BRENDA LAKE MINING PROSPECT

An essay submitted during the Third
Year of the course in Applied Science
at the University of British Columbia

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October 30, 1957

806 West 22 Ave.,
Vancouver 9, B. C.,
October 30, 1957.

Dr. H. C. Gunning,
Dean, Faculty of Applied Science,
University of British Columbia.

Dear Sir:

I hereby submit the essay entitled "Brenda Lake Mining Prospect", in fulfillment of the requirements of the course in Geology 398, during Third Year Applied Science.

Yours sincerely,

Don W. Hyndman

Don W. Hyndman

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ILLUSTRATIONS

PREFACE

This essay is based on information gathered by the writer while working for Northwestern Explorations limited during the summer of 1957. The work consisted chiefly of surveying and aiding the senior geologists in mapping the geology of the Brenda Lake prospect of the Okanogan district of British Columbia.

I wish to extend my thanks to Mr. C. S. Ney and Mr. K. O. Olien for their helpful suggestions and interpretations in the field. My thanks also to Mr. J. S. Scott for his cooperation in making this essay possible.

D. W. Hyndman

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BRENDA LAKE MINING PROSPECT

Introduction

This essay presents, in brief, the Brenda Lake mining prospect: its physical features, background, geology and mineralization. It includes a short description of some of the methods used to estimate the value and extent of the zone of mineralization.

The Brenda Lake mining prospect is situated 2 miles east of Brenda Lake and about 14 miles northwest of Peachland in the Okanogan district of British Columbia.* The prospect consists of about 85 mineral claims covering a large area of low-grade mineralization. The prospect is accessible by means of a 21 mile gravel road following the north side of Peachland Creek west from Peachland, B. C.

* See Appendix I

Physiography

Located between 5300 and 5700 feet in elevation, Brenda Lake prospect is about 1000 feet below treeline. The prospect is hilly in places, the maximum local relief being about 500 feet. The area is drained by Peachland Creek and Trepanege Creek and its tributary MacDonald Creek.*

Physiographically, the prospect can be divided roughly into four sections. The eastern part, burned by a forest fire about 1935, is covered with second-growth jack-pine and deadfall, while the western part retains its heavy spruce and balsam. The northern half of the property is well covered with outcrops, while the southern half, except on a few of the hills, is largely covered with glacial till.

Glaciation

Glaciation during Pleistocene** time caused a great deal of erosion in the area to the west of Okanogan Lake. These glaciers, moving in general SSE, were thick enough to override Pennask Mountain at 6500 feet, the highest mountain in the Brenda area. Likewise the valleys of the creeks draining east into Okanogan Lake bear evidence of U-shaped dredging by glaciers. The retreat of the ice left a mantle

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* See Appendix I
** See Appendix II

of glacial till over most of the area. Numerous eskers are found on the upper portions of Peachland Creek. Huge boulders, from 10 to 15 feet in diameter, are strewn throughout the upper reaches of Peachland and Trepanege Creeks where they have been left by the glaciers.

Economic Background

The old Copper King workings lie at the south-west end of the presently known area of mineralization. Here a small, high-grade chalcopyrite-in-quartz vein was worked on a small scale 15 to 20 years ago. A deep open-cut and two crosscut adits about 50 feet long were driven into the steeply-dipping quartz vein. Althouth a few shipments of ore were made to the smelter by pack train, the area was then relatively inaccessible and there was too little high-grade ore to prove profitable.

Recently, low-grade ores in large quantities have taken the place of the smaller-quantity high-grade ores as profit-making developments. The primary reason for this situation is that high-tonnage operations can mine ore at a lower cost per ton than low-tonnage operations. High-tonnage operations are also long range investments. It is not worthwhile building a concentrating mill for a short-lived, low-tonnage operation.

The widespread mineralization of the granite country rock at Brenda therefore looked interesting.

Geology

Location of the prospect*

The zone of mineralization of the Brenda prospect is located on and to the east of the contact between the two main geological formations of the area. These formations are the Nicola volcanics, to the west, and the Okanogan granodiorites, to the east.

Nicola Group - Volcanics

The Nicola group, consisting of volcanics and interbedded sediments was formed during Upper Triassic** time. It covers much of a belt, about 30 miles wide, from Princeton and the International Border, north to Kamloops Lake. This formation consists of dark, volcanic tuffs and argillites of varying thickness with interbedded argillaceous limestones in a few places.

Okanogan Intrusives - Granodiorites

Following the deposition of the Nicola volcanics, the Okanogan intrusives, in particular the "white"granodiorite, intruded the eastern side of the Nicolas. During Jurassic**

* See Appendix I
** See Appendix II

or early Lower Cretaceous** time, these intrusives advanced throughout an extensive section between Okanogan Lake and the Nicola volcanics to the west.

It is probable that the granodiorite originated at great depths but it is not known how far below the original "roof-contact" the present outcrop surface lies. It seems possible, from the appearance of the present contact, that the zone of mineralization was formed at the edge of a dome in the granodiorite batholith. The best evidence for this dome structure is the fairly shallow-dipping contact. This is indicated by the very gneissic lineations found up to several hundred feet to the volcanic side of the contact. In other places this gneissic structure is only a few feet wide, indicating a relatively steeply-dipping contact (see Figure 1).

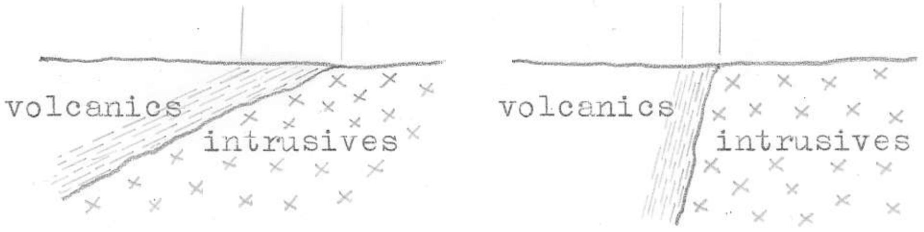

Figure 1. Shallow dipping contact indicated by a wide zone of gneissic lineations

In part at least, the granodiorite seems to have been derived from the granitization of volcanic rocks, rather than a strictly magmatic intrusive.

** See Appendix II

The average composition of the white granodiorite has been measured at approximately: 60% plagioclase, 20% quartz, 5% orthoclase, 10% biotite and some amphibole and secondary chlorite. This white granodiorite is distinguished from the red and grey granodiorite, in other parts of the batholith, by being slightly more basic in chemical composition. The red and grey phases contain more biotite, quartz and orthoclase and somewhat less plagioclase. In the vicinity of Peachland Lake, well within the white phase, lies a small body of basic intrusives. These rocks grade from a diorite around Peachland Lake to almost a gabbro in one area just north of the lake.

Tertiary** volcanics

Of relatively recent geological origin, that is within the last 60 million years, are the Tertiary volcanics. These consist largely of light grey, somewhat vesicular basalts. Since they did not gain any great thickness, these volcanics were probably largely removed from the surface by the action of the Pleistocene glaciers. Only a few remnant outcrops of them remain.

Dikes

Probably the most conspicuous of the several kinds of dikes found in the Brenda area are the quartz-feldspar, pegmatite dikes. These are found, up to 20 feet wide, on the contact zone between the Nicola volcanics and the white

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** See Appendix II

granodiorite (see Figure 2). These very coarse-grained dikes are composed of 60% to 80% feldspar, with the remainder quartz. They are almost entirely lacking in other minerals.

Figure 2. Bending of Nicola edge of contact due to intrusive pressures of the pegmatite

Throughout the western part of the granodiorite are scattered dark, basic, Tertiary** dikes. Usually a few inches to a foot wide, one reached a width of 15 feet and a total length of about 2000 feet. These dikes have a general east-west direction and are close to vertical.

** See Appendix II

Throughout the zone of mineralization but without any particular orientation are numerous aplite dikes. These have a composition similar to that of the pegmatite but, instead of being coarse, they are very fine grained. They are usually less than 8 inches wide and about 20 feet long. Since the same fractures cut the aplite as cut the granodiorite, the fractures are definitely post-aplite (see Figure 3).

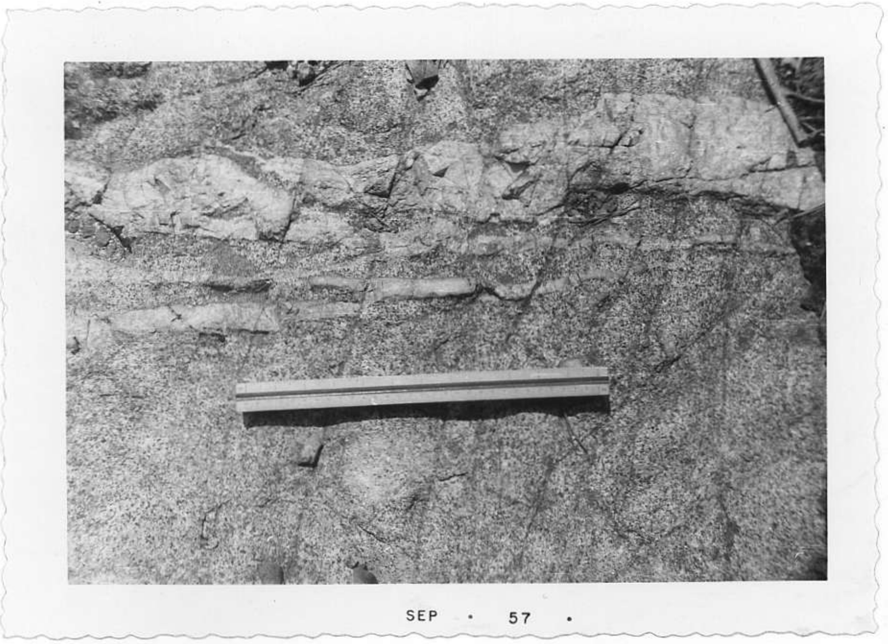
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Figure 3. Vertical mineralized fractures in granodiorite (post-aplite)

Of particular scientific interest but of no apparent importance to the prospect is a coarse-grained feldspar-porphyry dike about 10 feet wide. The chemical composition of this dike was changed, seemingly, to a more acidic phase while the dike was still in the molten state. This is indicated by the fact that the central parts of the larger crystals remained a much darker, more basic, plagioclase than the rest of the rock which is a light-colored plagioclase (see Figure 3).

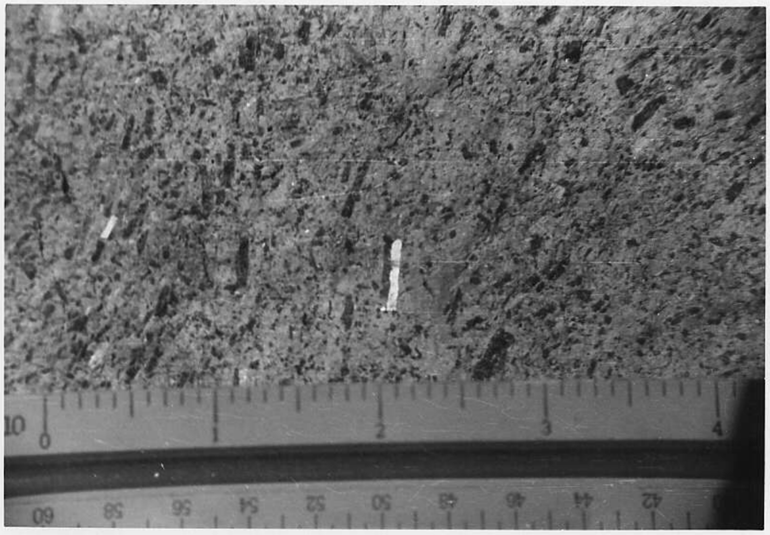

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Figure 4. Feldspar-porphyry dike

None of the dikes encountered on the prospect had any evident bearing on the origin or occurrence of the mineralization.

Fractures and Mineralization

As mentioned above in the Economic Background, the widespread mineralization of the Brenda claim group is interesting from a mining point of view. The two metallic minerals found on the prospect are chalcopyrite and molybdenite, respectively copper and molybdenum minerals. Both are located only in the fractures of the granodiorite (see Figure 3).

Fractures in the vicinity of the central part of the zone of mineralization are concentrated mainly in four vertical sets, three of which are approximately east to southeast and one which is approximately due north. These give rise to a theory which suggests that the intrusive pressures were probably largely from about S 70° E (see Appendix III).

Fracturing in some areas is mostly flat lying or nearly so. This is what is known as sheeting, that is it was probably caused by the release by erosion of overlying pressures. This is a relatively recent occurrence and consequently has no bearing on the mineralization.

The spacing of the vertical fractures varies from 2 to 10 inches in the mineralized zone, to 2 to 3 feet within the main body of the granodiorite to the northeast. It is unlikely that the mineralization affected the fractures.

More likely, the mineralization followed the zone of most intense fracturing where penetration of the mineral-bearing solutions was made easier. Since some cases were noted where the molybdenite definitely followed the chalcopyrite in deposition and other cases noted where the reverse was true, the general situation was likely a concurrent deposition. No one fracture direction seems to have been preferred over the others for mineralization, except where localized fractures contained wider spaces. Although mineralization is fairly constant over the central portion of the claim group, there are slight concentrations scattered more or less at random throughout. This central mineralized zone has no well-defined boundaries, especially on the north and east where it gradually tapers to a negligible amount.

The occurrence of a high-grade showing on the site of the old Copper King workings is apparently the exception rather than the rule. Here a short, steeply-dipping, quartz vein a few feet wide has been well mineralized with chalcopyrite, and some molybdenite and pyrite. Whether or not the mineralization of this vein was concurrent with the mineralization in the fractures of the country rock, is not yet known.

Locally, only one showing is known within the Nicola volcanics. About two miles west of the main mineralized area is a small lead-zinc occurrence. Two small exploratory pits were excavated several years ago exposing a one to two inch vein of coarsely-crystalline galena and sphalerite.

Several faults, lying about N 70° E, are indicated in the northern part of the Brenda property. Although their presence has not definitely been ascertained, several pronounced lineaments lines were noted on air photographs. These lines contain creeks, lakes and swamps which often indicate faults. They are decidedly lacking in outcrops. Nearby outcrops often show evidence of faulting, by slickensides parallel to the main fault zones.

Development of the Brenda Prospect

Modern development of mining prospects

In order to evaluate the merits of a mineralized area for the purpose of opening a mine, many new techniques have been developed. Along with surface geological mapping and subsurface diamond drilling, various types of geophysical surveys utilizing the inherent magnetic, electrical, physical and chemical properties of the earth's crust have been invented. These surveys provide a relatively fast, inexpensive method of finding the concentrations of mineralization or concealed geological contacts in a large area. Most geophysical surveys are not used alone but are used in conjunction with geology.

The following is a description of each of the above surveys.

Geological mapping

The basis for all surveys is usually the mapping of the geology of the prospect in detail and of the surrounding region in reconnaissance. At Brenda, outcrops, changes in rock composition, dikes, fractures and visible mineralization were mapped in particular.

Magnetometer survey

In the hope that there could be some relationship between magnetic values and mineralization, a magnetometer was used to measure, at intervals, the vertical intensity of the earth's magnetic field over the zone of known mineralization. A preliminary magnetometer survey indicated that topography had a noticable affect on the readings obtained in some areas. A comparison of the anomalies with the topography showed, however, that several magnetic anomalies do exist over the central part of the property. A check survey into the Nicola volcanics showed a very flat magnetic relief compared with that of the granodiorite.

Since no second magnetometer was maintained as a base-station standard, erratic readings obtained in times of sun spot activity were of no value and had to be discarded.

Induced Polarization survey

By far the most important type of geophysical survey used at Brenda, "Induced Polarization", is a very recent development by McPhar Geophysical Limited. This new survey utilizes the difference between A. C. and D. C. conductivity of the bedrock to calculate a resistivity and a "metal factor". The distribution of the results may be interpreted by a trained specialist. Induced Polarization was used primarily to trace the mineralization to the south and south-east where overburden obscures the bedrock.

In the field, ground contacts are set at intervals of about 400 feet along a straight line. A transmitting station is set up at one end of this line and a receiver is set up at a ground contact 400 feet away. The transmitter sets up currents in the ground which are picked up by the receiver. Readings are taken and the receiver moved, in 400 foot stages, farther from the transmitter until the line is completed (see Figure 5).

As may be seen from Figure 5, increasing the length of the survey increases, up to a maximum of about 1000 feet, the depth at which information may be gathered. Anomalies in

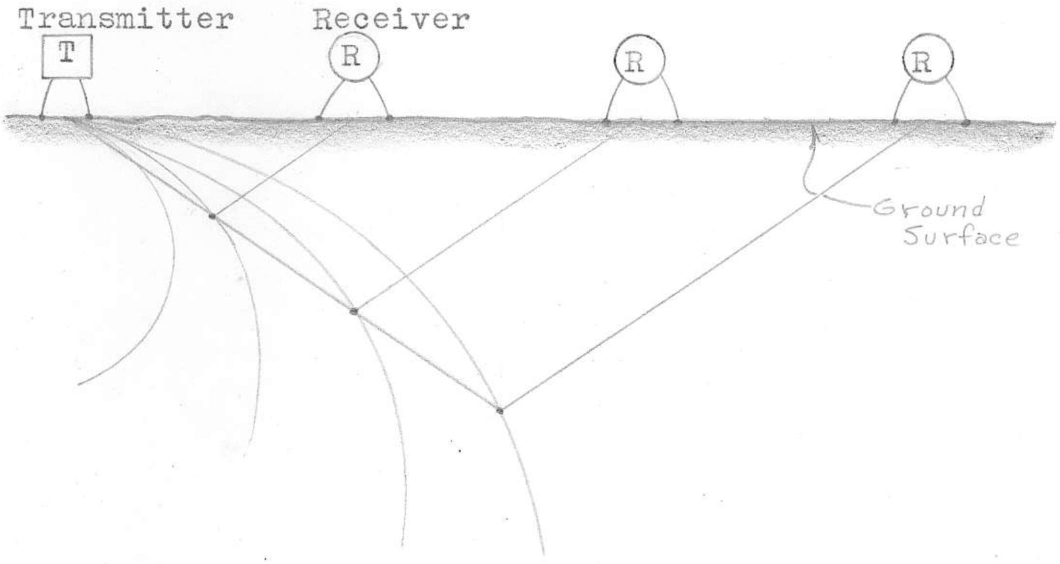

Figure 5. Systematic diagram of Induced Polarization Survey

the central part of the zone of mineralization were checked by magnetometer results to make sure these "highs" were not caused by magnetite.

Geochemical survey

A geochemical survey was run in the Brenda area on a reconnaissance basis. Stream silt samples were collected and tested on the property for minute amounts of copper which could indicate a zone of mineralization. These tests were only roughly quantitative.

Diamond Drilling

Diamond drilling on the Brenda prospect was accomplished by the use of three separate sizes of drill machines for three different purposes.

Most of the drilling on the prospect consisted of short holes at the corners of a 400 foot grid. These holes were placed by the use of an "X-ray" diamond drill (see Figure 6). Two holes 20 feet deep were drilled at each setup, one at N 45° W (-45°) and one at S 45° W (-45°) so as to cut the majority of fractures. The drill core thus obtained was examined for changes in mineralization and rock composition, and then assayed for copper and molybdenum.


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Figure 6. X-ray diamond drill

Secondary drilling, for assessment work on mineral claims and for assays outside the main zone of mineralization, was accomplished by the use of a "Pack-sack" diamond drill. Several holes 50 and 100 feet deep were drilled at approximately right angles to the fracture directions so as to obtain a more nearly correct assay.

Three deep holes were also drilled using a large drill rig. These were intended to supply information as to whether or not the amount of mineralization changed at depth. These holes were drilled at -45° to the horizontal for 300 feet and showed no significant change in mineralization.

General mapping

In order to correlate geological, geophysical and diamond drill information, a contour map was made from government air photos by Photographic Survey Corporation Limited of Vancouver. A grid of lines 400 feet apart were cut east-west for several thousand feet to facilitate locating drill holes and to make possible the running of the geophysical surveys. These grid lines were "tied in" by three transit survey lines, two running north-south and one running east-west. All grid lines were chained and marked at 100 foot intervals for reference.

Conclusion

The Brenda Lake mining prospect is an example of the modern trend of mining companies towards exploration of large areas of low-grade mineralization for future mines. The use of several geophysical surveys together and in conjunction with geology and diamond drilling form a combination which, when used properly under given conditions, should arrive at a reasonable explanation of subsurface conditions.

WORKS CONSULTED

Rice, H. M. A. - Geology and Mineral Deposits of the Princeton Map-area, G. S. C. Memoir 243, Ottawa, 1947.

Glossary of terms

Adit	- a horizontal mining tunnel cut in the side of a hill, usually for the extraction of ore
Anomaly	- a zone of abnormally high values in a geophysical or geochemical survey
Argillite	- a rock derived from the compaction of silt, clay and mud
Basic	- a general chemical composition of rocks containing more plagioclase and dark minerals, and less quartz and orthoclase
Batholith	- an enormous body of intrusive rock, often of continental proportions
Bedded	- layered, as in sediments
Country rock	- the main body of rock surrounding an area of particular interest
Dip	- the inclination of bedded rock or of a geological contact from the horizontal
Esker	- a long ridge of sand and gravel deposited under the sides of a glacier
Fault	- a break in the earth's crust with displacement of the two sides (rock masses)
Feldspar Porphyry	- a rock consisting mostly of feldspar with large crystals imbedded in a finer grained matrix
Formation	- a group of rocks formed under a given group of conditions, during a given time interval
Fracture	- a break or crack in the rock which is not displaced. A group of parallel cracks is called a "set of fractures"
Geochemical survey	- a survey which checks the chemical composition of rocks or soils, usually to detect small amounts of a metal
Geophysical survey	- a survey which uses the physical properties of the bedrock to locate changes in rock type, condition or composition
Glacial till	- an unsorted layer of rock and debris left in the wake of a glacier
Gneissic	- alignment of the biotite grains in a rock to give a lineated appearance. (often caused by pressure)

Granitization - the gradual change of a sediment or volcanic rock to a rock similar to granite (or granodiorite) by metamorphism

Intrusive - a rock which has, while molten, penetrated preexisting rocks beneath the earth's surface

Magmatic - a molten condition

Magnetometer - essentially a very sensitive magnetic needle, on a horizontal pivot, used to measure the vertical intensity of the earth's magnetic field

Mineralization - the impregnation of a body of rock with a metallic mineral

Open cut - a vertical notch cut in a hillside by removing rock

Outcrop - a place at which the main body of subsurface rock protrudes above the ground surface

Overburden - a surface layer composed of soil, loose rocks and vegetation which obscures the bedrock

"Pack-sack" Diamond drill - a portable drill which will penetrate 100 feet (two operators required)

Pegmatite - a very coarse grained dyke-rock composed usually of a large amount of quartz and feldspar

Prospect - a mineralized area developed by a mining company on the presumption that it could make a mine

Sediments - rock particles laid down under water and compacted and cemented to form a solid rock

Showing - an occurrence of mineralization

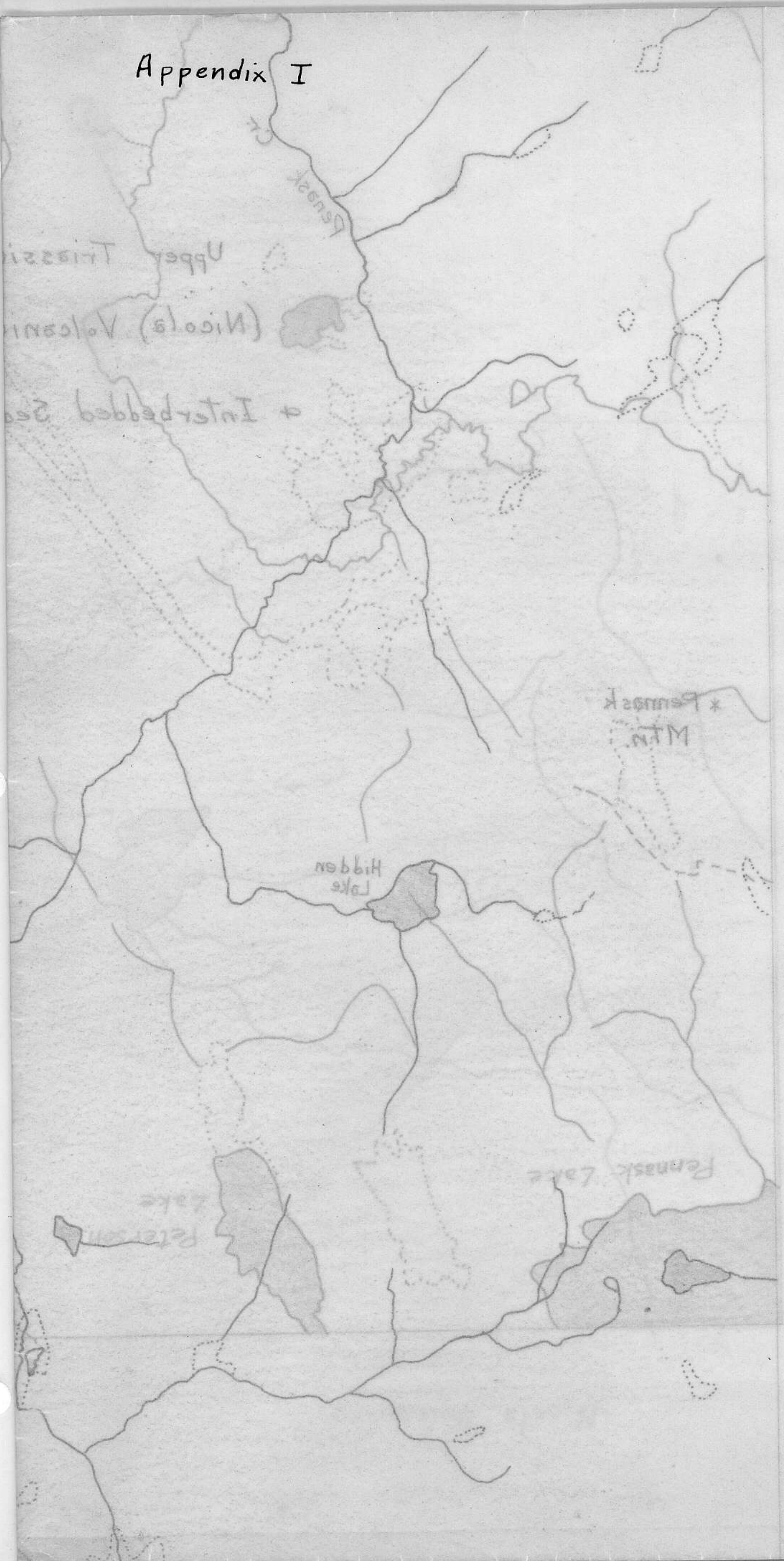
Slickensides - smooth surfaces produced when two rock surfaces slide past one another

Tuffs - volcanic rocks formed from the ashes and other fine particles blown out of a volcano

Vesicular basalt - a volcanic rock filled with small gas bubble holes (vescicules)

"X-ray" Diamond drill - a semi-portable drill which will penetrate 150 to 200 feet of rock and may be operated by one man

Appendix I



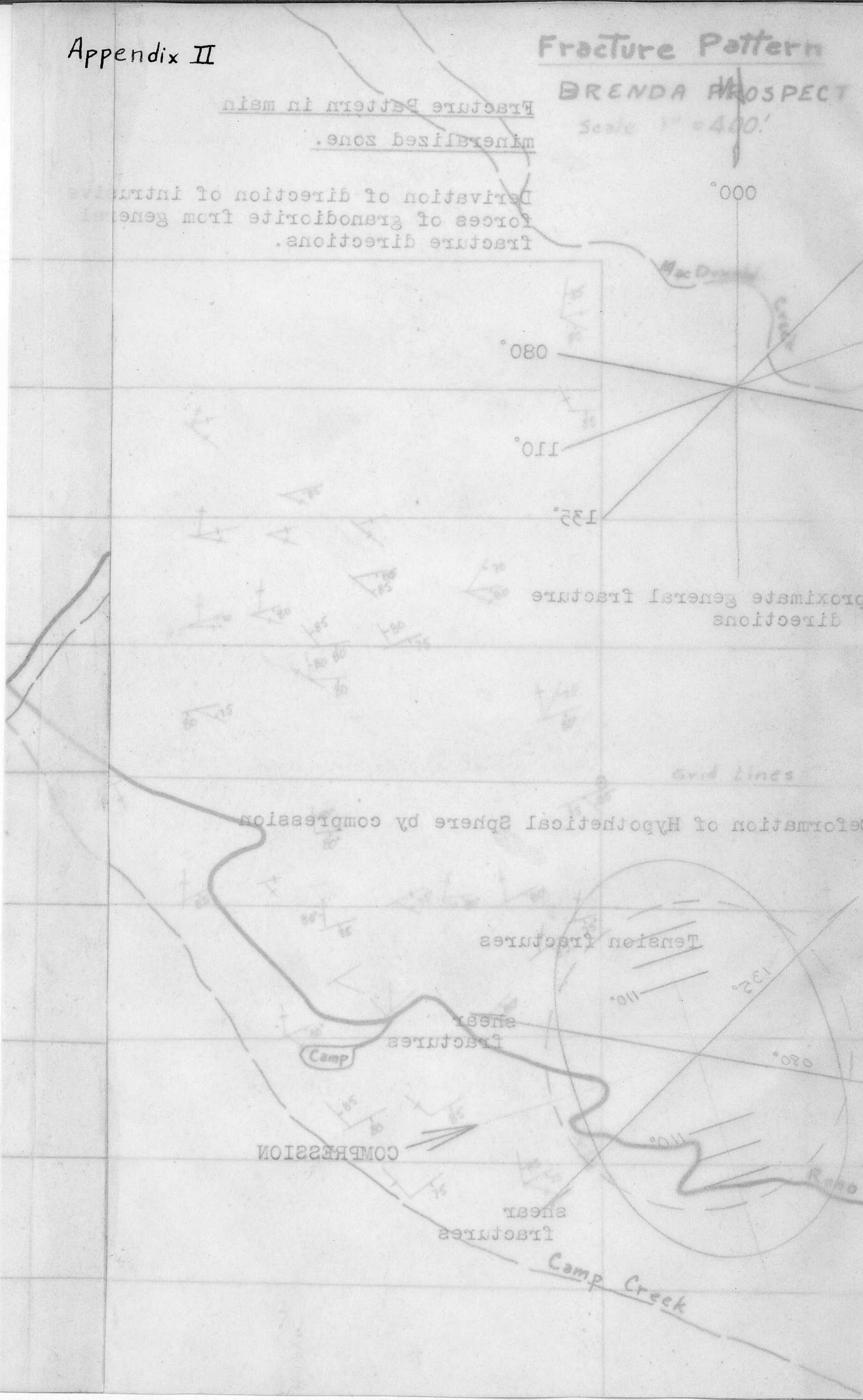
NORTHWESTERN EXPLORATIONS

BRENDA LAKE PROSPECT

Scale: 1" = 2640'

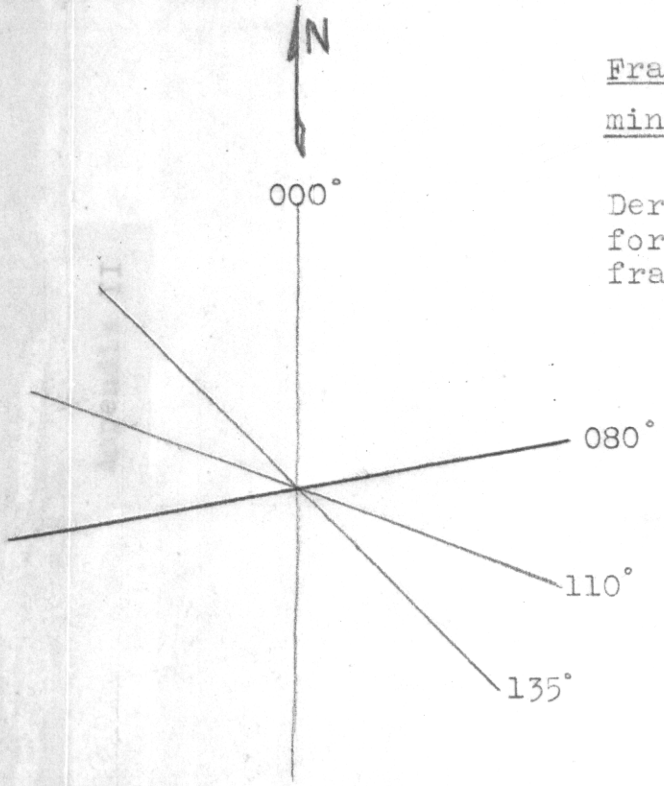
Boundary of Prospect
Road
Meadow

Appendix II


Fracture Pattern
BRENDA PROSPECT
Scale 1" = 400'
MacDonald Creek
Grid Lines
Camp
Camp Creek
Reno

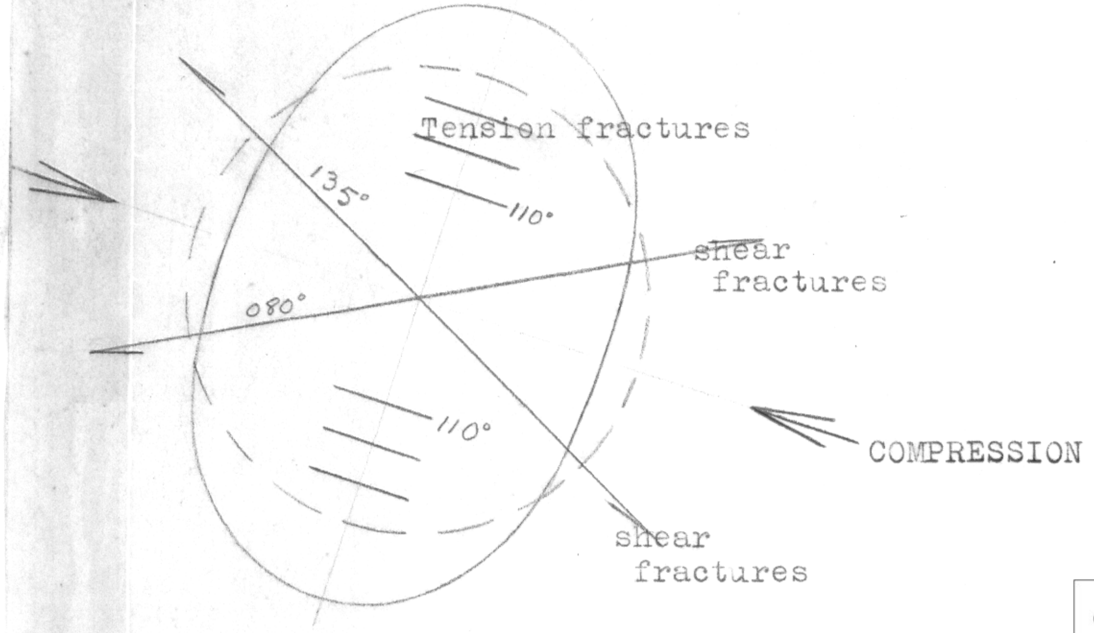
Fracture Pattern in main mineralized zone.

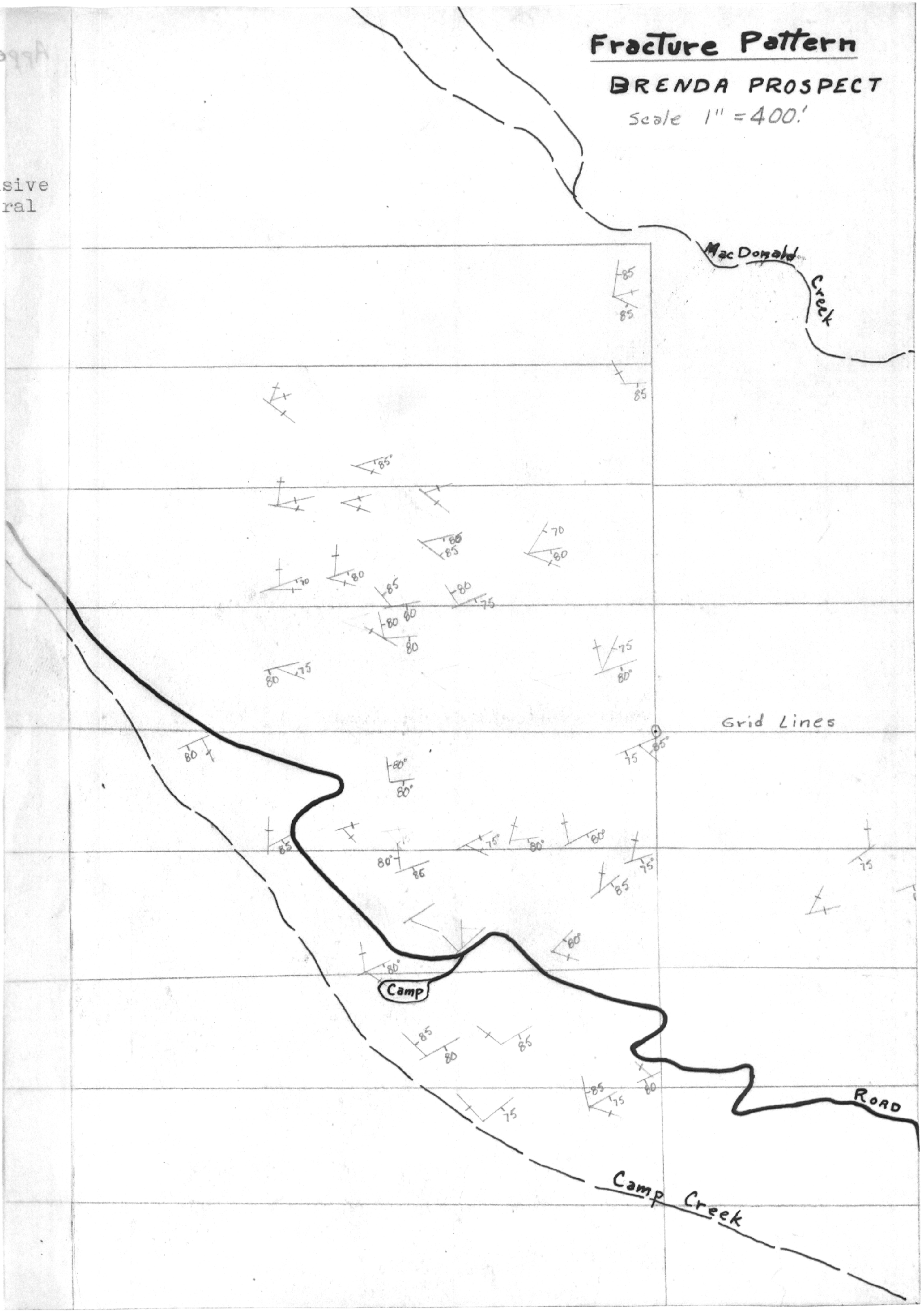
Derivation of direction of intrusive forces of granodiorite from general fracture directions.



Approximate general fracture directions

Deformation of Hypothetical Sphere by compression





Fracture Pattern

BRENDA PROSPECT

Scale 1" = 400.'

inches
0 1
0 1 2
centimetres

This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

Appendix III

Geological Time Chart

CENOZOIC ERA (60 million years ago to present)

Recent epoch		
Pleistocene epoch		Glaciation
Pliocene	"	
Miocene	"	
Oligocene	"	
Eocene	"	Deposition of Tertiary Volcanics
Paleocene	"	

MESOZOIC ERA (200 to 60 million years ago)

Cretaceous period		
Jurassic	"	Advance of Okanogan intrusives
Triassic	"	Deposition of Nicola group

PALEOZOIC ERA (500 to 200 million years ago)

Appendix IV.

Minerals and Rocks of the Brenda area

Mineral	Chemical Composition	
Quartz	SiO_2	silica
Plagioclase	$NaAlSi_3O_8$ to $CaAl_2Si_2O_8$	basic feldspar
Orthoclase	$KAlSi_3O_8$	acidic feldspar
Biotite	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	mica basic minerals
Chlorite	$(Mg,Fe)_5(Al,Fe''')_2Si_3O_{10}(OH)_8$	
Amphibole	Silicate of Ca, Mg, Fe", OH	
Magnetite	Fe_3O_4	

Rock — Mineral Composition

	Quartz	Plagioclase	Orthoclase	Basic minerals
Granite	10%	30%	40-80%	30%
Granodiorite	10-30%	60-70%	20%	30%
Diorite	10%	50-60%	10%	30-45%
Gabbro	5%	30-50%	--	45-70%