STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

This report is preliminary and has not been edited or reviewed for conformity with Alaska Geological and Geophysical Surveys standards.

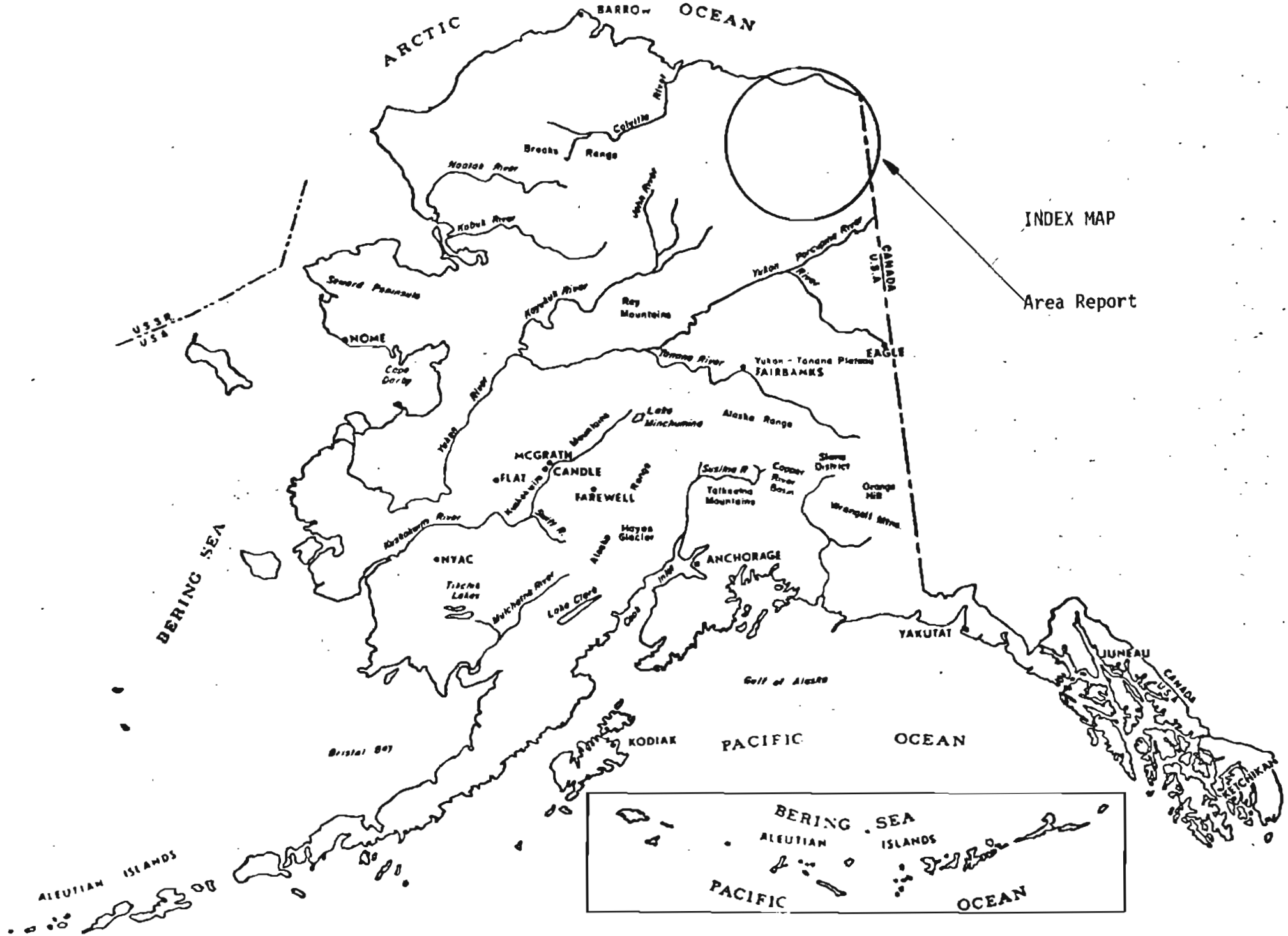
Resource Evaluation Section

January 1972
Revised January 1973

Alaska Open File Report 22

GEOLOGY AND MINERAL EVALUATION OF THE ARCTIC NATIONAL WILDLIFE RANGE, NORTHEAST ALASKA

By
D.C. Hartman


ARCTIC OCEAN
BARROW
Colville River
Brooks Range
Noatak River
Kobuk River
Selawik River
Seward Peninsula
Kuskokwim River
Ray Mountains
Yukon River
Porcupine River
CANADA
U.S.A.
INDEX MAP
Area Report
U.S.S.R.
U.S.A.
NOME
Cape Darby
Tanana River
EAGLE
Yukon - Tanana Plateau
FAIRBANKS
Yukon River
Lake Minchumina
Alaska Range
MCGRATH
Kuskokwim Mountains
FLAT
CANDLE
FAREWELL
Kuskokwim River
Hayes Glacier
Alaska Range
Susitna R.
Copper River Basin
Talkeetna Mountains
Alaska Range
Orange Hill
Wrangell Mtns.
BERING SEA
NYAC
Tikchik Lakes
Nushagak River
Lake Clark
ANCHORAGE
Cook Inlet
YAKUTAT
Gulf of Alaska
JUNEAU
CANADA
U.S.A.
KODIAK
PACIFIC OCEAN
Bristol Bay
ALEUTIAN ISLANDS
BERING SEA
ALEUTIAN ISLANDS
PACIFIC OCEAN

ABSTRACT

The Arctic National Wildlife Range includes the rugged and remote northeastern end of the Brooks Range in Alaska. Rocks exposed include metamorphic and sedimentary strata of virtually every geologic age from pre-Cambrian to the present. Several cycles of deformation and mountain-building, modified by erosion and glacial action, have caused the complex geological situation of today.

Granitic intrusions accompanied deformation of Devonian age, and these intrusives have generated metallic mineral deposits in the Romanzof Mountains and along the southern edge of the Brooks Range. Low-grade phosphate deposits are abundant in the Shublik Formation of Triassic age. An enormous oil and gas reserve may be trapped in the Marsh Anticline, just south of Camden Bay on the Arctic coast.

None of these mineral prospects have been thoroughly explored, and it is strongly urged that this exploration be done before the wildlife range is withdrawn from all such activities. It is especially recommended that exploration for oil and gas in the coastal plain be allowed, with the possible segregation of a narrow coastal strip as a transportation corridor.

INTRODUCTION

This report summarizes the geology of that part of the eastern Arctic emcompassed by the Arctic National Wildlife Range, with a special section on potential mineral resources within the subject area. Also included is a geologic map adapted from the most recent compilations of U.S. Geological Survey work by W.P. Brosge, H.N. Reiser, J.T. Dutro, Jr., and R.L. Detterman.

Earliest work in this region consisted of boundary and reconnaissance surveys by Schrader (1900), Mendenhall (1902), and Maddren (1912). Between 1906 and 1914, a monumental task of topographic and geologic mapping and investigation was carried out by Ernest de K. Leffingwell in the Canning River, Franklin Mountains, and Romanzof Mountains. Commencing in 1944, in cooperation with the U.S. Navy (1944-53), and continuing to the present time, the U.S. Geological Survey has compiled detailed geological maps and reports on this area through the efforts of many workers (see bibliography).

TOPOGRAPHY AND DRAINAGE

The dominating feature of the refuge area is the Brooks Range, here about 100 miles wide, that forms the Alaskan portion of the Rocky Mountain system. Mounts Chamberlin (9020 feet) and Michelson (8855 feet), two of the highest points in the Brooks Range, dominate the jagged landscape of the Franklin and Romanzof Mountains. This region of the Brooks

Range is further subdivided into the Sadlerochit, Shublik, British, and Davidson Mountains. This mountainous terrain has been extensively glaciated by at least six major ice advances and retreats, and many alpine glaciers and ice fields still mantle the higher slopes despite the present state of ice retreat.

Sloping gently northward from the abrupt mountain front to the shore of the Arctic Ocean is the Arctic coastal plain, interrupted by occasional low rolling hills, and ranging from 8 to 45 miles wide. Along the southern edge of the Brooks Range, near the south boundary of the refuge area, the mountains decrease in height and give way to more isolated groups of mountains and hills rising from marshy lowlands.

Drainage to the Arctic Ocean is divided among a dozen or so streams, the largest being the Canning, Hulahula, Kongakut, and Firth Rivers. Draining to the south are the Sheenjek and Coleen River systems, which connect with the Porcupine and Yukon drainages.

Permafrost underlies the entire region, probably reaching a maximum depth of about 2000 feet on the tundra-covered coastal plain, as this depth of frost has been penetrated by wells drilled a few miles to the west of the Canning River.

GEOLOGY

General

Bedrock consists of diverse types of metamorphic and sedimentary strata ranging in age from pre-Cambrian to Recent, with minor volcanic and

intrusive igneous rocks. Several episodes of uplift, deformation, and intrusion have produced complex patterns of folding, fracturing, and superimposed thrust-fault blocks, modified by Quaternary and Recent glaciation and stream erosion.

Stratigraphy

Neruokpuk Formation

The oldest rocks exposed comprise the Neruokpuk Formation, an extremely varied assemblage of altered sedimentary and volcanic strata at least 6,000 feet thick. These rocks crop out in a broad east-west band across the northern portion of the Brooks Range.

The formation is composed of sandstone, quartzite, argillite, phyllite, slate, and chert, with subordinate limestone and volcanic rocks. Based on fossil evidence, ages of pre-Cambrian, Cambrian, Ordovician, and Silurian are represented.

Baird Group

The Baird Group is represented in the Sadlerochit and Shublik Mountains by the Katakturuk Dolomite, of probable Silurian age, and the Nanook Limestone of middle Devonian age. To the south, considerable areas of undifferentiated limestone, slate, conglomerate, and sandstone are part of the Baird Group rocks, which may attain a thickness of about 6,000 feet.

Endicott Group

Formations making up the Endicott Group are the early Mississippian Kekiktuk Conglomerate, early to late Mississippian Kayak Shale and red beds of the Itkillyariak Formation. Overlying these rocks are the pervasive dolomitic limestones of the Lisburne Group, from late Mississippian to Pennsylvanian age. The Lisburne carbonates form the bulk of the eastern Brooks Range, and contain dolomite and limestone with some oil and gas reservoir potential, as proved by the Lisburne oil pool at Prudhoe Bay. Combined thickness of Endicott Group rocks approaches 5,000 feet. This group is shown on the geologic map by the single unit "PM".

Sadlerochit Formation

The sandstone, siltstone, and shale of the Sadlerochit contain nearly all the calculated reserves of the Prudhoe Bay oil field. In the wildlife range, up to 1,800 feet of Sadlerochit are exposed locally from the Sadlerochit Mountains southward to the upper reaches of the Coleen River. In outcrop the sandstones are hard and impervious, but as the Arctic platform is approached (approximating the seacoast), porosity and permeability seems to be markedly increased, making it a prime target for oil and gas exploration. Age of the Sadlerochit is Permian and early Triassic.

Shublik Formation

From 300 to 800 feet of black phosphatic shale and shaly limestone of the

Shublik Formation crop out across the northern part of the mountains, but is seldom seen to the south. Fossils date the formation at late Triassic. A persistent 40 - foot sand at the top of the Shublik is named the Sag River Sand at Prudhoe Bay, and forms an important hydrocarbon reservoir.

Kingak Shale

The Jurassic period is represented by about 4000 feet of the black Kingak shale in the vicinity of the Sadlerochit, Shublik, and northern Romanzof Mountains.

Colville Group

Rocks of Cretaceous age are nearly all assigned to the Colville Group in this part of the Arctic. A thin shaly section of early Cretaceous is present, but has not been differentiated or named at this time. Late Cretaceous sandstones and shales about 4,000 feet thick have been named the Ignek Formation in the Sadlerochit Mountains area, and these rocks are correlated with the Seabee, Prince Creek, and Schrader Bluff Formation to the west. To the east, along the course of the Jago River, up to 15,000 feet of unnamed muddy conglomerate is exposed, probably of late Cretaceous age.

West of the Canning River, sandstones of the Colville Group form important gas reservoirs at Square Lake and Gubik gas fields, and include the Kuparuk oil zone of the Prudhoe Bay area.

Tertiary Rocks

At least 7,000 feet of soft marine shale and sandstone are exposed on the north flank of the Marsh Creek anticline just south of Camden Bay. Fossils indicate a late Tertiary age for these sediments. The outcrops are very poorly consolidated, and weather readily to soft sand and clay. At least one four-foot ledge of dark brown oil sand crops out along Marsh Creek, and a kerosene odor can be detected in the Tertiary outcrop area along lower Carter Creek.

Quaternary Deposits

Quaternary and Recent deposits as shown by "Q" on the geologic map are a combination of glacial, alluvial, and colluvial sediments. At least six glacial advances and retreats have been documented in this region. Glacial advances never went far beyond the present mountain front, so that morainal debris has been concentrated in that area.

Alluvium is for the most part from reworked glacial deposits that have been eroded and spread along the north-sloping coastal plain by stream action, resulting in the present expanse of gravel, sand, and silt in stream beds, terraces, and flood-plain deposits. To the south, the same type of alluvium fills the broad upper valleys of the Coleen and Sheenjek Rivers. Permafrost has modified the alluvial lowlands with such features as patterned ground, stone rings and stripes, and ice lenses.

Colluvial deposits consist of talus cones, fans and mudflows and other residual weathered products in the process of downslope migration.

Structure and History

Following deposition of pre-Cambrian through Devonian rocks, a late Devonian orogeny formed a series of east-west folds, and was probably accompanied by intrusion of the Romanzof granitic intrusion and metamorphism of the Neruokpuk sequence. This was followed by deposition of Kekiktuk, Kayak, Lisburne, Sadlerochit, and Shublik rocks. In early Jurassic time, a strong regional uplift generated the Brooks Range geanticline. Late Jurassic through early Cretaceous deposition continued to the north of the Brooks Range, with the accumulation of several thousands of feet of sediments eroded from the Brooks uplift. A late Cretaceous orogeny imposed another set of east-west folds on the northern Brooks Range, accompanied by igneous intrusions and metamorphism in the southern part of the range. Uplift of the mountains continued through Cretaceous into early Tertiary, during accumulation of sediments to the north. A final early Tertiary deformation reinforced east-west folding and caused the profusion of south-dipping imbricate thrusts and overturned folds that are evident today.

Mineral Resources

Oil & Gas

The Marsh Creek anticline is a long, broad uplift near the mouths of Carter Creek and Marsh Creek, expressed at the surface in Tertiary sedimentary rocks bordering Camden Bay. Outcrops in the fold are continuous for 20 miles, but stream-bank outcrops of Cretaceous rocks indicate

that the fold axis continues southwestward for at least another 16 miles. In addition, the northeast plunge of the structure amounts to 22 feet per mile. This means that extension of the fold for another ten miles to the northeast would lose only 220 feet of structural elevation. Thus, a potentially oil-bearing structure 46 miles in length is suggested at Marsh Creek.

At least four formations are prospective for oil and gas in the Marsh Creek structure. Highly permeable marine Tertiary sands are present at the surface, some with residual oil saturation, and it is reasonable to expect Tertiary oil sands at depth.

The Colville group with excellent reservoir sands should underlie the Tertiary section. These sands have produced oil and gas at the Gubik, Square Lake and Kuparuk fields, and underlying early Cretaceous sands have produced at Umiat, Fish Creek, Simpson, Meade, and Wolf Creek.

Permeable delta-type sands of the Sadlerochit Formation should be developed at Marsh Creek similar to those of the great Prudhoe Bay reservoir, and the underlying Lisburne limestones should also be prospective.

Assuming a length of 40 miles and a width of three miles, assuming a conservative recovery factor of 200 barrels of oil per acre-foot of saturated reservoir rock, and assigning 200 feet of saturation to the Tertiary, Colville, and Lisburne, and 300 feet to Sadlerochit, a reserve of nearly 14 billion barrels of oil can be calculated, which exceeds the potential of the super-giant Prudhoe Bay field.

In view of the enormity of potential oil and gas reserves on this structure alone, it is recommended that the coastal strip north of latitude 69° 45', or the approximate south line of township 5N, U.M., be left open to geophysical exploration of the Marsh Creek structure and for other anticlines which may be present in this prospective terrain. Seismic operations in the winter months should cause little or no damage either to the tundra or to wildlife. Drilling and production operations at Marsh Creek or other fields in this area could be granted access by a single, narrow coastal corridor designed to accomodate both a roadway and pipeline facilities. In this way minimum disturbance of the Arctic Wildlife Range should ensue.

Metallic Minerals

At least two areas within the wildlife refuge are significantly mineralized, as indicated by both direct observation and by geochemical sampling, as follows:

1. Romanzof Granite.

The Romanzof pluton is a light gray gneissoid granite of probable late Devonian age, underlying about 200 square miles between the Hulahula and Jago Rivers and culminating in the high, ice-covered mass of Mt. Michelson. Roughly half of the pluton is exposed, the other half hidden by ice, snow, talus and alluvium. Many of the higher elevations are virtually inaccessible, so that detailed examination of all potential mineralized contacts has not been

made. However, exposures along the Okpilak and Jago Rivers are readily accessible, and stream-sediment analysis has turned up abnormally high values of various metals in drainage systems from the granitic outcrops.

Altered rocks such as tactites and hornfels are common along the western and eastern margins of the pluton, where the granite has intruded metamorphics and limestones of the Neruokpuk Formation. These altered zones contain minor pyrites and copper minerals, with subordinate sulfides of molybdenum, arsenic, lead, and zinc. Geochemical analysis of stream sediments from the granitic terrain show significantly high amounts of copper, lead, zinc, mercury, tin, beryllium, antimony, and nickel.

The classic elements of metallic ore genesis are present in the intrusion of granite into lime-bearing sedimentary rocks, and further detailed examination may reveal localized deposits of high value.

2. Bear Mountain

In the southern part of the refuge area, a mineralized granite - rhyolite intrusion involves about 100 square miles in and around Bear Mountain, just east of the Coleen River. Here the granitic body has intruded schistose rocks of undifferentiated Mississippian-Devonian age. Galena Creek is one of the streams draining the area, attesting to the conspicuous presence of metallic sulfides. Some

prospecting has been done by Mr. Ed Owens, but the area lacks drilling or other detailed evaluation.

Sulfide mineralization is concentrated in quartz veins along rhyolitic dikes and along layering in greenstone sills (W.P. Brosge, personal communication). Geochemical analysis of rock samples, residual soil, and stream sediments show very high amounts of copper, lead, zinc, silver, beryllium, and niobium.

Miscellaneous Areas

A rock sample from the mafic intrusive body of Double Mountain, on the Sheenjek River, shows abnormally high amounts of copper, lead, gold, and silver in geochemical analysis. This is another locality that deserves closer examination for mineral deposits.

Two units of altered Neruokpuk limestone are mapped in the British and Romanzof Mountains, characterized by reddish weathering typical of oxidized iron. One body lies astride the upper middle course of the Kongakut River, and the other is just east of the Egaksrak River near the north edge of the Romanzof Mountains. Neither of these deposits have been examined in detail.

Several areas of mafic intrusives are mapped along the southern part of the Brooks Range, one of them covering 75 square miles near the confluence of Monument Creek and the Sheenjek River. Apparently none of them have been closely examined or geochemically sampled.

Non-Metallic Minerals (Phosphate)

The Shublik Formation of Triassic age is a widespread and persistent unit across the northern part of the Brooks Range, from 300 to 800 feet thick. Most of the formation consists of sooty black shale and black shaly limestone containing from 5% to 25% phosphate, with some thin beds of up to 80% phosphate. The mineral occurs mostly as matrix, oolites, and nodules of carbonate fluorapatite resulting from alteration of lime muds. Phosphatic outcrops are characterized by a bluish-white bloom or efflorescence. A low-grade deposit such as this has no commercial value at this time, but may have some future value as a fertilizer with improved transportation and expanded agriculture in interior Alaska.

BIBLIOGRAPHY

Brosge, W.P., Dutro, J.T. Jr., Mangus, M.D., and Reiser, H.N., 1952, "Stratigraphy and structure of some selected localities in the eastern Brooks Range, Alaska": U.S.G.S. Geol. Inv. NPR 4, rept. 42.

_____, 1960, "Geologic map of the eastern Brooks Range, Alaska": U.S.G.S. open-file 199.

_____, 1962, "Paleozoic sequence in eastern Brooks Range, Alaska": AAPG Bull. v. 46, no. 12, pp. 2174-2198.

Brosge, W.P., and Reiser, H.N., 1965, "Preliminary geologic map of the Arctic quadrangle, Alaska": U.S.G.S. open-file 256.

_____, 1968, "Geochemical reconnaissance maps of granitic rocks, Coleen and Table Mountain quadrangles, Alaska": U.S.G.S. open-file 323.

Brosge, N.P., Reiser, H.N. and Estlund, M.B., 1970, "Chemical analysis of stream sediment samples from the Sadlerochit - Jago Rivers area, Mt. Michelson and Demarcation Point quadrangles, Alaska": U.S.G.S. open-file 409.

Brosge, W.P. et al., 1972, "Preliminary geologic map of the Demarcation Point quadrangle, Alaska": U.S.G.S. map (in press).

Holmes, G.W., and Lewis, C.R., 1961, "Quaternary geology of the Mt. Chamberlin area, Brooks Range, Alaska": U.S.G.S. Bull. 1201-B.

Leffingwell, E. de K., 1919, "The Canning River region, northern Alaska": U.S.G.S. Prof. Paper 109.

Maddren, A.G., 1912, "Geologic investigations along the Canada-Alaska boundary": U.S.G.S. Bull. 520-K.

Mangus, M.D., 1953, "Regional interpretation of the geology of the Kongakut - Firth Rivers area, Alaska": U.S.G.S. Inv. NPR 4 rept. 43.

Mertie, J.B. Jr., 1925, "Geology and gold placers of the Chandalar district, Alaska": U.S.G.S. Bull. 773-E, pp. 215-263.

Morris, R.H., 1957, "Reconnaissance study of the Marsh anticline, northern Alaska": U.S.G.S. open-file 146.

Patton, W.W. Jr. and Matzko, J.J., 1959, "Phosphate deposits in northern Alaska": U.S.G.S. Prof. Paper 302-A.

Reed, B.L., 1968, "Geology of the Lake Peters area, northeastern Brooks Range, Alaska": U.S.G.S. Bull. 1236.

Reiser, H.N., and Tailleur, I.L., 1969, "Preliminary geologic map of Mt. Michelson quadrangle, Alaska": U.S.G.S. open-file 340.

Reiser, H.N., Brosge, W.P., Dutro, J.T. Jr., and Detterman, R.L., 1971, "Preliminary geologic map, Mt. Michelson quadrangle, Alaska": U.S.G.S. open-file 490.

Sable, E.G., 1959, "Preliminary report on sedimentary and metamorphic rocks in part of the Romanzof Mountains, Brooks Range, northeastern Alaska": U.S.G.S. open-file report.

_____, 1965, "Geology of the Romanzof Mountains, Brooks Range, northeastern Alaska": U.S.G.S. open file 257.