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INTRODUCTION

This report presents information and preliminary conclusions regarding the geology and resource potential of hitherto unknown barite deposits in the Howard Pass 1:250,000 scale quadrangle (fig. 1) and compares these deposits with the Nimiuktuk barite deposit (Barnes and others, 1982) in the Misheguk Mountain 1:250,000 quadrangle and barite at the Red Dog mine (Moore and others, 1986 and Young, 1989) in the De Long Mountains 1:250,000 quadrangle (fig. 1).

The stratiform barite deposits described herein, and similar, but undiscovered deposits likely to be present elsewhere in the northwestern Brooks Range, may be a significant resource, however, the remote location of these deposits may make them unattractive for commercial exploitation. The host rocks of these deposits are described in terms of their lithofacies, biostratigraphy, and structural geologic setting. Deposits are described in terms of chemical and density analyses on representative grab samples, bedding characteristics, and Bouguer gravity expression. An attempt is also made to establish a tentative basis for comparing the stratiform barite described herein with barite associated with stratiform base metal mineralization at the Red Dog mine (Zierenberg and Schmidt, 1988 and Young, 1989). The report also estimates the number of metric tonnes of barite present in deposits in the Howard Pass quadrangle.

Most of the contributors to this report visited the barite deposits in the Howard Pass quadrangle during the 1990, 1991, and 1992 field seasons. In the course of geologic mapping in the central part of the Howard Pass quadrangle during the 1990 field season, Kelley discovered the Abby Creek barite deposit in the headwaters of a tributary to Cutaway Creek. During the 1991 field season, Kelley and Tailleur discovered the Bion and Stack barite deposits by visiting localities where the geology is similar to that of the Abby Creek barite deposit and where previous workers (Bion Kent and Irvin Tailleur, 1950, unpublished field notes) had noted "heavy rocks". Kelley also discovered the Tuck barite deposit in 1991 by examining a locality with a geologic setting similar to the geologic setting of the previously discovered deposits. In addition, Kelley and Tailleur completed a geologic map of the Abby Creek deposit and collected stratigraphic information relative to the geologic setting of the Abby Creek, Bion, Stack, and Tuck barite deposits. Also during the 1991 field season, Morin conducted gravity surveys of the Abby Creek and Bion barite deposits and Schmidt, Kelley, Tailleur, and Morin collected barite samples from the Abby Creek, Bion, and Stack barite deposits. Reed and Harris studied the microfossils and Brown coordinated chemical and physical analyses of samples from the 1991 field season. During 1992 field season, Tailleur, Kelley, and Morin visited localities prospective for barite, places where previous workers (Bion Kent and Irvin Tailleur, 1950, unpublished field notes) noted possible barite; this resulted in the discovery of the Ekakevik barite deposit. In addition, during the 1992 field season Kelley and Kurtak discovered two more barite deposits in the Howard Pass quadrangle: the Longview and Lakeview deposits. Kurtak visited all of the deposits in the Howard Pass quadrangle during the 1992 field season and collected data from which he calculated resource estimates.

BARITE DEPOSITS IN THE HOWARD PASS QUADRANGLE

Barite deposits in the Howard Pass quadrangle are within the Brooks Range fold and thrust belt which spans the Brooks Range and Arctic foothills of northern Alaska. Within the Howard Pass, Misheguk Mountain, and De Long Mountains quadrangles, the fold and thrust belt consists of north-transported thrust sheets and folds exposed in the Endicott and De Long Mountains and Arctic foothills. Barite deposits in the Howard Pass quadrangle are present within a belt of thrust faults cutting rocks that are Devonian to Cretaceous in age. The Nimiuktuk barite deposit and the Red Dog mine are in structural and stratigraphic trend with barite deposits in the Howard Pass quadrangle.

A geologic map, balanced cross section, and restored section of the upper Cutaway Creek area shows sufficient detail to characterize geologic setting for one of the barite deposits in the Howard Pass C-3 quadrangle and provide a basis for inferring the geologic setting for other deposits in the Howard Pass quadrangle. The map area is underlain by a series of imbricate thrust faults that sole in decollements in Mississippian strata and Permian stata. Barite deposits are present in cherty stata that are present above the decollement in Mississippian strata.

Two prominent lithofacies contrasts in coeval rocks are preseent within the map area. One transition is between rhythmically bedded chert of Permian and Triassic age of the upper chert of the Cutaway area (TRM) and coeval rocks of the Siksikpuk and Otuk

Formations. The other is between Mississippian limestone turbidites that have been extensively intuded by diabase sills and Mississippian rhythmically bedded chert of the lower chert of the Cutaway area (Mc). Contrasts in Mesozoic rocks are lithofacies transitions made abrupt modest amounts of structural telescoping by imbricate faulting. Contrasts in upper Paleozoic rocks are also lithofacies transitions but juxtaposed by an unknown amount of structural transport.

Stratiform barite crops out at the Abby Creek, Bion, Tuck, Stack, Longview, and Lakeview localities in the Howard Pass quadrangle C-3 quadrangle (fig. 2). The Ekakevik locality is east of the Howard Pass C-3 quadrangle (fig. 1). In general, barite is mostly high-grade and in rhythmically bedded chert of Mississippian age. The Ekakevik deposit, in contrast to other deposits in the Howard Pass quadrangle, is in Mississippian limestone and chert and consists of both witherite and barite rather than barite alone. Barite deposits in the Howard Pass quadrangle are up to tens of meters thick and hundreds of meters long and are locally associated with organic shale and solid hydrocarbon. They do not appear to be associated with either base- or precious metal-mineralization. Deposits typically crop out in rubble-covered small knolls and have local gravity anomalies associated with them.

The Abby Creek deposit is on a small knob with about 3 m of relief relative to surrounding tundra between two tributaries of Cutaway Creek in the Howard Pass C-3 quadrangle (fig. 2 and 3). The host rocks are Mississippian chert that dips about 35 degrees to the south. The deposit consists of rubbly outcrops in an area about 30 m along strike and about 15 m parallel to dip. The deposit is tabular and is within Mississippian chert of the Cutaway Creek area (unit Mc in fig. 4). A measured section in Mississippian and Pennsylvanian bedded chert about 1 km east of, but in the same fault block as the the Abby Creek barite deposit, includes a thin bed of barite and limestone turbidites containing conodonts that are middle Osage (late Early Mississippian) in age (fig. 5). The Abby Creek barite deposit appears to be stratigraphically lower than the horizon that contains these middle Osagean fossils. One of a series of thrust faults that repeat the chert of the Cutaway Creek area cuts the base of the Abby Creek deposit (fig. 4). Lower Cretaceous sandstone of the Okpikruak Formation, too thin to be shown on the geologic map (fig. 4), is in the footwall of the fault along the base of the barite body. The specific gravity of 30 representative grab samples of the barite ranges from 4.12 g/cc to 4.32 g/cc; mean specific gravity is 4.23 g/cc (table 1). Chemical analyses of the barite indicate no appreciable amounts of base or precious metals (table 2). A gravity anomaly of about 1 mGal is associated with the Abby Creek barite deposit (fig. 3). The indicated resource in the Abby Creek deposit is about 406,080 tonnes (metric tons; table 3)

The Bion barite deposit crops out adjacent to Cutaway Creek (fig. 2) in three rubble-covered mounds with as much as 10 m of local relief (fig. 3). The largest outcrop, about 150 m along strike and 40 m across strike, appears to be a tabular body that dips to the south and parallels bedding in chert and limestone (fig. 6). Host rocks in the largest outcrop are bedded chert of Late Mississippian or Early Pennsylvanian age, lesser petroliferous limestone, and minor organic shale. It is not clear whether the three outcrops are of a single body that has been structurally repeated by imbricate faulting or are separate barite bodies. Barite contains no visible base metal sulfides and chemical analyses of three samples show no appreciable base or precious metals (table 2). A gravity map of the two largest outcrops shows that the largest gravity anomaly, approximately 1.2 mGal, coincides with the most westward of the two outcrops (fig. 3). The mean specific gravity of seven barite grab samples from these outcrops is 4.25 g/cc (table 1), about 95 percent that of pure barium sulfate. The indicated resource in the Bion deposit is about 10,051,470 tonnes (table 3).

The Stack barite deposit crops out adjacent to a prominent limestone and marble monolith (The Stack) at the confluence of Cutaway Creek and an unnamed southwest-flowing lake-draining tributary to Cutaway Creek in the Howard Pass C-3 quadrangle (fig. 2). The barite is present as rubbly outcrops in elongate mounds (fig. 7) that strike west-northwest parallel to the regional structural grain. Structural and stratigraphic relations between the barite at the Stack deposit and host strata are not as clear as they are at the Abby and Bion deposits. Bedded chert and petroliferous limestone turbidites containing early Meramecian (early Late Mississippian) conodonts are present at the Stack deposit. The limestone turbidites are similar to the limestone turbidites at the Bion deposit. The mean specific gravity of 67 barite grab samples is 4.21 g/cc (table 1), about 94 percent of the density of pure barium sulfate. Samples contain a little calcite but no base metal or precious metal mineralization (table 2). The indicated resource in the Stack deposit is about 2,851,223 tonnes (table 3).

The Tuck barite deposit (fig. 2) crops out about 1.25 km north of the Stack barite deposit in a small bench on a southwest-facing slope (fig. 8). Clearly exposed bedding in barite at the Tuck deposit is rhythmic and the same as bedding in the chert host rocks to the Abby Creek, Bion, and Stack deposits. Beds of barite in the Tuck deposit dip northeast. The indicated resource in the Tuck deposit is 155,160 tonnes (table 3).

The Longview and Lakeview barite deposits crop out along strike with one another between 2 and 3 km northeast of the Stack deposit in the Howard Pass C-3 quadrangle (fig. 2). The barite in both locations is light gray and is present as rubble on a bench on an east- to southeast-facing slope. By projection of adjacent bedded chert and outcrop width, the deposits could be about 15 m thick. Outcrop lengths are about 455 m for the Lakeview deposit and about 155 m for the Longview deposit. These bodies of barite appear to be stratiform and be enclosed by beds of rhythmically bedded chert. Chert beds dip to the southeast but are locally vertical. It is possible that the Longview and Lakeview deposits are exposures of the same barite body that is partially concealed by tundra. If so, the single body could be more than 1.6 km long. The inferred resource of the Lakeview deposit is about 3,778,788 tonnes and the indicated resource of the Longview deposit is about 29,494,395 tonnes (table 3).

The Ekakevik barite deposit is located east of the Howard Pass C-3 quadrangle in the Howard Pass C-2 quadrangle (fig. 1). Barite and witherite, associated with Mississippian (?) limestone of the Lisburne Group, and overlain by bedded chert crops out in a series of ridges in a homoclinal structure that dips 45 to 25 degrees to the south. The width of the barite outcrops is about 200 m. The mineralization consists of massive barite and witherite which is present in clusters, as much as 15 cm across, of radiating acicular crystals about 1 mm in diameter. Mean specific gravity of barite and witherite is 3.87 gm/cc (table 1). Mineralization is in the lower part of the homocline and in association with limestone. Limestone is medium light gray and weathers medium gray. Solid hydrocarbon, oil stain, strong petroliferous odor, and organic shale are associated with the limestone. Bedded chert that is mostly dark-gray and at least in part buff-weathering and overlies the limestone. The indicated resource of the Ekakevik deposit is about 2,275,560 tonnes (table 3).

NIMIUKTUK BARITE DEPOSIT

The Nimiuktuk barite deposit is in the Misheguk Mountain 1:250,000 scale quadrangle about 125 km southwest of the Abby Creek, Bion, Stack, and Tuck barite deposits. The deposit consists of a rubble-covered hill composed of barite and surrounded by tundra

(Barnes and others, 1982). Bedrock outcrops closest to the Nimiuktuk deposit but hundreds of meters away from the barite deposit are Mississippian limestone, chert, and shale and Triassic chert (Mayfield and others, 1979). The deposit has a gravity anomaly of about 2.0 mGal and specific gravity measurements that range between 4.36 and 4.40 g/cc and have a mean of 4.37 g/cc (Barnes and others, 1982).

Barite samples from the Nimiuktuk barite deposit provided by David F. Barnes are nearly pure barite. Specific gravity measurements of three samples from the Nimiuktuk barite deposit range from 4.35 to 4.39 g/cc and have a mean specific gravity of 4.37 g/cc (table 1), or about 98 percent of the specific gravity of pure barium sulfate.

Barnes and others (1982) concluded that the gravity anomaly associated with the Nimiuktuk barite deposit is too small to be related to a base metal sulfide deposit similar to that associated with barite at the Red Dog mine. Furthermore, samples from the Nimiuktuk barite deposit examined in this work have no visible metallic sulfide minerals present. A chemical analysis of one sample from the Nimiuktuk barite deposit presented here shows no base or precious metal mineralization.

BARITE AT THE RED DOG MINE

Barite is present in several types of mineralization at the shale-hosted zinc-lead-silver deposits at the Red Dog mine in the De Long Mountains quadrangle (fig. 1). Moore and others (1986) recognized three facies of mineralization: sulfide rock, silica rock, and barite rock. In contrast, Young (1989) recognized four facies of mineralization: sulfide-bearing barite, sulfide-poor barite, sulfide rock, and silica rock. Barite in the

Red Dog mine area is dark colored and massive, and is present in aggregates of non-oriented crystals as much as several millimeters across (Moore and others, 1986; Young, 1989). Sulfide minerals and barite mixed with sulfide minerals are found in the upper part of the Kuna Formation consisting of grayish-black shale of Mississippian age; conodonts collected from these rocks in the Red Dog mine area are latest Osagian to early Chesterian (Early to Late Mississippian) in age (Moore and others, 1986, p. 1702). Barite is also present in the lower part of the overlying Siksikpuk Formation which is Permian in age. Barite-bearing rocks overlie sulfide-rich rocks (Moore and others, 1986; Young, 1989) and sulfide-poor barite overlies sulfide-bearing barite (Young, 1989).

Zierenberg and Schmidt (1988) and Young (1989) suggest that barite could have played a localizing role in sulfide mineralization in the Red Dog Mine area. In this hypothesis, barite mineralization predates sulfide mineralization and impeded the generally upward flow of the zinc-lead-silver-bearing hydrothermal fluids that emplaced the stratiform ore body at the Red Dog Mine. Such an interpretation is consistent with the replacement of barite by sulfide minerals, and with the observed upward mineral zonation of silica rock, sulfide rock, sulfide-bearing barite, and sulfide-poor barite(Zierenberg and Schmidt, 1988; Moore and others, 1986; and Young, 1989).

SUMMARY AND CONCLUSIONS

Barite deposits in the Howard Pass C-3 quadrangle are stratiform and present in host strata of middle Osagean to early Meramecian age (Early to Late Mississippian). Host rocks are rhythmically bedded dark-gray, grayish black, and grayish green chert, medium-gray limestone, and dark-gray organic shale. The barite bodies are tabular and together with host rocks are structurally repeated in imbricate fault blocks. At the Tuck deposit, barite has bedding characteristics the same as those in the enclosing rhythmically bedded chert. Samples from the deposits in the Howard C-3 quadrangle have mean specific gravities 94 to 95 percent that of pure barium sulfate, do not have visible metallic sulfides, or anomalous amounts of base or precious metals. Gravity anomalies measured over two of the barite deposits are between 1 and 1.5 mGal. The indicated and inferred barite and witherite resource in the deposits reported here is about 49,007,675 tonnes (table 3).

Barite deposits in the Howard Pass quadrangle are similar to the Nimiuktuk barite deposit in their high specific gravity, lack of visible sulfide minerals, chemical purity, and likely host rock. Although relations between barite and host rocks are not exposed at the Nimiuktuk barite deposit, rocks similar to the host rocks for barite deposits in the Howard Pass quadrangle crop out in the vicinity the the Nimiuktuk barite deposit.

Barite deposits in the Howard Pass quadrangle differ from barite at the Red Dog mine where barite is spatially associated with zinc-lead-silver sulfide mineralization and is present in the upper part of the Mississippian Kuna Formation, a formation composed largely of black silicious shale. Deposits in the Howard Pass quadrangle mostly are in bedded chert, except the Ekakevik deposit which is in limestone and chert.

The stratiform barite deposits reported here are of high grade, up to tens of meters thick, and extend hundreds of meters along strike. Similarity with the Nimiuktuk barite deposit implies a large area favorable for similar deposits. The mean specific gravity of the Howard Pass barite samples (4.23 to 4.27 gm/cc) exceed the minimum standard (4.20 gm/cc) required for barite used in oil-well drilling-fluid (API Specification for

Oil-Well Drilling-Fluid Materials, 1981, p. 3,). Further, the deposits in the Howard Pass quadrangle include very light gray, nearly pure barite containing small amounts of iron and titanium. This composition could make the barite suitable for uses in glass, fillers, extenders, pigments, or the manufacture of barium chemicals (Brobst, 1983, p. 486). Barite deposits described here appear to be unassociated with sulfide mineralization although barite in Mississippian rocks and associated with stratiform ore at the Red Dog mine (Moore and others, 1986) may be related to emplacement of a zinc-lead-silver ore body (Zierenberg and Schmidt, 1988; Young, 1989).

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