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

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GEOLOGY AND MINERAL EVALUATION OF PROPOSED WILDERNESS AREA, NUNIVAK NATIONAL WILDLIFE REFUGE AND CLARENCE RHODE NATIONAL WILDLIFE RANGE, ALASKA

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#### SUMMARY AND RECOMMENDATIONS

The Nunivak National Wildlife Refuge lies west of the Kuskokwim-Yukon Delta in the Bering Sea. The refuge consists of Nunivak Island, approximately 1 million acres in size and 2.5 million acres of surrounding pelagic waters. Very little is known about the geology or natural resource potential of Nunivak Island and its surrounding waters. Data available indicates the island is of volcanic origin with underlying Cretaceous or Tertiary sedimentary bedrock similar to that of Nelson Island.

Some coal outcrops have been reported on the north side of the island and Tertiary or Cretaceous rocks with petroleum potential could be present in the surrounding waters. There are no reports of metallic ore deposits.

Our research revealed no geophysical data published on the area and very little geologic information. We recommend additional geologic and geophysical investigation of the refuge be undertaken before it is considered for inclusion into the national wilderness system.

#### GEOLOGY

Nelson and Nunivak Islands are included in the Yukon-Koyukuk Cretaceous province as described by Patton (1970). This province extends from the Brooks Range to Nunivak Island along the west coast of Alaska but excludes the Seward Peninsula. The province is a vast tract of Cretaceous rocks locally veneered by Quaternary alluviated beds and volcanic rocks. Regional geology consists of basal andesitic rocks lying beneath a 10,000 foot section of graywacke and mudstone of Albian age overlain by 10,000 feet or more of shallow marine and non-marine paralic sandstones, shales, conglomerates, and coals of early late Cretaceous age.

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Nunivak Island is predominately of volcanic origin and geologically similar to Nelson Island located 23 miles to the east across the Etolin Strait. The volcanics on the islands represent the southernmost outcrops of a zone of flat lying Quaternary and Tertiary Olivine basalt flows that cover broad areas of Cretaceous strata on the west side of the Yukon River basin as far north as the Kobuk-Selawik lowland. Nephenitic and tholeiitic basalt flows ranging in age from 6.1 million years (Pliocene) to as young as 5000 years have been identified by Hoare (1970) on Nunivak. The U. S. Coast Pilot (1955, p. 526) notes that: "Near the center of the Island is Roberts Mountain 1,675 feet in altitude; this mountain is built up of a series of volcanic benches, the top being the steep side of a breached crater."

On the north coast of Nunivak Island pre-volcanic Cretaceous(?) rocks similar to those of Nelson Island have been reported (Hoare, 1968, Lyle, 1968). The Nelson Island Cretaceous(?) rocks are predominately marine and non-marine graywacke-type sandstone and siltstone with minor amounts of calcareous siltstone, sandy pebble conglomerate, and thin coal beds.

A detailed description of the regional geology is given in Hartman's (1973) report on the adjacent Clarence Rhodes Wildlife Refuge and is submitted as an attachment to this paper.

### MINERAL RESOURCES

#### Coal

Coal beds about 2 feet thick were reported on the north shore of Nunivak Island about 10 miles southwest of Cape Etolin (J. M. Hoare, oral communication to F. Barnes, 1965) and Cretaceous rocks having coal stringers 1" to 2" in thickness were observed at this locality in 1968 by W. Lyle. Coal in similar strata on Nelson Island is of bituminous to sub-bituminous rank. The coals

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of Nelson Island are considered non-commercial at this time but little is known of the extent or quality of the coals on Nunivak and there is no basis for commercial classification.

### Petroleum

Reconnaissance mapping suggests that petroleum prospects are generally unfavorable in most of the Yukon-Koyukuk province because of scarcity of reservoir beds, structual complexity and the widespread presence of volcanic and intrusive rocks (Patton, 1970).

The Cretaceous rocks described on Nelson and Nunivak Island are not favorable reservoir rocks and the Napatuk well located approximately 50 miles to the east of Nelson Island drilled 15,000 feet of graywacke-type low porosity sediments.

Younger prospective sediments could be present under the waters of the refuge to the west and south of Nunivak Island. Geophysical data would be needed to determine the petroleum potential of these areas.

### Other Energy Sources

The radioactive and geothermal potential of the area is unknown.

#### Metallic and Non-Metallic Minerals

No metallic or non-metallic minerals have been reported on the refuge.

#### CONCLUSION

The scientific data base is very limited for an area of this size. We did not fine the published work of any geoscience parties devoted solely to evaluating Nunivak Island or its surrounding waters. As far as we can

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determine, no geologic mapping has been done on the ground. Maps and reports are based on short visits or overflights. No radioactive or geophysical data was found in the literature. Existing information indicates the refuge to be poor in mineral resource potential but this information is too limited to fairly evaluate the area. More geoscience data is needed.

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### ABSTPACT

The Clarence Rhode National Wildlife Range lies in the western part of the Yukon-Kuskokwim delta region, a lake-pocked plain of some 21,000 square miles in western Alaska between the lower reaches of the Yukon and Kuskokwim Rivers. Isolated bedrock hills and low mountains rise above the lowlands. The geologic sequence consists of sedimentary and igneous rocks ranging in age from Cretaceous to the present. Most of the exposed bedrock is basalt of Quaternary age. Known mineral resources are limited to a few thin coal beds on Nelson Island. Reports of metallic ore deposits are unconfirmed, and oil and gas potential seems to be limited to the offshore areas of Norton Sound and Kuskokwim Bay.

#### GEOLOGY

#### STRATIGRAPHY

#### Cretaceous Sedimentary Rocks

The oldest rocks exposed within the refuge outline are the Cretaceous sediments of western Nelson Island. These are sandstones and siltstones with minor conglomerate beds and a few coaly seams, and are mainly of nonmarine origin. The small roof pendant areas of thermally altered rocks in the Askinuk Mountains, although barren of fossils, are presumed to be of Cretaceous age because of their similarity to fossiliferous Cretaceous sandstone and siltstone adjacent to the Yukon River, about 40 miles to the northeast. The strata in the Askinuk Mountains are surrounded by intrusive granodiorite of late Cretaceous age, and have been baked and recrystallized to a hornfels containing disseminated pyrite and magnetite.

The Cretaceous sandstones are fine to coarse-grained, dark gray and greenish-gray, and weather to light gray or brown. The coarser sandstone is

in thick beds, up to 30 feet, and locally with public conclomerate beds near the base. Finer soudstones are in thinner beds, and usually are interbedded with siltstone. Sandstones are of the graywacke type, composed largely of volcanic rock fragments and grains in a clay matrix. Calcium carbonate is locally an important constituent, and similar tuffaceous sandstones along the Yukon River to the northeast contain up to 50% laumontite, a calcium zeolite resulting from alteration of volcanic ash. Due to the high clay and lime content, porosity and permeability of the Cretaceous sandstones is extremely low.

Most of the Nelson Island Cretaceous rocks are clavey siltstone, which, in contrast to the hard sandstone beds, weathers to subdued tundra-covered swales and rounded slopes. Liny concretions are common in the siltstone.

### Cretaceous Intrusive Rocks

The main bulk of the Askinuk Mountains, which extend 32 miles eastward from Cape Romanzof, is medium to coarse-crystalline granodiorite of a light gray color. Geophysical data suggest that the exposed granodiorite may be part of a large intrusive body underlying as much as 1400 square miles. Radioactive dating yields a late Cretaceous age for this rock, or about 79 million years.

Near intruded roof pendants and inclusions of Cretaceous sedimentary rocks, the granodiorite is finer-grained and darker gray, and it is cut locally by some fine-grained dikes, but generally it is a homogeneous intrusive mass. Composition is plagioclase, orthoclase, and quartz, with accessory sphene, apatite, and magnetite.

The granodiorite is cut by a conspicuous horizontal fracture system which, together with well-defined vertical fracture sets, cut the rock mass into spectacular horizontal and vertical columns which are visible from a great distance. -2-

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### Quaternary Volcanic Rocks

Dark olivine basalt flows, generally 5 to 20 feet thick with columnar jointing, and local cinder and spatter cones and craters, all of a remarkably fresh appearance, occur east of Hooper Bay, in the Ingakslugwat Hills, over most of Nelson Island, and north of Kinak Bay. Except on Nelson Island, the volcanic rocks are probably of late Quaternary age, and near St. Michael eruptions in historic time are recounted in the native legends. These younger basalts are determined from palcomagnetic measurements to be less than 700,000 years old. The series of hasalt flows on Nelson Island, aggregating about 200 feet in thickness, dip very gently eastward, have a somewhat older aspect, and are partially covered by windblown silt.

The basalts are fine to medium-grained, dark gray, consisting of scattered crystals of pyroxene and olivine in a very fine matrix of feldspar, augite, and magnetite. Vesicular and scoriaceous phases are black and very fine to glassy-textured. On the southwest side of the Ingakslugwat Hills occur numerous mafic and ultramafic inclusions as large as 10 inches in diameter, consisting of gabbro and lherzolite in a volcanic ash.

# Younger Sediments

The lake-dotted lowlands that make up most of the Clarence Rhode wildlife area are composed of silt and sandy silt of Quaternary and Recent age, which has been deposited by the streams and distributaries of the Yukon-Kuskokwim River system and has since been reworked by wind, shifting stream channels, and by the surf and currents of the Bering Sea.

The silt and sandy silt of the plains is admixed with abundant woody plant debris. Coarser sand and some gravel deposits are present at depth, especially along old river courses. Permafrost is present over most of the area to a depth of 200 to 400 feet, and surficial thawing has produced most of the myriad lakes of the region.

Maximum thickness of these voung deposits is not known, but the presence of bedrock "islands" suggests that the thickness is highly variable. A deep well east of Baird Inlet penetrated about 1,000 feet of unconsolidated sediments before entering bedrock.

Colluvial deposits of sand, gravel, and loose boulders are limited to the steeper slopes of the Askinuk Mountains and Nelson Island. The higher parts of the Askinuk Mountains show evidence of glacial scour, and gravely glacial sediments are preserved there.

### STRUCTURE

Major regional faults include the inferred westward extension of the Kaltag Fault, which trends west-southwest across the northern tip of the Yukon delta. Geophysical data support a substantial subsurface disruption along this trend.

The Chirosky Fault, a southwest-trending feature that branches from the Kaltag Fault, is inferred to cross the area just northwest of Aropuk Lake and Nelson Island.

A few well-defined northwest-trending fractures and lineations cut across bedrock exposures of volcanic rocks and the granitic rocks of the Askinuk Mountains, but these are clearly subsidiary to the regional Kaltag and Chirosky fault trends.

Folding is expressed in the Cretaceous rocks of Nelson Island, which are thrown into northwest-trending flexures with steep southwest and moderate northeast limbs. These are modified by numerous faults, a few of which extend into the overlying Quaternary basalt layers.

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# MINERAL RESOURCES

# Coal

Thin sub-bituminous to bituminous coals with high ash content are exposed in Cretaceous sedimentary rocks on western Nelson Island. Most of the seams are less than 6 inches thick, but along a low beach bluff 4 miles northwest of the mouth of the Tooksook River are exposed two coal beds, 12 and 16 inches thick, separated by 8 inches of siltstone. Despite the gentle 5° to 10° easterly dip and thin overburden, only a few tons have ever been mined. The remote locale and high ash content suggests little likelihood of commercial development.

# Petroleum

The oil and gas potential of the onshore area of the Clarence Rhode Wildlife Range is severely limited. As demonstrated by the bedrock outcrops and by a deep well drilled near Napatuk Creek, east of Baird Inlet, the rocks underlying surficial deposits can be assumed to be siltstone and hard impervious sandstone of Cretaceous age. To date, no indications of the presence of hydrocarbons or of reservoir rocks have been observed. Petroleum potential seems to be confined, then, to possibly cleaner sands that may have been developed in sediments of Tertiary age. In the Norton Sound Basin, north of the Kaltag Fault, the presence of as much as 6600 feet of Tertiary rocks is indicated by geophysical surveys. The actual petroleum potential remains to be determined, but the chances for cil and gas accumulation in the Norton Sound Basin are much better than in the onshore areas. Similarly, the Kuskokwim Bay region, south of the Clarence Rhode outline, may be underlain by a substantial Tertiary embayment with considerable petroleum potential.

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### Metallic Minerals

Dall (1870) reported the occurrence of a sample of the copper mineral azurite from somewhere near Cape Romanzof, but the location was never confirmed, and no other copper minerals are known to occur in this region.

Hoare and Condon (1966) reported a similarly undocumented occurrence of "zinc ore" from the Kuzilvak Mountains, about 20 miles northeast of the Askinuk Mountains, but the only mineralization that is confirmed there is minor dissemination of arsenopyrite.

Rumors of placer tin (cassiterite) have been generated in years past involving the area between Cape Romanzof and Andreafski on the Yukon River, but these reports are also unconfirmed.

The granitic intrusive rocks in the Askinuk and Kuzilvak Mountains seem to have been accompanied by only very small amounts of mineralizing fluids, so that the principal effect on surrounding bedrock has been thermal alteration, mainly recrystallization and dissemination of small pyrite and magnetite crystals. Metallic ore potential, therefore, appears poor.

### Non-Metallic Minerals

Amber has been reported from the beaches of Nelson Island near Tanunak, but not in commercial amounts.

Laumontite, as yet a non-commercial zeolite mineral, is present in significant amounts in some Cretaceous sandstones north of the Yukon River, but its occurrence on Nelson Island is not confirmed.

Sand and gravel is present in the Clarence Rhode area, but is generally buried under a considerable thickness of silt. Practical sources of gravel may exist in the coarser debris associated with the Askinuk Mountains and Nelson Island, and possibly in the eastern reaches of old river courses. Good quantities of ground water are being produced from sand layers beneath permafrost in the Bethel area, at a depth of 430 feet. Similar water sources should be available over much of the Yukon-Kuskokwim lowland region.

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