THE GEOLOGY AND MINERALIZATION OF THE AMBLER DISTRICT, ALASKA

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Spokane, Washington
April 1976

INTRODUCTION

The area referred to as the Ambler District is located on the south flank of the Brooks Range between 66°45' to 67°30' North latitude, and 154°15' to 156°30' West longitude, between the Redstone River on the west and Walker Lake on the east. It is 300 air miles northwest of Fairbanks, Alaska, 150 air miles east of Kotzebue, and 40 miles north of the Arctic Circle (Figure 1).

The climate is typical of subarctic northern Alaska. Ice and frost conditions prevail from the middle of September to June. Average annual precipitation for a five-year period at Shungnak is 21.6 inches. While average temperature during the above period is 21.7° F, the highest and lowest temperatures recorded were 90° and -61° respectively.

Topography varies from moderately dissected hills in the Cosmos Hills region to the rugged alpine terrain of the Schwatka Mountains. The general level of peaks in the overall area is 3700 feet, and local relief is typically 1500 to 3500 feet. The Schwatka Mountains normally have sharply crested north flanks, with moderately sloped south flanks.

Early prospecting in the Ambler District began nearly 75 years ago with gold prospecting and placer mining in the Cosmos Hills. Following World War II, prospecting resumed for gold, copper and uranium. While prospecting for uranium in the Ruby Creek area, Rhinehart Berg, a local prospector, discovered significant copper mineralization. By 1957, enough mineralization had been exposed by Berg and his associates to interest Bear Creek Mining Company, who, after optioning the ground from Berg, initiated an extensive exploration program. Reconnaissance geologic mapping and stream sediment sampling of the south flank of the main Brooks Range began in 1962. Discovery of massive sulfides at Dead Creek and Arctic in 1965 led to intensive land acquisition and drilling programs. Since 1958, large boulders of altered mafics containing variable amounts of nephrite jade have been mined on a small scale in the Cosmos Hills.

REGIONAL GEOLOGY

The Ambler District can be divided into five subareas: Cosmos Hills, Kalurivik Arch, Schwatka Mountains, Angayucham Mountains, and Ambler Lowlands (Figures 1 and 2). This paper will deal mainly with the first two areas.

The Cosmos Hills consist of a complex window of Devonian to Cretaceous formations 20 miles long and 2 to 8 miles wide, which is bounded by at least four major overthrust faults (Fritts, 1970). Immediately north of the Cosmos Hills is the Ambler Lowland, a broad, gravel and silt-covered valley believed to be a major synform. Northward from the Ambler Lowlands and forming the southern limit of the Brooks Range is the proposed Kalurivik Arch (Pessel and others, 1972). The arch consists of a complex antiform of schists and metavolcanic rocks which have undergone considerable thrusting and compressional folding from south to north. The Kalurivik Arch is separated from the extensive carbonates, calcareous schists and Cretaceous intrusives of the Schwatka Mountains, by the Walker Lake lineament of Fritts (1971), Pessel and others (1972 and 1973). Immediately to the east of the Cosmos Hills are the Jurassic volcanics of the Angayucham Mountains (Figure 2).

STRATIGRAPHY

The following is a brief description of the gross lithologies in the Ambler District by area. Except where noted, the age relationships between various lithologies are not known.

Cosmos Hills

A sequence of limestones, dolomites and phyllites, approximately 2500 feet thick, form the basal section in the Cosmos Hills and are believed to be correlatives of the Skagit limestone (Devonian). Thousands of feet of graywacke, mudstone, and conglomerate of Cretaceous age overlie the older sediments as a result of later thrusting. Conformable, tabular intrusive bodies of serpentinized ultramafics from 10 to 400 feet thick accompanied the youngest thrusting. A granitic intrusive believed to be of mid-Cretaceous age is found in the Cosmos Hills near the Kogoluktuk River (Figure 2). A thermal metamorphic aureole consisting of garnetiferous greenstone and schist is present in the sediments adjacent to the intrusive.

Ambler Lowlands

Very limited outcrops are present in the lowlands. Rocks, where exposed, appear to be dominantly metavolcanics and phyllites.

Angayucham Mountains

Partially altered amygdaloidal andesites and basalts of Jurassic age form the Angayucham Mountains (Patton and Miller, 1973). Associated with the volcanics are complex faulted sections of phyllites.

Kalurivik Arch

Quartz mica schist with epidote and graphite is the dominant rock type in the Kalurivik Arch. Intercalated with the quartz mica schist is a complex assemblage of other felsic schists. Using the terminology established by Wiltse (1975), the dominant units are: blastoporphyritic micaceous quartzo-feldspathic schists, talc muscovite schist, porphyroblastic micaceous quartz schist, graphitic micaceous quartzose schist, chlorite schist, and calcareous muscovite quartz schist. Quartzites and chloritic quartzites along with marble, are also present within the felsic schist sequence.

Throughout the Kalurivik Arch are numerous tabular and pod-like masses of greenstone. The greenstone consists of actinolite, spessartite-garnet, epidote, chlorite, calcite, and quartz. The greenstone bodies are normally conformable but contain baked inclusions of surrounding host rocks. The geometry, mineralogy, and relict pillow structures in these greenstones suggest their subaqueous emplacement into surrounding sediments as hypabyssal and/or volcanic rocks.

Schwatka Mountains

Thick sequences of carbonates believed to be Skagit (Devonian) are present in the Schwatka Mountains. Other major rock types include quartzites, calcareous schists and carbonates other than Skagit age. The Schwatka Mountains are also characterized by abundant felsic intrusives of Cretaceous age.

STRUCTURE

Cosmos Hills

Regionally, the Cosmos Hills are a major northwest-trending anticline on the northern flank of the Kobuk trough. The anticline has a wave length of roughly 6 to 7 miles, and the axis is approximately 3 miles south of Bomite (Figure 2). Locally, in the Kogoluktuk River area, the sediments have been affected by outward doming adjacent to a granitic intrusive.

At least four major overthrust faults form the borders of what Fritts (1970) called the Cosmos Hills window. Fritts felt that the amount of displacement on these faults is 5 to 8 miles at a minimum, but 12 miles or more is possible. High angle, northeast-trending normal faults were mapped near the Kogoluktuk River by Bear Creek Mining (BCM), and have also been observed in the drilling at Ruby Creek. Displacement on the faults in the Kogoluktuk area is approximately 1000 feet (Fritts, 1970).

Kalurivik Arch

The Kalurivik Arch is a major antiform, the axis of which is approximately 3 miles north of the Arctic Camp. The antiform produces a regional west-northwest strike and south-southwest dip in the schist belt foliation (Figure 3). The antiform has been interpreted by Tailleur as the result of a hidden intrusive core of granite (Wiltse, 1975), and by Forbes and others (1973) as the possible root zone of a regional nappe structure.

Detailed mapping by BCM in the Sunshine Creek area indicates three sets of folds. The dominant F_1 folding consists of tightly compressed or near recumbent isoclinal folds with amplitudes from a few inches to half a mile. The fold axes are parallel to that of the regional schistosity. Recrystallization and metamorphism have apparently accompanied this type of folding, though the evidence of this being district-wide is not conclusive. Superimposed on the F_1 folds are minor folds and crenulations, the axes of which are roughly east-west and axial planes subhorizontal. These folds affect the metamorphic schistosity. F_3 folds are broad warps with wave lengths from a few inches to at least a mile. Fold axes are sometimes at right angles to the Kalurivik Arch.

Low angle bedding plane thrust faults are believed common in the Kalurivik Arch as a result of the compression from south to north. The displacement on these faults is difficult to ascertain, since lithologic sequences are poorly understood.

A major lineament has been proposed by Fritts (1971), Pessel and others (1972, 1973), to separate the Kalurivik Arch from the Schwatka Mountains. In the Walker Lake area, this lineament has been mapped by Fritts as a southward-dipping thrust fault, while to the west there is some question as to whether a fault is present. Work by Forbes and others (1973) suggests the lineament may be a metamorphic isograd separating biotite-stable schists on the north from biotite-free schists to the south. Wiltse (1975), based on the work of Pessel, mentions that the Walker Lake lineament may continue to the west as an unconformity between the Kalurivik Arch schist belt and the carbonate dominated terrain of the Schwatka Mountains.

METAMORPHISM

Cosmos Hills

Progressive thermal metamorphism of the rocks surrounding the intrusive granite in the Cosmos Hills has resulted in greenschist and albite-epidote-amphibolite facies assemblages.

Very low grade greenschist metamorphism is believed to have affected more distant Devonian strata at about the same time as the intrusion. The late overthrusting in the Cosmos Hills resulted in dynamic or dynamic-thermo metamorphism of the Cretaceous strata to lower greenschist facies.

Kalurivik Arch

With the exception of albite and pennine chlorite, the mineral assemblage present clearly indicates a metamorphic rank within the quartz-albite-epidote-biotite subfacies of the greenschist facies. Wiltse (1975) found that the porphyroblastic albite and pennine chlorite were introduced into the rocks after prior metamorphism had created the primary schistosity, and those minerals which define it.

To the north of Arctic, massive skarns have developed in calcareous sediments. Wiltse (1975) feels that these skarns are the local, contact metamorphic effect of unexposed intrusive masses. Similar upwarping and skarn development has been observed around exposed 96 m.y. old intrusives in other parts of the Brooks Range.

Dating of the metamorphism by Turner (1974) indicates greenschist metamorphism in Late Paleozoic to Triassic, and thermal metamorphism in Cretaceous time.

THE ARCTIC MASSIVE SULFIDE DEPOSIT

Location and Access

The Arctic deposit is located some 17 miles northeast of Bornite at the southern flank of the Brooks Range (Figures 1 and 2). Except for a winter trail, there is no surface access to the deposit. Exploration work during the summer season is supported by helicopter transport from Bomite.

History

Stratabound iron-zinc-copper sulfides were discovered on the east face of Arctic Ridge in 1965 while following up a geochemical stream sediment anomaly observed in 1962. A seasonal exploration program has been conducted since 1966. A total of 35,348 feet in 49 NX and BX holes have been drilled, outlining the deposit quite well. In addition, fifteen 6.5-inch diameter holes were completed in 1975 yielding some ten tons of ore grade material for metallurgical tests.

Geologic Setting

The Arctic massive sulfide ore body occurs as a polymetallic, stratabound volcanogenic deposit within a suite of low to medium-grade felsic metamorphic rocks of volcanic, volcanosedimentary, and sedimentary origin, where these rocks exhibit their apparent maximum thickness. This suite is composed of four major units, each of which can be differentiated into subunits (Figures 4 and 5). None of these units are confined to a specific stratigraphic position, but interfinger horizontally and vertically.

1. Metarhyolites

Three major textural subdivisions of the metarhyolites have been defined:

(a) The aphanitic metarhyolite porphyry (blastoporphyritic schist) consists of an aphanitic groundmass of quartz, muscovite and feldspar with large (± 2.5 cm) tattered phenocrysts of bluish

K-feldspar and somewhat smaller phenocrysts of bluish quartz. This unit marks the footwall in the northeast and southwest parts of the deposit. High in the section on the south margin of the deposit area, a similar unit is observed.

(b) A schistose metarhyolite porphyry is distinguished from the above subunit by a pronounced shistosity and the presence of large (± 10 mm) augen of fine-grained albite or quartz. Outcrops near the crest of Arctic Ridge exhibit nuee ardente features. In the north and west portions of the deposit area, this unit forms the footwall of the ore deposit.

(c) The aphanitic metarhyolite is a well foliated, fine-grained rock noted for its extreme hardness and resistance to weathering. Its mineralogy consists of muscovite, albite, microcline, quartz, and biotite.

II. Porphyroblastic Schists

The development of numerous, large porphyroblasts of quartz, muscovite, chlorite, and albite is attributed to the presence of high volumes of water or other volatiles, probably the result of the crystallization of the nearby rhyolites. Porphyroblasts increase considerably, and are well developed as the rhyolite units are approached. The porphyroblasts are anhedral, probably due to low crystalloblastic strength and poikilitic since their rapid growth did not allow sufficient time for destruction of inclusions developed during their growth.

Depending on its composition, two varieties can be distinguished:

(a) quartz, muscovite porphyroblastic schist

(b) quartz, muscovite, chlorite, albite porphyroblastic schist

No specific distribution pattern is observed in the deposit area, other than their close proximity to the rhyolite units.

III. Quartz Muscovite Schist

Depending on its composition, this unit may be differentiated in subunits in addition to a normal quartz muscovite schist:

(a) talc schist

(b) chlorite schist

(c) talc, chlorite schist

(d) albite schist

The talc and talc-chlorite varieties constitute the host for the sulfide mineralization in a major part of the deposit. The talc development is thought to be the result of metamorphism of dolomite and a silicate mineral such as feldspar or clay, as well as quartz. Lateral facies change from talc schist to graphitic-to-dolomitic marble have been observed and seem to indicate the necessary existence of dolomite and silica for talc formation.

Minor porphyroblast development occurs in this unit, and though this is not volumetrically important, it reflects the close relationship with porphyroblastic schist units. Quartz muscovite schist and its varieties are present throughout the deposit, but the important talc unit is restricted to the central and southeastern part of the deposit.

IV. Graphite Schist

The mineralogy of this unit is similar to the other schists at Arctic, but the presence of graphite has had a pronounced color effect.

Lenses of quartzite and dolomitic marble are found within the graphite schist. The black graphitic schists were formed by the deposition of organic muds, terrigenous detritus, calcium-magnesium carbonates, and volcanic ash in a low-energy, shallow marine environment. Where rhyolite flowed quickly onto the carbonaceous sediments, a fine-grained graphitic schist-phyllite developed. Carbonaceous sediments farther removed from the contact with the rhyolite are more siliceous, less graphitic, coarser grained, more schistose, and contain disseminated pyrite.

Although the graphite schists are probably the best correlation markers in the deposit, pinchouts, variations in thickness, and interfingering with other schist units restrict their use as marker beds.

The graphitic schist, together with the talc schist, is the host for the sulfide mineralization at Arctic.

Structure

The Arctic deposit lies on the south flank of the Kalurivik Arch. The dip within the deposit is approximately 35° southwest to the Ambler Lowlands. A shallow synclinal trough, marked by the footwall metarhyolite, plunges southwestward at about 10° through the center of the deposit. The location is coincident with a zone of rapid facies change and strong mineralization.

Several almost east-west trending, high angle faults cut Arctic Ridge. Field mapping and drill hole data indicate offsets of less than 50 feet.

Observation in drill cores indicate the presence of small-scale folding, but no conclusive evidence could be established that the multiple sulfide layers are the result of repetition by folding.

Mineralization

Drilling shows that the deposit is stratabound but not as a single massive layer. A number of high-sulfide horizons, variable in thickness from less than 1 foot to over 60 feet, alternate with much thicker layers of low to negligible sulfide content. The upper and lower limits of the mineralized horizons define the "ore zone". The individual massive sulfide bodies within this "ore zone" vary greatly in number and areal extent. Some are continuous between drill holes, others apparently pinchout over a short distance. The numerous high-sulfide layers and/or lenses overlap and interfinger to such a degree that in plan view the deposit appears as a "massive sulfide blanket". The high-sulfide layers range from 20 to 90% total sulfides, the principal minerals being pyrite, sphalerite, and chalcopyrite. Bornite, tennantite, galena, and pyrrhotite generally occur in small amounts.

Generally, ore-grade mineralization occurs in a dark grey to black graphitic schist-phyllite, or a light grey to green quartz muscovite schist with variable amounts of carbonate, talc, and chlorite. Minor amounts of ore are present in the porphyroblastic schist and in the quartz muscovite schist where these units are in contact with the graphitic-phyllite unit.

The spacial distribution of ore and types of ore minerals are directly related to the spacial distribution of the host rocks. Ore minerals associated with the graphitic schist-phyllite in the northern and western portion of the deposit are chalcopyrite, sphalerite, and galena, with lesser amounts of bornite, tetrahedrite, and native copper. Associated with the talc-carbonate rich muscovite schist in the central and southern portion are chalcopyrite, sphalerite, bornite, galena, and minor arsenopyrite. The massive pyrite content of the ore is high in the graphitic schist-phyllite and low in the quartz muscovite schist.

The zinc and zinc-lead-silver content of the mineralization increases to the west where the host rocks are graphitic schist-phyllite. The lead-silver mineralization is directly related to the zinc mineralization. In the eastern half of the ore body, the relative copper content increases in the interbedded graphitic schist-phyllite and talcose-bearing units. Vertically, the metal ratios of the individual ore lenses in the western part of the deposit generally show a relative decrease in zinc toward the footwall, while the copper content remains the same or increases slightly. In the eastern half of the ore body, the metal ratios are sometimes cyclic and often inconsistent. This could be due to structural effects or perhaps there were several phases of mineralization, or both.

The most intense mineralization for all the ore metals is confined to the central portion of the deposit and to a small area in the southeast. There is some evidence that this intensely mineralized area is located above the trough in the footwall metavolcanics, coinciding with the southeast flank of greatest graphitic schist-phyllite buildup and the northwest flank of greatest talc-carbonate accumulation.

Origin of the Arctic Deposit

We infer that the mineralization occurred penecontemporaneously with the deposition of the various rock types. Its source may have been a fissure or series of vents in the trough developed in the footwall volcanics where fumerolic activity supplied the metals that became interbedded with the carbonate-rich volcanosediments and iron-rich, ash-bearing muds. This trough may represent a flexure in the depositional basin in which shallow water carbonates developed to the southeast, and reducing conditions existed to the northwest where mud and volcanic ash accumulated. Volcanics and volcanoclastics were contemporaneously and rapidly introduced, resulting in rapid facies change and complex stratigraphic relationships.

Metal Inventory

Drilling completed to date outlines a somewhat triangular-shaped ore body measuring 3400 by 2400 feet, eroded to the east. Thickness of the individual sulfide layers containing ore-grade mineralization ranges from inches to over 60 vertical feet. The tonnage potential of the entire ore deposit is estimated to be between 30 and 35 million tons grading about 4% Cu, 5.5% Zn, 1.5 oz Ag/ton, 1% Pb, and a small credit in gold.

THE RUBY CREEK DEPOSIT

Location and Access

The Ruby Creek deposit and its attendant townsite, Bornite, are located in the north-central part of the Cosmos Hills, 18 miles north of the Eskimo village of Kobuk. Pardner Hill is located three miles west of Bornite. Access for freight haulage is by airlift from Fairbanks to the Dahl Creek airstrip or by barge up the Kobuk River from Kotzebue (Figures 1 and 2). An all weather road connects the camp with the Dahl Creek strip. A smaller airstrip is at Bornite.

History

Bear Creek Mining Company optioned the Ruby Creek-Pardner Hill property in 1957, and began an intensive exploration program. The claims were purchased in 1963 and turned over to Kennecott New Mines Division. Shaft sinking and underground development began in 1965, but were halted on October 27, 1966, when the last round in the shaft at 1078 feet broke into a major water course. The underground workings and shaft were flooded to within 50 feet of the collar within a few hours. In September 1967, a 23-foot-thick cement plug was poured, the shaft dewatered, and equipment removed. Underground development was terminated, but mineralized zones adjacent to the shaft were outlined by underground diamond drilling. All underground work was stopped in 1968, and the mine was allowed to flood, as emphasis was shifted to the newly discovered Arctic deposit. Surface exploration has continued seasonally.

Geology

The copper deposits at Ruby Creek lie on the north flank of the Cosmos Hills anticline. The host rocks occur within a 2500-foot-thick Devonian carbonate complex which dips north at approximately 35 degrees (Figure 6). The carbonates are underlain by quartz phyllite and unconformably overlain by Cretaceous clastic sediments.

The carbonate complex consists of interbedded massive and brecciated dolomites, impure limestone and limestone breccias, and albitic lime phyllite and calcarenite. The dolomites are locally biostromal and biohermal, the limestones contain some fossil debris, and the phyllites are generally devoid of fossils. The dolomites are the most favorable host rock with local sulfide occurrences in impure limestone and albitic lime phyllite.

The carbonate complex at Ruby Creek consists of an upper and lower carbonate sequence separated by a middle phyllite-carbonate sequence (Figure 7). The composition of the two carbonate units are similar with textures varying from coarse breccia to well-bedded calcarenite. The breccias vary from light grey dolomite breccias to dark grey limestone breccias containing high amounts of carbon, muscovite, and fragments of dolomite. The middle phyllite-carbonate consists of dark grey to black tuffaceous metasediments with inter-bedded calcarenites and some limestone breccias. The phyllites are composed of quartz, muscovite, amorphous carbon, calcite, dolomite, and syngenetic pyrite.

Mineralization and Zoning

The metallic minerals in the Ruby Creek deposit are pyrite, chalcopyrite, bornite, chalcocite, tennantite, tetrahedrite, sphalerite, galena, pyrrhotite, and trace amounts of marcasite, carrolite, and germanite.

Pyrite is the most widespread and common of the sulfides, occurring in the phyllites and carbonates, especially in the dolomite breccias. Pyrite usually comprises 1 to 20 volume percent of the phyllites, and locally up to 50% of the black carbonaceous phyllites (Runnells, 1963). The pyrite in the phyllites has a framboidal texture, and many crystal aggregates are elongated parallel to the foliation indicating the pyrite is sedimentary and pre-metamorphism in age (Runnells, 1969). The pyrite in the carbonate units occurs along the edges of dolomite fragments in limestone breccias (Runnells, 1969), locally comprises 60-80% of the drill core from dolomite breccias, and is intimately intergrown with copper sulfides.

The copper sulfides chalcopyrite, bornite, chalcocite, tennantite, and tetrahedrite occur as replacements of matrix in dolomite breccia, as crackle breccia and fracture filling in dolomite and limestone, as matrix material around pyrite masses, and less commonly as massive replacement of carbonate host rocks. Chalcopyrite is the dominant copper sulfide with bornite volumetrically more important in the high-grade mineralized zones and locally in mineralized phyllites. Chalcocite commonly veins and replaces bornite and tennantite; tetrahedrite is intimately associated with chalcopyrite and sometimes with sphalerite (Runnells, 1963).

Sphalerite occurs throughout the deposit, but is only locally abundant. Galena is associated with the sphalerite, but in trace amounts. The sphalerite occurs in carbonate breccias often intimately associated with pyrite. The sphalerite content of the mineralization appears to be highest above, and peripheral to high-grade copper mineralization.

Pyrrhotite is rarely associated with high-copper zones, but found mainly in siderite-rich, poorly mineralized carbonate breccia below the main copper zones (Runnells, 1963).

The copper-rich portions of the sulfide deposits occur in the lower portions of the upper and lower carbonate sequences. High-grade mineralization, irregular in both the vertical and horizontal dimension, is surrounded by larger, irregular areas of low-grade material.

The mineralized bodies are generally greater in their horizontal extent than their vertical dimension.

Zoning of sulfides at Ruby Creek is indicated by the distribution of the sphalerite and pyrrhotite relative to the high-copper concentrations. Runnells (1963) has defined a vertical zoning pattern in one copper-rich portion of the deposit area. This zoning pattern consists of roughly concentric layers extending upward and downward from a central core:

1) a central zone of chalcocite, bornite and pyrite
2) a concentric shell of bornite, chalcopyrite and pyrite
3) chalcopyrite, tennantite and pyrite
4) chalcopyrite and pyrite
5) pyrite extending into barren rock

The paragenetic sequence of the mineralization is not defined due to obscure textural relationships. The pyrite in the phyllites is early, but the age relationships of the pyrite in the carbonates and the copper mineralization is unclear (Runnells, 1969).

Dolomitization and Alteration

The presence of dolomite fragments in limestone breccia, as well as the mode of occurrence of the sulfides within dolomite breccia masses, indicates that dolomitization was unrelated to mineralization, but probably penecontemporaneous with sedimentation. Large volumes of dolomite are unmineralized, and there are locally heavily mineralized limestones and albitic lime phyllites.

Wallrock alteration of the host rocks is apparently very minor. There is no extensive bleaching, silicification or evidence of formation of calc-silicate minerals (Runnells, 1969).

Supergene alteration extends to a depth of 200 to 300 feet in the Old Camp area on the west side of Ruby Creek. Gossans with moderate amounts of malachite and minor azurite are present.

Origin of the Deposits

Whether or not the extensive dolomite and limestone breccias at Ruby Creek are truly reef debris that accumulated along the flanks of large bioherms is yet to be determined. The breccias may have formed along some sort of carbonate bank, but possibly are in part the result of later solution collapse and tectonism.

Two major northeast-trending breccia zones have been defined to date. One extends from south of the Old Camp to north of the No. 1 shaft, and contains several high-grade zones. The other is east of the heavily drilled area and appears to be longer and wider than the first (Figure 6). The two breccia zones may have formed along recurrently active structures that possibly served as channelways for later mineralizing solutions. Runnells (1963) found that the isotopic composition of sulfides from carbonate wallrocks in the Old Camp-No. 1 shaft trend is almost identical to the composition of sulfides from the magmatic hydrothermal deposits of Tintic, Utah.

OTHER MINERALIZED OCCURRENCES IN THE KALURIVIK ARCH

Though Arctic, and perhaps Picnic Creek, are the best known deposits in the Kalurivik Arch, copper, zinc, and lead mineralization has been found at numerous other localities. Without exception, the mineralization is confined to the belt of felsic schists described earlier, and for the most part, only along the south flank of the Kalurivik Arch.

Horse Creek is the only significant copper mineralization known to the writers within the felsic schist sequence found on the north flank of the arch. The known areas of mineralization extend over a strike length of at least 60 miles, and the felsic schist sequence may extend for some 180 miles from Iniakuk Lake in the east to the Salmon River in the west. The prospective schist belt is reflected very well by anomalous regional stream sediment geochemistry. Locally, however, stream sediments are not always anomalous, even within close proximity to mineralization.

SUMMARY

Work by Bear Creek Mining Company geologists and the Alaska Division of Geology, indicates the following general characteristics about the geology and mineralization in the Ambler District.

Kalurivik Arch

The mineralization in all the occurrences observed is conformable with the enclosing schists. Mineralization has been found in graphitic schist, talc schist, porphyroblastic schist, calcareous schist, and quartzitic units. The mineralization has been clearly deformed by the early, tightly-compressed F_1 folds. There is a definite thickening or buildup in the felsic schist sequence at Arctic and Picnic Creek. No significant cross-cutting veins have been observed in the mineralized occurrences. Minor veins, where observed, appear to have resulted from remobilization of sulfides into later fractures.

On the basis of the above observations, it is concluded that the felsic schist units are the original product of rhyolitic metavolcanic domes and volcanoclastic piles. The mineralogy, geometry, and internal zoning in the mineralization throughout the area indicate very strongly a volcanic exhalative origin for the ore deposits. Unlike many volcanic exhalative deposits, there is evidence at Arctic, at least, that more than one pulse of felsic volcanism was involved. Crude vertical zoning in the individual sulfide layers does not support the idea that the multiplicity in layers is the sole result of folding.

Cosmos Hills

The Ruby Creek deposit might best be presently classed as Mississippi Valley type. Early workers at Ruby Creek have speculated that the talc phyllites could be equivalent to the felsic schists in the Kalurivik Arch area. If this is the case, copper mineralization at Ruby Creek may have originated from the distant volcanic activity in the Kalurivik Arch.

ACKNOWLEDGMENTS

It would be impossible to mention all the geologists who have contributed to the understanding of the geology and mineralization in the Ambler District. Besides the many Bear Creek Mining Company personnel who have worked in the area since the late 1950's, members of the Alaskan Division of Geology and Geophysics and the U.S. Geological Survey have also contributed a great deal to the area.

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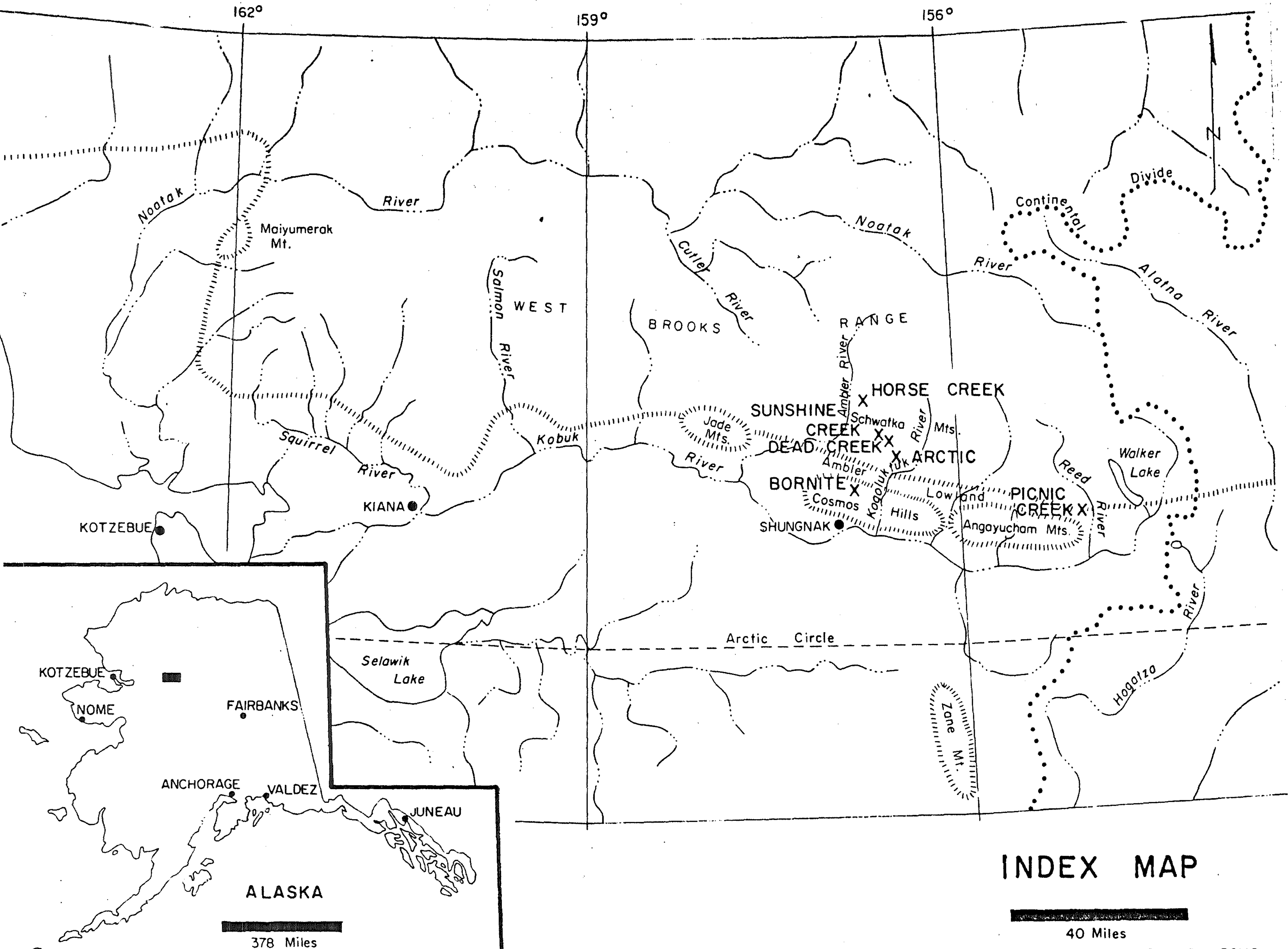


Figure 1

Data By: BCMC

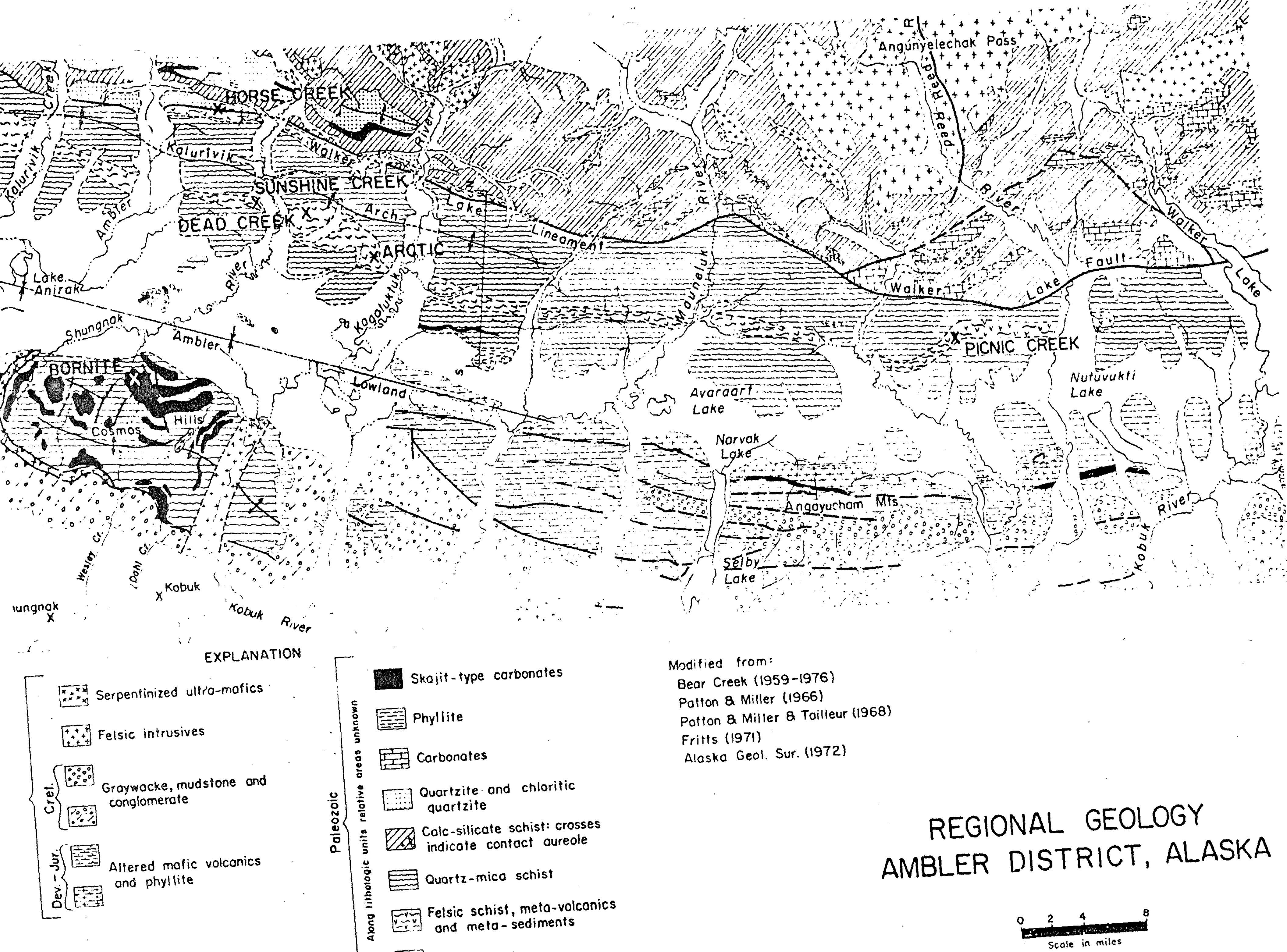
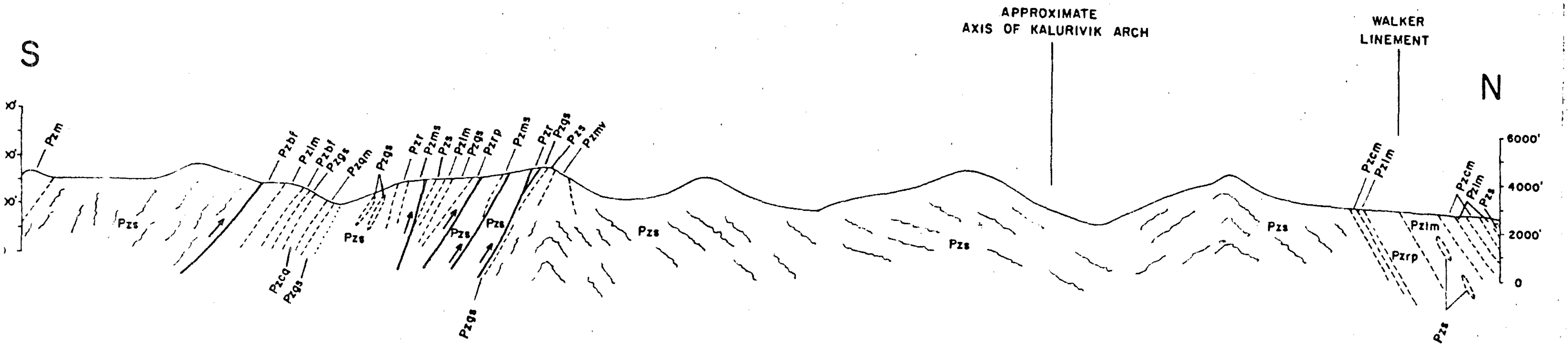

HORSE CREEK
SUNSHINE CREEK
DEAD CREEK
ARCTIC
PICNIC CREEK
BORNITE
Cosmos Hills
Angunyelechak Pass
Reed River
Kalurivik Creek
Ambler River
Walker Lake
Walker Lake Arch
Walker Lake Lineament
Walker Lake Fault
Mauneluk River
Kogoluktuk River
Shungnak
Ambler Lowland
Lake Anirak
Avaraart Lake
Nutuvukti Lake
Narvak Lake
Selby Lake
Angayucham Mts
Kobuk River
Wesley Cr.
Dahl Cr.
Kobuk
Shungnak
EXPLANATION
Serpentinized ultra-mafics
Felsic intrusives
Cret.
Graywacke, mudstone and conglomerate
Dev.–Jur.
Altered mafic volcanics and phyllite
Paleozoic
Along lithologic units relative areas unknown
Skajit-type carbonates
Phyllite
Carbonates
Quartzite and chloritic quartzite
Calc-silicate schist: crosses indicate contact aureole
Quartz-mica schist
Felsic schist, meta-volcanics and meta-sediments
Meta-volcanics
Modified from:
Bear Creek (1959-1976)
Patton & Miller (1966)
Patton & Miller & Tailleur (1968)
Fritts (1971)
Alaska Geol. Sur. (1972)
REGIONAL GEOLOGY
AMBLER DISTRICT, ALASKA
0 2 4 8
Scale in miles

Figure 2



EXPLANATION

DEVONIAN ??

Pzm	Metasediments
Pzs	Graphitic micaceous quartzose schist
Pzrp	Blastoporphyritic micaceous quartzo-feldspathic schist
Pzms	Porphyryoblastic micaceous quartzose schist
Pzgs	Graphitic schist
Pzlm	Calcite marble
Pzcm	Calcareous schist
Pzcq	Calcareous quartzite
Pzr	Biotite muscovite metarhyolite
Pzbf	Basic flows
Pzmv	Metamafics
Pzqm	Albite chlorite schist

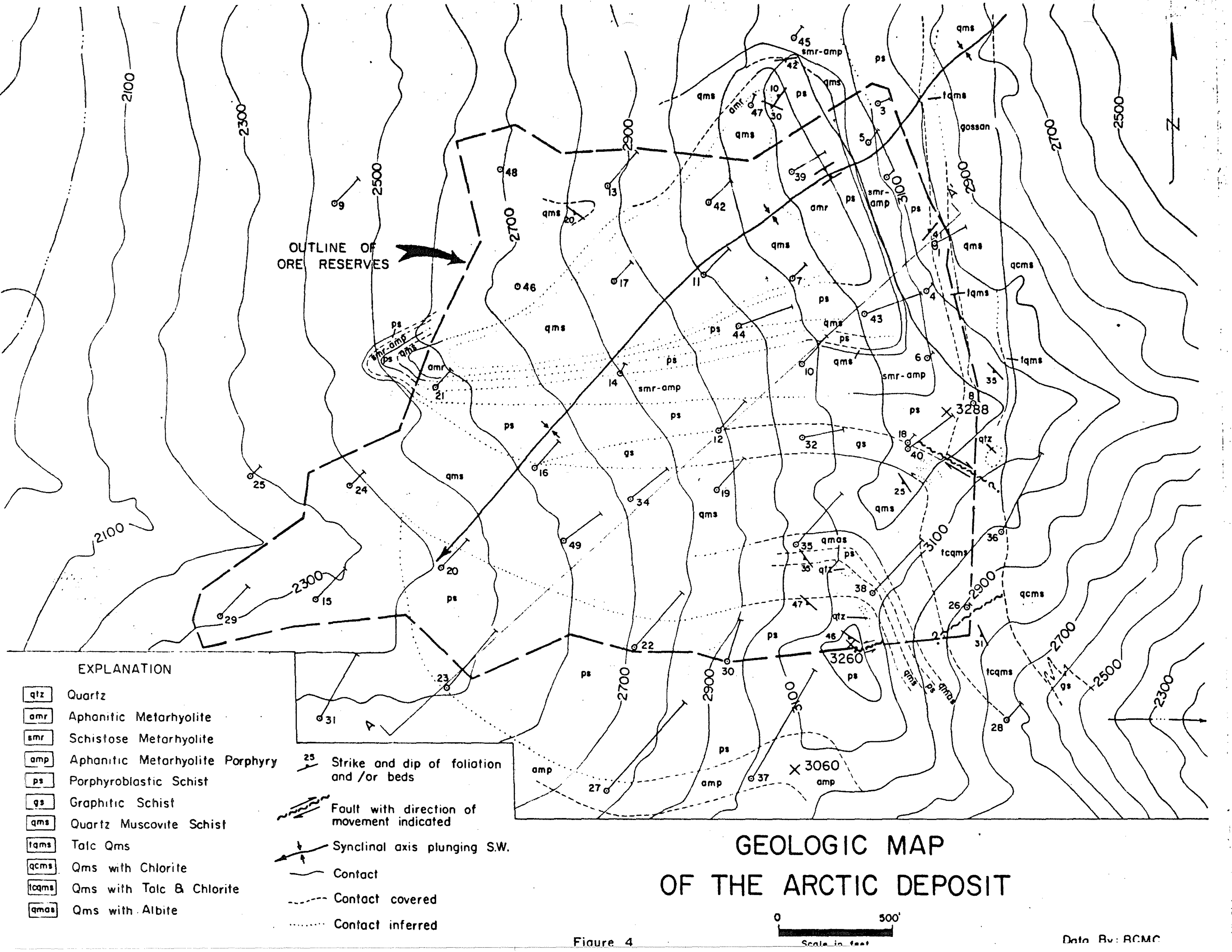
NOTE:
Age relationships between lithologic units not known.

Modified from:
Bear Creek (1969)
Wiltse (1975)

KALURIVIK ARCH
GENERALIZED GEOLOGIC CROSS SECTION

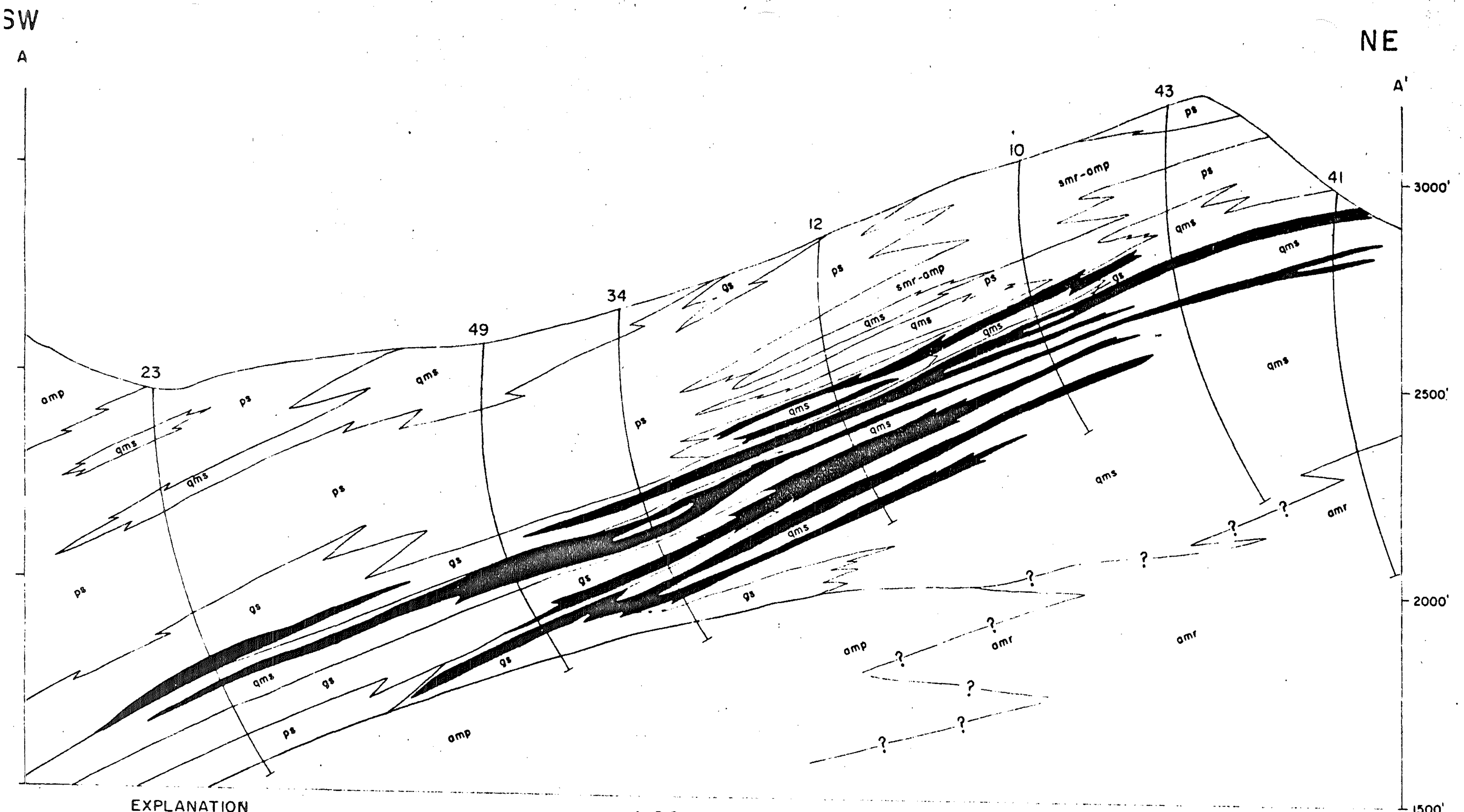
0 6000'
Scale in feet

Figure 3



GEOLOGIC MAP OF THE ARCTIC DEPOSIT

Figure 4



EXPLANATION

ps	Porphyroblastic schist
qms	Quartz muscovite schist
gs	Graphitic schist
amr	Aphanitic metarhyolite
smr	Schistose metarhyolite
amp	Aphanitic metarhyolite porphyry
	Sulfide mineralization

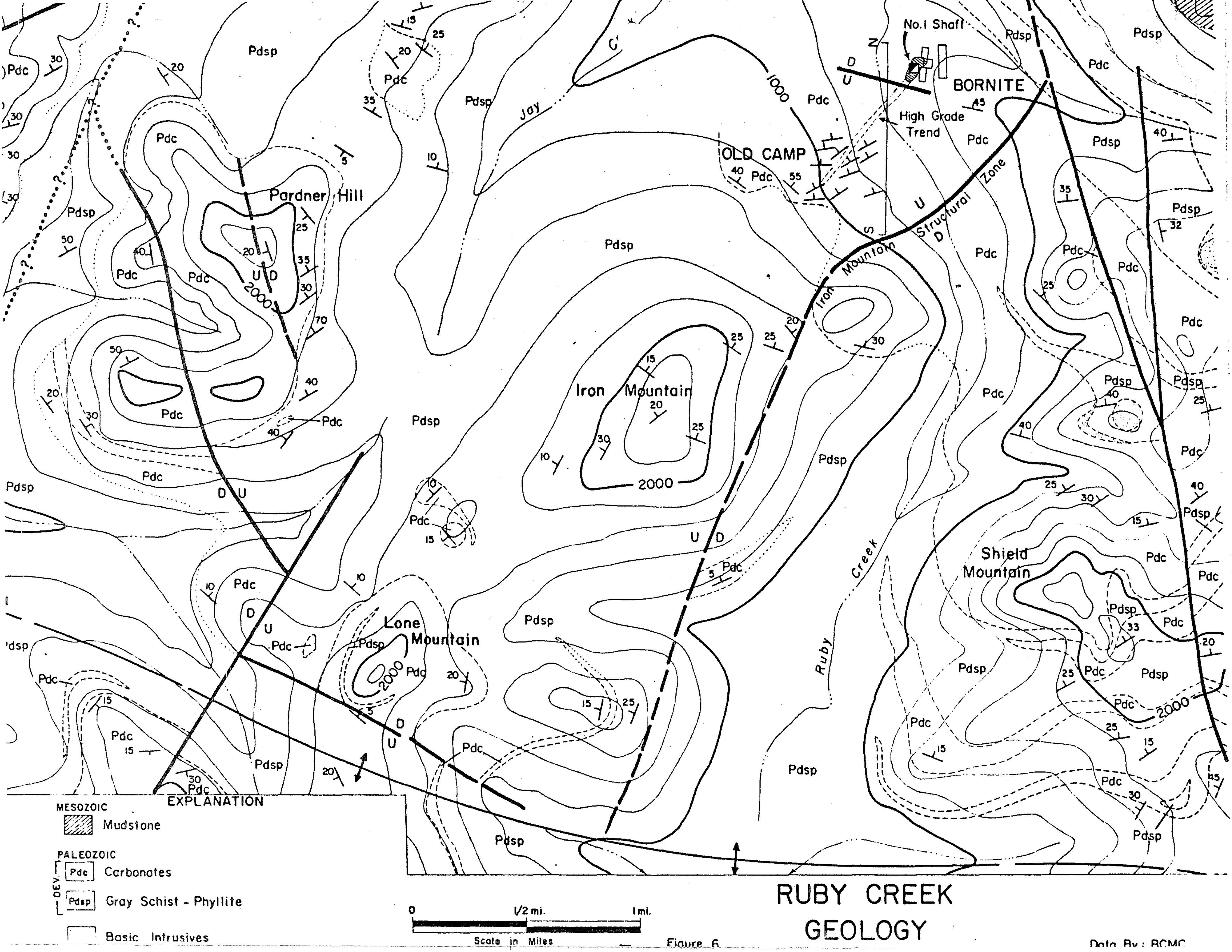
LOOKING WEST

GENERALIZED CROSS SECTION
ARCTIC DEPOSIT

0 500'
Scale in feet

Figure 5

Data By: BCMC



RUBY CREEK GEOLOGY

Figure 6

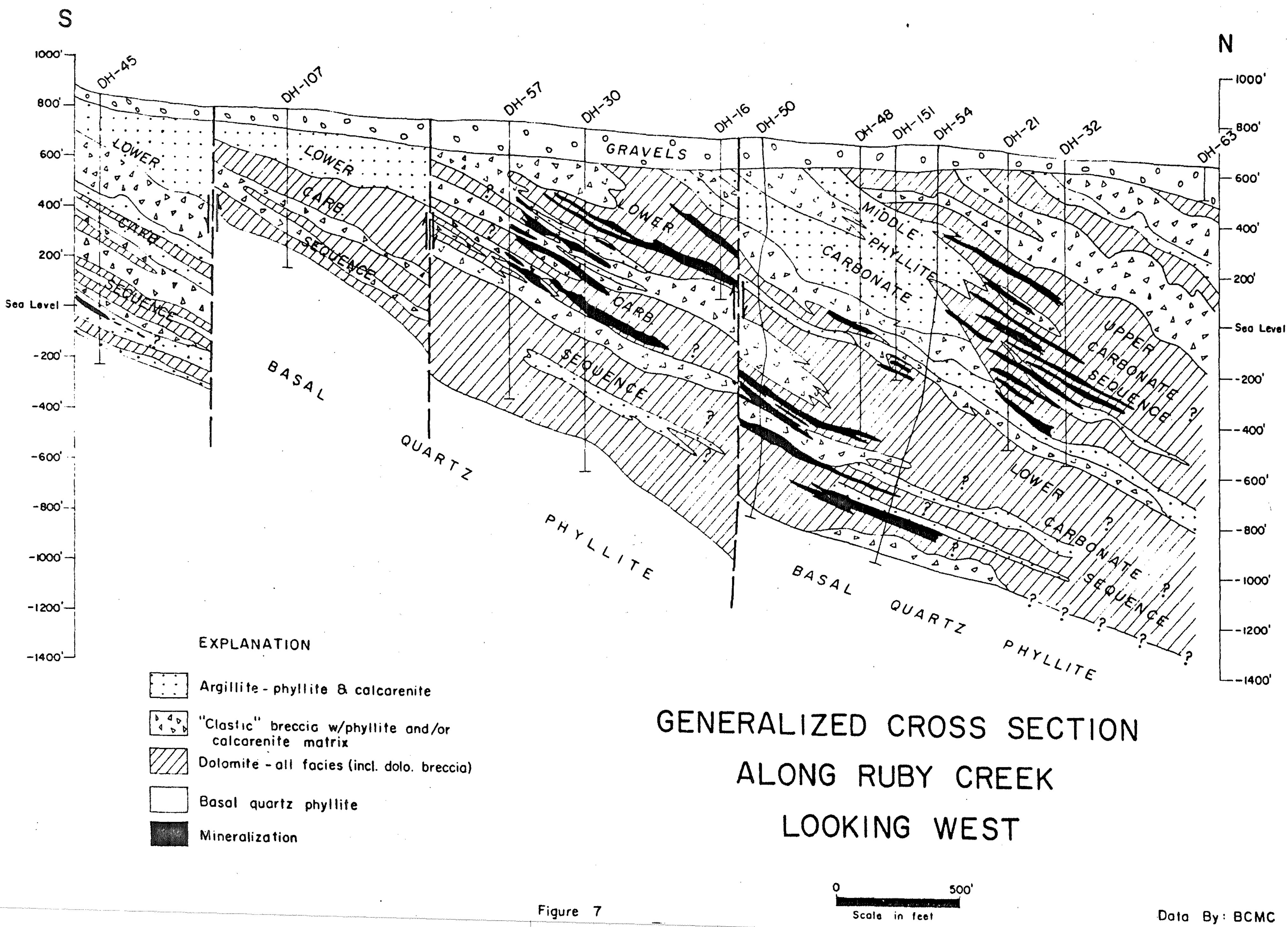


Figure 7

GENERALIZED CROSS SECTION ALONG RUBY CREEK LOOKING WEST