Geology of the Nelson and Radovan Copper Prospects,

Glacier Creek, Alaska

by

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GEOLOGY OF THE NELSON AND RADOVAN COPPER PROSPECTS, GLACIER CREEK, ALASKA

ABSTRACT

Renewed copper exploration by Alaska Copper Mines, Incorporated, at the Nelson and Radovan prospects, Nizina district, Alaska, led the Geological Survey in 1951 to map in detail the Nelson fault block, and to re-examine the old workings. In addition, two new prospects were studied.

The Nelson fault block is cut by many dominantly strike-slip faults of small displacement, and by bedding faults. Slickensided chalcocite shows post-mineral movement, and a chalcocite veinlet in a filled solution cavity indicates that some of the chalcocite is secondary, perhaps very recent. Structural relations indicate two overthrust faults cut the block.

The Radovan "Greenstone" prospect shows massive chalcocite, up to 3 feet wide, in a silicified, epidotized fault zone in the Nikolai greenstone. Ore indicated by surface exposures may amount to 450 tons of chalcocite.

The Radovan "Low-Contact" prospect is on a continuation of the same fault approximately 3 miles southwest of the Greenstone prospect, and 150 feet above the contact of the Nikolai greenstone and the overlying Chitistone limestone. Limonite staining is widespread in bedding planes and small faults near the fault zone; mineralization in the fault zone consists of pyrite, chalcocite, bornite, malachite, realgar, orpiment and stibnite. The sulphides in the fault zone, plus the widespread silicification and epidotization indicate a strong zone of hydrothermal activity which merits extensive prospecting.

INTRODUCTION

The Nelson and Radovan prospects are on Glacier Creek, a tributary of the Chitistone River, about 16 airline miles east by south of Kennecott. The general location is shown on the index map, figure 1.

The Nelson prospect was staked in 1928 by C. A. Nelson and was taken under option in 1929 by the Kennecott Copper Corporation. The Corporation drove about 1,100 feet of underground workings before abandoning the property in 1930. In 1951 three of the five adits were accessible.

The Radovan "Low-Contact" and "Binocular" prospects were staked in the period from 1929 to 1931. The Radovan "Greenstone" prospect was staked in 1950. The "Binocular" prospect is described in detail by Miller (1946, pp. 114-117). The "Greenstone" and "Low-Contact" prospects have not been described heretofore.

In 1951 the Radovan and Nelson properties were under option by the Alaska Copper Mines, Incorporated. The company is actively engaged in diamond drilling the Nelson prospect, and in drifting on the Radovan "Greenstone" prospect to exploit the ore showing in a fault approximately 200 feet above. ~~Tentative plans are made for diamond drilling the "Binocular" prospect in 1952.~~

The field work upon which this report is based was done in 1951, September 1 to 8, inclusive, when the writer, ably assisted by John C. Reed, Jr. spent six days in mapping the Nelson prospect and Nelson fault block, and one day each at the Radovan "Greenstone" and "Low-Contact" prospects. The writer wishes to thank William A. O'Neill, Mining Engineer and Superintendent, and Walter Holmes, Foreman, of the Alaska Copper Mines, Incorporated, for helpful assistance and cooperation while we lodged at their Glacier Creek camp. Special thanks is tendered Martin Radovan who accompanied us to the "Low-Contact" prospect, and who gave us much valuable history of the area.

AREAL GEOLOGY AND STRUCTURE

The regional geology of the Nizina district is described by Moffit (1938, pp. 1-100). In general, the rocks consist of a thick sequence of basaltic lavas (Nikolai greenstone) of Permian and Triassic (?) age conformably overlain by the Chitistone and Nizina limestones of Upper Triassic age. The Nizina limestone grades upward into the McCarthy shale, also of Upper Triassic age, which is overlain by a sequence of Cretaceous shales, sandstones and conglomerates. Thick Tertiary and Quaternary lavas overlie the older rocks with angular unconformity. The bedded rocks of the Nizina district are intruded by igneous rocks ranging in age from Mississippian to Tertiary, and ranging in composition from dunite to granite.

The bedded rocks cropping out along Glacier Creek and in its vicinity are the Nikolai greenstone and the Chitistone limestone; no intrusive rocks are known in the area discussed in this report.

The rocks in the Glacier Creek area are on the northeastern limb of a syncline trending northwest; within the area discussed in this report, the beds strike from N. 10° E. to N. 20° W. and dip 15°-25° to the southeast and southwest, respectively. Two major faults are known—an overthrust fault striking about N. 45° W., and a high-angle normal fault striking about N. 25° E. Minor structures are discussed under the individual prospects.

NELSON PROSPECT

GEOLOGY AND STRUCTURE

The Nelson prospect has been explored by surface pits and five adits at, or directly above, the contact of the Chitistone limestone and the Nikolai greenstone in a fault block referred to here as the Nelson fault block. This block is on the footwall side of a large overthrust fault which crosses the Chitistone River below the mouth of Glacier Creek and is traceable northwest to the valley of the West Fork of the Nizina River, a distance of at least 12 miles. The throw on this fault is approximately 5,000 feet at the Nelson prospect; the magnitude of the displacement is such that the fault probably extends a great distance up Glacier Creek and may account for the position of the valley.

The Nikolai greenstone, in the section exposed in the deep gorge shown on the south end of the geologic map (see Plate 1), consists of a sequence of dense, purple flows with chlorite amygdules, overlain by about 50 feet of highly vesicular flows which in places contain scoria. Abundant angular fragments in the vesicular flows could be either flow breccia or agglomerate. Above the scoriaceous flows is a succession of greenish, vesicular flows with abundant chlorite amygdules and subordinate calcite amygdules. The purplish flows could be distinguished throughout the area mapped, but the scoriaceous zone was not found elsewhere in the Nelson fault block. No attempt was made to differentiate the lava types on the geologic map. The lavas show no secondary cleavage, and because of their fresh appearance the writer prefers to call them basalts or andesites rather than greenstones. The lavas appear to dip more steeply than the overlying limestone, though reliable dips are hard to find as the flow surfaces are very uneven.

Between the Nikolai greenstone and the Chitistone limestone is a 6-foot bed of shale and siltstone. The lower 2 feet of the bed is a brownish siltstone, and the upper 4 feet is a greenish clayey shale with little shaly bedding. Bedding plane faulting has occurred within the shale, as shown by angular limestone fragments in the shale and by small masses of the brown siltstone rolled into the green clayey shale. This shale is not seen on surface exposures owing to its tendency to weather rapidly and leave an undercut at the base of the limestone which is soon covered with limestone rubble and vegetation. It is exposed well in the lower drift, where a fault repeats the contact, and in diamond-drill holes 1 and 2.

The 40 feet of Chitistone limestone immediately overlying the shale is made up of beds of grey limestone ranging in thickness from 2 to 4 feet and containing scattered pyrite crystals. The lowest 15 feet of these beds are fossiliferous. Above the 40-foot zone is a thick zone of highly broken and brecciated ~~and~~ dolomitic limestone which extends to the top of the hill. The change from the lower, unbroken beds to the upper, brecciated dolomites is very abrupt.

The lower beds strike from N. 10° E. to N. 15° W. and dip 15°-21° W. A shallow syncline is mappable south of the lower drift. Accurate measurements of strikes and dips are difficult to obtain because of the solution of bedding planes by groundwater. Solution caverns and channels are common in the lower beds.

Though bedding is difficult to recognize in the upper brecciated zone, enough bedding planes were found to show that the strike of these beds is from N. 20° W. to N. 85° W. and their dip from 42° to 83° SW., a very abrupt and marked change from the attitude of the underlying beds. Fairly continuous exposures near the top of the ridge dip steeply southwest. Near the top of the ridge up slope from the diamond-drill holes is an outcrop of a bed of limestone containing pebbles and boulders of a black, dense, non-cherty limestone which appears to be foreign to the Chitistone limestone. These pebbles and larger fragments range in size from 1 to 18 inches and lie with their long axes approximately parallel to the bedding of the enclosing limestone. This conglomeratic bed may represent a local unconformity in the Chitistone limestone.

Faulting of the Nelson block is extreme. In general, the faults make a large angle with the strike of the inferred overthrust fault plane. Strikes of the faults cutting the contact of the greenstone and the limestone range from N. 10° W. to N. 40° E. Many of these faults have striated surfaces which indicate a dominately strike-slip movement. Mappable faults in the upper portion of the block strike approximately east-west, with one exception. Bedding faults are difficult to recognize in surface exposures owing to widespread solution of bedding surfaces by groundwater; however, the underground workings show that bedding-plane faulting is widespread. In fact, almost all fractures exposed underground are striated, showing movement of adjoining blocks. No sequence of faulting can be determined as bedding faults are cut by high-angle faults which in turn are cut by other bedding faults. Much of the faulting has been post-mineral, as many chalcocite stringers are cut off and slickensided by faults of many types. Several surfaces were noted which strongly indicated slickensiding of malachite. Some of the larger faults show fault zones in which the wall rocks are shattered and brecciated over a 20-foot width. The writer believes much of the faulting definitely is post-mineral and had no influence in localizing ore. The faults show little displacement of the mapped contact owing to the steepness of the slope at the contact.

The structure as shown on the structure section of Plate 1 is compiled from the underground maps and the diamond-drill hole logs. The writer believes the zone marked "strongly shattered zone" on the cross section represents an early thrust plane which is cut by a later, steeper overthrust fault. This situation is noted on the overthrust fault opposite the mouth of the West Fork of the Nizina River where an early overthrust has pushed an overturned fold of limestone out upon gently dipping limestone (see Moffit, 1938, page 48). A later overthrust dipping steeply has isolated a section of the first overthrust creating a situation on the underthrust block where flat beds are overlain by steeply dipping beds. The inability to project dips into a reasonable picture, and the juxtaposition of highly shattered beds dipping steeply directly above unshattered beds of approximately the same competency dipping gently strongly supports this interpretation. The beds in the upper portion of the block may be overturned, but no direct evidence could be found to show overturning.

Some question exists in the minds of those directly concerned with the present exploration of the Nelson block as to the lateral extent southward of the limestone beneath the overthrust fault.[1/] Two possibilities exist: 1. The Nelson block is a normal fault block dropped from the overthrust sheet by later faulting; consequently, it cannot extend southward beneath the overlying greenstone, or 2. that the Nelson block belongs to the underthrust block of the major overthrust, and the limestone may continue for a considerable distance beneath the overlying lavas.

1/ Personal communication from Walter Holmes and Martin Radovan.

A projection along the approximate strike of the limestone at the north end of the Nelson block to the limestone-lava contact across the Chitistone River shows that the Nelson block limestone is about the right altitude to be an uninterrupted continuation of the underthrust block. No normal faults with a throw even approximately 5,000 feet (the probable throw of the fault that isolated the Nelson block) occur in the vicinity of Glacier Creek. Any normal fault that could have isolated the Nelson block would strike at right angles to the normal fault in Radovan Gulch, the only major normal fault in the vicinity of the Nelson and Radovan prospects. The writer believes the Nelson fault block is a part of the underthrust block of the major overthrust fault trending up Glacier Creek. However, the dip of the latest overthrust fault plane is about 55°-60° S. which limits the subsurface extension southward of the limestone in the vicinity of the Nelson prospect to a few hundreds of feet beyond the surface trace of the overthrust fault.

ORE DEPOSITS

The ore deposits of the Nelson prospect have been discussed in detail by Bateman (1932, pp. 297-306), Miller 1946, pp. 110-114), Wright (1945) and Pilgrim (1933, pp. 88-90). In general they consist of stringers and discontinous veins and bunches of massive chalcocite associated with subordinate covellite, enargite, bornite, chalcopyrite, malachite and native copper in the basal beds of the Chitistone limestone. Reference to the geologic map of the workings (see Plate 2), shows that the more persistent veins approximately are parallel to the strike or dip of the beds. The most persistent vein is along the fault which repeats the contact in drift 1, and is traceable through diamond-drill hole No. 3 into drift 2, a vertical distance of 50 feet (see structure cross-section, plate 2). Several tons of chalcocite were mined by the Kennecott Copper Corporation from a small underhand stope on this vein in the crosscut of drift 1.

Chalcocite-covellite ore is exposed in the north side of the portal area of drift 2. The vein near the portal attains a width of 1 foot, but it pinches out down the drift. The long east-west crosscut of drift 2 probably was driven to intersect this vein but with no success.

The north-south drift of drift 2 ends in a filled solution cavity whose dimensions are undetermined. This filled cavity contains much relict dolomite breccia interstratified with a brownish clay. Boulders of limestone up to 18 inches in size with solution pitted surfaces are supported in the clay and breccia, and many stream pebbles of different rock types are supported in the clay. Stream pebbles are found in many of the solution cavities shown on the geologic map of the underground workings (see Plate 2). Thin seams of chalcocite in the filling of the large cavity in drift No. 2 indicate some of the chalcocite is secondary, perhaps very recent. These filled solution cavities show a change in the erosion cycle, perhaps during Pleistocene glaciation, as no large underground water courses are likely to have formed in the Nelson block during Recent time. To the writer the only conceivable source for water flow strong enough to transport pebbles of diverse rock types into solution cavities near a steep slope 400 feet above the present stream level is glacial stream water flowing upon, or laterally along, a glacier at least 400 feet thick. This indicates the solution cavities pre-date glaciation of the area.

In drift No. 4, a 4-inch vein of chalcocite is cut off on the bottom by a bedding fault that has slickensided the chalcocite. An east-dipping chalcocite veinlet 2 inches thick is displaced by a west-dipping chalcocite veinlet. In the south crosscut of drift No. 4, a chalcocite veinlet is slickensided by later movement along it and is cut off by a bedding fault. Some malachite appears to be slickensided in this drift.

In summation, though chalcocite-covellite minerals are found at the Nelson prospect in massive bodies containing up to several tons of ore, little continuity exists between these bodies. Replacement of limestone by copper minerals was sporadic, and the ore-bearing veins were broken and displaced by post-mineral faults. Replacement on bedding planes is restricted to a small area around the intersecting fracture—chalcocite thicker than a few inches cannot be found on any bedding plane. Overall, the ore is discontinuous even in the more persistent veins, and the several veins do not appear to conform to a definite structural pattern.

The only gangue minerals at the Nelson prospect are calcite and dolomite.

ORE GENESIS

The minerology and genesis of the ores is discussed by Bateman (1932, pp. 297-306) who says, "The Glacier Creek deposit is shown, by the presence of isometric chalcocite, unmixed covellite, enargite, and bornite, to have formed from hypogene solutions at a temperature above 91° C. The mode of emplacement was chiefly by replacement of the dolomitic limestone, and some of the covellite and chalcocite may have been deposited as colloids. The solutions apparently were sufficiently attenuated to penetrate minute cracks.

"As to the source of the solutions and of the introduced metals, the deposit and its surroundings offer no conclusive evidence. It is customary, in keeping with the modern conceptions of the origin of ore deposits, to associate the solutions and metals genetically with some nearby intrusive or magmatic reservoir. In the case of the Glacier Creek deposits there is no immediately adjacent intrusive. The nearest one, a light colored quartz-diorite porphyry, lies about ten miles to the west. It may be a possible source of the copper and the solutions. The gold-quartz deposits of the Nizina district are believed to be genetically connected with it, and the Kennecott deposits may possibly be connected with another part of the same intrusion. However, at Kennecott, a light-colored dike, an apophysis of this intrusive, cuts diagonally across one of the copper veins and is later than the ore. Consequently, if the Glacier Creek and Kennecott deposits are of the same age, as seems reasonable, the Glacier Creek ore must also be earlier than the dikes which extend out from the main intrusive mass. This fact, combined with the lack of iron and silica in the deposit, and the distance of the deposit from the intrusive, offers difficulties in the acceptance of a genetic connection between the ore and the quartz-diorite intrusive.

"The only definite evidence, therefore, is that the solutions were hot and hypogene, that they were of uniform composition over a wide area, and that the deposition of metals was confined largely to the lowermost beds of the Chitistone formation."

The only additional information the writer offers is that the chalcocite noted in the filled solution cavity of drift 2 appears supergene. These chalcocite veinlets are accompanied by chalcocite coatings on malachite-cemented limestone breccia found in other solution cavities. These occurrences show that a small portion of the chalcocite of the Nelson prospect is secondary.

Because of the discontinuity of the veins at the Nelson prospect, and the abundant evidence of post-mineral faulting which may have broken up and displaced any large ore bodies, it seems unlikely that significant amounts of copper will be produced from the Nelson property. The writer considers it improbable that any continuous ore vein extends between the lower chalcocite outcrops near the drifts and the upper outcrops near the mineral marker. However, if further exploration is undertaken the following recommendations are made: (1) The area near the synclinal axis south of the drifts should be investigated, and the fault northwest of tunnel 4 should be explored. This fault probably is continuous with the fault about which are grouped the chalcocite outcrops near the mineral marker. (2) Diamond-drill holes should stay low in the limestone, but should be started high enough to miss small offsets in the greenstone-limestone contact. When interpreting fault gouge as a guide to favorable fracture zones, care should be taken to differentiate between true fault gouge and water-deposited clay seams filling solution channels.

RADOVAN GREENSTONE PROSPECT

The Radovan Greenstone prospect is on the southwest slope of Glacier Creek valley at an altitude of 4,000 feet (see Figure 2). It is about 2 miles S. 20° E. of the airfield near the Nelson prospect. Special interest is attached to the Greenstone prospect because of its location approximately 3,000 feet below the contact of the Nikolai greenstone and the Chitistone limestone. However, if the major overthrust fault which isolated the Nelson fault block continues up Glacier Creek, the prospect may be near the normal stratigraphic top of the Nikolai greenstone.

The outcrops of chalcocite make a continuous vein from 1 to 8 inches wide over a slope distance of 150 feet in a major normal fault zone that strikes N. 15°-26° E. and dips 73° SE. At the upper or south end of the chalcocite outcrop, the vein is 4 feet wide over a distance of 10 to 15 feet, and averages about 80 per cent of chalcocite. The vein branches irregularly and includes horses of country rock and vein breccia; erratic offshoots up to 4 inches wide branch off into the country rock, but usually pinch out within a few tens of feet. Shortly above the widest part, the vein narrows abruptly and disappears completely within 30 feet. No chalcocite is found immediately beyond though the fault zone can be traced up the hill for 350 yards before crossing into a steep-walled cirque. The trace of the fault on the cirque is shown by sporadic limonite stains.

The ore is essentially chalcocite accompanied by minor amounts of covellite, enargite, bornite, cuprite and malachite. Some native copper occurs and probably accounts for an assay of 78 per cent of copper from a sample taken by Mr. Radovan. A polished section of the same ore collected by Mr. S. H. Lorain of the U. S. Bureau of Mines contained all of the above named minerals and an unknown tentatively identified by the Bureau of Mines as algodonite. Assuming an average width of 6 inches, a length of 100 feet, and a depth equal to one-half the strike length, the vein may contain as much as 450 tons of chalcocite ore averaging 78 per cent of copper.

The fault zone contains a limonite-stained zone that was referred to by the prospectors as a dike. Careful observation failed to disclose any dike rock; the limonite zone is a re-crushed and re-cemented vein which, in places, is micro-breccia containing abundant fragments of the wall rock lavas. In unbroken segments the vein contains colloform bands of calcite, dolomite and chalcedony with masses of spongy limonite which probably were derived from pyrite. The agglomerate and lava wall rocks are extensively silicified and epidotized with epidote occurring as large masses and as small fracture fillings.

Development work at the Greenstone prospect consisted, on September 7, 1951, of 65 feet of a 5 by 7 foot drift trending S. 3° W. The drift is collared approximately 250 feet below and 200 feet north of the massive chalcocite in the fault. An oral statement that the drift was in approximately 165 feet by the last of November, 1951, was made by a member of the camp. Plans call for completion of about 200 feet of drift and a raise to exploit the ore above. A jeep and cat road leads from the camp near the Nelson prospect to the workings.

RADOVAN LOW-CONTACT PROSPECT

The Radovan Low-Contact prospect (see figure 2) is on a continuation of the fault zone of the Greenstone prospect. It is at the head of a steep, glacial valley about 150 feet above the contact of the Nikolai greenstone and Chitistone limestone on the east or downthrown side of the fault which here has a throw of approximately 1,000 feet. The fault strikes about N. 25° E. and dips 70°-75° SE. At the prospect the fault is indicated by a shattered zone as much as 100 feet wide containing dike-like bodies of a light rock that are cut by later shears and gouge zones. A limonite-stained band 8 feet wide represents the last movement through a zone which has been repeatedly broken and re-cemented with chalcedony, dolomite and calcite in colloform bands. Early banded vein material was re-crushed into fragments which contain colloform bands oriented at various angles to the latest colloform bands. A gouge about 1 foot thick is on the hangingwall of the zone, and contains scattered sulphides which appear to be bornite. Gangue minerals in the fault zone are quartz, calcite, dolomite and epidote.

A vein of copper minerals is exposed about 100 feet above the lower prospect tunnels. The writer was not able to sample the outcrop because the ice filling of the gully had melted away leaving a steep overhang just below the outcrop. Visual inspection from a distance of 30 to 40 feet indicated veins of chalcocite 1 to 6 inches wide over a surface length of 50 feet. The surrounding rocks were stained with malachite. Frequent rock showers down the fault zone make it hazardous to venture to this prospect and force one to take refuge in the tunnels in the ice filling the lower part of the cut. It is unlikely that a lone prospector will ever be able to examine safely the outcrops in the zone above.

Miller (1946, page 115) describes a "small dike of highly altered igneous material" in the lower part of the fault zone. Extensive sampling of the igneous-appearing bodies in the fault zone failed to convince the writer that they were truly dikes. In the writer's opinion they are hydrothermally altered fault breccias and micro-breccias locally containing enough of the lava footwall to appear in thin section as "highly altered igneous rock". The bodies contain no chill phases, and no baking effects are noticeable in the enclosing rocks. Limestone in contact with the bodies is not changed visibly.

Abundant float of realgar and orpiment appears in the loose material migrating down the fault zone although neither mineral was found in place. Mr. Radovan presented the writer with a specimen of stibnite-bearing calcite which came from a vein associated with the fault zone. Many of the bedding planes and minor associated faults within 500 yards of the fault zone are stained heavily with limonite indicating widespread lateral migration of sulphide-bearing solutions from the faults.

The following facts add up to a strong probability that deposits of copper and antimony are associated with this fault zone: 1. The fault zone is a major one showing sulphide minerals over a distance of 3 miles horizontally and 4,000 feet vertically. 2. Calcite filled fractures containing stibnite associated with the fault indicate movement well into the period of sulphide mineralization. 3. Bedding planes in the limestone, and minor cross faults, are stained heavily with limonite. 4. The rocks of the fault zone have been extensively silicified and epidotized by hydrothermal solutions circulating along the fault zone.

5. The projected continuation of this zone intersects a parallel-trending valley in Dan Creek, approximately 4 miles distance, in which is found massive stibnite float.1/ When considered together, these factors indicate that the zone should be prospected in detail, and that sulphide occurrences near the zone warrant exploratory work. The deterring factor to such prospecting is the almost unbelievable ruggedness of the terrain, and the shortness of the summer snow-free season which may amount to but a few weeks in late August and early September.

1/ Personal communication from Walter Holmes.

Because of a present tendency to call all copper deposits in the Chitistone limestone "Kennecott-type" deposits, the writer wishes to point out that little similarity exists between the mineralization at the Greenstone and Low-Contact prospects and the Kennecott and Nelson ore bodies. Realgar, orpiment and stibnite do not occur in the Kennecott ores, and the colloform bands of chalcedony and calcite at the Radovan prospects almost certainly denote relation to an igneous source. Widespread epidotization also indicates a magmatic source for the ores and gangues. The mineral assemblage, when considered in conjunction with the abundant colloform banding, indicates that associated ore deposits will be epithermal in habit. Another possibility is that the copper minerals in the fault zone at the Greenstone and Low-Contact prospect may belong to a different period of ore deposition than do the realgar, orpiment and stibnite. No evidence to support this possibility was noted, though the writer has not studied polished sections of ores. If the copper minerals do represent a period of mineralization distinct from that represented by the antimony and arsenic minerals, any exploration for massive chalcocite deposits may be based upon the assumption that structural controls of ore deposition similar to those conditions which obtained at the Kennecott mines may be encountered at the Low-Contact prospect. In the absence of definite information to indicate two separate periods of mineralization, the writer considers the various minerals to belong to one prolonged period of mineralization, and classes the deposits as epithermal.

BIBLIOGRAPHY

Bateman, A. M., 1932, Notes on a Kennecott type of copper deposit, Glacier Creek, Alaska: Econ. Geol., vol. 27, no. 3, pp. 297-306.

Miller, D. J., 1946, Copper deposits of the Nizina district, Alaska: U. S. Geol. Sur. Bull. 947-F, pp. 110-117.

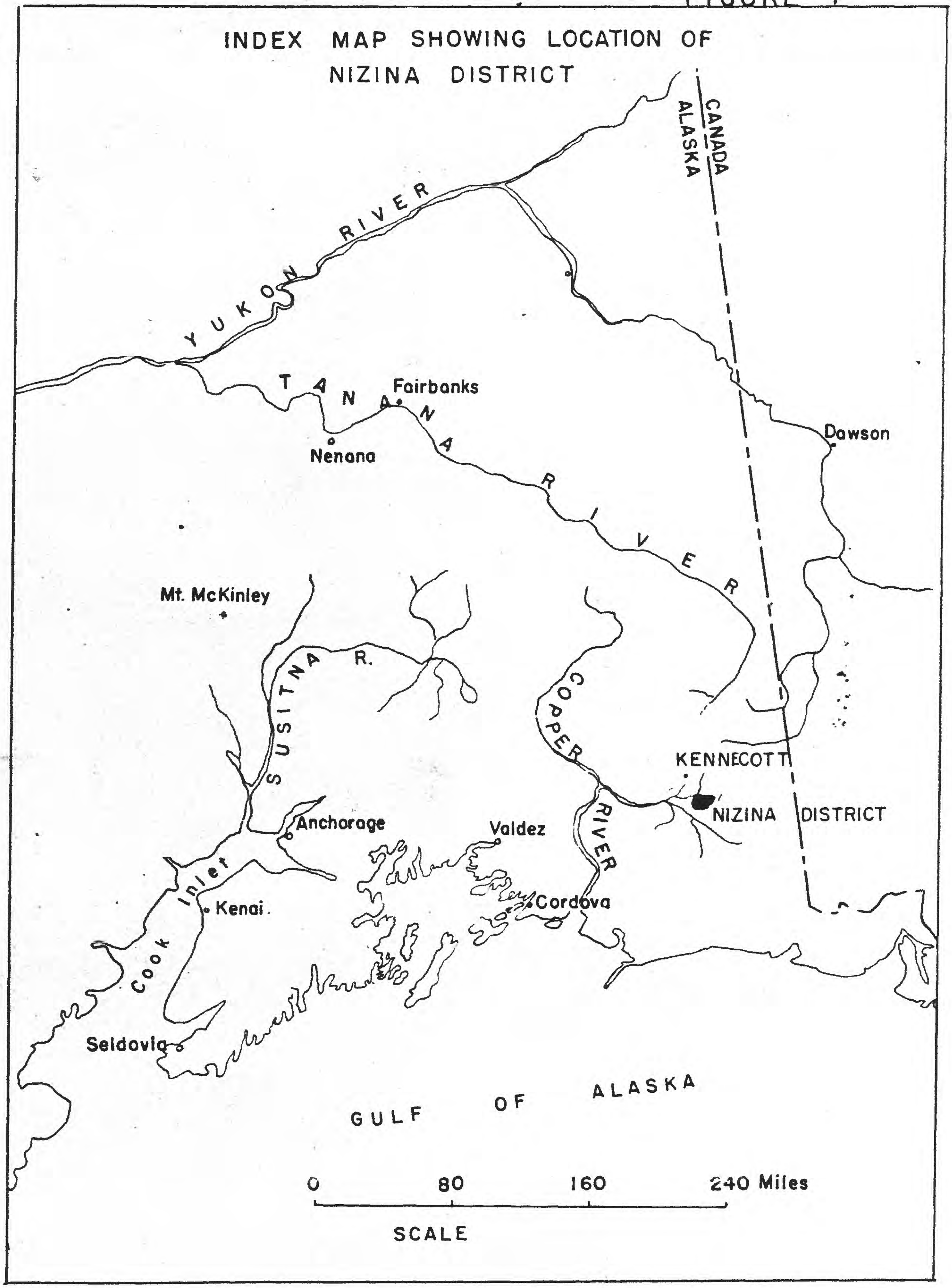
Moffit, F. H., 1938, Geology of the Chitina Valley and adjacent area, Alaska: U. S. Geol. Sur. Bull. 894.

Pilgrim, E. R., 1933, Mining investigations and mine inspection in Alaska, biennium ending March 31, 1933 (Report of Alaska Supervising Mining Engineer), pp. 88-90.

Richelsen, W. A., 1931, Supplemental report, Radovan prospect on Glacier Creek, Chitistone River district, Alaska: private report for Kennecott Copper Corporation.

Wright, W. S., and Tolonen, A. W., 1945, Chitistone Copper Deposits, Chitistone River area, Alaska: unpublished Report of Investigations, Bureau of Mines.

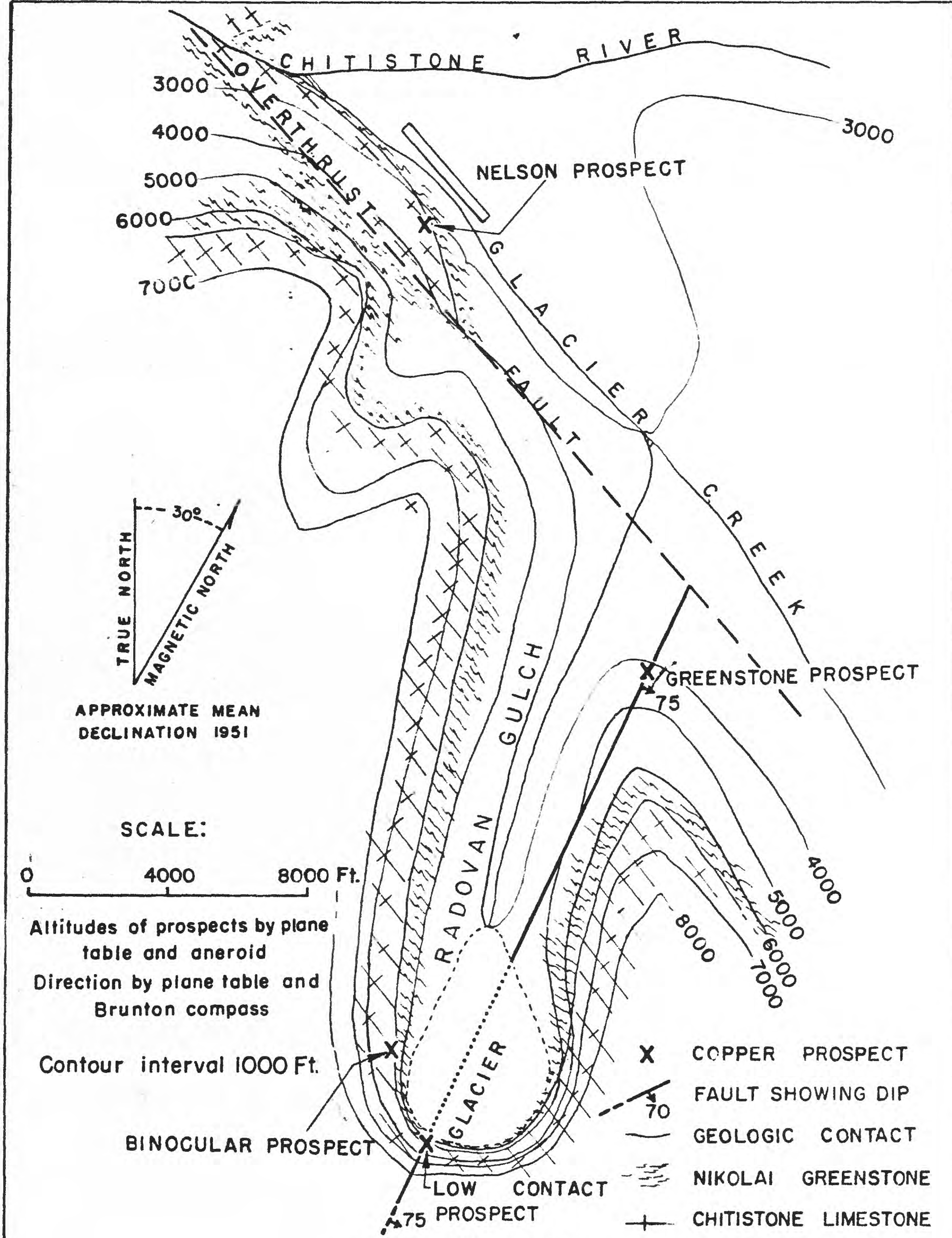
FIGURE 1


INDEX MAP SHOWING LOCATION OF NIZINA DISTRICT
CANADA
ALASKA
YUKON RIVER
TANANA RIVER
Fairbanks
Nenana
Dawson
Mt. McKinley
SUSITNA R.
COPPER RIVER
KENNECOTT
NIZINA DISTRICT
Anchorage
Valdez
Cook Inlet
Kenai
Cordova
Seldovia
GULF OF ALASKA
0
80
160
240 Miles
SCALE

U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

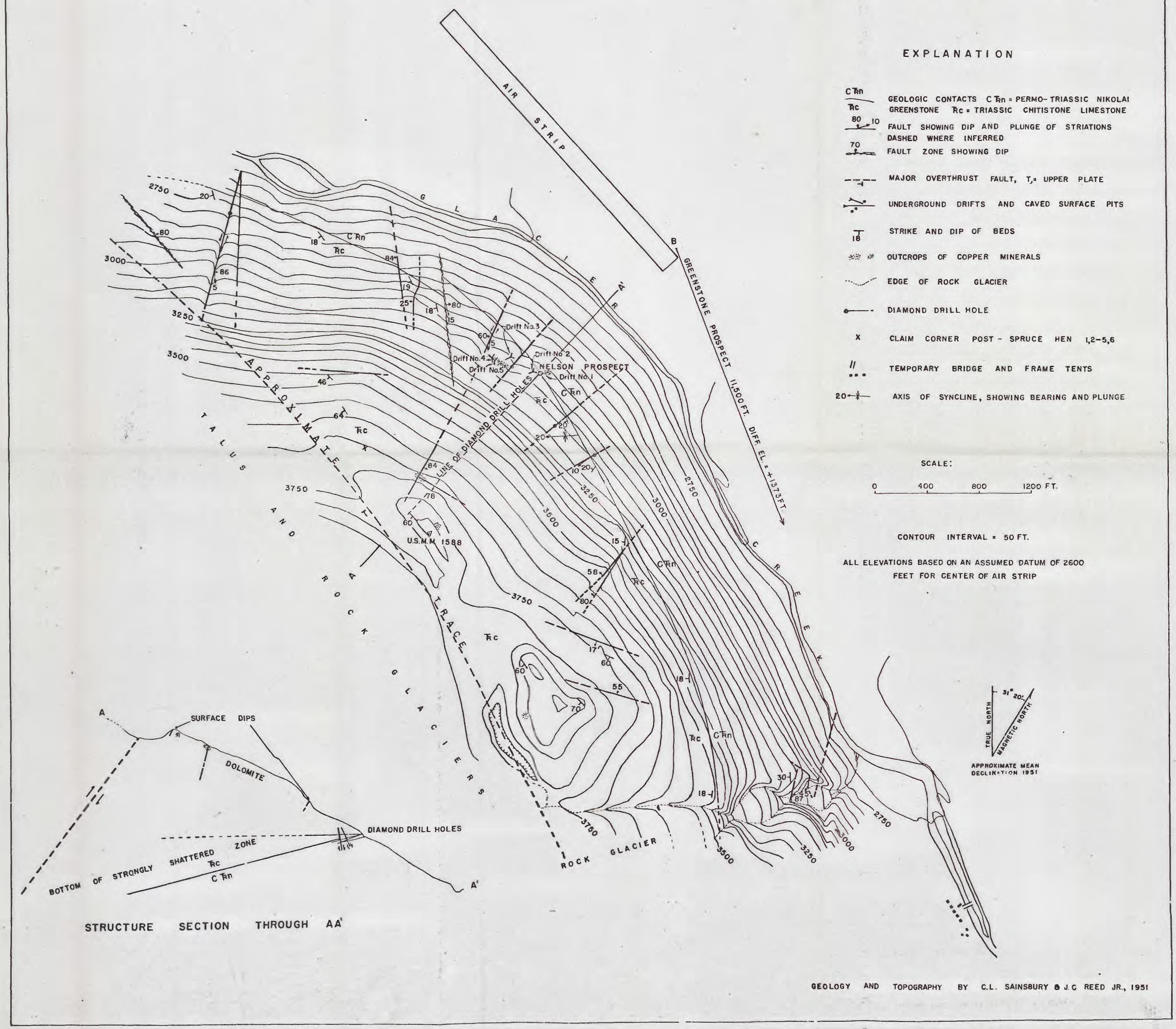
FIGURE 2



SKETCH MAP
NELSON AND RADOVAN PROSPECTS, GLACIER CREEK, ALAŞKA

Map by C.L. Sainsbury, Sept. 1951

GEOLOGIC MAP
NELSON PROSPECT AND VICINITY — NIZINA DISTRICT, ALASKA



GEOLOGY AND TOPOGRAPHY BY C.L. SAINSBURY & J.C. REED JR., 1951

SZ-134
OF-61

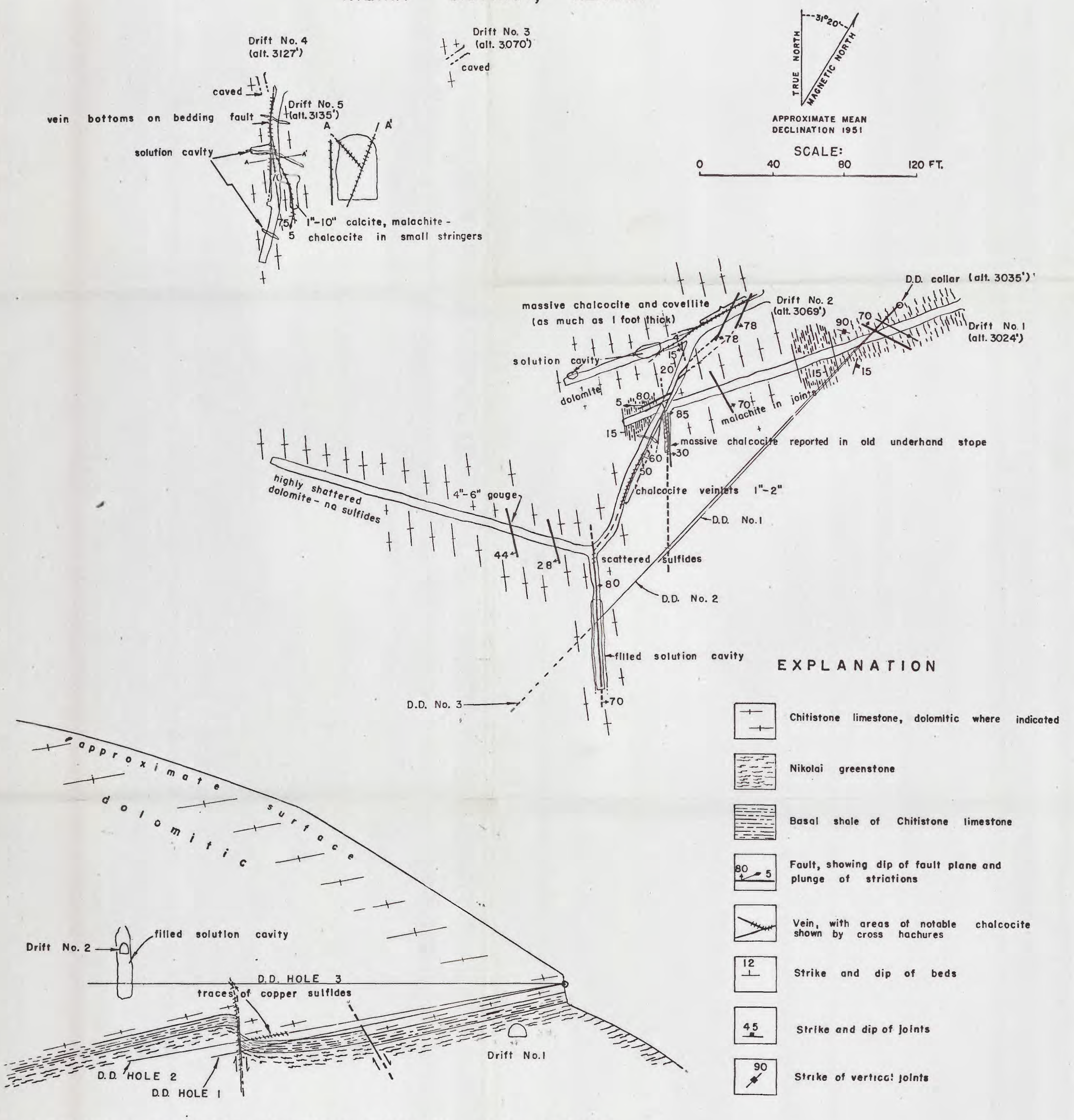
U. S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PLATE 2

UNDERGROUND WORKINGS

COMPOSITE GEOLOGIC MAP, NELSON PROSPECT

NIZINA DISTRICT, ALASKA



STRUCTURE SECTION THROUGH DIAMOND DRILL HOLES

SCALE:
0 40 80 120 FT.

ALL ELEVATIONS BASED ON AN ASSUMED DATUM OF 2600 FEET FOR CENTER OF AIR STRIP

MAP AND GEOLOGY BY C. L. SAINSBURY & J.C. REED JR., SEPT. 1951