

GEOLOGICAL
and
MINERAL EVALUATION REPORT
on the
d-2 LANDS
in the
NORTHERN WRANGELL RANGE, ALASKA

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GEOLOGICAL AND MINERAL EVALUATION REPORT ON THE
d-2 LANDS IN THE NORTHERN WRANGELL RANGE, ALASKA

SUMMARY

The d-2 Lands of the Northern Wrangell Mountains lie athwart the Continental Margin Porphyry Copper Belt, a fact of considerable significance to the mineral potential of the area. In addition, the Nikolai Greenstone formation contains important concentrations of copper that constitute a major low-grade copper resource.

The principal factor limiting the mineral potential of the area is the extensive post mineral Wrangell lava flows which cover over two-thirds of the d-2 Lands.

Based upon the conclusions drawn that the northeast portion of the area is highly potential for the development of mineral deposits containing copper, molybdenum, zinc, gold and silver, it is recommended that the boundary of the proposed Wrangell - St. Elias National Park be modified to exclude those lands that are of major resource value.

Purpose and Scope of Study

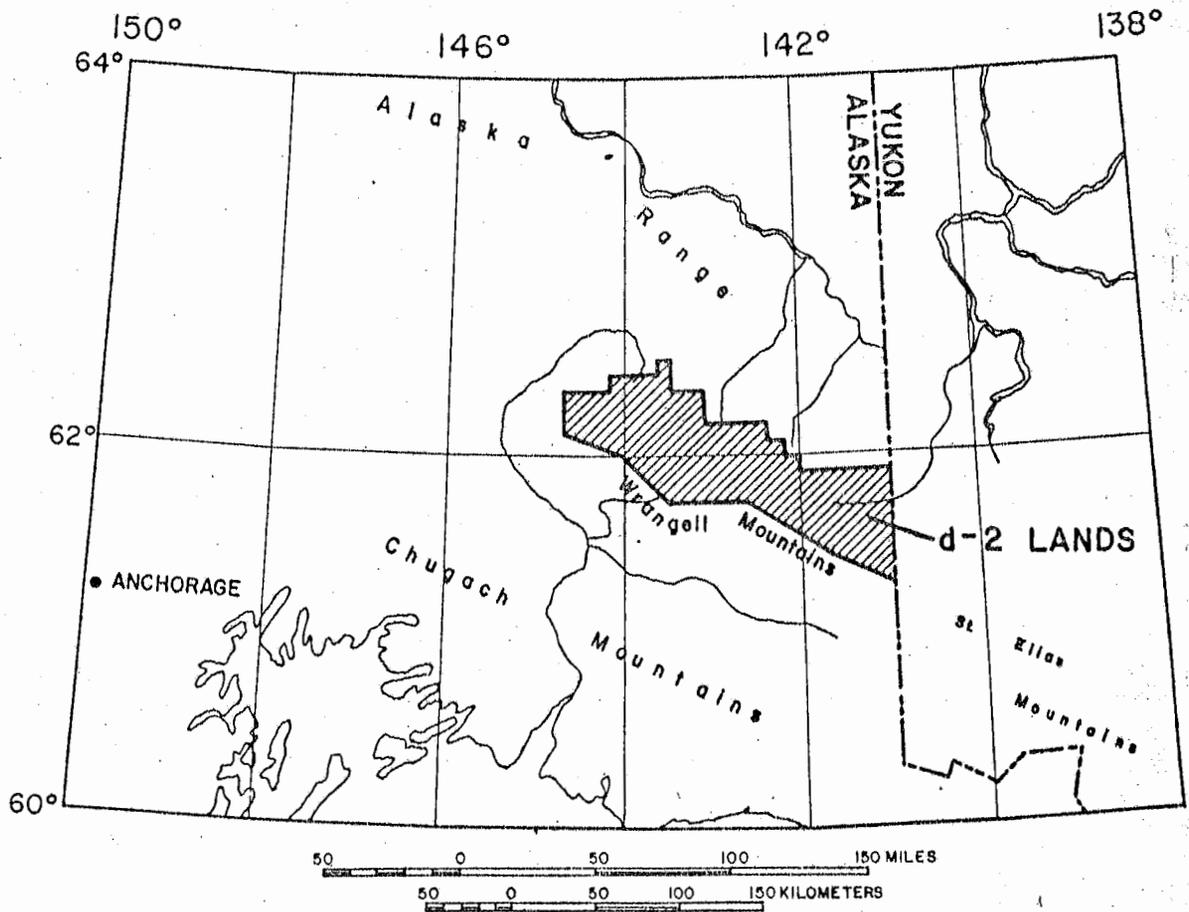
This study has been undertaken for the purpose of compiling and summarizing in draft form, the geological and mineral evaluation data for the d-2 Lands lying in the northern part of the proposed Wrangell-St. Elias National Park and Wrangell National Forest.

Much of the land lies within the Nabesna and McCarthy quadrangles in which investigations have been recently completed by interdisciplinary research teams under the Alaskan Mineral Resource Assessment Program. As a result, much of the traditional requirements for research and data compilation have been satisfied by the findings published under the program and are incorporated in this report. A relative greater allocation of time, therefore, has been devoted to the acquisition and compilation of private data helpful to the evaluation of the mineral potential of the area.

Location and Access

The area of the d-2 Lands covered by the study approximates 6400 km within the proposed Wrangell-St. Elias National Park and Wrangell National Forest. The study also covers certain adjacent d-1 Lands within which mineralization considered pertinent to the evaluation of the mineral potential of the d-2 Lands occurs.

The d-2 Lands encompassed by the study are on the north flank of the Wrangell Mountains delimited on the north by the d-2 Lands boundary and on



INDEX MAP OF EASTERN ALASKA
 SHOWING
 STUDY AREA d-2 LANDS

FIGURE 1

the south by a line drawn southeasterly from the western boundary of the d-2 Lands through Mount Drum to Mount Wrangell peak; thence southeasterly to Mount Blackburn; thence easterly to Chimney Mountain; thence southeasterly to Mount Churchill; thence southeasterly through Mount Bear to the Alaska-Canadian boundary. Figure 1 is an index map of eastern Alaska showing the location of the area.

Access to within one-half mile of the d-2 Lands is afforded by the Nabesna Highway to Mile Post 43 at the old Nabesna mine. An approximately 13 mile long Cat trail from Mile Post 42 on the Nabesna road provides seasonal access to the Orange Hill air strip, a distance of about one-half mile from the northern boundary of the Lands.

Ground access from the east is provided by a long established Cat trail which crosses from Canada to Alaska to Beaver Creek or Baultoff Creek, skirts to the south of Braye Lakes, and follows the Beaver Creek valley to its headwaters at Beaver Lake where it crosses a low divide into the Chathenda Creek and from there to the village of Chisana. Pack horses have been used in the White River and Chisana areas for years. However, for the more remote and rugged areas, helicopters or snow-field-landing fixed wing aircraft are the only feasible means of transportation.

Geologic and Tectonic Summary

Historically, emergent conditions prevailed in the area during the period from Late Permian to Middle Triassic when local marine sedimentation was succeeded by the largely subaerial volcanism of the Nikolai Greenstone formation.

The Nikolai represents an extensive and voluminous lava field, and it and its feeder gabbroic bodies reflect tensional tectonics that tapped deep-seated magma.

A marginal sea developed on parts of the wide-spread emergent Nikolai platform during the late Triassic and persisted, at least locally, until late in the Jurassic. Thus in the southwest portion of the area, pre-Jurassic rocks are overlain by fossiliferous, mainly shallow marine, sedimentary rocks that include local Jurassic rocks and wide-spread Cretaceous rocks. To the northeast, pre-Jurassic rocks are overlain mainly by turbidites and andesitic volcanic and volcanoclastic rocks of Middle (?) Jurassic to Lower Cretaceous age.

The area southwest of the Totschunda fault system near the Canadian boarder is underlain by the Kaskawulsh group of probable Devonian age. The unit is mainly a multiply folded low-grade metamorphic sequence that is believed to represent an old fault bounded continental crust which has been tectonically juxtaposed against the Late Paleozoic and Mesozoic rocks.

When and how the two terrains were juxtaposed are not well understood, but their coupling is believed to have started during the Late Paleozoic and to have been completed during the early Cretaceous.

Major ore genesis began during late Jurassic and continued to Early Tertiary and was accompanied by numerous intrusions of predominantly granodiorite to quartz monzonite plutons.

The Cenozoic history is dominated by extrusive products of Wrangell lava volcanism. The Wrangell lava together with associated sub-volcanic plutons is interpreted to have been caused by northward directed oblique underthrusting of the Pacific plate beneath the continent.

Structure

The Wrangell Mountains occupy an area in which the processes of mountain building have repeatedly occurred with the resultant effects of folding, faulting, intrusion of igneous bodies, and the extrusion of lava being wide spread.

All bedded rocks show some measure of folding stemming from compressional stresses exerted from the southwest and northeast as evidenced by the axis of folds and the strike of thrust faults in the eastern portion of the area.

The most important structural feature is that of the Totschunda fault system (Richter, 1971), a system of several discrete fault segments which cross the area in a southeasterly direction.

The northwest end of the system originates in a complex zone of high angle reverse faults and tight folds within a few km of the Denali fault approximately 80 km to the northwest. The southeasterly projection of the system aligns with, and has the same sense of slip, as the Fairweather fault in the Gulf of Alaska.

Two segments of the system, the Cooper pass and the Cross Creek faults, named after associated topographic features and drainages, trend through the area at strikes of between $S35^{\circ} E$ and $S45^{\circ} E$, entering the northern boundary of the d-2 Lands in the vicinity of Enchre Mountain and exiting at the Alaskan-Canadian boundary on the north side of the Klutlan glacier.

Movement along the fault system is well defined by small scarps of off-set glacial deposits and streams. Such scarps indicate that the predominant vertical movement of the fault during Holocene has been with the northeast side up and the horizontal movement as being right lateral. Well-defined glacial deposits and stream offsets range from 130 m to 330 m on the Cross Creek fault and as much as 90 m on the Cooper Pass fault.

Notwithstanding the evidence that the northeast side of most of the faults in the Totschunda system moved up during the Holocene, the net long-term relative movement is seen to be in the opposite direction. Detailed mapping by Richter and Matson indicate that the faults composing the system vertically offset the Wrangell lava by as much as 1500 m with the southwest side

upthrown. The maximum lateral displacement along the system, as inferred from topographic evidence, has been estimated by Richter to be about 10 km.

Based upon the offsets of the Wrangell lava flows and related dating of the flows, the age of the Totschunda fault system is indicated at probably less than two million years.

Other faults associated with the Totschunda fault system are evident, in addition to which, there are a vast number of smaller faults with displacements on the order of 100 m or less that are local in nature. Such faulting together with jointing played an essential role in relieving the stresses created by intrusions and other deforming forces.

Description of Rock Units

Surficial Deposits

Diverse Quaternary surficial deposits are abundant in the area and include alluvium, glacial deposits, rock glacier deposits, colluvium, and glaciolacustrine deposits.

Alluvium (Qa) deposits of boulders, gravel, sand, and locally, silt and clay are found on the active flood plains and lowest terraces of the major streams. Undivided alluvium (Qau) includes older alluvium on higher terraces of major streams alluvium of small streams, alluvial deposits on broad pediment surfaces, and outwash from the glaciers.

In the Nabesna quadrangle, Richter has distinguished between three ages of glacial deposits, namely Holocene (Qag); Wisconsin age (Qug); and Older age (Qog).

Rock glacier deposits (Qr) are active in the area. Only the large active and recently active rock glaciers and the tail of aprons feeding them are noted. Smaller rock glaciers and the deposits of old rock glaciers are included in undivided colluvium.

Of the colluvial deposits, most are noted under the category Undivided Colluvium (Qc) which cover talus and other slope debris and numerous minor streams composed of rubble, gravel, sand and silt. Landslide deposits (Ql) are chiefly debris avalanches and block slides.

Glaciolacustrine deposits (Qgl) consisting of stratified clay, silt, sand and minor gravel deposits are locally numerous as small post-glacial alluvial and pond deposits.

In the Gulkana and McCarthy quadrangles, glaciers and glacial deposits (g) are grouped as one category of surficial deposit and are not otherwise distinguished. Also within the Gulkana and McCarthy quadrangles surficial deposits are not differentiated (Qu).

Sedimentary, Volcanic and Metamorphic Rocks

Wrangell Lava (QTw - Qw - Qwr - QTwr)

(QTw) The Wrangell lava of Quaternary and Tertiary age is part of an extensive calc-alkaline volcanic province that dominates the upland regions of the Wrangell Mountains and has spread into the less mountainous terrain of the eastern part of the area. The rocks are largely effusive flows, tuffs and breccias with subordinate shallow intrusive rocks, dikes, and domes that are products of a number of composite strato volcanos and large shield volcanos and many satellitic cones and other small eruptive centers.

The distinction between its younger part (Qw and Qwr) and the older part (QTwr), as mapped by Richter in the Nabesna quadrangle is based on the freshness of volcanic form, the degree of alteration of the rocks and K-Ar dates.

(Qw) The younger part includes andesite flows from Mount Wrangell and andesite and dacite flows, dacite domes and interbedded breccias and pyroclastic rocks from the Mount Jarvis strato volcanos and, elsewhere basalts, andesites, dacite flows, and lapilli tuff. Most of the rocks are typically porphyritic, with phenocrysts of mafic minerals and plagioclase in fine-grained intersertal to equigranular ground mass. The thickness of the unit varies from zero to more than 2100 m.

(Qwr) Rhyolite cinder cones and associated nuee ardente deposits consist of light-buff and cream glassy blocks, scoria, and ash composed of hypersthene-bearing rhyolite. The thickness of the unit is up to 180 m.

In the McCarthy and Gulkana quadrangles of the area, the above described Quaternary part of the Wrangell lavas is not distinguished. In the Nabesna quadrangle, Richter reserves the symbol (QTw) for the lower part of the Wrangell lavas consisting of undivided flows, tuffs, and breccias, chiefly of andesite and basaltic andesite composition, dacite domes and flows, and volcano glacial deposits from a number of poorly defined and locally covered older eruptive centers. Rocks of the older part are petrographically similar to rocks of the younger lavas but are locally altered to chlorite and clay minerals with their vesicles generally filled with quartz, chlorite, chalcedony, calcite, and zeolite minerals. The thickness of the older part alone may be greater than 2000 m in some areas.

(QTwr) Domes and flows of rhyodacite to rhyolite composition associated with nuee ardente and air-fall deposits consisting of volcanic mud flows and tillites together with pumice lapilli tuff are scattered throughout the main part of the volcanic field.

The rocks range from rough to light tan or gray for the pyroclastic deposits and from light gray or light pinkish gray to black for the flowouts. The thicknesses of the unit range from zero to more than 300 m.

Glacial, Fluvioglacial, Boulder Deposits (Tg)

The unit consists of weakly consolidated and poorly sorted fluvioglacial deposits, volcanic boulder deposits and many small limited occurrences of tillite under the older part of the Wrangell lava. The fluvioglacial and ground deposits locally contain fragments of lignitized wood and in the instance of the Gold Hill deposits contain disseminated native gold.

Continental Sedimentary Rocks (Ks)

In the vicinity of Chisana, a unit of upper Cretaceous age, up to 90 meters thick, consists of drab brown, buff, and greenish-gray conglomerates, coarse-to-fine grained sandstones, siltstone and mudstone with subordinate dark gray shales. The rocks are well consolidated and locally contain volcanic ash, carbonaceous debris, and fragments of petrified wood. The unit is relatively flay lying and has not been thermally metamorphosed.

Chisana Formation (Kc)

The Chisana formation of Lower Cretaceous age is a thick unit of marine and the subaerial volcanic and volcanoclastic rocks characteristic of a volcanic arc assemblage.

The upper part of the formation consists of maroon and dark-green andesite and basalt andesite flows, green gray to dark-green fragmental volcanic rocks, and subordinate dark-green dense porphyritic andesite, thin bedded green and maroon conglomerate, grit, sandstone and light-gray tuff. The fragmental rocks are apparently lahars and avalanche deposits containing rounded to angular fragments of various volcanic rocks associated locally with nonvolcanic clasts, lignitized wood, and other carbonaceous debris.

The base of the upper part of the formation is locally marked by thick accumulations of amygdaloidal flows. The lower part of the Chisana formation is composed chiefly of dark-green to gray-green fragmental volcanic rocks in units as much as 100 m thick. The unit also contains minor dark-green porphyritic flows ranging from dacite to andesite, thin beds of maroon volcanic sandstone and siltstone, and lenses of dark-gray marine sedimentary rock rarely more than 30 m thick. The fragmental volcanic rocks are similar to those

in the upper part but generally lack nonvolcanic clasts and contain no carbonaceous debris. The marine sedimentary rocks, apparently confined to the lower 600 m of the formation, consist of dark-gray argillite, thin bedded greywacke, pebble to cobble conglomerate, and gray-green tuffaceous mudstone.

The total thickness of the Chisana formation varies from 0 m to more than 3000 m.

Marine Sedimentary Rocks (KJs)

The formation is a thick sequence of predominantly shallow and deep intertonguing marine sedimentary rocks which range in age from late Jurassic to early Cretaceous. Informally the formation is referred to as the Nutzotin Mountains sequence. Three lithologic units are recognized in the sequence which has a probable thickness of greater than 3000 m.

The upper unit consists of about 900 m of dark-gray graded argillite and greywacke overlain by 180 m to 450 m of gray mudstone. Tuffaceous mudstone beds near the top are conformably overlain by massive andesite breccias of the Chisana formation. In an outlier outcropping south of the Totschunda fault on the Nabesna River, the upper unit is chiefly non-marine and consists of about 300 m of carbonaceous,

thin bedded drab brown, and gray sandstone, siltstone and shale with minor grits and conglomerates.

The middle and major unit of the sequence consists of turbidite deposits, chiefly graded beds of gray to dark-gray argillite, siltstone, and greywacke that locally alternate with massive beds of pebble to cobble conglomerate, pebbly greywacke, and argillite. The graded beds are exceptionally well developed and consist of rhythmically alternating units one centimeter to more than 30 centimeters thick. Much of the strata has developed a strong slaty cleavage. Isoclinal folds and thrust faults are common structural features within the unit.

The lower unit of the sequence in the outlier west of the Totschunda fault is about 1500 m thick consisting of massive beds of shallow water pebble to cobble conglomerates, as much as 40 m thick, interbedded with dark gray siltstone and argillite that locally contain fragments of coalified wood and other carbonaceous debris. Clasts in the conglomerate consist of well rounded volcanic and volcanic clastic rocks, limestone, chert, and crystalline igneous rocks derived from underlying strata as well as white quartz and metamorphic rocks probably derived from the metamorphic terrain north of the Denali fault.

Chitistone and Nizina Limestones (Triassic, TR1)

The Chitistone and Nizina limestones mapped in the McCarthy quadrangle are probably correlative with the Upper Triassic carbonate rocks that are noted simply as limestones in the Nabesna quadrangle.

The Chitistone disconformably overlies the Nikolai greenstone and grades upward into the Nizina. Whereas it has a maximum thickness in the McCarthy quadrangle of about 600 m that has a variable thickness of from 20 m to more than 250 m in the Nabesna quadrangle.

The lowermost 105 m of the Chitistone contains abundant dolomite, algal, mat chips, stromatolites, relics of evaporites, and other features indicative of intertidal-supratidal conditions. The upper part consists of diverse limestones, including lime mudstone, wackstone, packstone, grainstone and minor chert nodules. Some Chitistone and Nizina rocks emit fetid odors when freshly broken.

The Nizina limestone consists of diverse limestones that generally contain subordinate chert as nodules, lenses, and coalescing masses. The upper strata of the Nizina contain small components of non carbonate detritus which is believed

lithologically gradational with parts of the overlying McCarthy formation. The total thickness of the Nizina in the McCarthy quadrangle is about 500 m.

An upper unit of limestone in the Nabesna quadrangle is believed correlative to the McCarthy formation in the McCarthy quadrangle. The unit consists of dark gray, fine grained, thin bedded limestones a few centimeters to as much as 2 m thick with thin interbeds of black cherty argillite and dark gray carbonaceous shale. Minor beds of medium- to-coarse grained calcareous sandstone and calcareous grit, as much as one m thick, are scattered through the unit. The thickness of the unit varies up to 120 m.

Nikolai Greenstone (T_{pn})

The Nikolai greenstone of Upper and/or Middle Triassic age consists of dark gray green, dark brown, reddish brown, and maroon gray subaerial amygdaloidal basalt flows separated locally by thin beds of reddish brown non marine volcanic clastic rock. The base is generally marked by discontinuous volcanic conglomerate-breccia containing fragments of basalt and underlying sedimentary rocks. Individual flow units range from 5 cm to more than 15 m thick with intermixed aa and pahoehoe flows. The flows are generally porphyritic,

containing phenocrysts of saussuritized plagioclase feldspar and subordinate clinopyroxene and relic olivine in an intergranular ground mass of feldspar and pyroxene that has been largely altered to chlorite, epidote, and serpentine.

Amygdules consist mainly of calcite and chlorite or quartz and epidote; some contain zeolites. Native copper occurred locally in flow tops, fracture zones and amygdules. Near large intrusive bodies, the basalt has been thermally metamorphosed to massive fine grained amphibolite. The thickness of the Nikolai greenstone in the Nabesna quadrangle varies from 150 m to 1800 m, averaging 1500 m.

Mankomen Group (Pe, Pel, in the Nabesna Quadrangle)
(Ph, Pl, in the McCarthy Quadrangle)

The Mankomen group was first described by Mendenhall, (1905) and revised by Richter and Dutro, (1975). The group is a marine sedimentary rock sequence including an upper formation of non volcanogenic argillite and limestone (Eagle Creek formation and its correlative, the Hasen Creek formation) and a lower formation consisting chiefly of volcanic clastic rocks (Slana Spur formation).

The Eagle Creek Formation (Pe, Pel)

The Eagle Creek formation in the Nabesna quadrangle is correlative to the Hasen Creek formation (Ph, Pl) in the

McCarthy quadrangle and is Lower Permian in age. The formation consists chiefly of dark-gray and greenish-gray thin-bedded argillite and siliceous siltstone with thin interbeds of calcareous siltstone and sandstone, dark-gray silty bioclastic limestone, grit and pebble to cobble intraformational conglomerate.

In the Nabesna quadrangle, a light gray to gray, thin to thick bedded fossiliferous limestone containing minor nodules of gray chert and locally abundant volcanic clasts occurs at the base of the Eagle Creek formation but is locally absent.

In the McCarthy quadrangle, a limestone as much as 250 m thick ranging from thin to thick bedded is mainly confined to the upper part of the formation.

Tetelna (P IPT) -- Station Creek Formation (P IPsc)

The Tetelna volcanics (P IPT) of Permian and Pennsylvanian age, consist chiefly of interbedded dark green to purplish gray green volcanic flows, volcanic mud and debris avalanches, lapilli-pumice tuffs and fine to coarse grained volcanic clastic rocks. Flows are generally of massive porphyritic andesites, commonly amygdaloidal. Volcanoclastic rocks range from mudstone to conglomerate and are locally gradational into volcanic-rich limestone. The conglomerate and volcanic

fragmental rocks are massive whereas the finer grained volcanic clastic rocks are thin bedded and locally graded. Along the east side of the Nabesna glacier (T 4 and 5 N., R 14 E) and locally elsewhere between the Nabesna glacier and Cross Creek, the formation includes buff to gray green massive rocks with conspicuous quartz eyes in fine grained dense matrix of quartz, feldspar, white mica, and locally, sulfides.

The Station Creek (PIPsc) formation in the McCarthy quadrangle is correlative to the Tetelna volcanics and is informally divided into a volcanoclastic member and volcanic flow member separated by a gradational contact. Flows in the volcanic flow member are between three and 60 m thick and are locally pillowed and brecciated. The flow member consists of altered lavas, mainly andesites and basalt, and minor intercalated volcanic clastic rocks. The volcanic clastic member is broadly correlative stratigraphically and lithologically with the middle Pennsylvanian to early Permian Slana Spur formation of the Mankomen group which in turn is believed to inter tongue with the Tetelna volcanics. In addition, the volcanic flow member of the Station Creek formation correlates according to Richter (1975) with the Pennsylvanian part of the Tetelna volcanics in the Nabesna quadrangle.

Kaskawulsh Group (Pzk)

The Kaskawulsh group is a metamorphosed marine sequence of Devonian or older age consisting mainly of marble. Volumetrically, the group consists of about two-thirds fine to coarse-grained marble and one-third schist, phyllite, and minor amphibolite. The marbles are locally schistose, banded or granulated and range from rocks that consist almost entirely of calcite to calcite-dominant multimineral assemblages. Most other rocks are strongly schistose with locally developed pink banding and slip cleavage. The degree of metamorphism is green schist to green schist-amphibolite transition. The thickness of the unit is estimated at 2000 m.

Intrusive Rocks

Hypabyssal (Th) - Younger Porphyry (Tp)

Rocks designated Hypabyssal in the McCarthy quadrangle and Younger Porphyry in the Nabesna quadrangle consist of dikes, sills, and small, mainly concordant stocks, which intrude rocks as young as the lower part of the Wrangell lava. The intrusions are dominantly dacite, andesite, and ryodacite in composition and are typically strongly porphyritic with plagioclase and less abundant quartz or sanidine phenocrysts. Color of the unit varies from light gray to dark pinkish brown, and

ground mass textures are generally fine grained intergranular or trachytic. The larger irregular bodies are generally unaltered whereas the smaller dikes and sills and the complex intrusive bodies generally exhibit varying degrees deuteritic and hydrothermal alteration. K-Ar dates (M. A. Laphere, unpublished data; J. von Essen, unpublished data, 1972; M. L. Silverman, unpublished data, 1975) indicate that the time span of the hypabyssal rocks coincides with that of the Wrangell volcanism yielding ages of from 3.8 plus or minus 0.8 M. Y. in the McCarthy quadrangle to as old as 39 M. Y. in the vicinity of Cross Creek in the Nabesna quadrangle.

Older Porphyry (PKp)

The unit categorized as Older Porphyry has a restricted aerial distribution having been mapped near Baultoff Creek and near the village of Chisana. The porphyry is gray-green massive andesite porphyry containing conspicuous phenocrysts of plagioclase, as much as 1 cm long in a fine grained altered ground mass. The intrusions are believed by Richter to be hypabyssal equivalents of flows of the Chisana formation.

Diorite Undifferentiated (TKd)

The unit includes a number of small complex porphyritic to equigranular granitic intrusives scattered throughout the

Nabesna quadrangle. The intrusions are predominantly regular in outline consisting of intimately mixed augite-hornblende porphyritic diorite and fine-to medium-grained equigranular hornblende diorite. The intrusions are believed to represent small stocks of the Middle Cretaceous plutonic event.

Nabesna Pluton (Kng)

The Nabesna Pluton is a large complex intrusive consisting chiefly of hornblende-biotite-granodiorite but with quartz diorite, diorite, and trondhjemite as locally abundant phases. Younger porphyry (Tp) dikes and small stocks are common throughout the pluton. Large zones of the pluton, especially along its south margin, have been effected propylitic and argillic alteration and containing deposits of disseminated sulfides including chalcopyrite and molybdenite .

Devils Mountain Pluton (Kdd)

The Devils Mountain Pluton is an elongate pluton composed chiefly of hornblende diorite, quartz diorite and hornblende granodiorite. The intrusive is strongly propylitically altered with most of the original hornblende having been replaced by chlorite and minor epidote and the plagioclase replaced by saussurite.

Chisana Pluton (Kcs)

The Chisana Pluton grades from a dark colored clinopyroxene diorite at the exposed west end of the pluton, through a central zone of clinopyroxene syenodiorite, to clinopyroxene-hornblende monzonite along the eastern margin of the pluton. Biotite occurs sparsely throughout most of the pluton, and magnetite is an abundant accessory mineral.

Klein Creek Pluton (Kkg)

The Klein Creek Pluton is a large complex intrusive similar to the Nabesna pluton but with a number of small satellitic stocks and a generally higher potassium feldspar content. The composition of the pluton is chiefly hornblende-biotite granodiorite and quartz monzonite. Phases of the pluton, however, are composed of hornblende syenodiorite, biotite gabbro, and mafic hornblende diorite. Zones of strong propylitic and argillic alteration are conspicuous throughout the pluton and locally contain deposits of disseminated sulfide minerals, including chalcopyrite and molybdenite.

Mineral Resources

Copper and molybdenum are the metals of principal potential value occurring within the d-2 Lands. In addition, zinc, silver and gold occur in significant quantities, generally in association with the copper or copper-molybdenum. Lead and cobalt, while known to occur in the area, are judged to hold a minimal potential for economic exploitation.

Modes of Mineral Occurrence

Copper is the commodity of greatest economic potential, occurring within the area being both the major recoverable metal associated with hydrothermal deposits of Middle Cretaceous to Tertiary age and a significantly anomalous constituent of the Nikolai Greenstone formation. Because of this, the mineral occurrences of the area have been categorized as to mode of occurrence, being either hydrothermal deposits associated with the Middle Cretaceous plutons or Tertiary Porphyry intrusions (H) or Nikolai Greenstone copper deposits (N).

Summary of Prospects and Mineral Occurrences

Table 1, pages 40-46, is a summary of the prospects and mineral occurrences within the d-2 Lands. The research sources for the compilation are the AMRAP maps by Donald H. Richter, et. al. (1975) and E. M. MacKevett, Jr., (1976), the Alaska State Division of Geological and Geophysical Survey Kardex File, the U. S. Bureau of Mines Minerals Availability System and private files.

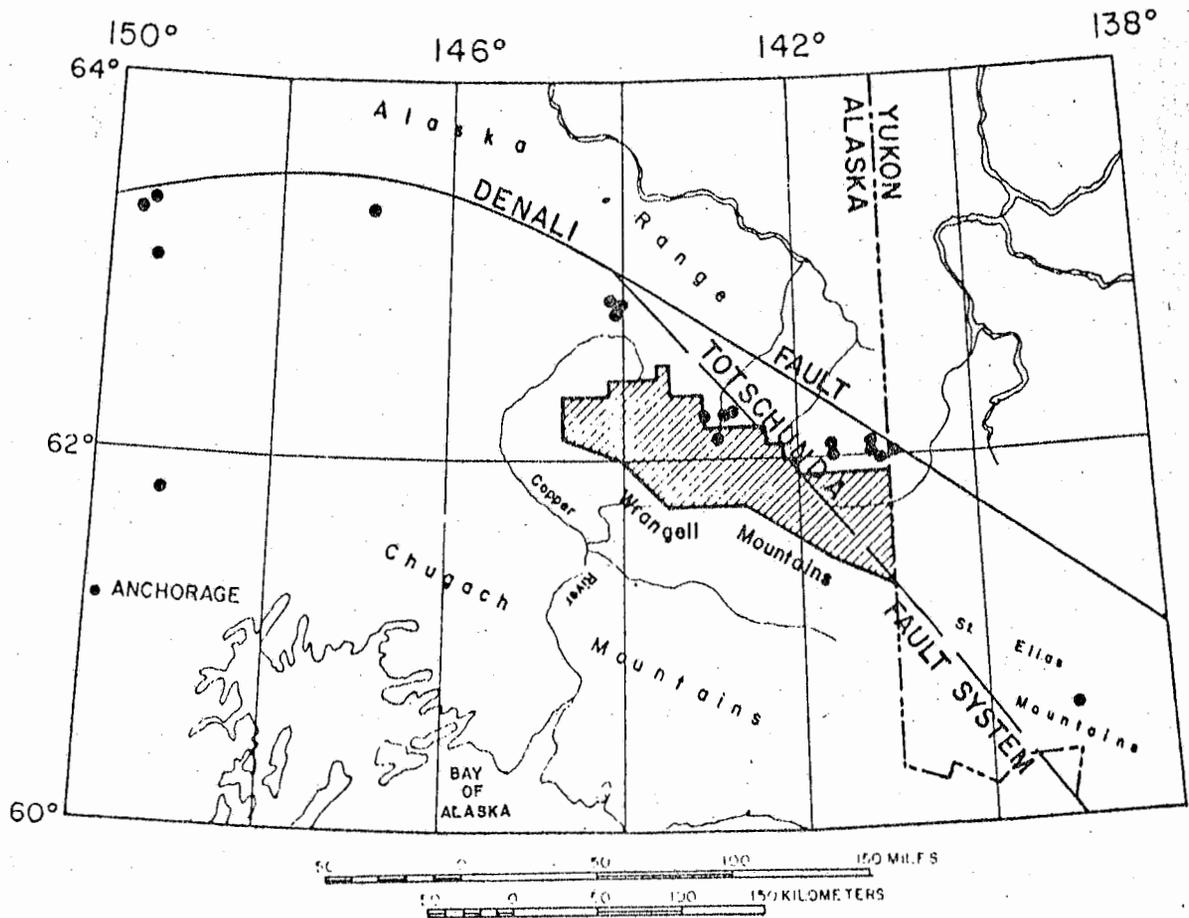
Table No. 2, pages 47-57, summarizes the prospects and mineral occurrences within the mineralized area lying immediately to the north of the d-2 Lands and has been compiled from the same research sources.

Regional Geologic Setting of Hydrothermal Mineralization

The regional geologic setting of the porphyry copper deposits (the term "porphyry copper" as used in this context, is intended to mean a large, low-grade copper, and/or molybdenum deposit usually associated with porphyritic igneous rocks that may be mined by low-cost methods) has only recently been recognized. Thus, it was in 1974 that V. F. Hollister, S. A. Anzalone and D. H. Richter first described what is known as the Continental Margin Porphyry Copper Belt which trends northwesterly from southeastern Alaska through the contiguous Yukon Territory into interior Alaska. Figure 2 illustrates the relationships of the porphyry copper belt to the regional structures and to the d-2 Lands.

As noted in the Geologic and Tectonic Summary, most of the rocks in the area represent volcanic arc-trench deposition. Radiometric dating of the plutons in the Continental Margin Porphyry Copper Belt indicate five principal periods of intrusive activity, the four oldest periods of which are known to be coeval and spatially related to the volcanic arc-trench systems. The porphyry copper deposits, in turn,

MAP SHOWING
 RELATIONSHIP OF Cu-Mo DEPOSITS
 IN THE
 CONTINENTAL MARGIN PORPHYRY COPPER BELT
 TO THE
 d-2 LANDS



EXPLANATION

● — Porphyry Cu/Mo Deposits

SOURCE: V.F. HOLLISTER, et. al. 1974

FIGURE 2

appear to be spatially related to the plutons associated with the four oldest trench systems. Within the study area, the plutons with associated copper mineralization occurred during the Middle Cretaceous having been dated from 100 M. Y. to 114 M. Y. in age. Some mineralization also appear to be associated with porphyry intrusions of more recent emplacement dating from 41 M. Y. to 25 M. Y. (Lanphere and Reed, 1973).

Two types of mineral deposits compose the belt; those associated with quartz monzonite, quartz diorite or granodiorite intrusions; and those associated with quartz-poor diorite intrusions.

The trend of the Continental Margin Porphyry Copper Belt, as a whole, conforms in general to the strike of the Danali fault. Within the limits of the study area, the grouping of deposits suggest a more westerly trend than the belt as a whole. The explanation for the apparent variance in trend may lie in the fact that the extensive surficial deposits and cover of Wrangell lavas in the White River area mask the true distribution of the mineralized plutons.

Description of Hydrothermal Systems in the Northern Wrangell-Nutzotin Mountains

The copper-molybdenum mineralization associated with the Middle Cretaceous plutons are of major resource significance. As noted on Overlay No. 1, there are at least three and possibly four

hydrothermal systems relating to Middle Cretaceous plutons and Tertiary intrusives within the area.

Nabesna Pluton Hydrothermal System

The mineralization relating to the Nabesna pluton located in the vicinity of the Nabesna glacier is of major aerial extent covering an area approximately 18 km in an easterly direction and 14 km in a northerly direction. The pluton, including the metavolcanic and metasedimentary formations into which it intrudes, is the host of major porphyry copper-molybdenum deposits similar in grade, tonnage and in some geologic features to many deposits in British Columbia and the Yukon Territory, some of which are presently being exploited.

The Orange Hill (Map No. 109) and the Bond Creek (Map No. 112) deposits have been the most actively explored prospects in the area during recent times. Because the deposits are representative of the porphyry copper mineralization of the area, they are herein briefly described. Together, the Orange Hill and Bond Creek deposits are estimated by Richter (1975) to constitute a resource of approximately 850 million metric tons of mineralization averaging 0.3 or greater per cent copper and 0.02% molybdenum.

Both deposits are characterized by multiple porphyritic intrusions, intensive shattering and vein quartz stockworks and zoned hydrothermal alteration.

The stockwork zones are elliptical in shape, the southern stockwork zone of the Bond Creek deposit being east-west and the main Orange Hill deposit being northeasterly in direction. Both deposits exhibit many of the mineral zoning and alteration features typical of porphyry copper deposits that are being mined. Copper occurs almost entirely as fracture coatings and vein chalcopyrite. However, important chalcopyrite mineralization occurs in association with tactites within the Pennsylvanian-Permian metavolcanic-metasedimentary sequence.

In general, there is a low sulfide core surrounded by a high sulfide halo. The core area is dominated by very strong stockwork quartz veining, whereas the high sulfide zone is predominantly pyrite. The better grade copper values (+0.1% Cu) occur within the inner part of the sulfide halo, and pyrite to chalcopyrite ratios in this area are on the order 1/1 to 3/1. However, both the quartz-rich core and the high pyrite portion of the sulfide halo contain several hundred ppm copper.

The zone of +0.1% Cu mineralization forms an irregular elliptical-shaped band averaging .4 km or more in width.

Small amounts of molybdenite are observed in quartz veins and as coatings on tight fractures within both the core area and the high copper zone. The higher grade molybdenite, however, does not necessarily coincide with the higher grade copper mineralization.

The dominant alteration in the stockwork zone is the biotization. Secondary biotite is common, although sparse in the quartz rich core and in the sulfide halo. There is a particularly close correlation of biotization and the higher grade copper zones. The biotization occurs in the Nabesna diorite and the metavolcanics-metasediments as a replacement of hornblende in and along sulfide and quartz sulfide veins.

Sericite and minor secondary orthoclase occur throughout the biotite zone but with the exception of strong sericite within the quartz porphyries, they are not abundant.

With regard to the Orange Hill deposit specifically, sphalerite occurs in important concentrations in selected areas to the extent of exceeding one per cent over core intervals of ten feet in some instances.

The Nabesna Glacier Prospects (Map Nos. 4, 5, 6, 7) represent more or less continuous mineralization though of variable intensity over a north-south distance of approximately 5 km. Significantly, the mineralization is in an area of a small apophysis of the Nabesna pluton into the Tetelna volcanics which in turn have been multiply intruded by quartz porphyries.

The mineralization consists of chalcopyrite, molybdenite and sphalerite associated with quartz-pyrite veins and veinlets within the intrusive rock in association with skarn type mineralization within the metasediments-metavolcanics. The more intense molybdenite mineralization is seen to be associated with the more acidic late porphyritic intrusions. The total sulfide content is low being estimated at 2%, although it grades to as much as 5% suggesting a pyritic halo perhaps indicative of more intensely mineralized copper-molybdenum mineralization at depth.

The West Side Nabesna Glacier Prospects (Map Nos. 1, 3, 106, 107 and 108) occupy an area between the Nabesna Glacier on the east and the overlying Wrangell lavas on the west. The significance of their distribution, therefore, is not in the northerly trend they would appear to establish, but rather, the fact that they are indicative of the strength of the hydrothermal system which projects westerly under the Wrangell lavas.

The prospect described as a stockworks in the Hypabyssal rocks (Map No. 107) may be judged from Richter's description to relate to the east side Nabesna Glacier mineralization because of the mineral suite and stockwork quartz veins carrying the copper-zinc and silver values.

Breccia Pipe Occurrences (Map Nos. 11, 111, 114) are associated with intense hydrothermal alteration in volcanic flow rocks and late porphyritic intrusion. They are a distinctive form of hydrothermal mineralization about which more needs to be learned to evaluate their economic potential. For the fact that at least two of the three breccia pipes are centered on late porphyritic intrusions, there is reason to believe that they represent mineralization of a later stage hydrothermal event. Also of significance is the fact that lead is associated with the breccia pipe mineralization whereas it is of trace occurrence in the other hydrothermal prospects.

Klein Creek Pluton Hydrothermal System

The area outlined on Overlay 1 as favorable for a porphyry copper mineralization extending into Canada is here referred to as the Klein Creek pluton hydrothermal system. In fact, the area probably includes at least two systems and possibly more. The Baultoff (Map No. 125) and Ptarmigan Creek

(Map No. 134) deposits appear to be of a type unique to the Continental Margin Porphyry Copper Belt being associated with a quartz-poor diorite and therefore probably represents a separate mineralizing event. Supporting such a conclusion is the fact that the intrusions have been dated at slightly older age of 114 M. Y. The other deposits in the Klein Creek hydrothermal system include the Johnson Creek (Map No. 121), Carl Creek (Map No. 123), Horsfeld (Map No. 128) and the un-named occurrence (Map No. 129) may more readily be thought of as one system even though spatially they group into two mineralized areas.

Chisana Pluton Hydrothermal System

The Chisana pluton located in the vicinity of the village of Chisana has associated hydrothermal mineralization considered favorable for porphyry copper type mineralization. The favorable area is interpreted to extend westerly under the Quaternary gravels of the Chisana River based upon an aeromagnetic anomaly in the area.

Sheep Creek Pluton (?) Hydrothermal System

An intrusive mapped on the south side of the White River has been grouped as an outlier of the Klein Creek pluton. The greater probability is that it is a separate pluton though of

similar age. For this reason, the intrusive is here referred to as the Sheep Creek Pluton. The intrusion's particular significance is considered to be the proof it provides of Mid Cretaceous intrusive activity in the White River area thus establishing the potential for sub-outcropping mineralized plutons in the broad covered area of the White River drainage. Supporting such a likelihood, J. E. Case and E. M. MacKevett (1976) interpret the aeromagnetics of the area to indicate buried plutons. A number of magnetic lows, moreover, could represent hydrothermal alteration associated with porphyry copper/molybdenum mineralization. Of further significance is the fact that an outcrop of the intrusive on Sheep Creek is hydrothermally altered and carries anomalous molybdenum values. (Map No. 24).

Description of Nikolai Greenstone Copper Occurrences

The Nikolai Greenstone copper occurrences are indicated by the symbol N under the heading Mode of Occurrence in Tables 1 and 2. The Nikolai Greenstone formation consists of a series of predominantly subaerial amygdaloidal basalt flows totaling as much as 2000 m in thickness containing an average of 0.015% Copper. Not only is such an intrinsically high copper content of obvious resource value but the formation also hosts higher grade copper concentrations consisting of native copper, bornite, chalcocite and chalcopyrite occurring within

amygdules, flow tops and bottoms, fractures and veins.

As will be noted on Map Overlay 1, Mineral Prospect and Occurrence Location Map, such higher grade copper occurrences within the Nikolai Greenstone are wide spread. Some of the prospects have been slightly explored but none to the extent that perhaps the potential for ore deposition justifies.

A noteworthy prospect sampled by Richter (1975) in Section 16, T.3N., R.14E. (Map No. 8) assayed greater than 2% copper over a sample length of 50 feet. The prospect is described as a "zone of copper bearing Triassic amygdaloidal basalt 200 feet long by 30 feet thick". No sulfides were observed by Richter but the rocks were described as containing relatively abundant malachite.

A more specific description of the Nikolai mineralization is that given by Capps (1916, p. 121) of a prospect located in Section 20, T.1S., R.19E. (Map No. 16):

"Native copper is apparently limited in its occurrence to a certain definite volcanic sheet - a reddish lava that is locally amygdaloidal to a high degree. For 200 feet along the outcrop of this sheet, metallic copper intergrown with prehnite, calcite, and zeolites can be found here and there in encouraging amounts. The cupriferous portion of the amygdaloid appears to be about six feet thick, but as almost no development work has been done on the property, figures of this kind have little value.

The copper occurs as irregular reticulating masses of metal several inches long and as small lumps and minute particles

embedded in the minerals that fill or line the former vesicles in the lava flow. In places these minerals either ramify in small veinlets through the body of the rock surrounding the amygdules or form irregular masses, and such places are eminently favorable for metallic copper."

Similar mineralization is described in an Alaska Territorial Department of Mines Memorandum (1931) about the mineralization on the Chisana patented claim group located on upper Gehoenda Creek in T. 1N., R. 19E. (Map No. 14). The prospect is described as a "belt mineralized with native copper that occurs in amygdaloidal lava associated with calcite, pectolite, quartz and possibly prehnite. . . . The lava outcrops prominently and shows native copper in scattered globs, and fine stringers. An open cut . . . shows the same amygdaloidal andesite mineralized with native copper and the oxidation products, cuprite and malachite No copper was visible to the eye, but on crushing and panning, this rock showed copper in considerable amounts."

Although the known grades are low by the standards which must be applied to the area under current economic conditions, the potential exists for the discovery of substantial tonnages of copper in locally enriched zones within the Nikolai Greenstone.

Conclusions and Recommendations

The Wrangell lavas being of post mineral age and of wide aerial extent in the northern Wrangell Mountains play an important role in the evaluation of the mineral potential of the d-2 Lands. On the other hand, the positive aspects of the mineral potential relate to the hydrothermal activity which accompany the Middle Cretaceous to early Tertiary intrusions of the area and to the distribution of the copper anomalous Nikolai Greenstone formation.

On the basis of such criteria, it is concluded that roughly two-thirds of the d-2 Lands in the southwestern portion of the area hold essentially no potential for mineral development whereas the northeastern portion of the area holds an exceptional potential.

The areas favorable for mineral developments are shown in Overlay 1 as the Nikolai Greenstone formation outcroppings and sub-outcroppings and as the areas potential for porphyry copper/molybdenum deposits. Within the areas outlined for porphyry deposits must be included the potential for zinc, gold and silver resources which occur in association with the primary metals copper and molybdenum.

It is judged that the Nikolai Greenstone formation will eventually be the object of more intensive investigation as technological advances increase the significance of low-grade resources.

Considering the number, size and distribution of the known mineral deposits within the area and the potential for the discovery of additional deposits, it is recommended that the proposed Wrangell - St. Elias Mountains National Park boundary be modified as shown on Overlay 2 and that the area thus recommended for exclusion from the proposed national park be opened to mineral entry under the concept of multiple purpose land use.

TABLE 1

PROSPECTS ON MINERAL OCCURRENCES ON d-2 LANDS

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
1	T. 4N., R. 14E.	Cu	Contact metamor- phic	H	O	Massive magnetite with pyrite and minor chalco- pyrite in amphibolitized volcanic rock.	Richter, 1975
2	T. 4N., R. 14E.	Au, Co	Vein	H	O	Thin (10-20 cm) calcite vein that contains gold and cobaltite.	Richter, 1975
3	T. 4N., R. 13E.	Cu	Contact metamor- phic	H	O	Small irregular masses of pyrite and minor chalco- pyrite in contact zone of diorite stock.	Richter, 1975
4	T. 4N., R. 14E.	Cu	Stockworks in volcanic rocks	H	P/A	Quartz-pyrite veins and veinlets with minor chalcopryrite in volcanic flows.	Richter, 1975
5	T. 4N., R. 14E.	Cu	Stockworks in volcanic rocks	H	P/A	Quartz-pyrite veins and veinlets with minor chalcopryrite in quartz-eye volcanic flows or shallow intrusive.	Richter, 1975

* H-Hydrothermal, N-Nikolai greenstone

** O-Occurrence; P/A-prospect, active; P/I-prospect inactive

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
6	T. 4N., R. 14E.	Cu, Mo, Zn	Vein	H	O	Quartz-pyrite vein with minor chalcopyrite and sphalerite in quartz-eye volcanic flow or shallow intrusive.	Richter, 1975
7 Nabesna Glacier	T. 4N., R. 14E.	Cu, Mo, Zn, Au	Stockworks in volcanic rocks	H	P/A	Quartz-pyrite veins and veinlets, with minor sphalerite, in altered quartz-eye volcanic flow or shallow intrusive. Locally gold bearing.	Richter, 1975
8	T. 3N., R. 14E.	Cu	Volcanogenic	N	O	Zone of malachite and azurite stain in amygdaloidal basalt flows.	Richter, 1975
9	Sec. 32, T. 3N., R. 14E.	?	?	?	-	(Believed to be mislocated occurrence No. 8	Alaska Kardex file No. 78-82
10	T. 4N., R. 15E.	Cu, Pb, Zn, Ag	Vein	H	O	Quartz vein with minor chalcopyrite, galena and sphalerite.	Richter, 1975

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
11 Cross Creek	T. 4N., R. 15E.	Cu, Pb, Zn, Ag	Breccia pipe	H	P/I	Zone of strong hydro- thermal alteration con- taining fragments of volcanic rock cemented by quartz containing minor pyrite, sphalerite, galena, and chalcopyrite.	Moffit, 1943, p. 143-145
12	T. 3N. R. 15E.	Cu, Pb, Zn	Vein	H	O	Quartz vein with minor pyrite, chalcopyrite, galena, and sphalerite in volcanic and volcanoclastic rocks.	Richter, 1975
13	T. 2N., R. 18E.	Cu, Ag	Vein	H	O	Thin cc- and bn-bearing qz veins along brecciated con- tact of a Tertiary felsite; sq. sp. 15 ppm Ag, >20,000 ppm Cu	MacKevett, 1976
14	T. 1N., R. 19E.	Cu	Dissemi- nated	N	P/I	Native Cu, ml, and cup in amygdules within a small isolated outcrop of Nikolai Greenstone	Alaska Terri- torial Dept. Mines mem., unpub. data, 1931
15	T. 1S., R. 20E.	Au	Placer	-	P/I	Very little gold found	Alaska Kardex file No. 87-96

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
16 Copper King	Sec. 20, T. 1S., R19E.	Cu	Dissemi- nated	N	P/I	Native Cu and its alteration products in about a 2-m- thick zone in Nikolai Green- stone.	Capps, 1916, p. 121, 122
17	T. 1S., R. 19E.	Cu	?	N	O	No information. 1956 Discovery.	Alaska Kardex file No. 87-113
18	T. 1S., R. 19E.	Cu	?	N	O	Generalized location. May be Copper King (Map No. 16)	Alaska Kardex file No. 87-95
19	T. 2S., R. 19E.	Cu	Vein	N	P/I	Old prospect in Cu- stained Nikolai Green- stone.	Capps, 1916, p. 122
20 Skolai Mining Co.	T. 2S., R. 20E.	Cu	Vein	N	P/I	Small occurrences of cc and ml in sheared Nikolai Greenstone; an old pros- pect.	Capps, 1916, p. 123; Knaebel, 1970, p. 16
21	T. 2S., R. 20E.	Cu	Vein	N	P/I	Thin bn- and cc-bearing veins in Nikolai Green- stone; traces of old sur- ficial workings.	Moffit and Knopf, 1910, p. 57

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
22	Sec. 17, T. 2S., R. 18E.	?	?	?	P/I	No geologic description. Ten patented claims foreclosed to State in 1957.	Alaska Kardex file No. 87-117
23	T. 2S., R. 20E.	Ag	Vein and Dissemi- nated	H?	O	Altered material along brecciated and sheared zone about 50 m wide; sq. sp. 3 ppm Ag, 300 ppm As, 200 ppm Co, 200 ppm Cu, 200 ppm Zn.	MacKevett, 1976
24	T. 2S., R. 21E.	Ag?, Mo?	Dissemi- nated	H	O	Alteration zones in sheared granodiorite; sq. sp. 0.7 ppm Ag, 50 ppm Mo.	MacKevett, 1976
25	T. 2S., R. 20E.	Cu	Vein	H?	P/I	Old prospect with minor workings; not found dur- ing current investigation; reportedly explored small stringers of cp.	Capps, 1916, p. 123
26	T. 2S., R. 21E.	Cu	Dissemi- nated	N	P/I	Caved adit in Nikolai Green- stone; sparsely distributed Cu minerals in amygdules.	Capps, 1916, p. 124
27	T. 2S., R. 21E.	Cu	Dissemi- nated	H?	O	Altered mafic dike about 60 m thick; sq. sp. 1,500 ppm Cu.	Capps, 1916, p. 124

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
28	T. 2S., R. 20E.	Cu	Vein and Dissemi- nated	N	P/I	Cu-bearing veinlets and amygdules in Nikolai Greenstone.	Moffit and Knopf, 1910, p. 56
29	T. 3S., R. 20E.	Cu	Coating	N	O	Fe- and Cu-stained Nikolai Greenstone; probably old Cu prospect in vicinity but workings are obliterated.	MacKevett, 1976
30	T. 3S., R. 21E.	Cu, Ag, Au	Vein and Dissemi- nated	H	O	Cu-bearing veinlets and disseminations in altered volcaniclastic rocks of Station Creek Formation; 0.9 ppm Au(AA), sq. sp. 15 ppm Ag, 10,000 ppm Cu.	MacKevett, 1976
31	T. 4S., R. 22E.	Cu	Vein and Dissemi- nated	N	O	Native Cu, cc and their alteration products in a poorly exposed outcrop of Nikolai Greenstone.	MacKevett, 1976
32	T. 3S., R. 23E.	Cu, Ag	Vein	H?	O	Cu minerals, mainly ml, in veinlets within a shear zone that cuts Triassic <u>Daonella</u> beds; minerali- zed outcrop about 3 x 30 m; sq. sp. 100 ppm Ag, 1,500 ppm As, >20,000 ppm Cu.	MacKevett, 1976

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
33	T. 3S., R. 24E.	Cu	Massive and Dissemi- nated	N	O	Native Cu in Nikolai Green- stone; the Cu ranges from shot-size pellets to ramify- ing masses weighing a few pounds.	MacKevett, 1976
34	T. 3S., R. 24E.	Cu	Placer	-	P/I	Fairly abundant Cu nuggets in gravels of Kletsan Creek, mainly in Canada, have been staked for placer Cu.	Moffit and Knopf, 1910, p. 57; Capps, 1916, p. 124, 125.
35	T. 1N., R. 24E.	Au	Placer	-	O	Placer gold occurrence	MacKevett, 1976.

* H-Hydrothermal, N-Nikolai greenstone

** O-Occurrence; P/A-prospect, active; P/I-prospect inactive

Descriptive Abbreviations: cc-chalcocite; bn-bornite; ml-malachite; AA-Atomic Absorption

TABLE 2

PROSPECTS AND MINERAL OCCURRENCES ON LANDS ADJACENT TO d-2 LANDS

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
101 Golden Eagle group; Rambler Mine	T. 7N., R. 13E.	Au	Contact meta- morphic	H	P/A	Massive gold-bearing pyrrhotite and pyrite in recrystallized limestone	Wayland, 1943
102 Nabesna Mine	T. 7N., R. 13E.	Au, Cu, Ag, magnetite	Contact meta- morphic	H	M/I- 1940 P/A	Massive magnetite with pyrite, veins and masses of pyrrhotite, and veins of bold-bearing pyrite at con- tact of quartz diorite and limestone. Production when mine closed (1940) was \$1, 870, 000.	Wayland, 1943
103 Royal Develop- ment Co.	T. 7N., R. 13E.	Au	Dissemi- nated gold	H	M/I- 1907	Quartz diorite stock with disseminated pyrite and small quartz-pyrite veins. Sixty tons of ore milled in 1907.	Wayland, 1943

* H-Hydrothermal, N-Nikolai greenstone

** O-Occurrence; P/A-prospect, active; P/I-prospect inactive; M/I-mine inactive

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
104 Camp Creek	T. 7N., R. 14E.	Cu	Volcano- genic	N	O	Chalcocite vein in amygdaloidal basalt flows.	Mendenhall and Schrader, 1903, p. 39.
105 Monte Cristo Creek; Marie Nabesna	T. 5N., R. 13E.	No	Porphy- molyb- denum	H	P/A	Disseminated molybde- nite and quartz-pyrite- molybdenite veins in strongly altered zone at contact of granodiorite pluton and volcanic breccia.	Richter, 1975 Private File
106	T. 5N., R. 13E.	Zn, Pb, Cu, Au, Ag	Contact meta- morphic	H	P/I	Quartz veins with sphal- erite, galena, and minor chalcopyrite in recrystal- lized limestone.	Richter, 1975
107 Nabesna River	T. 5N., R. 13E.	Cu, Ag, Zn	Stockworks in hypabyssal rocks	H	P/A	Quartz-pyrite veins and veinlets with minor chal- copyrite in hornblende dacite dike and volcanic country rock.	Richter, 1975
108	Sec. 32 T. 3N., R. 14E.	--	--	?		Judged to be mislocated	Ak. Kardex file No. 78-82

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
109 Orange Hill	T. 5N., R. 14E.	Cu, Mo, Au, Ag	Porphyry Copper	H	P/A	Pyrite, chalcopyrite, and minor molybdenite in quartz veinlets and as dissemi- nations in quartz diorite. Additional data given in "Nabesna Pluton Hydro- thermal System"	Van Alstine and Black, 1946. Private file.
110 Lemon Claims (Adit E prospect)	T. 5N., R. 14E.	Cu, Zn, Ag, Au	Contact meta- morphic	H	P/A	Disseminated pyrrhotite, pyrite, and chalcopyrite in magnetite; and veins of pyrite, chalcopyrite, and sphalerite in magnetite and calc-silicate rock.	Van Alstine and Black, 1946. Private file.
111	T. 5N., R. 14E.	Pb, Cu, Ag	Breccia pipe?	H	O	Zone of intense hydro- thermal alteration in volcanic flows containing brecciated rock cemented by quartz that contains minor pyrite, chalcopyrite, and galena.	Richter, 1975

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
112 Bond Creek	T. 5N., R. 15E.	Cu, Mo, Au, Ag	Porphyry copper	H	P/A	Pyrite, chalcopyrite, and minor molybdenite in quartz veinlets and as dis- seminations in granodio- rite and quartz monzonite porphyry. Additional data given in "Nabesna Pluton Hydrothermal System".	Richter, 1975
113 East Fork	T. 5N., R. 15E.	Mo	Porphyry molybdenum	H	P/A	Quartz-pyrite-molybdenite veins and veinlets in strongly altered and brec- ciated trondhjemite.	Richter, 1975
114	T. 5N., R. 15E.	Cu	Breccia pipe?	H	O	Fragments of volcanic rock cemented with quartz and minor pyrite and chalcopyrite in area of intense hydrothermal alteration.	Richter, 1975
115 Big Eldorado	T. 4N., R. 19E.	Cu, Au	Vein	H	P/A	Quartz vein with pyrite, chalcopyrite and gold in syenodiorite.	Richter, 1975
116	T. 4N., R. 19E.	Au	Vein	H	P/I	Quartz vein with pyrite in volcanic breccias.	Richter, 1975

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
117, 118, 119	T. 4N., R. 19E.	Au	Vein	H	P/I	Locally gold bearing quartz-pyrite veins in small altered zones in volcanic breccias.	Capps, 1916, p. 118
120	T. 4N., R. 20E.	Zn, Pb, Cu, Ag	Vein	H	P/I	Quartz-carbonate veins with sphalerite, galena, and minor chalcopyrite in agrillite.	Richter, 1975
121 Johnson Creek	T. 4N., R. 21E.	Cu	Porph. copper	H	P/A	Disseminated pyrite and chalcopyrite in small diorite stock and surrounding hornfelsed argillite.	Richter, 1975
122 Carl Creek	T. 3N., R. 21E.	Cu, Mo, Au Ag	Porph. copper	H	P/A	Pyrite and chalcopyrite in quartz veinlets and as disseminations in granodiorite and quartz monzonite.	Richter, 1975
123	Sec. 16, T. 3N., R. 21E.	Cu	Vein	H	P/A	Small area of granodiorite contains disseminations of chalcopyrite. Intensity of mineralization ranges up to 0.5% chalcopyrite zones of heavy malachite and azurite.	Richter, 1975 Private file.

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
124	T. 4N., R. 22E.	Cu	Vein	H	O	Massive quartz vein with minor pyrite and chalcopryrite in marine volcani-clastic rocks.	Richter, 1975
125 Baultoff	T. 4N., R. 23E.	Cu, Au, Ag	Porph. copper	H	P/A	Disseminated and fracture filling pyrite and chalcopryrite in diorite and quartz porphyry within pyritic halo. Intense crackling.	Richter, 1975. Private file.
126	T. 4N., R. 23E.	Cu	Porph. copper	H	P/I	Disseminated pyrite and minor chalcopryrite in small diorite stock.	Richter, 1975
127	T. 3N., R. 23E.	Cu	Vein	H	P/I	Quartz vein with chalcopryrite in volcanic breccias.	Richter, 1975
128 Horsfeld	T. 3N., R. 23E.	Cu, Au, Ag	Porph. copper	H	P/A	Pyrite and chalcopryrite in quartz veinlets and as disseminations in monzonite and monzonite porphyry. Associated with breccia pipe.	Richter, 1975. Private file.

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
129	T. 3N., R. 23E.	Cu	Porph. copper	H	O	Disseminated pyrite and chalcopyrite in porphy- ritic mafic diorite.	Richter, 1975
130	T. 4N.R. 23E.	Pb, Ag, Au	Vein	H	O	Quartz-barite vein with minor galena in marine sedimentary rocks.	Richter, 1975
131	T. 4N., R. 24E.	Cu, Ag	Vein Porph. copper	H	O	Quartz veins with minor chalcopyrite in small quartz monzonite stock and volcanic country rock.	Richter, 1975
132	T. 2N., R. 24E.	Cu	Dissemi- nated and vein	H	O	Py and cp disseminations and veinlets in granodio- rite and pendants of horn- fels mainly near a shear zone; several other small, similarly mineralized out- crops in vicinity.	Knaebel, 1970, p. 16
133 5 patented claims	T. 2N., R. 24E.	Cu, Au	Massive	H	P	Small outcrop of massive sulfides surrounded by sur- ficial deposits; probably of contact metamorphic origin; mainly pyrrhotite, chalco- pyrite, arsenopyrite and gold; explored by a short adit.	Moffit and Knopf, 1910, p. 59; Knaebel, 1970, p. 16; Irving, 1907, p. 57-60.

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
134	T2N., R24E.	Cu	Dissemi- nated	H	O	Py and minor cp dissemi- nated in argillite and in a small gabbro mass near a fault.	Knaebel, 1970, p. 16
135	Sec. 9, T. 3N., R. 24E.	Cu	Dissemi- nated	H	O	An area near the head of Lamb Creek and Eureka Creek is composed of granodiorite and diorite intrusions cut by andesite porphyry dikes. The area contains disseminated sul- fide mineralization which is usually less than one per cent. The copper content ranged up to 250 ppm.	Private file
136	Sec. 4, T. 3N., R. 24E.	Cu	Vein	H	O	Small massive pyrite veins ranging from 1" to 4" wide and less than 10 feet long are exposed in landslide scars in the creek bottom. The veins are within a diabase-serpen- tine (?) intrusion rather than the shale. The highest assay in the area was 0.58% copper which represented a 3" wide calcite vein containing sulfides and copper oxides.	Private file

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
137	Sec. 16, T. 4N., R. 24E	Cu	Vein	H	O	A gabbro and serpentine mass centered at approximately the common Sec. corner of 8, 9, 16 and 17 contained disseminated sulfides of up to 1% over a broad area. Pyrite is the most abundant sulfide seen with minor chalcopyrite also noted. Malachite widely distributed. Nickel and cobalt analyses were less than 100 ppm and the highest copper analysis was 0.14%.	Private file
138	Sec. 28, T. 4N., R. 22E.	Cu	Disseminated	H	O	The country rock along the north side of the glacier in Secs. 28 and 29 is quartz-monzonite grading in areas to granodiorite. Malachite staining locally coats cliff faces and is found on some fractures. No chalcopyrite was found.	Private file
139	Sec. 32, T. 4N., R. 22E.	Cu, Mo	Disseminated	H	O	On the ridge in the southwest quarter of Sec. 32, the quartz monzonite to granite country rock has been K-spar flooded. Blebs of chalcopyrite and molybdenite were found in float but the mineralization in place was not located.	Private file

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
140	Sec. 33, T. 4N., R. 24E.	Cu	Vein	H	O	The ridge along the bound- ary is composed of ser- pentine and diorite and multiple diabase intrusions. Small widely spaced quartz veins are present which con- tain up to 5% chalcopryrite. The veins, however, are less than 3" wide, not greater than 10 ft. long and con- sequently, are of no economic value.	Private file
141	Sec. 28, T. 4N., R. 22E.	Cu	Dissemi- nated and vein	H	O	Nea† the common corner of Secs. 28, 29, 32 and 33, interesting chalcopryrite as disseminations and veinlets occurs in a restricted zone of shearing about 15 ft. wide. Spotty chalcopryrite, mainly in the form of blebs associated with orthoclase pods, per- sists along the quartz mon- zonite ridges in the center of Sec. 28.	Private file

Map No. Name	Location	Resource(s)	Type of Deposit	Mode of Occur- rence*	Cate- gory**	Description	Reference
142, 143 144, 145, 146, 147 Chisana (Bonanza) district	T. 4, 5N., R. 19, 20E.	Au	Placer	-	M/A	Chiefly coarse-grained smooth gold; coarse-grained rough gold from placer deposit #64. Production of about \$1,000,000 principally from deposits 63 and 65. About half of total production was from years 1913-1915; some mining has continued to present time.	Capps, 1916 p. 92-116; Moffit, 1943, p. 170-173.
148 Bryan Creek	T. 3N., R. 19E.	Au, Cu	Placer	-	P/I	Some coarse-grained gold and native copper recovered.	Moffit, 1954, p. 200

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