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GERALD ROBIE SANFORD

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GEOLOGY OF THE SPEARHEAD MOUNTAIN STOCK SHELDON LAKE MAP SHEET YUKON TERRITORY

GEOLOGY 499 1968-1969

14736 Thrift Avenue,
White Rock, B. C.
April 4, 1969.

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Department of Geology,
University of British Columbia,
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Dear Sir:

This graduating thesis is submitted in accordance with Page C 48 of the 1968 - 1969 Calendar for the Faculty of Applied Science regarding the course Geology 499.

It deals with a Tertiary stock, located in the Yukon Territories.

Yours truly,

G. R. Sanford

Gerald R. Sanford

ABSTRACT

A two square mile stock of biotite quartz monzonite forms the core of Spearhead Mountain-Peak 6923, Sheldon Lake Map Sheet, Yukon Territory. The stock has intruded Ordovician and Silurian sediments and has thermally altered them for a distance of up to one quarter mile. Mineralizing fluids ascended near vertical cooling fractures in the quartz monzonite, creating a porphyry copper deposit of chalcopyrite and pyrrhotite.

Trend surfaces from the first to the third order were established from plagioclase, orthoclase, quartz and total mafic minerals modal data and specific gravity values for the intrusive rock. Quartz, total mafic minerals and specific gravity vary systematically while orthoclase and plagioclase have erratic distributions. Contoured modal data and second degree trend surfaces for quartz, specific gravity and total mafic minerals show a circular distribution pattern. Linear trend surfaces indicate northwesterly and southeasterly gradients for quartz, plagioclase, orthoclase and specific gravity.

The original homogeneous granitic magma was contaminated by silica assimilation of the intruded, highly siliceous sediments. Incomplete diffusion of the contaminating silica lead to a circular outward increase in silica and a corresponding outward decrease in mafic minerals, but did not significantly affect the distribution of orthoclase or plagioclase. The circular zonation of the high specific gravity mafic minerals gave rise to a similar zonation of specific gravities.

GEOLOGY OF THE SPEARHEAD MOUNTAIN STOCK

SHELDON LAKE MAP SHEET

YUKON TERRITORY

A Graduating Thesis submitted during the Fourth Year of the Course in Applied Science at the University of British Columbia.

GERALD ROBIE SANFORD

APRIL 4, 1969

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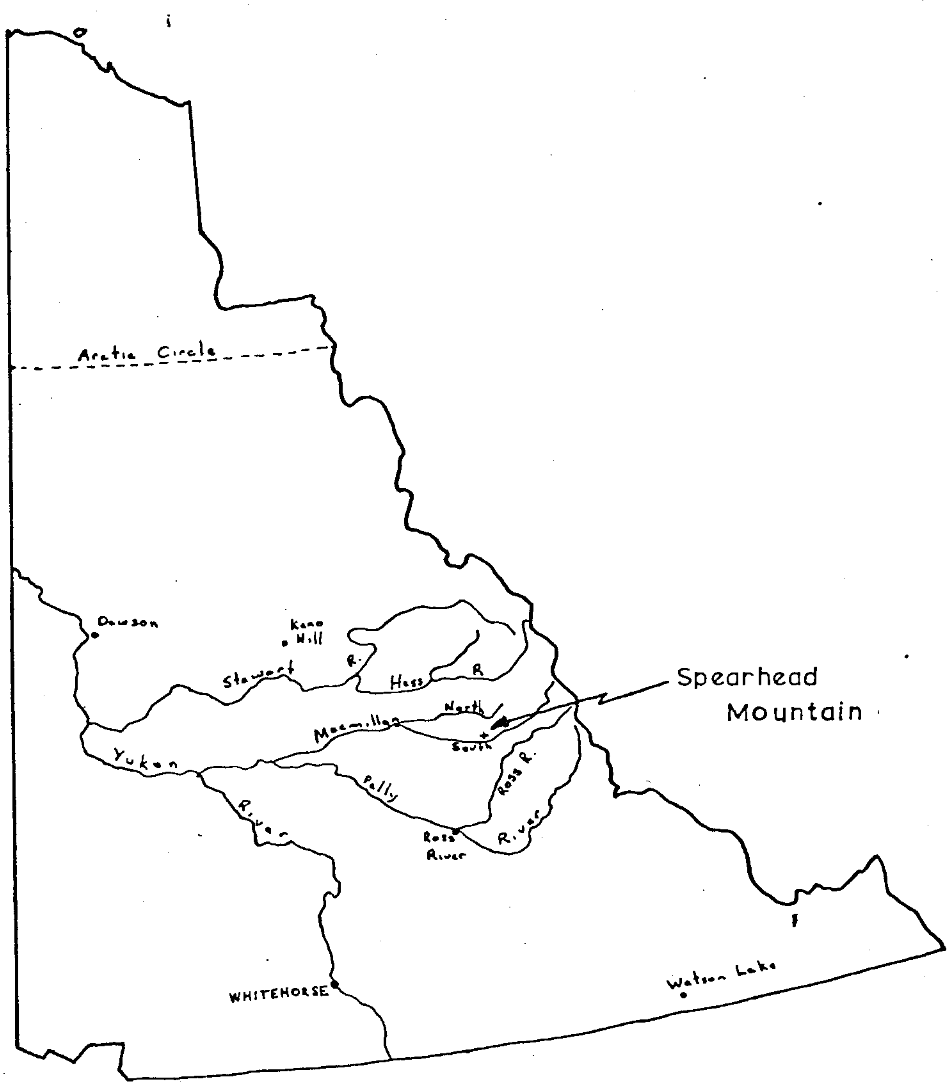
FIGURE 1

LOCATION MAP

SPEARHEAD MOUNTAIN — PEAK 6923

YUKON TERRITORY



Scale: 1 Inch to 120 Miles

100 0 100 200 300 400

GEOLOGY OF THE SPEARHEAD MOUNTAIN STOCK

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YUKON TERRITORY

INTRODUCTION

This thesis is based on part of the geological mapping done by the writer during the summer field season of 1968 while employed by Atlas Explorations (NPL), Vancouver, B. C. The field work was carried out while working on the Hess Project, an extensive regional geological and geochemical reconnaissance program in the Hess River region of the Yukon Territories. (See Figure 1). Essentially all of the region encompassed by this program had never been mapped on any but the largest scale (1" = 120 miles). Minor portions had been mapped on a 1" = 4 miles scale. Atlas Explorations carried out spot checks in the region during the previous year and noted several gossans, geochemical anomalies and mineralized zones. Apart from this, the area has been untouched except for periodic visits by trappers, hunters, government surveyors and prospectors. As there are no residents or settlements in the area only the major topographical features have been named on the National Topographic Series (NTS) Maps and for reference purposes, many of the lakes, streams and mountains were named by the company. One of these many names was Spearhead Mountain.

The Spearhead intrusion was mapped in mid-August 1968, by a three man field party which spent a total of eleven days in the area. The crew consisted of the writer who mapped the geology, a prospector who checked the mineralization in the stock noted the year previously, and a silt sampler who collected silt samples from all creeks in the area for geochemical analysis. Mapping was done on air photo overlays at a scale of one half mile to the inch. The intrusion had not been mapped accurately the previous year and the extent of the mineralization was unknown. It was hoped that a detailed map of the pluton might provide useful information regarding controls of mineral deposition.

Location and Access

Spearhead Mountain is the highest and most prominent of several closely associated peaks located approximately at latitude 62°50' North and longitude 131°40' West. It is four miles north of the South Macmillan River, near the southern end of the Hess Mountain Range and is shown as Peak 6923 in the northwest corner of NTS Sheet 105 J, Sheldon Lake, Yukon Territory. This peak, approximately 65 miles NNE of Ross River, Y. T. and 200 miles NE of Whitehorse, is near the eastern edge of the Yukon Plateau.

The mountain is easily accessible from Ross River only by helicopter, or by float plane to one of the nearby lakes or the South Macmillan River. The Canol Pipeline Road lies some 26 miles to the east. This road, built during World War Two by the United States War Department, accompanied a pipeline that was designed to provide an emergency source of oil from the fields near Norman Wells, NWT. It connected with the Alaska Highway some 80 miles southeast of Whitehorse and was abandoned early in 1945. From Ross River north, the road at present is all but impassible due to neglect. Reconstruction is underway and by the end of the end of the summer of 1969 it is hoped that it will be passable to Sheldon Lake, some 20 miles southeast of Spearhead Mountain. Sheldon Lake, a broadening of the Ross River is accessible by power boat from Ross River.

Topography

Spearhead Mountain is the highest peak within its immediate surroundings. This peak is isolated from several lower peaks, three quarters of a mile to the east. Spearhead Mountain is partially underlain by a granitic core to the north and east while the lower peaks are entirely granitic. Near vertical jointing in this granitic rock has created steep, often sheer faces, some over 500 feet high. (See Plate III.). Jointing, combined with frost action, has made walking hazardous and in some cases impossible along the knife edge ridges in the granitic rock. Ridges extending down from the granitic core are also sharp and are covered with broken shales. To the west, lower ridges are broad and rolling and contain only scattered outcrop. These ridges have been rounded by glaciation, slope gently to the south and drop off steeply to the north, a feature noted throughout the northern portions of the Yukon Plateau. (See Plates I and II).

Tree line is approximately 4500 feet elevation and the limit of the last glaciation is probably a few hundred feet higher. (Stockwell, 1957). Below this elevation, the slopes are drift covered and outcrop can be found only in creek beds and on cliff faces. Drift-covered areas sustain a stunted growth of black spruce, pine, dwarf birch, alder and buck brush. Most of the Spearhead pluton is near or above tree line with the result that location of and access to outcrop is relatively easy.

There are several small alpine lakes in the high valleys on the northern side of the mountain area. There is also a rock glacier one half mile wide by one mile long, found in the alpine valley to the northeast of Peak 6923.

Climate

As with most northern areas, the winters are very cold but summers are mild and pleasant. The temperature extremes at Mayo, Y. T., some 140 miles to the west, are from 73°F below to 96°F above. In June and July, daylight is almost continuous. Precipitation averages about ten to fifteen inches per year, about half of which falls in the four months from June to September.

Ice breaks up in the rivers in early May but lakes generally remain frozen until late May. By early June snow still covers much of the ground above 4000 feet and it is early July before the higher peaks become essentially snow-free. Freeze-up begins in October.

Flora

Forest growth is generally light but widespread. In the lower valleys, trees up to twelve inches diameter are common with some trees exceeding eighteen inches diameter. They are seldom more than sixty feet high and the largest trees are found along river banks. The native trees include lodgepole pine, black and white spruce, alpine fir (balsam), western and Alaska paper birch, poplar and trembling aspen. Stunted willow and alder are generally present in swampy ground. Willow, heather, mosses, grasses and other alpine plants are found at elevations at or above tree line.

Fauna

Large game animals are fairly plentiful. The higher regions of the Spearhead area are inhabited by a herd of some twenty-five to thirty Dall sheep. Woodland caribou in small groups frequently can be seen grazing on the moss covered slopes of the lower ridges. Grizzly, black, and brown bear are not plentiful but are seen occasionally near tree line. Moose inhabit the lower swampy areas. Small fur bearing animals are common.

Grayling are found in almost all of the streams in the district and pike abound in many of the lakes. Whitefish are found in many of the larger streams and lakes. Game birds include grouse, ptarmigan, ducks and geese.

PREVIOUS WORK

In 1902, R. G. McConnell and J. Keele explored the Macmillan River and its main branches from its junction with the Pelly River. McConnell Followed the North Fork and Keele the South. Keele reached as far as the Riddell River, about 26 miles west of the Spearhead area and then returned. Both found little bedrock along the drift-filled Macmillan Valley and had to examine bordering ridges and mountains.

In 1908 Keele passed close to the Spearhead area while mapping the area from the Pelly River to the Mackenzie River. He passed through Sheldon Lake on his journey up the Ross River, a main feeder of the Pelly, and noted that Mt. Sheldon, just west of Sheldon Lake, contained a granitic core.

In 1944, F. D. Kindle made a geological reconnaissance along the Canol Road to Macmillan Pass. His mapping was limited to a belt ten miles wide along the road. He did limited reconnaissance work around Mt. Sheldon.

In 1949 - 1951 Topographical Survey parties mapped most of this region of the Yukon and used Spearhead Mountain as one of many horizontal control points.

In 1959 and 1960 Roddick and Green mapped on reconnaissance scale (1" = 4 miles) the geology of the Sheldon Lake Sheet and the adjoining westerly Sheet, Tay River. The Spearhead intrusion was mapped as part of the Sheldon Lake Project.

In the summer of 1967 Atlas personnel observed disseminated chalcopyrite and pyrrhotite in the Spearhead stock and decided that further work was advisable in the following year.

REGIONAL GEOLOGY

This part of the Yukon is underlain by rocks that range in age from Proterozoic to Mesozoic. Regional strike is northwest-southeast with a moderate dip to the northeast. Exceptions to this regional attitude of beds occur locally.

Proterozoic

Proterozoic rocks, generally referred to as Yukon Group, constitute a metamorphic complex that has been folded into westerly-northwesterly trending structures. Cairnes (1914) defined the Yukon Group as a useful field name under which "may be included all the older metamorphic, probably Precambrian, schistose and geneissoid rocks that are encountered regardless of their origin which is often difficult or impossible to determine." In this region, the Yukon Group is composed mainly of poorly sorted, medium-grained, buff to grey weathering quartzites with lesser amounts of phyllite, chlorite-mica schists and slates. These beds of limestone and lenses of intraformational conglomerate occur at various intervals in the sequence. The quartzites are brittle rocks and numerous small fractures that have formed in them are now filled with quartz as stringers and veins.

<u>Paleozoic</u>

Paleozoic rocks consist of two main sequences, an Ordovician-Silurian sequence and a Devonian-Mississippian (?) sequence. An unconformity marks the contact between the Proterozoic and the younger, very thick assemblage of Ordovician-Silurian rocks. This contact coincides with a regional topographic depression.

The Ordovician-Silurian sequence consists mainly of chert and slate. The cherts are generally grey or black, but green and red varieties are also known. Some of the black cherts weather white along bedding planes. Shales are interbedded with the cherts. The lower part of the section is dominantly shaley, the upper part dominantly cherty. Near granitic bodies, the argillaceous rocks have been silicified and altered to hornfels, forming deep, rusty-red aureoles around the stocks. (See Plate IV). Graptolites collected from this unit, range in age from Lower Ordovician to Silurian. The total thickness of this unit is thought to be about 10,000 feet. (Roddick et al. 1958, 1960).

The Devonian-Mississippian (?) sequence contains many rocks similar to those found in the Ordovician-Devonian sequence. This unit is composed of graphitic, argillaceous sediments, cherts, greywacke and massive chert pebble conglomerate. The chert pebble conglomerate is polymictic with pebbles and cobbles of chert, quartzite and argillite. It usually weathers to a light grey.

This sequence is probably about 7000 feet thick. (Roddick et al., 1958, 1960).

Mesozoic

Granitic rocks (quartz monzonite and granodiorite) of Cretaceous age intrude the rocks of the region. These rocks are clearly intrusive, with sharp, cross-cutting contacts. Xenoliths are rare. The intrusions are commonly biotite granodiorite but textures and compositions vary. These intrusions commonly underlie mountains of the region. Hornfels and pyrite are commonly associated with the contacts of these intrusions. Granodiorite stocks are found in an east-west trending belt that passes through the northern part of the Hess River area. Quartz monzonite stocks follow a northwest-trending belt. Peak 6923 lies near the southeast end of the quartz monzonite belt. Diabase dykes are associated with both types of intrusive rocks.

Cenozoic

Quartz and feldspar porphyries of granodiorite composition and commonly of plutonic appearance outcrop in the southwest corner of the Sheldon Lake Map Sheet. They are closely associated with Tertiary volcanic rocks and possibly were feeder dykes to, or intrusive equivalents of, the volcanic sequence. Volcanic rocks are chiefly massive, dark andesite, dacite and basalt flows that unconformably overlie Paleozoic strata. Individual flows are from ten to 300 feet thick. It appears that the flows were extruded onto a surface of moderate relief. (Roddick et al., 1958, 1960).

Numerous rusty-weathering, limonite-cemented conglomerates are found throughout the region. These conglomerates often contain plant fossils and are usually situated at the base of mountain slopes, valley margins or stream beds. The limonite is derived from nearby pyritic beds. These deposits are thought to be Paleocene in age. (Roddick et al., 1958, 1960).

STRUCTURAL GEOLOGY

Unconformities

A major unconformity separates the Pre-Cambrian from the Paleozoic. This is usually indicated by a topographic low along the contact. Little else is known of this unconformity at the present time. An unconformity may separate the Ordovician-Silurian from the Devonian-Mississippian (?), but evidence is lacking.

Folding

Regional strike of the rocks is northwest-southeast, with moderate dips to the northeast. The most prominent structure in the Proterozoic rocks is the metamorphic foliation (schistosity). Pre-Cambrian rocks are buckled into fairly open folds with axes plunging northwest at angles of 10-30 degrees. Phyllitic layers in the Yukon Group give evidence of at least three periods of deformation (opposing lineations and kink banding). Folding in the Ordovician-Devonian is more complex than in the Proterozoic, a consequence of penecontemporaneous deformation and the superposition of the regional fold pattern over local intraformational folding. In the Anvil-Vangorda area to the south, Templeman-Kluit (1967) believes the Cambrian sediments were deformed during regional metamorphism in the post-Cambrian, pre-Devonian time. Wheeler (1964) also considers this to be possible.

Faulting

The Tintina Trench is a major fault zone found south of the Hess River Region. Many faults in the Hess Region trend northwest-southeast, paralleling this major rift zone. Movement along these faults is generally minor and the only evidence of movement is an abnormally well-developed schistosity over narrow zones. Another fault set trends northeast-southwest and is paralleled by a pronounced joint set. Only minor displacement ordinarily occurs along these faults. Most of the major fault zones have undergone extreme preferential weathering with the result that they are now topographic lows filled with alluvium and glacial debris.

TABLE I

TABLE OF FORMATIONS

CENOZOIC

Tertiary

Grey and dark grey massive porphyritic andesite, dacite, basalt

Granodioritic quartz and feldspar porphyry, probably plutonic equivalent of above

Intrusive-Extrusive Contact

Paleocene

Limonite and calcium carbonate cemented conglomerate

Unconformity

MESOZOIC

Cretaceous

Late mafic intrusive rocks: Diabase dykes

Felsic intrusive rocks: granodiorite, quartz monzonite, diorite

Intrusive Contact

PALEOZOIC

Devonian-Mississippian (?)

Carbonaceous rocks, cherts, slates, quartzite, phyllite, greywacke, limestone, minor alkalic basalt

Ordovician-Silurian

Varicolored slates, green chert, argillite, siltstone etc.

Great Unconformity

PRECAMBRIAN

Proterozioc

Quartzite, phyllite, limestone, chlorite schist, sericite schist, conglomerate, slates

SPEARHEAD MOUNTAIN GEOLOGY

Approximately 25 square miles were mapped in the Spearhead area. About eight percent of this was outcrop. The granitic intrusion is nearly two square miles in area and is almost totally exposed although parts are inaccessible. Most of the units mapped were based on the legend proposed by Roddick and Green (1958, 1960) modified to suit the company's needs.

Proterozoic (1)

Quartzite (1d)

This unit is characterized by massive, gritty, quartz pebble quartzite interbedded with dark shales and slates. The fine-grained matrix of some of the quartzite beds is partly limey. In some areas where this unit is massive and coarse grained, it resembles granite from a distance. This unit is in fault contact with the overlying Paleozoic rocks just north of the South Macmillan River.

Ordovician and Silurian (3)

Carbonaceous Rocks (3a)

This unit consists of carbonaceous rocks: black argillites, black chert and minor amounts of interbedded chert breccia. (See Plate VI). The argillites are normally a pale charcoal grey to black, well indurated rocks that commonly have a prominent slaty cleavage. They are usually fairly massive and some are slightly schistose. Bedding is often not visible under field conditions but on sawn faces it is quite evident. Bedding is sometimes evidenced as color banding. These rocks contain minor amounts of disseminated pyrite. They weather to a light greyish color. Near the granitic stock these units become paler in color and coarser in grain size as they begin to recrystallize. Some individual bands become more hornfelsic than do others.

In thin sections these rocks are seen to consist largely of quartz and carbon-rich laminations. Quartz grains generally are rounded and of silt size although in one section the grains are angular and up to 0.1 mm. diameter, slightly above the limits for silt size. The quartz sometimes shows undulatory extinction under crossed nicols, indicating a metamorphic source, possibly the Yukon Group. Little if any feldspars are present. Quartz rests in a fine-grained matrix of authigenic sericite and (?) chlorite. The sections contain rare quartz veinlets about one-half mm. thickness.

Black cherts commonly weather grey. They are cut by numerous quartz stringers ranging in thickness from fractions of a mm. to one-half cm. in hand specimens (See Plate VII). In places, some of the stringers appear to be quartz filled tension gashes. There is often a gradation from argillite to cherty argillite to chert. Concretionary barite nodules are found in the black cherts and argillites near the northern edge of the map area (See Geology Map). These nodules average one to two inches in diameter and consist of radiating barite crystals.

Calcareous Rocks (3b)

This unit consists of crystalline and argillaceous limestone and calcareous argillite. Most of the limestones contain argillaceous material. These rocks are usually dark in color but weather to a pale grey. Near a small intrusion to the southwest of the main intrusion a limestone bed has locally thermally altered to a tremolite-actinolite skarn. In thin section, a sample taken four miles from the main intrusion consists of lenses of calcite (1 cm. x 3 mm.) in a groundmass of micrite. The lenses have recrystallized from the micrite, as stylolites in the micrite are not continuous across the lenses, but are found on either side of them. A sample taken about 1000 feet from the intrusion contained carbonaceous bands in a matrix of recrystallized calcite grains averaging 0.1 mm. diameter.

Chert Pebble Conglomerate (3d)

This unit consists of massive chert pebble conglomerate, usually interbedded with quartzites, shales and chert breccias. The pebbles consist of pale and dark chert, but quartzite and argillite pebbles are by no means rare. Cobbles of chert up to a foot in diameter can be found, but the diameter averages from 5 mm. to 2 cm. (See Plate VIII). A fresh surface is black and textural features cannot be seen readily. However, on the light grey weathered surface the individual pebbles can be seen easily. Less than 20 percent of the rock is matrix. Chert breccia differs from the conglomerate only in the angularity of the pebbles. It contains more matrix material in places and could be classified as sub greywacke. Elongate fragments in the chert breccia are often aligned parallel to bedding. (See Plate IX). Graded bedding is visible in both breccia and conglomerate although it is only rarely seen. (See Plate X).

Grey Bedded Chert (3f)

This chert appears to differ from the cherts mapped as 3a in carbon content only. It is coarsely laminated or bedded at intervals of 2 - 14 inches. Manganese stain and dendrites are common along these laminations. This unit may be the stratigraphic equivalent of the more graphitic black cherts in unit 3a, but deposition took place in surroundings poor in organic materials.

Cretaceous

Quartz Monzonite (11)

Spearhead stock is composed of medium to coarse-grained biotite quartz monzonite with varying amounts of hornblende. The hornblende is not easily recognized in hand specimens but is easily found in thin sections. Near vertical joints in this rock locally are spaced at one foot intervals but are normally more widely spaced. (See Plate V). They strike almost due north. In places where the joint spacing is a foot or less, massive slabs have weathered off and have been stacked like a pile of books. Lofty sheer faces are a common feature resulting from this jointing. Much of the granitic rock has weathered deeply and obtaining a fresh surface can be difficult. Disseminated chalcopyrite and pyrrhotite are common throughout the intrusion. Azurite and tarnished chalcopyrite, resembling bornite are seen on weathered surfaces. Weathering of the sulphides has caused many of the cliffs to be limonite-stained as are many joint faces. (See Plate III).

Xenoliths are seldom seen in the rock although they are by no means absent. The xenoliths are generally dark in color, are well-rounded, and range in size from a centimeter to a foot or more (See Plate XI). They are composed chiefly of biotite and hornblende.

The stock is definitely intrusive. Contacts are sharp (See Plate XII) and the intrusion abruptly interrupts and transects bedding of the enclosing sedimentary rocks. In places, "fingers" of granitic rock up to fifty feet long and twenty feet wide have invaded the enclosing rocks. However, there is no indication of folding or crumpling of beds.

Another quartz monzonite stock about one-eighth of a square mile in area crops out at the end of a ridge three miles southwest of the main stock. It is poorly exposed but also contains disseminated pyrrhotite. Relationship of the two stocks is not known, but they may represent offshoots of a common magma chamber. This intrusion also has a small hornfelsic halo and locally has metamorphosed a nearby limestone bed to a tremolite-actinolite skarn.

In thin sections, the intrusive rock is remarkably uniform. Seven thin sections from various points across the intrustion show that the fabric is essentially uniform except near the contacts.

Plagioclase. Plagioclase composition is similar throughout the stock, ranging from An_{35}-An_{45} (Andesine) in a single crystal. Crystals are euhedral to subhedral, tubular and well zoned. They are commonly from one to two mm. in diameter. Most of the feldspar is slightly altered to sericite, especially the calcic core. Carlsbad, albite and carlsbad-albite twins are common. Pericline twinning was seen in a few cases. Plagioclase forms 30-40 percent of the rock.

Quartz. Quartz grains are equidimensional and from 1/4 to 2 mm. diameter, the smaller sizes prevailing. Some quartz has been stressed as it shows undulatory extinction. Quartz forms 20-30 percent of the rock.

Orthoclase. Orthoclase is usually found as equidimensional grains about the same size as the smaller quartz grains. Forms 15-20 percent of the rock.

Biotite. Biotite is the most prominent and common mafic mineral. It is commonly euhedral to subhedral and up to 3 mm. diameter. Numerous well developed biotite books are apparent in hand specimens. Radiation halos are common. Near the contact, biotite is generally finer grained than in the core. Near the contact the biotite is found as rounded blebs 0.01-0.1 mm. diameter and scattered throughout the slide. Some larger subhedral grains are also present. Some of the biotite has formed by alteration of hornblende and some biotite has altered to chlorite, probably penninite. Biotite forms 10-12 percent of the rock.

Hornblende. Hornblende is the only other mafic mineral present and can be found as well developed twinned crystals. It is commonly partly or completely altered to both biotite and chlorite. The hornblende content decreases to almost nothing near the contacts. Hornblende was absent in a specimen taken from a well mineralized area, but this sample was not collected by the author and may have come from near the contact. Hornblende composes about 5 percent of the rock.

Chlorite. Chlorite has formed by alteration of both biotite and hornblende. It forms less than 5 percent of the rock.

Calcite. Minor amounts of calcite are present in some samples. It formed as a secondary alteration product along fractures in plagioclase crystals. Some interstitial calcite is also present. Calcite forms less than 1 percent of these rocks.

Apatite. Minute euhedral crystals of apatite are scattered throughout the rocks. The maximum size is 0.2 by 0.05 mm. Apatite forms less than one percent of the rock.

Sphene. Crystals of sphene were found only rarely.

Opaques. Bronze coloured pyrrhotite forms approximately one to two percent of most slides.

Metallic Minerals

Polished section studies showed that only two metallic minerals are present in the stock. These are chalcopyrite and pyrrhotite. Massive sulphides are found only along fracture surfaces. Disseminated sulphides are more common. Chalcopyrite appears to be concentrated along the fracture surfaces although some of it is found as disseminated grains in the granitic rock. Pyrrhotite is more common as disseminations in the granitic rocks. Chalcopyrite-pyrrhotite grain contacts are smooth. In areas where the metallic minerals have been concentrated, the quartz monzonite is noticeably darker than elsewhere.

Dyke Rocks

Three varieties of dyke rocks were observed. In general these dykes parallel the northerly trend of areal joints and are approximately vertical. They are seldom more than a few tens of feet wide. No relationships are known but their age is probably close to that of the intrusion. The dykes are classified by their appearance in hand specimens only.

Type 1: Lamprophyre. One dyke of the lamprophyre clan was found cutting across the crest of the ridge joining the Spear-head stock and the small plug to the southwest. It is five feet wide and stands two to three feet above the surrounding sediments. It has weathered spheroidally around cooling cracks. (See Plate XIII). In hand specimen phenocrysts of plagioclase and some quartz (1 and 2 mm. diameter respectively) rest in a dense dark ground-mass. Cleavage faces can be seen in the groundmass but an identification was not made. The plagioclase phenocrysts often weather out.

Type 2: Dacite. Several dykes of a light green-grey variety were found. They are fine grained and contain fair amounts of disseminated pyrite. They weather to a light orangy color that forms a rim about 1/8 - 1/4 inch thick. (See Plate XIV). There are a few phenocrysts of quartz and zoned plagioclase about one mm. diameter. This rock is probably a dacite porphyry.

Type 3: Biotite-Feldspar Porphyry. Several closely associated dykes of this type are found in a creek bed in the valley to the south of Spearhead peak. The continuation (?) of these dykes can be found near the peak of the mountain and also on the ridge south of the valley. Several dykes of this variety are also closely associated with the small intrusion to the southwest and may be the dyke equivalent of the quartz monzonite. Well developed medium-sized grains of biotite and feldspar sit in a dark greyish, light weathering matrix. Rare hornblende phenocrysts up to one cm. in length are found. Phenocrysts make up approximately 40 percent of the rock.

CONTACT METAMORPHISM

The quartz monzonite stock is surrounded by a rusty halo, up to one quarter mile wide. Haloes up to one mile wide have been reported to the North (Wheeler 1964). The sediments surrounding the intrusion have been metamorphosed into hornfels, quartzites and recrystallized cherts. These "baked" rocks stand out in rugged relief over the adjacent unmetamorphosed strata. The metasediments have been impregnated with pyrite, which upon weathering, produces the rusty color that makes the halo such a conspicuous feature. (See Plate IV).

One thin section was made from a rusty quartzite specimen taken within a few feet of the contact. In hand specimen, the grains averaged one half mm. in diameter and the weathered surface had a sugary texture. Ninety percent of the slide consisted of interlocking quartz grains of two dominent sizes. Grains about one half mm. in diameter predominated, but forty percent of the quartz consisted of grains 0.05-0.1 mm. in diameter, usually clustered together in masses about the same size as the larger grains. About eight percent biotite is present, most of it subhedral (0.1 × 0.05 mm.) and found with the smaller quartz grains. Rounded blebs of biotite about 0.01 mm. in diameter are scattered through the slide. Two percent pyrite, most about 0.1 mm. but some up to 0.5mm. diameter is also scattered through the slide.

Before thermal alteration, this rock was probably a quartz rich sediment with iron, magnesium and aluminum impurities in the clay size portions. An examination of thin sections taken at several hundred foot intervals outward from the intrusive contact showed that thermal metamorphic minerals, if present, would be extremely hard to find.

MODAL ANALYSIS OF PLUTONIC ROCKS

Modal analyses were done for sixteen rock slabs taken from various places within the intrusion. (See Appendix B). The slabs averaged two by two inches. The slabs were stained following the technique of Bailey and Stevens, using an etch time of twenty seconds in 48 percent hydrofluoric acid. Attempts were made to stain the plagioclase feldspar red, using rhodizonate reagent, but this did not give satisfactory results. Initially, point counting was done by using an overhead projector to project the slabs magnified image onto a grid of one-half inch squares. Two thousand points per slab were counted in this manner but the method proved time consuming, and difficulty in distinguishing minerals were encountered. A second method, using a binocular microscope and a fine mesh screen as a grid was found to be much more satisfactory. Six hundred points per slab were counted using this method. Studies after Van der Plas and Tobi, 1965, indicated that no more than six hundred points needed to be counted to achieve an accuracy of from three to four percent in the modal analysis. This is at the 95 percent confidence level. Counting two thousand points increases the accuracy of the count to from one to two percent and the time and effort involved in achieving this accuracy was not deemed necessary. Also, comparisons between control samples with counts of 500, 1000, 1500 and 2000 points showed that the mode determined with 500 points was not significantly different from that obtained with an increased number of points. For results of the modal analyses and the check counts, see Appendix C.

SPECIFIC GRAVITY DETERMINATIONS

Specific gravities were measured for twenty-two specimens of granitic rock. The dry weights were taken and the samples were allowed to soak in water for twenty-four hours to remove any air entrapped in fractures, etc. Appendix D shows the results of these determinations and five control determinations.

The specific gravities differed only slightly, ranging from 2.69 to 2.74. A value of 2.66 was for a highly siliceous specimen.

HAND CONTOURED DATA

Hand contoured original distributions of total mafic minerals, specific gravity, quartz and orthoclase are shown in Figures 2, 3, 4 and 5. From these Figures it may be seen that there is a roughly circular distribution of quartz, total mafics and specific gravity. The total mafics and the specific gravity zone outward from a central low. There are two local specific gravity highs near the southern edge of the intrusion. Quartz zones outward from a central low. Orthoclase and plagioclase do not follow this circular trend. Orthoclase is concentrated in the northeast and southwest corners of the intrusion while the plagioclase has no obvious simple distribution pattern.

ANALYSIS OF VARIANCE

Analysis of variance is a powerful and useful statistical tool. Using this procedure it can be determined whether or not there is any significant difference or interaction between items drawn from random populations. If there is no significant interaction between the means of the data, the items have all been taken from the same population. We use analysis of variance to show that the possible error in the mode of a single sample is less than the variations in modes between samples. Such a procedure is necessary if it is desired to do a trend analysis as we must know if there is a true difference between modes in order to justify comparing them. Proving that one sample is different is enough to justify a trend analysis. For a complete description of the theory and principles behind analysis of variance see Moroney or Dixon and Massey. The method followed is after Dixon and Massey.

The samples whose modes were compared came from three different areas of the intrusion, one from near the center, sample 479, one about 1200 feet from the center, sample 480, and one about 3000 feet from the center, sample 527. Appendix E gives the results of the analysis, indicating that we do indeed have modes which differ. The samples only 1200 feet apart did not vary to any extent , but the samples 3000 feet apart showed a significant variance.

TREND ANALYSIS

In a trend analysis, systematic changes in any type of mapped data are studied by fitting, as closely as possible, the observed values to polynomial surfaces, i.e. linear, quadratic and higher degree surfaces. Studies may be done directly on the basis of these fitted surfaces or on the residuals of these surfaces. A residual is the difference between the observed value and the trend value at a point. Residuals are contoured using the standard deviation appropriate to each residual as contour values. The standard deviation of each surface gives a measure of the variability of data about a surface. The coefficient of determination indicates how closely the map data fits the polynomial surface. ie. fraction of total variance accounted for by surface. From Table II it can be seen that there is a large jump in the coefficient of determination values between the third and fourth degree surface. At this point the polynomial surface "blows up" as there is insufficient data for the number of polynomial coefficients required. These "blown up" surfaces are meaningless.

Linear Surfaces

Linear surface contours indicate a northwest-southeast planar gradient. Orthoclase and plagioclase gradients are almost identical and increase to the southeast. Quartz and specific gravity

TABLE II

STATISTICAL DATA FOR TREND SURFACES

SURFACE	1st degree	2nd degree	3rd degree	4th degree
ORTHOCLASE				
Standard Deviation	2.27	2.01	1.90	0.09
Coefficient of Determination	0.310	0.457	0.514	0.892
PLAGIOCLASE				
Standard Deviation	4.22	3.95	3.15	1.31
Coefficient of Determination	0.130	0.237	0.516	0.916
QUARTZ				
Standard Deviation	5.97	5.00	3.18	0.40
Coefficient of Determination	0.276	0.492	0.795	0.997
MAFIC				
Standard Deviation	5.37	4.63	3.66	0.03
Coefficient of Determination	0.099	0.331	0.582	0.999
SPECIFIC GRAVITY				
Standard Deviation	0.02	0.02	0.01	0.01
Coefficient of Variation	0.048	0.372	0.482	0.718

gradients increase to the northwest. The mafic minerals do not follow the northwest-southeast trend but follow a planar gradient dipping to the southwest. The increase in quartz to the northwest has probably influenced the specific gravity in this direction but the gradient of the gravity plane is almost horizontal.

Second Degree Surfaces

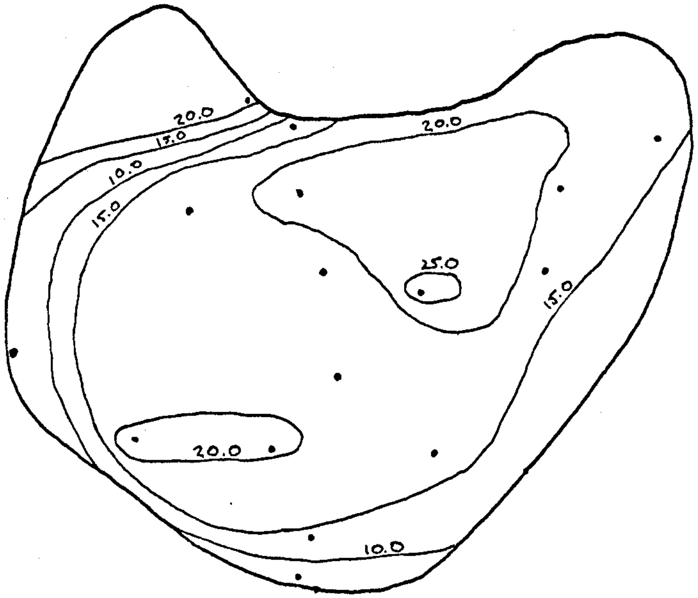
The second degree surfaces for total mafics and specific gravity exemplify the circular zonation of the intrusion from a central high as shown in the hand contoured data. (See Figures 2 and 3). The second degree quartz surface increases outwards from a central low. (See Figure 4). The circular pattern of the three components above is also seen on the third degree surfaces. The second degree surface for plagioclase is roughly a syncline plunging slightly to the southwest. The trough axis lies near the northwestern edge of the intrusion. The orthoclase second degree surface is an approximately horizontal anticline trending northeast-southwest. The axis passes through the center of the intrusion. The plagioclase syncline and orthoclase anticline interact in such a manner that the specific gravity differences between these minerals will be approximately constant throughout the intrusion except for an increase in specific gravity in the southeastern corner. This increase influences the circular and oval patterns of mafic and quartz distribution and the resulting circular specific gravity pattern arises. The circular increase in quartz is to be expected as near the contact the granitic melt becomes increasingly contaminated with silica from the melting quartz rich country rock ie. argillites, cherts and chert pebble conglomerates.

Third Degree Surfaces

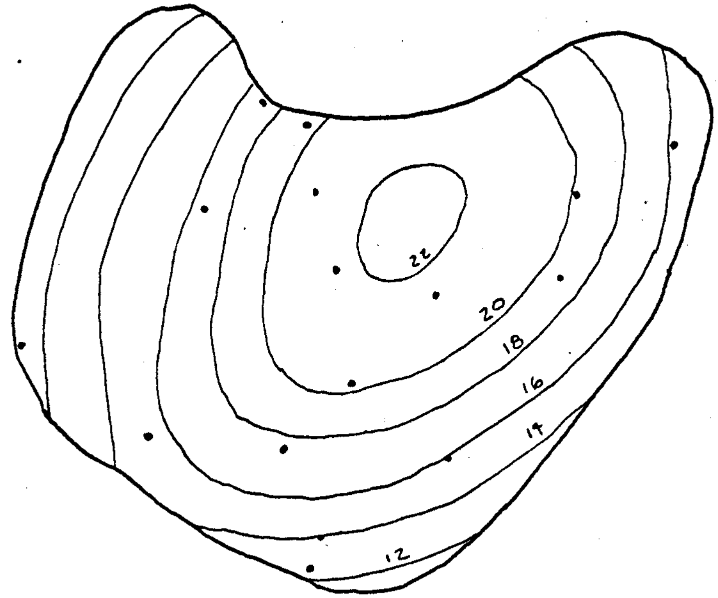
Third degree surfaces are very roughly similar to the second degree surfaces. The orthoclase anticline and plagioclase syncline are still visible and a general circular distribution of the quartz and mafic minerals is still visible. The specific gravity distribution is still circular.

Residuals

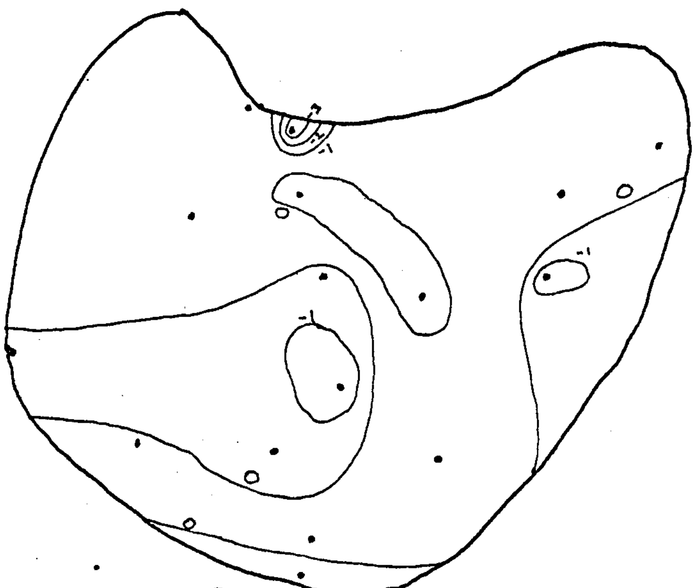
Residuals were contoured for all five variables from the first to the third degree. Quartz first degree residuals corresponded reasonably well with hand contours of the original data. (See Figure 4). A vague correspondence could be seen between the first degree residuals of orthoclase and plagioclase and the original values. (See Figure 5). With the orthoclase and plagioclase the highs in the original data are also areas of large standard deviation on the first degree surfaces. With the higher ordered residual surfaces, no correspondence could be seen for quartz, orthoclase or plagioclase. The third degree residuals of mafics and specific gravity corresponded reasonably well with the original data. (See Figures 2 and 3). Again, highs in the original data correspond to areas of large standard deviation on the third degree surfaces.



A



B



C

Figure 2

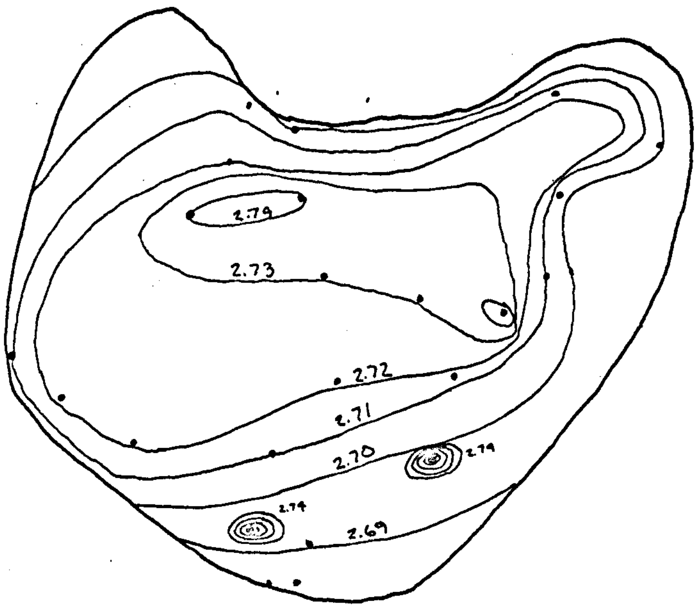
Total Mafic Minerals: Selected Trends and Residuals

A Hand Contoured Original Percentages

B 2 nd Degree Trend Percentages

C Hand Contoured 3 rd Degree Residuals. (Contour values are numbers of standard deviations relative to the 3 rd degree surface)

Scale: 1" 1/2 mile



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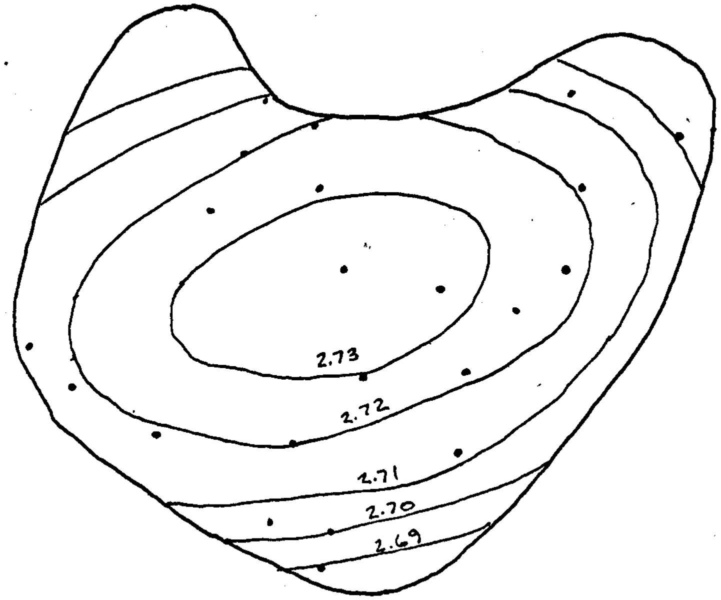

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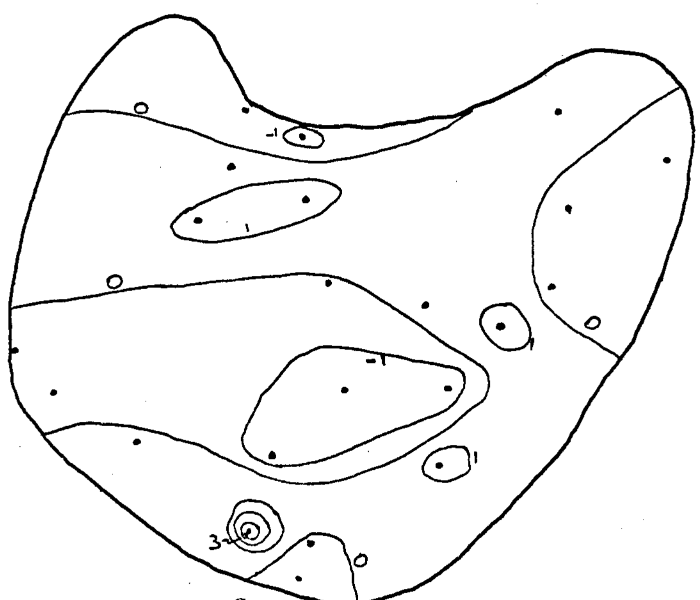


C

Figure 3

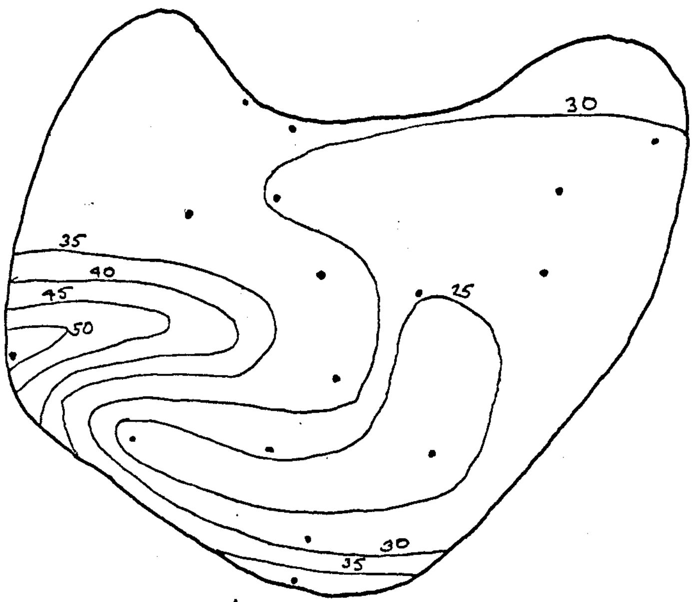
Specific Gravity: Selected Trends and Residuals

A Hand Contoured Original Percentages

B 2 nd Degree Trend Surface Percentages

C Hand Contoured 3 rd Degree Residuals (Contour values are numbers of standard deviations relative to the 3 rd degree surface)

Scale: 1" 1/2 mile



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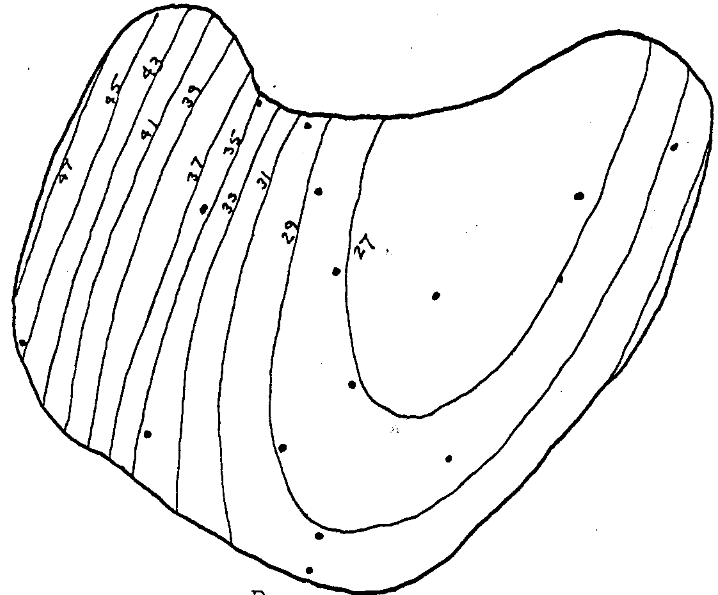
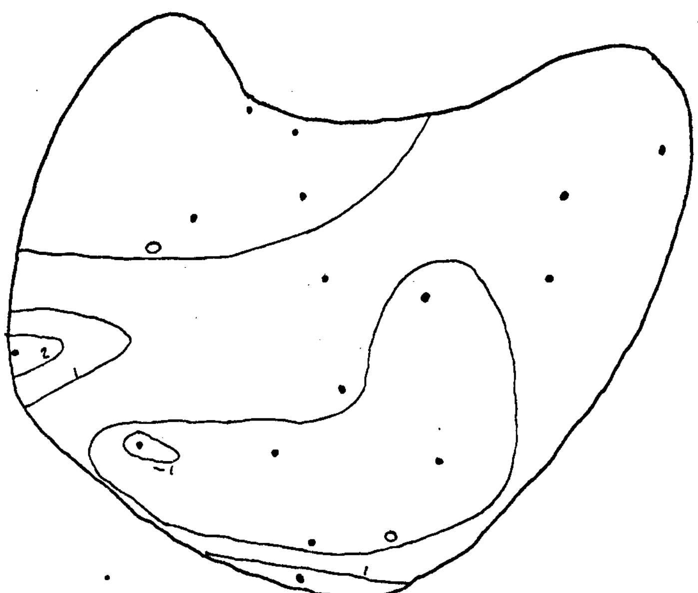


B



C

Figure 4

Quartz: Selected Trends and Residuals

A Hand Contoured Original Percentages

B 2 nd Degree Trend Surface Percentages

C Hand Contoured 1 st Degree Residuals (Contour values are numbers of standard deviations relative to the 1 st degree surface)

Scale: 1" 1/2 mile

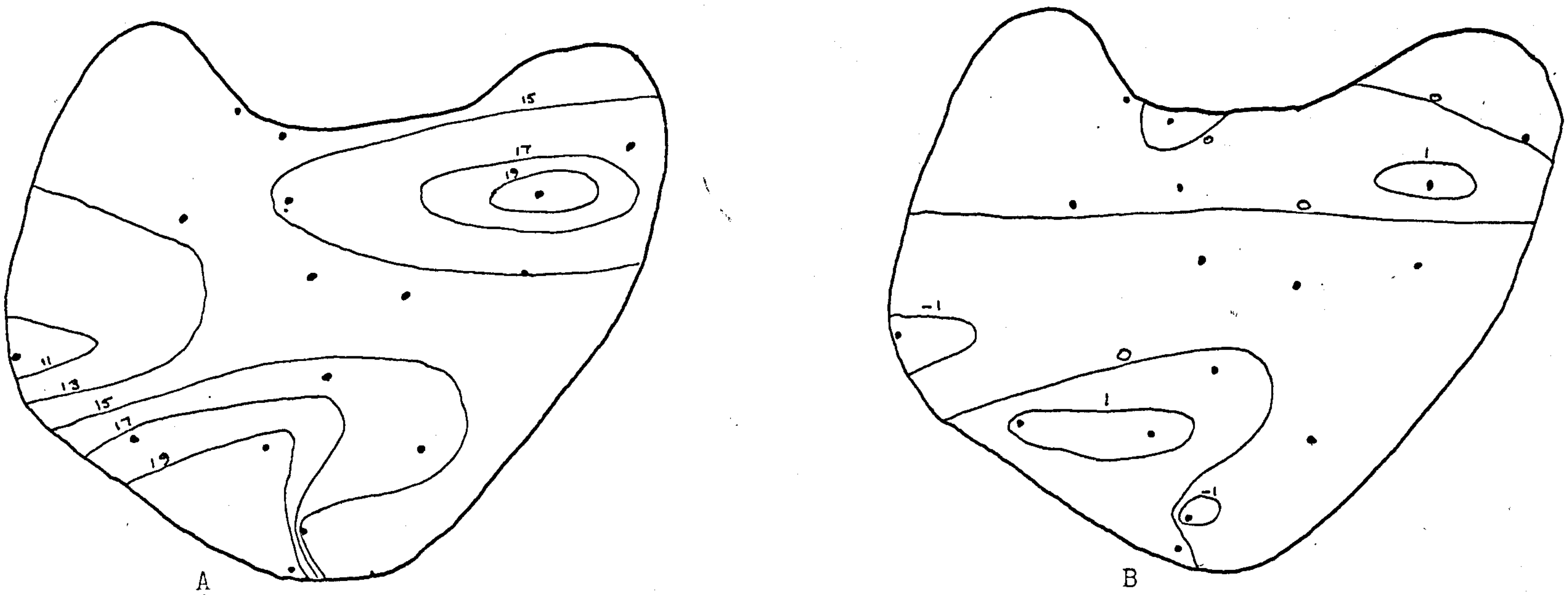


Figure 5

Orthoclase: Selected Trends and Residuals

A Hand Contoured Original Percentages

B Hand Contoured 1 st Degree Residuals
(Contour values are numbers of standard deviations relative to the 1 st degree surface)

Scale: 1" 1/2 mile

DISCUSSION

The trend analysis indicates distinct distribution patterns. A planer gradient on linear trend maps slopes northwesterly or southeasterly. Orthoclase and plagioclase increase to the southeast and quartz and specific gravity increase to the northwest. This indicates that a decrease in the amount of quartz is accompanied by an increase in the amount of plagioclase and orthoclase and vice versa. As the percentages of these minerals do not vary greatly throughout the intrusion, the increase or decrease in components would not be detectable in the field. The distributions of Ca and K in the cooling granitic melt followed the same gradient as linear trends of these minerals have virtually the same slope.

Hand contoured data and second degree trends indicate a roughly circular distribution of minerals from the center of the intrusion outwards. This is especially true for quartz, mafic minerals and specific gravity. The outward increase in quartz content may be due to increasing silica contamination from the siliceous wall rock. Although mafic minerals compose less than twenty percent of the granitic rock, they have the highest specific gravity of the major minerals present. The outward decrease in mafic mineral content accounts for the outward decrease in specific gravity. The correspondence between mafic minerals and specific gravity is also shown through a correspondence between the third degree residuals and the original data.

CONCLUSIONS

Eugeosynclinal Ordovician and Silurian sediments, some possibly derived from weathering of Proterozoic quartzites, were intruded at epizonal, near mesozonal depths by a quartz monzonitic magma during the Cretaceous Period. While forcing its way through these highly siliceous sediments - cherts and chert pebble conglomerates - the magma was contaminated by the melting silica rich wall-rock. Convection currents in the magma were not of sufficient strength to maintain a homogeneous magma and the diffusion of the contaminating silica was not complete, leaving the outer portions of the magma richer in silica than the inner portions. As the magma cooled, apatite was the first mineral to form, followed by hornblende and biotite, then plagioclase, quartz and orthoclase. As a consequence of silica dilution by assimilation in the outer portions of the magma chamber, less material was available for the formation of mafic minerals here than was available in the central portions of the chamber. This incomplete diffusion did not significantly alter the proportions of plagioclase or orthoclase.

When the upper portions of the magma had solidified, numerous parallel cooling fractures developed, some of which extended into the surrounding thermally altered sediments. These openings in the granitic rock provided pathways along which hot residual fluids rich in copper and iron from the still fluid core ascended, and chalcopyrite and pyrrhotite were deposited along the vertical fractures. These hot fluids also caused alteration of biotite and hornblende to chlorite. Some magma also forced its way up several of these fractures, creating the dykes found in the rock surrounding the intrusion. Subsequent erosion exposed the weather resistant granitic intrusion and hornfels halo which now stand well above the surrounding terrain. Either prior to or after the intrusion of the granitic rock, a large block of Proterozoic sediments were thrust from the south over the younger Ordovician and Silurian rocks.

BIBLIOGRAPHY

Bailey, E. H. and Stevens, R. E. Selective Staining of K Feldspar and Plagioclase on Rock Slabs and Thin Sections. American Mineralogist, 45 (1960) pp. 1020-1025.

Campbell, R. B. Reconnaissance Geology of Glenlyon Map-Area, Yukon Territory (105 L). Geol. Surv. Can., Memoir 352, (1967).

Cairnes, D. C. Yukon-Alaska International Boundary Between Porcupine and Yukon Rivers. Geol. Surv. Can., Memoir 67, (1914). pp. 38-44.

Coates, M. E. "Hess Project Report" Unpublished Report, Atlas Explorations, Vancouver, B. C. 1968.

Dixon, W. J. and Massey, F. J. Introduction to Statistical Analysis. Toronto, McGraw-Hill, 1951.

Keele, J. A Reconnaissance Across the Mackenzie Mountains on the Pelly, Ross and Gravel Rivers Yukon, and North West Territories. Geol. Surv. Can., Report 1097, 1910.

Kendrew, W. G. and Kerr, D. The Climate of British Columbia and the Yukon Territory. Ottawa, Queens Printer, 1955.

Kindle, E. D. Geological Reconnaissance Along the Canol Road From Teslin River to Macmillan Pass, Yukon. Geol. Surv. Can., Paper 45-21, 1945.

Krumbein, W. C. and Graybill, F. A. An Introduction to Statistical Models in Geology. New York, McGraw-Hill, 1965. (International Series in the Earth Sciences).

McConnell, R. G. The Macmillan River, Yukon District. Geol. Surv. Can. Summary Report 1902, pp. 20-36.

Moroney, M. J. Facts From Figures. London, Penguin Books Ltd., 1951.

Pettijohn, F. J. Sedimentary Rocks. 2d ed., New York, Harper and Row, 1957.

Roddick, J. A. and Green, L. H. Sheldon Lake, Yukon Territory Sheet 105J; Geol. Surv. Can., Map 12-1961.

______________________________. Tay River, Yukon Territory Sheet 105K; Geol. Surv. Can., Map 13-1961.

Stockwell, C. H. (ed.). Geology and Economic Minerals of Canada. Geol. Surv. Can. 1957. (Economic Geology Series No. 1, 4th ed.).

Sinclair, A. J. and Libby, W. G. Distribution of Major Minerals in a Stock of Nelson Plutonic Rock, South-Central British Columbia. Geol. Ass. of Can., Proceedings - Vol. 20, 1969. pp. 41-46.

Templeman-Kluit, D. J. Geologic Setting of the Faro, Vangorda and Swim Base Metal Deposits, Yukon Territory (105K). Geol. Surv. Can. Paper 68-1, Part A, 1968. pp. 43-52.

Wheeler, J. O. A Geological Reconnaissance of the Northern Selwyn Mountains Region, Yukon and North West Territories. Geol. Surv. Can., Paper 53-7, 1954.

Williams, H., Turner, F. J., Gilbert, C. M. Petrography. San Francisco, W. H. Freeman and Company, 1954.

Van der Plas, L. and Tobi, A. C. A Chart For Judging the Reliability of Point Counting Results. American Journal of Science, Vol. 263, (January 1965) pp. 87-90.

APPENDIX A

PHOTOGRAPHS

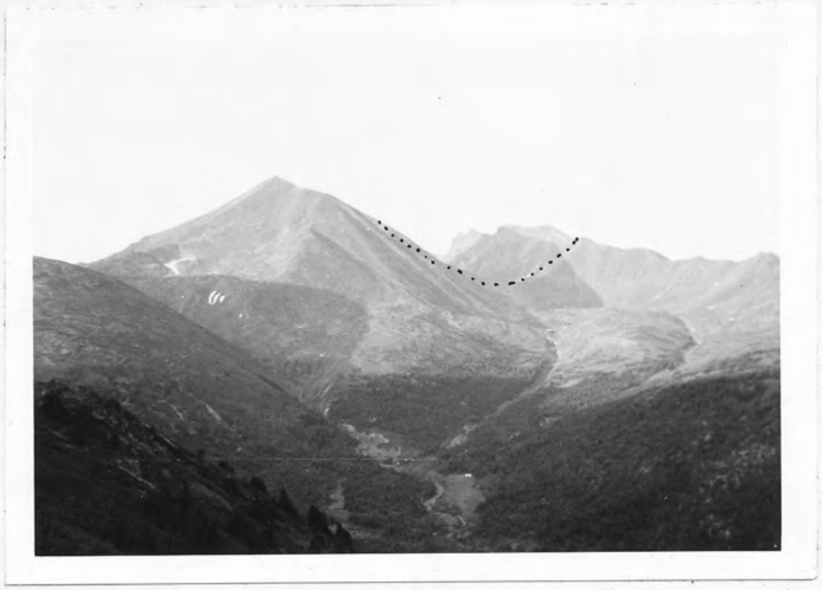


Plate I. Spearhead Mountain from the southwest. Intrusion is north of dotted line.

Plate II. View to the west from Peak 6923. Note the sharp drop off to the north compared to the gentle southern slopes shown in Plate I.

Plate III. View S. E. from Peak 6923 showing prominent faces and rusty weathering in quartz monzonite. Mt. Sheldon in centre rear, twenty miles away.

Plate IV. View looking S. E. showing distinct color change at contact. Quartz monzonite to right, hornfels to left. Peaks shown in Plate III. are in upper right hand corner.

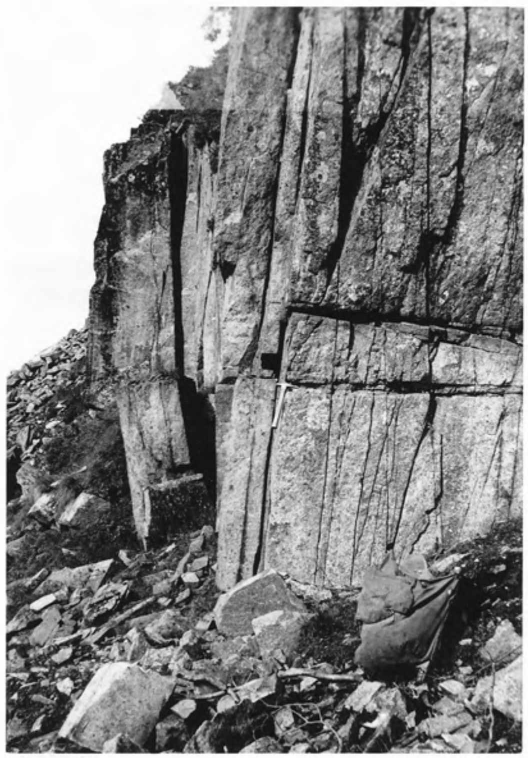


Plate V. Vertical jointing in quartz monzonite.

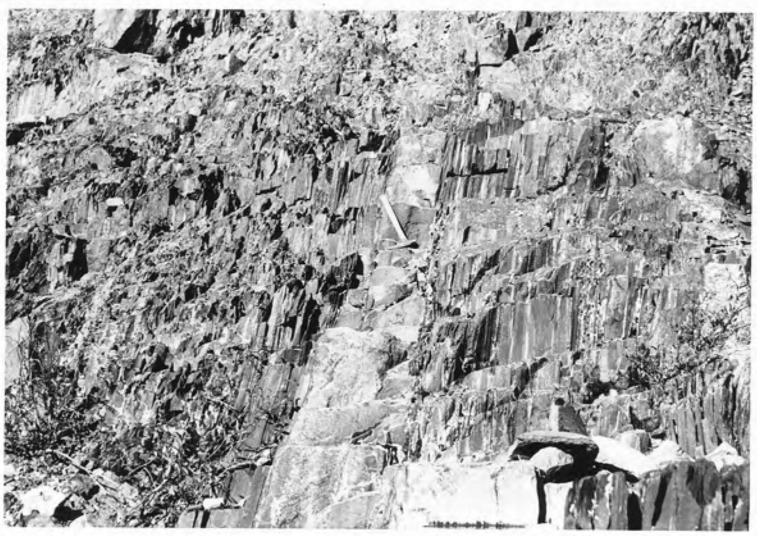


Plate VI. Black bedded argillites with interbed of chert breccia.

Plate VII. Black chert with quartz stringers. Full size.

Plate VIII. Chert pebble conglomerate with light and dark chert pebbles. Large white pebble near centre right is quartzite. Full size.

Plate IX. Alligned chert breccia fragments. Full size.

Plate X. Chert pebble conglomerate with graded bedding. Full size.

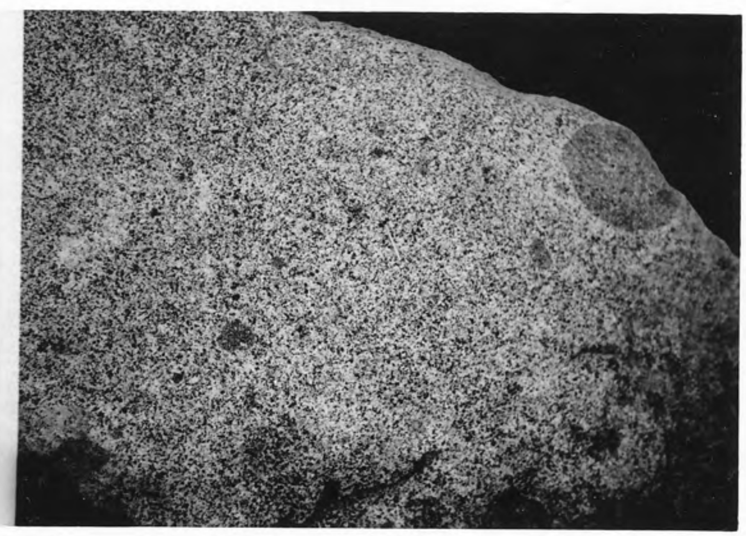


Plate XI. Xenoliths. Match in centre indicates scale.

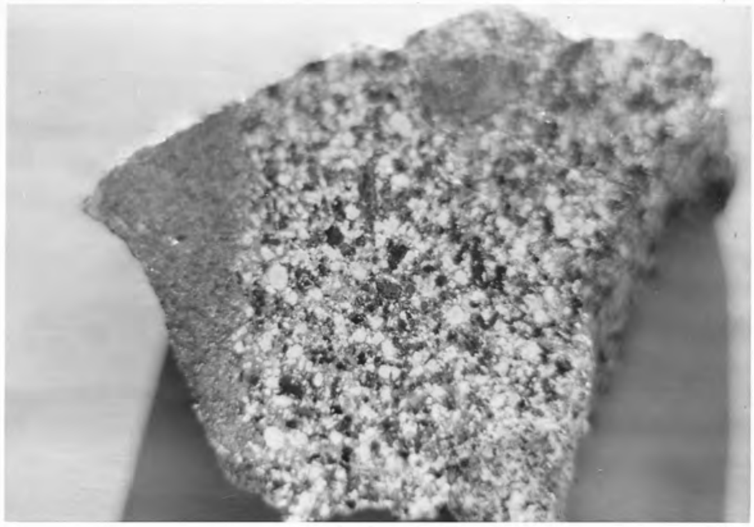


Plate XII. Sharpness of contact. Portion to left is quartzose hornfels. Full size.

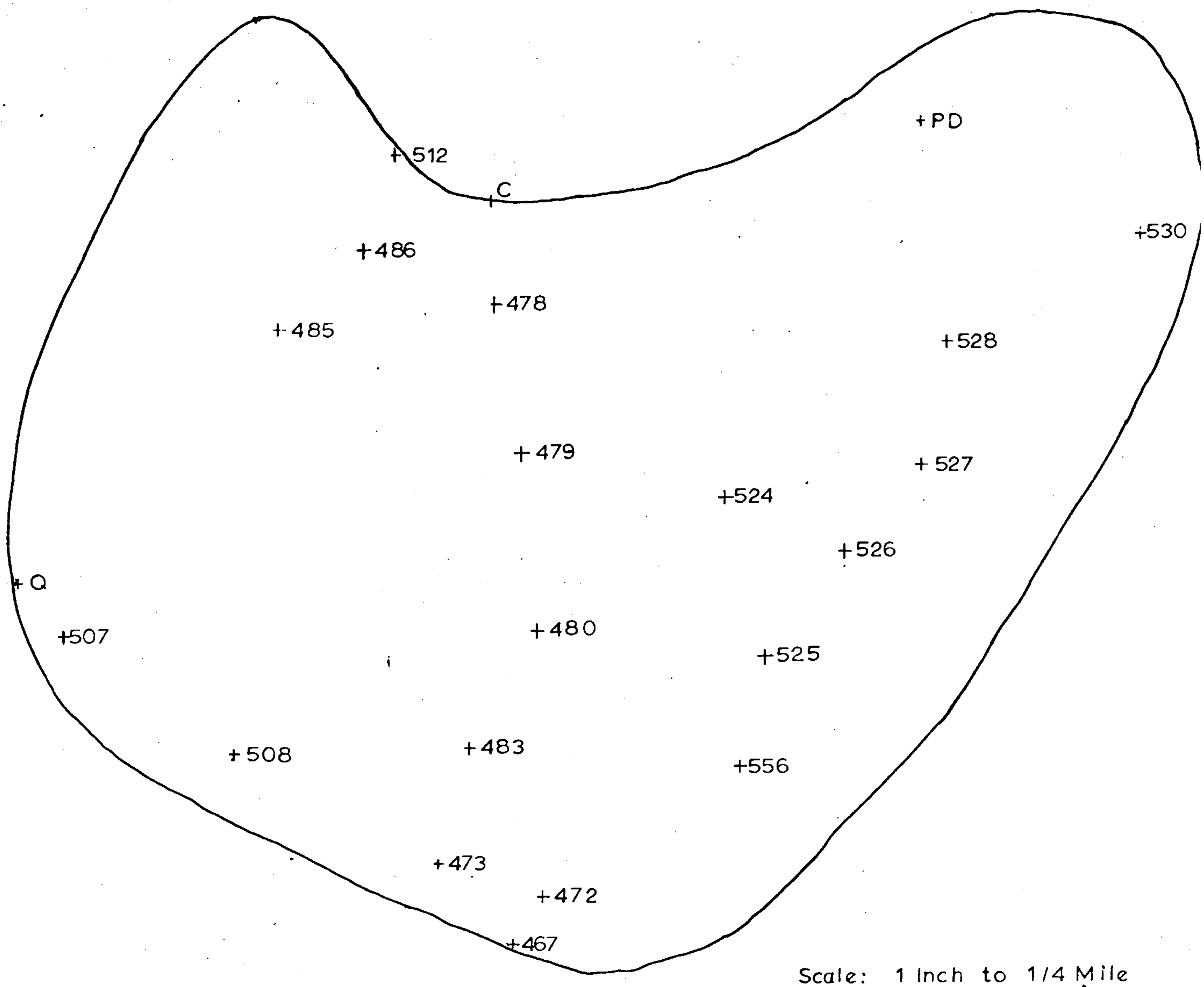
Plate XIII. Lamprophyre dyke. Note spheroidal weathering. Peak 6923 in background.

Plate XIV. Dacite dyke rock with weathered rim.
Full size.

APPENDIX B

SAMPLE LOCATIONS

SPEARHEAD STOCK
SAMPLE LOCATIONS



Scale: 1 Inch to 1/4 Mile

APPENDIX C

MODAL ANALYSIS DETERMINATIONS

MODAL ANALYSIS

SAMPLE NO.	ORTH	PLAG	QUARTZ	MAFIC
Q	10.4	31.9	51.1	6.6 *
C	13.2	45.2	31.4	10.2
467	19.3	35.4	38.4	7.0
472	14.7	44.2	22.3	18.8
478	16.1	35.8	29.5	18.6 *
479	13.5	33.0	35.2	18.3
480	17.8	32.2	30.7	19.3
483	19.8	34.2	25.2	20.8 *
485	14.6	32.6	33.2	19.6 *
508	17.8	36.8	22.8	22.5
512	13.9	33.9	30.4	21.8 *
524	14.8	33.3	25.0	26.8
527	12.0	47.0	25.3	15.8
528	21.1	32.2	28.1	18.2
530	16.3	35.9	29.2	18.6
556	16.5	41.3	22.7	19.5

* 2000 points counted. 600 points for all others.

MODAL ANALYSIS CHECK COUNTS

SAMPLE NO.	ORTH	PLAG	QUARTZ	MAFIC
472	14.2	43.4	32.5	10.0
	14.7	44.2	22.3	18.8
478	16.5	31.7	26.5	25.3
	16.1	35.8	29.5	18.6 *
479	12.7	35.6	33.8	17.9
	13.5	33.0	35.2	18.3
480	14.7	36.4	34.4	14.5
	17.8	32.2	30.7	19.3
512	14.2	31.2	31.6	22.9 **
	14.4	30.7	31.6	23.4 ***
	14.3	31.3	31.2	23.6 ****
	14.1	32.6	30.8	22.7 *
527	18.7	42.2	22.3	16.8
	14.8	40.2	30.5	14.5
	12.0	47.0	25.3	15.8

* 2000 points counted
** 500 points counted
*** 1000 points counted
**** 1500 points counted
600 points for all others

APPENDIX D

SPECIFIC GRAVITY DETERMINATIONS

SPECIFIC GRAVITY DETERMINATIONS

SAMPLE NO.	DRY WEIGHT	WET WEIGHT	LOSS WEIGHT	SPEC. GRAV.
PD	162.20	102.60	59.60	2.72
Q	399.40	251.80	147.60	2.71
C	119.65	75.40	44.25	2.70
467	541.95	337.90	204.05	2.66
472	164.40	103.25	61.15	2.69
473	189.50	120.25	69.25	2.74
478	385.80	245.20	140.60	2.74
479	44.80	28.40	16.40	2.73
480	234.90	148.40	86.50	2.72
483	469.70	296.60	173.10	2.71
485	538.15	341.50	196.65	2.74
486	237.00	150.00	87.00	2.72
507	160.85	101.70	59.15	2.72
508	293.40	185.40	108.00	2.72
512	247.40	156.20	91.20	2.71
524	125.10	79.25	45.85	2.73
525	306.95	193.50	113.45	2.71
526	71.60	45.45	26.15	2.74
527	384.20	242.45	141.75	2.71
528	154.00	96.90	57.10	2.70
530	298.45	188.00	110.45	2.70
556	75.50	45.40	26.10	2.74

SPECIFIC GRAVITY DETERMINATIONS

CHECK SAMPLES

SAMPLE NO.	DRY WEIGHT	WET WEIGHT	LOSS WEIGHT	SPEC. GRAV.
473	189.50	120.25	69.25	2.74
	189.12	120.15	68.97	2.74
478	385.80	245.20	140.60	2.74
	310.95	197.43	113.52	2.74
480	234.90	148.40	86.50	2.72
	234.80	148.37	86.43	2.72
507	160.85	101.70	59.15	2.72
	234.80	148.25	86.55	2.71
525	306.95	193.50	113.45	2.71
	145.00	91.52	53.48	2.71

APPENDIX E

ANALYSIS OF VARIANCE CALCULATIONS

ANALYSIS OF VARIANCE

MODAL ANALYSIS TOTALS

SAMPLE	QUARTZ	PLAG	ORTH	MAFICS	TOTALS
479 a	33.8	35.6	12.7	17.9	100.0
479 b	35.2	33.0	13.5	18.3	100.0
480 a	34.4	36.4	14.7	14.5	100.0
480 b	30.7	32.2	17.8	19.3	100.0

SUBTOTALS

479	69.0	68.6	26.2	36.2	200.0
480	65.1	68.6	32.5	33.8	200.0
	134.1	137.2	58.7	70.0	400.0

SUM OF SQUARES FOR TOTAL

$$(33.8)^2 + (35.2)^2 + (34.4)^2 + (30.7)^2 + \ldots\ldots\ldots + (14.5)^2 + (19.3)^2 - \frac{(400.0)^2}{16} =$$

$$= 11340.1 - 10000.0$$

$$= 1340.1$$

SUM OF SQUARES FOR ROWS

$$\frac{(200.0)^2}{8} + \frac{(200.0)^2}{8} - \frac{(400.0)^2}{16} = 0.0$$

SUM OF SQUARES FOR COLUMNS

$$\frac{(134.1)^2}{4} + \frac{(137.2)^2}{4} + \frac{(58.7)^2}{4} + \frac{(70.0)^2}{4} - \frac{(400.0)^2}{16} =$$

$$= 11288.1 - 10000.0$$

$$= 1288.1$$

SUM OF SQUARES FOR SUBTOTALS

$$\frac{(69.0)^2}{2} + \frac{(65.1)^2}{2} + \frac{(68.6)^2}{2} + \ldots + \frac{(36.2)^2}{2} + \frac{(33.8)^2}{2} - \frac{(400.0)^2}{16} =$$

$$= 11303.2 - 10000.0$$

$$= 1303.2$$

	Sum of Squares	d.f.	Mean Square
Row Means	0	1	0
Column Means	1288.1	3	429.4
Interaction	15.1	3	5.0
Subtotal	1303.2	7	
Within Groups	36.9	8	4.6
Total	1340.1	15	

TEST FOR SIGNIFICANT INTERACTION

$$F = \frac{5.0}{4.6} = 1.1 \qquad F_{.95}(3.8) = 4.07$$

The value is not significant. This means that statistically there is no difference in the two samples.

ANALYSIS OF VARIANCE

MODAL ANALYSIS TOTALS

SAMPLE	QUARTZ	PLAG	ORTH	MAFICS	TOTALS
479 a	33.8	35.6	12.7	17.9	100.0
479 b	35.2	33.0	13.5	18.3	100.0
527 a	22.3	42.2	18.7	16.8	100.0
527 b	30.5	40.2	14.8	14.5	100.0

SUBTOTALS

479	69.0	68.6	26.2	36.2	200.0
527	52.8	84.2	33.5	31.3	200.0
	121.8	151.0	59.7	67.5	400.0

SUM OF SQUARES FOR TOTAL

$$(33.8)^2 + (35.2)^2 + (22.3)^2 + (30.5)^2 + (35.6)^2 + \ldots\ldots\ldots\ldots + (16.8)^2 + (14.5)^2 - \frac{(400.0)^2}{16} =$$

$$= 11622.5 - 10000.0$$

$$= 1622.5$$

SUM OF SQUARES FOR ROWS

$$\frac{(200.0)^2}{8} + \frac{(200.0)^2}{8} - \frac{(400.0)^2}{16} = 0.0$$

SUM OF SQUARES FOR COLUMNS

$$\frac{(121.8)^2}{4} + \frac{(151.0)^2}{4} + \frac{(59.7)^2}{4} + \frac{(67.5)^2}{4} - 10000.0 =$$

$$= 11439.2 - 10000.0$$

$$= 1439.2$$

SUM OF SQUARES FOR SUBTOTALS

$$\frac{(69.0)^2}{2} + \frac{(52.8)^2}{2} + \frac{(68.6)^2}{2} + \cdots + \frac{(36.2)^2}{2} + \frac{(31.3)^2}{2} - \frac{400.0}{16} =$$

$$= 11571.8 - 10000.0$$

$$= 1571.8$$

	Sum of Squares	d.f.	Mean Square
Row Means	0	1	0
Column Means	1439.2	3	479.7
Interaction	131.6	3	43.9
Subtotal	1571.8	7	
Within Groups	50.7	8	6.4
Total	1622.5	15	

TEST FOR SIGNIFICANT INTERACTION

$$F = \frac{43.9}{6.4} = 6.9 \qquad F_{.95}(3.8) = 4.07$$

The value is significant. This means that statistically there is a difference between the samples.

APPENDIX F

GEOLOGY MAP OF SPEARHEAD MOUNTAIN

GEOLOGY
SPEARHEAD MOUNTAIN
YUKON TERRITORY

Scale: One Inch to One Half Mile

Miles

1/2 1/4 0 1/2 1 2

LEGEND

CRETACEOUS

11	Medium to coarse grained quartz monzonite

ORDOVICIAN AND SILURIAN

3	3a black chert, argillite, minor sandstone
	3b limestone
	3d chert pebble conglomerate, chert breccia
	3f grey bedded chert

CAMBRIAN

1	1d medium grained grey quartzite, and dark slate

Geological Boundary (defined, approximate)

Bedding (inclined, vertical)

Slaty Clevage

Jointing

Fault (assumed)

Rock altered to hornfels

Lineation

Mineral Occurrence

- Cu Copper
- Ba Barite
- As Arsenopyrite

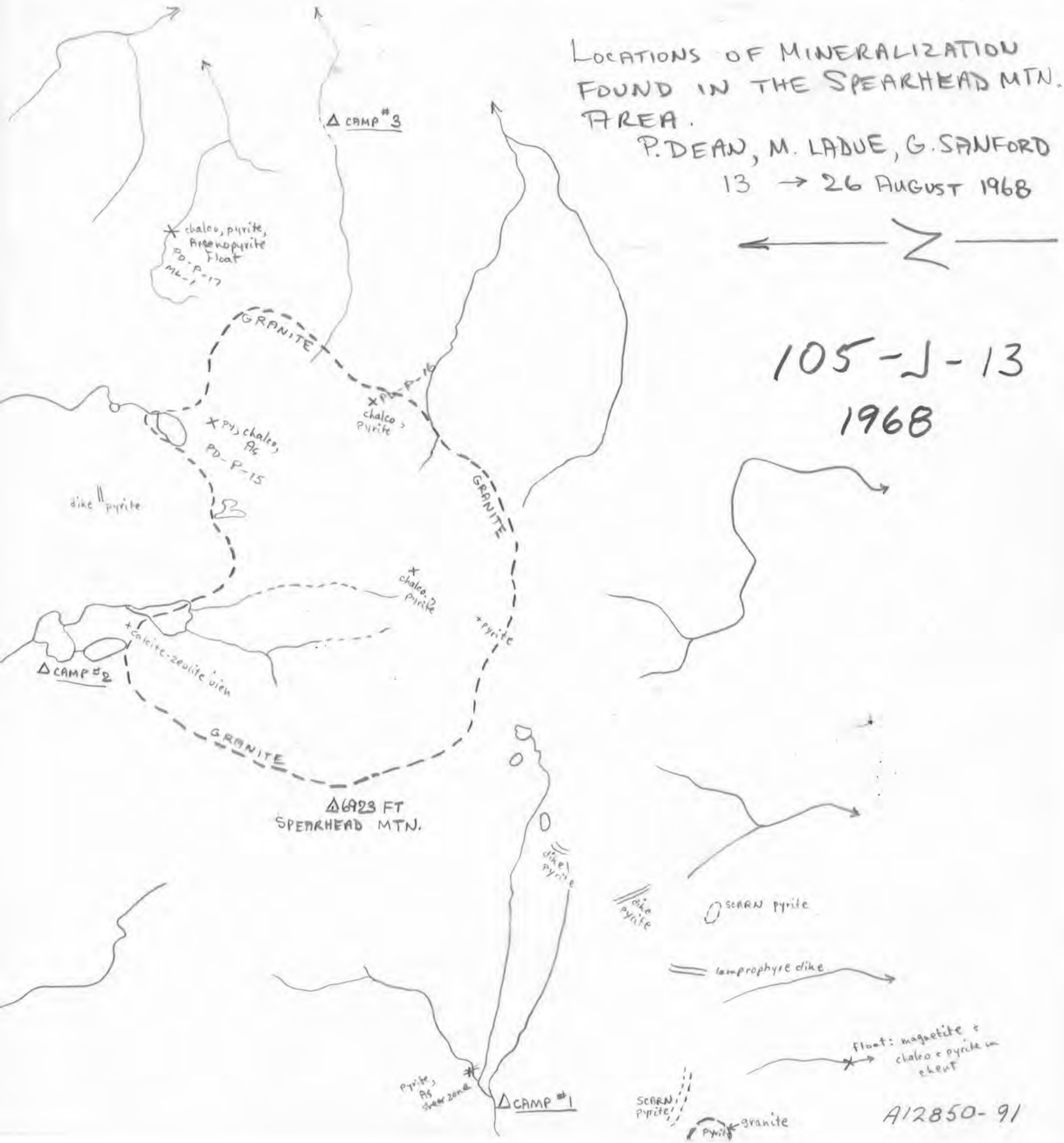
LOCATIONS OF MINERALIZATION FOUND IN THE SPEARHEAD MTN. AREA.

P. DEAN, M. LADUE, G. SANFORD

13 → 26 AUGUST 1968

105-J-13

1968



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