UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

RECONNAISSANCE GEOLOGY OF THE GINNY CREEK ZINC-LEAD-SILVER AND NIMIUKTUK BARITE DEPOSITS, NORTHWESTERN BROOKS RANGE, ALASKA

By

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INTRODUCTION

Discoveries of several base metal deposits in the DeLong Mountains in recent years have brought a new perspective to the economic potential of the northwestern Brooks Range. Awareness of this potential has helped lead to the discoveries of two new mineral deposits. One deposit is predominantly zinc-lead-silver and is herein called the Ginny Creek deposit; the other consists entirely of the mineral barite and is called the Nimiuktuk deposit. Both were discovered in the 1978 summer field season during reconnaissance geologic mapping in the south half of the Misheguk Mountain quadrangle. The Nimiuktuk deposit was found on investigation of an anomalous massive silver-gray outcrop. The Ginny Creek deposit was found by follow-up of a stream-sediment geochemical anomaly.

Time limitations did not permit detailed field study of the new discoveries. Only parts of two days were spent on the ground at the Ginny Creek deposit, and less than one hour was spent on the Nimiuktuk deposit. Because the deposits have received only superficial study, the purpose of this report is to release the geologic maps and analyses of samples from the area around the deposits and to provide a regional stratigraphic and structural framework.

Funding for this study is provided by the Office of National Petroleum Reserve in Alaska to make reconnaissance geologic maps that will enhance general understanding of geology of the mountains in the southern part of the reserve. Geologic maps of the Misheguk Mountain quadrangle at 1:63,360 scale, currently being compiled by the authors, will also help to identify those geologic terranes which have high potential for future discoveries of zinc, lead, silver, and barite deposits.

The authors wish to acknowledge the initiative and awareness of our helicopter pilot, Richard Rossiter, who took the initial geochemical samples at Ginny Creek. We also thank Richard O'Leary of the Branch of Exploration Research, whose efficiency in getting our samples analyzed made it possible to investigate the source of the geochemical anomaly during the same field season. Determination of the radiometric date from the volcanic rocks near the Nimiuktuk deposit was greatly facilitated by technical advice and diligence of M. L. Silberman.

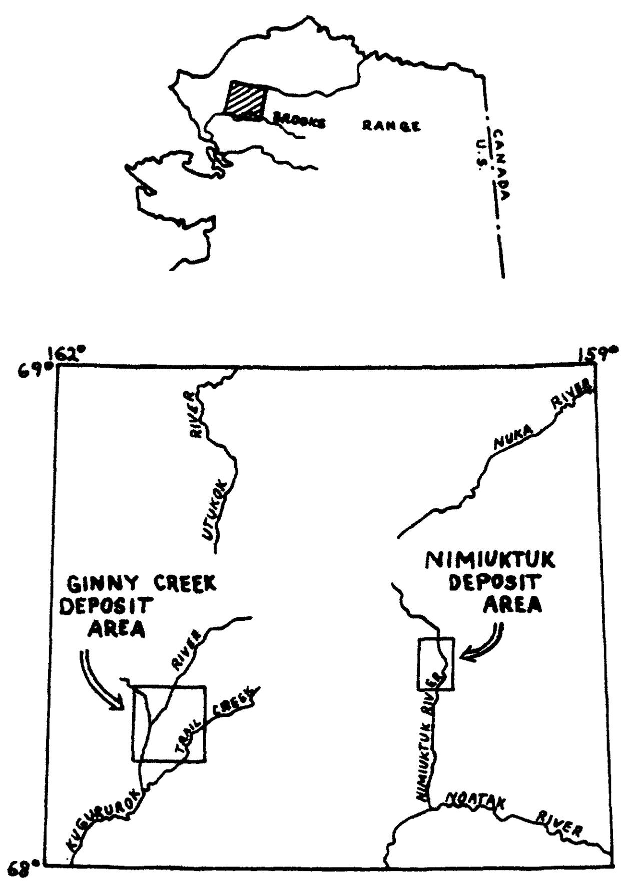

Figure 1. Location of Misheguk Mountain quadrangle, Ginny Creek deposit, and Nimiuktuk deposit.

LOCATION AND GEOGRAPHY

The locations of the Misheguk Mountain quadrangle and of the Ginny Creek and Nimiuktuk deposits are shown on figure 1 and plate 1. The Ginny Creek deposit is located approximately halfway between Trail Creek and the Kugururok River near the headwaters of Ginny Creek in an area where many of the creek gravels are conspicuously stained by iron oxides. The surrounding terrane consists of barren treeless hills and low mountains with local relief of up to 244 m (800 ft). The Nimiuktuk deposit is near the Nimiuktuk River, 59 km (37 miles) east of Ginny Creek. The exposure of the deposit consists of a small isolated hill, less than 10 m high, in the middle of a flat tundra-covered field. The surrounding terrain consists of low, gently sloping, treeless hills with rubbly outcrops of bedrock at the crests and tundra or pebbly soil-covered flanks. Local relief is less than 45 m (150 ft).

The nearest village is Noatak, 106 km (66 miles) southwest of the Ginny Creek deposit. The regional center for this area is Kotzebue, about 170 km (105 miles) to the southwest. There are no roads, and the only effective means of access in the summer is by light plane or helicopter.

STRATIGRAPHIC SETTING

The complex relationships between sedimentary rocks in the southern part of the Misheguk Mountain quadrangle can be most easily understood if the sediments are grouped in generally coeval stratigraphic sequences which are superimposed upon each other. Each stratigraphic sequence is a succession of rocks that ranges in age from Devonian or Mississippian to Lower Cretaceous and extends over many square kilometers. Comparison of coeval rocks from one sequence to another shows minor lithologic differences in Permian to Jurassic rocks and major lithologic differences in Carboniferous rocks. In places

Devonian and Cretaceous rocks also show major differences between sequences. The distinctive lithologies of Carboniferous rock units are generally the most important factor in distinguishing stratigraphic sequences.

Coeval rocks of different sequences must have been deposited in widely separated and, in part, under different depositional conditions. Dramatic differences in the lithology of closely spaced coeval rock units in different sequences cannot be adequately explained by ordinary rapid facies changes. For instance, there are many places where two and occasionally three stratigraphic sequences, each with a different facies of Mississippian rocks, are stacked directly upon one another on a single mountain face. The best explanation for these observations is that the various stratigraphic sequences were superimposed along subhorizontal thrust faults of major displacement (Tailleur and others, 1966; Martin, 1970).

STRUCTURAL SETTING

For the areas covered by this report, each stratigraphic sequence defines a designated thrust sequence. However, on a regional scale in the larger area of the central and western Brooks Range, in some instances two stratigraphic sequences can be demonstrated to be linked by gradational lateral facies change without juxtaposition by major thrust faults. In such cases two stratigraphic sequences form a single thrust sequence. This is the case, for example, in the Brooks Range thrust sequence which has a distinct eastern and western stratigraphic facies (Mayfield and others, 1978).

With few exceptions, each thrust sequence seems to have a consistent structural position relative to adjacent sequences. For example, thrust sequence 5 (plate 1) is almost always observed to structurally overlie lower-numbered thrust sequences and underlie sequences with higher numbers. Most thrust sequences are not continuous throughout the region, because it is common for sequences to be missing altogether or for portions of sequences to crop out in boudins along major thrust faults. Thrust faults are not confined to boundaries between different sequences. There are also major intrasequence thrust faults which superimpose a particular thrust sequence onto itself two, three, or more times in the same area.

We have been able to distinguish nine thrust sequences in the southern half of the Misheguk Mountain quadrangle. Portions of five thrust sequences are mapped in the areas around the Ginny Creek and Nimiuktuk deposits (plate 1). From structurally highest to lowest, the sequences with their designated numbers are called the Misheguk Mountain (9), Ipnavik River (5), Kelly River (3), Kuruk Creek (2), and Brooks Range (1) thrust sequences. They are best distinguished from each other as follows:

Misheguk Mountain thrust sequence (9) consists of peridotite, dunite, pyroxenite, and gabbro believed to be part of a dismembered Jurassic? ophiolite that was once rooted at the south edge of the Brooks Range (Patton and others, 1977). Gabbro is coarser grained than any other mafic rocks in the area, and ultramafic rocks only occur in this sequence.

Ipnavik River thrust sequence (5) is best distinguished by the occurrence of diabase sills and dikes which occur abundantly in Mississippian, Permian, and Triassic sedimentary rocks. Lower Cretaceous flyschoid rocks usually contain a higher proportion of wacke and conglomerate than do coeval rocks in the lower sequences.

Kelly River thrust sequence (3) is the only sequence to have a thick succession of Mississippian carbonate with sandy limestone at the base (Utukok Formation), crinoidal limestone with black chert nodules in the middle (Kogruk Formation), and limestone interbedded with black chert at the top (Tupik Formation).

Kuruk Creek thrust sequence (2) is the only sequence where Mississippian rocks are well-bedded black chert overlying a thinner unit of fine-grained, thin-bedded limestone.

Brooks Range thrust sequence (1) is the only sequence where Upper Mississippian rocks are predominantly black shale with lesser amounts of black chert. The black shale unit locally contains felsic volcanic and volcanoclastic rocks and is overlain by a prominent yellow- to orange-weathering, thin clay (bentonite?) zone of regional extent. The Upper Devonian to Lower Mississippian Noatak Sandstone is mapped only in this sequence.

STRUCTURAL HISTORY

The stratigraphic record from the western Brooks Range shows that major foreshortening of Paleozoic and lower Mesozoic rocks took place during Late Jurassic to mid-Cretaceous (Tailleur and Brosgé, 1970). Large thrust sheets, many with differing stratigraphic sequences, were stacked upon one another to produce the ancestral Brooks Range. Axial planes of most major and minor folds dip southward indicating that movement of upper thrust sequences was northward relative to lower thrust sequences. Tailleur and Snelson (1969) have suggested that the actual movement, relative to a fixed point, could be described as the underthrusting of lower sequences southward beneath upper ones. The cumulative foreshortening which must have occurred is more than 260 km (160 miles) for the rocks exposed in just the Misheguk Mountain quadrangle. Continuing Upper Cretaceous and Tertiary deformation of the thrust sheets resulted in broad open folds and high angle faults, further complicating the structure.

THE MINERALIZED THRUST SEQUENCE

It has been observed during previous studies (Tailleur and others, 1977; Churkin and others, 1978) that all of the zinc-lead-silver and/or barite deposits that have been found in the northwestern Brooks Range occur in the lowest structural sequence, which corresponds to the Brooks Range thrust sequence of this report. The Ginny Creek deposit and probably the Nimiuktuk deposit also occur in this sequence. Rocks of the Brooks Range thrust sequence are believed to underlie the entire southern two-thirds of the Misheguk Mountain quadrangle where they are exposed in erosional windows or at the edges of overlying thrust sequences.

A simplified schematic geologic column for the Brooks Range thrust sequence is given in fig. 2, which is lithologically similar to, but not as thick as, the column published by Martin (1970). On the basis of studies in the northern part of the Misheguk Mountain quadrangle, Churkin and others (1978) reported a schematic stratigraphic section ranging in age from Mississippian to Cretaceous for this sequence. Work in the southern part of the quadrangle shows that the lowest visible rocks in the sequence extend from the Lower Mississippian and Upper Devonian Endicott Group into the Mississippian Lisburne Group. Mineralized rocks at the Ginny Creek deposit occur mainly near the top of the Noatak Sandstone and locally in limestone beds, thought to be a tongue of the Utukok Formation (Dutro, 1952) at the base of the overlying Kayak Shale. Barite of the Nimiuktuk deposit occurs in an isolated hill without any contiguous rock exposed. However, nearby outcrops suggest that Upper Mississippian black chert and shale are the host

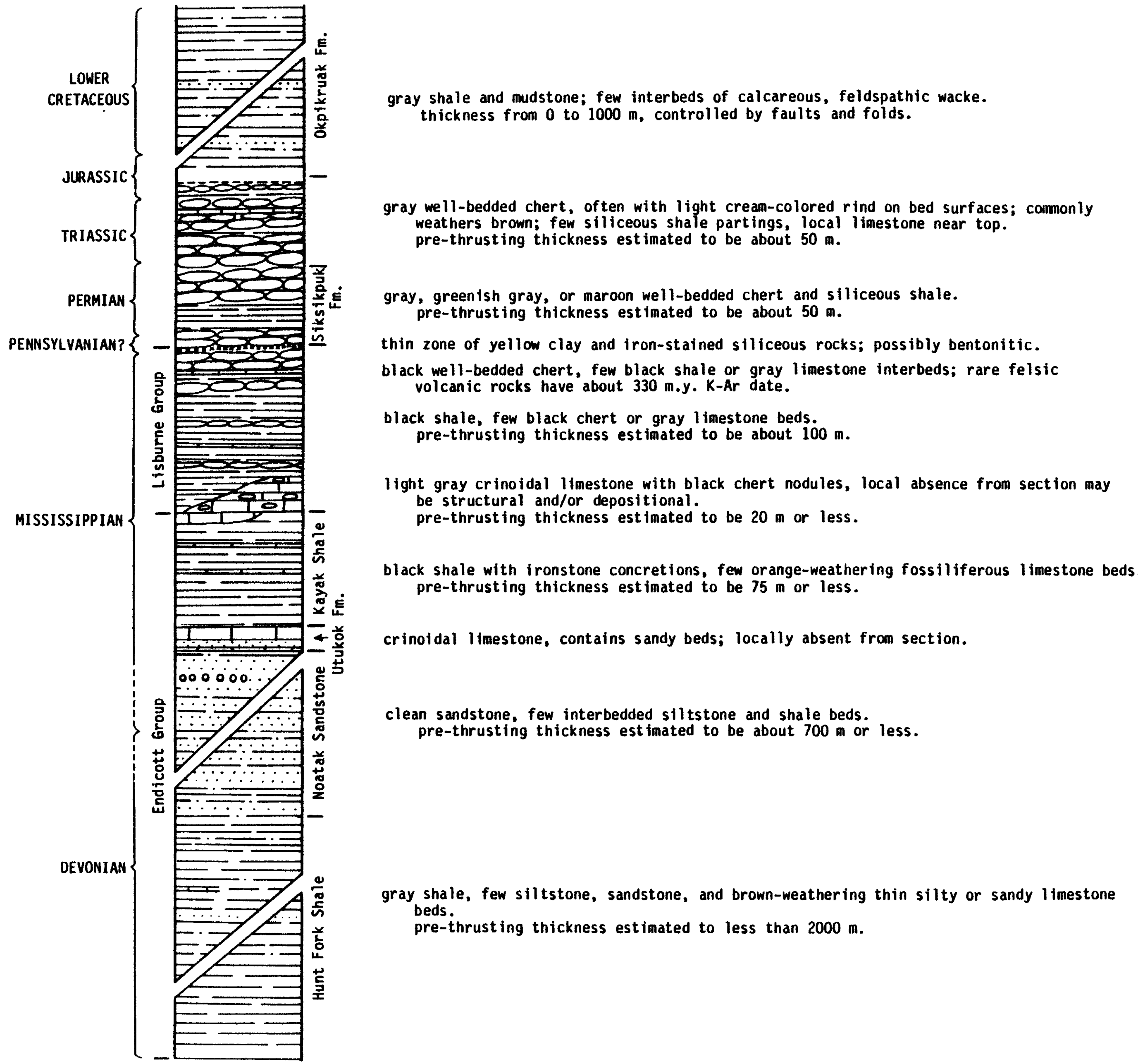

Figure 2. Schematic columnar section of the Brooks Range thrust sequence in the south half of the Misheguk Mountain quadrangle.

rock, because this is the relationship of a similar barite occurrence at the Red Dog deposit (Tailleur and others, 1977).

THE GINNY CREEK Zn-Pb-Ag DEPOSIT

The Ginny Creek deposit is located at the headwaters of Ginny Creek (plate 1). The known exposures of sulfides occur mainly in a rubbly slope on the lower half of a south-facing hill north of the creek. Bedrock in most of the mineralized area consists of sandstone and shale correlative with the upper part of the Noatak Sandstone of Upper Devonion and Lower Mississippian age. Surface rubble is a discontinuous mixture of gossan and partly iron-stained sandstone. Sulfides are preserved only in the least weathered surface rocks and are usually visible as small disseminated grains in sandstone or limonite. Surface leaching produces a pitted appearance on many of the limonite-rich rocks, and well-developed large boxwork textures (suggesting leached massive sulfides) are rare. A small outcrop of massive sulfides occurs near the top of the northeast end of the mineralized zone. Some outcrops of sandstone and shale near the center of the mineralized area apparently are not mineralized. Outcrops in which zinc and lead minerals have been found are shown by the stippled pattern on plate 1. The main mineralized zone is a minimum of 900 m long and 600 m wide and is covered by tundra on the east, west, and south. To the north, it is overlain by younger rocks. Grab samples, each made up of a random selection of surface float weighing about 1.3 kg (3 lb), were collected from nine short (50-100 m) traverses across the top and near the bottom of the mineralized hill. The location of these traverses is plotted on plate 2 (sample numbers 25-27 and 33-38). All the samples that were analyzed contained from 0.3 to 1 percent zinc and had variable concentrations of lead. Lead analyses give inconsistent values, see plate 2.

Another much smaller outcrop of mineralized rock occurs 1 km southwest of the mineralized sandstone. At this location (plate 1) a gossan occurs in a southeast facing rubbly slope of limestone. A randomly selected grab sample of surface gossan analyzed 3 percent zinc (sample 43, plate 2). The size of the gossan is only a few meters in diameter, but exposures, are poor and the mineralized area could be more extensive. A stream-sediment sample (no. 40, plate 2) collected in the small stream draining this occurrence gives anomalous values in both zinc and lead. We interpret the host rock at this location as a thin tongue of the Utukok Formation. In this area the Utukok Formation appears to be gradational with the top of the Noatak Sandstone, but in other areas, such as at the main mineralized zone to the northeast, it seems to be missing from the section. Whether the reason for this is depositional or structural is uncertain. The fact that a thin geologic unit may be locally missing is not unusual in this region of extreme thrust faulting.

The mineralogy of the deposit appears to be fairly simple. The only sulfide minerals that we have observed are sphalerite, galena, pyrite, and rare chalcopyrite. Rock and stream-sediment samples indicate the deposit may also contain silver, but the mineral(s) in which the silver occurs has not been determined. Sphalerite with subordinate galena, and pyrite commonly occurs as minute crystals scattered throughout the mineralized sandstone. Thin quartz veins cut the sedimentary beds; most are barren, but sulfides occur sparsely in some of them. Petrologic examination of the mineralized sandstones reveal that they contain a high proportion of siderite which, when weathered, produces much of the iron staining in the mineralized areas. Some siderite crystals are euhedral, suggesting that this mineral crystallized in intergranular porosity or minute cracks in the host sandstone. Siderite has not been observed in outcrops of the Noatak Sandstone away from the mineralized area and therefore should not be overlooked as a possible indicator of zinc and lead sulfides.

The large scale structure in the host rocks at the Ginny Creek deposit is that of an anticline overturned to the northwest (fig. 3). The sulfide minerals that we have found in outcrop occur on the north flank of the

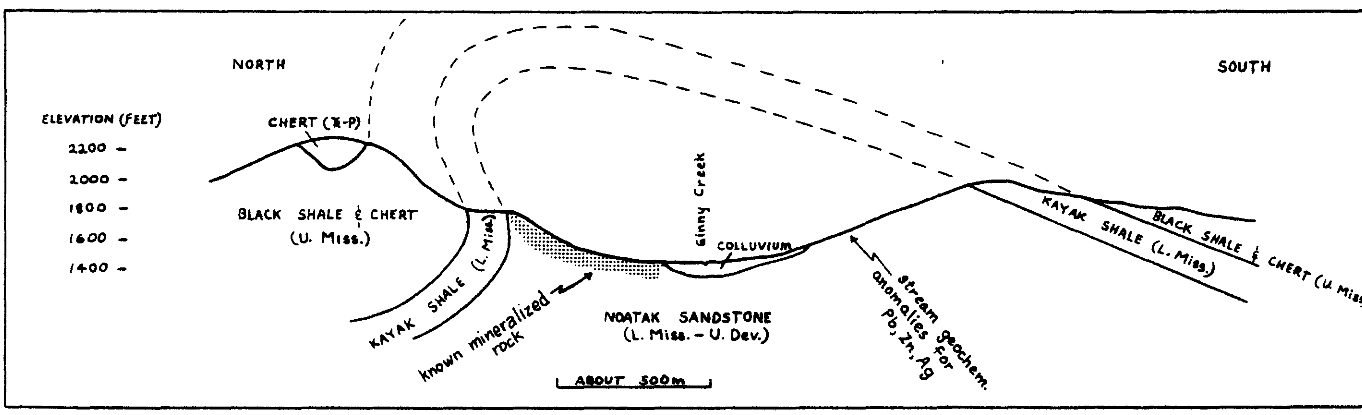

Figure 3. Schematic north-south cross section through the Ginny Creek deposit.

anticline. No attempt is made to show the numerous small folds and faults which must exist in the area (plate 1). Mississippian through Lower Cretaceous rocks consist of relatively incompetent shale and chert which has been so highly folded and dismembered by thrust faults as to make detailed reconstruction of rock units beyond the scope of this report.

Indications of mineralized rock at the Ginny Creek deposit occur over a large area. South of the deposit, on the other side of the Ginny Creek Valley, geochemical anomalies (samples 21-23 and 49, plate 2) indicate that zinc and lead minerals are present here also. North of the mineralized area the rocks are Upper Mississippian or younger in age. A high zinc geochemical anomaly from a stream which drains the north side of the mineralized hill (sample 14, plate 2) suggests that zinc sulfides may also extend to the north and occur in Upper Mississippian black shale and chert.

THE NIMIUKTUK BARITE DEPOSIT

The Nimiuktuk deposit is located in the lowlands west of the upper Nimiuktuk River in an area where bedrock exposures are poor. The surface expression of the deposit consists of a small hill about 7-10 m high, 40 m wide, and 60 m long. The entire hill is composed of cobble- to boulder-sized fragments of barite.

The nearest bedrock is 500 m to the northeast and consists of low rubbly outcrops of Upper Mississippian black chert and shale in contact with Lower Cretaceous shale and wacke (plate 1). Outcrops 600 m southwest of the deposit are Upper Mississippian volcanic rocks and Lower Mississippian sandy limestone of the Utukok Formation. The main mineralogic components of the volcanic rocks are altered feldspar, biotite, and leucoxene (after ilmenite?). Plagioclase and potassium feldspar crystals are almost completely altered to carbonate and phyllosilicate minerals. Minor minerals include apatite, brown hornblende, and corroded clinopyroxene. The lack of visible quartz in thin section and the high percentage of feldspar suggests that the rock originally was an andesite or latite. An age of 333 ± 17 million years, Upper Mississippian, was obtained by M. L. Silberman from the mineral biotite using K-Ar dating methods (table 1). This age corresponds closely with biotite dates from similar volcanic rocks at the Drenchwater deposit (table 2), 53 km east northeast of the Nimiuktuk deposit. The close spatial association of igneous rocks and concentrations of barite at many deposits in the western U.S. (Dunham and Hanor, 1967) suggests that the mineralization may be related to the Mississippian volcanism.

The size of the deposit can not be ascertained without sensing the substratum. An estimate of the volume of the barite hill above the level of the surrounding tundra indicates that the deposit must contain a minimum of 12,500 metric tons of high grade barite. The actual size of the deposit is likely to be several times this figure.

Table 1.--Potassium-argon age from the Nimiuktuk volcanic rocks

Sample number	Rock type	Mineral dated	Average K_2O (wt. percent)	$^{40}Ar_{rad}$ (moles/gm) X 10^{-11}	$^{40}Ar_{rad}$ (percent)	Age in millions years plus or minus analytical uncertainty
78Md116A	Latite or andesite	Biotite	7.64 7.67 7.655	406 X 10^{-11} 401 X 10^{-11}	92 95	333 ± 17

Table 2.--Potassium-argon ages from the Drenchwater volcanic rocks

Sample number	Rock type	Mineral dated	Average K_2O (wt. percent)	$^{40}Ar_{rad}$ (moles/gm) $\times 10^{-11}$	$^{40}Ar_{rad}$ (percent)	Age in millions years plus or minus analytical uncertainty
77Md90	Basalt	Biotite	5.37 5.31	279.1 277.2	96 94	330 ± 17
65ATr102.1	Quartz latite	Biotite	7.19 7.15	368.4	97	319 ± 10

Because of the poor exposures in the area, it is not possible to present a detailed picture of the structural complexity. We consider the Utukok Formation to be part of an overlying thrust sequence unrelated to the barite occurrence. If the thrust sheets were unstacked to their pre-thrusting position, the Utukok Formation now in this area would be located tens of kilometers south relative to the barite deposit. It seems probable that host rocks for the deposit belong to the Brooks Range thrust sequence (plate 1).

Time constraints precluded complete geochemical sampling of the area around the Nimiuktuk deposit. However, three samples were taken from the watershed of the deposit and six were taken from streams east of the Nimiuktuk River (plate 2). It is unclear whether or not high values of barium in these samples (greater than 20,000 ppm Ba, sample no. 8, plate 2) are indicative of other large barite concentrations in the immediate area. The high values are consistent with those from stream-sediments from the similar geologic terrane to the north (Theobald and Barton, 1978). Samples from streams draining the barite deposit are not high in lead, zinc, or silver.

ORIGIN OF THE MINERAL DEPOSITS

Although there is too little data to give conclusive details about the way in which the Ginny Creek and Nimiuktuk deposits were formed, we feel that our initial impressions about the origin of these and other deposits in the DeLong Mountains may be of value. All of the large deposits in the DeLong Mountains mineral belt have been discovered within the last 11 years. Comparison of their important characteristics, listed in table 3, reveals two obvious similarities:

1) the most important metals are zinc and lead, and

2) the host rocks are no younger than Mississippian.

At Drenchwater and Red Dog, the sulfides are reported to have, in part, a syngenetic origin in black shale and chert of Upper Mississippian age (Nokleberg and Winkler, 1978; Plahuta and others, 1978. Note--The term "syngenetic origin" for these deposits has been used to mean that sulfides were deposited, at least in part, with the deposition of the enclosing sediments, and encompasses the fact that there was also some replacement or fracture filling which occurred in slightly older sediments). Since the host rocks at other Zn-Pb-Ag-barite deposits in the DeLong Mountains are also Upper Mississippian or older, it is probable that their time of mineralization was the same as that of the Drenchwater and Red Dog deposits.

These deposits formed under a variety of conditions. Observations at Drenchwater and Red Dog indicate that sulfides may have been precipitated at or near the surface of the sedimentary pile. The spatial association of Upper Mississippian volcanic rocks and sulfides at Drenchwater suggests a volcanogenic origin. The occurrence of disseminated sulfides at Red Dog in black siliceous shaly rocks suggests the deposit was, in part, formed syngenetically, perhaps by precipitation from sea floor hot springs. However, at Ginny Creek a subsurface mode of origin is indicated by the occurrence of sulfides in sandstone and limestone where replacement and open-space filling was probably an important process.

The movement of sulfides in both surface and subsurface conditions indicates that there probably was a high geothermal gradient in the area of the mineral deposits. The association of volcanics and sulfides in some of the deposits suggests that the magmatic source for the volcanic rocks may have produced metal-bearing hydrothermal solutions that resulted in the zinc-lead-barite mineral deposits of the northwestern Brooks Range.

Table 3.--Summary of important characteristics of larger or better known deposits in the northwestern Brooks Range

Deposit	Qandrangle	Important minerals	Gangue minerals	Host rock lithology	Age(s) of host rock	Possible igneous source rocks	Hypothesized origin
Ginny Creek[1]	Misheguk Mountain	Sphalerite galena	Siderite pyrite (minor)	Sandstone, shale,and limestone	Lower Missis-sippian to Upper? Devo-nian	No igneous rocks at deposit, nearest Mis-sissippian volcanics 9 km SE of deposit	Hydrothermal open-space filling and replace-ment
Nimiuktuk[1]	Misheguk Mountain	Barite	?	?	?	Mississippian volcanics 0.5 km SE of deposit.	?
Red Dog[2]	DeLong Mountains	Sphalerite galena barite	Pyrite (minor)	Black shale and chert	Upper? Mississippian	Mississippian? volcanics 1 km NE of deposit	Syngenetic; fracture filling
Lik[3]	DeLong Mountains	Sphalerite galena barite	?	Black shale and chert	Upper? Mississippian	?	?
Drench-water[4]	Howard Pass	Sphalerite galena barite (minor)	Pyrite (minor) fluorite (rare)	Black shale, chert, and volcanics	Upper Mississipian	Mississippian volcanics at deposit	Volcanogenic (exhalative); fracture filling
Story Creek[5]	Howard Pass	Sphalerite galena	Vein quartz	Sandstone, siltstone, and shale	Lower? Mis-sissippian to Upper? Devonian	Fine-grained igneous dikes at west and of deposit [1]	Hydrolthermal fracture filling and replacement [1]

[1]This report.

[2]Plahuta and others, 1978; Tailleur, 1970; this report.

[3]Wall Street Journal, 1977; Bundtzen and Henning, 1978.

[4]Nokleberg and Winkler, 1978.

[5]Oral commun. Uldis Jansons, U.S. Bureau of Mines, 1978.

References

Bundtzen, T. K., and Henning, M. W., 1978, Barite in Alaska: Alaska Division of Geology and Geophysical Surveys, Mines and Geology Bulletin, v. 27, no. 4, p. 1-3.

Churkin, Michael, Jr., Mayfield, C. F., Theobald, P. K., Barton, H. N., Nokleberg, W. J., Winkler, G. R., and Huie, Carl, 1978, Geological and geochemical appraisal of metallic mineral resources, southern National Petroleum Reserve in Alaska: U.S. Geological Survey Open-File Report 78-70A, 82 p.

Dutro, J. T., Jr., 1952, Stratigraphy and paleontology of the Noatak and associated formations, Brooks Range, Alaska: U.S. Geological Survey, Geological Investigations of Naval Petroleum Reserve No. 4, Special Report 33, 144 p.

Dunham, A. C., and Hanor, J. S., 1967, Controls on barite mineralization in the western United States: Economic Geology, v. 62, no. 1, p. 82-94.

Martin, A. J., 1970, Structure and tectonic history of the western Brooks Range, DeLong Mountains and Lisburne Hills, northern Alaska: Geological Society of America Bulletin, v. 81, p. 3605-3622.

Mayfield, C. F., Tailleur, I. L., Mull, C. G., and Sable, E. G., 1978, Bedrock geologic map of the south half of the National Petroleum Reserve in Alaska: U.S. Geological Survey, Open-File Report 78-70B, 2 sheets, scale 1:500,000.

Mull, C. G., 1979, Nanushuk Group deposition and the late Mesozoic structural evolution of the central and western Brooks Range and Arctic slope: U.S. Geological Survey Circular 794 (in press).

Nokleberg, W. J., and Winkler, G. R., 1978, Geologic setting of the lead and zinc deposits, Drenchwater Creek area, Howard Pass quadrangle, western Brooks Range, Alaska: U.S. Geological Survey, Open-File Report 78-70C, 16 p.

Patton, W. W., Jr., Tailleur, I. L., Brosgė, W. P., and Lanphere, M. A., 1977, Preliminary report on the ophiolites of northern and western Alaska, in Coleman, R. G., and Irwin, W. P., eds., North American ophiolites: Oregon Department of Geology and Mineral Industries Bulletin 95, p. 51-58.

Plahuta, J. T., Lange, I. M., and Jansons, Uldis, 1978, The nature of mineralization at the Red Dog Prospect, western Brooks Range, Alaska, abs.: in Geological Society of America Abstracts with Programs, Cordilleran Section, 74th Annual Meeting, Tempe, Arizona, March 29-31, 1978, p. 142.

Snelson, Sigmond, and Tailleur, I. L., 1968, Large-scale thrusting and migrating Cretaceous foredeeps in the western Brooks Range and adjacent regions of northwestern Alaska abs.: Bulletin of the American Association of Petroleum Geologists, v. 52, p. 567.

Tailleur, I. L., 1970, Lead-, zinc-, and barite-bearing samples from the western Brooks Range, Alaska, with a section on petrography and mineralogy by G. D. Eberlein and Ray Wehr: U.S. Geology Survey Open-File Report 445, 16 p.

Tailleur, I. L., and Brosgė, W. P., 1970, Tectonic history of northern Alaska: in Adkinson, W. L., and Brosgė, M. M., eds., Proceedings of the geological seminar on the north slope of Alaska: American Association of Petroleum Geologists, Pacific Section, p. E1-E19.

Tailleur, I. L., Ellersieck, I. F., and Mayfield, C. F., 1977, Mineral resources of the western Brooks Range, _in_ Blean, K. M., United States Geological Survey in Alaska: accomplishments during 1976: U.S. Geological Survey Circular 751-B, p. 24-25.

Tailleur, I. L., Kent, B. H., Jr., and Reiser, H. N., 1966, Outcrop/geologic maps of the Nuka-Etivluk region, northern Alaska: U.S. Geological Survey Open-File Report 266, 7 sheets, scale 1:63,360.

Tailleur, I. L., and Snelson, Sigmond, 1969, Large scale thrusting in northwestern Alaska possibility related to rifting of the Arctic Ocean: Geological Society of America Special Paper 121, p. 569.

Theobald, P. K. and Barton, H. N., 1978, Basic data for the geochemical evaluation of National Petroleum Reserve, Alaska: U.S. Geological Survey Open-File Report 78-70D, 102 p.

Wall Street Journal, 1977, Houston Oil, partner have significant finds of minerals in Alaska: September 13, 1977, (final *** eastern edition), p. 16.