TO ACCOMPANY OPEN FILE MAP 76 -539 SHEET 4 OF 4

MINERAL RESOURCES OF THE ARCTIC NATIONAL WILDLIFE RANGE

RESOURCES:

The Wildlife Range contains known resources of phosphate rock, uranium, hydrocarbons, and coal. These resources have been observed, but not measured, and may be of small size or low grade. In addition, it has potential for resources of tin, molybdenum, tungsten, copper, lead and zinc, barite and gold. The areas thought to be most favorable for phosphate rock and for some of the metals have been sampled in reconnaissance fashion. The rest of the Wildlife Range has not been explored for resources, and in much of it the rocks are concealed by surficial deposits; an estimate of potential resources in those areas can only be made by inference from the geologic relationships found in the sampled areas.

GEOLOGIC SETTING:

The geologic divisions of the Wildlife Range correspond generally to its physiographic divisions. The Romanzof Mountains form the backbone of the Range. Low linear ranges form the mountain front north of the Romanzofs, while rugged mountains and broad valleys make up the Brooks Range to the south. The still lower Arctic foothills and coastal plain and the Porcupine plateau form the northern and southern extremities of the Wildlife Range. The Arctic coastal plain and foothills are covered with unconsolidated deposits and are underlain by Cretaceous and Tertiary sediments that dip regionally northward and were probably derived from erosion of the ancestral Brooks Range. The low northern mountains are characterized by long open to recumbent east-trending folds. In the east they consist mostly of lower Paleozoic or Precambrian rocks, and in the west are mostly of upper Paleozoic and Mesozoic rocks, with older rocks exposed in the cores of the folds. The Romanzof Mountains are a broad anticlinorium of slightly metamorphosed Precambrian sedimentary rocks, overlain by lower Paleozoic rocks and intruded by granite. The anticlinorium includes large areas of lower Paleozoic chert and interbedded volcanic rocks and limestone, whereas in the folded mountains to the north, volcanic rocks are less abundant and limestone and dolomite are more abundant.

The Porcupine plateau and the mountains of the Brooks Range south of the continental divide are composed mostly of imbricate thrust-sheets of Carboniferous limestone and Permian and Triassic shale and sandstone. Lower Paleozoic rocks are exposed in three long faulted anticlinal belts, and in domical uplifts around granite intrusions at Bear Mountain and Ammerman Mountain. Volcanic rocks probably equivalent to those in the north are exposed in the cores of the larger anticlines. The southernmost rocks in the Wildlife Range are a separate sequence of chert, shale and mafic igneous rocks of probable Mesozoic age that have been thrust northward over the Paleozoic rocks.

At least three intervals of uplift and erosion in and north of the Romanzof Mountains are evidenced by unconformities at the base of the Mississippian, Lower Cretaceous and Upper Cretaceous rocks. Folds in very young Tertiary rocks, and tilted Quaternary gravels along the Arctic coast show that the most recent folding continued into Quaternary time.

The granite intrusions have a wide range in age. The South stock in the Romanzof Mountains has been radiometrically dated as Silurian (Reiser and others, 1974), and the neighboring Okpilak batholith as Cretaceous (Sable, 1965). The granites near Bear Mountain have not been dated, but probably are younger than Mississippian.

FAVORABLE POTENTIAL MINERAL RESOURCE AREAS:

The areas outlined on the Mineral Resources map (sheet 4) are those considered favorable for mineral resources on the basis of available data. The probability of the occurrence of a deposit of any size or grade has not been estimated, nor has any account been taken of the economic factors that determine whether or not any deposit would be exploitable.

Favorable areas are outlined on the basis of two kinds of evidence: 1) direct evidence from mineral occurrences or from chemical analyses of samples that a particular element is present, at least locally, in above-average concentrations in rocks that are generally favorable for deposits of that element; 2) inference that an element may be present because the rocks are the same kind as those in which it is present elsewhere in the region, or, in the case of uranium, inference that an element may have been eroded from its known host rock and redeposited into another favorable kind of rock.

Using these criteria, the selection of favorable areas is severely limited by the amount and geographic distribution of the geochemical samples, most of which are from the areas around the granitic rocks. In particular, the large unsampled areas of lower and upper Paleozoic limestone and dolomite, which could be favorable hosts for mineral deposits, have been omitted for lack of data.

The available information consists of the geologic mapping, which is based on fieldwork in the area north of 69° latitude, but is based on photointerpretation in about half the area south of 69° latitude; observations of mineral occurrences incidental to the mapping; brief reconnaissance studies of phosphate and uranium; and 284 samples of stream sediments--less than one-fourth the number needed for a reconnaissance of the whole Wildlife Range. Little prospecting and no known mining has been done.

OIL AND GAS:

Oil and tar occur in seeps on the Arctic coast. The potential oil and gas resources of the Wildlife Range will be discussed in a separate report.

COAL:

Minor amounts of coal occur in the Mississippian Kekiktuk Conglomerate and Kayak Shale, and in the Upper Cretaceous and Tertiary rocks, but all the known beds are less than 1 foot thick. The Lower Cretaceous formation that contains abundant coal farther west is apparently not coal-bearing in this area, nor is the lower part of the Upper Cretaceous nonmarine unit (Detterman and others, 1975). The extensive surficial deposits in the coastal plain may conceal some Tertiary or Upper Cretaceous coal beds in Area A, but from the existing data coal is not considered a significant resource in the Wildlife Range.

PHOSPHATE ROCK:

Phosphatic rocks are common in the Triassic Shublik Formation. In the only complete exposure of the formation sampled at 1-foot intervals (locality 8) 25 feet of beds containing an average 8.6 percent to 19.2 percent P205 per 5-foot interval occur about 100 feet above the base of the Shublik, and 30 feet of beds containing an average 5.6 percent to 18.7 percent P205 per 5-foot interval occur about 300 feet above the base. Single grab samples that contain 15 percent to 35.8 percent P205 at other localities (4, 5, 10, 12, 15) indicate that phosphate rock occurs in the lowest 100 feet and about 300 feet above the base of the formation in Areas D, E, and F. Phosphate rock may also be present in parts of Area H, but at locality 11, near the east end of the Shublik outcrop belt, no more than 1 percent P205 was found in five samples from a completely exposed section. At the next exposures to the east, in Canada, and to the southeast at Joe Creek, the Shublik is sandy, and no phosphate is reported (Mountjoy, 1967). Along the northeast edge of the Sadlerochit Mountains and within parts of the Brooks Range, the Shublik is missing because of erosion during Cretaceous time. Phosphate rock at depths less than 500 feet is therefore probably confined to the areas shown.

BARITE:

A bed or lens of white massive barite about 20 feet thick and at least 100 feet long is interbedded with the chert and shale of unit Mzm (sheet 1) at locality 54. Unit Mzm extends into the southern part of the Wildlife Range in Area Y. Although no barite was found in Area Y, the area is considered favorable for bedded barite deposits because chert and shale are a common environment for such deposits, and because of the proximity of the known deposit.

URANIUM:

Four samples of granite from the Okpilak batholith (localities 22 and 24) contain 50 to 80 ppm (parts per million) equivalent uranium, 10 to 20 times as much as the uranium content of the average granite (Finch and others, 1973). One analyzed sample of granite from an unknown locality in the batholith contains 17 ppm chemical uranium and 52 ppm thorium (A. H. Lachenbruch and J. H. Sass, personal commun., 1976), more than four times as much uranium as the average granite. Most of the uranium may be within the biotite crystals (White, 1952). Stream-sediment samples suggest that the uranium may be concentrated in the interior of the Okpilak batholith, and is less abundant at its margins and in the Jago and South stocks. Sixty-six samples of sediment from streams in and around the granites were analyzed for uranium[1/]. Eight of the 11 from the interior of the Okpilak batholith contain 5 to 39 ppm uranium, whereas the eight samples from the Jago and South stocks contain less than 1.5 ppm uranium, and all but three of the 47 samples from the margins of the Okpilak batholith contain less than 5 ppm uranium. One of the three exceptions is near locality 31, where analysis of panned concentrates confirms the presence of uranium. Rocks that have large volume and contain about 70 ppm uranium are classed as conditional, subeconomic resources (Finch and others, 1973). For this reason the Okpilak batholith is shown as a favorable potential resource area.

Uranium also occurs in higher than average concentrations in the Jurassic Kingak Shale (20 to 30 ppm at localities 1, 8, 10, and 11) and in the more phosphatic beds of the Shublik Formation (30 to 80 ppm at localities 4, 5, 10, 15, 16). The uraniferous granite and sedimentary rocks in the mountains may have been part of the source area from which the Cretaceous and Tertiary nonmarine sediments of the coastal plain were derived. Nonmarine and marginal marine sedimentary rocks are the principal site of uranium deposits in the United States (Finch and others, 1973). Therefore, although no uranium is known to occur in it, the approximate area in which these Cretaceous and Tertiary nonmarine rocks crop out (Area A) is shown as favorable for uranium.

TIN:

Tin localized in the area around the Okpilak batholith (Area J) is the metallic resource most likely to occur in the Wildlife Range. The only stream-sediment samples that contain tin in detectable concentrations (10 ppm or more) are from the area of the batholith (sheet 2), and about half of the samples from this area contain tin in concentrations of 10 to 300 ppm. Beryllium, a common associate of tin, also occurs in anomalous concentrations (10 to 70 ppm) in stream-sediment samples only in this area. Panned concentrates of stream sediments near the north, south and west borders of the batholith also confirm the presence of tin.

Fifteen samples of granite from the batholith contain an average 10 ppm tin and 11 ppm beryllium, twice as much as the average granite (3 to 5 ppm tin, 2 to 5 ppm beryllium, Hawley, 1966), and as much beryllium, but less tin than the average tin granite from productive areas (16 to 23 ppm tin, 7 to 14 ppm beryllium, Hawley, 1966). The Okpilak batholith also resembles the tin granites in the abundance of fluorite, which occurs in the granite, and also in greisens and contact rocks (localities 26, 28, 30, 36). In contrast, no evidence of tin has been found around the nearby Jago stock and South stock, where stream sediments contain no detectable tin and no more than 3 ppm beryllium. Analyses of single granite samples from each stock also show no detectable tin and only 2 to 5 ppm beryllium.

The highest known concentrations of tin are near the zone of skarn and pyritic schist at the west contact of the Okpiklak batholith, where 300 ppm tin occurs in one stream-sediment sample near locality 33, and more than 0.1 percent tin (the maximum limit of the analytic method) occurs in panned concentrates of stream sediments at localities 32, 33 and 39. According to Sainsbury and Reed (1973) tin is evident in ordinary unpanned stream-sediment samples only where the tin occurs with sulfides. The good correlation of the results from the stream-sediment samples and the panned samples thus suggests that the tin near the contact zone is associated with sulfides just as it is associated with lead, zinc and copper sulfides at localities 27 and 30.

Small detrital fragments of cassiterite (locality 29) and large fragments of tourmaline occur in the Mississippian Kekiktuk Conglomerate from west of the batholith to Lake Schrader. Recycled tin from this conglomerate may be the source of the tin in the single stream-sediment sample shown 8 miles southwest of the batholith (sheet 2). Reed (1968) suggested that the tin and tourmaline in the Kekiktuk might have come from veins high in the batholith or in the overlying pre-Mississippian sedimentary rocks that were exposed to erosion in Early Mississippian time. If so, many of these veins have long since been eroded away. However, tin deposits may still exist in the remaining parts of the contact zones or in the greisens and pyritic zones that occur within the granite (Sable, 1965).

Samples of granite and rhyolite from the Lois stock and Bear Mountain intrusives (fig. 2) contain about 7 ppm tin and 8.5 ppm beryllium, more than the average granite, but less than the Okpilak batholith. A trace of tin occurs with tungsten in gossan on a rhyolite dike near Bear Mountain (locality 48), but no other evidence of tin was found.

MOLYBDENUM:

Molybdenum in concentrations large enough to be detected analytically (5 ppm) is uncommon in stream-sediment samples from the Wildlife Range (sheet 3). It occurs in three different geologic associations: 1) around granitic intrusives, 2) in some areas of mafic volcanic rocks, 3) in an area of Cretaceous and Tertiary sedimentary rocks.

The highest concentrations of molybdenum are in the stream draining a small rhyolite intrusive at Bear Mountain (Area V), where two stream-sediment samples contain 200 to 1,000 ppm molybdenum, 50 to 200 ppm tungsten and 150 to 200 ppm lead. Just east of the intrusive smaller amounts of molybdenum occur with high concentrations of lead, zinc, and locally with copper where small unmapped rhyolite dikes intrude phyllite, greenstone and quartzite. One dike contains 30 ppm molybdenum, and soil from the contact zone of another dike (locality 50) contains 200 ppm molybdenum in addition to lead, zinc and copper in high concentrations. The association of anomalous amounts of molybdenum with tungsten, lead, zinc and some copper suggests a porphyry-type molybdenum deposit in Area V.

Although no molybdenum was detected in the 15 analyzed granite samples from the Okpilak batholith, visible molybdenite occurs locally in the batholith (localities 25 and 34), and 5 to 10 ppm molybdenum was found in five samples of stream sediments in and around the batholith, generally with high concentrations of tin, lead and zinc. Area J is therefore shown as favorable for the occurrence of molybdenum, although the potential is low, because of the low concentrations found.

In the area of volcanic rocks and chert south of the Okpilak batholith and South stock, the association of detectable molybdenum in stream sediments with high concentrations of copper and locally of zinc is interpreted as evidence of copper mineralization in Areas N and P.

Molybdenum and zinc in stream sediments from the areas of Jurassic and Cretaceous rocks north and south of the Sadlerochit Mountains may be derived from black shales. In the nearest sampled sections (localities 8 and 14) 10 samples of the Jurassic Kingak Shale contain an average of 18 ppm molybdenum. The highly organic Upper and Lower Cretaceous black shales in this area may contain even more, but none has been analyzed. The molybdenum in the area of Tertiary rocks near the Arctic coast has no apparent nearby source.

Area T has been interpreted from aerial photographs to be granitic like those near Bear Mountain, and on that account has been shown to have questionable potential for molybdenum.

COPPER:

The older volcanic rocks in the Wildlife Range have a high intrinsic copper content. Most of the observed occurrences of copper minerals are in or near these volcanic rocks, and half of the stream-sediment samples that contain high concentrations of copper (sheet 3) are also near those areas.

Four samples of the extensive unit of volcanic rocks and limestone (Ꞓv) collected in the Hulahula and Egaksrak River areas contain an average of 280 ppm copper (range 30 to 700 ppm). The unit of basalt, andesite and rhyolite (rmv) that underlies Devonian or older limestone along the northwestern mountain front contains an average of 108 ppm copper in 10 samples (range 20 to 200 ppm), and the unit of basaltic subaerial flows, intrusives and slate (mv) that underlies this limestone in parts of the same area contains an average of 217 ppm copper in 13 samples (range 50 to 500 ppm). Elsewhere, this unit (mv) contains 150 to 300 ppm copper in basalt at the one locality sampled near the lower Kongakut River. In the southern part of the Wildlife Range basalt in the rhyolite and volcanic unit (rmv) 5 miles west of locality 47 contains 200 ppm copper, whereas rhyolite and dacite in that unit contain only 3 ppm to 20 ppm. No molybdenum was detected in any of the volcanic rocks.

Minor amounts of copper minerals occur in the volcanic rocks at localities 2, 6, 17, 41, and 47, and in adjacent sedimentary rocks at localities 7, 42, and 43; native copper in basalt has been reported at localities 3 and 7. Because of their high copper content the areas of older volcanic rocks have been shown as favorable for potential copper deposits (Areas B, C, G, I, L, M, O, Q, R. S), omitting the areas where unit mv contains volcanic wacke and slate rather than igneous rocks and slate.

Stream-sediment samples that contain 100 to 150 ppm copper cluster around the volcanic rocks (sheet 3). Although these samples contain less copper than the average amount found in the volcanic rocks themselves, they may be significant of higher concentrations. Elsewhere in the Brooks Range, samples from streams that drain massive sulfide volcanogenic copper deposits contain up to 15,000 ppm copper near the deposit, but less than 200 ppm copper 2 miles downstream, and copper values above 125 ppm have been considered anomalous (Garland and others, 1973, 1975).

Two irregular areas (N and P) of favorable potential for copper have been outlined around the granitic South stock and part of the volcanic rocks. In these areas stream sediments locally contain relatively high concentrations of zinc, molybdenum or arsenic in addition to copper, and the sedimentary rocks overlying the volcanics show signs of copper mineralization (localities 42 and 46). A high concentration of copper occurs in stream sediments at the South stock. These data suggest mobilization of the copper and the addition of other metals, possibly related in part to intrusion of the South stock. The Jago stock (Area K) has been shown as having questionable potential for copper because of its relatively high concentration in one sample of stream sediments there.

Potential copper resources may occur in veins, strata-bound, or massive sulfide deposits in the volcanic rocks, in vein or replacement deposits in the adjacent sedimentary rocks, and possibly as porphyry deposits in or around the South stock.

LEAD AND ZINC:

Galena and sphalerite occur in quartz veins in the Okpilak batholith and the adjacent schist (localities 28, 37 and 27), and in skarn at the contact zone west of the batholith (locality 30). Galena, and locally sphalerite, also occur with quartz at the contacts of small rhyolite dikes near Bear Mountain (localities 49 and 50), and disseminated in veinlets in the nearby greenstone (locality 53).

Anomalous amounts of lead were found in stream sediments at both the Okpilak batholith and the Bear Mountain intrusives. The highest concentrations are in the area of small unmapped rhyolite dikes near Bear Mountain (Area W) where 200 ppm to 1,500 ppm lead occurs with 190 ppm to 560 ppm zinc and locally with as much as 150 ppm copper. Samples from the area of the mapped rhyolite intrusive immediately to the west in Area V contain much molybdenum, but less lead and zinc. Lower concentrations of all metals were found to the east around the Lois stock (Area X), but both areas W and X have potential for vein deposits.

Mineralization in the pyritic zones of the Okpilak batholith is indicated by stream sediments that contain 200 ppm to 500 ppm lead, locally accompanied by relatively high concentrations of molybdenum and arsenic (near locality 34). Mineralization at the batholith margins is indicated by sediment samples with 300 ppm lead and anomalous amounts of tungsten and arsenic (near localities 27 and 32). Area J has favorable, but low potential for lead deposits in the altered contact zones.

TUNGSTEN:

The only known occurrence of tungsten minerals in the Wildlife Range is the scheelite in panned concentrates of stream sediments from near the Okpilak batholith (locality 21). The anomalous concentrations of tungsten in stream-sediment samples also indicate that it is present in the outer part of the batholith and in the altered schist and skarn along its western margin (Area J). The highest concentration of tungsten in stream sediments (200 ppm) is with the highest concentration of molybdenum at the rhyolite intrusive near Bear Mountain (Area V), where tungsten may occur as part of a molybdenum porphyry-type deposit.

GOLD:

The only known mineral claim in the Wildlife Range is the gold placer claim reported to have been near locality 40. No production is reported, but probably enough of a showing was present to warrant bringing in the equipment found a few miles away. Traces of gold were found in one stream-sediment sample at the east contact of the batholith and in another stream-sediment sample and a panned sample (locality 33) downstream from the zone of altered schist on the west flank of the batholith. The presence here of gold in two streams whose sediments also contain anomalous amounts of arsenic indicates that at least this margin of the batholith (Area J) has favorable potential for gold.

1/ Analyses for uranium in stream sediment samples were made by J. D. Hoffman and D. E. Detra, U.S. Geological Survey, Denver, Colorado, 1976.

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