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OCCURRENCE AND DISTRIBUTION OF BARITE IN THE PERMO-TRIASSIC SIKSIKPUK FORMATION ALONG THE BROOKS RANGE HAUL ROAD

by

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Introduction

Barite commonly occurs in Permian to Triassic age rocks along the north flank of the Brooks Range. The Siksikpuk Formation (Wolfcampian to lowest Guadalupian age) is noted for its barite and is well exposed in the vicinity of Galbraith Lake along the pipeline haul road (Figure 1). The proximity of these barite deposits to an existing road made them a logical selection for investigation. The study was designed to provide detailed stratigraphic information on barite quantity and quality, associated clay mineralogy, and relationship of barite to environments of deposition.

Geologic Setting

The north flank of the Brooks Range is a well defined geologic and geographic boundary. Regional overthrusting and folding to the north are the dominate structures, with the Carboniferous age Lisburne limestone being the major relief former in the study area. The study area occurs within the overturned limb of a faulted fold with the Permian and Triassic shales being the ductially deforming members. Highly variable but locally intense folding and slippage are characteristics of these rocks. Outcrops of the Siksikpuk Formation occur along the valley floor of Atigun Gorge and along the slopes and scarps on the south side of the Atigun River.

The Siksikpuk Formation was originally described from north central Alaska (Patton, 1957) where the type section is a composit of two exposures at the confluence of two creeks. It consists of 350 feet (109 m) of varigated shale and siltstone disconformably resting on the Lisburne Group carbonates and disconformably overlain by the Shublik Formation. Ellipsoidal concretions of barite characterize the lower two-thirds of the type section. Porter's (1966) description from the section at Anaktuvuk Pass is similar but has been structurally thinned. Brachiopods and gastropods found within the Siksikpuk give early Permian age and constitute the oldest rocks that lie above the Lisburne Group. It is difficult to separarate the Siksikpuk from the overlying Shublik and the two have not been separated in maps from several areas of north central Alaska.

NOTE: This report summarizes the data collected to this date. The work entailed several time consuming projects including clay mineralogy, petrography, and stable isotope studies. The analytical aspects of the work are being completed by Barbara Sellars as a master's thesis from the University of Alaska, Geology Department with Dr. M.W. Payne as her advisor. The work completed as of January, 1980 is included in this report. The final master's thesis should be completed by summer, 1980 and will be sent as a followup to this report.

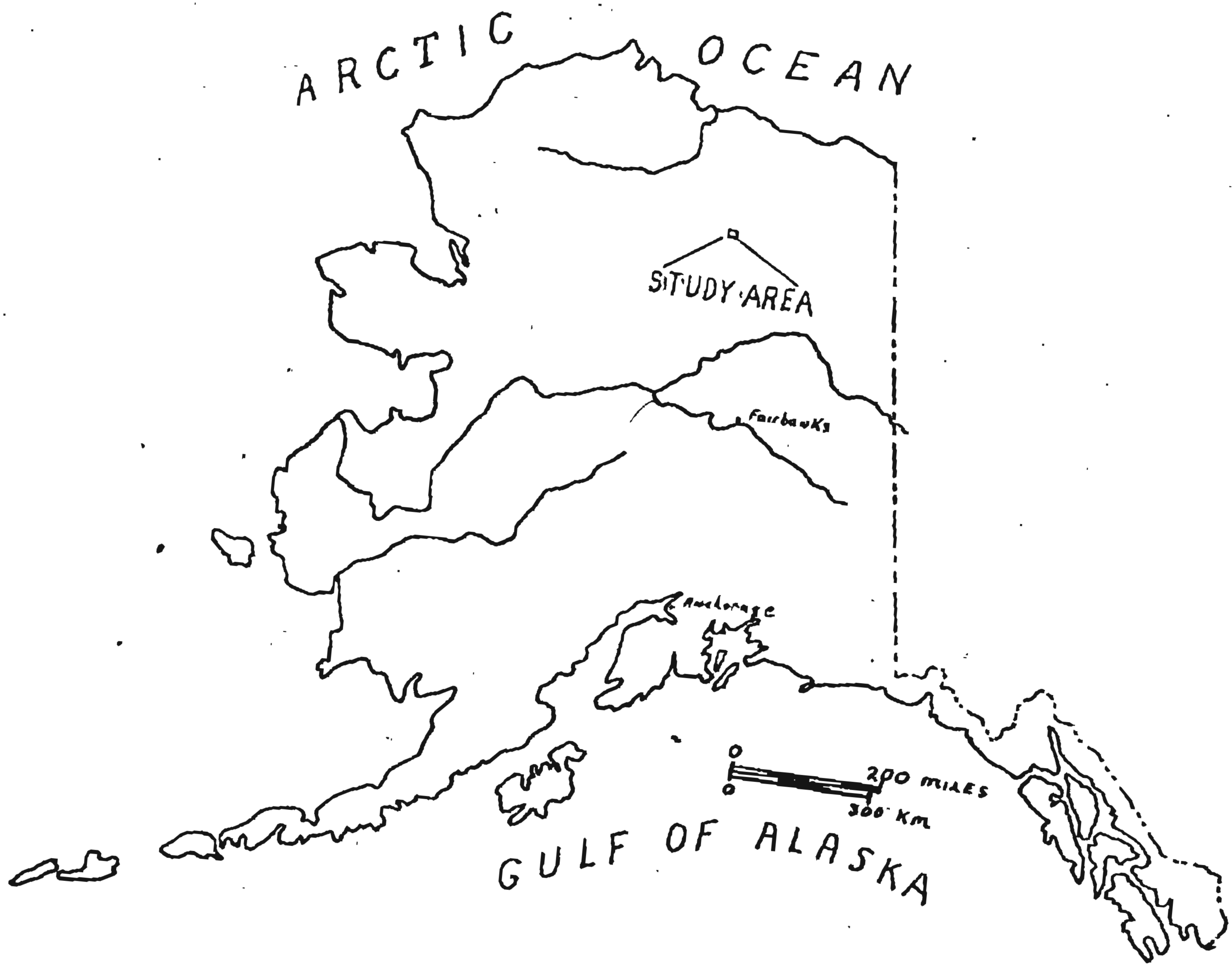

FIGURE 1 - Location Map Showing Study Area.

Regional correlations suggest the Siksikpuk is time equivalent to the Joe Creek member of the Echooka Formation of the Sadlerochit Group in northeast Alaska. The Echooka was deposited on a stable shelf while the Siksikpuk most likely reflects deposition in an euxinic basin. This interpretation is compatible with basinal rocks of the same age that lie further to the west (Churkin, et. al. 1979).

Atigun Gorge Section

The Siksikpuk Formation in Atigun Gorge is part of a large fold overturned to the north. The measured section is overturned and has an undetermined amount of internal folding and bedding plane slippage. Exposure quality ranges from fair to excellent along steep slopes and knolls. The primary section is on the east side of a large waterfall and measured from a well exposed contact with the Wahoo Limestone of the Lisburne Group. Successive measurements downslope required lateral correlation to adjacent ridges to the east using marker horizons for lithostratigraphic control. Plate 1 presents a composit section of the Siksikpuk in Atigun Gorge. All thickness measurements were made by compass and tape with corrections for dip calculated later. No attempt has been made to compensate for an undeterminable amount of structural thickening within the section. It is estimated that some zones of extreme ductile deformation may measure two to three times their true stratigraphic thickness.

The base of the section consists of 22 meters (749 - 771 m interval) of gray, massive, silty limestone that weathers a light grayish brown. These are interbedded with gray, tan weathering, platy, calcareous shales. The limestones are very fossiliferous while pyritic and some barite concretious are common throughout. The contact with the underlying Wahoo Formation appears conformable but published literature indicates that a time break occurs here and the contact is probably disconformable in this area.

The 644 to 749 meter interval consists of 105 meters of distinctive dark gray to black platy shales and thin, very resistant chert beds and scattered chert nodules. The shale weathers into shards and maintains a steeper slope than that of other shales in the area. Small barite rosettes in chert beds and thin cross-cutting fracture fillings are common.

Petrographic analysis of the shales revealed the presence of detrital quartz and feldspar, and chlorite in a cherty matrix with secondary siderite. The veining in the shales varies in composition but usually contains calcite, barite, and quartz mineralization.

The black shale interval is separated from the next interval by a highly sheared zone of dark shale. Drag features are common along the contact and demonstrate the presence of a reverse motion fault of unknown displacement.

The interval from 561 to 644 meters is the most distinctive unit in this section. It consists of tan to orange weathering, silty limestones interbedded with gray, green, and maroon varigated shales related to a shelf-like setting. Pyrite nodules within the sales are very abundant but deeply weathered, accounting for the brown and orange weathered cover over the unit.

The pyrite nodules in this shelf sequence are very pure, range up to 30 cm in diameter, and often weather into soft, gray, spheres with a bitter-salt taste. Cross-cutting fractures in the unit are typically filled with white blocky calcite. Some cherty nodules consisting of detrital quartz in a chert cement are scattered throughout this interval.

There is a definite cyclic character that shows a systematic pattern of varigated shales grading upward into gray, platy, fossiliferous, rippled, silty limestones with thin gray shale interbeds. This cycle (Figure 2) repeats many times and is typical of what might be found in a shallow moring shelf setting. The unit itself does not have any characteristics of the type Siksikpuk Formation and is interpreted to be correlative with the Joe Creek member of the Echooka Formation of the Sadleochit Group. This indicates that the section occurs along a shelf margin boundary and contains rocks deposited both in a basinal and a shelf setting.

Laterally, this interval shows dramatic intertonguing, pinchout, and truncation. The abrupt truncation of the unit near the waterfalls is dramatic and suggests significant thrusting along that horizon. The intertonguing with dark shales reflects juxtaposed shelf and deeper water facies in this area.

The interval between 512 and 561 meters is characterized by maroon, green, and gray shales with interbedded brown weathering, gray, locally fossiliferous, siltstone. Nodular chert occurs within the shale beds and barite mineralization is noticeably absent. The base of this interval provides a distinctive marker horizon that can be traced laterally for several miles. It is conformable with the younger horizons above it and is interpreted to represent a rapid facies transition between shallow marine and deeper restricted marine conditions.

All rocks exposed between 89 and 512 meters constitute what could be called a "barite potential" interval. Dark shales of varying shades of gray create extensive shale talus slopes with some obvious folding. Pyrite nodules, chert nodules, siderite nodules, and various forms of barite are common. The barite is most abundant within the 220 - 320 meter interval. This thickness is not a true measurement because gentle folding and differential erosion have exaggerated the apparent thickness. It is estimated that 20 meters is a more realistic thickness. A second anomalous concentration of barite occurs along a 5 meter thick zone at the 98 meter position. It is associated with abundant siderite and chert nodules.

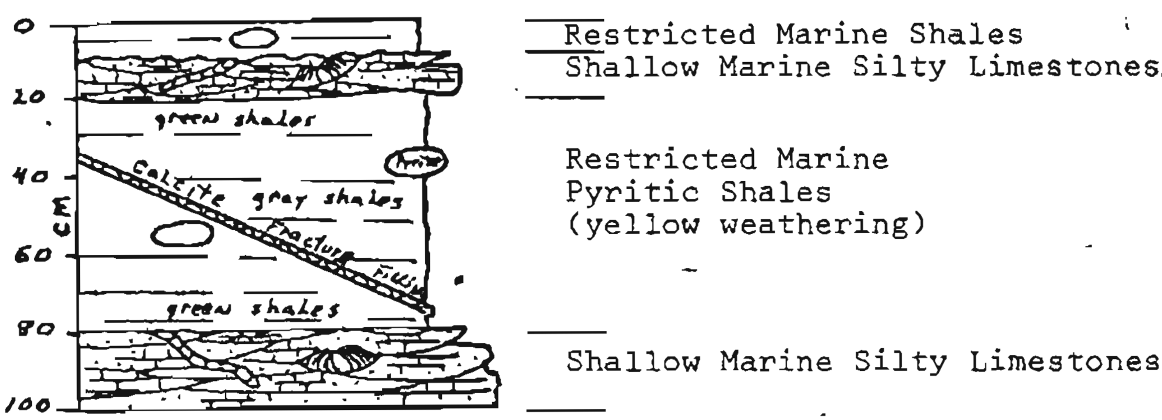

FIGURE 2 - Schematic of Cyclic Sedimentation Found in the Shallow Marine Shelf Deposits within the Siksikpuk Formation along Atigun Gorge.

The "barite potential" shale interval is conformably overlain by 13 meters (72 - 85 m) of medium gray, slightly calcareous, siltstone. Brachiopods and plant stem impressions are common in this interval and suggest shallower, higher energy, normal marine conditions.

The remaining section of Siksikpuk rocks are similar in character to the preceeding shales. Barite is virtually absent but siderite, chert, and pyrite nodules are very common. A pyrite zone is developed at the 20 meter level where very resistant shale layers contain disseminated pyrite and chalcopyrite, and eliptical sideritic layers. The top of the Siksikpuk Formation was not observed but it is in local contact with the Shublik Formation beneath heavily vegetated slopes.

Barite

Occurrence

The barite mineralization occurs in several forms within the Siksikpuk, but notably missing is well developed bedded barite. Three basic barite associations are present: isolated rosettes, fracture fillings, and occurrences on or within cherty and sideritic concretions.

Barite rosettes are common in local zones and range up to 30 cm in diameter. They are almost pure light gray barite isolated within dark shales. They quickly weather into piles of prismatic barite crystals along slopes. The fracture filling barite ranges from pure barite to a mixture with calcite and quartz. Maximum fracture thickness never exceeds 2 - 3 cm but they are often continuous for 100 meters or more. The fracture filling barite has the broadest stratigraphic distribution and is related to a late state fracturing and barite solution recrystallization event.

The most abundant barite deposits are associated with siderite and cherty concretions. Within the concretions, barite occurs in three basic modes. Most commonly it is developed as a blocky crystal mossaic replacing cherty material along a fracture network to produce a brecciated appearance in the cherty material. It may also be developed as prismatic crystals and cone-in-cone structures around concretions. The third mode of occurrence is as thin coatings or crusts on the surface of cherty and siderite nodules.

Origin

Selective barite mineralization within certain rock types in the Siksikpuk Formation suggests a syngenetic-diagenetic origin. An early origin would mean that the isotopic composition of the sulfate should reflect the same general isotopic composition of the Permo-Triassic seas at that time.

Holser and Kaplan (1966) demonstrated that the isotopic composition of marine sulfate during the Permo-Triassic was unusually low, ranging from 9 to 15 parts permil for σS^{34}. Values less than this would suggest a later epigenetic origin. Values exceeding this range must originate from some σS^{34} enrichment process that involves biogenic activity of bacteria, and would suggest a very early syngenetic origin (Thode, H.G., Harrison, A.G. and Monster, J., 1960). This same isotopic fractionation would affect the sulfide minerals like pyrite within pyrite nodules in such a way that a trend toward isotopic equilibrium with the sulfate is established.

The results of sulfur isotope analysis from six samples is presented in Table 1. All minerals show isotopic values well above that expected in normal marine seawaters during the Permo-Triassic. These high values indicate that the barite has a syngenetic origin and probably developed during the initial stages of burial when reducing bacterial activity was high. A reduction of marine sulfate by bacteria apparently gave rise to pyrite formation and subsequently negative values σS^{34}. The sampling used for this isotopic analysis is limited but the results are consistent. Additional samples and supporting work with oxygen isotopes is needed before a more definitive statement can be made.

TABLE 1: Stable Isotope Data on Barite from Siksikpuk Formation (See Map for Sample Locations)

Sample Number	Map Locality Number	Description	σS^{34} (Permil)
B167	1	Radiating barite around pyrite nodule	+29.4
B170	1	Barite rosette in shale	+34.2
B187	2	Vein barite	+41.8
79MP161	*8	Barite rosette	+27.9
B167	1	Pyrite nodule	-29.1
B172	1	Pyrite nodule	-42.4

* Not part of measured section but approximately equivalent to 250m position.

The localization of barite within the section and the evidence for a syngenetic origin suggests a close relationship between environment of deposition and barite formation.

Quantity

The economic potential for these barite deposits will be a function of their abundance and purity. Within the study area, the actual amount of barite in the Siksikpuk is relatively small and somewhat localized. The surface expression of barite suggests it may be locally very abundant but this is only a function of erosion. Barite is considerably heavier than the encasing shales and tends to remain on slopes and knolls as lag deposits. Many areas seemed to be covered with a barite layer 2 to 5 cm thick and underlain by a shale package with well developed by widely disseminated barite mineralization. It is not likely that any commercial quantities of drilling mud quality barite will be in this immediate area. The association of barite with basinal shales would indicate that laterally equivalent deposits west and northwest of Galbraith Lake have better potential. They occur in more distal deposits of the Permo-Triassic rocks and have a greater probability of having thicker syngenetic-diagenetic barite deposits.

Conclusion

Significant barite mineralization in the Siksikpuk Formation from the vicinity of Galbraith Lake is restricted to a black shale sequence. It occurs as vein fillings and rosettes, and in association with cherty and sideritic concretions. The barite is locally abundant on slopes and knolls as lag deposits but is quantitatively minor within the shale itself.

The barite is related to basinal black shales and has a syngenetic-diagenetic origin. This was inferred from field relationships and substantiated by stable isotope analyser. All δS^{34} values fall well above the values for Permo-Triassic seas and reflect biogenic degradation of sulfates by bacteria. These processes probably occurred shortly after burial and with the first 30 or 40 meters of burial.

The association of early barite with a basinal black shale facies provides a predictive tool for barite mineralization within the Siksikpuk Formation. Regional lithofacies relationships indicate more basinal conditions to the west and northwest and thus greater potential for barite mineralization. No direct evidence of volcanic association was seen and no attempt at modeling is being attempted at this stage of study.

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