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Geology and Geochemistry of the Chandalar Area
Brooks Range, Alaska

By

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College, Alaska

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C O N T E N T S

APPENDICES

ILLUSTRATIONS

GEOLOGY AND GEOCHEMISTRY OF THE CHANDALAR AREA

BROOKS RANGE, ALASKA

By

E. R. Chipp

A B S T R A C T

The Chandalar area is the easternmost well-known gold district within a large mineralized belt in the Wiseman and Chandalar quadrangles of Northern Alaska. The area has long been recognized to contain some of the highest grade gold-quartz lodes in the Interior. During 47 days in July and August, 1969, 63 square miles were mapped and 147 stream sediment and 28 bedrock samples were collected.

Bedrock consists mainly of pelitic schist of Devonian age intruded by mafic to intermediate rocks metamorphosed to greenstone or greenschist. Intrusive rocks are considered Devonian(?) or younger, and possibly Jurassic, age. Two main lithologic units are mapped: the thick lower plate schist sequence with local beds of slate and siltstone, and the upper plate sequence of schist with mappable phyllite and quartzite-schist beds. Biotite or garnet-bearing schist occur locally near greenstone obtrusives in the lower plate sequence, but most of the schists are within the quartz-albite-muscovite-chlorite subfacies of the greenschist facies of regional metamorphism.

The gross structure is a homocline dipping northwest to northeast that is displaced by a thrust fault and high-angle, N57W trending, normal faults. Open folds trending north-northeast in the lower plate sequence suggest pressure from the east-southeast that is probably pre-thrusting and syn-metamorphic age. Metamorphism is postulated to be of Late Jurassic age. Minor east-west trending small folds approximately parallel the axis of the synclinal-shaped thrust fault and occur mostly within the upper plate sequence. A second and minor metamorphism may have occurred during thrusting and east-west folding.

The direction of thrust fault displacement is inferred to be northeast to north-northeast, but of unknown magnitude. The age of thrusting may be related to regional east-west folding and granitic intrusion in the southern part of the Chandalar quadrangle. An inferred middle Cretaceous age for this tectonic and igneous event is based in part upon isotopic age determinations by earlier workers. Generally east-west trending joints are prominent features and important in gold mineralization.

Known gold mineralization is confined to a north-northeast trending zone including upper Big Creek, Tobin Creek, Little Squaw Creek, and Big Squaw Creek. Small gold-quartz veins are best developed along N57W trending normal faults and east-west trending joints in the vicinity of the fault zones. Most of the veins are in phyllite in fault contact with more resistant schist or quartzite. Gold mineralization is probably related to a buried north-northeast trending granitic intrusion; however, a relationship to the metasomatism of greenstones is possible.

Gold, arsenopyrite, galena, sphalerite, and pyrite are minor constituents of the mineralized veins. Much of the gold is in native form and quite spectacular. Most sulfides are oxidized and leached in near surface exposures with scorodite, beudantite, limonite(?), and crystalline gold as secondary products.

Stream sediments in the north-northeast trending zone contain anomalous copper and silver values, although the copper content of lode samples is low. Anomalous values of lead and other elements in the northwestern area warrant additional sampling and analyses.

INTRODUCTION

PURPOSE AND SCOPE

The Chandalar area has been placer mined many years and has long been known to contain some of the highest grade gold lodes in the Interior. Recently the Chandalar Gold Mining and Milling Company completed its 100 ton per day mill and is currently mining one of the better known lodes. A detailed study was undertaken to relate the mineral deposits in the area to local and regional structures.

During 47 days in July and August, 1969, 63 square miles were mapped and 175 stream sediment and rock samples were collected for analyses. Definite controls are indicated which should assist future exploration and development in the area.

LOCATION AND ACCESS

The Chandalar area is in the Brooks Range of northern Alaska, approximately 200 miles north of Fairbanks and 100 miles northeast of Bettles. The area is centralized within the Chandalar quadrangle at about 67° N latitude and 148° 15' W longitude (*fig 1*).

A large airstrip on upper Tobin Creek and two short airstrips on upper Big Creek, as well as a winter trail from the maintained airstrip at Chandalar Lake, provide access to the area.

PREVIOUS INVESTIGATIONS

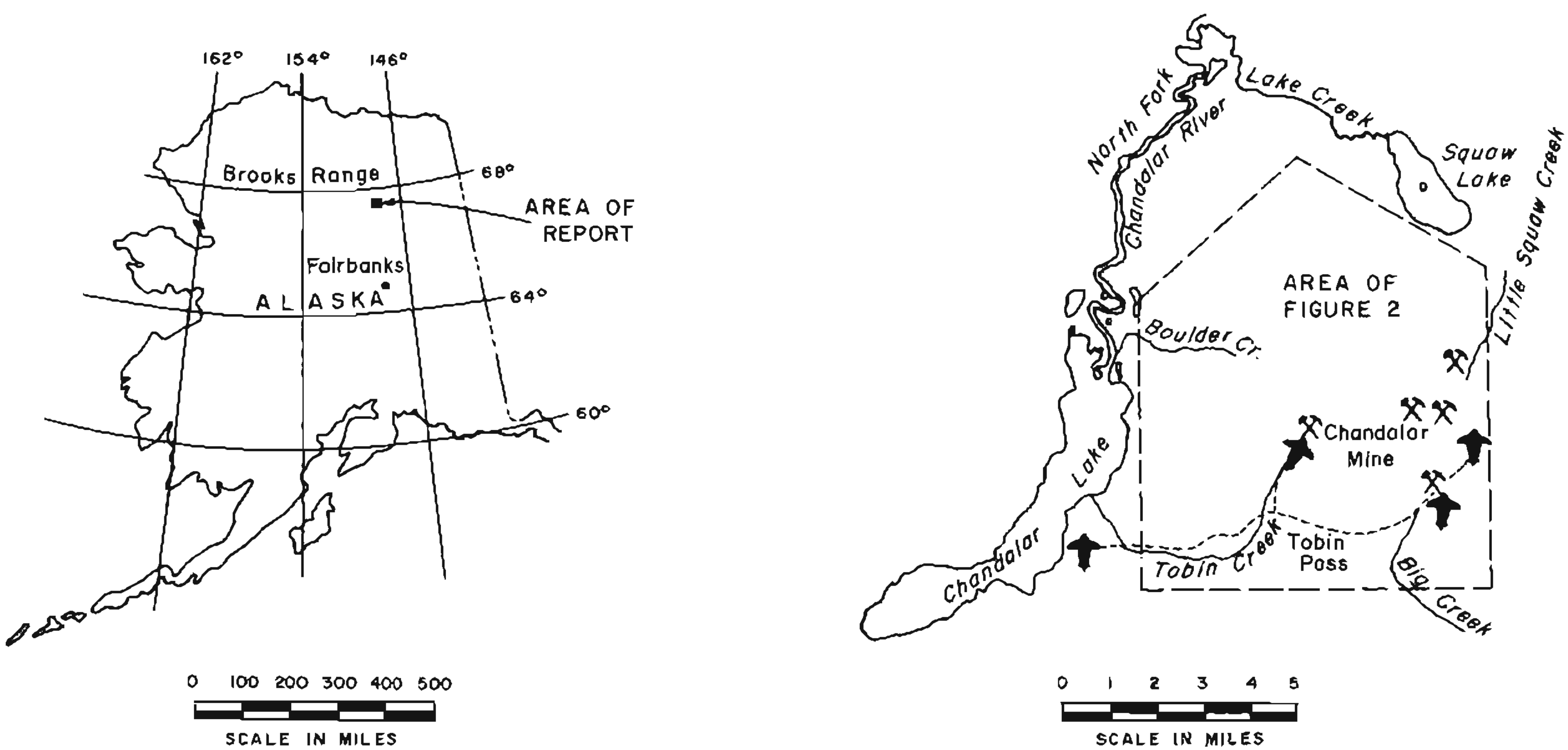
Schrader and Gerdine (1899) conducted the first geologic and topographic reconnaissance in the Chandalar and Koyukuk Rivers for the U. S. Geological Survey. Maddren (1909) included the Chandalar area within a more complete study of the Koyukuk Valley and in 1923, Mertie mapped most of the Chandalar quadrangle.

Specific reports on the Chandalar gold occurrences have been made by the Alaska Territorial Department of Mines. From 1927 to 1934, I. M. Reed and J. V. Stanford compiled data on the progress within the mining area and visited many of the prospects and mining operations. In 1946, Eskil Anderson examined and offered significant advice on the Big Creek placers. R. H. Saunders with the Alaska State Division of Mines and Minerals described the progress in the area after the revival of interest in the lode prospects in 1962.

The "Geology and Section of the Chandalar Quadrangle" by W. P. Brosge and H. N. Reiser was published by the U. S. Geological Survey in 1964. Their revised stratigraphy and structural interpretation has been of great value.

HISTORY AND PRODUCTION

The first known gold discoveries were between 1885 and 1890 at Tramway Bar, 70 miles southwest of Chandalar. About 1000 or more prospectors entered the Koyukuk Valley in 1899, and in 1901 and 1902 gold discoveries were made near Wiseman. A stable population of 200 people in the general area created a small mining community. Maddren (1909, p 291) stated



Location Maps of the Chandalar Area, Alaska

Figure 1

that placer gold production in the Nome and Fairbanks districts was larger, but the Koyukuk probably had an average higher per capita income than any other district in Alaska.

Thomas Carter and Frank Yasuda discovered placer gold in 1905 on Little Squaw Creek in the Chandalar area (Reed, 1929). Discovery on Big Creek followed in 1906. The new discovery took men out of the Koyukuk into Chandalar. About 100 men were engaged in prospecting and mining by 1907, with a total production of $28,000 (Brooks and others, p 46). Between 1906 and 1909 the largest placer production came from Big Creek and St. Mary's Gulch.

The Little Squaw camp was well established by 1908 and a post office was built. Most of the miners, however, wintered at Caro 48 miles south of Chandalar or at Beaver on the Yukon River. The Alaska Road Commission, about 1911, built a wagon road 74 miles from Beaver to Caro (Reed, 1929). From Caro, there was a trail 48 miles long up Big Creek and over the divide to Little Squaw. Much of the food and supplies were freighted by dog-team from Beaver.

By 1909, four principal gold-quartz lodes were recognized and considered by Maddren (1910) to hold the most promise for the Chandalar. A road was built from the Little Squaw lode to the mill-site on Spring Creek in 1909-1910, and a small stamp mill was hauled to Big Creek to test the Little Squaw lode. Shafts and tunnels had been driven by 1913 on the showings in upper Tobin Creek (the Little Mikado lode), the Summit area, and Little Squaw Creek. Regardless of the early interest in the rich lode deposits, placer mining continued to be the only important mining until the present time. Placer mining had been done by hand methods, shoveling-in, ground-sluicing, or drifting.

After World War II, Anderson (1946) pointed out that the Chandalar area was one of the few important placer districts that had not been mined by mechanical methods. Since then Big Creek was mined with the use of bulldozers and has subsequently produced as much or more than the original value of gold mined by hand methods. By 1931, placer ground had been blocked out on Tobin Creek and Frank Birch is currently placer mining there.

In 1960, the Little Squaw Mining Company reopened the underground workings on the Little Mikado lode and drove more than 600 feet of new underground workings. With OME assistance in 1962, the Little Squaw Mining Company began trenching on some of the veins in the area using bulldozers formerly used for placer mining. Currently, Chandalar Gold Mining and Milling Company under sub-lease from Little Squaw Mining Company, a subsidiary of Grandview Mines and Metaline Mining and Leasing Company, is mining the Little Mikado lode and milling approximately 100 tons per day in their mill on Tobin Creek.

Placer production in the area is estimated at 40,000 ounces of gold (Heiner and Wolff, p 14), or $1,400,000 at $35.00 per ounce. Big Creek produced a total of $500,000 or more, and approximately $350,000 total since 1950 (Wolff, personal communication). With the recent placer production from Tobin Creek and the expected lode production in the future, the Chandalar area promises to become still more important.

ACKNOWLEDGEMENTS

The author is indebted to many people, especially Mr. Frank Birch of the Chandalar Gold Mining and Milling Company, for allowing use of their cabin and airstrip on Big Creek. His assistance in many other ways, as well as numerous suggestions, is greatly appreciated. Mr. Richard S. Kunter of the University of Idaho ably and cheerfully assisted the author in the field. Private reports on the mines and prospects were generously provided by Mr. Eskil Anderson of the Chandalar Gold Mining and Milling Company.

GEOLOGY

REGIONAL SETTING

Around the Chandalar area, bedrock is mostly schist, phyllite, and slate of Devonian age and limestone of earlier Devonian age (Brosge and Reiser, 1964). Metamorphism is greenschist facies grade, but locally higher grade metamorphism occurs around granitic intrusions. Greenstone sills and dikes are locally abundant and believed to be equivalent to pyroxene andesite flows and pyroxene diorite intrusions of Late Devonian(?) age that occur in the southern part of the Chandalar quadrangle (Brosge and Reiser, 1964). However, the greenstone sills and dikes may be the same relative age as the large mafic igneous complex in the Christian quadrangle to the east that was dated as Early or Middle Jurassic (Reiser, Lanphere, and Brosge, 1965; and Brosge and Reiser, 1964).

Structurally, the Chandalar area is part of a large region containing northeast trending folds and thrust plates, locally intruded by granitic intrusives elongated mostly northeast, and bordered along the south by east-west trending folds (best observed within the Wiseman quadrangle, Brosge and Reiser, 1960) and a granitic batholith elongated east-west.

STRATIGRAPHY

Lower Plate Sequence

Black Schist unit (D_{bls})

The lower plate sequence of black schist, phyllite, and slate is considered to be the oldest unit in the Chandalar area. Thin beds of quartzite occur in the area near the Dome and numerous bodies of greenstone and greenschist have intruded this unit in many localities (*fig 2*). Volcanic material is a minor constituent of the dominantly pelitic lithology.

The D_{bls} unit is approximately equivalent to the quartz-muscovite-chlorite schist (D_{qs}) mapped by Brosge and Reiser (1964). The D_{qs} unit is stated by Brosge and Reiser to be approximately equivalent to the black siltstone (D_{st}), of Late Devonian age, and to occur locally over basal conglomerate of the "Slate and Sandstone" unit.

The black schist unit is in thrust contact with the overlying schist, phyllite, and quartzite-schist units. Bedding and foliation dip 20 to 40 degrees northeast to northwest in the southern area and flatten considerably in the north. Crenulations and open folds plunge 10 to 40 degrees generally north to northeast. The black schist unit is estimated to be greater than 3000 feet thick.

In the upper Big Creek and northern area, the D_{bls} unit is dominantly fine-grained, dark gray to black, carbonaceous, quartz-muscovite-chlorite schist to phyllite. Quartz is subordinate to muscovite in many localities, albite is locally abundant, and chlorite is mostly less than 10%. Very fine-grained white quartzite seams less than 2 mm thick are common locally and probably represent bedding. Crenulations and chevron folds locally contain quartz segregations along the axial crests and parallel to axial plane cleavages.

In the Dome and Tobin Creek area, the D_{bls} unit contains black slate and phyllite beds usually less than 200 feet thick, interbedded with thin beds of fine-grained quartzite and schist. The phyllite is occasionally spotted with chlorite or albite and locally changes laterally into schist within a few hundreds of feet. One bed of black metasiltstone occurs beneath the greenstone sill west of Tobin Creek. This bed indicates minor metamorphism and shearing in local areas of the lower plate rocks.

South of Tobin Creek, as well as in the extreme eastern area of black schist exposure in upper Big Creek, the D_{bls} unit contains thin boudins of greenschist in the centers of small folds. They are dark green to black, up to 3 inches thick and less than 6 inches long, and commonly rolled and twisted with folding in the schist. One thin section contains quartz, calcite, and chlorite in approximately equal proportions and totaling 75% of the rock; the remaining 25% consists of albite, epidote, muscovite, and sphene. Approximately one half mile east of the Dome, one outcrop of interbedded quartzite and greenschist contains fine laminations and cross-bedding structures. The greenschist may be a water-laid tuff with considerably detrital quartz.

Pelitic sediments regionally metamorphosed to lowest grade greenschist facies are most prevalent in the D_{bls} unit. Individual beds of phyllite, slate, and siltstone in a predominantly schist sequence suggest that schistosity was produced only in zones where shearing was important. However, the chemical composition of some beds may have retarded recrystallization. Slightly-spotted slate occurs in St. Mary's Gulch and Pedro Gulch, but most rock type is schist in the upper Big Creek area. Albite schist with biotite and garnet near greenstone contacts indicates higher-grade metamorphism in local thermal aureoles. Within a few feet of the greenstone along the south side of the Dome, medium-grained, quartz-albite-biotite-chlorite schist occurs with minor garnet. Albite porphyroblasts are up to 5 mm in diameter and gray, on occasion, due to inclusions. Chlorite partially replaces biotite and, to a lesser extent, garnet. Ragged garnet crystal borders and marginal chloritization of biotite suggest metamorphism may be retrogressive.

The interbedded schist and slate near the Dome and Tobin Creek forms a ridge and terrace topography due to the varying resistance to weathering in individual beds. Jointing and schistosity cause the schist to weather into pencil-like pieces. Where jointing is not closely spaced, the schists form flat slabs. The metasiltstone and slate beds form terraces covered by small, flat chips that are excellent for walking and building roads.

Upper Plate Sequence

The upper plate sequence includes the lower-most schist unit (Ds) and a major interbed of phyllite (Ds_{ph}), called the Mikado Phyllite, overlain by the phyllite-schist unit (Dphs) and quartzite-schist to schistose quartzite unit (Dqts). Contacts between the units are gradational and generalized in some areas. The upper plate sequence is approximately equivalent to the quartz-muscovite schist (Dqm) of Brosge and Reiser (1964), which is considered Upper Devonian age.

The Ds unit is estimated to be more than 5000 feet thick west of Tobin Creek and approximately 3500 feet thick west of Big Creek. Within the Ds unit, the Mikado Phyllite bed averages 600 feet thick. The Dphs unit is approximately 700 feet thick and appears to pinch out to the northwest. The uppermost Dqts unit is faulted and eroded, and probably more than 1000 feet thick. Local beds and contacts suggest that most foliation is parallel to bedding, and most thickness estimates are based largely upon foliation.

Schist unit (Ds) with the Mikado Phyllite (Ds_{ph})

The basal unit of the upper plate sequence is primarily quartz-muscovite schist with interbeds of phyllite and minor schistose quartzite. The thickest and most lithologically distinct interbed is called the Mikado Phyllite (Ds_{ph}), but most interbeds of phyllite and quartzite are less than 10 feet thick and lenticular. A few greenschist occurrences are less than 10 feet thick and probably represent metamorphosed mafic sills.

White quartz segregations and bands less than 10 mm wide, which often resemble Z-configurations, are locally abundant and characteristic of the Ds unit. The most notable occurrences are found above the Mikado Phyllite and east of the Dome area within the lower part of the unit. Along the road and between the Mikado and Star lodes (*fig 2*), this same phenomenon is found within the Mikado Phyllite bed. There the Mikado Phyllite contains thin (less than 5 mm) quartz seams en echelon fashion along the crests of crenulations trending N60W.

The dominant rock is medium to dark gray, slightly carbonaceous, quartz-muscovite schist with minor chlorite and rare albite. Grain size ranges from 0.1 to 0.5 mm. The rock is resistant to weathering and forms bold outcrops with large, angular slabs in frost-heaved piles. Weathered surfaces commonly have yellow to orange stains due to iron oxides.

The Mikado Phyllite (Ds_{ph}) trends northwest across most of the mapped area. It is repeated by high-angle faulting, especially by the Mikado fault. The best known gold lodes occur in the bed where it is highly sheared, jointed and iron-stained.

The phyllite is a conspicuous dark gray, fine-grained rock with much less quartz in veinlets or original bedding than the enclosing schist. One thin section contained 35% quartz, 40% muscovite, 10% chlorite, and 15% opaques (mostly carbonaceous material and hematite-limonite). Quartz in thin seams parallel to bedding is fine-grained and apparently granulated, but some quartz occurs in slightly cross-cutting veinlets. Chlorite occurs up to 1 mm long with the long axis oriented parallel to the cleavage, or on occasion oblique or perpendicular to the cleavage where it apparently crystallized late with the cross-cutting quartz.

Along ridge crests, the phyllite weathers to low saddles or flat terraces. It is much less resistant to weathering processes and the talus is mostly small chips or thin plates.

Phyllite-Schist unit (Dphs)

The Dphs unit crops out in the northern part of the area, mostly in the Little Squaw and Big Squaw Creek drainages. High-angle faulting repeats the unit in both creeks. Contacts are gradational with the Ds unit stratigraphically below and the Dqts unit above. Fine grain size and commonly lighter color is characteristic as well as small segregations of quartz and pyrrhotite.

Quartz-muscovite-chlorite phyllite to phyllite-schist is the dominant rock in the Dphs unit. Thin laminae of quartz-rich, phyllitic schist and chlorite-rich phyllite are common and suggest original compositional variations. The coarser-grained phyllitic schist is medium gray and the phyllite is darker gray with more carbonaceous material. The rock weathers rusty red in some areas due to iron oxides and is commonly jointed and considerably less resistant to weathering processes than the two contiguous units. Pyrrhotite masses, or rarely crystals, occur abundantly with or without quartz in the Dphs unit in both the Little and Big Squaw Creek areas. They are common to the northwest and rarely occur in the contiguous units. The pyrrhotite masses are up to 1-1/2 inches thick and 3 inches long, but the average size is much less. Zones of dilation caused by differential movement within thin laminae may be the control for emplacement. Crenulations are often strong in the phyllite laminae and fade out in harder quartz-rich laminae. They produce a lineation that commonly plunges down dip parallel to the major schistosity. Pyrrhotite masses occur along the axial crests of the crenulations or form in rolls with quartz. Chalcopyrite and arsenopyrite(?) occur sparingly along with the pyrrhotite.

Quartzite-Schist unit (Dqts)

Approximately 1000 feet of interbedded schistose quartzite to quartzite schist with minor, but locally abundant, interbeds of schist and phyllite comprise the uppermost unit of the upper plate sequence. It is in thrust contact with the lower plate sequence to the north and in gradational contact with the Dphs unit lying stratigraphically lower and to the south. The unit is relatively resistant to erosion and forms a prominent ridge as well as a sharp break in slope with both contiguous units. Very hard quartzite beds up to 5 or 10 feet thick are numerous and form sharp serrated ridges along ridge tops.

The schistose quartzite beds contain up to 90% quartz with minor muscovite, chlorite, and a trace of apatite, sphene, epidote, and albite. Carbonaceous material along with hematite and limonite comprise less than 2% of the total rock. Individual beds vary from almost white to tan or light gray. Quartz grains are less than 0.3 mm in diameter and indicate granulation with recrystallization into mosaics of xenoblastic quartz. Muscovite and chlorite flakes are lepidoblastic and impart schistosity to the rock. Many thin beds of quartz-muscovite schist and phyllite are medium to dark gray and not distinctly different than beds in the lower units.

West of the landslide (*fig 2*) at approximately 4000 feet elevation, minor areas of quartz-albite-muscovite-chlorite schist occur with a trace of sphene, magnetite, and carbonaceous material. Albite porphyroblasts up to 2 mm in diameter contain microlites and carbonaceous material. The small areas of albitic schist may indicate the proximity of greenstone intrusions. Albitization with gneissic banding is similar to that found near the Dome area.

INTRUSIVE ROCKS

Greenstone (Dg) and Greenschist (Dgs)

Greenstone sills and a few dikes intrude the lower plate sequence in many areas. The upper plate sequence is lacking in larger greenstone bodies, but does contain a few thin sills, or rarely dikes, of greenstone or greenschist. Some of the larger greenstone sills are schistose along the borders and gradationally less schistose toward the centers. Greenstone and greenschist rocks are considered to be the same relative age and of the same origin, but differing in the degrees of shearing and metamorphism. Brosge and Reiser (1964) have mapped greenstone and greenschist as Devonian(?) age and probably equivalent to volcanic rocks in the southern part of the Chandalar quadrangle. They note that, since the Chandalar quadrangle map was submitted for publication, similar volcanic rocks intruding sedimentary rocks of Carbonaceous or younger age were mapped in the Christian and Coleen quadrangles. The large mafic igneous complex in the Christian quadrangle may be Early or Middle Jurassic age by potassium-argon isotopic age determinations on hornblende and plagioclase (Reiser, Lanphere, and Brosge, 1965). Their suggested age is further substantiated by Triassic age fossils in some of the intruded rock. Patton and Tailleur (1964, p 481) in the Killik-Itkillik region, date by field relations small sills of albite-diabase, diabase, and basalt, as latest Jurassic age. They find only one episode of igneous activity in that area. Mertie (1925, p 224 and 245) described three types of greenstones in the Chandalar region and thought they represented intrusions of more than one Paleozoic age. He felt that the ones intruding the Devonian and Mississippian rocks may be late Paleozoic in age and correlated them with the basic extrusive and intrusive rocks of the Rampart group. For these reasons greenstone and greenschist in the Chandalar area are tentatively considered Devonian(?) or younger, and possibly Jurassic in age.

The greenstone intrusives are mineralogically similar, but grain size and textures vary locally. Actinolite, clinozoisite and epidote comprise about 80% of the rock with minor calcite-dolomite, chlorite, albite, sphene, and quartz. In Pedro Gulch, most greenstones are granoblastic to blastoporphyritic with actinolite porphyroblasts up to 5 mm. Actinolite porphyroblasts are intimately associated with clinozoisite, epidote, and sphene, which may indicate replacement of titaniferous pyroxene or hornblende. Concentrations of fine grained quartz-albite-clinozoisite-calcite may be former plagioclase phenocrysts. Groundmass minerals are fine grained aggregates of clinozoisite, epidote, calcite, chlorite, with minor quartz and albite.

Greenstone in Pedro Gulch is green to dark gray-green, locally schistose near borders, and iron stained on weathered surfaces. Minor pyrrhotite and chalcopyrite occur near fault zones. Small segregations of albite (An_3) with minor quartz, calcite, and chlorite occur in the weathered talus. Some albite crystals are up to 15 mm long, partially bent and granulated. Small blades of chlorite are aligned along the albite cleavages, suggesting they both crystallized simultaneously.

In the Dome area, greenstone is fine grained and granoblastic. In one thin section, pyroxene(?) less than 0.1 mm in diameter is mostly replaced by epidote, clinozoisite, sphene, and chlorite. Sphene in very small peripheral granules suggests the pyroxene(?) may be titaniferous augite.

The larger greenstone body in the southern area is coarse grained and blastophitic. Actinolite up to 4 mm poikilitically encloses relic plagioclase with Carlsbad twinning. Concentric zones of quartz or clinozoisite and albite parallel to the relic crystal outlines indicate that the plagioclase was zoned and partially replaced by silica. Thin fractures are filled with quartz and chlorite.

The schistose border of the larger greenstone in the southern area contains albite porphyroblasts in a matrix of chlorite with minor clinozoisite and epidote. One thin section taken in the transitional zone between the chlorite-rich and actinolite-rich areas indicates fracturing and shearing were instrumental in producing the chlorite-albite mineralization or schistosity in the greenschist phase. Chlorite replaces the clinozoisite-epidote suite along thin fractures that occasionally wrap around albite porphyroblasts.

X-ray diffraction patterns of three greenstone and greenschist samples tentatively identify the chlorite in each case as aphrosiderite. Aphrosiderite contains abundant ferrous iron. Microscopically, it is medium green, biaxial (+), and anomalous brown under crossed nicols. Weathering of the chlorite results in abundant iron staining.

Quartz in the greenschists often appears in fine grained (less than 0.1 mm) mosaics that suggest partial replacement of chlorite, clinozoisite, and calcite. Zircon is abundant as microlites poikilitically enclosed by quartz, muscovite, or albite. Chlorite rarely contains pleochroic haloes surrounding very small crystals of monazite(?). Monazite is reported to occur in the placer concentrates of the area (Mertie, 1925, p 263; White, 1952, p 8; Nelson et al, 1952, p 16).

The greenstone and greenschist probably represent pre-metamorphic or syn-metamorphic mafic to possibly intermediate intrusives that were metamorphosed to low grade greenschist facies during regional metamorphism. Relic textures indicate they varied from equigranular and fine grained to porphyritic or ophitic and coarse grained. This would suggest that they were gabbroic, diabasic, or possibly dioritic.

The mineralogy of the greenstone and greenschist, as well as albite segregations and albitization of the host rocks in local areas near greenstones, indicate soda metasomatism was related to the greenstone intrusions. Quartz veining around the greenstone bodies and silica replacement of minerals in the greenstone and greenschist suggest silica metasomatism was also associated with the emplacement of the instrusions. Minor veins of quartz and albite occur throughout the area. They are usually less than 3 inches thick and mostly found in the weathered talus rubble. More than one stage of quartz veining occurred in the area, which will be discussed more fully in the section on ore deposits.

SURFICIAL DEPOSITS

The larger streams in the Chandalar area contain locally thick deposits of silt, sand, gravel, and boulders. Slopes are mostly covered by colluvium consisting of large angular slabs of schist or greenstone. Colluvium deposits are similar to and merge with frost-heaved deposits along ridge tops.

Pleistocene glacial deposits that are largely transported from the north are found up to 3000 feet elevation, and locally higher. Glacial deposits occur only along the western and northern areas. They are made conspicuous by the presence of granodiorite, marble, and coarse-grained graywacke boulders.

Large benches of glacial lake deposits occur in lower Tobin Creek and Boulder Creek. They are unconsolidated and slightly stratified silt to boulder beds and average sand size. They were probably formed in small lakes adjacent to large valley glaciers during Pleistocene time. The lower reaches of most of the large streams contain glacial deposits that include much material transported from the north. Mertie (1923, p 239 and 254-260) discusses glaciation and the history of the major drainages much more completely.

STRUCTURE

Regional Structure

Northeast and east-trending structures are major features along the southern flank of the Brooks Range in the Wiseman, Chandalar, and Christian quadrangles (Brosge and Reiser, 1960, 1962, and 1964). Large northeast-trending fold belts, with lithologic contacts commonly thrust faulted, occur in the northern parts of the quadrangles, and the northeast-trending granitic intrusion in the Baby Creek area 20 miles west of Chandalar forms the core of a large anticlinal fold (Brosge and Reiser, 1964). East-trending structural features are dominant in the southern parts of the quadrangles. The Kobuk Trough, which contains continental strata of Cretaceous age, pinches out eastward in the southwest corner of the Chandalar quadrangle about 40 miles southwest of the mapped area.

Isotopic age determinations on micas indicate that the latest metamorphism occurred in Late Jurassic to middle Cretaceous time (Brosge and Reiser, 1964). Mica from the pluton in the northern part of the Chandalar quadrangle has an isotopic age of 125 million years, and mica from the southern pluton is 101 million years old. The two ages of metamorphism from northeast and east-trending plutons may indicate the northeast-trending structures are Late Jurassic in age and the east-trending structures are middle Cretaceous in age. These two inferred ages of tectonism with different orientations agree with observations in the Chandalar area.

In the Killik-Itkillik region in the Arctic foothills section of the Brooks Range (north and east of the Chandalar quadrangle), the source material for Triassic shelf deposits was derived from the north. Jurassic and Cretaceous rocks, in contrast, are geosynclinal deposits derived mainly from the south (Patton and Tailleur, 1964, p 493). They state that "from Late Jurassic until Late Cretaceous time recurrent tectonic activity in the region of the Brooks Range provided a rising land mass which shed vast quantities of detritus northward into a subsiding eastward trending trough, the Colville geosyncline, that lay across the area of the Arctic foothills and coastal plain".

General Structure in the Chandalar Area

The Chandalar area includes a northeast to northwest dipping homocline with minor north-northeast folds. The upper plate sequence was overthrust and both lower and upper plate sequcnces were later displaced by northwest and east-northeast-trending, high-angle, normal faults. North-northeast-trending folds suggest pressure from the east-southeast. They were possibly contemporaneous with the Late Jurassic age of metamorphism and inferred tectonism on the regional scale. Minor folds and crenulations that trend northwest to nearly west occur mostly in the northern part of the mapped area in the upper thrust plate. These small folds are approximately parallel to the axis of the synclinal-shaped thrust plate and are probably related to the forces that produced thrust faulting towards the northeast or north-northeast. The thrust fault and minor northwest to west-trending folds may be related to the generally east-west folding assumed to have occurred during Middle Cretaceous time. Northwest and east-northeast-trending, high-angle, normal faults are probably related to uplift in Cretaceous or Tertiary time.

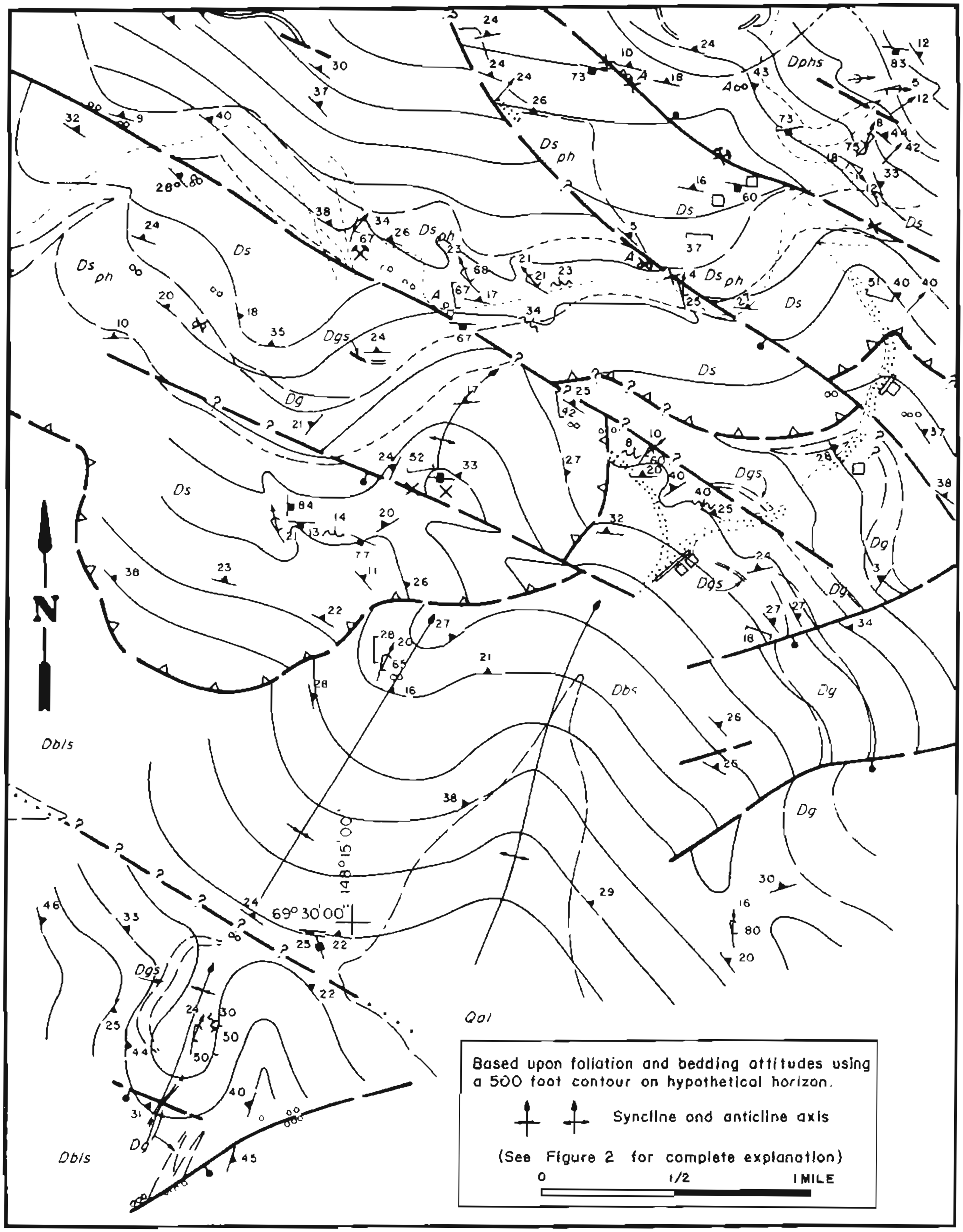
Thrust Faulting

Field evidence for thrust faulting of the upper plate sequence over the lower plate sequence includes: (1) the lower plate sequence (Dbls) is in contact with the stratigraphically highest unit (Dqts) of the upper thrust plate, (2) a slight angular discordance exists between the lower and upper plate rocks in many areas, (3) fold patterns and attitudes of small folds and crenulations are mostly discordant between the two plates (*figs 2 and 3*), (4) the upper plate rocks are pervasively metamorphosed but contain only minor greenstone intrusions; the lower plate rocks are locally metamorphosed to higher and lower grades and contain abundant greenstone intrusions, and (5) the upper plate rocks locally display evidence of much shearing and minor polymetamorphism (Z-configurations and two orientations of mica).

The synclinal shape of the thrust plane is inferred on the basis of mapped field relations. The trace of the thrust in upper Big Creek indicates a horizontal to 20° northerly dip (*fig 2, section B-B'*). West of Tobin Creek the dip is approximately 17° northeast. A variable to opposite southwest dip is suggested by mapping in the northern area.

Contacts along the thrust fault are rarely clean exposures. The upper plate sequence is more resistant than the lower plate rocks and an abrupt or gradual break in slope occurs along this tectonic zone. In many areas, large angular slabs of upper plate schist forms a thick accumulation of colluvium over lower plate rocks.

North-northeast to northeast direction of thrust fault displacement is suggested for the following reasons: (1) axes of small folds and crenulations along the northern contact area are mostly oriented northwest to west-northwest approximately parallel to the long axis of the synclinal-shaped thrust plane (*fig 2*), and (2) folds have steeper northern



Form - Line Contour Map Upper Big Creek Area

Figure 3

limbs indicating north-directed pressure (*fig 4*). A few small folds with the same trend occur in the lower plate sequence, but the majority are within the upper plate sequence in the northern area.

Folding

North-northeast-trending folds are mapped in the southeastern part of the area and largely confined to the lower plate sequence. Smaller northwest to west-northwest-trending folds are most numerous in the upper plate sequence and in the northern and northwestern areas.

North-northeast-trending folds in the southern and upper Big Creek areas are mostly open, plunge north-northeast to northeast, and have large amplitudes and wave lengths (*figs 3 and 5*). The northwest to west-northwest-trending folds are small, isoclinal to open folds plunging northwest. Amplitudes range from inches to perhaps tens of feet. Other larger unmapped folds are suggested by the presence of numerous crenulations and small folds. Crenulations and small folds are concentrated within the axial portions of larger folds in the southern area. During the course of mapping, most crenulations observed had magnitudes less than 10 millimeters. The folds are less than 3 feet from crest to crest with amplitudes less than a foot.

Compression along a generally east-west axis produced the north-northeast to north-trending folds. In many observations, westward displacements of a few millimeters occur between thin bedding laminae. Some folds are assymetrical with the eastern limbs steeper. East-west compression and the primary metamorphism were probably synchronous events. Pyrrhotite and quartz segregations are metamorphic phenomena that produce a B-lineation perpendicular to the generally east-west compression. In the upper part of Little Squaw Creek pyrrhotite and quartz fill minor dilations along the crests of north-northeast trending small folds and plunge up to 42 degrees northeast parallel to the dip of the primary foliation (*fig 5*).

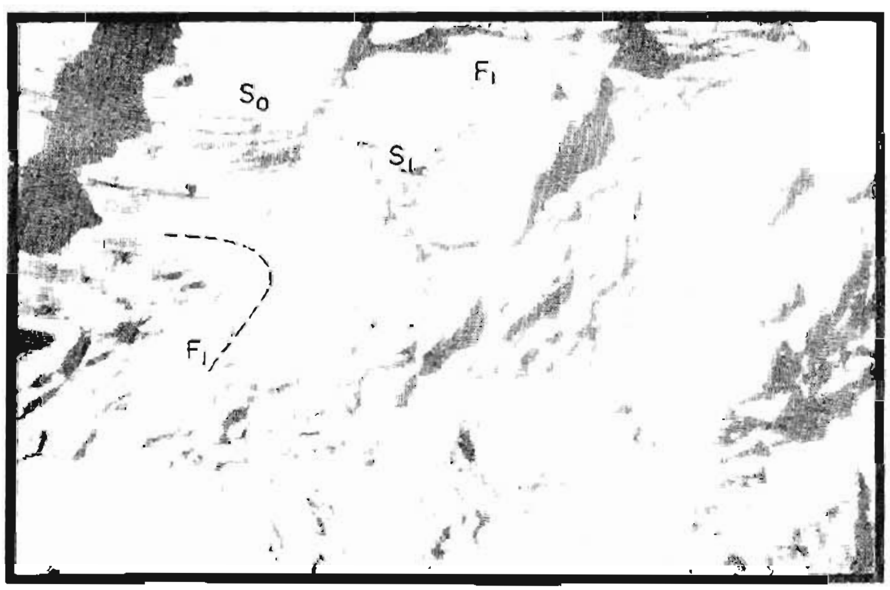
The northwest to west-northwest trending small folds and crenulations along the northern part of the thrust plate are not obviously related to larger folds, although sufficient detail is lacking in these areas at present. In the upper part of Little Squaw Creek, crenulations trend N70E and parallel small folds with wave lengths varying from 1 to 3 feet. Similar observations were noted along the spur between Little Squaw and Big Squaw Creeks. As stated previously, these folds and crenulations are probably related to thrust faulting.

High-Angle Faulting

Two sets of high-angle normal faults occur in the mapped area. Prominent N57W trending faults have large displacements and trend approximately N30W to the west and northwest where they have less offset or terminate. In the southern area, N70E trending faults displace greenstone intrusions with offsets measured in hundreds of feet.

Major N57W trending faults have had recurrent movement and are the loci for gold lode deposits. The Mikado fault is nearly vertical and displaces the Mikado Phyllite more than 500 feet down on the southwest side. The Summit fault dips up to 65° northeast and has probably displaced the Dphs unit at least 1500 feet, as shown by the sections in figure 1.

Other minor N57W trending faults undoubtedly occur within the mapped area. By the construction of form-line contours (*fig 3*), a fault is inferred in Tobin Pass trending approximately northwest along the course of the stream.



PHOTOGRAPHS OF ROADCUT NEAR LITTLE SQUAW MINE PORTAL

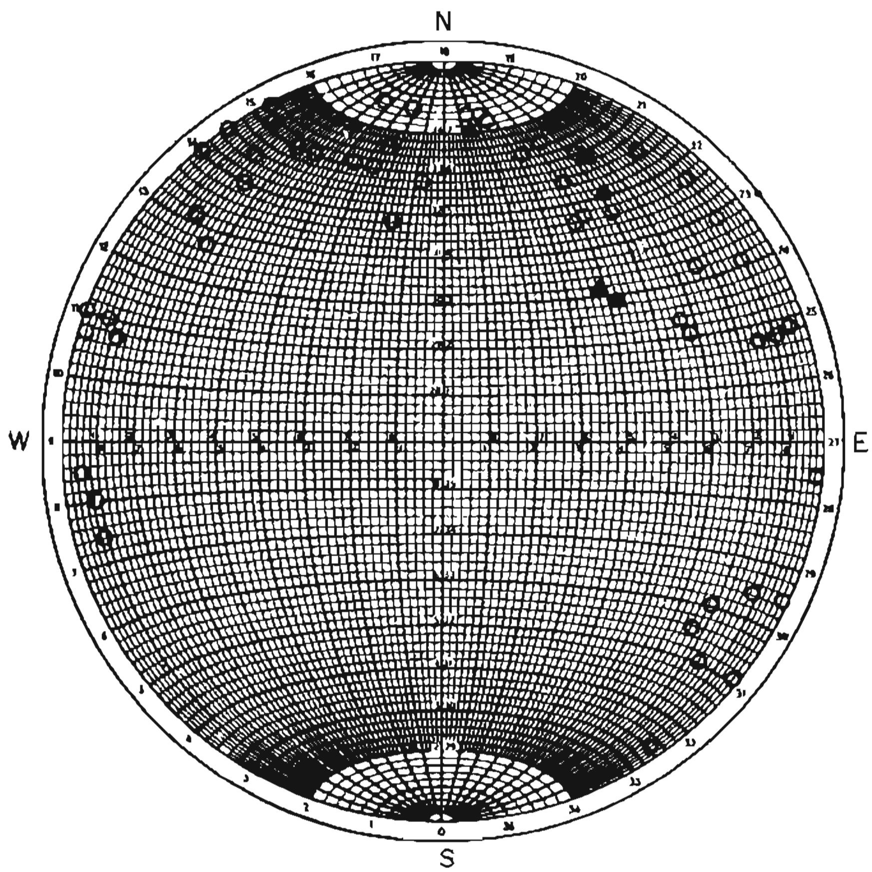
(Looking approximately west). Bedrock is Dgts unit (mostly schist with quartzite-schist interbeds here). S_0 is primary foliation; S_1 is axial plane cleavage trending N 80° W, and dipping 18° SW. F_1 shows small folds and crenulations trending N 85° W, and dipping 9°-29° south. Small folds are partially confined to joints. a-quartzite bed. b-fault with minor reverse displacement. c-note fractures trend E-W (±) with steep south dip.

Figure 4

EXPLANATION

○ Plunge of folds and crenulations - lineations defined by plunge of fold axis along fold crests

▲ Plunge of pyrrhotite and quartz segregations.



Equal Area Projection of Lineations

Chandalar Area, Alaska

Faults trending approximately N70E in Pedro Gulch and the southern area dip 60° to 75° southeast with the southeast side down. These faults do not indicate recurrent movement but are loci for quartz in some areas. A north-trending fault along the east side of the Dome shows greenschist offset and quartz veining. This may be a northwesterly trending fault that has deflected more northerly than most along the western part of the mapped area.

Many of the fault traces are obvious only where they cross ridge tops and form low passes. Quartz float is common along the traces of many faults and the early prospectors dug many prospect pits which help in the recognition of some faults.

Uplift within the Brooks Range geanticline began in the Jurassic and continued intermittently throughout Cretaceous and Tertiary time (Payne, 1955). The age of high-angle faulting in the Chandalar area is post thrusting and probably related to uplift in Cretaceous or Early Tertiary time. Brecciation and shearing in some quartz veins indicates there was more than one period of movement.

Jointing

Two prominent joint patterns occur in the Chandalar area (*fig 6*). Fractures trending N80W and dipping 65° to 90° south are the most numerous and persistent. A few of these joints dip northward at high angles. A less prominent fracture pattern occurs at right angles to the N80W set. These trend approximately N10E and dip at high angles east or west. A few other trends occur but are not persistent. Shallow dipping joints are random, often follow foliation and stop at steeper joints.

The tectonics that produced the persistent joint patterns are highly speculative. East-trending joints depicted in figure 4 rarely have minor offset and are probably related to northward compression. Most of these east-trending joints, however, are extensional, and contain vuggy quartz crystals which may indicate they are related to the relaxation of northward directed compressional forces or tension produced by northward compression and uplift. The fact that the east-trending joints are commonly quartz filled, and that many of the larger quartz veins strike approximately east, suggests that they are early fractures and very important in exploration for gold lodes.

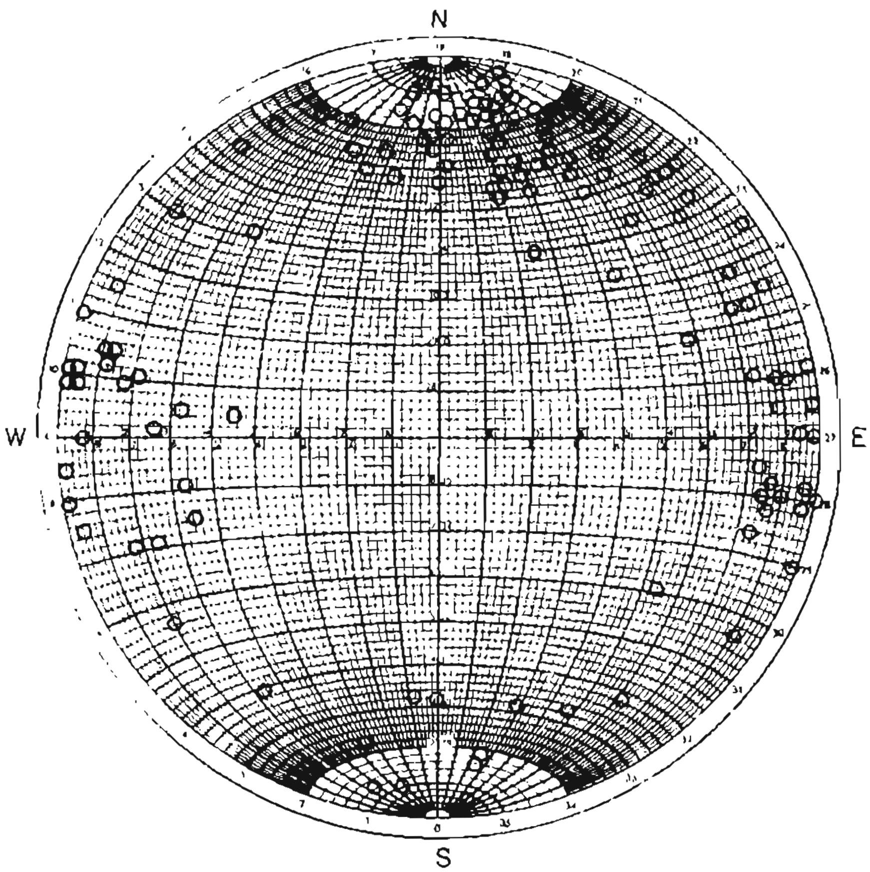
The N10E trending joints may be related to early east-west compression or uplift later than the quartz mineralization. They do not contain quartz which suggests that they are later or were under compression during the time of quartz mineralization.

ECONOMIC GEOLOGY

Gold Placer Deposits

Placer mining in the Chandalar area is estimated to have produced 40,000 ounces of gold, or $1,400,000 at $35.00 per ounce (Heiner and Wolff, p 14). Current placer mining by Mr. Frank Birch on Tobin Creek should add substantially to this figure.

Known placer deposits occur on upper Big Creek, lower Little Squaw Creek, St. Mary's Gulch, Tobin Creek, and near the head of Big Squaw Creek. Big Creek was the major producer and is estimated to have produced $500,000 or more, and approximately $350,000 since 1950 (Wolff, E., personal communication). Below the airstrip on Big Creek pros-



Equal Area Projection of Joint Pole Orientations
Chandalar Area, Alaska

pecting indicates no encouraging results (Frank Birch, personal communication), but coarse gold is reported on claim number 19 below discovery on Big Creek about one mile southeast of the mapped area (unpublished report by Wm. A. Hesse, mining engineer, 1924).

The placer gold is generally thought by earlier investigators to have been derived from the known gold lodes. Most of the placer deposits mined are just below mineralized quartz lodes in the adjacent bedrock. Pan samples in Big Creek and St. Mary's Gulch indicate the gold is bright yellow, irregular shot-like to flattened, and averages about 1 mm with many nuggets 2 to 3 mm. A few nuggets contain included quartz crystals, limonite, and goethite, and the gold occurs occasionally as crystals.

Quartz Vein Deposits

Known quartz lodes containing variable amounts of gold are confined mainly to a northeast trending zone approximately one mile wide and 2-1/2 miles long between the Tobin, Big, Big Squaw, and Little Squaw Creeks area. A few additional quartz veins with minor gold are reported east of Little Squaw Creek, and one small vein with visible arsenopyrite was found south of the landslide in the northern area *(sample 175, Appendix II)*.

Most of the gold-bearing quartz veins occur in or near N57W trending normal faults, and largely confined to the hanging walls. Many of the more highly-mineralized veins occur in phyllite beds, especially when the footwall is harder schist or quartzite-schist. Apparently, beds on opposite walls with different resistance to deformation were important for localization of the quartz veins. The major joint system trending approximately east-west must have been important as well. Most of the discontinuous quartz veins trend more westerly than the N57W fault trend, suggesting control by the east-west joints. Many of the early investigators noted from underground observations that quartz and sulfides were introduced in at least two stages, as some of the quartz and sulfides are sheared. Most of the quartz veins are less than 10 feet thick and discontinuous. They pinch out within a few tens or hundreds of feet. Many are parallel and en echelon, and a few are up to a few hundred feet away from the major high-angle faults.

Four vein systems have been prospected to some degree within the north-east-trending zone. The Mikado vein is currently being mined by the Chandalar Gold Mining and Milling Company, and the other vein systems have had underground or surface development work. The four vein systems from south to north are the Mikado, Star, Summit, and Little Squaw. Minor prospecting has been done on the Tonopah claim (easternmost Star group), just west of the Big Creek and the upper airstrip; the Bonanza, Eneveloe, Woodchuck, and Jupiter claims, between the Summit mine and Little Squaw Peak along the divide between Little and Big Squaw Creeks; the Grubstake and Prospector claims north of the Little Squaw Mine between Big and Little Squaw Creeks; and the Pioneer, Little Johnny, Matchless, and Big Mick claims on the divide east of Little Squaw Creek (mostly after Reed, 1930).

On the Mikado vein, a shaft 100 feet deep was sunk and a tunnel some distance down the hillside was driven 160 feet but failed to intersect the vein (Mertie, 1923). Considerably more work has been done since that time, but the writer did not go underground. Boadway (1933) relates that the Mikado vein is exposed in the shaft and tunnel and consists of lenses of auriferous quartz, mostly on the hanging wall side of a gouge filled fault. Drilled holes intersected additional quartz in both hanging and footwall sides, and veins may be repeated at unknown intervals along this fault zone for a considerable length. One ore shoot in the Mikado shaft averages $49.50 per ton over a 35 inch width between 10-1/2 and 64-1/2 feet deep. Values averaging $37 per ton were found between 69 and 89 feet deep. A 4-foot crosscut at the bottom of the shaft (99 feet) exposes a 16-inch vein with channel samples indicating $79 to $439 per ton in gold (at $20 per ounce).

Grab samples 186, 187, and 188 are from dump material or surface exposures on the Little Mikado claim (*Appendix II*). A prominent quartz vein along the road and at the crest of the divide between St. Mary's Gulch and Tobin Creek trends N78W and dips 56° to 78° south with a brecciated footwall. The roadcut going into St. Mary's Gulch from the crest exposes thin quartz veins en echelon and trending N70W with visible scorodite ($FeAsO_4 \cdot 2H_2O$). The surface exposure of the Little Mikado claim on the Tobin Creek side of the crest is similar to that on the other side, except more thin quartz veins and gouge zones are exposed, as well as more iron staining in the phyllite.

The Star group of claims is south of St. Mary's Peak along the fault between the Mikado and Summit faults. A 10-foot shaft was sunk on the Star No. 2 claim and a few trenches and pits have been made on the Star No. 3 and Star No. 1 claims (Reed, 1930). Star No. 3 claim lies across the road and Star No. 1 claim is southeast toward Big Creek. Two pits are still visible in this area near the road. The pit closest to the road shows a 6-foot wide quartz vein that is partly vuggy with visible arsenopyrite and scorodite. One grab sample assayed 11 ppm gold (sample No. 189). The vein trends approximately N70W and dips 70° to 90° northeast. The second and more westerly pit contains vuggy, brown-stained quartz with included phyllite fragments and minor arsenopyrite. West of the upper airstrip in upper Big Creek (The Tonopah claim), a strong fracture zone is trenched and is probably the continuation of the Star vein system. The fracture zone is about 50 feet wide with numerous east-west fractures 1/4 to 2 inches wide and filled with vuggy, iron-stained quartz. The small placer occurrence on the east fork of upper Big Squaw Creek is probably due to erosion of quartz veins along the northwestern extension of the Star fault zone.

The Summit mine is just north of St. Mary's Peak along the trace of the Summit fault. Prospect pits in the pass area between Big Creek and McClellan Creek (east of the map area) are along the eastern extension of the Summit Fault. Pits on the spur going into Big Squaw Creek are along the western extension of the Summit fault. A shaft was sunk 54 feet, and a tunnel 72 feet long was driven along the vein at the Summit mine (Maddren, 1913). The vein is reported to be 1-1/2 to 2 feet wide. Dump samples from the Summit mine contain abundant arsenopyrite and scorodite in a brecciated and sheared quartz matrix. Grab samples there assayed 0.5 to 6.6 ppm gold (samples 184 and 185). The major quartz vein on the surface trends N80W and dips approximately 80° south. In the prospect pits on the spur going into Big Squaw Creek, minor arsenopyrite and scorodite occurs in the quartz veins (Jupiter claim). North of the Summit mine area and south of Little Squaw Peak, minor quartz veins crop out on the Eneveloe and Bonanza claims. Prospect pits there show small and discontinuous quartz veins with minor galena and scorodite.

Boadway (1933) describes the Little Squaw mine as having a proven length of 200 feet and a depth of 130 feet, with a weighted average of $38.50 per ton over 4 feet (gold at $20.00 per ounce). Stanford (1934) states the adit is driven 185 feet on a vein striking S75W. A raise at 160 feet was driven to the surface, and at 135 feet a winze was sunk 60 feet. The vein is reported to dip approximately 80° south and averages 67 inches wide. It is mostly unmineralized quartz except for a band of quartz on the vein footwall 8 to 12 inches wide with a streaked and ribbony appearance, due to the presence of much pyrite and arsenopyrite. Free gold is sometimes common in the samples, and Stanford took the lower of duplicate assays to arrive at a weighted average value of 0.505 ounces of gold per ton. Reed (1930) reports the 2-stamp mill on Spring Creek milled 27 tons from the Little Squaw mine with an average recovery of $22.00 per ton ($20.00 gold). The free gold was probably the only gold recovered.

Samples 182 and 183 represent selected grab samples from the dump at the Little Squaw mine. No. 182 contains abundant scorodite and probably represents more oxidized vein material. It assayed 59 ppm gold by atomic absorption. Sample 183 contains abundant arsenopyrite and assayed 53 ppm gold, which may represent the less oxidized material.

Limited prospecting on quartz veins north of the Little Squaw mine was performed on both sides of Little Squaw Creek, but nothing is stated regarding values and characteristics. No prominent veins were observed in this area.

Along the extensions of the high-angle faults in the northwestern area, minor quartz mineralization is evident by numerous chips or boulders of quartz float found locally. The quartz indicates rare brecciation and no obvious signs of sulfide mineralization; however, no prospect pits expose the quartz veins in these areas. In the southern area along the northeast trending fault, quartz veins up to 20 feet wide occur without noticeable brecciation or mineralization. Small and en echelon quartz veins with abundant gossan (probably after pyrite) occur in sample areas 167, 168, and 169. These are grab samples of quartz float with the highest assaying 0.14 ppm gold. Each sample assayed 100 ppm antimony by spectrographic analysis, which is quite low but possibly significant. East of the Dome, large and discontinuous quartz veins occur along the course of a north-trending fault. They are probably related to the greenstone intrusion there. A hasty observation indicates no brecciation or mineralization.

Mineralization of the Gold-Quartz Lodes

White, crystalline to microcrystalline quartz is the dominant gangue material in all the gold lodes. Crystals of quartz commonly project into small vugs that rarely contain sulfides or limonitic material. Banding in quartz veins is produced by shearing and elongated cavities that parallel the vein walls. Inclusions of bedrock within quartz veins are more chloritic and often contain small cubes of pyrite. Siderite occurs in minor amounts in samples from the Little Mikado lode.

The sulfide content of the mineralized quartz veins is less than 5 percent, with the principal sulfides being arsenopyrite, galena, sphalerite, and pyrite, in that order of relative abundance. Massive arsenopyrite with scorodite ($FeAsO_4.2H_2O$) occurs in small segregations in Summit and Little Squaw lode samples. Galena and sphalerite with subordinate arsenopyrite and pyrite appear to be more common in Little Mikado samples.

Native gold in small flakes or wires is common in the Little Mikado and Little Squaw lodes. Gold concentrations are most common along sulfide borders or in the quartz near sulfides. A polished section of the Little Mikado lode sample shows gold in blebs as small as 4 microns in galena, and most commonly along galena borders adjacent to arsenopyrite. Arsenopyrite and minor pyrite replace galena in part, and gold replaces galena and arsenopyrite. Small islands of unreplaced galena were noted within arsenopyrite, and arsenopyrite penetrates galena along cleavage planes and fractures. In the more oxidized samples, crystalline gold rarely occurs in vugs and may be secondary or residual concentrations left from oxidized and leached sulfides.

Scorodite and limonite(?) are the most abundant oxidation products. Beudantite ($PbFe_3(AsO_4)(SO_4)(OH)_6$) was identified by X-ray diffraction in one sample of gold-quartz in an area of numerous and parallel joints just north of the Little Mikado lode and in the pass area going into Big Squaw Creek. Limonite was not identified by X-ray diffraction, but diaspore ($Al_2O_3.H_2O$) may be present in the limonitic type of material.

Origin of the Gold-Quartz Lodes

Granitic rock, possibly of pegmatitic character was postulated by Mertie (1923) as the possible source of mineralization. He states that granitic gneiss too small to be mapped was found near the Chandalar area on the north side of Glacier Valley. The postulated granitic source is based largely on the presence of monazite in the placers. In one thin section of greenschist, monazite(?) may be present in very small crystals which would relate them to the greenstones. Boadway (1934), from the presence of monazite and rutile in the placers, suggests a genetic association between the gold-bearing quartz veins and a granitic rock, probably a diorite. The only occurrence of rutile found is in the quartz-albite vein material in Tobin Creek. This sample indicates a genetic association with the albitization of the greenstone.

The known gold mineralization is confined to a northeast-trending zone which is parallel to the northeast structural trend postulated to be of Late Jurassic age (Regional Structure section). Large granitic intrusions are mapped west of Chandalar with generally northeast trends (Brosge and Reiser, 1964). It is tenable that the gold mineralization in the Chandalar area could be related to a buried granitic intrusion, and that the later cross fractures tapped residual solutions genetically related to the intrusive process. Slight doming may be present in the mineralized area suggesting a possible buried intrusion (*section B-B', fig 2*), near Mikado fault. Larger greenstone intrusions, however, produced minor warping of the host rocks as well.

Quartz veins are localized along N57W trending high-angle faults as well as near larger greenstone bodies. Many of the east-trending joints contain vuggy quartz as well, but these occur primarily near high-angle faults and in the general area of known gold-quartz mineralization. In the Big Creek and St. Mary's Gulch areas, east-trending joints in the lower plate slate and phyllite, just beneath the thrust fault contact with upper plate rocks, are closely-spaced and partly filled with vuggy quartz.

The spatial distribution of quartz veins near larger greenstone bodies suggests that some quartz veins are genetically related to the greenstone intrusions or to metasomatism associated with them. Minor silicification and more pervasive albitization of the greenstone-greenschist bodies, as well as local areas along contacts, is suggested by field relations and thin section studies.

Quartz-albite segregations like that found in greenstone in Pedro Gulch (sample 190) occur in two other areas. A small piece of quartz-albite float was found in the area east of the Dome, and in Tobin Creek along the road just up from the Chandalar mill, quartz-albite vein material (sample 191) was found in an area of numerous quartz-limonite-filled joints (sample 178). The quartz-albite material in Tobin Creek contains rutilated quartz crystals up to 25 mm long and albite crystals up to 5 mm long in a limonite matrix. Samples 190 and 191 indicate a fair trace-element comparison, except that sample 191 contains more strontium.

Stream-sediment geochemistry does not suggest a relationship between gold mineralization and the greenstones, nor does the spatial distribution of known gold deposits. The northeast-trending zone containing gold deposits is characterized mainly by somewhat higher copper values in the stream sediment samples (*fig 2*). The greenstones do not reflect higher copper values, but locally reflect higher molybdenum, chromium, antimony, cobalt, nickel, and possibly zinc and vanadium.

A bedrock or regional metamorphic origin is not indicated by limited sampling. Pyrrhotite segregations in the Phyllite-Schist unit (Dphs) may suggest minor syngenetic sulfides that were later remobilized and concentrated during regional metamorphism. This mineralization could also have been introduced from an external source during regional metamorphism. One pyrrhotite sample (No. 164) assayed relatively high values in copper, lead, molybdenum, silver, cobalt, iron, tin, tungsten, lanthanum, antimony, and bismuth. Sample 166 represents the Phyllite-Schist (Dphs) over a distance of 100 feet (random chip samples every 5 feet or so), and exclusive of most quartz and pyrrhotite. This sample was not anomalous except in antimony. The Black Schist unit (Dbls) was selectively sampled (Nos. 191 and 173) exclusive of quartz, and indicates slightly higher values in barium and tungsten.

Sample 173 contains 5% iron and 100 ppm boron but may be altered due to the proximity of a small quartz vein assaying 0.14 ppm gold (sample 172).

G E O C H E M I S T R Y

Geochemical studies include the collection and analyses of 147 stream-sediment and 28 vein and bedrock samples. Sample collection sites are shown on figure 2 (in pocket), with samples considered anomalous in solid color along with the listed anomalous elements. In general, the geochemical distribution indicates adequately the known mineralized areas, as well as other areas deserving more attention. Collection site intervals average approximately one-third of a mile, and a closer grid with soil samples is suggested for the detection of small gold veins.

STREAM SEDIMENT SAMPLES AND ANALYTICAL METHODS

Stream sediment samples contain the finer fractions of sand and silt taken in the active parts of streams or small tributaries. Organic material was excluded when possible. Samples were dried, screened to -80 mesh, and analyzed by atomic absorption for copper, lead, and zinc by Namok Cho in the Division of Mines and Geology laboratory (see Anderson and Cho, 1969, for specific methods). Semiquantitative spectrographic analysis for 30 elements and a computer program to tabulate the samples and calculate statistical characteristics of the analytical data were under the direction of L. E. Heiner, Mining Engineer, University of Alaska. Samples were analyzed in camp by dithizone field tests described by Hawkes (1963) before being sent to the laboratory.

The computer program includes the calculation of the mean, the standard deviation, threshold, and anomaly for both normal and lognormal distributions, as well as histograms of frequency distributions for selected elements (*Appendices III, IV, and V*). Threshold and anomalous values for each element were computed by methods described by Hawkes and Webb (1962, p 30). Threshold value is taken as the mean plus twice the standard deviation and anomalous value as the mean plus thrice the standard deviation. These values are meaningful for a normal distribution and less reliable the more the data departs from normalcy. To calculate averages and standard deviations, a value equal to one half the value of the lower detection limit or the crustal average for the element, whichever was less, was substituted for values below detection limits (ND).

Computed anomalous values for copper (102 ppm) appeared to be unreasonably high. In figure 2, samples with 80 ppm copper or more are in solid color and considered possibly anomalous for this area. For the other elements, the computed anomalous values appear to be adequate; however, many of the elements such as niobium, yttrium, strontium, chromium, and cobalt are not noted in figure 1. There is some doubt whether the computed anomalous values are significant.

DISCUSSION OF STREAM SEDIMENT ANOMALIES

In general, three areas contain anomalies with mostly different suites of elements. The upper Tobin, Little and Big Squaw Creeks area contains probably anomalous copper and silver. This is approximately the area of the known gold lode deposits. Therefore, higher copper and silver values are probably the most significant for these data. The southern area indicates anomalous molybdenum, iron, tin, and bismuth(?). The northwestern area contains a few samples, mostly with anomalous lead and molybdenum *(Appendix V)*.

Upper Tobin, Little and Big Squaw Creeks Area

Upper Tobin Creek samples (94-96) average 76 ppm cooper. Big Squaw Creek samples (38-55) average 87 ppm copper. The average copper value for the whole mapped area is 46 ppm. The average lead value for this area is very nearly the average for the whole area, and the zinc average is slightly higher.

For the total 26 samples in this area, 5 contain 1 ppm silver, 3 contain 100 ppm yttrium, 4 contain 100 ppm antimony, 1 contains 20 ppm molybdenum, and 1 contains 10 ppm gold. The anomalous gold sample (94) was taken very near bedrock on stripped ground prior to sluicing. The semiquantitative spectrographic analysis for silver should be considered with caution, as the method is subject to personal interpretation and a value of 1 ppm is very near the limits of detection.

Southern Area

The southern area includes sample sites 85 through 89, and 107 and 108. Samples 86 and 88 contain 10 to 20 percent iron, 10 to 20 ppm tin, and 10 ppm bismuth.

Quartz veins in the area are fairly numerous, especially near the crest of the hill. Samples 167-169, 176, and 177 are of quartz float or veins in this area. Sample 168 indicates 0.14 ppm gold. Samples 168 and 169 contain 50 ppm tungsten and 100 ppm antimony, but less than 10 ppm tin.

Anomalous concentrations of molybdenum with higher values in chromium and nickel may indicate a genetic relationship to the greenstone in the southern area. The tin and bismuth association suggests a genetic relationship to a more felsic intrusion than the greenstone. Greenstone intrusions in Pedro Gulch may have caused the higher zinc and vanadium values in stream sediment samples 76 and 78; and in the northern area, samples 13 and 14 near the greenstone are anomalous in molybdenum and antimony.

Northwestern Area

Most of the anomalous samples in the northwestern area occur in unmapped areas and their significance is largely speculative. Additional sampling may be warranted, as many of the samples indicate anomalous concentrations of lead. Samples 9, 12, 15, and 136 vary between 70 ppm and 100 ppm lead by atomic absorption analyses. Sample 134 assayed by atomic absorption 130 ppm copper, 990 ppm lead, 420 ppm zinc, and by spectrographic analysis 20 ppm molybdenum and 5 ppm silver. This sample was rerun by both methods with similar results. The area would be along the projected extension of the Summit fault.

Nearer the greenstone in the northwestern area, samples 13 and 14 showed higher concentrations of molybdenum, cobalt, chromium, antimony, nickel, and strontium. This suite of elements would appear to reflect the influence of the greenstone.

GUIDES TO MINERALIZATION

1. The Wiseman-Chandalar gold belt may comprise a unique structural setting, whereby a large area may have potential for gold and other mineral concentrations. Lode and placer gold occurrences are known between the John River in the Wiseman quadrangle, and the Sheenjek River in the western part of the Coleen quadrangle (approximately 180 miles from west to east).

Favorable structures on the regional scale appear to be along the southern borders of large northeast-trending folds and north of generally east-trending folds and granitic intrusions. High-angle faults and a strong joint pattern are loci for mineralization on the local scale.

2. Based upon the Chandalar area, phyllite in fault contact with more resistant schist and quartzite is probably the most favorable lithologic criterion.

3. Northeast-trending granitic intrusions suggest more of a genetic relationship to gold mineralization than do greenstones, but some quartz veins may be genetically related to greenstones.

4. Pyrrhotite and other sulfides in favorable phyllite-schist beds may be original syngenetic or metamorphic features, suggesting the possibility of syngenetic copper or lead-zinc deposits.

5. Brecciated, streaked, and vuggy quartz veins with arsenopyrite or scorodite are favorable for gold mineralization in the Chandalar area. However, trenching may be necessary to expose these favorable features, as many quartz veins are oxidized on the surface with only a little massive quartz float exposed.

6. Placer gold occurrences may be expected close to quartz veins, as in No. 5 above, and possibly near thin and lenticular quartz veins or vuggy quartz filling joints. Conversely, gold-quartz vein deposits may occur near placer deposits.

7. Copper, and possibly silver, are apparently the best geochemical trace elements for the detection of gold veins in the Chandalar area.

8. Anomalous lead concentrations in stream sediments along the extension of the Summit fault and in the northwestern part of the Chandalar area warrant additional sampling and analyses.

9. Stream-sediment samples near greenstone intrusions contain anomalous concentrations of molybdenum, antimony, chromium, nickel, cobalt, zinc(?), and vanadium(?).

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APPENDIX I

Stream Sediment Sample Analyses of the Chandalar Area (Atomic Absorption Analyses [AA] and Semiquantitative Spectrographic Analyses - all values in parts per million unless noted by percent)

Map Number	Field Number	Gold (AA)	Copper (AA)	Lead (AA)	Zinc (AA)	Copper	Lead	Zinc	Molybdenum	Silver	Cobalt	Chromium	Nickel	Manganese	Titanium	Iron (%)	Magnesium (%)	Calcium (%)	Barium	Strontium	Boron	Beryllium	Tin
1	69K121	NA	20	15	90	10	ND	200	ND	ND	10	50	20	300	5000	2	0.2	0.1	500	50	50	ND	ND
2	69K120	NA	20	55	100	10	10	100	5	ND	10	100	20	300	5000	5	1	0.1	500	100	10	ND	ND
3	69K122	NA	15	25	40	15	10	150	5	ND	10	50	20	200	5000	2	0.5	0.1	500	100	50	ND	ND
4	69K119	NA	35	40	135	20	20	200	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	1	ND
5	69K118	NA	20	20	95	10	ND	200	ND	ND	10	100	20	300	3000	2	0.2	0.1	500	100	50	ND	ND
6	69K102	NA	20	30	50	20	20	200	10	1	20	200	50	500	>1.0	5	1	0.1	500	100	50	ND	ND
7	69K115	NA	35	30	45	20	20	200	5	ND	20	100	20	500	>1.0	2	1	0.1	500	100	50	ND	ND
8	69K116	NA	20	25	90	10	10	200	5	ND	20	100	20	200	>1.0	2	1	0.1	500	50	20	ND	ND
9	69K117	NA	40	100	120	20	20	100	10	ND	50	100	10	500	5000	5	1	0.1	500	100	50	1	ND
10	69K108	NA	40	25	110	20	20	100	5	ND	50	100	20	1000	5000	5	1	0.5	500	100	50	1	ND
11	69K304	NA	30	15	100	10	10	100	5	ND	20	100	20	300	5000	2	1	0.1	500	100	30	1	ND
12	69K303	NA	35	70	110	20	20	100	5	ND	50	100	20	1000	5000	2	0.5	0.2	500	50	50	2	ND
13	69K301	NA	35	40	135	50	20	100	20	ND	100	500	50	1000	5000	3	2	0.5	1000	200	50	ND	ND
14	69K300	NA	30	40	160	10	10	100	20	ND	30	500	100	500	5000	2	0.5	0.2	500	100	50	ND	ND
15	69K305	NA	45	70	105	25	10	200	5	ND	30	100	20	500	5000	2	1	1	500	100	50	ND	ND
16	69K271	NA	35	20	105	20	ND	100	5	ND	20	100	20	200	5000	2	0.5	0.1	500	100	50	ND	ND
17	69K270	NA	35	20	95	20	10	100	5	ND	20	100	20	500	5000	2	0.5	0.2	1000	100	100	ND	ND
18	69K272	NA	45	20	100	10	ND	100	ND	ND	10	50	20	500	2000	1	0.2	0.2	500	50	20	ND	ND
19	69K267	NA	25	15	70	20	40	100	ND	ND	20	100	50	2000	5000	2	0.5	1	500	100	20	1	ND
20	69K268	NA	30	20	100	20	20	100	5	ND	20	100	20	500	5000	5	1	0.2	1000	100	50	ND	ND
21	69K269	NA	25	20	110	20	20	200	10	ND	20	200	20	500	>1.0	5	1	0.1	1000	100	100	ND	ND
22	69K266	NA	25	20	110	20	10	100	5	ND	100	200	50	5000	>1.0	5	1	0.2	500	100	50	ND	ND
23	69K265	NA	25	20	90	20	20	100	10	ND	20	200	20	500	>1.0	5	1	0.1	1000	100	100	2	ND
24	69K264	NA	25	15	85	20	20	100	ND	1	20	500	20	1000	5000	2	1	0.5	500	100	50	1	ND
25	69K263	NA	25	20	100	10	10	100	ND	ND	20	100	20	500	5000	2	2	0.2	1000	100	50	ND	ND
26	69K254	NA	75	30	110	20	50	ND	10	ND	20	500	200	1000	5000	2	0.5	0.5	500	100	20	ND	ND
27	69K255	NA	50	20	155	20	20	200	ND	ND	20	300	20	2000	>1.0	5	2	0.2	500	100	50	1	ND
28	69K256	NA	50	25	115	50	20	200	5	ND	20	100	30	2000	>1.0	5	2	0.1	500	100	50	1	ND
29	69K260	NA	50	25	135	20	20	200	5	ND	50	100	20	1000	>1.0	5	2	0.1	500	100	50	1	ND
30	69K261	NA	55	25	140	50	20	200	10	ND	20	200	20	500	>1.0	5	2	0.1	500	100	50	2	ND
31	69K262	NA	35	25	140	20	20	200	5	ND	50	150	20	500	>1.0	5	2	0.1	500	100	50	1	ND
32	69K259	NA	65	25	160	50	20	200	10	ND	20	200	50	500	>1.0	5	1	0.1	500	100	50	2	ND
33	69K258	NA	55	25	145	20	20	200	5	ND	20	50	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
34	69K257	NA	60	30	150	50	20	200	5	ND	30	100	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
35	69K250	NA	45	25	155	20	10	200	ND	ND	50	100	50	500	>1.0	5	2	0.1	500	50	50	ND	ND
36	69K251	NA	55	20	150	20	10	200	10	ND	50	500	50	500	>1.0	5	1	0.1	500	100	20	1	ND
37	69K253	NA	40	15	110	20	10	100	ND	ND	30	100	20	500	>1.0	2	1	0.2	500	100	50	1	ND
38	69K252	NA	60	25	190	50	10	200	5	ND	50	100	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
39	69K246	NA	55	25	160	20	10	100	5	ND	30	100	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
40	69K247	NA	55	30	210	20	10	100	5	ND	50	200	50	500	5000	2	1	0.2	500	100	50	2	ND
41	69K243	NA	45	30	110	20	20	100	5	ND	30	200	50	500	>1.0	5	1	0.1	500	50	100	1	ND
42	69K248	NA	85	35	150	100	20	100	ND	ND	100	200	20	1000	>1.0	2	1	0.1	500	100	20	1	ND
43	69K245	NA	75	25	190	50	10	200	ND	ND	20	100	20	500	>1.0	5	1	0.1	500	100	20	1	ND
44	69K244	NA	75	30	170	50	10	100	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	1	ND
45	69K241	NA	70	30	180	50	10	200	5	ND	50	100	50	500	>1.0	5	1	0.1	500	100	50	1	ND
46	69K240	NA	80	35	180	50	20	100	10	ND	20	500	50	500	>1.0	5	1	0.1	500	100	50	1	ND
47	69K263	NA	40	25	180	50	20	100	10	ND	20	500	50	500	>1.0	5	2	0.1	500	100	50	ND	ND
48	69K212	NA	40	20	160	50	20	200	5	1	50	100	20	500	>1.0	5	2	0.1	500	100	50	1	ND
49	69K219	NA	70	35	135	100	20	200	10	1	50	200	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
50	69K237	NA	65	30	120	50	10	200	5	ND	20	100	20	500	>1.0	5	1	0.05	500	100	50	ND	ND
51	69K238	NA	70	15	150	100	20	200	5	ND	30	200	20	500	>1.0	5	2	0.1	500	100	100	1	ND
52	69K235	NA	85	60	175	50	10	100	5	ND	50	200	20	500	5000	2	0.5	0.1	500	50	50	2	ND
53	69K236	NA	60	60	105	100	50	100	5	1	20	200	20	500	5000	5	1	0.1	500	50	100	2	ND
54	69K234	NA	75	40	140	50	50	100	10	ND	20	500	100	500	>1.0	5	1	0.05	500	100	100	1	ND
55	69K211	NA	85	65	130	50	50	100	5	1	20	200	20	300	5000	5	1	0.05	500	100	100	1	ND
56	69K214	NA	65	25	210	50	20	200	ND	ND	50	100	50	1000	>1.0	5	1	0.1	500	100	50	1	ND
57	69K173	NA	80	25	195	50	20	200	5	ND	50	100	50	1000	>1.0	5	1	0.2	500	100	50	1	ND
58	69K215	NA	85	30	210	50	20	200	5	ND	50	100	50	1000	>1.0	5	1	0.1	500	100	50	2	ND
59	69K174	NA	90	50	185	50	20	200	5	ND	50	100	50	1000	>1.0	5	1	0.1	500	100	50	1	ND
60	69K213	NA	95	35	220	100	20	200	20	ND	50	500	200	1000	>1.0	5	2	0.1	500	100	50	2	ND
61	69K210	NA	60	30	140	50	50	200	10	ND	20	100	20	500	>1.0	5	1	0.05	500	100	50	1	ND
62	69K209	NA	55	30	105	20	20	100	5	ND	20	50	20	500	3000	5	1	0.1	500	100	50	ND	ND
63	69K208	NA	70	30	120	50	20	100	5	ND	30	200	50	1000	>1.0	5	1	0.1	500	100	50	2	ND
64	69K207	NA	35	25	100	20	10	100	ND	ND	20	200	50	1000	>1.0	5	1	0.1	500	100	50	1	ND
65	69K206	NA	30	15	110	10	10	100	5	ND	10	100	20	500	>1.0	5	1	0.2	500	100	20	ND	ND
66	69K172	NA	35	20	115	20	10	200	10	ND	20	200	50	1000	>1.0	5	2	0.2	1000	100	20	ND	ND
67	69K171	NA	80	35	210	100	20	200	10	ND	20	100	20	1000	>1.0	5	1	0.1	500	100	50	1	ND
68	69K170	NA	55	15	150	20	20	200	5	ND	20	100	20	1000	>1.0	5	1	0.1	500	100	50	2	ND
69	69K175	NA	50	25	130	20	10	200	5	ND	50	100	20	1000	>1.0	5	1	0.1	500	100	50	1	ND
70	69K176	NA	40	25	115	10	10	100	5	ND	20	100	20	1000	5000	2	1	0.1	500	100	50	ND	ND
71	69K177	NA	65	40	105	20	10	100	5	ND	10	100	20	200	5000	2	1	0.1	100	100	50	2	ND
72	69K178	NA	40	30	140	50	10	100	5	ND	30	100	20	500	5000	5	1	0.2	500	100	50	1	ND
73	69K179	NA	30	25	150	50	20	100	5	ND	30	100	20	1000	>1.0	5	1	0.05	500	100	50	1	ND
74	69K180	NA	55	25	150	20	10	200	10	ND	20	200	50	1000	>1.0	5	1	0.05	500	100	20	ND	ND
75	69K202	NA	35	15	105	20	10	100	ND	ND	10	100	20	500	>1.0	2	1	0.5	500	100	20	ND	ND
76	69K203	NA	50	20	250	50	10	500	5	ND	50	150	50	1000	5000	5	1	0.2	500	100	20	ND	ND
77	69K205	NA	40	20	210	50	20	200	5	ND	50	100	20	500	3000	5	1	0.1	500	100	20	ND	ND
78	69K204	NA	50	20	170	50	10	100	5	ND	50	200	50	1000	>1.0	5	2	1	1000	100	20	ND	ND

Tungsten	Zirconium	Lanthanum	Niobium	Scandium	Yttrium	Vanadium	Arsenic	Antimony	Bismuth	Cadmium	Gold	Field Test	Weight of Stream Float	Location of Sample	Organic Content	Size of Sample Material	Description of Stream Float	Map Number	General Area of Sample Location
ND	100	50	20	10	20	100	ND	ND	ND	ND	ND	0	5	B	HI	C	SCH SCH50 PHYL10 GR10 CHKRS MARBS VQTZ10	1	
ND	100	50	20	10	10	100	ND	ND	5	ND	ND	0	5	B	MD	C	SCH SCH50 PHYL20 GR10 CHKRS MARBS VQTZ10	2	
ND	100	50	20	10	10	100	ND	ND	ND	ND	ND	0	3	A	HI	C	SCH SCH70 PHYL20 VQTZ10	3	
ND	200	20	50	20	20	100	ND	ND	5	ND	ND	0	5	B	MD	C	SCH SCH70 PHYL20 VQTZ10	4	
ND	50	50	10	10	20	100	ND	ND	ND	ND	ND	0	4	A	MD	C	SCH SCH60 PHYL10 VQTZ10	5	
ND	100	20	20	20	20	100	ND	100	5	ND	ND	1	2	B	MD	C	SCH SCH90 PHYL5 VQTZ5	6	
ND	100	50	50	20	50	100	ND	ND	ND	ND	ND	0	2	A	HI	C	SCH SCH60 PHYL20 SH10 MARBS VQTZ5	7	
ND	200	50	20	20	20	100	ND	ND	5	ND	ND	0	A	B	MD	M	SCH SCH70 PHYL10 GR10 CHKRS VQTZ5	8	
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	0	3	B	MD	C	SCH SCH75 PHYL10 VQTZ5	9	
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	3	3	B	MD	C	SCH SCH60 PHYL10 GNST10 GR10 VQTZ10	10	
ND	100	100	10	10	10	100	ND	ND	ND	ND	ND	0	5	B	MD	C	SCH SCH60 PHYL20 GNST5 GR5 MARBS VQTZ5	11	Northern
ND	200	100	20	10	50	100	ND	ND	ND	ND	ND	4	3	B	MD	C	SCH SCH80 PHYL15 VQTZ5	12	
ND	100	100	20	20	50	100	ND	100	5	ND	ND	1	6	B	MD	C	SCH SCH50 PHYL10 GNST10 GR10 MARB10 CHKRS VQTZ5	13	Area
ND	100	100	20	20	50	100	ND	200	ND	ND	ND	0	6	B	LO	C	SCH SCH60 PHYL10 GNST20 GR20 MARBS VQTZ5	14	
ND	100	100	20	20	50	100	ND	ND	5	ND	ND	0	5	B	MD	C	SCH SCH70 PHYL20 VQTZ10	15	
ND	100	20	10	20	10	100	ND	ND	ND	ND	ND	0	A	B	MD	C	BSCHSCH60 PHYL20 GNST10 VQTZ10	16	
ND	100	50	20	20	50	100	ND	ND	ND	ND	ND	2	A	B	MD	C	BSCHSCH60 PHYL20 GNST10 VQTZ10	17	
ND	50	100	20	10	20	100	ND	ND	ND	ND	ND	1	5	B	HI	F	BSCHSCH50 PHYL20 GNST10 GR10 VQTZ10	18	
ND	50	100	20	10	10	100	ND	ND	ND	ND	ND	1	B	B	HI	F	BSCHSCH60 PHYL20 MARB10 VQTZ10	19	
ND	100	20	20	5	20	100	ND	ND	5	ND	ND	0	5	B	MD	C	BSCHSCH60 PHYL20 GNST10 VQTZ10	20	
ND	100	20	10	10	50	100	ND	ND	5	ND	ND	0	A	B	MD	C	BSCHSCH60 GNST10 PHYL10 VQTZ10	21	
ND	100	50	20	10	20	100	ND	ND	5	ND	ND	0	2	A	HI	F	BSCHSCH60 PHYL20 GNST10 VQTZ10	22	
ND	200	50	30	20	50	100	ND	ND	5	ND	ND	0	2	B	HI	C	BSCHSCH50 PHYL30 GNST10 VQTZ10	23	
ND	100	50	20	10	20	100	ND	ND	ND	ND	ND	0	2	B	HI	F	SCH SCH70 PHYL10 GNST10 VQTZ10	24	
ND	100	ND	20	10	10	100	ND	ND	ND	ND	ND	0	2	B	HI	C	SCH SCH70 PHYL10 GNST10 VQTZ10	25	
ND	50	100	10	10	100	100	ND	100	ND	ND	ND	0	8	B	MD	C	SCH SCH50 PHYL20 GNST10 GR10 VQTZ10	26	
ND	200	20	20	10	20	100	ND	ND	5	ND	ND	0	12	A	MD	L	SCH SCH70 PHYL10 GNST10 VQTZ10	27	
ND	200	20	20	20	50	100	ND	ND	5	ND	ND	0	7	A	MD	C	SCH SCH60 PHYL10 GNST10 GR10 VQTZ10	28	
ND	100	50	20	20	20	100	ND	ND	5	ND	ND	0	5	B	MD	C	SCH SCH80 PHYL10 VQTZ10	29	
ND	200	50	50	20	50	100	ND	ND	5	ND	ND	0	B	A	MD	C	SCH SCH80 PHYL10 VQTZ10	30	McNatt Fork
ND	200	50	50	20	50	100	ND	ND	5	ND	ND	0	3	A	MD	C	SCH SCH50 PHYL30 GNST10 VQTZ10	31	and
ND	100	50	50	20	50	100	ND	ND	5	ND	ND	0	4	B	MD	C	SCH SCH50 PHYL35 GNST5 VQTZ10	32	Lower Big
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	0	6	B	MD	C	SCH SCH60 PHYL30 GNST10 VQTZ10	33	Squaw Creek
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	5	B	MD	C	SCH SCH70 PHYL10 GNST10 VQTZ10	34	
ND	100	70	20	20	20	100	ND	ND	5	ND	ND	0	10	B	MD	C	SCH SCH50 PHYL20 GNST10 GR10 GNEI10 VQTZ10	35	
ND	100	50	20	10	50	100	ND	ND	ND	ND	ND	0	10	B	MD	C	SCH SCH50 PHYL30 GNST10 VQTZ10	36	
ND	200	20	20	20	70	100	ND	ND	ND	ND	ND	0	8	A	MD	L	SCH SCH50 PHYL20 GNST10 GR10 VQTZ10	37	
ND	100	50	20	10	10	100	ND	ND	ND	ND	ND	0	10	B	MD	C	SCH SCH50 PHYL20 GNST10 GR10 VQTZ10	38	
ND	100	50	50	10	50	100	ND	ND	5	ND	ND	1	10	B	MD	M	SCH SCH50 PHYL30 GR10 VQTZ10	39	
ND	100	100	10	20	50	100	ND	ND	ND	ND	ND	4	3	B	HI	C	SCH SCH60 PHYL10 GR10 VQTZ10	40	
ND	100	50	10	20	20	100	ND	ND	5	ND	ND	0	2	A	HI	C	SCH SCH70 PHYL20 VQTZ10	41	
ND	100	100	20	20	50	100	ND	ND	ND	ND	ND	2	2	B	HI	C	SCH SCH50 PHYL40 VQTZ10	42	
ND	200	50	20	20	50	100	ND	ND	ND	ND	ND	0	15	B	MD	C	SCH SCH50 PHYL30 GNST10 VQTZ10	43	
ND	200	100	20	20	50	100	ND	ND	ND	ND	ND	0	12	B	MD	C	SCH SCH50 PHYL30 GNST10 VQTZ10	44	Big Squaw
ND	100	50	20	20	20	100	ND	ND	5	ND	ND	0	6	B	MD	C	SCH SCH60 PHYL30 VQTZ10	45	Creek
ND	100	100	20	10	50	100	ND	100	5	ND	ND	0	4	A	MD	C	SCH SCH60 PHYL30 VQTZ10	46	
ND	100	50	10	10	50	100	ND	100	5	ND	ND	0	8	A	MD	C	SCH SCH50 PHYL30 GNST10 VQTZ10	47	
ND	100	20	20	20	50	100	ND	ND	5	ND	ND	0	A	B	MD	C	SCH SCH60 PHYL30 VQTZ10	48	
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	0	B	B	MD	C	SCH SCH60 PHYL30 VQTZ10	49	
ND	100	100	20	20	50	100	ND	ND	ND	ND	ND	0	B	B	MD	C	SCH SCH50 PHYL40 VQTZ10	50	
ND	200	20	20	20	20	100	ND	ND	5	ND	ND	0	A	B	MD	C	SCH SCH70 PHYL20 VQTZ10	51	
ND	100	50	10	10	50	100	ND	ND	ND	ND	ND	0	A	B	MD	C	SCH SCH60 PHYL30 VQTZ10	52	
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	0	A	A	MD	C	SCH SCH50 PHYL40 VQTZ10	53	
ND	100	100	20	20	50	100	ND	100	5	ND	ND	0	7	A	MD	C	SCH SCH70 PHYL20 VQTZ	54	
ND	100	100	20	20	50	100	ND	ND	5	ND	ND	1	2	B	HI	C	SCH SCH60 PHYL30 VQTZ10	55	
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	13	B	MD	C	SCH PHYL40 SCH30 GR10 VQTZ20	56	
ND	200	100	10	90	100	100	ND	ND	5	ND	ND	0	A	B	MD	M	SCH SCH50 PHYL20 GNST10 VQTZ20	57	
ND	100	100	20	20	50	100	ND	ND	5	ND	ND	2	11	B	MD	C	SCH PHYL40 SCH40 GNSC10 VQTZ10	58	Little Squaw Creek
ND	100	100	20	20	50	100	ND	ND	5	ND	ND	0	8	B	LO	M	SCH SCH50 PHYL30 GNST10 VQTZ10	59	
ND	200	100	20	20	100	100	ND	100	5	ND	ND	0	16	B	MD	C	SCH PHYL50 SCH30 VQTZ20	60	
ND	100	50	20	20	100	100	ND	ND	5	ND	ND	0	5	B	MD	C	SCH SCH50 PHYL40 VQTZ10	61	
ND	100	10	10	10	50	100	ND	ND	5	ND	ND	0	2	B	MD	C	SCH PHYL40 SCH40 VQTZ20	62	Upper Big
ND	200	100	20	30	50	100	ND	ND	5	ND	ND	0	5	B	MD	C	BSCHPHYL50 SCH30 VQTZ20	63	Creek
ND	200	50	70	70	20	100	ND	ND	ND	ND	ND	0	2	B	MD	M	BSCHSCH50 GNST40 VQTZ10	64	
ND	100	50	20	20	10	100	ND	ND	ND	ND	ND	0	10	B	MD	C	BSCHSCH40 GNST30 PHYL10 VQTZ20	65	
ND	200	ND	20	20	20	100	ND	ND	5	ND	ND	0	3	B	LO	C	BSCHGNSC45 SCH20 GR15 VQTZ10 PHYL5	66	
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	2	20	B	LO	C	BSCHPHYL50 GNSC30 SCH10 VQTZ10	67	
ND	200	100	20	20	50	100	ND	ND	5	ND	ND	0	8	B	MD	C	BSCHPHYL45 GNSC30 SCH10 VQTZ10 SL5	68	
ND	100	50	20	20	20	100	ND	ND	5	ND	ND	0	6	B	MD	C	BSCHPHYL50 GNSC20 SCH20 VQTZ10	69	
ND	200	50	20	20	50	100	ND	ND	ND	ND	ND	0	3	B	MD	C	BSCHPHYL40 GNSC40 VQTZ10 SCH5	70	St. Mary's
ND	100	100	10	20	50	100	ND	ND	ND	ND	ND	0	2	A	HI	F	BSCHSCH60 GNSC30 VQTZ10	71	Gulch
ND	100	100	20	20	50	100	ND	ND	ND	ND	ND	3	2	B	HI	F	SCH PHYL40 SCH40 GNSC10 VQTZ10	72	
ND	200	100	20	30	50	100	ND	ND	5	ND	ND	1	8	B	HI	C	SCH PHYL50 GNSC30 SCH30 VQTZ10	73	
ND	200	50	50	20	20	100	ND	ND	ND	ND	ND	0	1	B	LL	L	SCH PHYL60 SCH30 VQTZ10	74	
ND	200	50	50	20	20	100	ND	ND	ND	ND	ND	2	6	B	MI	M	BSCHGNST50 SCH30 PHYL10 VQTZ10	75	
ND	100	50	20	20	50	100	ND	ND	ND	ND	ND	1	8	B	MI	C	BSCHGNST40 SCH20 SL30 VQTZ10	76	Pedro Gulch
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	8	B	6	C	BSCHSCH40 PHYL30 GNST20 VQTZ10	77	
ND	100	ND	20	20	50	200	ND	ND	5	ND	ND	3	3	B	HI	C	BSCHGNST50 PHYL30 SL10 VQTZ10	78	

APPENDIX B - continued

Map Number	Field Number	Gold (AA)	Copper (AA)	Lead (AA)	Zinc (AA)	Copper	Lead	Zinc	Molybdenum	Silver	Cobalt	Chromium	Nickel	Manganese	Titanium	Iron (%)	Magnesium (%)	Calcium (%)	Barium	Strontium	Boron	Beryllium	Tin
79	69N230	NA	30	20	130	20	20	160	5	ND	50	100	20	1000	>1.0	3	2	0.5	500	300	70	ND	ND
80	69N281	NA	40	25	150	20	10	200	5	ND	50	200	20	1000	5000	5	2	0.2	500	100	20	ND	ND
81	69N243	NA	30	15	90	20	30	100	3	ND	30	50	20	200	5000	3	1	0.2	1000	100	20	ND	ND
82	69N281	NA	35	20	130	20	10	200	5	ND	30	100	20	500	>1.0	3	2	0.2	500	100	20	ND	ND
83	[illegible]	NA	35	20	90	20	10	200	10	ND	10	50	10	200	>1.0	3	1	0.3	1000	100	20	ND	ND
84	[illegible]	NA	40	15	80	50	ND	100	5	ND	40	20	10	200	5000	2	0.5	0.05	500	50	10	1	ND
85	[illegible]	NA	35	20	125	20	20	300	3	ND	20	100	20	300	>1.0	5	2	0.2	500	100	20	2	ND
86	[illegible]	NA	40	20	60	100	50	100	5	ND	20	100	100	500	5000	5	[illegible]	0.1	1000	500	50	1	ND
87	[illegible]	NA	40	20	50	20	30	200	10	ND	50	50	10	100	2000	5	0.2	0.05	700	50	30	ND	10
88	69N183	NA	50	20	60	20	30	200	10	ND	50	50	10	100	2000	20	<1	0.05	300	100	20	1	20
89	[illegible]	NA	70	15	115	20	50	100	3	ND	10	100	20	200	5000	2	2	0.1	500	100	20	1	ND
90	[illegible]	NA	40	15	110	10	20	200	ND	ND	20	100	20	500	>1.0	5	1	0.2	500	100	50	ND	ND
91	[illegible]	NA	35	20	75	10	10	100	ND	ND	10	100	20	500	5000	2	1	0.1	500	100	20	1	ND
92	[illegible]	NA	50	20	85	20	10	150	ND	ND	10	100	20	200	5000	1	0.5	0.1	500	100	30	2	ND
93	[illegible]	NA	40	15	125	20	10	200	5	ND	20	100	20	500	5000	5	1	0.1	200	100	50	ND	ND
94	[illegible]	NA	55	15	150	50	20	100	5	ND	50	100	50	1000	>1.0	5	1	0.2	500	100	50	1	ND
95	69N200	NA	50	20	195	100	50	200	5	1	50	200	50	1000	>1.0	5	2	0.3	500	100	100	2	ND
96	69N201	NA	85	50	150	100	50	200	5	ND	50	200	20	500	5000	5	2	0.2	500	150	50	2	ND
97	[illegible]	NA	40	15	100	30	20	100	ND	ND	30	100	20	200	5000	2	1	0.1	500	100	30	1	ND
98	[illegible]	NA	50	30	130	50	20	150	5	ND	50	100	50	500	NA	5	1	0.2	200	100	200	5	ND
99	[illegible]	NA	40	20	120	30	30	200	5	ND	50	100	20	500	>1.0	2	2	0.1	500	100	30	ND	ND
100	[illegible]	NA	40	20	130	20	20	200	5	ND	20	100	20	500	>1.0	3	2	0.1	500	100	50	1	ND
101	[illegible]	NA	25	15	105	10	10	200	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
102	[illegible]	NA	35	20	55	10	20	100	10	ND	50	100	20	1000	5000	3	1	0.1	1000	150	50	1	ND
103	69N192	NA	35	20	100	10	100	100	1	ND	20	100	20	500	5000	3	1	0.1	500	100	20	ND	ND
104	[illegible]	NA	45	15	125	15	10	100	5	ND	50	100	20	500	>1.0	5	1	0.2	500	100	30	ND	ND
105	[illegible]	NA	20	15	45	10	20	100	5	ND	10	50	20	200	>1.0	2	1	0.1	500	100	50	1	ND
106	69N145	NA	40	15	70	10	10	100	5	ND	10	50	10	200	5000	2	0.5	0.1	500	100	20	ND	ND
107	[illegible]	NA	40	15	75	10	10	100	5	ND	10	200	100	200	5000	2	1	0.1	500	100	20	ND	ND
108	[illegible]	NA	45	15	70	20	30	200	33	ND	ND	500	50	200	5000	3	1	0.1	500	100	20	1	ND
109	[illegible]	NA	40	20	120	20	20	200	10	1	20	100	20	500	>1.0	5	1	0.2	500	100	30	5	ND
110	[illegible]	NA	35	15	35	10	20	100	5	ND	20	100	20	300	5000	5	1	0.1	500	100	20	1	ND
111	[illegible]	NA	50	15	80	20	10	100		ND	20	100	20	500	5000	3	5	0.1	500	100	50	1	ND
112	[illegible]	NA	20	15	80	10	10	100	[illegible]	ND	10	100	20	500	5000	3	1	0.1	1000	100	50	ND	ND
113	69N166	NA	30	15	115	10	10	200	[illegible]	ND	20	100	20	1000	>1.0	2	1	0.5	500	100	20	ND	ND
114	[illegible]	NA	35	15	145	10	20	100	ND	ND	10	50	20	500	5000	2	0.5	0.5	200	50	10	ND	ND
115	[illegible]	NA	40	15	125	15	10	200		ND	10	100	50	1000	5000	5	2	0.5	300	100	20	ND	ND
116	[illegible]	NA	25	15	55	20	10	300	5	ND	20	100	20	500	>1.0	3	1	0.5	200	300	20	ND	ND
117	[illegible]	NA	30	15	100	10	10	200	ND	ND	20	50	20	500	>1.0	3	1	0.5	700	100	10	ND	ND
118	[illegible]	NA	30	20	110	20	10	200	5	ND	20	100	20	1000	>1.0	2	2	0.5	500	100	20	ND	ND
119	[illegible]	NA	30	20	100	10	10	100	5	ND	20	100	20	500	>1.0	2	2	0.5	500	100	30	1	ND
120	[illegible]	NA	20	20	65	10	10	100	10	ND	10	100	20	200	>1.0	2	1	0.1	500	100	50	ND	ND
121	[illegible]	NA	50	30	700	20	20	200	20	ND	30	200	50	500	>1.0	3	2	0.1	500	100	50	ND	ND
122	[illegible]	NA	35	25	145	20	10	200	5	ND	20	100	20	500	>1.0	3	-	0.1	500	100	50	1	ND
123	[illegible]	NA	40	20	105	20	20	100	10	ND	20	100	20	500	>1.0	1	1	0.1	500	100	50	2	ND
124	[illegible]	NA	40	20	110	20	20	100	5	ND	20	100	20	500	>1.0	5	2	0.1	500	100	50	1	ND
125	[illegible]	NA	40	20	115	20	20	200	5	ND	20	100	20	500	>1.0	3	1	0.1	500	100	50	1	ND
126	69N291	NA	30	20	120	10	20	200	5	ND	20	100	20	500	>1.5	5	1	0.1	500	100	50	1	ND
127	[illegible]	NA	50	15	120	20	30	100	[illegible]	ND	20	100	20	500	>5.0	3	1	0.1	500	100	50	ND	ND
128	69N293	NA	45	15	115	20	20	200	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	1	ND
129	[illegible]	NA	45	15	120	10	10	500	ND	ND	10	50	20	200	5000	2	0.5	0.1	500	100	50	1	ND
130	69N295	NA	40	35	135	20	20	200	5	ND	20	100	20	500	>1.0	2	1	0.1	500	100	50	2	ND
131	69N299	NA	NA	NA	NA	20	30	200	10	ND	20	500	50	300	5000	3	3	0.1	500	100	50	1	ND
132	[illegible]	NA	25	15	115	20	30	200	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	2	ND
133	[illegible]	NA	25	20	115	10	10	200	5	ND	10	50	20	500	>1.0	2	1	0.1	500	100	50	1	ND
134	69N298	NA	130	190	420	50	100	100	20	1	20	200	50	500	5000	1	1	0.1	700	100	100	1	ND
135	[illegible]	NA	45	15	115	20	50	100	10	ND	20	100	20	200	>1.0	5	3	0.2	500	100	50	ND	ND
136	[illegible]	NA	45	25	120	10	10	100	10	ND	10	100	20	500	5000	3	0.5	0.1	500	100	50	1	ND
137	[illegible]	NA	40	40	125	20	50	200	5	ND	20	100	20	500	>1.0	3	1	0.1	500	100	50	1	ND
138	[illegible]	NA	NA	NA	NA	50	50	200	5	ND	20	100	20	500	>1.0	3	1	0.1	500	100	50	3	ND
139	[illegible]	NA	60	25	127	20	20	100	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	1	ND
140	69N290	NA	60	25	125	20	10	100	5	ND	10	150	20	500	>1.0	2	1	0.1	500	100	50	ND	ND
141	69N286	NA	60	20	90	20	10	100	30	ND	10	100	20	500	5000	3	1	0.2	500	100	50	1	ND
142	69N277	NA	35	20	110	20	20	200	5	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	1	ND
143	69N275	NA	35	15	55	10	10	100	15	ND	10	100	20	200	5000	2	0.5	0.1	500	100	50	2	ND
144	69N276	NA	45	15	130	20	20	100	10	ND	50	500	50	1000	5000	2	1	0.1	500	100	50	[illegible]	ND
145	[illegible]	NA	45	25	115	20	20	200	ND	ND	20	100	20	500	>1.0	5	1	0.1	500	100	50	ND	ND
146	[illegible]	NA	35	25	115	10	10	200	ND	ND	20	100	20	500	>1.0	2	1	0.1	500	100	50	ND	ND
147	69N279	NA	45	35	130	20	20	200	10	ND	20	100	20	500	>1.0	5	2	0.1	500	100	50	ND	ND

NA — Not analyzed
ND — Not detected
AA — Atomic Absorption analyses
35 — Considered anomalous

Organic Content of Sample: Hi — High; Md — Medium; Lo — Low

Size of Sample Material: Z — Silt or Mud; S — Sand; G — Gravel

Bedrock and Rock Float Abbreviations: SCH - Schist; B SCH - Black Schist; PHYL - Phyllite; GNST - Greenstone; GRSC - Greenschist; VQZZ - Vein Quartz; GRWK - Graywacke; GR - Granite; MARB - Marble (Glacial)

Location of Sample in Stream Channel

Tungsten	Zirconium	Lanthanum	Niobium	Scandium	Yttrium	Vanadium	Arsenic	Antimony	Bismuth	Cadmium	Gold	Field Test	Width of Stream in Feet	Location of Sample	Organic Content	Size of Sample Material	Description of Stream Float	Map Number	General Area of Sample Location
ND	100	50	20	20	50	100	ND	ND	ND	ND	ND	0	6	B	MU	C	SSCHSCH30 GNST10 PHYL20 VQTZ20	79	Lower Big Creek
ND	100	ND	10	20	50	100	ND	ND	5	ND	ND	0	20	F	LU	L	BSLMPHYL50 GNST10 SCHJ10 VQTZ10	80	
ND	100	10	10	10	10	100	ND	ND	ND	ND	ND	1	7	A	MU	L	BSCHSCH50 GNST30 SL10 VQTZ10	81	
ND	100	20	20	20	20	100	ND	ND	5	ND	ND	1	20	A	MO	C	BSLMPHYL50 GNST20 SCH20 VQTZ10	82	
ND	100	20	20	20	20	100	ND	ND	ND	ND	ND	0	3	B	HI	M	BSCHSCH60 PHYL30 SL20 VQTZ10	83	
ND	50	50	10	10	50	100	ND	ND	ND	ND	ND	0	1	A	HI	L	BSCHSCH30 PHYL30 VQTZ20	84	
ND	200	20	20	20	50	100	ND	ND	5	ND	ND	0	20	A	MO	C	BSLMPHYL50 GNST20 SCH20 VQTZ10	85	
ND	200	20	20	20	20	100	ND	100	ND	ND	ND	1	2	B	HI	C	SSCHSCH50 PHYL30 GNSC20 VQTZ10	86	West Side of Southern Area
ND	50	20	20	10	10	50	ND	ND	10	ND	ND	0	3	A	MU	C	SSLMPHYL40 SCH30 GNSC20 VQTZ10	87	
ND	50	ND	20	5	10	50	ND	ND	ND	ND	ND	0	3	B	MU	C	BSCHPHYL30 SCH30 GNSC30 VQTZ10	88	
ND	150	20	10	10	20	100	ND	ND	ND	ND	ND	0	6	A	HI	M	BSCHSCH60 SCH30 VQTZ10	89	
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	4	B	MO	F	SCH SCH60 PHYL20 VQTZ10 GNSC10	90	Tobin Creek Area
ND	100	50	10	20	50	100	ND	ND	ND	ND	ND	0	2	A	HI	F	SCH SCH50 PHYL20 GNSC10 VQTZ10	91	
ND	100	100	10	20	50	100	ND	ND	ND	ND	ND	0	2	A	HI	A	SCH SCH60 PHYL30 VQTZ10	92	
ND	100	50	10	10	20	100	ND	ND	ND	ND	ND	0	4	A	MO	M	SCH SCH60 PHYL20 GNSC10 VQTZ10	93	
ND	200	100	20	20	50	100	ND	ND	ND	ND	10	0	10	B	MO	L	SCH SCH50 PHYL20 GNSC10 VQTZ20	94	
ND	200	100	20	20	100	100	ND	ND	5	ND	ND	12	12	A	MU	L	SCH SCH50 PHYL20 GNSC10 VQTZ10	95	
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	15	A	B	MO	L	SCH SCH50 PHYL20 GNSC20 VQTZ10	96	
ND	200	50	20	10	50	100	ND	ND	ND	ND	ND	0	2	A	HI	M	SCH SCH60 PHYL30 VQTZ10	97	
ND	300	50	50	20	50	100	ND	ND	5	ND	ND	0	6	B	MO	F	SCH PHYL40 SCH40 GNSC10 VQTZ10	98	
ND	200	20	20	20	20	100	ND	ND	5	ND	ND	0	10	A	MO	C	SCH SCH40 PHYL30 GNSC20 VQTZ10	99	
ND	200	20	20	20	50	100	ND	ND	5	ND	ND	0	15	B	LO	L	SCH SCH50 GNST30 PHYL20 VQTZ10	100	
ND	200	20	20	20	50	100	ND	ND	ND	ND	ND	5	6	A	HI	F	SCH SCH60 PHYL30 GNSC10 VQTZ10	101	
ND	200	50	10	20	50	100	ND	ND	ND	ND	ND	0	3	A	MU	L	SCH SCH60 PHYL20 GNSC10 VQTZ10	102	
ND	200	20	20	20	50	100	ND	ND	ND	ND	ND	0	12	A	MU	C	BSCHSCH60 PHYL30 GNST10 VQTZ20	103	
ND	200	20	20	20	50	100	ND	ND	5	ND	ND	1	25	A	MO	M	BSCHSCH40 PHYL20 SL20 GR10 VQTZ10	104	
ND	200	50	50	20	20	100	ND	ND	ND	ND	ND	1	7	A	HU	M	BSCHSCH40 PHYL30 SL20 VQTZ10	105	Lower Tobin Creek and West Side of Southern Area
ND	100	50	10	10	50	100	ND	ND	ND	ND	ND	2	4	A	HI	C	BSCHSCH40 PHYL30 GNSC20 VQTZ10	106	
ND	100	50	10	10	20	100	ND	100	ND	ND	ND	0	1	A	MO	C	BSCHPHYL45 GNSC20 SCH25 VQTZ10	107	
ND	100	50	20	10	50	100	ND	100	ND	ND	ND	0	3	B	MO	C	BSCHPHYL70 GNSL10 SCH10 VQTZ10	108	
ND	300	50	50	20	50	100	ND	ND	5	ND	ND	0	25	A	MO	M	BSLPHYL40 SCH30 GNSC20 VQTZ10	109	
ND	100	50	20	10	50	100	ND	ND	5	ND	ND	0	4	B	HI	L	BSCHSCH30 PHYL20 GNSC20 GNST20 VQTZ10	110	
ND	200	50	20	20	ND	100	ND	ND	ND	ND	ND	0	5		MO	C	BSCHSCH50 PHYL30 SL20	111	
ND	200	20	20	20	20	100	ND	ND	5	ND	ND	0	5	B	MO	C	BSCHSCH30 PHYL30 GNST20 GNSL10 GR10 VQTZ10	112	
ND	200	50	20	20	10	100	ND	ND	ND	ND	ND	3	20	B	MO	C	BSCHSCH65 VQTZ10 GR15 GNKR10	113	Southwestern Area
ND	100	50	10	10	20	50	ND	ND	ND	ND	ND	1	2	B	HI	L	BSCHSCH60 GNST20 VQTZ10 GR10	114	
ND	200	20	20	20	50	100	ND	ND	5	ND	ND		2	B	HI	L	BSCHSCH40 GNST25 VQTZ15 GR15 GNKF5	115	
ND	100	20	50	20	50	100	ND	ND	5	ND	ND	2	8	A	MO	M	GNSPGNST80 GR20	116	
ND	100	20	10	20	20	100	ND	ND	5	ND	ND	1	A	A	MO	L	SCHPHY70 VQTZ10 GR15 GNKF5	117	
ND	200	20	10	20	20	100	ND	ND	5	ND	ND	1	3	A	HI	C	BSCHSCH60 GR30 VQTZ10	118	
ND	200	20	10	20	20	100	ND	100	ND	ND	ND	1	3	A	MI	V	BSCHSCH100	119	
ND	200	20	20	20	10	100	ND	ND	ND	ND	ND	3	1	A	HI	V	BSCHSCH90 VQTZ10	120	
ND	200	50	20	10	10	100	ND	100	5	ND	ND	0	3	A	MO	L	SCH SCH50 PHYL20 GNST20 VQTZ10	121	Boulder Creek Area
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	4	B	MO	M	SCH SCH60 PHYL20 GNST20 VQTZ10	122	
ND	200	100	20	10	50	100	ND	ND	5	ND	ND	1	10	A	HI	C	BSCHSCH40 PHYL20 GNST10 GR10 MARB10 GNKF10	123	
ND	200	100	20	10	50	100	ND	100	5	ND	ND	1	9	B	HI	M	BSCHSCH40 PHYL10 GNST10 GR10 MARB10 VQTZ10	124	
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	5	B	MO	M	SCH SCH40 PHYL10 GNST10 GR20 MARB10 VQTZ10	125	
ND	200	50	20	20	50	100	ND	ND	ND	ND	ND	0	6	B	MO	C	SCH SCH60 PHYL10 GR10 MARB10 VQTZ10	126	
ND	200	50	20	20	50	100	ND	ND	ND	ND	ND	0	2	A	MO	M	SCH SCH70 PHYL10 VQTZ20	127	
ND	200	50	20	20	50	100	ND	ND	ND	ND	ND	0	3	A	MU	M	SCH SCH80 PHYL10 VQTZ10	128	
ND	100	50	20	10	10	100	ND	ND	ND	ND	ND	0	1	A	MO	C	SCH SCH70 PHYL20 VQTZ10	129	
ND	200	20	20	20	50	100	ND	ND	ND	ND	ND	0	5	B	MO	C	SCH SCH70 PHYL20 GR5 VQTZ5	130	
ND	100	50	10	10	50	100	ND	100	ND	ND	ND	0	A	B	LO	C	SCH SCH70 PHYL20 VQTZ10	131	
ND	200	20	50	20	50	100	ND	ND	5	ND	ND	0	3	B	MU	C	SCH SCH80 PHYL10 VQTZ10	132	
ND	300	10	20	20	50	100	ND	ND	ND	ND	ND	0	7	A	MO	C	SCH SCH90 PHYL10	133	
ND	200	50	50	20	50	100	ND	50	ND	ND	ND	0	3	A	LO	C	SCH SCH70 PHYL25 VQTZ5	134	
ND	200	50	20	10	50	100	ND	ND	5	ND	ND	0	A	B	MU	C	SCH SCH80 PHYL20	135	
ND	300	50	10	10	50	100	ND	ND	ND	ND	ND	0	5	B	MO	C	SCH SCH70 PHYL20 VQTZ10	136	
ND	200	50	20	20	50	100	ND	ND	5	ND	ND	0	3	B	MU	C	SCH SCH60 PHYL30 VQTZ10	137	
ND	100	100	50	20	50	100	ND	ND	5	ND	ND	0	4	A	HI	M	SCH SCH70 PHYL20 VQTZ10	138	
ND	200	100	10	20	50	100	ND	ND	ND	ND	ND	0	4	B	HI	C	SCH SCH80 PHYL10 VQTZ10	139	
ND	100	50	20	20	50	100	ND	ND	ND	ND	ND	0	6	B	MI	M	SCH SCH70 PHYL20 VQTZ10	140	
ND	100	100	10	10	50	100	ND	ND	ND	ND	ND	0	5	A	HI	F	SCH SCH60 PHYL30 VQTZ10	141	
ND	300	50	10	ND	50	100	ND	ND	ND	ND	ND	0	A	B	MO	M	SCH SCH50 PHYL40 VQTZ10	142	
ND	100	100	10	10	50	100	ND	ND	ND	ND	ND	0	3	A	MI	F	SCH SCH50 PHYL40 VQTZ10	143	
ND	200	100	10	20	50	100	ND	ND	ND	ND	ND	1	1	A	MI	M	SCH SCH50 PHYL40 VQTZ10	144	
ND	200	50	20	20	50	100	ND	ND	ND	ND	ND	0	1	B	MO	C	SCH SCH70 PHYL20 VQTZ10	145	
ND	200	50	10	20	50	100	ND	ND	5	ND	ND	0	A	B	MO	F	SCH SCH60 PHYL20 GNST10 VQTZ10	146	
ND	100	50	20	20	50	100	ND	ND	5	ND	ND	0	4	B	MO	C	SCH SCH65 PHYL20 GNST10 VQTZ5	147	

APPENDIX II

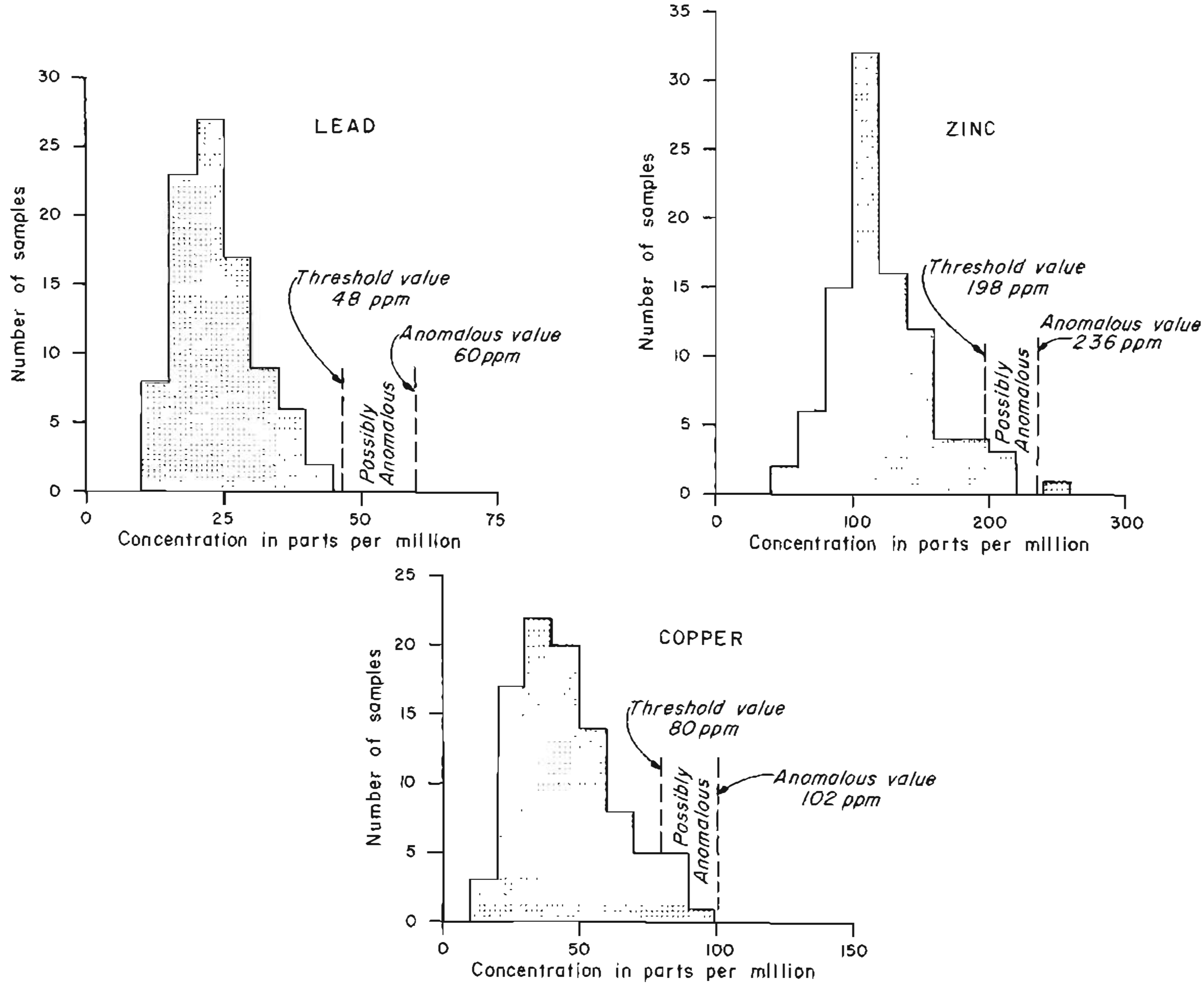
Rock Sample Analyses of the Chandalar Area - Atomic Absorption and Semi-quantitative Emission Spectrograph Analyses

(all values in parts per million (ppm) unless indicated otherwise)

Map Number	Field Number	Gold*	Copper#	Lead#	Zinc#	Copper	Lead	Zinc	Molybdenum	Silver	Cobalt	Chromium	Nickel	Manganese	Titanium	Iron	Magnesium	Calcium	Barium	Strontium	Boron
164	69D323	ND	1800	3700	20	2000	2000	500	50	20	500	100	100	200	1000	20	0.2	0.5	200	50	2
165	69D324	ND	25	14	66	20	20	100	5	ND	ND	100	10	200	500	2	0.1	ND	100	50	1
166	69D325	ND	40	17	175	20	20	100	5	ND	10	100	20	200	5000	2	1	0.05	500	100	5
167	69D326	ND	13	7	7	10	ND	100	5	ND	ND	100	10	100	100	3	0.05	ND	100	100	N
168	69D327	0.14	13	10	140	10	20	200	5	ND	ND	100	10	200	200	3	0.2	0.05	100	100	N
169	69D328	ND	26	12	20	10	ND	100	5	ND	ND	100	10	100	500	2	0.1	0.05	200	100	2
170	69D329	.14	24	5	23	10	ND	200	ND	ND	ND	50	10	100	100	2	0.05	ND	100	100	N
171	69D330	ND	14	8	135	10	10	200	5	ND	10	100	20	200	5000	5	2	0.05	1000	100	3
172	69D331	0.14	27	3	20	10	ND	100	ND	ND	ND	100	10	100	1000	2	0.2	ND	200	200	N
173	69D332	ND	45	8	100	20	20	200	10	ND	ND	200	10	200	5000	5	2	0.05	1000	100	10
174	69D333	.08	60	10	75	50	20	200	5	ND	ND	100	20	200	1000	5	0.1	ND	500	100	2
175	69D334	.26	15	4	5	10	ND	100	ND	ND	ND	50	10	100	ND	1	ND	ND	50	50	ND
176	69D335	ND	12	3	5	5	ND	ND	ND	ND	ND	100	10	100	ND	1	ND	ND	100	50	ND
177	69D336	ND	45	6	10	20	ND	100	5	ND	10	100	20	200	50	1	0.05	0.5	100	50	ND
178	69D337	ND	32	32	37	20	10	ND	5	ND	10	100	20	100	500	2	0.1	0.05	50	100	10
179	69D338	ND	15	10	13	5	ND	100	ND	ND	10	50	10	100	100	1	0.05	ND	100	100	ND
180	69D339	NA	40	10	180	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
181	69D340	ND	23	6	67	10	ND	100	5	ND	20	100	20	200	500	2	0.5	0.1	100	100	ND
182	69D341	59.	15	10	10	10	10	100	5	1	ND	50	10	100	500	2	ND	ND	500	50	10
183	69D342	53.	10	10	10	5	100	200	20	5	10	50	10	200	ND	20	ND	0.05	100	50	20
184	69D343	0.3	15	10	10	10	10	100	ND	ND	10	100	10	200	ND	2	ND	ND	ND	50	ND
185	69D344	6.6	150	15	35	200	100	200	10	2	20	50	20	200	100	10	ND	ND	20	50	20
186	69D345	2.8	115	20	60	100	20	100	5	1	100	20	20	100	200	5	0.1	0.2	ND	200	100
187	69D346	896.	25	NA	NA	10	*1.0	*1.0	ND	500	10	100	10	200	100	2	0.05	0.1	50	50	ND
188	69D347	168.	16	15	20	5	10	100	ND	20	10	100	10	100	100	2	0.05	ND	100	50	ND
189	69D348	11.	17	ND	10	10	ND	100	ND	ND	ND	100	10	100	100	1	0.05	ND	100	50	ND
190	69D349	ND	NA	NA	NA	5	ND	ND	ND	ND	10	ND	5	50	50	0.1	0.1	0.2	20	ND	ND
191	69D350	ND	NA	NA	NA	10	ND	ND	ND	ND	10	ND	10	50	50	0.2	0.05	0.1	20	500	ND

* Values reported in percent rather than ppm.
\# Denotes atomic absorption analysis
ND Not detected (see detection limits, appendix VI)
NA Not assayed
qtz = quartz
lim = limonite
v = vein

Beryllium	Tin	Tungsten	Zirconium	Lanthanum	Niobium	Scandium	Yttrium	Vanadium	Arsenic	Antimony	Bismuth	Cadmium	Gold	Rock Sample Descriptions	
ND	50	100	50	500	50	ND	50	50	ND	1000	20	ND	ND	Pyrrhotite segregation in D_{phs} units near Little Squaw mine.	164
ND	ND	30	50	ND	10	ND	20	50	ND	500	5	ND	ND	Vuggy quartz with hematite in footwall joints near Summit mine.	165
2	ND	ND	100	ND	20	20	20	100	ND	200	5	ND	ND	100 foot random chip sample of D_{phs} unit (no qtz or pyrrhotite).	166
ND	ND	ND	ND	ND	5	ND	ND	ND	ND	100	ND	ND	ND	Grab sample of v quartz with goss in southern area.	167
1	ND	50	ND	20	20	ND	20	20	ND	100	5	ND	ND	Grab sample of v quartz with goss in southern area.	168
1	ND	50	50	ND	20	ND	ND	20	ND	100	ND	ND	ND	Grab sample of v quartz with goss in southern area.	169
1	ND	ND	ND	20	10	ND	ND	10	ND	ND	ND	ND	ND	Grab sample of v quartz with goss west of Tobin Creek.	170
2	ND	50	200	ND	20	10	ND	100	ND	ND	5	ND	ND	Grab sample of D_{bls} unit (no qtz) near Spine.	171
ND	ND	ND	20	ND	10	ND	ND	20	ND	ND	ND	ND	ND	Grab sample of v qtz in D_{bls} unit near Spine.	172
2	ND	ND	200	ND	50	10	ND	200	ND	ND	5	ND	ND	Grab sample of D_{bls} unit with iron stains near Spine.	173
1	ND	ND	100	50	20	10	10	100	ND	ND	ND	5	ND	Grab samples of v qtz in fractures east of Tobin Creek.	174
1	ND	ND	ND	ND	ND	ND	ND	ND	1000	ND	ND	ND	ND	Grab sample of v qtz with arsenopy south of landslide.	175
1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	Grab sample composite of v qtz in fractures near Tobin Pass.	176
ND	ND	ND	ND	50	ND	10	20	ND	ND	ND	ND	ND	ND	Grab sample of qtz near greenstone dike contact in southern area.	177
1	ND	ND	50	20	10	ND	10	20	ND	ND	ND	ND	ND	Grab sample composite of v qtz (rare albite) - lim near Chandalar mill	178
ND	ND	ND	ND	20	ND	ND	ND	10	ND	ND	ND	ND	ND	Grab sample of v qtz near thrust and greenstone in northern area.	179
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Grab sample of D_{bls} unit near thrust contact in St. Mary's Gulch.	180
ND	ND	ND	20	20	ND	5	10	50	ND	ND	ND	ND	ND	Grab sample of metamorphic qtz in same area as 180.	181
ND	ND	ND	ND	20	10	ND	ND	10	NA	ND	ND	ND	ND	Grab sample of v qtz with arsenopy and scor (Little Squaw dump).	182
1	50	100	ND	ND	20	ND	ND	10	NA	ND	10	ND	20	Grab sample of v qtz with mass arsenopy (Little Squaw dump).	183
1	ND	ND	ND	20	10	ND	ND	ND	NA	ND	ND	ND	ND	Grab sample of v qtz with arsenopy and scor (Summit mine dump).	184
1	20	ND	ND	ND	20	20	ND	20	NA	ND	10	ND	10	Grab sample of v qtz with mass arsenopy.	185
5	ND	ND	ND	20	10	ND	10	20	NA	ND	5	ND	ND	Grab sample of v qtz with lime on surface Little Mikado area.	186
ND	ND	ND	ND	20	ND	ND	ND	10	5000	ND	200	200	1000	Grab sample of v qtz with gal, sphal, py, gold (Little Mikado).	187
ND	ND	ND	ND	20	ND	ND	ND	10	NA	ND	ND	ND	200	Grab sample of v qtz with arsenopy, scor, and gold (Little Mikado dump)	188
ND	ND	ND	ND	20	ND	ND	ND	10	*1.0	ND	ND	ND	ND	Grab sample of v qtz with arsenopy, scor (Star Lode #3).	189
ND	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	ND	Albite-qtz segregation in greenstone at Pedro Gulch.	190
5	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	ND	ND	ND	Albite crystals in qtz-albite vein material near Chandalar mill.	191



Frequency Distribution of Atomic Absorption Values in Stream Sediment Samples Chandalar Area, Alaska

Appendix III

Appendix IV

Average, Standard Deviation, Threshold, and Anomalous Values for Stream Sediment Samples, Chandalar Area (Values in parts per million unless indicated; AA = Atomic Absorption)

Element	Average	Standard Deviation	Threshold	Anomalous
Gold (AA)	NOT	ANALYZED		
Copper (AA)	46.03	18.56	83.15	101.71 (80)
Lead (AA)	25.69	11.49	48.66	60.14
Zinc (AA)	123.04	37.64	198.31	235.95
Copper	28.78	22.55	73.88	96.43
Lead	18.33	13.47	45.27	58.74
Zinc	150.26	57.80	265.85	323.65
Molybdenum	5.86	3.87	13.59	17.45
Silver	0.12	0.25	0.61	0.86
Cobalt	26.57	18.07	62.70	80.77
Chromium	141.47	112.47	366.41	478.87
Nickel	30.00	25.80	81.61	107.41
Manganese	596.15	454.64	1505.43	1960.06
Titanium	7923.07	2746.23	13,415.54	16,161.77
Iron (%)	3.99	2.01	8.01	10.03
Magnesium (%)	1.14	0.50	2.13	2.63
Calcium (%)	0.19	0.22	0.63	0.85
Barium	520.51	164.11	848.73	1012.84
Strontium	97.12	18.18	133.47	151.64
Boron	45.96	23.47	92.89	116.36
Beryllium	2.30	1.21	4.71	5.92
Tin	2.17	1.57	5.31	6.89
Tungsten	1.50	0.00	1.50	1.50
Zirconium	149.68	66.36	283.39	348.75
Lanthanum	51.47	29.49	110.45	139.93
Niobium	20.03	7.88	35.79	43.67
Scandium	17.69	4.34	26.37	30.71
Yttrium	41.03	18.29	77.60	95.89
Vanadium	100.00	13.91	127.82	141.74 (?)
Arsenic*	1.80	0.01	1.82	1.83
Antimony	10.44	32.43	75.30	107.72
Bismuth	2.77	2.54	7.86	10.40
Cadmium*	0.20	0.00	0.20	0.20
Gold*	0.07	0.80	1.67	2.48

*Values are probably meaningless due to limits of detection

Appendix V

Stream Sediment Samples Considered Anomalous in the Chandalar Area

Map No.	Significant Elements and Values in ppm	Other Possibly Anomalous Elements & Remarks
6	Ag 1	Sb 100; Spec. value for Ag is near limit of detection
9	Pb 100	Spec. Analyses 20
12	Pb 70	Spec. Analyses 20
13	Mo 20	Co 100; Cr 500, Sr 200; Sb 100
14	Mo 20; Sb 200	Cr 500; Ni 100. Spec. value for Mo may be too high
15	Pb 70	
24	Ag 2	
26	Ni 200	Cu 75; Cr 500; Y 100; Sb 100
42	Cu 85	Co 100
46	Cu 80	Cr 500; Sb 100
48	Ag 1	Spec. value for Ag is near limit of detection
49	Ag 1	Spec. value for Ag is near limit of detection; Cu 70
52	Cu 85	
53	Ag 1; Cu 80	Spec. value for Ag is near limit of detection
55	Ag 1; Cu 85	Spec. value for Ag is near limit of detection
56	Cu 85	Zn 210
57	Cu 80	Zn 195; Y 100
58	Cu 85	Zn 210
59	Cu 90	
60	Cu 95; Zn 250 No 20; Ni 200	Cr 500; Y 100; Sb 100
67	Cu 80	Zn 210
76	Zn 250	
78	V 200	
86	Mo 20	Cr 500; Ni 100; Sr 200; Sb 100
87	Fe 10%; Sn 10	Bi 10
88	Fe 20%; Sn 20	Bi 10
94	Au 10	Area stripped for placer mining
95	Cu 90, Ag 1	Y 100; Field test 12 milliliters
96	Cu 85	Field test 15 milliliters
98	B 200	Zr 500; Be 5
108	Mo 20	Cr 500; Sb 100
109	Ag 1	Be 5; Zr 500
121	Mo 20	Zn 200; Sb 100
134	Cu 130; Pb 990; Zn 420; Mo 20; Ag 5	Analyses apparently valid - AA rerun and Spec. rerun. Spec. values much lower.
136	Pb 70	Spec. Analysis 10

Appendix VI

INTERVALS OF ESTIMATION AND DETECTION LIMITS

SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES

Copper ppm*	Lead ppm	Zinc ppm	Molybdenum ppm	Silver ppm	Cobalt ppm	Chromium ppm	Nickel ppm	Manganese ppm	Titanium ppm	Iron (%)	Magnesium (%)	Calcium (%)	Barium ppm	Strontium ppm
20,000	20,000	10,000	2,000	5,000	2,000	5,000	5,000	5,000	10,000	20	10	20	5,000	5,000
10,000	10,000	5,000	1,000	2,000	1,000	2,000	2,000	2,000	5,000	10	5	10	2,000	2,000
5,000	5,000	2,000	500	1,000	500	1,000	1,000	1,000	2,000	5	2	5	1,000	1,000
2,000	2,000	1,000	200	500	200	500	500	500	1,000	2	1	2	500	500
1,000	1,000	500	100	200	100	200	100	200	500	1	0.5	1	200	200
500	500	200	50	100	50	100	50	100	200	0.5	0.2	0.5	100	100
200	200	100	20	50	20	50	20	50	100	0.2	0.1	0.2	50	50
100	100	L	10	20	10	20	10	20	50	0.1	0.05	0.1	20	L
50	50		5	10	L	10	5	L	L	L	L	0.05	L	
20	20		L	5		5	L					L		
10	10			2		L								
5	L			1										
2				L										
L**														

Boron ppm	Beryllium ppm	Tin ppm	Tungsten ppm	Zirconium ppm	Lanthanum ppm	Niobium ppm	Scandium ppm	Yttrium ppm	Vanadium ppm	Gold ppm	Bismuth ppm	Cadmium ppm	Antimony ppm	Arsenic ppm
2,000	1,000	1,000	10,000	1,000	1,000	2,000	100	200	10,000	500	1,000	500	10,000	10,000
1,000	500	500	5,000	500	500	1,000	50	100	5,000	200	500	200	5,000	5,000
500	200	200	2,000	200	200	500	20	50	1,000	100	200	100	2,000	2,000
200	100	100	1,000	100	100	200	10	20	500	50	100	L	1,000	1,000
100	50	50	500	50	50	100	5	10	200	20	50		500	500
50	20	20	200	20	20	50	L	L	100	10	20		200	L
20	10	10	100	L	L	20			50	L	10		100	
10	5	L	50			10			20		5		50	
L	2		L			L			10		L		L	
	1								L					
	L													

*ppm indicates parts per million
**L = Lowest limit of detection