinc, 3.9% lead, 159 g/mt silver, and 111 ppb gold. The samples were collected across a portion of a 36 m-wide mineralized zone.

Two subparallel, quartz-cemented, siltstone breccia zones within the Isikut Formation are exposed in rubblecrop on the east and west banks of a northeast-trending stream, 1.9 km west of the main Story Creek Occurrence. The zones vary from 3-31 m in width and can be traced for up to 155 m along an approximate N65 deg. E. strike. Linear float traces across the stream banks indicate that the bodies are steeply dipping.

The breccia contains sulfides consisting of sphalerite, galena, and minor chalcopyrite. Select samples contain up to 11% zinc, 2.8% lead, 1366 ppm copper, and 104 g/mt silver (5778, 5782, 5914, 5923). A grab sample taken across 4.6 m of rubblecrop (5917) contained 0.53% zinc, 0.20% lead, 1344 ppm copper, and 9.6g/mt silver. The strikes of the zones are approximately parallel to that of the main Story Creek zone to the west, but are not on strike with it. These two breccia veins may have originally comprised a single 470 m-long zone. It was later offset by a northwest-trending fault, which follows the stream bottom.

A 180 kg bulk sample of high-grade material was collected and analyzed at the Bureau's Albany, Oregon Research Center. Chemical analysis of the sample reported 2.1% lead, 5.4% zinc, and 41.1 g/mt silver. A fire assay detected no gold. A beneficiation test was done, using tabling and floatation to recover a galena/sphalerite concentrate. These methods recovered 96% of the zinc and 74% of the lead, indicating that the sulfides are amenable to traditional recovery techniques. The lead loss may be due to the presence of oxidized lead minerals such as cerrusite and anglesite (Summers et al, 1993).

RESOURCE ESTIMATE:

Indicated resource: 1.05 mmt at 8.1% zinc, 12.4% lead, and 1028 g/mt silver. An additional inferred resource totalling 11 million tonnes is speculated (64).

Inferred resource by Bureau: 2.9 mmt at 14.2%, zinc, 3.9% lead, and 159 gmt silver.

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential for high-grade lead, zinc, silver in massive veins and breccia zones.

RECOMMENDATIONS:

Drilling to test geochemical anomalies and thickness of mineralized zones.

REFERENCES:

64, 72, 112, 150, 267

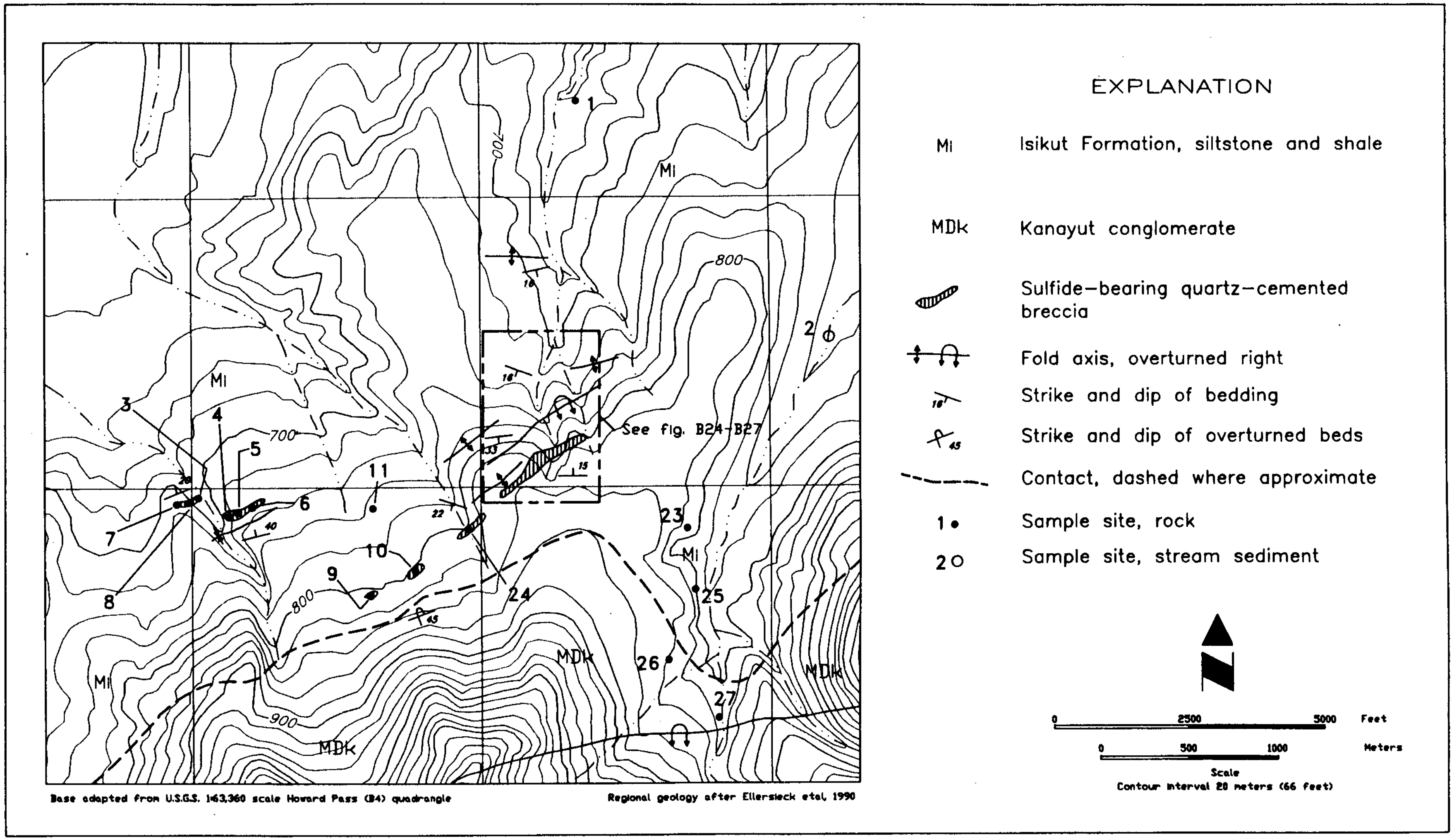


Figure B23. - Story Creek area - geology and sample sites.

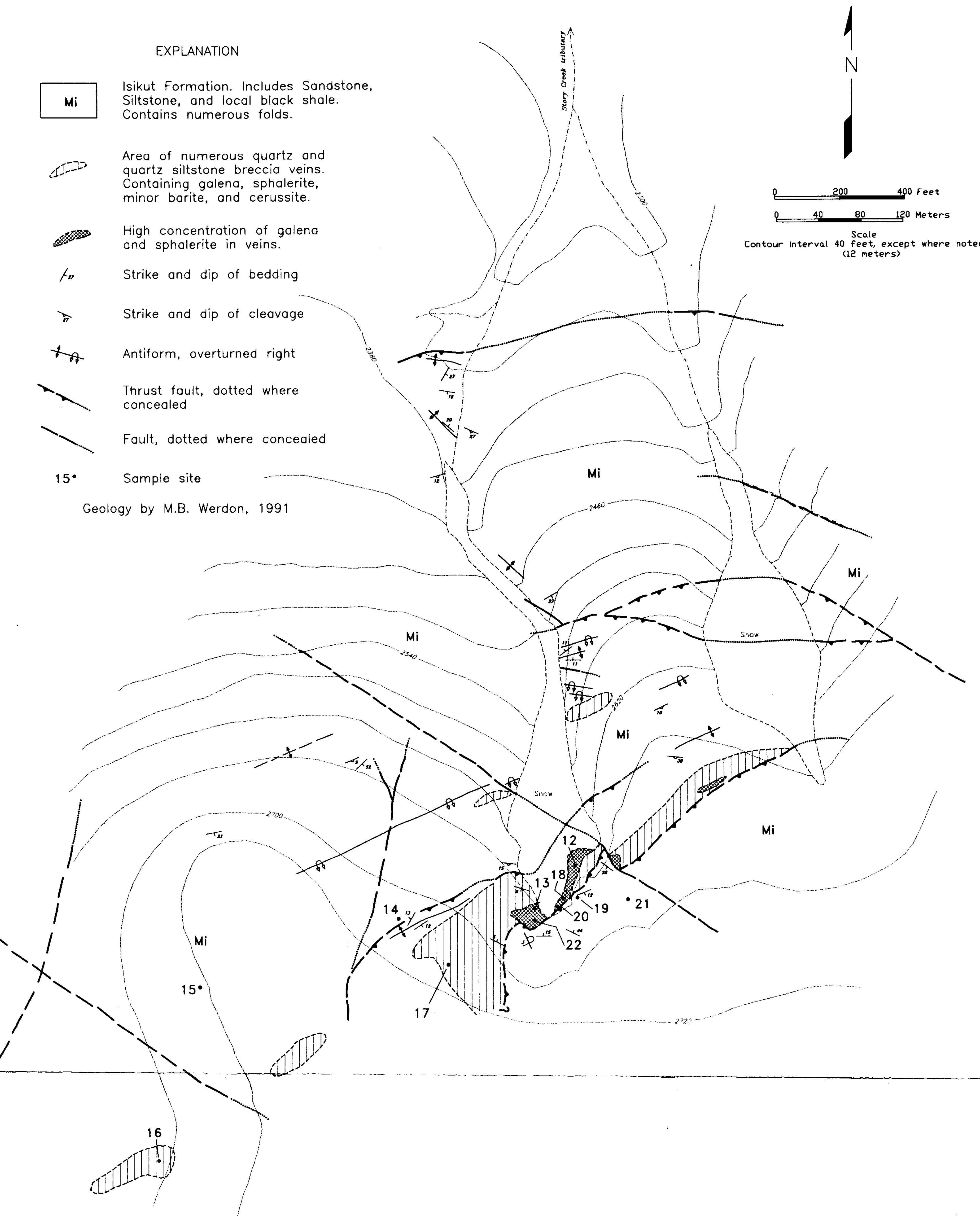


Figure B24. - Story Creek occurrence - geology and sample sites.

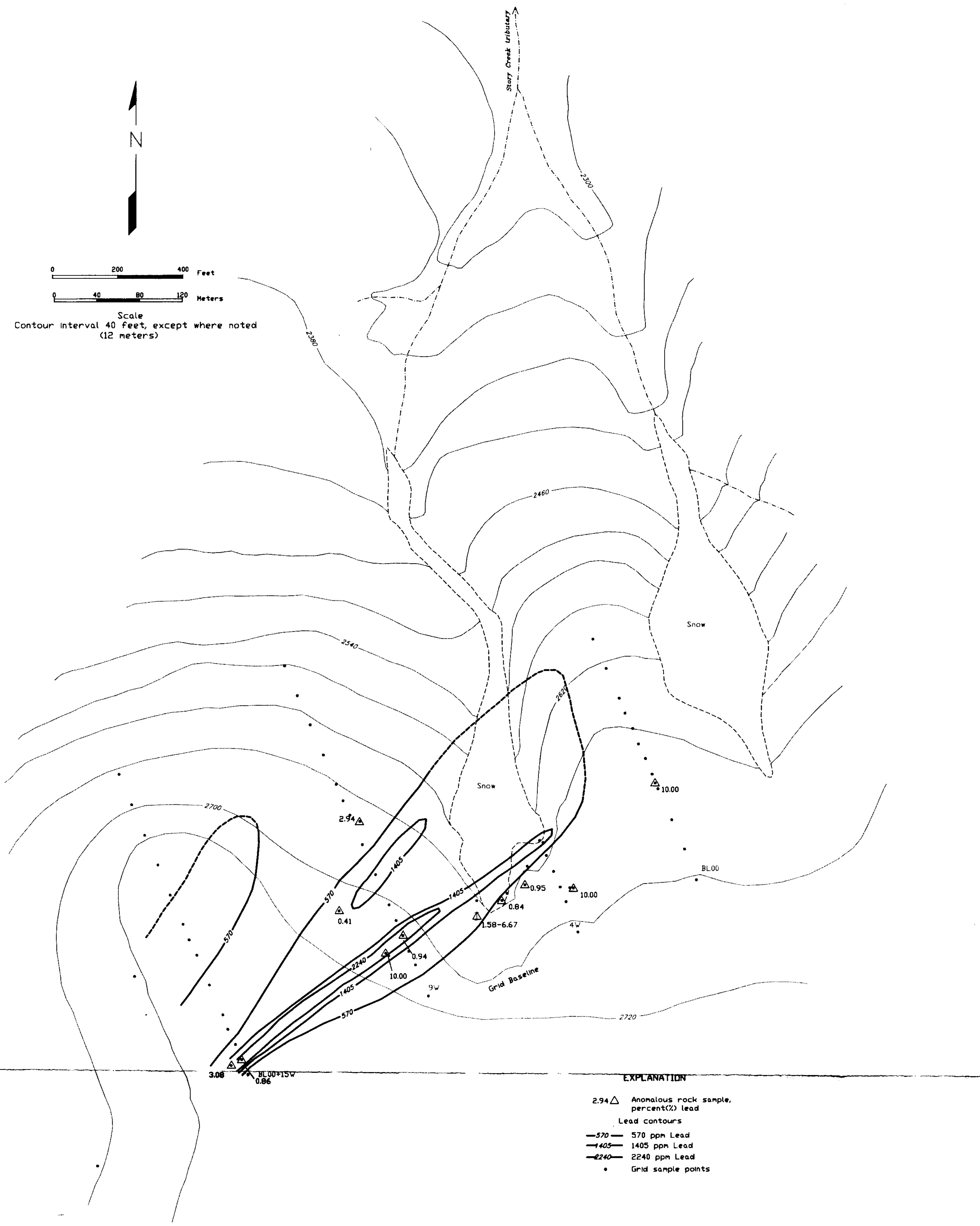


Figure B25. - Story Creek soil geochemistry - lead

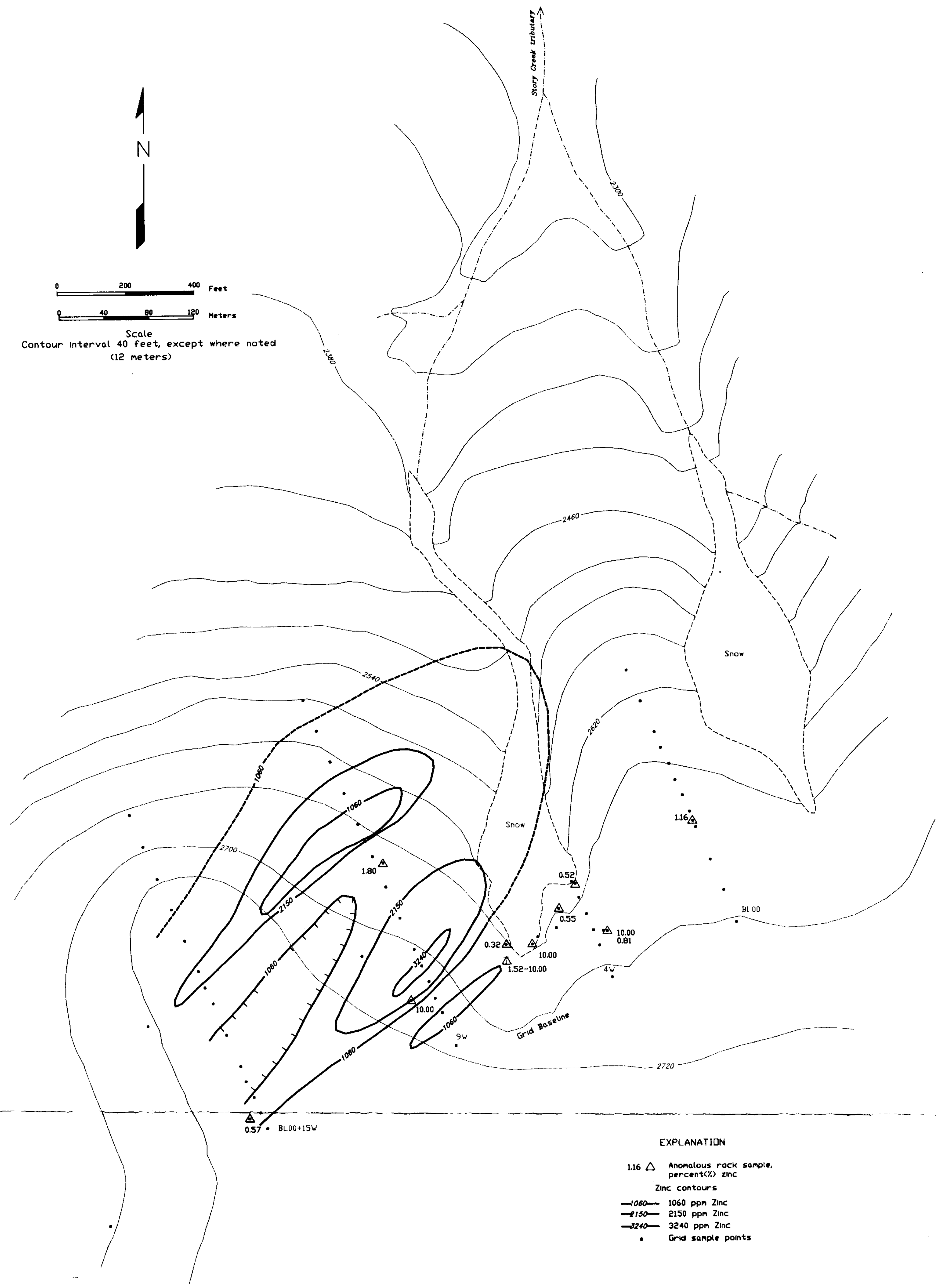


Figure B26. - Story Creek soil geochemistry - zinc

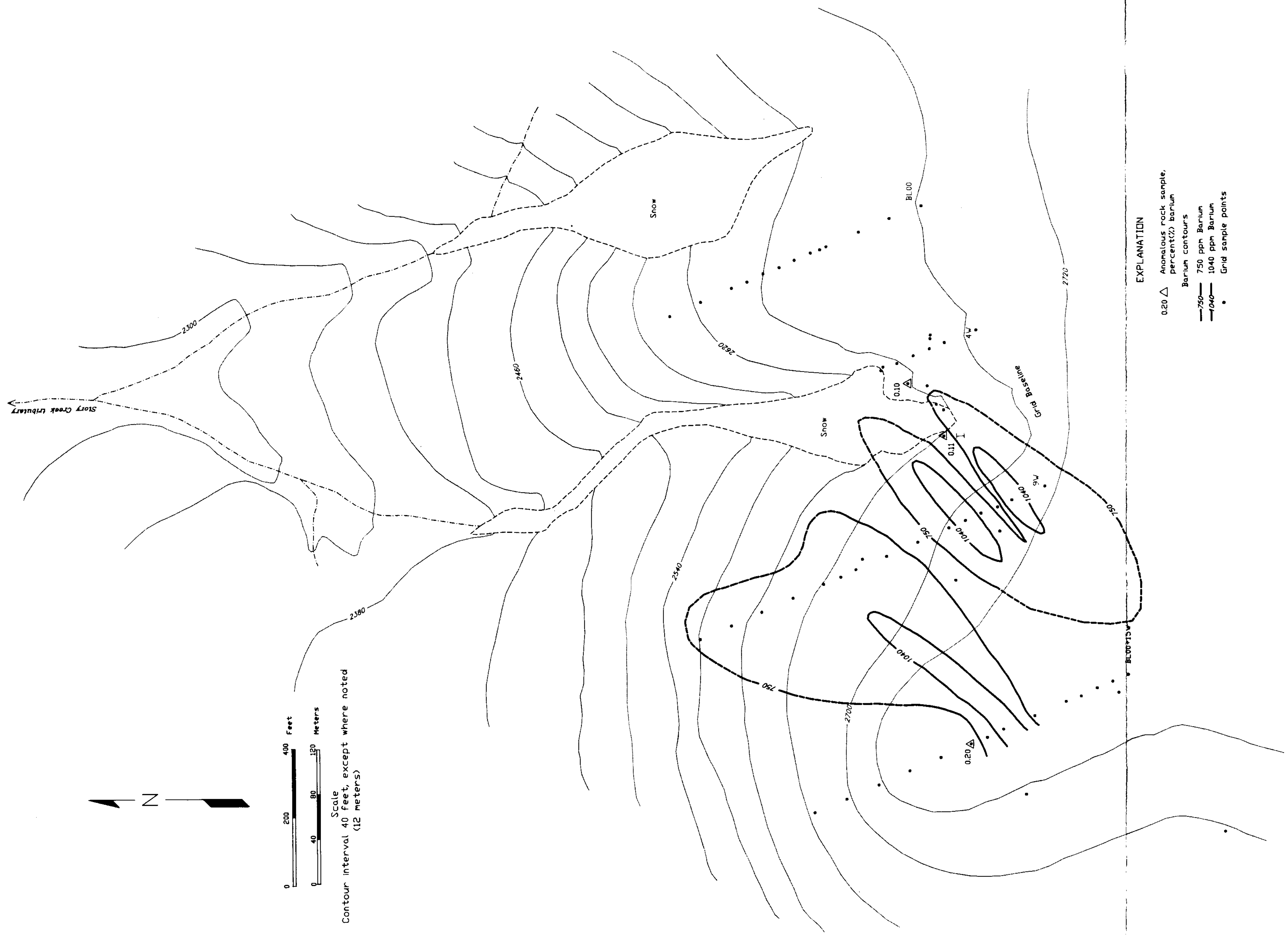


Figure B27. – Story Creek soil geochemistry – barium

Table B9 - Analytical Results - Story Creek Occurrence, Excluding Geochemical Grid Samples

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
1	4086	Chert	Outcrop	Random chip				0.8	6	359	3.9	51	1228	3444	80	2304
2	5912	Stream sed		Stream sed				<0.5	3	396	<2.0	33	1291	24	116	123
3	5916	Siltstone brec	Float	Grab	9.60	0.11	0.72	8.3	35	163	40	955	82	1129	18	7765
3	5917	Siltstone brec	Float	Grab	9.60	0.20	0.53	8.1	27	145	30	1304	347	1983	21	5826
4	5773	Siltstone brec	Float	Select	4.80	0.33	0.58	4.3	23	120	31.6	226	898	3581	40	6735
5	5777	Siltstone	Rubblecrop	Grab	3.77	0.01	0.16	3.4	26	79	5.3	34	115	208	18	1800
5	5779	Siltstone brec	Float	Select	5.83	0.05	0.15	5.2	45	293	8.5	84	50	500	9	1620
5	5780	Siltstone brec	Float	Select	13.7	0.15	3.20	14.2	60	29	185	530	55	1537	18	>20000
6	5778	Siltstone brec	Float	Select	11.0	0.74	11.01	10.6	22	22	579	118	373	7729	40	>20000
7	5914	Breccia	Float	Select	52.8	2.81	0.08	49.5	94	114	<2.0	267	111	>10000	23	857
8	5781	Siltstone brec	Float	Select	4.11	0.03	2.56	4.0	24	42	135	45	95	372	33	>20000
8	5782	Siltstone brec	Float	Select		1.18		18.8	59	106	74	1366	49	>10000	18	10995
8	5918	Silicious gossan	Float	Select	39.8	0.43	1.75	34.7	186	43	64	142	40	4195	14	17160
8	5919	Quartz vein	Float	Grab	6.17	0.09	0.19	4.1	15	203	3.4	45	505	919	49	2048
8	5920	Breccia	Float	Select	6.86	0.11	0.72	5.0	29	200	28	79	320	1142	38	7594
9	5793	Siltstone brec	Rubblecrop	Select	17.1	1.08	0.52	15.4	41	115	29	360	35	>10000	15	5653
10	5792	Siltstone brec	Float	Select	24.7	1.46	0.58	22.5	17	78	24	27	781	>10000	23	5819
11	5923	Quartz vein	Float	Grab	104	6.94	0.04	>50.0	31	60	<2.0	7	895	>10000	14	440
12	5296	Sandstone	Float	Grab	0.69	0.32	0.55	3.1	6	1,038	36.0	27	1526	2675	97	5674
13	5421	Siltstone	Float	Select	31.9	3.08	0.57	28.3	23	553	24.9	27	2225	>10000	55	5316
14	5546	Sandstone	Float	Select	29.1	2.86	0.41	25.1	34	267	27.8	45	1295	>10000	48	4737
15	5423	Siltstone	Float	Select	6.86	0.40	0.45	4.7	11	728	12.2	101	1135	3852	77	4375
16	5425	Siltstone	Rubblecrop	Select	60.4	2.12	1.45	>50.0	84	597	71.6	118	68	>10000	22	14207
17	5545	Sulfides	Float	Grab	139	1.99	25.90	>50.0	110	36	1438.7	377	75	>10000	9	>20000
18	5298	Mudstone	Rubblecrop	Random chip	0.69	0.33	0.40	2.0	2	560	13.2	9	932	3109	78	3887
19	5297	Mudstone	Rubblecrop	Random chip	7.54	0.95	0.44	7.0	3	494	12.2	20	649	8666	81	4113
20	5432	Sulfides	Float	Select	274	0.82	55.57	>50.0	86	75	>2000	359	50	8765	14	>20000
21	5293	Sandstone	Rubblecrop	Random chip	3.77	0.21	0.81	3.7	6	540	46.9	28	928	2001	77	7852
21	5294	Sulfides	Float	Select	696	30.03	18.94	>50.0	705	118	1288.8	374	113	>10000	18	>20000
22	5426	Sulfides	Rubblecrop	Contin chip	119	3.40	9.03	>50.0	59	390	466.6	223	425	>10000	108	>20000
22	5427	Sulfides	Rubblecrop	Contin chip	450	3.79	54.23	>50.0	216	74	>2000	886	33	>10000	10	>20000
22	5428	Sulfides	Rubblecrop	Contin chip	121	6.67	5.01	>50.0	131	471	247.8	128	205	>10000	93	>20000
22	5429	Sulfides	Rubblecrop	Contin chip	38.4	1.58	1.17	34.4	49	694	59.6	78	422	>10000	115	11191
22	5430	Sulfides	Rubblecrop	Contin chip	64.8	4.25	1.52	>50.0	98	172	85.9	51	634	>10000	90	15012
23	4066	Shale	Outcrop	Grab				<0.5	<1	220	<2.0	7	5331	12	54	141
24	5422	Siltstone	Float	Select	20.9	1.41	0.09	20.0	22	332	7.6	34	360	>10000	43	867
24	5424	Siltstone	Float	Select	0.69	<0.01	0.23	<0.5	2	276	13.4	17	893	96	79	2247
25	4044	Shale	Float	Grab				1.8	3	145	<2.0	13	7793	13	36	85
26	4045	Shale	Float	Grab				1.6	1	175	<2.0	15	3546	27	46	121
27	4085	Shale	Outcrop	Select				0.9	11	125	<2.0	25	4098	15	46	241

PROPERTY SUMMARY

NAME: Tuck MAS NO. 0020200031

DEPOSIT TYPE: Stratiform

COMMODITIES: Barite

LOCATION:
Quadrangle: Howard Pass C3
NW 1/4, Sec. 3, T. 10S , R. 24W , Meridian: Umiat
Lat. 68 deg. 36' 38" N.,Long. 157 deg. 30' 05" W.
Geographic: Cutaway Basin, 750 m northwest of lake 573 m.
Elevation: 567 m

GEOLOGIC SETTING:

Stratiform barite deposits in the Cutaway Basin area are hosted by Middle Osagean to Early Meramecian (early to late Mississippian) sedimentary rocks of the Endicott Mountains allochthon, exposed in the Cutaway Fenster (fig. B2)(93). The Tuck occurrence consists of an isolated 30 x 60 m area of barite float and rubblecrop (fig. B28). Barite exposures in rubblecrop contain rhythmic bedding, oriented along a northwesterly strike with a 32 deg. northeasterly dip (128). The enclosing sedimentary rocks are not exposed at the occurrence. The occurrence may lie along a possible northwest-trending fault.

BUREAU INVESTIGATION:

Barite was noted in the Cutaway Basin area by USGS geologists while geologic mapping during the 1950's (271). Further prospecting in the area during the present study by USGS geologists led to the discovery of several other barite bodies, including the Tuck occurrence. The Bureau mapped and sampled the one small exposure (fig. B28)(Table B1). Grab samples of rubblecrop contain up to 96.8% barite (5873) and specific gravity of 4.1 (5872) as determined by Bondar Clegg Inc.
Determinations by the USGS resulted in an average specific gravity of 4.31 (128). None of the samples were anomalous in base metals.

RESOURCE ESTIMATE:

Indicated resource: 155,000 tonnes at 95.9% Barite and specific gravity of 4.31.

MINERAL DEVELOPMENT POTENTIAL:

Low potential for use as drilling mud, due to small size of occurrence.

RECOMMENDATIONS:

Gravity survey to determine extent of barite under covered areas, followed by test drilling.

REFERENCES:

128, 271

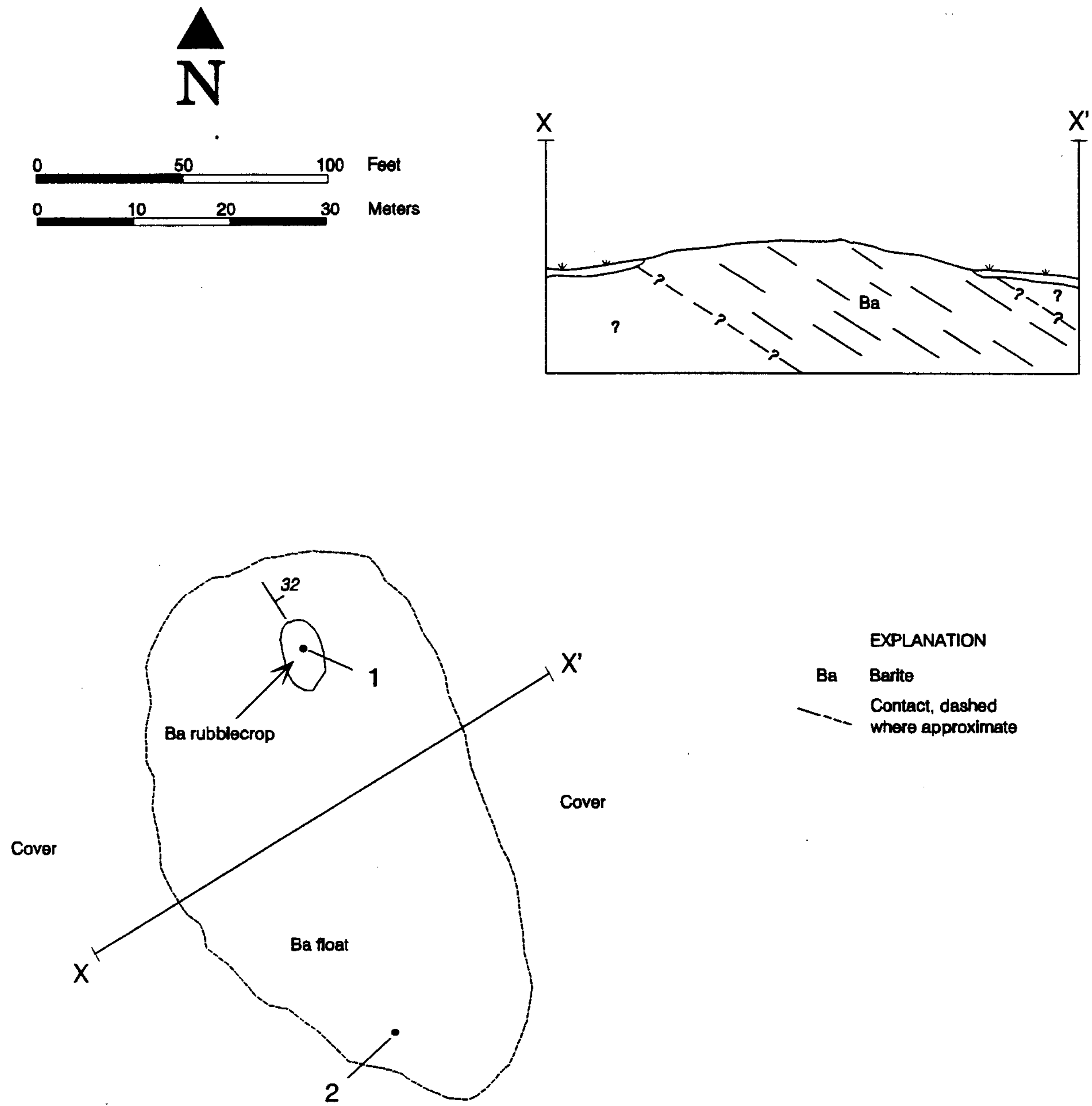


Figure B28. --Tuck barite occurrence - geology and sample sites.

PROPERTY SUMMARY

NAME: Tukuto Creek MAS NO. 0020200034

DEPOSIT TYPE: Volcanogenic/sedimentary exhalative

COMMODITIES: Lead, zinc

LOCATION:

Quadrangle: Howard B2
NE 1/4, Sec. 14, T. 34N, R. 7E, Meridian: Kateel River
Lat. 68 deg. 22' 10 " N., Long. 157 deg. 10' 50"W.
Geographic: On top of low ridge, just west of west fork of Tukuto Creek, 3 km northwest of divide with the Ipnavik River.
Elevation: 800 m

GEOLOGIC SETTING:

The rocks in the area have been mapped as volcanic agglomerates and rhyolites, in gradational contact with the Lower Mississippian Kayak Shale (plate 1)(183).

BUREAU INVESTIGATION:

Near the crest of a low ridge just west of Tukuto Creek, lithic tuff was found intercalated with Endicott Group sandstone. The tuffs were iron stained. The site was examined briefly and a single grab sample of tuffaceous rubblecrop collected (5800). The sample contained 1838 ppm zinc and 1686 ppm lead. No visible sulfides were noted (table B10). These values are very anomalous and unique as very few occurrences of sulfides in volcanic tuffaceous rocks are known in the district.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for volcanic-hosted? zinc-lead deposits.

RECOMMENDATIONS:

Resample site and search for similiar rocks in the area, which may contain sulfides.

REFERENCES:

183

APPENDIX C - ALPHABETICAL LISTING OF MINERAL OCCURRENCES IN THE KILLIK RIVER QUADRANGLE

PROPERTY SUMMARY

NAME: Ivotuk Hills MAS NO. 0020210005

DEPOSIT TYPE: Sedimentary

COMMODITIES: Phosphate, uranium, vanadium

LOCATION:
Quadrangle: Killik River B5
NW 1/4, Sec. 20, T.11S, R.16W, Meridian: Umiat
Lat.68 deg. 28' 53" N.,Long.155 deg. 42' 40" W.
Geographic: West end of Ivotuk Hills, 100 m from Otuk Creek
Elevation: 560 m

GEOLOGIC SETTING:

The highest portion of the Ivotuk Hills consists of undivided Upper Mississippian interbedded light-gray dolomite and black chert of the Lisburne Group. On the south side of the ridge, this sequence is stratigraphically overlain by interbedded, fossiliferous black chert, limestone, and shale.of the Middle Jurassic to Triass Otuk Formation. On the north side of the ridge, the Lisburne Group rocks have been thrust over the top of the Otuk Formation (186). Phosphorites occur within the Otuk Formation near the base of the north side of the ridge, beneath the thrust-fault contact.

BUREAU INVESTIGATION:

In 1991 the Bureau identified phosphatic pelletal limestone on the north side of the Ivotuk Hills near Otuk Creek, 700 m due west of the Lisburne No. 1 test well site. A 45 kg bulk sample (4219) was collected from a 1.2 m-thick sequence of interbedded phosphatic shale and oolitic to pisolithic limestone in the Otuk Formation. The phosphatic beds lie adjacent to chert containing abundant Monotis sp. The limestone beds are lensey, average approximately 78 mm thick, and comprise up to 50% of the 1.2 m-thick section. The sample was found to have radioactivity approximately 5 times that of background. The limestone and shale give a petroliferous odor upon breakage.

The sample was examined at the Bureau's Albany, Oregon Research Center. Analysis showed it to contain 30.7% P2O5, 0.11% vanadium, and 150 ppm uranium (Table C1). Approximately 73% of the rock is composed of apatite. No nuclei are visible in individual ooliths, although some incorporate several small, rounded collophane bodies into one. One oolith examined contains an arcuate fragment of dense, uniform collophane, which might be a bone fragment or part of a phosphatic exoskeleton. The rims of the ooliths are composed of relatively pure apatite. Other bands, defined by differences in color, texture, or chemistry or by increased organic material, may or may not be present in oolith interiors. Small hexagonal crystals of quartz are scattered within the ooliths. Up to 20% of the area of each oolith is made up of these crystals, with fewer on the rims than in the interiors.

Some ooliths have areas that were originally voids. These are now lined with crystalline, radial, fibrous apatite in one or two narrow layers and are filled with dolomitic calcite, quartz, organic matter, or a combination of these. The cementing material of the rock consists of dolomitic calcite and quartz, with traces of pyrite and potassium feldspar. The matrix also contains approximately 0.4% manganese and small amounts of vanadium.

Analysis with a scanning electron microscope (SEM) showed the vanadium to be concentrated interstitially in clusters of tiny pyrite crystals These clusters are a very small part of the rock matrix and are only 5 to 10 micrometers in diameter. Vanadium is also concentrated in dolomitic calcite and in earthy areas of the rock, composed of apatite, quartz, and potassium feldspar. Late fractures in the rock contain some barite. Other components include kerogen, with traces of pyrite and clay (205, 266).

Using scintillometers, the phosphorite was prospected along its eastern extension as far as Ivotuk Creek, but no significant exposures of phosphatic material were located. Tundra cover is extensive along the north side of the Ivotuk Hills.

This occurrence is unique as rocks with such a high phosphate content were rarely found within the Otuk Formation. All other significant phosphate occurrences within the district are confined to the stratigraphic top of the Lisburne Group.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential as a source of phosphate. The phosphate grade is quite high, but the bed is too thin and has no obvious lateral extentions.

RECOMMENDATIONS:

Drilling to determine extent of phosphorites along strike to the east and west. The Lisburne Ridge Phosphate occurrence, 47 km to the northwest may be an extension of the Ivotuk phosphorites. The trend of the Lisburne Group and Otuk Formation between the two sites should be prospected with scintillometer.

REFERENCES:

205, 266

Table C1 - Analytical Results - Ivotuk Hills - Bulk Sample

Sample no.	Analyses, percent																	
	C	TOC*	CaO	MgO	Mn	P2O5	S	SiO2	V	La	Nd	Th	U	Y	Al	Cd	Cr	Fe
4219	3.47	2.93	45.9	0.71	0.004	30.7	0.671	9.52	0.11	0.012	0.021	0.002	150**	0.022	0.44	42.4**	206**	0.29

*Total organic carbon **parts per million

PROPERTY SUMMARY

NAME: Kady MAS NO. 002010001

DEPOSIT TYPE: Vein breccia

COMMODITIES: Zinc, lead, silver, copper

LOCATION:
Quadrangle: Killik River A4
SE 1/4, Sec. 04, T. 32N, R. 17E, Meridian: Kateel River
Lat. 68 deg. 11' 58" N., Long. 154 deg. 58' 50 " W.
Geographic: Located near the headwaters of a northeastern tributary to Outwash Creek.
Elevation: 1400 m

GEOLOGIC SETTING:

The Kady occurrence is hosted by sandstone along with minor conglomerate and shale of the Shainin Lake Member of the Kanayut Conglomerate. These rocks lie within a slice of the Kanayut Conglomerate that has been thrust over the Ear Peak Member of the Kanayut Comglomerate to the north. This slice has in turn has been overthrust from the south by a plate comprised of the Hunt Fork Shale. These rocks have been intensely deformed into a series of generally east-west-trending folds, formed during thrusting caused by the Late Jurassic to Cretaceous Brooks Range Orogeny (186). In the immediate area of the occurrence fold axes have an average N 65 E trend, and plung to the south.

A series of quartz vein swarms and quartz-cemented breccia zones crosscut bedding and fold axes in the sandstones and to a minor degree the shales. Some veins are barren and others mineralized. The majority of the mineralized veins have a N 30 deg. E trend and are near vertical. Another set averages approximately N 40 deg. W, dipping steeply to the south. This set is less common, but contains higher metals values. The structure indicates that the quartz veins and breccia zones may have been emplaced along conjugant joint sets and faults, developed semi-normal to fold axes, late in the Brooks Range Orogeny.

The veins and breccia zones pinch, swell, and split along their length. Veins range from a few cm to a possible 30 m-width and can be traced for up to 229 m along strike. Some veins are barren, while others contain both massive and disseminated sulfides. Sphalerite and galena are the dominant sulfides, followed by chalcopyrite and pyrite. Mineralized veins are coated by abundant limonite stain. Veins also contain quartz, calcite, and siderite(?). Massive sphalerite is commonly cut by quartz veinlet swarms in a lace-like pattern and sphalerite boxwork textures are common. Some of the veins show multiple periods of brecciation, suggesting a lapse between pulses of mineralization. This could be the result of successive movements along fault zones.

Clasts of sphalerite occur within the breccias. These may originally be from sulfides formed early in vein development and later torn out from below and deposited as clasts during a subsequent pulse of fault movement. Lead isotope ratios for galena from this occurrence are comparable with Mississippian shale-hosted deposits such as Red Dog, and Drenchwater Creek. This represents the original age of the lead and not necessarily the mineralization at Kady (314).

BUREAU INVESTIGATION:

The Kady Occurrence was discovered by the USGS in 1986(?) during during follow up of anomalous stream sediment samples (61). In 1991 the Bureau mapped the geology of the occurrence and did detailed sampling of the vein breccias (figs. C1,C2) (Table C2).

Select samples of massive galena from some of the vein breccias contain up to 59.8% lead, 0.7% zinc (5455) and 745 g/mt silver (5443). A random chip sample collected across a 3 m-wide massive sulfide-bearing quartz vein exposed for 30 m along strike (5556) contained 10% zinc, 0.10% lead, 1.7% copper, 10.8 g/mt silver, and 53 ppb gold. A continuous chip sample, collected across 1.7 m-wide quartz vein containing sandstone breccia fragments (5561) contained 1.06% zinc, and 3.4 g/mt silver. Sample (5447) collected across a 10.7 m-wide zone of mineralized quartz-cemented samdstone float contained 12.5% zinc, 1.9% lead, and 16.5 g/mt silver.

Several other, less extensive mineralized veins occur in the vicinity of Kady and are shown in fig. C1. A N 20 deg. E-trending zone of vein breccia rubblecrop and float can be traced for 200 m across a ridgetop, 900 m southwest of the main Kady occurrence. A grab sample collected across the 6 m rubblecrop width of the zone (5457) contained 14,560 ppm copper, 0.24% lead, 2.3% zinc, and 5.8 g/mt silver. The veins at the Kady occurrence are also reported to be anomalous in tin and arsenic (61). This is a unique vein breccia occurrence as it lies totaly within sandstone, having no apparent relationship with Kayak Shale or Isikut Formation.

RESOURCE ESTIMATE: Unknown

MINERAL DEVELOPMENT POTENTIAL:

Moderate potential for small, high grade zinc-lead-silver-bearing vein breccias.

RECOMMENDATIONS:

Further mapping and sampling in area to determine size and grade of known veins. Prospect surrounding area for larger, undiscovered veins.

REFERENCES:

61, 186

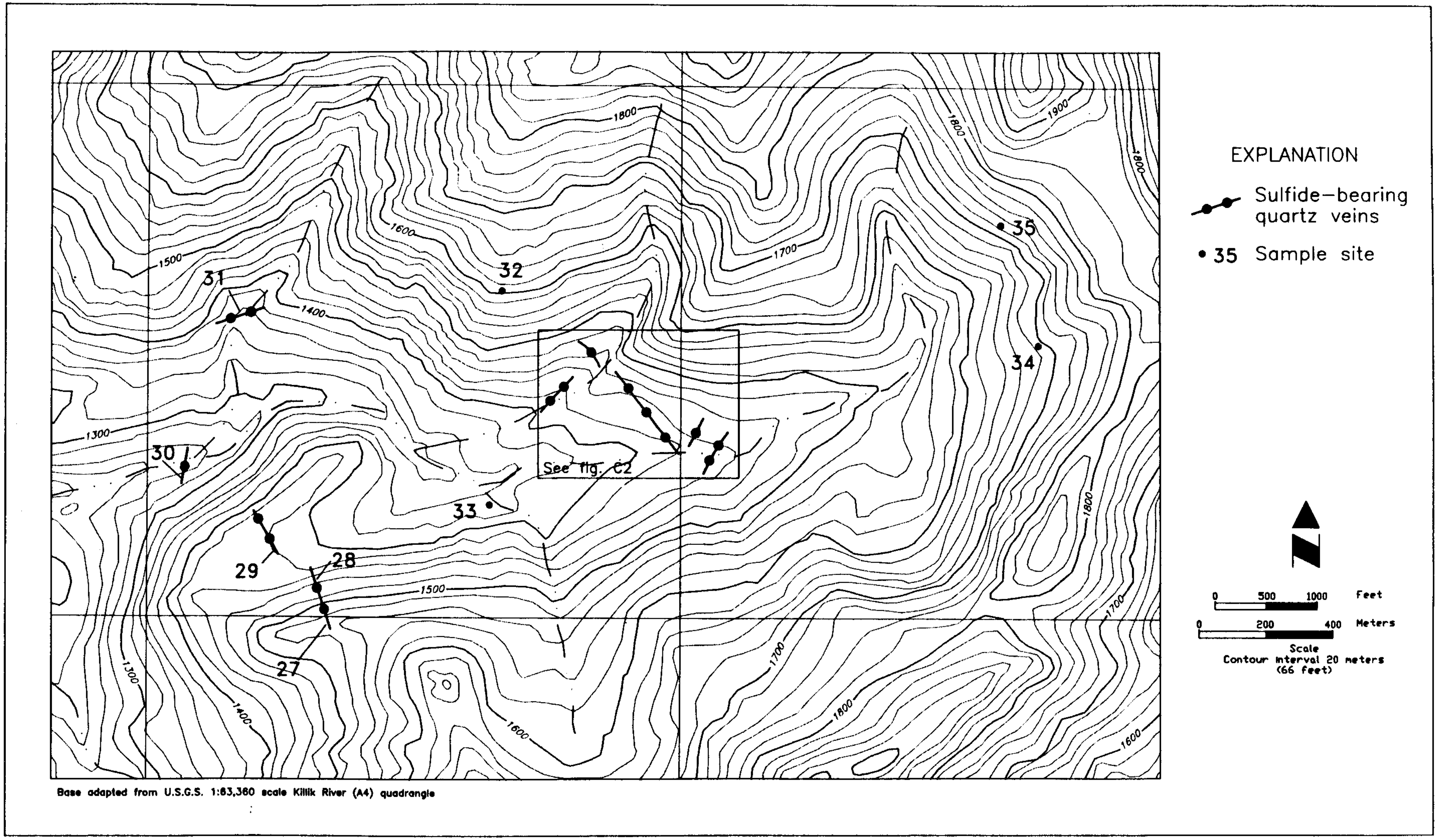


Figure C1. – Kady occurrence area – sample sites.

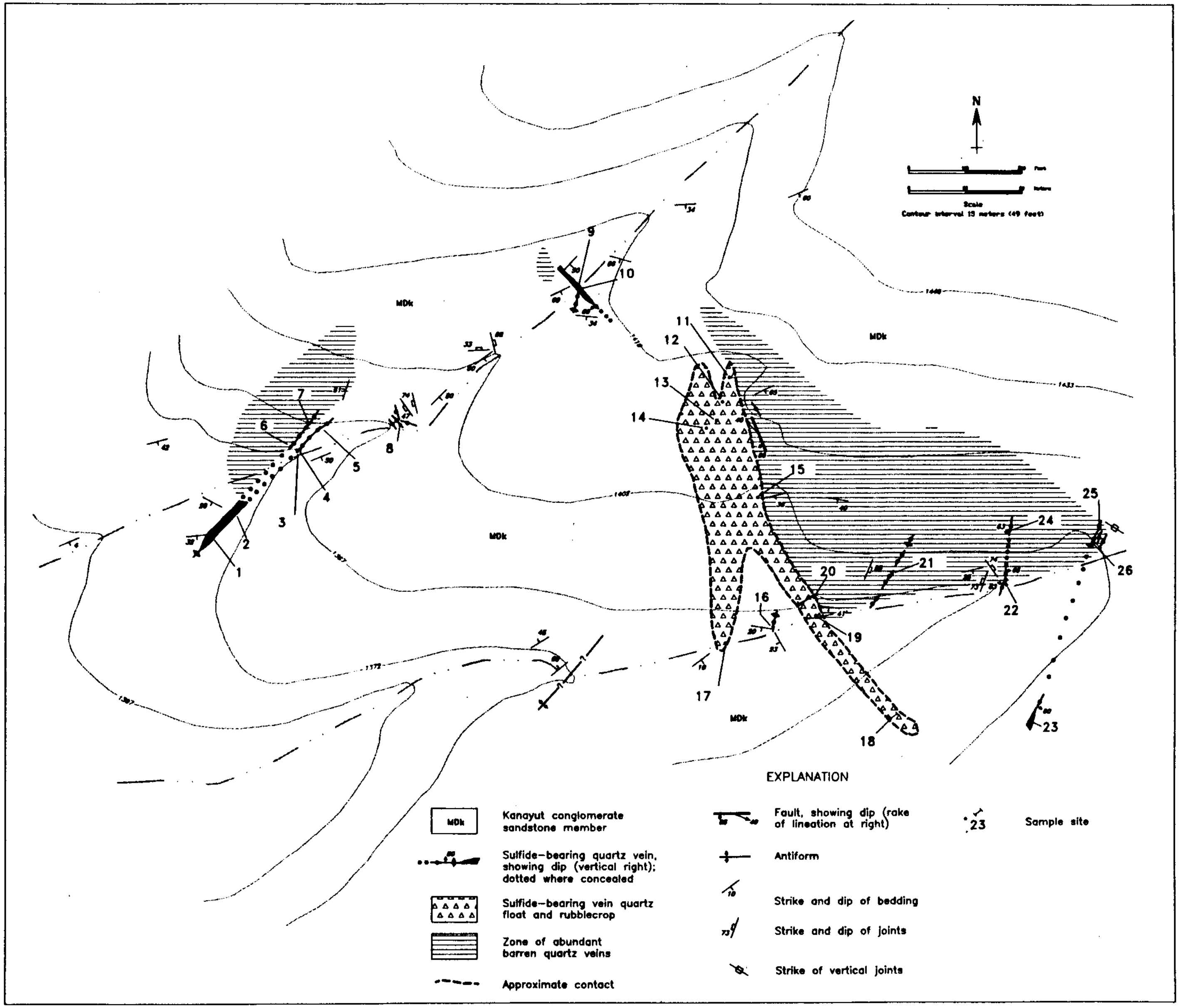


Figure C2. – Kady occurrence – geology and sample sites.

Table C2 - Analytical Results - Kady Occurrence Area

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
1	5556	Sulfides	Outcrop	Random chip	10.8	0.07	10.95	9.4	53	159	962	12138	29	636	1.5	>20000
2	4172	Sandstone	Outcrop	Chip channel		0.44	10.89	8.2	31	9	1167	12213	37	3281	3	>20000
3	4171	Sandstone	Outcrop	Chip channel		<0.01	2.20	1.7	16	43	184	3589	31	43	20	19935
3	4173	Massive sulfides	Outcrop	Select		0.03	22.01	5.7	13	12	>2000	>20000	23	303	7	>20000
4	5562	Sulfides	Outcrop	Random chip	7.89	0.10	15.14	6.3	27	31	1784	5419	63	997	12	>20000
5	5557	Sandstone	Outcrop	Random chip	0.69	0.02	1.08	1.1	8	105	78	719	90	156	24	11742
6	4155	Sandstone	Outcrop	Chip channel		0.75	5.69	5.5	64	25	517	5260	96	6333	27	>20000
7	5558	Quartz vein	Rubblecrop	Select	2.40	<0.01	5.12	3.0	15	53	450	2454	27	104	9	>20000
8	5559	Quartz vein	Outcrop	Random chip	3.09	<0.01	10.47	1.1	22	93	837	1559	39	135	24	>20000
9	4076	Massive sulfides	Rubblecrop	Grab		<0.01	23.88	0.9	11	10	1808	688	23	154	3	>20000
10	4074	Massive sulfides	Outcrop	Select		0.09	1.30	3.6	9	40	106	3454	34	731	5	12461
10	4075	Massive sulfides	Outcrop	Select		<0.01	35.79	5.1	31	14	>2000	844	29	207	8	>20000
10	5560	Sulfides	Outcrop	Select	15.1	1.80	35.76	16.0	63	58	>2000	397	24	>10000	17	>20000
10	5561	Quartz vein	Outcrop	Contin chip	3.43	<0.01	1.06	2.8	10	135	112	264	36	154	32	12630
11	5444	Quartz vein	Outcrop	Random chip	9.94	0.10	2.22	8.2	47	167	207	1746	31	1626	16	>20000
12	5445	Sulfides	Float	Select	18.9	0.49	48.21	12.9	73	33	>2000	330	26	5765	<2	>20000
13	4073	Massive sulfides	Rubblecrop	Select		0.09	12.45	12.6	30	11	1067	5428	29	864	3	>20000
14	5443	Quartz vein	Float	Select	745	53.20	0.06	>50.0	100	135	7.3	332	10	>10000	8	729
15	5446	Quartz vein	Rubblecrop	Random chip	12.7	0.76	2.86	11.5	115	52	135	470	30	8503	14	>20000
16	5456	Quartz vein	Outcrop	Contin chip	5.83	0.91	2.28	4.7	4	259	154	497	32	>10000	65	12924
17	4071	Massive sulfides	Rubblecrop	Select	73.4	0.32	22.98	>50.0	58	53	880	387	34	2900	10	>20000
18	5454	Quartz vein	Float	Grab	118	10.75	0.79	>50.0	31	94	49	2905	23	>10000	24	8054
18	5455	Massive sulfides	Float	Select	572	59.76	0.70	>50.0	133	29	46	2798	11	>10000	11	7799
19	4072	Massive sulfides	Rubblecrop	Select	139	23.56	23.46	>50.0	59	10	1140	354	16	>10000	6	>20000
20	5447	Quartz vein	Float	Random chip	16.5	1.96	12.52	15.1	29	86	975	259	197	>10000	19	>20000
21	5453	Quartz vein	Outcrop	Contin chip	5.14	0.44	0.54	4.9	48	16	35	131	18	4580	6	5047
22	5448	Quartz vein	Outcrop	Contin chip	9.60	0.86	27.17	8.3	25	88	>2000	563	26	>10000	19	>20000
23	5450	Quartz vein	Rubblecrop	Random chip	2.74	0.06	0.47	1.7	19	81	26	339	22	559	12	4472
24	5452	Quartz vein	Outcrop	Contin chip	0.69	0.02	0.43	0.9	2	51	29	513	34	243	10	4708
25	5449	Quartz vein	Outcrop	Grab	20.2	0.04	7.79	17.2	16	60	702	558	31	560	14	>20000
26	5451	Quartz vein	Outcrop	Contin chip	2.06	0.01	0.66	3.6	4	43	58	3594	29	148	11	6952
27	4183	Massive sulfides	Rubblecrop	Select	54.9	0.01	<0.01	>50.0	15	10	<2.0	>20000	22	160	3	53
27	5457	Quartz vein	Rubblecrop	Grab	30.2	0.24	<0.01	26.1	18	25	<2.0	14560	30	2372	6	127
28	5458	Quartz vein	Float	Select	22.6	0.02	2.95	20.0	19	31	108	>20000	150	478	6	>20000
29	4181	Massive sulfides	Rubblecrop	Grab		0.10	0.57	5.0	12	67	31	5342	32	923	11	5457
29	4182	Massive sulfides	Rubblecrop	Select	91.9	8.99	1.00	>50.0	29	49	54	240	31	>10000	42	9337
29	5563	Quartz vein	Rubblecrop	Select	9.60	1.71	1.44	7.9	32	40	114	163	27	>10000	15	14804
29	5564	Quartz vein	Float	Grab	4.11	<0.01	9.75	2.2	26	21	675	172	34	172	6	>20000
30	4210	Sandstone	Float	Select		0.18	4.73	5.8	43	40	235	2266	<5	1840	13	>20000
30	5603	Quartz vein	Outcrop	Contin chip	5.83	0.06	0.22	4.9	17	200	11	17280	204	525	6	2310

Table C2 - Analytical Results - Kady Occurrence Area (continued)

Map no.	Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
30	5604	Quartz vein	Float	Grab	15.8	1.83	0.71	16.5	13	875	31	108	29	>10000	6	7559
31	4222	Quartz	Outcrop	Select		0.06	0.40	7.1	12	36	19	>20000	457	545	22	3881
31	4223	Quartz	Outcrop	Channel		0.02	0.03	1.5	19	108	3.2	1459	256	132	72	280
32	4140	Sandstone	Float	Grab		0.20	<0.01	0.9	5	48	<2.0	40	31	1585	21	125
33	4174	Sandstone	Outcrop	Select		0.34	5.54	6.2	32	117	296	431	32	2902	19	>20000
34	4176	Sandstone	Outcrop	Select		0.16	0.03	<0.5	6	51	<2.0	52	40	1561	25	297
35	4177	Sandstone	Rubblecrop	Grab		<0.01	<0.01	<0.5	4	122	<2.0	333	79	10	34	174

PROPERTY SUMMARY

NAME: Kakivilak Creek — MAS NO. 0020210006

DEPOSIT TYPE: vein

COMMODITIES: lead, zinc, silver, copper

LOCATION:
Quadrangle: Killik River A4
W 1/2, Sec. 22, T. 32N, R. 17E, Meridian: Kateel River
Lat. 68 deg. 09' 30" N., Long. 154 deg. 08' 00"W.
Geographic: Located at the Headwaters of a northwest tributary to Kakivilak Creek.
Elevation: 1540 m

GEOLOGIC SETTING:

Rocks in the area are included within the Upper Devonian Hunt Fork Shale. The upper part consists of dark and olive gray shale, along with minor interbedded quartz-chert wacke, quartzite, sandstone, and minor conglomerate. The lower part is dominated by phyllitic shale and contains scattered fossiliferous beds with brachiopods and corals (186).

BUREAU INVESTIGATION:

Sulfide-bearing quartz veins were discovered and sampled by the Bureau in 1991 during investigation of anomalous geochemical samples collected previously by the USGS (268). Sulfides consist of galena, chalcopyrite, and sphalerite. A select sample from a 1.5 m-wide quartz vein of unknown extent contained 3.6% lead and 2729 ppm copper (4197)(table C3). A select sample from a 6.4 cm-wide quartz-cemented breccia vein contained 7.7% zinc, 0.25% lead, and 2.8 g/mt silver (4196). A select sample of quartz float collected downslope from the veins contained 2.4% lead, and 1.1% zinc (4218).

RESOURCE ESTIMATE: Unknown

MINERAL DEVELOPMENT POTENTIAL:

Low potential for small low-grade lead-zinc-silver bearing quartz veins.

RECOMMENDATIONS:

Determine extent of veins and prospect area for more such occurrences.

REFERENCES:
172, 186, 268

Table C3 - Analytical Results - Outwash and Kakivilak Creek Areas

Sample no.	Property name	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	Zn ppm
4135	Outwash Ck West	Quartz	Float	Grab		0.26	24.04	24.1	44	22	1305	2303	111	2969	>20000
4136	Outwash Ck West	Quartz	Float	Grab		1.55	5.43	42.2	91	29	339	819	153	>10000	>20000
4137	Outwash Ck West	Quartz	Float	Grab		0.63	2.67	47.5	9	57	206.9	133	103	6126	>20000
4138	Outwash Ck West	Quartz	Outcrop	Random chip		1.95	7.05	33.9	92	23	418.6	1627	268	>10000	>20000
4139	Outwash Ck West	Quartz	Float	Grab	171	8.93	11.70	>50.0	16	18	840	667	60	>10000	>20000
4153	Outwash Ck SW	Conglomerate	Rubblecrop	Select		0.62	2.51	6.9	4	78	167.7	49	711	5838	>20000
4154	Outwash Ck SW	Sandstone	Rubblecrop	Select		0.10	2.79	3.2	6	91	205.6	89	4370	850	>20000
4156	Outwash Ck SE	Quartz/shale	Outcrop	Select	352	25.39	0.07	>50.0	17	14	6.6	719	418	>10000	712
4157	Outwash Ck SE	Quartz	Rubblecrop	Select	128	7.26	9.31	>50.0	17	5	685.1	785	123	>10000	>20000
4158	Outwash Ck SE	Quartz	Outcrop	Select		3.30	0.17	35.7	70	21	7.6	915	33	>10000	1524
4159	Outwash Ck SE	Felsic intrusive	Float	Grab		1.64	4.96	2.9	11	29	287.9	163	11844	>10000	>20000
4194	Kakivilak Creek	Shale	Float	Grab		15.37	0.07	8.5	57	26	<2.0	6430	370	807	272
4195	Kakivilak Creek	Shale	Outcrop	Select		0.08	0.03	12.5	7	38	338.9	112	1255	2695	>20000
4196	Kakivilak Creek	Quartz	Outcrop	Select	2.76	0.25	7.72	>50.0	6	39	2.9	31	119	>10000	397
4197	Kakivilak Creek	Quartz	Outcrop	Select		3.61	0.03	2.1	8	11	6.3	2729	67	133	754
4218	Kakivilak Cr North	Quartz	Rubblecrop	Select		2.44	1.14	39.9	11	26	62.2	189	227	>10000	11292

PROPERTY SUMMARY

NAME: Kurupa River MAS NO. 0020210007

DEPOSIT TYPE: Vein

COMMODITIES: Copper

LOCATION:
Quadrangle: Killik River A3
SW 1/4, Sec. 28, T. 33N, R. 18E, Meridian: Kateel River
Lat. 68 deg. 13' 45" N., Long. 154 deg. 43' 00"W.
Geographic: Located on an unnamed northwestern tributary near the headwaters of the Kurupa River.
Elevation: 1600 m

GEOLOGIC SETTING:

Bedrock in the area consists of the Ear Peak Member of the Kanayut Conglomerate. It is composed of black shale, siltstone, sandstone, quartzite, and conglomerate. The quartzite, conglomeratic sandstone, and conglomerate generally occur in beds 1-3 m thick. Conglomerate clasts are composed of quartz and gray, black green, and occassionally red to maroon chert (186).

BUREAU INVESTIGATION:

In 1991 the Bureau discovered sulfide-bearing anastomosing quartz veins cutting sandstone in the area while investigating anomalous geochemical samples collected by the USGS (268). The veins are north-south-trending, east-dipping, and are exposed for 60 meters along strike on the margins of a gully. Chalcopyrite was the only sulfide identified and it occurs with associated malachite and azurite stain. Select samples from outcrops contained up to 0.56% copper (4170). A 2 m-wide representative chip sample across a zone of mixed sandstone and quartz veins contained 0.01% copper (4168) (table C4).

RESOURCE ESTIMATE: Unknown

MINERAL DEVELOPMENT POTENTIAL:

Low potential for small high-grade copper-bearing quartz veins.

RECOMMENDATIONS:

Determine extent of known veins and prospect for others in the area.

REFERENCES:

172, 186, 268

Table C4 - Analytical Results - Kurupa River Area

Sample no.	Basic rock type	Sample site	Sample type	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Cu %	Mn ppm	Pb ppm	V ppm	Zn ppm
4167	Sandstone	Outcrop	Repr chip	<0.01	<0.01	<0.5	3	55	<2.0	2315	0.23	158	21	36	23
4168	Sandstone	Outcrop	Repr chip	<0.01	<0.01	<0.5	10	45	<2.0	378	0.01	173	35	36	22
4169	Sandstone	Outcrop	Repr chip	<0.01	<0.01	<0.5	12	57	<2.0	1455	0.14	29	13	31	14
4170	Quartz	Outcrop	Select	<0.01	<0.01	1.2	4	23	<2.0	4075	0.41	82	15	14	15
4187	Shale	Float	Grab	<0.01	<0.01	<0.5	1	29	<2.0	1514	0.15	97	<2	16	18
4200	Sandstone	Outcrop	Select	<0.01	<0.01	0.6	4	47	<2.0	5236	0.56	214	<2	31	26

PROPERTY SUMMARY

NAME: Outwash Creek Southeast MAS NO. 002010009

DEPOSIT TYPE: Quartz breccia veins

COMMODITIES: Lead, zinc, copper, silver

LOCATION:

Quadrangle: Kilik River A4
NW 1/4, Sec. 28, T. 32N, R. 16E, Meridian: Kateel River
Lat. 68 deg. 09' 00" N., Long. 155 deg. 13' 30" W.
Geographic: Near the head of a southwest tributary to upper Outwash Creek.
Elevation: 1350 m

GEOLOGIC SETTING:

The rocks in the area consist of an undivided assemblage of upper Devonian Hunt Fork Shale and Noatak Sandstone (186).

BUREAU INVESTIGATION:

The Bureau discovered sulfide-bearing quartz-cemented shale breccia and quartz veins in the area in 1991 during investigation of anomalous geochemical samples collected by the USGS (268). Visible sulfides consisted of galena and pyrite. A Select sample (4156), collected from quartz-cemented shale breccia outcrop, contained 25.4% lead and 352 gmt silver (Table C3). The width and extent of the breccia is unknown. A Select sample (4157), collected from rubblecrop of the same material, contained 7.3% lead, 9.3% zinc, >50 ppm silver, and 785 ppm copper. The widths and strike lengths of the veins and breccia zones are unknown (172).

RESOURCE ESTIMATE: Unknown

MINERAL DEVELOPMENT POTENTIAL:

Low potential for small high-grade lead-zinc-silver veins and breccia zones.

RECOMMENDATIONS:

Determine extent of known mineralization and search for undiscovered occurrences in the area.

REFERENCES:

186, 172, 268

PROPERTY SUMMARY

NAME: Outwash Creek Southwest MAS NO. None

DEPOSIT TYPE: Disseminated

COMMODITIES: Lead, zinc

LOCATION:

Quadrangle: Killik River A4
SE 1/4, Sec. 20, T. 32N, R. 16E, Meridian: Kateel River
Lat. 68 deg. 09' 10" N., Long. 155 deg. 14' 55"W.
Geographic: Near ridgetop on southwest side of Outwash Creek, near headwaters.
Elevation: 1420 m

GEOLOGIC SETTING:

Rocks in the area are included within the Upper Devonian Hunt Fork Shale. The upper part consists of dark and olive gray shale, along with minor interbedded quartz-chert wacke, quartzite sandstone, and minor conglomerate in the upper part. The lower part is dominanted by phyllitic shale and contains scattered fossiliferous beds with brachiopods and corals (186).

BUREAU INVESTIGATION:

The occurrence was discovered and sampled by the Bureau in 1991 (172). It is located along a topographic bench and consists of silicified sandstone and conglomerate rubblecrop, containing sphalerite, galena, and pyrite. Samples contained up to 2.8% zinc and 0.62% lead (4153, 4154) (table C3). The width and extent of the mineralized zone is unknown.

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for sandstone-hosted, lead-zinc deposits.

RECOMMENDATIONS:

Further prospecting in area to determine extent of mineralization.

REFERENCES:

172, 186

PROPERTY SUMMARY

NAME: Outwash Creek West MAS NO. 0020210008

DEPOSIT TYPE: Vein

COMMODITIES: Zinc, lead, silver, copper

LOCATION:

QUADRANGLE: Killik River A4
SE 1/4, Sec. 17, NE 1/4, Sec. 20, T. 32N, R. 16E
Meridian: Kateel River
Lat. 68 deg. 10'00" N., Long. 154 deg. 15' 45"W.
Geographic: Near divide between headwaters of Etivluk River and Outwash Creek.
Elevation: 1600-1760 m

GEOLOGIC SETTING:

Rocks in the area consist of quartzite and sandstone of the Hunt Fork Shale which are in thrust contact with the Kanayut Conglomerate. These rocks are crosscut by silicified shear zones(?) and quartz veins, mostly exposed as rubblecrop (186).

BUREAU INVESTIGATION:

The Bureau examined the area in 1991 while investigating anomalous stream sediment geochemical samples collected by the USGS (268). A sulfide-bearing quartz vein and quartz float were discovered at this time. Sulfides consist of sphalerite, galena, and pyrite. A random chip sample (4138) from an outcropping quartz vein of unknown width and extent contained 7.1% zinc, 1.95% lead, and 0.2% copper (table C3). A series of select samples of vein quartz float contained up to 24% zinc (4135), 1.6% lead (4136), and 171 g/mt silver (4139) (172).

RESOURCE ESTIMATE: None

MINERAL DEVELOPMENT POTENTIAL:

Low potential for high-grade zinc-lead-silver veins.

RECOMMENDATIONS:

Further prospecting in area to determine width and extent of known veins and determine if more exist in area.

REFERENCES:

172, 186, 268

PROPERTY SUMMARY

NAME: Vidlee

MAS NO. 0020210004

DEPOSIT TYPE: Vein breccia

COMMODITIES: Zinc, lead, silver

LOCATION:
Quadrangle: Killik River A4
SW 1/4, Sec. 32, T. 32N, R. 16E, Meridian: Kateel River
Lat. 68 deg. 09' 00" N., Long. 154 deg. 16' 50" W.
Geographic: On northeast tributary to Itilyiargiok Creek
Elevation: 1040 m

GEOLOGIC SETTING:

Sulfide-bearing rocks were located in the area by the USGS in 1986. This consisted of a single 5 m-wide outcrop, exposed for 25 m along strike (62). These rocks are exposed at stream level on the north side of a first-order tributary of Itilyiargiok Creek, near the contact between the Hunt Fork Shale and the Kanayut Conglomerate. Sulfides consist of galena, sphalerite, chalcopyrite, and pyrite, concentrated in quartz veins and in the matrix of quartz-cemented shale and sandstone breccia.

Segregation of sulfides into individual pyrite, sphalerite, and galena-dominant bands has been noted.

BUREAU INVESTIGATION:

Three continuous chip samples were taken by the Bureau across the discovery outcrop (4145, 4146, 4148). These averaged 2.6 m in length and contained an average of 2.0% zinc, 1.1% lead, 1103 ppm copper, and 130 g/mt silver. A select sample from the outcrop (4150) contained 56.9% lead, 9.8% zinc, 1287 g/mt silver, and 1056 ppm copper (table C5). The veins have an average trend of N 40 deg. E with shallow northwesterly dips. White encrustations on the sulfide-bearing rocks are probably hydrozincite.

Further prospecting by the Bureau led to the discovery of two other mineralized sites in the area. At one site, located on a ridgetop, 1.3 km north of the discovery outcrop, galena and sphalerite occur in quartz veinlets and veins from 6 - 150 mm wide in sandstone float and rubblecrop. Two select samples (4151, 4152) contained up to 1.4% lead, 12.1% zinc, and 32.5 ppm silver.

At another site, 1.0 km northwest of the discovery outcrop, a grab sample of vein quartz float (4130), found in a gully, contained 3.5% lead and 32 ppm silver.

RESOURCE ESTIMATE: Unknown

MINERAL DEVELOPMENT POTENTIAL:

Low potential for small high-grade lead-zinc-silver veins

RECOMMENDATIONS:

Prospect area for possible, larger, undiscovered veins.

REFERENCES:

62, 172, 186

Table C5 - Analytical Results - Vidlee Occurrence

Sample no.	Basic rock type	Sample site	Sample type	Ag g/mt	Pb %	Zn %	Ag ppm	Au ppb	Ba ppm	Cd ppm	Cu ppm	Mn ppm	Pb ppm	V ppm	Zn ppm
4130	Quartz	Float	Grab		3.47	<0.01	32.0	3	48	<2.0	27	61	>10000	5	38
4131	Sandstone	Outcrop	Random chip		0.05	0.01	0.7	3	200	<2.0	9	329	302	41	75
4132	Quartz	Outcrop	Random chip				<0.5	2	186	<2.0	8	159	164	44	42
4133	Sandstone	Outcrop	Random chip				0.7	5	122	<2.0	11	294	9	81	21
4134	Quartz	Outcrop	Random chip		<0.01	<0.01	0.8	2	244	<2.0	473	3510	<2	49	51
4145	Sandstone	Outcrop	Chip channel		0.18	3.08	5.6	8	121	183	51	244	1674	100	>20000
4146	Sandstone	Outcrop	Chip channel	99.4	2.85	2.87	>50.0	370	54	243	3088	33	>10000	32	>20000
4148	Sandstone	Outcrop	Chip channel	291	0.18	0.09	3.7	49	117	4.3	169	82	1699	73	791
4149	Sandstone	Outcrop	Chip channel	298	2.80	1.96	>50.0	41	86	169	510	30	>10000	62	18415
4150	Sandstone	Outcrop	Select	1287	56.93	9.80	>50.0	168	<5	877	1056	13	>10000	3	>20000
4151	Sandstone	Rubblecrop	Select		1.40	12.14	46.6	27	15	556	82	30	>10000	4	>20000
4152	Sandstone	Outcrop	Select		0.92	10.44	32.5	23	35	776	115	45	8962	21	>20000

Appendix D - Alphabetical Listing of Mineral Occurrences in the Colville Mining District and Southern NPRA

Name	Page no.	Quadrangle (fig.)	Deposit type	Commodities	Associated elements	Mineral development potential (resources)
Abby	105	Howard Pass (10)	stratiform	barium		low (0.40 mmt)
VABM Apex	111	" "	disseminated in gabbro	copper	platinum palladium nickel	unknown
Bion	112	" "	stratiform	barium		moderate (10.1 mmt)
Mt. Bupto	115	" "	veins in limestone	fluorite		low
Cobblestone Creek	64	Chandler Lake (12)	sedimentary	manganese		low
Cockedhat Mtn.	67	" "	metalliferous black shale	zinc	lead	low
Drenchwater Creek	118	Howard Pass (10)	stratiform shale-hosted	zinc, lead silver	barium cadmium antimony arsenic	moderate
Ekakevik Mtn.	137	" "	stratiform	barium		moderate (2.3 mmt)
Ipnavik River East	140	" "	disseminated, in sandstone	zinc, lead silver	barium	low
Ipnavik River West	144	" "	vein breccia, disseminated	lead, zinc silver	copper	moderate

Appendix D - Alphabetical Listing of Mineral Occurrences in the Colville Mining District and Southern NPRA (continued)

Name	Page no.	Quadrangle (fig.)	Deposit type	Commodities	Associated elements	Mineral development potential (resources)
Itkillik River East	71	Chandler Lake (12)	quartz-carbonate veins	zinc, copper		low
Itkillik River West	73	" "	quartz-carbonate veins	silver	lead copper barium	low
Ivotuk Hills	195	Killik River (11)	sedimentary	phosphate	uranium vanadium	low
Kady	198	" "	vein breccia	zinc, lead silver copper	cadmium	moderate
Kakivalik Creek	204	" "	quartz veins	lead, zinc silver copper	cadmium	low
Kiruktagiak River	75	Chandler Lake (12)	sedimentary	phosphate	zinc vanadium uranium	moderate
Kivliktort Mtn. East	146	Howard Pass (10)	vein breccia	lead, zinc silver	cadmium	low
Kivliktort Mtn. West	149	" "	" "	zinc, lead silver	" "	moderate
Koiyaktot Mtn. East	155	Howard Pass (10)	vein breccia	lead, zinc silver	cadmium antimony copper	low

Appendix D - Alphabetical Listing of Mineral Occurrences in the Colville Mining District and Southern NPRA (continued)

Name	Page no.	Quadrangle (fig.)	Deposit type	Commodities	Associated elements	Mineral development potential (resources)
Koiyaktot Mtn. West	158	Howard Pass (10)	vein breccia	zinc, lead silver	cadmium	low
Kurupa River	206	Killik River (11)	quartz veins	copper		low
Lakeview	160	Howard Pass (10)	stratiform	barium		moderate (3.8 mmt)
Lisburne Ridge	163	" "	sedimentary	phosphate	zinc vanadium uranium	low
Longview	167	" "	stratiform	barium	uranium	moderate (29.5 mmt)
Memorial Creek	170	" "	disseminated in sandstone	zinc	lead	unknown
Monotis Creek	82	Chandler Lake (12)	sedimentary	phosphate	vanadium zinc uranium	moderate
Nanushuk River	87	" "	quartz veins	copper zinc	lead	low
Outwash Creek Southeast	208	Killik River (11)	quartz veins vein breccia	lead, zinc silver	copper	low
Outwash Creek Southwest	209	Killik River (11)	disseminated in sandstone	lead, zinc		low

Appendix D - Alphabetical Listing of Mineral Occurrences in the Colville Mining District and Southern NPRA (continued)

Name	Page no.	Quadrangle (fig.)	Deposit type	Commodities	Associated elements	Mineral development potential (resources)
Outwash Creek West	210	" "	quartz veins	zinc, lead silver	copper	low
Safari Creek	171	Howard Pass (10)	vein breccia disseminated	lead, zinc silver	copper	moderate
Siksikpuk River	89	Chandler Lake (12)	metalliferous black shale	zinc	lead	low
Skimo Creek East	92	" "	sedimentary	phosphate	vanadium zinc	moderate (14.2 mmt)
Skimo Creek West	98	" "	" "	phosphate	vanadium zinc	moderate
Stack	176	Howard Pass (10)	stratiform	barium	uranium vanadium	moderate (2.9 mmt)
Story Creek	179	" "	vein breccia	zinc, lead silver	barium copper	moderate (2.9 mmt)
Tiglukpuk Creek	176	Chandler Lake (12)	sedimentary	phosphate	vanadium zinc	moderate
Tuck	190	Howard Pass (10)	stratiform	barium		low (0.16 mmt)
Tukuto Creek	193	" "	volcanic (?) tuffs	lead, zinc		unknown
Vidlee	211	Killik River (11)	vein breccia	zinc, lead silver	copper	low