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ABSTRACT

The Nabesna quadrangle in south-central Alaska is the first of the 1:250,000-scale Alaskan quadrangles to be investigated by an interdisciplinary research team in order to furnish a mineral resource assessment of the State. The assessment of the 17,600-km² (6,800-mi²) quadrangle is based on field and laboratory investigations of the geology, geochemistry, geophysics, and satellite imagery. The results of the investigations are published as a folio of maps, diagrams, and accompanying discussions. This report provides background information on the investigations and integrates the published components of the resource assessment. A comprehensive bibliography cites both specific and general references to the geology and mineral deposits of the Nabesna quadrangle.

INTRODUCTION

GOAL AND METHOD

This circular, together with a separately available folio of maps of the Nabesna quadrangle, Alaska, is the first of a planned series of U.S. Geological Survey reports designed to produce a rapid, yet accurate, inventory of Alaska's mineral resources. Under the sponsorship of the Alaskan Mineral Resource Assessment Program (AMRAP), authorized by Congress to begin on July 1, 1974, the reports are intended to furnish information both for long-range national minerals policy and for Federal, State, and industry decisions concerning the future use of Alaskan land and its resources. The Nabesna mineral resource assessment comprises an interrelated collection of U.S. Geological Survey publications and consists of this circular and a folio of maps that includes a modern geologic map, a variety of geochemical and geophysical maps, interpretations of satellite imagery, an analysis of the mineral endowment, and a land status map (table 1). Many of the basic data for this report were collected prior to July 1, 1974. Since then, an interdisciplinary team of earth scientists has completed additional field and laboratory studies required for resource appraisal under AMRAP and has collaborated in preparing this report.

ADDITIONAL SOURCES OF INFORMATION

Traditional scientific publications such as books and maps inevitably face traditional problems, including limited space, timeliness, obsolescence, and cost. In the Nabesna mineral resource assessment, for example, the size of the maps limits the
amount of known geological, geochemical, and geophysical data that can be published. To supplement the selected data contained on the maps, as well as to document the facts cited in the accompanying descriptions, this report contains an extensive bibliography of geological literature pertinent to the Nabesna quadrangle.

It may take months or even years to print scientific reports, which reduces their timeliness. In addition, the value of these publications commonly diminishes with time because new data or improved understanding, no matter how important, cannot be incorporated in a report after it is published. The usual remedy for such obsolescence is to publish revised editions. However, because of rising costs, manpower limitations, and lengthy delays, we plan no revised editions of this series.

Partly to compensate for these problems, the U.S. Geological Survey has created computer-based files of economic mineral occurrences for the State of Alaska. This approach allows new data to be added for any previously known Alaskan mineral occurrence, prospect, or mine, as well as for new discoveries and for mines that come into production. Such additions or revisions ("updates") probably will be made annually. For purposes of the Nabsena mineral resource assessment, we have added even more information to the file than currently is available for other Alaskan quadrangles. This information includes a classification for the level of development of mineral occurrences, as well as other data suggested by mineral resource specialists who used the file in 1974. Experience from the Nabsena quadrangle update will be applied to successive quadrangles under the Alaskan Mineral Resource Assessment Program.

LOCATION AND ACCESS

The Nabsena quadrangle covers approximately 17,600 km² (6,800 mi²) in south-central Alaska (fig. 1) between lat 62° and 63° N. and long 141° and 144° W. It includes the eastern part of the Alaska Range (Mentasta and Nutzotin Mountains), the northern Wrangell Mountains, and parts of the Northway-Tanacross Lowland and Copper River Lowland. Drainage is chiefly to the north into the Tanana River and thence into the Yukon River; the western quarter of the quadrangle is drained by the Copper River. Elevations range from about 4,240 m (13,900 ft) above sea level on the slopes of Mount Wrangell in the extreme southwest corner of the quadrangle to 518 m (1,700 ft) above sea level where the Nabsena River flows north out of the quadrangle near Northway.

Highway access to the quadrangle is limited. The Alaska Highway crosses the northeast corner, and the Glenn Highway crosses the northwest corner (fig. 2). A maintained gravel road extends 74 km (46 miles) from Slana on the Glenn Highway to the inactive gold mine at Nabsena. Other short spur roads serve the native villages at Mentasta Lake and Northway. Resident population in the quadrangle is less than 500 people; it is concentrated chiefly at Slana, Mentasta Lake, and Northway, and the remainder is scattered along both the Glenn and Alaska Highways, the Nabesna Road, and at Chisana.

MINERAL PRODUCTION

Total mineral production from the quadrangle, excluding sand and gravel, has been about $2,900,000, principally from lode and placer gold mining. Of the total, $1,870,000 was from the Nabsena mine, which closed in 1940; the remainder was from placer deposits, chiefly the Bonanza gold fields near Chisana. At present there are no producing mines in the quadrangle; a few small gold placer operations are currently active.

PREVIOUS GEOLOGIC AND MINERAL RESOURCE INVESTIGATIONS

Lieutenant H. T. Allen's remarkable explora-
tion journey across the eastern Alaska Range in 1885 for the U.S. War Department (Allen, 1887) marked the beginning of scientific observations in the Nabsena quadrangle. Geologic studies, however, did not begin until 1898 when Brooks (1900a), with a U.S. Geological Survey party, traversed a limited part of the northeast corner of the quadrangle. In 1899 Brooks (1900b) made a second and more extensive traverse through the northeast part of the quadrangle, and in the same year Rohn (1900), with the U.S. War Department, traversed north to south across the central part of the quadrangle. During the next 30 years, three geological reconnaissance and mineral resource surveys, which included parts of the Nabsena quadrangle, were undertaken by the U.S. Geological Survey. In 1902 Mendenhall and Schrader (1903a) surveyed the Copper River basin and east into the Nabsena River drainage. In 1908 Moffit and Knopf (1910) undertook a similar study in the McCarthy quadrangle between the Nabsena River and the White River, and in 1914, spurred by the discovery of placer gold near Chisana, Capps (1916b) mapped the remaining unexplored country between the Chisana and White Rivers.

Between 1929 and 1944, F. H. Moffit of the U.S. Geological Survey conducted a more thorough geologic reconnaissance of the eastern Alaska Range. Six of the many geologic reports authored by Moffit during this period concern the Nabsena

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**Figure 2.—Reference map of the Nabsena 1:250,000-scale quadrangle showing the 24 larger scale (1:63,360) quadrangles and the published maps.**
quadrangle (Moffit, 1932, 1933, 1938, 1941, 1943, 1944). After his retirement in 1945, Moffit continued to work on a comprehensive summary report that was eventually published in 1954 and that has proved invaluable to those involved in the third generation of geologic investigations in the eastern Alaska Range.

PRESENT STUDY

Fieldwork for the present study, consisting principally of detailed reconnaissance mapping of the bedrock and geochemical investigations of stream sediments, began in 1967. By 1974, when the fieldwork was completed, approximately 25 geologist-months, 8 of which were helicopter supported, had been devoted to the field study. Data on the surficial geology are chiefly from interpretation of aerial photographs in collaboration with H. R. Schmoll and A. T. Fernald, who generously allowed the use of their unpublished material. The availability of more detailed, larger scale modern geologic maps of the Nabesna quadrangle authored by D. H. Richter and his colleagues is shown on the reference map in figure 2.

ACKNOWLEDGMENTS

Several members of the U.S. Geological Survey contributed significantly to preparing this report. The extensive bibliography was prepared for publication, using computer-assisted methods, by Betsy Yount and Marianne Fujii. Gerald Askevold summarized how interested readers can obtain additional background information for this study and described the computer-based methods that will be used to keep the Nabesna mineral resource assessment up to date as possible. Henry Berg, AMRAP program manager, prepared table 1 and other parts of the introduction to this report and coordinated the published components of the Nabesna mineral resource assessment.

DESCRIPTIONS OF COMPONENT MAPS OF THE NABESNA QUADRANGLE MINERAL RESOURCE ASSESSMENT

GEOLOGY (MAPS MF-655A AND I-932)

The Nabesna quadrangle is separated into two grossly distinct geologic terranes by the Denali fault, a major and presently active dextral fault. North of the Denali fault the terrane consists chiefly of multiply deformed and regionally metamorphosed sedimentary rocks and subordinate igneous rocks as old as Devonian and possibly older. South of the fault the oldest exposed strata are volcanic flows, breccias, pyroclastic rocks, and volcanoclastic rocks of Pennsylvanian and Permian age that are parts of an extensive andesitic volcanic arc. Deposited on this arc are marine sedimentary rocks of Pennsylvanian age and subaerial tholeiitic basalt flows and marine limestone of Triassic age. Rocks representing a second period of volcanic arc activity and associated marine sedimentation during Late Jurassic through Early Cretaceous time (the Gravina-Nutzotin belt of Berg and others, 1972) unconformably overlie remnants of the upper Paleozoic arc and the younger Permian and Triassic assemblages. Late Tertiary and Quaternary volcanic flows, tuffs, and breccias and associated sedimentary rocks of a third period of andesitic volcanic arc activity mantle all older rock units in the southwestern part of the quadrangle.

A number of complex plutons, chiefly granodiorite and quartz monzonite in composition, were emplaced during two distinct intervals in Cretaceous time (105-117 m.y. and 89-94 m.y.) and in early Tertiary time (61 m.y.) (Richter, Lanphere, and Matson, 1975). In addition, plutonic rocks of diorite and quartz diorite occur in a large plutonic-metamorphic complex of Late Triassic to Middle Jurassic age, and metaplutonic rocks of granite and granodiorite occur in a small plutonic-metamorphic complex of Miocene age within the Denali fault zone. The younger Cretaceous plutons and the Tertiary pluton are recognized only in the regionally metamorphosed Devonian and older terrane north of the Denali fault. Plutons of the older Cretaceous event and the large plutonic-metamorphic complex are restricted to the younger terrane south of the Denali fault. A variety of porphyritic intrusive rocks of Oligocene and Miocene age are also restricted to the terrane south of the fault and may represent the early hypabyssal phases of the Tertiary and Quaternary volcanic effusive rocks.

The absence of rocks older than Pennsylvanian south of the Denali fault and the close association of ultramafic bodies with the Pennsylvanian volcanic assemblage, as seen outside the Nabesna quadrangle, suggest that the upper Paleozoic volcanic arc was built directly on oceanic crust (Richter and Jones, 1973b). Between Late Permian and
Middle Jurassic time, this arc apparently im-
inged against a Devonian and older continent
(terrane north of the Denali fault) and since then,
together with superjacent strata, has been periodi-
cally deformed. The present Denali fault system,
which may have been activated as recently as late
Miocene time (Richter and Matson, 1971), appears
to follow the old suture zone between the upper
Paleozoic volcanic arc and the Devonian continent.
The Totschunda fault system is an even younger
active structure short-circuiting the southeast
part of the Denali fault probably in response to
changes in Pacific plate motion.

GEOCHEMISTRY (MAPS MF-655B–G)

Geochemical investigations in the Napesna
quadrangle were undertaken between 1967 and
1974 to help determine the mineral resource po-
tential of the quadrangle and to outline areas of
anomalous metal content. During this period, a
total of 2,005 stream-sediment and rock samples
were collected and analyzed. In the geochemical
maps of this report, only data resulting from the
stream-sediment sampling are used; data from the
rock samples, which are chiefly samples of
mineralized and altered rock and hence very selec-
tive, are available in open-filed maps by Matson
and Richter (1971a–d and 1972a,b) and by Richter
and Matson (1969a,b and 1970a,b) for nine of the
1:63,360-scale Napesna quadrangles.

About 1,350 stream-sediment samples were col-
clected from active streams, then air dried and
sieved. The -80 mesh (-177 micrometres) frac-
tions were analyzed by semiquantitative emission
spectrographic methods for 30 elements. All gold
and some copper and lead analyses were done by
atomic absorption. The geochemical maps show
the distribution and abundance of copper, lead,
gold, chromium, and cobalt in stream sediments on
a base map of the generalized geology. The ele-
ments depicted on the maps were selected for their
economic importance and because their concentra-
tions range widely enough to reflect the geochemi-
cal nature of the bedrock. A map of perspective
drawings of seven other elements is included to
show their regional distribution patterns.

Complete Geological Survey analytical data on
the rock and stream-sediment samples collected in
the Napesna quadrangle are available on a com-
puter tape (O’Leary, Van Trump, and others, 1975)
that can be obtained from the National Technical
Information Service, Department of Commerce,
Springfield, Virginia 22161.

GEOPHYSICS

AEROMAGNETIC MAP AND INTERPRETATION
(MAP MF-655H (2 SHEETS))

The aeromagnetic map (sheet 1) of the Napesna
quadrangle was made in 1971 and subsequently
released by the State of Alaska as an open-file map
(Alaska Division of Geological and Geophysical
Surveys, 1973). The variations in the magnetic
field on maps such as these provide valuable in-
formation concerning the lateral and vertical ex-
tent of rock units containing various percentages
of magnetic minerals, usually magnetite. Aero-
magnetic maps thus are a most useful support for a
geologic mapping program as well as for mineral
resource assessment. An interpretive map (sheet
2) identifies numerous rock units in the Napesna
quadrangle that possess characteristic magnetic
anomalies and enables the interpreter to extrapo-
late geologic information from known areas into
covered or inaccessible regions. In particular,
the aeromagnetic map makes it possible to locate
covered extensions of potentially chromite-
bearing ultramafic rocks and to locate areas of
altered plutonic rocks that may be associated with
porphyry copper-type mineral deposits.

GRAVITY MAP (MAP MF-655I)

The Bouguer gravity map summarizes approx-
imately 600 gravity measurements that have been
made in the Napesna quadrangle by the Geologi-
cal Survey. The Bouguer gravity field reflects the
variations in rock density within the quadrangle
and probably shows deeper structures than any
other map in this folio. One predominant feature of
the map is a negative gradient that probably
represents an increase in crustal thickness from
about 35 km (21 miles) beneath the Tanana Valley
near the northeast corner of the quadrangle to 45
km (27 miles) beneath the Wrangell Mountains at
the southeast corner. Local anomalies correlate
with some of the intrusive rocks associated with
mineralization and suggest that more detailed
gravity surveys, for which this map could serve as
a framework, would help to define the form of the
intrusion. Other features of the gravity map may
be correlated with some fault movements and pos-
sibly with changes in the metamorphic grade of
the rocks.
Interpretations of satellite images of the Nabesna quadrangle are based on data supplied by ERTS-1, the Earth Resources Technology Satellite. Two types of images were used in these interpretations: (1) an ERTS photomosaic of the State of Alaska compiled by the U.S. Department of Agriculture and (2) computer-enhanced ERTS imagery processed by the U.S. Geological Survey in Flagstaff, Ariz.

The ERTS photomosaic of Alaska largely consists of images taken during the fall months. Because of the low sun angle and the synoptic view, the photomosaic is most useful for identifying regional linear and circular structural features. Computer-enhanced imagery, on the other hand, has proved to be valuable in detecting subtle surficial variations in reflectance due to differences in vegetation, rock types, soil, and other variables.

As a preliminary geologic mapping tool, ERTS imagery can be used effectively for reconnaissance studies. Remotely sensed information about geomorphology, structural features, and variations in spectral response of surficial materials, for example, can help in the plan and conduct of geologic mapping.

Applications of ERTS imagery directly to mineral appraisal are still developing. For example, using the images to correlate structural features, vegetation, and soil and rock variations with geochemical and geophysical data can contribute significant information bearing on mineral resource assessment. Another application has been to correlate linears with metallogenic provinces (Lathram and Gryc, 1973). Research on other techniques for applying this new tool to geologic and mineral resource problems in Alaska is being carried out under AMRAP.

Mineral Resources (MAP MF-665K)

The potentially favorable mineral resource areas of the Nabesna quadrangle based on the investigative components of this report—geology, geochemistry, geophysics, and satellite imagery—are shown on the mineral resources map together with the location and a brief description of the known prospects, mineral occurrences, and inactive mines. In addition, the resource potential of the principal mineral commodities is reviewed, and where data are deemed adequate, a quantitative estimate of the resource is provided. Terms used in defining the resource potential follow the classification that has recently been jointly adopted by the Bureau of Mines and the Geological Survey (McKelvey, 1973).

Copper is the principal mineral resource of the Nabesna quadrangle. It occurs in a number of porphyry copper, stockwork, contact metamorphic, vein, and volcanogenic deposits, many of which are virtually unexplored. Especially significant are the identified porphyry copper deposits that contain an estimated $1.08 \times 10^9$ metric tons of potential ore averaging about 0.3 percent copper, 0.02 percent molybdenum, and minor gold and silver. Volcanogenic copper in the basalt flows of the Nikolai Greenstone may also constitute a vast future resource of the metal.

Other resources are molybdenum, gold, silver, and possibly chromite. Molybdenum, a coproduct in the porphyry copper deposits, also occurs as the principal metal in at least two porphyry molybdenum deposits. The largest resources of gold and silver occur as byproducts in the copper porphyries; gold is also present in contact metamorphic, disseminated, and stockwork deposits. The placer gold deposits of the quadrangle are largely depleted, but small deposits are probably still present. Chromite has been found in the alpine ultramafic bodies north of the Denali fault and may constitute a significant resource.

Deposits of oil and gas, coal, and radioactive minerals are not known in the quadrangle, and the likelihood of an occurrence of these commodities is small.

Land Status (MAP MF-655L)

The land status map shows the classifications and boundaries of 10 proposed and existing categories of land in the Nabesna quadrangle. The map was compiled from a much smaller scale map prepared in March 1974 by the U.S. Bureau of Land Management according to the terms of the Alaska Native Claims Settlement Act (ANCSA) of December 18, 1971.
BIBLIOGRAPHY

Starred references indicate those cited in this report.

1. SPECIFIC REFERENCES (Principally references restricted to the Nabesna quadrangle or references in which the Nabesna quadrangle constitutes a significant part of the paper.)


II. GENERAL REFERENCES (Principally references of regional scope in which the Nabesna quadrangle is incidental to the main theme of the paper.)


