GEOLOGIC AND GEOCHEMICAL INVESTIGATION OF THE "NAIL" ALLOCHTHON, EAST-CENTRAL ALASKA

By D. D. Southworth

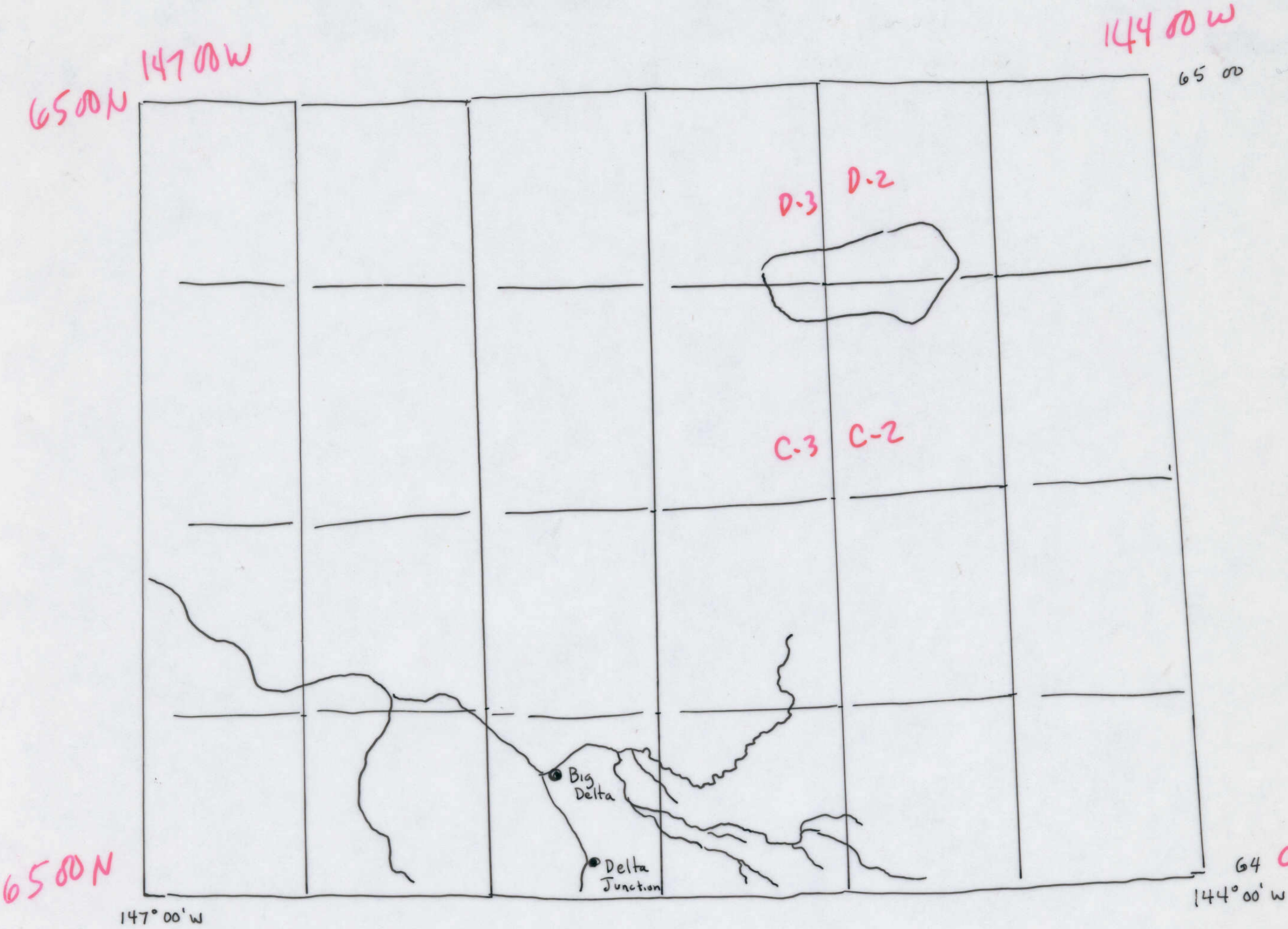

Figure 1. ~~Big Delta~~ Quad

Location of Study Area within the Big Delta Quadrangle

FIGURE 1. - Location of the study area within the Big Delta Quadrangle.

~~The~~ Use this as a base for making your location map

FIGURE 2. - Photomicrograph of silica-carbonate rock. Cdy - chalcedony, Crb - carbonate, Op - opal, Sil - silica.

CONTENTS

ILLUSTRATIONS

TABLES

Page

UNIT OF MEASURE ABBREVIATIONS

Abbreviation	Unit of measure	To convert to--	Multiply by--
cm	centimeter	inches	2.54
ft	foot	meters	.30
g	gram		
km	kilometer	miles	.622
km^2	square kilometers	square miles	.386
m	meter	feet	3.28
pct	percent		

GEOLOGIC AND GEOCHEMICAL INVESTIGATION OF THE "NAIL" ALLOCTHON, EAST-CENTRAL ALASKA

By D. D. Southworth[1]

INTRODUCTION

This report describes the geology of an approximately 24 square mile (60 km^2) area in the northwestern portion of the Big Delta Quadrangle. Included are geochemical analyses of 58 rock samples, 29 stream sediment samples, and 29 pan concentrate samples from the area, which includes portions of the Big Delta C-2, C-3, D-2 and D-3 Quadrangles (sampling procedures are described in the appendix). This investigation was undertaken during June, 1983 as a cooperative effort by the U.S. Bureau of Mines, in its effort to develop more definitive information on Alaska's strategic mineral reserves, the U.S. Geological Survey (USGS), and the Alaska Division of Geological and Geophysical Surveys (DGGS), as part of the DGGS "Chena Project."

ACKNOWLEDGMENTS

The author wishes to personally thank all of the personnel involved in the "Chena Project" for their cooperation, advice, assistance and companionship. Special thanks go to Thomas E. Smith, for advice and encouragement and to Florence Weber for helpful consultations on the metamorphic rocks.

J. Y. Foley and M. D. Albanese kindly consented to review this report and each offered many helpful comments and suggestions.

The author assumes sole responsibility for any errors of fact or omission. He also welcomes criticism, comment, or correction by the reader.

[1]Physical scientist technician, AFOC, Bureau of Mines, Fairbanks, AK.

LOCATION AND GENERAL GEOLOGY

The study area lies in the northeastern portion of the Big Delta Quadrangle, Alaska (fig. 1), approximately 55 miles (88.5 km) N 25° E from Delta Junction, Alaska. The focus of this study was on an area 24 square miles (60 km^2) in size. The surrounding terrain is characterized by relatively unglaciated, well-rounded hills and mountains. This portion of the Big Delta quadrangle is included in the Yukon-Tanana Upland physiographic province (Wahrhaftig, 1965). Drainages are mature and well-developed. Elevations below 3,300 ft (1,000 m) are covered by dense brush and trees. Higher elevations are frequently tundra-covered, however most of the ridge (here informally referred to as "Nail Ridge") is relatively unvegetated, laying as it does between 3,500 ft (1,067 m) and 5,531 ft (1,685 m) in elevation and being composed of rock types generally not conducive to plant growth. The creeks which drain the northwestern and western sides of Nail Ridge are tributary to the North Fork of the Salcha River; those draining to the northeast or south empty into the main channel of the Salcha.

The geology of the region is dominated by a complex assemblage of greenschist- to amphibolite-facies metamorphic rocks that have been locally intruded by Mesozoic and Tertiary stocks of dioritic to granitic composition (Foster and others, 1979). Locally, Tertiary sedimentary and volcanic rocks overlie both the intrusives and the metamorphic complex (Foster and others, 1979). On the basis of lithologic similarities to Paleozoic sequences elsewhere in Alaska and the Yukon Territory of Canada, Foster and others believe that the greenschist facies rocks mentioned above are probably Paleozoic in age. The ultramafic rocks, which are the subject of this report, are associated with and structurally overlie cherts that have yielded radiolaria and conodonts of Permian age (D. L. Jones, cited in Foster and others, 1979).

HISTORY AND PREVIOUS INVESTIGATIONS

Although portions of the Big Delta quadrangle were visited by H. T. Allen in 1885 (Allen, 1900), Brooks and Peters in 1898 (Brooks, 1900), and Prindle in 1903 (Prindle, 1905), the first published geologic description of the region was by Prindle (1906). Mertie's excellent compilation of the geology of the Yukon-Tanana region (Mertie, 1937) was published in 1937, and it remained the most detailed description of the area until 1978, when the Preliminary Geologic Map of the Big Delta Quadrangle (Weber and others, 1978) became available. This was followed in 1979 with the publication of the results of the Alaska Mineral Resource Assessment Program (AMRAP) for the Big Delta quadrangle (Foster and others, 1979). The Bureau of Mines visited the Nail Ridge area in 1964 (Thomas, 1965) and carried out a geochemical investigation of the 'Ricks prospect', a reported copper-nickel occurrence (see also Cobb, 19--). The present study was done in conjunction with DGGS, 1983, mapping and geochemical sampling of the Upper Chena River area (Smith and others, 1984, and Albanese, 1984).

LOCAL GEOLOGY

Collectively, the fresh and altered mafic and ultramafic rocks that form Nail Ridge constitute an approximately 8-mile- (12 km-) long, 2,000-ft- (610 m-) thick thrust sheet, overlying a complex assemblage of greenschist-facies metamorphic rocks. Tectonic slivers of gabbro a few meters in maximum dimension are scattered along the crest of the ridge. The main rock types forming Nail Ridge, however, are peridotites and altered peridotites including harzburgite, dunite, serpentinite, bright orange-weathering silica-carbonates, and massive, gray silica-carbonates.

Gabbroic Rocks

Medium-grained gabbroic and dioritic rocks are found along the crest of Nail Ridge, usually occurring as patches of rubble a few meters in area. Larger boulders occur, but are less frequently observed. Along the crest of the ridge these rock types are always surrounded by and structurally overlie peridotite.

The gabbroic rocks are medium- to dark gray in color. They are composed of subequal amounts of plagioclase and pyroxene with minor quartz, sphene, and chlorite. About one percent of fine magnetite is disseminated throughout, along with trace amounts of chalcopyrite. In thin section, actinolite is seen replacing pyroxene. Clay alteration of the feldspar is pronounced.

Similar gabbroic rocks are found in apparent fault contact with the ultramafic body along the south side of Nail Ridge, as well as at the western end of the ridge. At the eastern end, however, the dominant mafic mineral is more commonly hornblende, hence those rocks are more properly termed diorite.

Dunite

Dunite occurs as pods or lenses in harzburgite and constitutes an estimated 10 to 15 pct of the peridotite mass. In outcrop, dunite is distinguished from harzburgite primarily on the basis of an absence on weathered surfaces of the 'hobnail' texture common to the harzburgite.

The dunite is composed of medium- to coarse-grained olivine and 25 to 30 pct or more secondary serpentine minerals. Chromite (0.25 to 4 pct) is fairly evenly distributed, usually as individual grains, throughout the dunite; however rare schlieren and pods of chromite, a centimeter or two in maximum dimension, do occur. In addition, minor clinochrysotile asbestos (Weber and others, 1978) and finely-disseminated secondary magnetite are also present.

Harzburgite

Most of the relatively unaltered ultramafic rock present at Nail Ridge is harzburgite. In both chromite content and degree of serpentinization, the harzburgite is very similar to the dunite, however the harzburgite typically contains 20 to 30 pct orthopyroxene (enstatite). On weathered surfaces the relatively resistant, coarse orthopyroxene grains stand out in relief against the more recessive-weathering olivine, resulting in a classic 'hobnail' texture. As with the dunite, harzburgite at Nail Ridge contains 0.25 to 4 pct coarse, disseminated chromite; however chromite schlieren were not observed in harzburgite.

In several outcrops one can observe mineral lineations defined by the alignment of orthopyroxene or chromite grains in harzburgite. Such lineations are thin (<0.25 cm) and relatively long (up to 1.5 m). The blocky, rubbly nature of the outcrops at Nail Ridge, however, prevented tracing mineral lineations any great distance or for using them as structural indicators of 'up' or 'down', etc.

Enclosed within harzburgite are also rare, small vein-like segregations of clinopyroxene a few centimeters in size. Clinopyroxene appears to be restricted to these concentrations, and it is not a common constituent of most of the peridotite.

As exposed on the steeper north side of the ridge, the peridotite unit varies in thickness, from less than 50 ft (15.25 m) thick at the eastern and western ends of the ridge, to more than 800 ft (245 m) thick in the central portions.

Serpentinite

Over a vertical distance of a few meters, the degree of serpentinization of the peridotite increases dramatically until the original rock has become a massive, dark green to black serpentinite. Along the northern side of the ridge, this massive serpentinite forms a more or less continuous zone roughly 100 (30.5 m) to over 300 ft (90 m) thick. Thrust fault surfaces within and at the base of the serpentinite are well-exposed on the north side of the ridge, where they can be seen dipping to the south at an angle of about 20° to 30°. Slickensides are common. Although these thrust faults are not well exposed along the southern margin of Nail Ridge, they are observed at both the eastern and western extremities, there also seen dipping at low to moderate angles into the ridge.

Bright Orange Weathering Silica-Carbonate Rock

Directly underlying the massive serpentinite in most places is a bright orange-weathering, silica-carbonate rock. This distinctive alteration type is occasionally found in the same specimen with massive serpentinite at the contact between these two units and is believed to represent silica-carbonate replacement of serpentinite rock. The carbonate present in these rocks has been identified as ankerite by W. L. Gnagy (1965). The silica is mostly quartz, with minor opal and chalcedony (see fig. 2). Relict chromite grains with an associated mineral, identified as fuchsite by Gnagy (1965), are common. Fuchsite is a bright green, chromium mica here resulting from the alteration of chromian spinel, and in these rocks it is commonly observed as overgrowths on individual grains of chromian spinel. Fuchsite somewhat resembles malachite but is darker in color; it is also easily mistaken for garnierite, a hydrous nickel silicate, however both the copper and nickel content of these rocks is very low (table 3).

The bright orange-weathering unit forms a layer from 3 ft (1 m) to 55 ft

(50 m) thick and is exposed along most of the length of the north side of the ridge. This same unit is also found locally on the other sides of the ridge at approximately the same stratigraphic position.

Gray Silica-Carbonate Rock

For a distance of about three miles (5.5 km) in the central portion of the ridge, the orange-weathering quartz-ankerite rock is underlain by massive, gray silica-carbonate. This unit is easily mistaken for massive dolomite, however the carbonate has been identified by Weber and others (1978) as dominantly magnesite, with lesser dolomite. Relict grains of chromian spinel are present in some specimens near the contact with the orange-weathering unit, as are patches of the orange silica-ankerite. Chromian spinel content of the massive gray unit elsewhere is very low to nil, and fuchsite is absent. At one locality near the base of the gray carbonate unit small pods a few centimeters in diameter of malachite and azurite occur in the quartz and carbonate. The mineralized area however, is less than a few square meters, and mineralization is unevenly distributed. Interestingly, the orange-weathering carbonate unit is absent above the mineralized outcrop but was present above the gray unit immediately to both the east and west.

Metamorphic Assemblage

Underlying the ultramafic thrust sheet is a generally undifferentiated assemblage of various rock types: including andesitic volcanics, chert, calcareous black paper-shale, tan calc-phyllite, dark green quartz-chlorite schist, and tan to dark gray quartzite (Weber and others, 1978).

Along the northern side of Nail Ridge, the dark-green quartz-chlorite schist is commonly found directly beneath the ultramafic thrust sheet.

Both foliation and crenulation axes within the quartz-chlorite schist are oblique to the overlying thrust fault surface and clearly pre-date thrusting. The calcareous black paper shale and tan calc-phyllite are found only as very limited outcrops and as rubble beneath tundra. Neither is very thick nor very extensive; their structural relationships are not clear, but they occur between the quartz-chlorite schist and quartzite units.

The quartzite is fine to medium grained and locally contains minor chalcopyrite and pyrrhotite.

Minor chert is found underlying the ultramafic thrust sheet at the extreme eastern end of Nail Ridge. Weber and others (1978) report that radiolaria and conodonts from these cherts have been dated as Permian by D. L. Jones of the USGS.

Vesicular andesite occurs in section 18 (T2S. R14E) and may partially underlie the ultramafic thrust sheet. In this location small slivers of strongly serpentinized peridotite are found intercalated with andesite about 1.5 miles (2.4 km) south of the main body of Nail Ridge.

MINERAL OCCURRENCES

The investigation examined the economic potential of the Nail Ridge area for:

1) concentrations of chromite associated with peridotites,
2) platinum-group metals associated with chromite concentrations,
3) nickel and cobalt mineralization,
4) copper, antimony, arsenic and silver in quartz-carbonate rock, and
5) magnesite.

The results of these mineral investigations are as follows.

Chromium

Four samples of dunite containing disseminated chromian spinel were collected along the crest of Nail Ridge for beneficiation and metallurgical tests by the Bureau of Mines Albany Research Center. The chromian spinel was assumed to be chromite prior to these tests based on the common association of that mineral with dunite in ultramafic assemblages similar to those at Nail ridge. Results of the metallurgical tests run on samples of chromite-bearing dunite by Albany Research Center, are listed in table 4. These results indicate that the chromian spinel present at Nail Ridge is, based on the proportions of Cr, Fe, Mg, and Al (Irving, 1965), probably a high-aluminum, high-magnesium picrochromite, not chromite. A concentrate produced from EA20903 does not meet the requirements for industrial uses of chromian spinel, as specified by Papp (1983). The chromic oxide (Cr_2O_3) contents and chromium-to-iron ratios are too low to meet the requirements for metallurgical-grade (high-chromium), refractory-grade (high aluminum), or chemical-grade (high-iron) concentrates (Papp, 1983). Furthermore, because of the low chromian spinel content in the sample, only 26 pct of the chromium was recovered. This concentrate, therefore, may be classified as submarginal high-aluminum and would, at best, have limited uses as a refractory material for furnace lining in the metallurgical industry.

Platinum-Group Metals and Gold

Neither rock samples (table 3) collected on Nail Ridge nor pan concentrate samples (table 2) collected nearby from streams draining the ridge contained significant levels of any platinum-group metals or gold.

Nickel and Cobalt

Although portions of Nail Ridge were at one time staked for copper and nickel mineralization, the present investigation encountered no anomalous levels of nickel, in any sample.

Similarly, cobalt is present at Nail Ridge in no greater than average crustal abundances [average crustal abundance of cobalt in ultramafic rocks is 150 ppm (Levinson, 1974, p.43)].

Copper, Antinomy, Arsenic and Silver

At one location (49) within the silica-magnesite unit, small (<5 cm) pods of azurite and malachite-stained rock were found, which proved to be strongly anomalous in Cu (1.14 pct), Sb (6,800 ppm), As (174 ppm), and Ag (24.6 ppm). The mineralized area represented by this high-graded sample, however, is less than a few square meters, and mineralization is spotty within that. A few other samples of silica-carbonate rock (table 3) contained up to several hundred ppm Sb or As or both, but nowhere approached economic tenor.

Magnesite

The massive gray silica-carbonate rock present for about 3.5 miles at the base of Nail Ridge contains only up to 17 --- pct MgO (tables). Similar magnesite-rich bodies formed by carbonate alteration of peridotite and serpentinite do form mineable bodies elsewhere in the United States (see for example, Bodenlos, 1949), however MgO contents below about 95 to 98 pct are presently considered subeconomic.

DISCUSSION

Similar instances of silica-carbonate alteration of ultramafic rock are reported by other authors (Bailey and Everhardt, 1964, Barnes and others, 1973). Barnes and others (1973) give a brief overview and discussion of the literature on silica-carbonate alteration of serpentine, along with a detailed description of this type of alteration asociated with the mercury deposits of northern California, and Abbott (1982) gives a brief description of similar alteration associated with asbestos-bearing serpentinites in nearby Yukon Territory. In each of these descriptions, the alteration products consist dominantly of quartz, chalcedony, opal, and magnesite with lesser ankerite (or ankeritic dolomite), dolomite and calcite.

At Nail Ridge, the massive, gray silica-carbonate rock is composed dominantly of magnesite, with quartz, opal and chalcedony ~~(fig. 2)~~. Based on cross-cutting relationships and textures, the order of replacement appears to have been magnesite, quartz, opal, chalcedony.

In the silica-ankerite unit some serpentine veinlets still remain but are cross-cut by later veinlets of carbonate and silica (fig. 2). Relict grains of chromian spinel are also frequently preserved. It is apparent that carbonate replacement of serpentine occured along the mesh of serpentine veinlets that replaced the original olivine in an earlier, undated event. The fact that a few relict serpentine veinlets remain in the orange-weathering unit indicates that within that unit the alteration is not quite complete, although nearly so.

Further evidence that the alteration may not be complete in the upper portions of the silica-carbonate units is the preservation of the serpentinite texture, clearly evident on weathered surfaces of many of the silica-carbonate rocks examined. This strikingly preserved texture observed in similar rocks in California, suggests to Bailey and Everhart (1964) that the replacement involves a constant volume reaction. They conclude that this type of alteration involves the addition of CO_2, the loss of H_2O (and some MgO), and the retention of silica. The alteration fluid is not, according to Bailey and Everhart (1964), derived from the serpentine.

Barnes and others (1973) made a special study of the source of the fluids responsible for silica-carbonate alteration in mercury deposits of northern California and concluded that the source of the fluids was probably locally derived meteoric water with added metamorphic CO_2. Additionally, Barnes and others (1973) suggest that the fluids involved were at less than 100° C. No special study of similar fluids or their sources was made at Nail Ridge, and no conclusions can be reached, beyond pointing out that (1) the carbonate alteration clearly post-dates serpentinization, (2) the alteration is most pervasive at the base of the thrust sheet and hence, (3) the thrust fault surfaces probably served as the conduits for fluid migration.

At the base of the thrust sheet the alteration is most complete, with no serpentine textures or grains of chromian spinel preserved. As one approaches the orange-weathering, fuchsite-bearing horizon, both the serpentine textures and chromian spinel become more common. In the orange-weathering unit, chromian spinel is present in abundance similar to that of the relatively unaltered peridotite. The orange color probably results from higher Fe^{+2} content of the carbonate, ankerite or ankeritic dolomite, another indication that it is probably further from the main fluid conduit.

SUMMARY AND CONCLUSIONS

The peridotites and former peridotites in the vicinity of VABM "Nail" constitute an approximately 8-mile-long, 2000-ft-thick thrust sheet of probable Permian age which overlies a complex assemblage of Paleozoic(?) greenschist-facies metamorphic rocks. An extensive zone of carbonate alteration is present at the base of the ultramafic thrust sheet, probably resulting from the movement of fairly low temperature (<125°C) fluids, rich in CO_2, along the thrust plane. The carbonate alteration probably occurred some time after the structural emplacement of the thrust sheet.

The results of geochemical analyses of samples collected in the vicinity of Nail Ridge indicate that (1) the ultramafic rocks present do not constitute a potential chromite resource, (2) significant concentrations of platinum-group elements or gold are not present in either the bedrock or as placer concentrations in the streams draining the area, (3) although a single occurrence of silica-carbonate rock was found to be very strongly anomalous in copper, antimony, arsenic and silver, the very limited extent and mode of occurrence of the mineralization suggests that the likelihood of finding these elements in economical abundance is very low, and (4) although an extensive zone of magnesite-rich silica-carbonate rock is present at Nail Ridge, the relatively low MgO content of the rocks compared to other sources of MgO makes the economic potential of the silica-carbonate rock very low.

REFERENCES

Abbott, Grant, 1982, Origin of the Clinton Creek asbestos deposit: Yukon Exploration and Geology, p. 18-25.

Albanese, M. D., 1984, Geochemical reconnaissance of the upper Chena River area, Alaska: Analytical data on stream-sediment, pan concentrate and rock samples. Alaska Geological and Geophysical Surveys Report of Investigations 84-4, in press.

Allen, H. T., 1900, Report of an expedition to the Copper, Tanana, and Koyukuk Rivers, in the Territory of Alaska, in the year 1885. Ch. in Compilation: Narratives of explorations in Alaska, U.S. Govt Printing Office.

Bailey, E. H. and D. L. Everhart, 1964, Geology and quicksilver deposits of the New Almaden district, Santa Clara County, California: U.S. Geological Survey Professional Paper 360, 260 p.

Barnes, I., J. R. O'Neil, J. B. Rapp and D. E. White, 1973, Silica-carbonate alteration of serpentine: Wall rock alteration in mercury deposits of the California coast ranges: Economic Geology, v. 68, 1973, p. 388-398.

Bodenlos, A. J., 1950, Geology of the Red Mountain magnesite district, Santa Clara and Stanislaus Counties, California: California Div. of Mines and Geology Jour., v. 46, p. 233-278.

Brooks, A. H., 1900, A reconnaissance in the White and Tanana River basins, Alaska, in 1898: U.S. Geological Survey 20th Ann. Rep., Pt. 7, p. 425-494.

Cobb, E. H., Metallic mineral resources map of the Big Delta Quadrangle, Alaska: U.S. Geological Survey MF-388, scale 1:250,000, 1 sheet.

Foster, H. L. , N. R. D. Albert, Andrew Griscom, T. D. Hessin, W. D. Menzie, D. L. Turner, and F. H. Wilson, 1979, The Alaska mineral resource assessment program: Background information to accompany folio of geologic and mineral resource maps of the Big Delta Quadrangle, Alaska: U.S. Geological Survey Circular 783, 19 p.

Gnagy, W. L., 1965, Petrographic report on rock samples from the Big Delta Quadrangle, Alaska: Unpublished report. Available for inspection at U.S. Bureau of Mines, Fairbanks, AK.

Levinson, A. A., 1974, Introduction to exploration geochemistry: Applied Publishing, Ltd, Maywood, IL, 612 p.

Mertie, J. B., 1937, The Yukon-Tanana region, Alaska: U.S. Geological Survey Bulletin 872, 276 p.

Papp, J. F., 1983, Chromium: U.S. Bureau of Mines Mineral Commodity Profile, 21 p.

Prindle, L. M., 1905, The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, Alaska: U.S. Geological Survey Bulletin 251, 89 p.

Prindle, L. M., 1906, The Yukon-Tanana region, Alaska--description of Circle Quadrangle: U.S. Geological Survey Bulletin 295, 27 p.

Smith, T. E. and others, 1984, Geology of the upper Chena River area, Alaska: Alaska Geological and Geophysical Surveys Report of Investigations, in press.

Thomas, B. I. Written communication, 1965. Available for inspection at U.S. Bureau of Mines, Fairbanks, AK.

Wahrhaftig, Clyde, 1965, Physiographic division of Alaska: U.S. Geological Survey Professional Paper 482, 24 p.

Weber, F. R., H. L. Foster, T. E. C. Keith, and Cynthia Dusel-Bacon, 1978, Preliminary geologic map of the Big Delta Quadrangle, Alaska: U.S. Geological Survey Open-file report 78-529-A, scale 1:250,000.

APPENDIX.--SAMPLING AND ANALYTICAL PROCEDURES

Stream sediment and pan concentrate samples were collected by members of the DGGS staff, including J. W. Lindhorst, B. A. Doyle, D.- Coleman, and T. D. Balog.

Stream sediment samples (table 1) were collected with a steel shovel from the finer sandy portion of the active channel or deepest most active part of a dry creek bed. Organic-rich material was avoided. Samples were air-dried before screening at minus-80 mesh. Float rock and stream characteristics were noted and recorded at each station.

At each stream sediment sample location, separate pan concentrate samples (table 2) were collected to enhance recognition of resistant minerals with high specific gravity. As with the stream sediment samples, the pan samples were collected with a steel shovel from the silty, poorly sorted material in the active channel. One 16-in gold pan was filled with material which had passed through a 0.25-in mesh screen. This was panned to an approximately 50 to 100 g sample.

Rock samples (table 3) were usually taken as random chip samples across a geologic unit of interest; for example a suspected mineralized area or a zone of alteration. The outcrop characteristics of the area covered by the chip sample were recorded. Each sample approximated 1 to 2 lb in weight.

Lead, gold, silver, molybdenum, antimony and arsenic were analyzed at the DGGS laboratory by atomic-absorption spectrophotometry on aqua-regia digest. Copper, zinc, cobalt, nickel, iron, manganese and cadmium were analyzed at the DGGS laboratory by inductively coupled plasma atomic-emisssion spectrophotometry on aqua-regia digests. Lower limits of detection were 1 ppm for lead, antimony, molybdenum, copper, zinc, and cadmium; 10 ppm for arsenic, cobalt, nickel, iron, and manganese; and

STILL AWAITING Cr numbers from Milt

0.1 ppm for gold and silver. Chrome was analyzed by --------------. DGGS staff involved in these analyses include M.A. Wiltse,------------
--.

Platinum, paladium and gold were analyzed at the U.S. Bureau of Mines Reno, Nevada, Research Center by fire assay preconcentration followed by inductively coupled plasma, atomic-emission spectrophotometry on aqua-regia digests.

TABLE 1. - Stream sediment samples collected in the vicinity of VABM 'Nail,' Big Delta Quadrangle, Alaska.

(All analyses in ppm)

Sample[1]	Ag	Au	As	Cd	Co	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Zn
1......	<0.1	<0.1	<10	<1	19	24	37,600	552	<1	66	12	<1	66
2......	<.1	<.1	<10	<1	17	27	33,500	458	<1	136	15	<1	70
7......	.1	<.1	<10	<1	13	24	30,800	431	<1	65	14	<1	71
11.....	.1	<.1	<10	<1	21	33	36,800	566	<1	221	12	<1	86
18.....	<.1	<.1	<10	<1	22	31	42,100	552	<1	136	16	<1	74
23.....	.1	<.1	31	<1	15	27	32,700	513	<1	35	14	7	84
26.....	.4	<.1	21	<1	17	23	34,300	418	<1	122	71	4	83
34.....	<.1	<.1	19	<1	26	26	44,000	629	<1	261	16	<1	77
36.....	<.1	<.1	34	<1	17	37	39,600	643	<1	41	21	<1	81
37.....	<.1	<.1	51	<1	17	33	38,000	649	<1	39	38	2	97
44.....	.1	<.1	90	<1	27	32	46,000	670	<1	254	19	21	94
54.....	.2	<.1	235	<1	13	30	37,800	252	<1	36	43	13	101
56.....	<.1	<.1	21	<1	19	28	34,900	548	<1	171	19	9	87
60.....	.1	<.1	11	<1	22	29	38,000	490	<1	197	12	4	80
62.....	<.1	<.1	<10	<1	19	20	29,600	312	<1	146	12	<1	58
63.....	<.1	<.1	<10	<1	17	25	33,800	525	<1	78	12	<1	76
66.....	<.1	<.1	20	<1	17	26	33,100	1,150	<1	63	10	<1	71
67.....	<.1	<.1	<10	<1	17	26	30,600	577	<1	123	21	<1	68
68.....	<.1	<.1	<10	<1	18	25	31,600	437	<1	156	9	1	85
69.....	<.1	<.1	<10	<1	16	27	29,800	248	<1	161	14	<1	70
70.....	<.1	<.1	<10	<1	77	22	50,500	709	<1	1,420	<1	<1	46
71.....	<.1	<.1	<10	<1	81	29	56,500	801	<1	1,550	<1	<1	55
76.....	<.1	<.1	<10	<1	34	24	47,900	769	<1	310	10	<1	91
77.....	<.1	<.1	<10	<1	36	19	34,700	480	<1	594	4	<1	63
80.....	<.1	<.1	<10	<1	19	33	37,000	433	<1	186	31	<1	138
81.....	<.1	<.1	<10	<1	45	37	50,600	742	<1	690	7	<1	74
95.....	<.1	<.1	<10	<1	22	22	26,600	302	<1	239	7	<1	60
96.....	<.1	<.1	<10	<1	35	38	40,900	786	<1	491	11	<1	68
97.....	.3	<.1	<10	<1	19	29	35,700	450	<1	171	15	1	54

[1]At each stream sediment sample location a separate pan concentrate sample (see table 2) was also collected.

TABLE 2. - Analyses of pan concentrate samples collected in the vicinity of VABM 'Nail,' Big Delta Quadrangle, Alaska

Sample[1]	Au, oz/ton	Pd, oz/ton	Pt, oz/ton
1......	0.002	<0.002	<0.002
2......	<.002	<.002	<.002
7......	<.002	<.002	<.002
11.....	<.002	<.002	<.002
18.....	<.002	<.002	<.002
23.....	<.002	<.002	<.002
26.....	<.002	<.002	<.002
34.....	<.002	<.002	<.002
36.....	<.002	<.002	<.002
37.....	.002	<.002	<.002
44.....	<.002	<.002	<.002
54.....	<.002	<.002	<.002
56.....	<.002	<.002	<.002
60.....	<.002	<.002	<.002
62.....	<.002	<.002	<.002
63.....	<.002	<.002	<.002
66.....	<.002	<.002	<.002
67.....	<.002	<.002	<.002
68.....	<.002	<.002	<.002
69.....	.002	<.002	<.002
70.....	<.002	<.002	<.002
71.....	<.002	<.002	<.002
76.....	<.002	<.002	<.002
77.....	<.002	<.002	<.002
80.....	<.002	<.002	<.002
81.....	<.002	<.002	<.002
95.....	<.002	<.002	<.002
96.....	.002	<.002	<.002
97.....	.002	<.002	<.002

[1]At each pan concentrate sample location a separate stream sediment sample (see table 1) was also collected.

TABLE 3. - Geochemical analyses of rock samples collected in the vicinity of VABM 'Nail,' Big Delta Quadrangle, Alaska

Sample	Au, oz/ton	Pt, oz/ton	Pd, oz/ton	Ag, ppm	As, ppm	Cd, ppm	Co, ppm	Cr,	Cu, ppm	Fe, ppm	Mn, ppm	Mo, ppm	Ni, ppm	Pb, ppm	Sb, ppm	Zn, ppm
4.....	<0.0005	<0.0007	<0.0007	0.3	11	<1	55		12	39,400	505	<1	998	13	<1	13
6.....	<.0004	<.0007	<.0007	.1	<10	<1	<10		7	6,820	125	<1	76	6	1	10
8.....	--	--	--	<.1	<10	<2	93		11	41,400	630	<1	1,930	15	<1	36
9.....	<.0004	<.0006	<.0006	<.1	<10	<1	20		34	61,200	821	<1	76	6	<1	100
10....	<.0004	<.0006	<.0006	<.1	<10	<1	11		26	60,300	984	<1	35	10	<1	95
12....	<.0004	<.0006	<.0006	<.1	<10	<1	27		68	58,100	1,100	<1	62	5	<1	49
13....	<.0004	<.0006	<.0006	<.1	<10	<1	<10		6	17,700	473	2	16	2	<1	15
16....	<.0004	<.0006	<.0006	<.1	<10	<1	29		70	59,800	1,130	1	63	6	<1	50
17....	<.0004	<.0006	<.0006	<.1	<10	<1	87		5	45,300	757	<1	19	8	<1	32
19....	<.0005	<.0007	<.0007	<.1	<10	<1	<10		12	37,900	361	6	19	5	<1	31
20....	<.0004	<.0006	<.0006	<.1	<10	<1	11		44	85,800	766	3	12	8	<1	130
21....	<.0004	<.0006	<.0006	<.1	<10	<2	95		8	47,700	733	<1	2,040	9	<1	39
22....	<.0004	<.0006	<.0006	<.1	<10	<2	105		3	53,000	813	<1	2,230	18	<1	49
24....	<.0005	<.0008	<.0008	.1	<10	<1	<10		14	10,700	244	<1	37	13	<1	11
25....	<.0004	<.0006	<.0006	<.1	<10	<2	94		5	45,400	698	<1	2,210	18	<1	39
27....	<.0004	<.0006	<.0006	<.1	<10	<1	<10		8	24,300	160	<1	57	11	<1	16
28....	<.0004	<.0006	<.0006	<.1	<10	<1	<10		11	4,430	618	<1	14	27	<1	8
29....	<.0004	<.0006	<.0006	.1	<10	<1	<10		13	4,990	538	<1	10	22	4	10
30....	<.0004	<.0006	<.0006	<.1	<10	<1	<10		9	3,930	563	<1	13	25	<1	7
31....	<.0004	<.0006	<.0006	<.1	<10	<1	42		74	78,300	1,270	<1	148	16	<1	94
32....	<.0008	<.001	<.001	<.1	<10	<1	32		27	64,200	803	<1	124	17	<1	65
33....	<.0004	<.0006	<.0006	.1	16	<1	<10		11	7,380	749	<1	<10	25	1	6
35....	<.0008	<.001	<.001	.1	<10	<1	15		31	43,900	956	<1	30	35	<1	71
38....	<.0007	<.001	<.001	<.1	<10	<1	12		23	34,100	484	<1	30	7	<1	50
39....	<.0004	<.0006	.007	<.1	<10	<1	55		8	36,500	675	<1	1,040	15	1	11
40....	--	--	--	<.1	<10	<1	56		38	53,800	537	<1	911	13	<1	42
41....	<.0004	<.0006	<.0006	<.1	186	<1	61		7	35,200	572	<1	775	14	270	9
42....	<.0007	<.001	<.001	<.1	<10	<2	90		6	49,100	729	<1	1,920	16	<1	37
43....	<.0004	<.0006	<.0006	<.1	12	<1	56		12	35,800	630	<1	1,150	17	13	12
45....	<.0008	<.001	<.001	<.1	<10	<1	<10		40	38,700	130	<1	33	6	<1	55
46....	.001	<.0007	<.0007	<.1	<10	<1	17		25	40,600	914	<1	47	11	<1	79
47....	<.0004	<.0006	<.0006	<.1	234	<1	56		47	54,100	885	<1	599	8	<1	48
48....	<.0007	<.001	<.001	<.1	<10	<1	16		39	49,200	515	<1	53	16	<1	82
49....	<.0005	<.0007	<.0007	24.6	174	5	<50		11,400	9,160	537	<1	136	17	6,800	151
50....	<.0007	<.001	<.001	.7	<10	<1	<10		46	4,250	655	<1	<10	26	69	16
51....	<.0004	.001	<.0006	<.1	<10	<1	<10		119	20,300	298	<1	38	15	<1	27
52....	<.001	<.002	<.002	<.1	<10	<2	97		8	51,200	756	<1	2,070	18	<1	47
53....	.001	<.0006	<.0006	<.1	156	<1	40		10	29,600	102	<1	630	5	157	10
55....	<.002	<.003	<.003	<.1	<10	<2	88		14	47,700	618	<1	1,860	15	<1	35
57....	<.0005	<.0008	<.0008	<.1	344	<1	39		10	29,600	494	<1	715	14	91	8
58....	<.0006	<.0009	<.0009	<.1	<10	<1	10		81	21,800	341	<1	46	10	<10	20
59....	<.0005	<.0007	<.0007	.1	<10	<2	86		16	45,200	647	<1	1,880	15	<1	35
64....	<.0007	<.001	<.001	.1	104	<1	51		11	31,200	443	<1	887	11	155	12
72....	<.0004	<.0006	<.0006	<.1	<10	<2	93		18	48,300	724	<1	2,080	18	<1	38
73....	<.0004	<.0006	<.0006	.1	<10	<1	10		66	18,600	294	<1	32	11	<1	20
74....	<.0006	<.0009	<.0009	.1	<10	<2	104		24	53,100	806	<1	2,260	16	<1	46
75....	<.0005	<.0008	<.0008	<.1	<10	<1	41		36	29,200	452	<1	763	12	<1	23
78....	<.0006	<.0009	<.0009	<.1	<10	<1	10		70	17,800	913	<1	33	4	<1	17
82....	.001	<.0007	<.0007	<.1	<10	<2	89		12	45,000	715	<1	1,930	9	<1	34

See explanatory note at end of table.

Geochemical analyses of rock samples collected in the vicinity of VABM 'Nail,' Big Delta Quadrangle, Alaska--Continued

Sample	Au, oz/ton	Pt, oz/ton	Pd, oz/ton	Ag, ppm	As, ppm	Cd, ppm	Co, ppm	Cr,	Cu, ppm	Fe, ppm	Mn, ppm (MgO pct)	Mo, ppm	Ni, ppm	Pb, ppm	Sb, ppm	Zn, ppm
84....	<0.0004	<0.0006	<0.0006	<0.1	<10	<2	94		9	47,900	~~723~~	<1	2,000	20	<1	41
85....	--	--	--	<.1	<10	<2	87		14	45,300	~~701~~	<1	1,820	14	<1	31
87....	<.0004	<.0006	<.0006	<.1	<10	<1	22		48	65,800	~~864~~	3	28	5	<1	60
88....	<.0005	<.0008	<.0008	<.1	15	<1	20		40	39,900	~~858~~	<1	58	6	<1	33
89....	<.0004	<.0006	<.0006	<.1	<10	<1	<10		3	18,900	~~479~~	<1	16	2	<1	15
90....	<.0004	<.0006	<.0006	<.1	<10	<2	87		16	43,700	~~644~~	<1	1,900	8	<1	32
91....	<.0004	<.0006	<.0006	<.1	<10	<2	99		10	48,600	~~760~~	<1	2,110	16	<1	40
93....	<.0004	<.0006	<.0006	<.1	<10	<1	77		6	39,900	~~603~~	<1	1,240	8	<1	20
94....	<.0004	<.0006	<.0006	<.1	<10	<1	22		42	73,100	~~988~~	<1	22	5	<1	75

NOTE.-- -- indicates sample was not analyzed for this element.

Jean- SORRY!
We need to squeeze in
the two MgO results, so
let's just delete Mn column.
(MgO is in pct.)
Thanks
[illegible]

TABLE 4. - Analyses[1] of chromian spinel collected in the vicinity of VABN 'Nail,' Big Delta Quadrangle, Alaska

Sample	Type	Analysis, in pct					Cr recovery, pct	Cr:Fe ratio
		Cr_2O_3	Fe	Mgo	Al_2O_3	SiO_2		
EA20902	Bulk sample..	0.50	6.51	40.8	1.19	40.4		
EA20903	Bulk sample..	1.69	7.13	44.7	1.19	35.4		
EA20904	Bulk sample..	.53	6.60	39.4	1.38	39.1		
EA20905	Bulk sample..	.61	6.81	40.9	.57	34.6		
EA20903	Concentrate..	25.9	15.6	18.2	27.1	4.5	26	1.1

[1]Analyses performed by U.S. Bureau of Mines Albany, Oregon, Research Center. For description of analytical procedures, see U.S. Bureau of Mines Information Circular 8916, 1983.

DESCRIPTION OF MAP UNITS

Qac ALLUVIUM AND COLLUVIUM---Boulders, gravel, sand, silt, angular rock fragments. Includes alluvium of valley floor, alluvial fan debris, and colluvium on valley sides.[1]

Pgc GREENSTONE AND CHERT---Greenstone is light to dark green; fine to coarse grained; weakly developed foliation in places and at one locality contains small quartz-filled vesicles. Commonly composed of light-green to bluish-green amphibole with minor epidote, zoisite, chlorite, sericite, sphene and opaque minerals and randomly cut by thin veinlets of quartz, epidote and hematite. In places chert and greenstone are interlayered. Radiolaria and conodonts in red chert indicate a Permian age for this unit.[1]

Pgb GABBRO/DIORITE---Medium gray to dark gray in color; medium grained. Structurally overlies peridotite. Usually occurs as patches of rubble a few meters in area, larger boulders are less common. Gabbroic rocks contain subequal amounts of plagioclase and pyroxene, with minor quartz, sphene and chlorite along with about one percent fine disseminated magnetite and trace amounts of chalcopyrite. Actinolite is replacing pyroxene and clay alteration of feldspar is pronounced. Similar rocks along the eastern end of Nail Ridge contain hornblende as the dominant mafic mineral and are henced termed diorite.

Psa SILICA-ANKERITE ROCK--Bright orange-weathering silica-carbonate rock contains several percent disseminated fuchsite and relict chromite grains. Original peridotite texture visible on weathered surfaces. Forms a layer 3 to 55 ft thick directly beneath massive serpentinite along most of north side of Nail Ridge and found locally on other sides. Occasional veinlets of unreplaced serpentinite. Contact with overlying and underlying units locally gradational, locally faulted.

Psm SILICA-MAGNESITE ROCK---Dominantly magnesite and fine-grained quartz, with lesser dolomite and minor opal and chalcedony. Some late cross-cutting veinlets of quartz. From less than 100 to 250 ft thick. Original texture of peridotite locally preserved and visible on weathered surfaces. Relict chromite grains rare, occasionally preserved near contact with quartz-ankerite unit, locally contains small pods of azurite and malachite. In thrust contact with underlying metamorphic assemblage, contact with overlying quartz-ankerite rarely gradational, occasionally thrust fault.

Psr SERPENTINITE---Dark green to black, weathers dark reddish brown to greenish black to black. Massive. Dominant minerals are serpentine, lizardite and with minor veinlets of cross-fiber clinochrysotile and secondary magnetite. Forms a more or less continuous zone about 100 to over 300 ft thick on north side of Nail Ridge. Thrust faults at base of the unit dip into the ridge at about 20° to 30°. Slickensides common. On south and at eastern and western ends of ridge, serpentinite is dark brown in color and not well exposed.

Pu PERIDOTITE, PARTLY SERPENTINIZED--- Dark green to black; weathers a reddish orange brown; massive. Primary minerals are olivine, orthopyroxene (enstatite), clinopyroxene (scarce except where it occurs in lenses), and chromite. Secondary minerals are serpentine, lizardite and clino-chrysotile replacing olivine and orthopyroxene, and magnetite, formed during serpentinization. Cross-cutting veinlets of poorly developed cross-fiber clinochrysotile in a few places.[1]

Pzsg SEMISCHIST, GREENSCHIST, QUARTZITE, PHYLLITE, MARBLE, AND GREENSTONE---Greenish gray or gray and fine to coarse grained; very quartzitic to very feldspathic. Feldspar commonly micro-cline. Semischist interlayered with light green quartz mica schist, quartz sericite schist, and quartz chlorite epidote schist, tan and gray, fine- to medium-grained quartzite, gray and tan phyllite, and some grayish-green to dark green weakly foliated greenstone. Greenschist facies. Age unknown, but possible stratigraphic equivalent of the Totalinika schist in the northern Alaska Range and to the Klondike schist in the Yukon Territory.[1]