A FIELD GEOLOGICAL STUDY AND ANALYSIS OF JOINT PATTERNS RELATED TO THE FRANCOEUR-ARNTFIELD (GOLD MINES) SHEAR ZONE, BEAUCHASTEL TOWNSHIP, TEMISCAMINGUE COUNTY, ABITIBI GREENSTONE BELT, QUEBEC.

by

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Honours Thesis

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March, 1980

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DALHOUSIE UNIVERSITY, DEPARTMENT OF GEOLOGY

B.Sc. HONOURS THESIS

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Title: A Field Geological Study and Analysis of Joint Patterns Related to The Francoeur-Arntfield (Gold Mines) Shear Zone, Beauchastel Township, Temiscamingue County, Abitibi Greenstone Belt, Quebec.

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ABSTRACT

by

Dean R. Cutting

Field mapping (1:5000) and study of joints in an area of 7.3 square kilometres centered around the Arntfield Gold Mines, during the summer of 1979, forms the basis for this study.

East-striking, north-dipping rocks of the Archean Age Blake River Group, consisting predominantly of metamorphosed intermediate (andesitic) and felsic (rhyolitic) volcaniclastics and flows, occur in the south limb of a regional syncline. They are intruded by small bodies of diorite, quartz-feldspar porphyry and syenite. Meta-greywackes and conglomerates of the Proterozoic Cobalt Group unconformably overlie all the above rocks.

Now-abandoned and inaccessible gold mines lie within the Francoeur-Arntfield shear zone, an east-trending, sinuous, wide (over 100 m), regional feature that traverses the area. Field relationships seem to indicate that the formation of this major fault was later than the deposition of the volcanic pile but earlier (or synchronous with ?) than the intrusions. Metamorphism to greenschist facies has affected all rocks.

Analysis of over 400 joint sets in different structural domains in the area and comparison with experimental data for rock deformation suggest that the major shear zone evolved as a "Riedel" type sinistral (left lateral) strike slip shear. The joint patterns are distinct in the proximity of the shear zone, even in the absence of outcrops of sheared rock. Systematic studies of this kind may provide a practical tool for locating the shear zone in the field and thus may provide a useful guide to the controls of gold-telluride-quartz-carbonate mineralization locally associated with the shear zone.

ACKNOWLEDGEMENTS

I am greatly indebted to Explorations Noranda Limitée, particularly Dr. W. A. Hogg, who gave permission to do this thesis using the material from the company files, and the data collected by me while in their employ. I wish to thank the office, drafting, and field support staffs for the assistance and courtesies extended to me during the four months I spent in Noranda. I wish also to thank Explorations Noranda Limitée for their generous financial support in the form of summer salary, supplying thin sections and assays, and covering various field and thesis expenses.

I am extremely grateful to Dr. Marcos Zentilli whose supervision and guidance through the duration of this study was invaluable. I wish also to express gratitude to Dr. Simon Hanmer for his many fruitful discussions and constructive criticism with regard to the aspects of structural geology dealt with in this study.

Gratitude is also extended to the members of my family whose support and encouragement helped me pass the trials and tribulations always associated with a study of this kind.

CHAPTER 1

INTRODUCTION

GENERAL STATEMENT

The Abitibi region of Ontario and Quebec has been the target of many exploration programs and, more importantly, mining developments. The mining operations of this region of the Canadian Shield have exploited rich and varied ore deposits of metals such as copper, lead, zinc, gold, and silver. As the prices for these metals increase in modern markets, mining companies and their associated exploration divisions have renewed the search for new mineral deposits in the region. As well, detailed re-assessments of many old mining operations and their ore deposits have utilized the up-to-date tools and techniques available to the science. As a result of the particularly sharp increase in the price and demand of gold, mining companies have renewed active exploration and re-assessments of the past-producing gold districts of the Abitibi region of northwestern Quebec. This project was conceived as a result of this renewed interest. The detailed mapping of an area of 7.3 square km with an emphasis on the distribution and character of lithologies and on structural observations is the basis for this thesis.

LOCATION AND ACCESS

The study area is located in western Quebec at Latitude 48°12' North, Longitude 79°16' West. The area lies in the vicinity of the village of Arntfield, on the eastern boundary

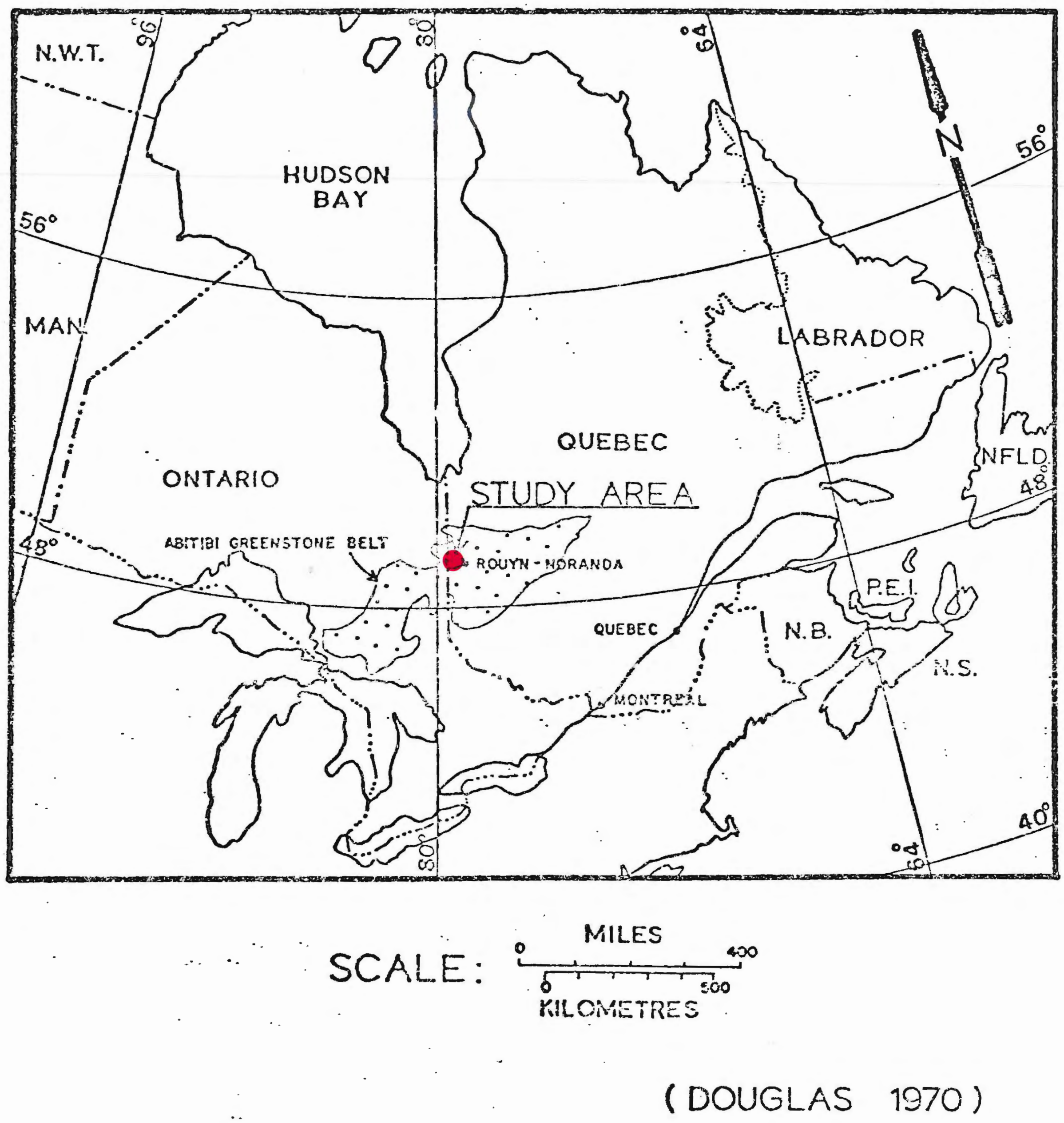


Figure 1. General location map of study area.

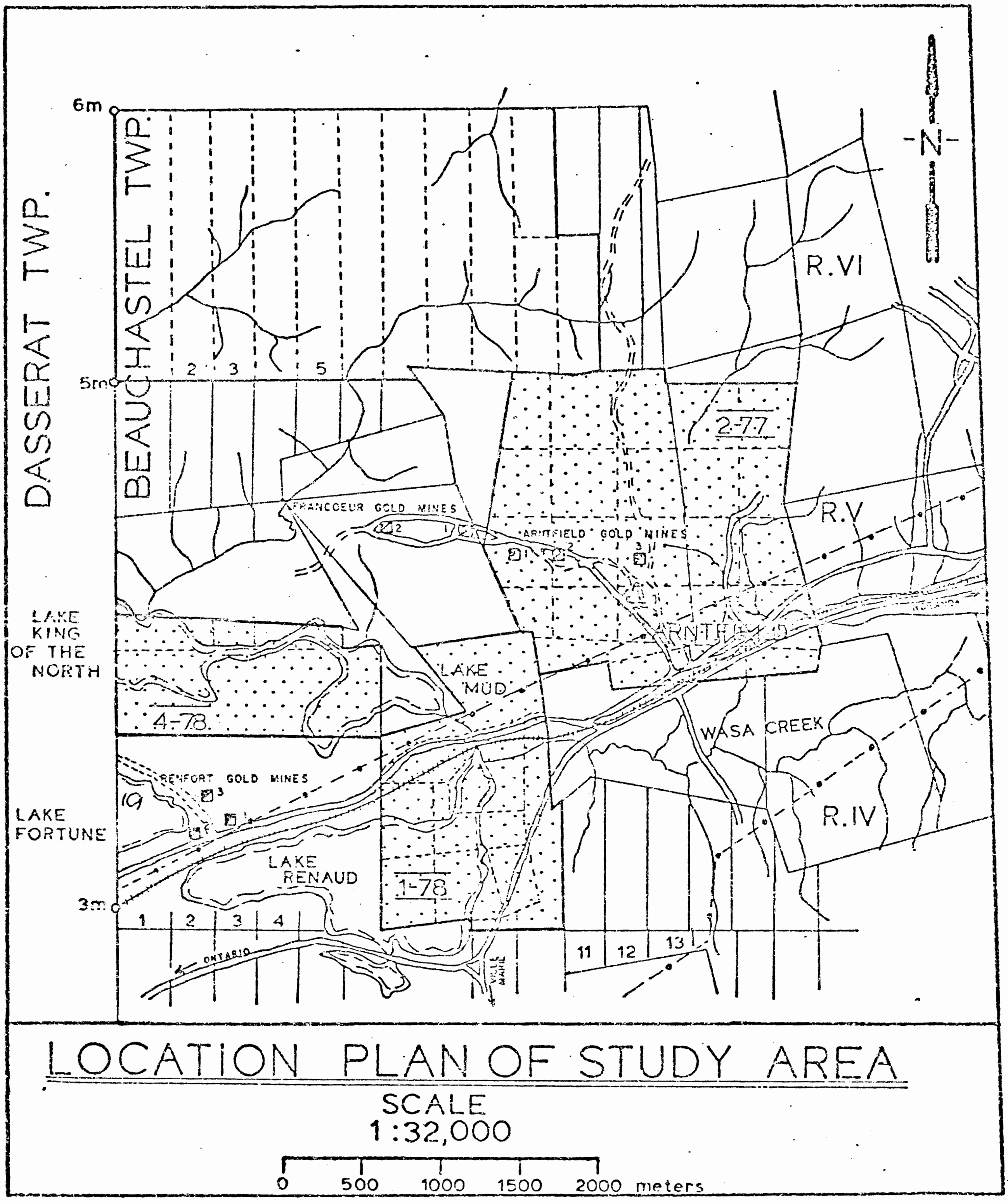
of Beauchastel Township in Temiscamingue County, approximately 24 km (15 miles) west of the towns of Rouyn-Noranda, Quebec (Figure 1).

The study area was comprised of three contiguous properties (claim groups) (Figure 2). The names assigned to the properties (Beauchastel 2-77, Beauchastel 1-78 and Beauchastel 4-78) are Noranda company designations whose code indicates the township, the number of the claim group staked in the township, and the year the group was staked. These property names will be used to refer to the subdivisions of the study area throughout this paper, where each property was treated as an individual unit.

The study area has approximately 627 ha (1550 acres). Table 1 contains a listing of claim numbers, mining blocks, and land and water areas for the three properties.

Good access to the properties from the towns of Rouyn-Noranda is provided by paved Highway 101-117. Road access to the Beauchastel 2-77 and Beauchastel 1-78 properties is quite convenient from a network of secondary gravel roads and private camp access roads.

Direct access to the western extremity of the study area, the Beauchastel 4-78 property, is less convenient because there are no roads on the southwestern corner of that property. Foot traverses of over 0.5 km (0.33 miles) along the Dasserat-Beauchastel township cut line or canoe traverses via the lake system are the only means of access.



DASSERAT TWP.
BEAUCHASTEL TWP.
6m
5m
3m
LAKE KING OF THE NORTH
LAKE FORTUNE
LAKE MUD
LAKE RENAUD
FRANCOEUR GOLD MINES
ARNTFIELD GOLD MINES
BEAUFORT GOLD MINES
WASA CREEK
R.VI
R.V
R.IV
2-77
4-78
1-78
N
ONTARIO
LOCATION PLAN OF STUDY AREA
SCALE
1:32,000
0 500 1000 1500 2000 meters

Figure 2.

Table 1. Claim numbers, mining blocks and land and water areas for the three properties in the study area.

Property and claim number	Old series mining blocks Beauchastel Township	Approximate area covered by water	Approximate area covered by land	Total area
Beauchastel 2-77 C.366681-claims 1 to 5 C.366682-claims 1 to 5 C.366683-claims 1 to 3 Section added to original group C.370662-claims 1 to 5 C.370889-claims 1,2,3,5 C.370890-claims 1 and 2	Blocks H,J,19, U,V,L and Sections of blocks 22,23,0 and 157	negligible	370.3 ha (915 acres)	370.3 ha (915 acres)
Sub total 24 claims				
Beauchastel 1-78 C.366760-claims 1 to 5 C.370890-claims 3 to 5 C.370891-claims 1 to 3	Blocks 10,11, 12,13,14,152,Z, and Range 4, Lots 8,9,10	48.1 ha (109.8 acres)	112.2 ha (286.2 acres)	160.3 ha (396 acres)
Sub total 11 claims				
Beauchastel 4-78 C.372072-claims 1 to 6 C.372071-claim 1	Block B and part of Range 5 Lots 1 to 6	46.4 ha (114.7 acres)	50.3 ha (124.3 acres)	96.7 ha (239 acres)
Sub total 7 claims				
Totals 42 claims		94.5 ha (224.5 acres)	532.8 ha (1325.5 acres)	627.3 ha (1550 acres)

PHYSICAL FEATURES

Average elevation of the region under investigation is approximately 300 m (1000 feet). Occasional knolls or intermittent ridges give the area variable low to intermediate relief. Elevation variation within the area is not great, with a maximum relief of approximately 90 m (300 feet).

Surface waters in the study area and vicinity drain down the creeks and streams into the three lake basins partially on the properties. The lakes drain through Lake Renaud southward via the Ottawa River into the Great Lake system (Figure 3).

The topography and vegetation cover are quite variable. Figure 4 indicates the major topographic features.

Three sections of the study area and vicinity are, relatively speaking, topographic highs. These sections are located southeast of the study area (Kekeko Hills) and in the northeast and northwest corners of the Beauchastel 2-77 property (Plate 1). These sections of high ground are typified by large expanses of relatively unobscured rock outcrop with occasional clumps of jack pine or other scrubby softwoods in the surface depressions. As in all boreal forests, large populations of lichens and mosses cover the surfaces of the rocks.

Large areas of swampy, low-lying ground are located primarily along the edges of the lake system on the Beauchastel 4-78 property; on Beauchastel 1-78, at the head of Lake Renaud where Lake Mud and Wasa creeks flow into the lake; and in the center and southeast corner of the Beauchastel 2-77 property.

Figure 3. General surface water drainage pattern on the Beauchastel study area, Arntfield, Quebec.

Explanation:

Lake

Minor volume of water flow

Major volume of water flow

Note: Water flow quantifications made from empirical observations only.

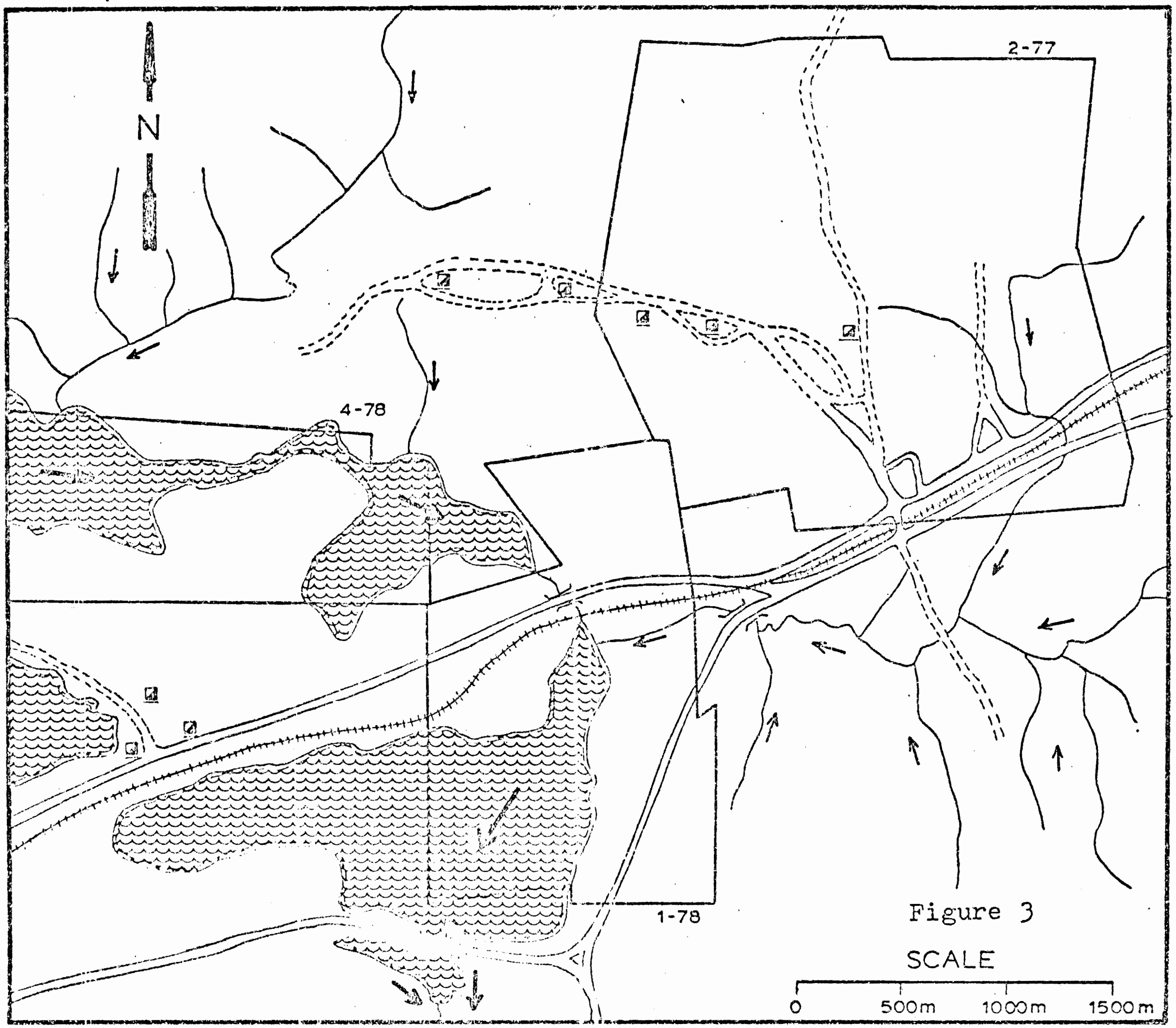
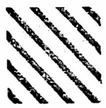


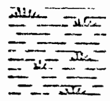
Figure 3

Figure 4. General topographic features of the Beauchastel study area, Arntfield, Quebec.

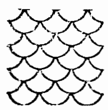
Explanation:



High ground



Swamp



Mine tailings

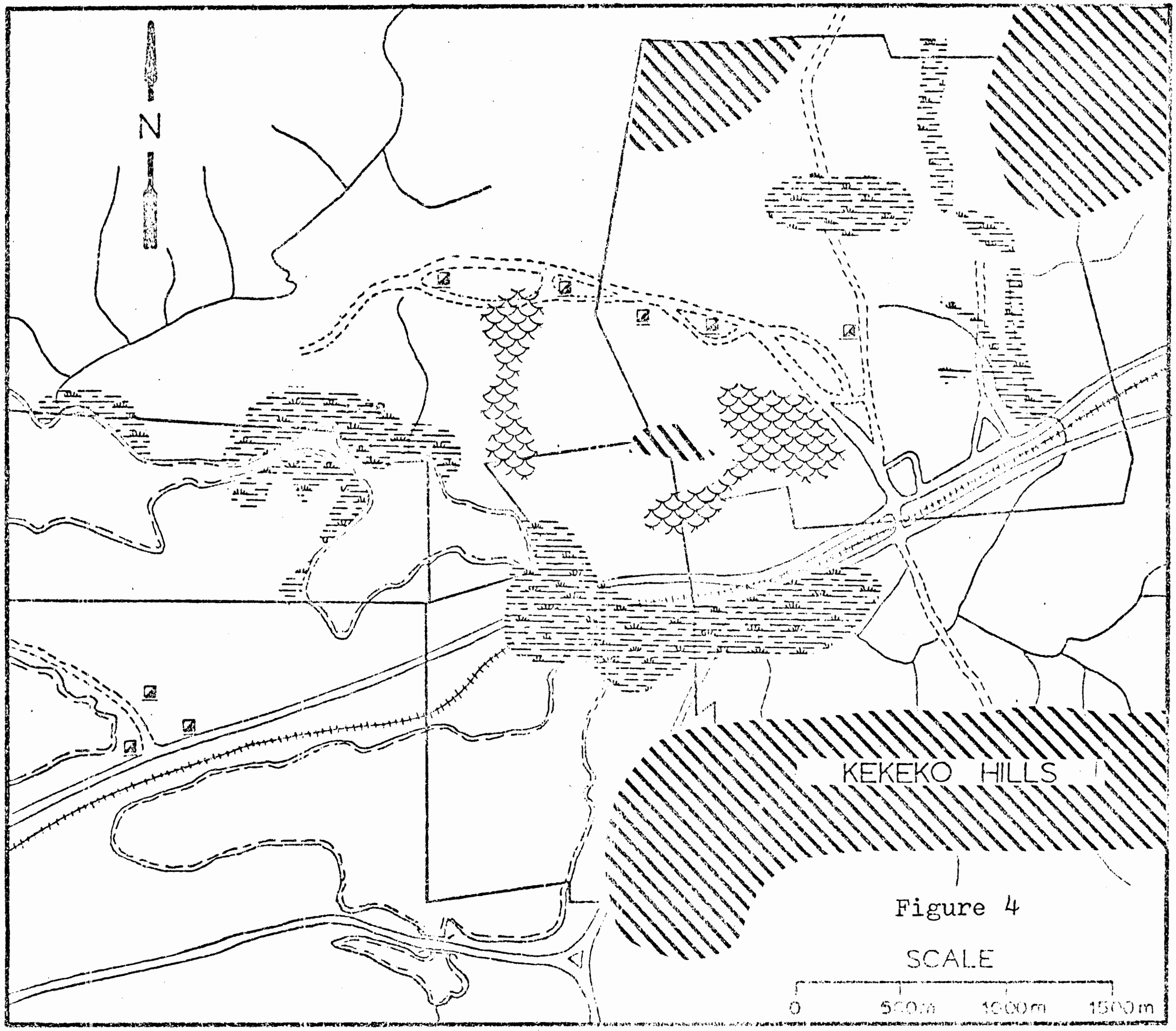


Figure 4

Plate 1. View south across the eastern side of the Beauchastel 2-77 property. Village of Arntfield and Kekeko Hills in the background. Photograph indicates the low, swampy ground typical in the center of the property. Photograph taken from the large outcrop on the northeast corner.

The swamps between the lakes on Beauchastel 4-78 are particularly wet, with cattails (and minor sedges) as the primary vegetation cover. The other swamps on the property are not as wet; these areas are primarily populated by heavy growths of alders and other shrubby hardwoods.

A series of old farm fields with a series of beaver ponds and swamps running north-south is located in the west-central part of the Beauchastel 2-77 property. The fields are becoming overgrown with a succession of hardwood shrubs and small conifers (Plate 2).

On the southwest corner of the Beauchastel 2-77 property extending south into the Beauchastel 1-78 property and just to the north of the Beauchastel 1-78 property are located old tailings ponds. These tailings ponds were in use when the Francoeur and Arntfield Gold Mines were in operation. The ponds now take the form of well-packed, deeply grooved flats composed of fine grains varying in size from sand to silt. The deep grooves on the surface of the sand flats are erosion features formed as the surface runoff carries the fine particles out of the dammed ponds to areas of lower elevation.

Forest vegetation cover generally falls into two categories, (1) hardwood forest with a population of intolerant hardwoods primarily birch and poplar species or (2) mixed forest with a population of both coniferous and deciduous species including fir, spruce, pine, birch, poplar, alders, and the occasional maple. This vegetation cover is the result of environmental influences, the major ones being

Plate 2. View from the farm in the center of the Beauchastel 2-77 property towards the large set of outcrops on the high ground in the northeast corner of the property.

(1) distribution of soil cover (glacial drift) and (2) repeated forest burnings. Understory growth is typically heavy.

Outcrop exposure is estimated to be approximately one quarter of the surface area. Natural outcrop exposures can be predicted with a substantial degree of accuracy, being almost exclusively on topographic highs, lake shores, or in areas of changing relief (Plate 3). Other outcrop exposures are found where Man has influenced the surficial environment, such as along rights-of-way of roads, railroads and power lines. The limited outcrop exposure and logs of diamond drillings indicate the substantial mantle of glacial drift material covering most of the area ranges in thickness to 25 m (80 feet).

Surface water supply is abundant and should be sufficient to provide for some industrial purposes such as a diamond drill program. At present, there would appear to be no conflict with other land or water uses and a drilling program or mining operation.

MINING HISTORY

The study area and immediate vicinity have been the site of fairly intensive, and successful, gold mining activity intermittently from about 1905 to the late 1940's when both money and manpower ran out because of the economic stresses created by World War II. Data obtained by these mines in their last days of operation give reasonable indication of the presence of mineable gold ore at depth. The gold mines

Plate 3. Photograph indicating typical lakeshore outcrop morphology. Photograph of diorite outcrops on the southern shore of Lake King of the North, Beauchastel 4-78 property.

have complicated, somewhat poorly documented history. Many of the mine records have been lost since the mining operations ceased. General information can, however, be obtained from mining reports submitted to the government and from reports written by staff of government agencies.

One of the earliest gold mines operated in northwestern Quebec was located just outside the study area, to the south of the southwestern corner of the Beauchastel 4-78 property approximately one-half kilometre (one-third mile) south of the southern shore of Lake King of the North approximately 250 metres (800 feet) from the eastern end of Lake Fortune toward Lake Renaud. This mine has had two names, the Lake Fortune Gold Mine and the Renfort Gold Mine (Figure 2).

The gold mineralization at Lake Fortune was discovered, along with the deposit in Larder Lake, Ontario, in the summer of 1906. The deposit located in the Lake Fortune Shear Zone has been interpreted to be a part of the major Horne Creek Fault System, in turn related to the regional structure, the Val d'Or-Larder Lake Break.

The Pontiac and Abitibi Mining Company carried on the first development work on that mine from 1907 to 1910. From 1910 to 1914 the property was worked by the Union Abitibi Mining Company. Details regarding the nature of the development work done on the property in these early years are not readily available from the literature. The Lake Fortune Mining Company was formed and took control of the property in 1922. During this year, the mine workings were drained and sampled (Bruce, 1933).

In 1923, yet another company took over control of the mine property, a company called Towagmac Exploration Company Limited. In subsequent years this company did much development work on the property. The surface was examined by stripping and trenching. Later, a 150-foot (46 m), two-compartment, inclined shaft was sunk into the shear zone at an attitude of 55° from the horizontal on a North azimuth. Associated with this shaft were 550 feet (170 m) of lateral workings.

Towagmac Exploration Company Limited carried out an extensive diamond drilling program in 1926 and 1927 to try to delineate the ore zone. Encouraging assay results were obtained. An ore body was delineated at between 300-and 500-foot (90-150 m) depth, averaging 3 feet 7 inches (1 m) in width and being approximately 500 feet (150 m) long (Quebec Bureau of Mines, 1927). Operations at the mine ceased about 1930 for some unexplained reason.

In 1934, Lake Fortune Gold Mines, Limited was formed, and work at the mine resumed during the summer. Work during the year included the construction of several new mine buildings, the acquisition of electrical power for the mine, installation of a large compressor, and finally the installation of a larger capacity hoist. During the same summer, though late in the season, another vertical, two-compartment shaft was sunk into the shear zone approximately 500 feet (150 m) east of Lake For une. By December, the shaft had reached a depth of 365 feet (110 m), the first level was driven at a depth of 355 feet (108 m) (Quebec Bureau of Mines, 1934). Considerable surface trenching across the shear zone revealed encouraging assay values. In addition the company drilled 15 diamond drill holes from the surface to intersect the shear zone. Those 15 drill holes totaled 6675 feet (2035 m) in length (Fritzsche, 1934).

A second vertical shaft was completed to a depth of 490 feet (150 m), in addition to the establishment of a second level at the 465-foot (140 m) depth in 1935. This same year, the mine did a considerable amount of cross-cutting, and drifting was completed on both levels (Quebec Bureau of Mines, 1935).

Early in the summer of 1935 all mining operations were discontinued. The mine remained closed for many years, with no record of any work being done on the property (Quebec Bureau of Mines, 1935).

In 1944, Renfort Gold Mines Limited dewatered the old shafts. There is, however, no record that the mine actually was reworked and put back into production. A magnetic survey was run over the property, as well as other geophysical surveys. A large diamond drilling program was initiated, which resulted in the sinking of approximately 36 holes representing a total of 14 691 feet (4480 m) of drilling (Quebec Bureau of Mines, 1944).

During 1945, 15 holes were completed, totaling a further length of 8120 feet (2480 m) (Quebec Bureau of Mines, 1945). The completion of the drill program in 1945 is the last reference to the mine that could be located in the literature.

The above history is a synthesis from several reports. The information contained in those reports did not always agree with information contained in other reports. The reasons for these discrepancies are not clear.

The Arntfield Gold Mine operated within the boundaries of the study area; the collars of its three shafts are located in an east-west orientation across the center of the Beauchastel 2-77 property (Figure 2). These shafts are located on the Francoeur-Arntfield Shear Zone, which hosted the gold mineralization.

The mine property was staked late in 1923 by F. S. Arntfield. Surface exploration on the property showed encouraging results, so the exploration program was initiated. In the summer of 1924, a number of trenches were dug across the surface exposure of the Francoeur-Arntfield Shear Zone. The trenching yielded assay values as high as 0.10 oz./ton gold and 0.10 oz./ton silver. All the mineralization detected on the property was located desseminated in the schist zone in the shear. Twelve diamond drill holes totalling a length of 3000 feet (910 m) were also drilled in 1924 from the surface to intersect, trace, and evaluate the shear zone. These drill holes were drilled from the north side of the shear zone with all but one of the holes drilled at angles of 60° or 45° from the horizontal, in a southerly azimuth. This drilling program evaluated a 4000-foot (1220 m) section of the shear zone in which the mineralized zone varied in width from 60 to 100 feet (19-30 m). This same year, suitable road access to the property was constructed, and, as well, several buildings were constructed (Quebec Department of Mines, 1924).

Although the exploration program on the property is known to have continued in 1925, there is no record of the results obtained. The company changed its name from the Arntfield Syndicate to Arntfield Gold Mines Limited. This same year, Porcupine Goldfields Development and Finance Company of London, England, was given an option on the property (Quebec Bureau of Mines, 1925).

Porcupine Goldfields Development put down a series of four drill holes in 1926, totalling approximately 2050 feet (625 m). This drilling extended the known ore-bearing zone westward, to over 6000 feet (1830 m) in length (Arntfield, 1928).

Records of the development work on the property in 1927 seem somewhat confused. It appears, however, that the Towagmac Exploration Company took an option on part of the property. Towagmac drilled 1291 feet of core and did a considerable amount of trenching on the western extremity of the property (Fritzsche and Armstrong, 1927).

About the fall of 1929, the first vertical, two-compartment exploration shaft was sunk into the Francoeur-Arntfield Shear Zone. This first shaft can still be located on the Beauchastel 2-77 property as a large "glory hole" just to the south of the main road across the property, just to the east of the western boundary of the property. There is little detailed information regarding this first shaft.

It appears that, after completion of the exploration shaft, the mine closed and remained dormant until 1935 when the first production figures were compiled (Table 2). A second, inclined (-45°N) shaft was completed at an attitude of 45° from the horizontal on approximately a North azimuth, and then a third shaft was sunk. No data on this shaft were available for the early period of its existence (Ambrose,1945).

The Arntfield Gold Mine went into production early in 1935. In this year, development continued on the inclined (-45°N) Number 3 shaft, a total mining distance of 4553 feet (1390 m). As well, 6002 feet (1830 m) of surface and 7740 feet (2360 m) of underground diamond drilling were completed. The calculated ore reserve at the mine as of December 31 was 112 400 tons (101 968 tonnes) of a grade of 0.24 oz./ton gold. This reserve included 97 400 tons (88 360 tonnes) above the 375-foot (115 m) level.

Gold production continued from 1936 to 1940. During this period, production increased at a steady rate with calculated ore reserves of 123 800 tons (112 310 tonnes) @ 0.162 oz./ton gold above the 650-foot (200 m) level in 1936, 138 700 tons (125 830 tonnes) @ 0.143 oz./ton in 1937, and finally 252 000 tons (228 610 tonnes) @ 0.120 oz./ton. The production figures for this period can be found in Table 2 (Oille, 1947).

The mining continued from 1940 to 1942; however, the company was falling further into debt with losses increasing as each year went by. On April 10, 1942, the Arntfield Gold Mines suspended operations when the banks refused to meet the

Table 2. Arntfield gold mine production figures (Oille, 1947).[1]

	1935	1936	1937	1938	1939	1940	1941	1942	Totals
Tons milled	26 082	67 881	65 692	95 259	121 730	84 425	45 111	23 809	529 989
Daily rate (tons)	165	186	180	281	334	293	182	222	
Grade (oz./ton)	--	0.162	0.143	0.120	0.100	0.148	--	--	
Average grade ($/ton)	6.83	5.15	4.53	4.21	3.88	3.75	3.78	3.80	
Recovered grade ($/ton)	6.83	4.50	3.64	3.69	3.17	3.27	3.86	4.26	
Total cost/ton ($)	--	5.31	6.03	4.34	3.64	3.91	--	--	
Ore reserves (tons)	--	123 800	138 700	252 000	120 000	54 971	--	--	
Production value ($)	178 045	305 679	238 819	351 676	386 232	276 337	174 059	101 486	2 012 333
Gold produced (oz.)	5 037.48	8 706.75	6 801.89	9 960.82	10 660.60	7 168.05	--	2 622.06	50 957.65
Silver produced (oz.)	505.24	--	1 958.03	2 520.36	2 535.13	--	--	2 300.54	9 819.30

[1]No production in 1946 and 1947, although there was activity at the mine.

payroll. In August, 1924, the 350-ton-per-day (320 tonne) capacity mill was offered for sale to help pay some of the company's debts (Oille, 1947).

In 1944, the Arntfield Mining Corporation was formed. In May, a drilling program was initiated to explore further the surface geology. By the end of the year, the Number 2 shaft had been dewatered and put back into operation. A detailed geological study of the workings had been completed as well. An exploratory cross-cut was driven north from the Number 2 workings on the 1075-foot (330 m) level for a distance of 267 feet (80 m). At the end of the cross-cut a diamond drill station was established, and a fan-shaped, downward-oriented series of 14 holes was drilled to search for the extension of the ore body in the shear zone. This diamond drilling program revealed much mineable, ore-grade classes below the 1075-foot (330 m) level (Table 3) (Oille, 1947).

The results of the 1075-foot (330 m) level drilling program led to the sinking of a three-compartment internal shaft from the end of the 1075-foot (330 m) level cross-cut in 1945. This internal shaft, called the "4-Winze", was sunk 320 feet (100 m). Two levels were established (4-100 and 4-200 levels) below the 4-Winze level. A total of 593 feet (180 m) of drifting and cross-cutting was completed on the two newly established levels. There was no production from the mine in either 1945, 1946, or 1947 (Quebec Department of Mines, 1946; Steward, 1947).

Table 3. Results of exploration drilling program below the end of the 1075-foot level cross-cut, Arntfield Gold Mine, Number 2 Shaft, 1944.

Hole no.	Core length (feet)	Depth of intersection below 1075 (feet)	Gold assay (oz./ton)
769	---	---	L.V.[1]
770	2.8	146	0.39
771	2.9	155	0.24
772	---	---	L.V.
773	---	---	L.V.
774	7.7	108	0.31
775	5.6	155	0.46
776	---	---	L.V.
779	---	---	L.V.
782	19.5	186	0.237
783	9.5	215	0.19
784	12.6	182	0.23
797	2.6	205	0.20
804	---	---	L.V.

[1] L.V. means low values.

(Oille, 1947)

Mining operations were suspended by New Arntfield Mines Limited early in 1947 (Steward, 1947), the last closure of the mine. Since that date, there has been no mining activity on the property. The new ore body identified before the mine closed was never exploited. The current price of gold provides good incentive for further exploration and/or development around the identified ore body.

The horizontal projections of the approximate locations of the mine workings of the Arntfield Gold Mine can be seen on the detailed geological survey map of the Beauchastel 2-77 property included in the pocket of this report (Figure 5).

On the western extension of the Francoeur-Arntfield Shear Zone to the west of the study area was located yet another series of mine shafts. The Francoeur Gold Mine was operational at approximately the same time as the other mines in the area. The history of this mine, as with the other mines, is complicated and, because it is not located in the study area, is not described.

PREVIOUS GEOLOGICAL WORK

Much geological work has been done in the region of the Beauchastel study area. The most primitive mapping investigations were done by prospectors during the preparation for the mining activity in the area. As described above, much of this work was done during the period from approximately 1907 to the late 1920's. The information obtained from these early surveys is very sketchy. The terrain description and location of outcrop exposures is very good; however, the descriptions of the various rock types encountered are not very detailed. Much of the data obtained from these surveys may have been destroyed or lost in the interim period, leaving the appearance of incompleteness.

In 1933, E. L. Bruce, under the Quebec Bureau of Mines, produced a report on the region including a surficial geological map and a preliminary examination of the active mining operations.

In 1940, G. S. MacKenzie, under the Quebec Department of Mines, mapped and described the surficial geology of the areas to the east and west of that described by Bruce in 1933. Part of the Lake Fortune map area described in MacKenzie's report overlaps with the area being examined in this paper.

After working as mine geologist, first at the Arntfield Gold Mine then as the Francoeur Gold Mine, S. E. Malouf wrote a Ph.D. thesis at McGill University in 1941. In the thesis, Malouf described in detail the geology of the two gold mines. This thesis is a valuable piece of work because its interpretations are not only drawn from the surface exposures of the geology but in addition include data obtained from detailed examinations of the underground workings.

In 1945, J. W. Ambrose and S. A. Ferguson working under the Geological Survey of Canada again mapped and examined the mining operations in the region. This paper was essentially written as the Canadian Government's version of the reports produced by Bruce and MacKenzie.

The final major published work dealing with the geology of the study area was written in 1948 by E. A. Hart, and J. E. Gill. This paper was written for the Canadian Institute of Mining and Metallurgy as a general description of the geology and structure of the Arntfield Gold Mine to be used as a comparison with several other ore deposits in Canada.

The paper by Hart and Gill in 1948 was the last paper dealing specifically with the geology of the western Beauchastel Township region for many years. In 1977, as part of a major regional project accessing the geology of northwestern Quebec, the Ministère des Richesses naturelles of Québec produced a large scale (1:10 000) geological compilation map of the study area. This map (Carte De Compilation Géoscientifique) is adequate for a large-scale examination of the region; however, for detailed geological examinations the map is not sufficient.

In 1978, Noranda Exploration Company Limited undertook an exploration program on the properties making up the study area. One drill hole was sunk on the Beauchastel 2-77 property to try to intersect the ore zone located in the 1075-foot (330 m) level drilling of the mid 1940's. The drill hole, AR-78-1, with a total depth of 1630 feet (497 m), did not make an intersection with the ore zone. Late that same year, Noranda put down two, shallow, x-ray, diamond drill holes in the northeastern corner of the Beauchastel 1-78 property near the center of the study area. Also, several geophysical surveys were run over the northern section of the study area (Beauchastel 2-77), including induced polarization, VLF electromagnetics (Radem), and magnetics. Finally, in the summer of 1979, a detailed surficial geological mapping survey was carried out.

PURPOSE AND SCOPE

The main purpose of this thesis is to provide an internally consistent description of the surficial geology exposed in the study area. The project includes the preparation and interpretation of a set of three detailed geologic maps, one of each property included in the study area; general descriptions of the rock lithologies encountered in the study area; and an analysis and evaluation of structural data acquired by measurements made during the mapping procedure.

The thesis project reports on information collected by the author during four months of field mapping during 1979. The project is therefore not an academic study of one particular subject, but instead a rather detailed field geological report. Detailed studies of any particular aspect were beyond the scope of this project. The only strongly academically oriented section of the study is an investigation of the relationships of the shear and jointing patterns with formation of major shear zones which host the gold ore making this area an attractive target for exploration.

METHODS

The field work for this project was done by the author during the summer of 1979 while employed as a summer project geologist by Explorations Noranda Limitée of Noranda, Quebec. The project was supervised by Dr. W. A. Hogg, Exploration Manager, Quebec Division.

Standard pace and compass procedures were utilized during the surficial mapping of the study area. The geological maps of the three properties included in the back pocket (Figures 5, 6, and 7) of this report are in two different English unit scales. The Beauchastel 2-77 property had a cut line grid upon it. The grid was the last English unit grid cut by the company. The cross-lines were placed at 400-foot intervals along the east-west base line and run perpendicular to the base line. Cross-lines were picketed at 100-foot intervals. To allow ease of mapping with good ground control and to provide compatibility with previous surveys it was decided best to map the property in English units (200 feet to the inch) without conversion to metric units.

The mapping of the Beauchastel 1-78 and Beauchastel 4-78 properties was not as convenient since there was no cut grid placed on them. Mapping was done using lakeshores, roads, township lines, and railroad rights-of-way as the basic ground control for the cross-country pace and compass traverses. Because the outcrop exposure in the area proved to be quite predictable to occur on topographic highs, extensive use was made of air photo coverage and topographic observations from the ground to choose the traverse routes. To be compatible with the other maps of the study area these two properties were again mapped English units. As the ground control was extremely poor, a scale of 400 feet to the inch was chosen.

The mapping incorporated all outcrops located on the properties, gross lithological variations in the rocks, measurements of representative planar structural features such as joints and shears, accurate locations of topographic features such as beaver ponds, etc., and finally the location of cultural features such as diamond drill collars, shaft collars and buildings. The position of the underground workings shown on the geological maps were scaled down from assorted maps provided from the files of the Ministere des Richesses naturelles du Quebec.

Thin sections of the hand specimens of some lithologies were cut by Noranda to facilitate identification. The drafting and report writing was completed during the fall of 1979 and winter of 1980 at the Geology Department of Dalhousie University.

CHAPTER 2

REGIONAL GEOLOGY

The area under investigation lies within the Abitibi Greenstone Belt of the Superior Structural Province of the Canadian Shield (Figure 1). The Abitibi Belt is crossed by a major structural feature in the form of a series of large, east-west-trending, discontinuous, sinuous strike-slip faults and shear zones. The region in the broad vicinity of the study area is well-known throughout the world for the large number of gold mines (including the Renfort, Arntfield, and Francoeur Gold Mines) along this series of faults and shear zones known generally as the Val d'Or-Larder Lake Break. These mines as a rule exploit the economic gold mineralization associated with "dilation zones" formed in the rocks within these regional structural features.

STRATIGRAPHY

In general, the rocks of the Superior Province are considered to be of Early Precambrian Age (Archean). The rocks have been dated by K/Ar (Potassium/Argon) techniques which indicate the last major tectonic event was the earliest known orogeny in the Precambrian Era, the Kenoran Orogeny approximately 2480 million years ago (Douglas, 1970). Field relations indicate subsequent orogenies had relatively minor effects on the rocks of the Superior Province as compared with the effects of these orogenies on the Canadian Shield.

The effects of this tectonic activity on the rocks will be dealt with in a little greater detail later in this chapter.

The rocks of the Superior Province have been categorized by Latulippe, et al., (1979) into three major subdivisions:

(1) Greenstone "Belts" consisting of a series of volcanic lava flows ranging in composition from mafic to felsic but primarily being of intermediate (andesitic) composition. Also included in this category are the contemporaneous intrusive bodies associated with the volcanic pile.

(2) Synclinal troughs of primarily clastic sediments such as greywacke, conglomerate and sandstones believed to be deposited on top of the volcanic piles.

(3) Granitic intrusive bodies intruding the lava-sediment complexes.

(Jolly, 1974)

The Superior Province has been divided into a series of mappable belts and plates on the basis of the three rock categories described above and the structures contained within them (Douglas, 1970; Price and Douglas, 1972). However, the relationships between the belts and rocks of the province are very complicated and a detailed stratigraphy for the entire Superior Province has not been yet constructed.

The Abitibi Belt has had its stratigraphy studied for many years and the stratigraphy of local areas has been put together. It is however, very difficult to correlate the stratigraphy between the areas because of the discontinuous nature of the volcanic flows and lateral facies variations.

The following progress reports of projects describing the stratigraphy of the Rouyn-Noranda region have been recently published by the Ministère des Richesses naturelles du Québec: Dimroth et al., 1973; Dimroth et al., 1974; Dimroth et al., 1974; Dimroth et al., 1975; and Gelinas et al., 1976. The complex stratigraphy described in these papers appears to be conclusive, however, it is not yet fully accepted by workers in the region.

REGIONAL STRUCTURE OF THE ROUYN-NORANDA REGION

The Archean volcanic and sedimentary rock sequences of the Abitibi Belt in the Rouyn-Noranda area have a measured thickness of close to 10 700 m (35 000 feet) (Douglas, 1970). The rocks of the Abitibi Belt, along with the other rocks of the Superior Province have been deformed and regionally metamorphosed by the Kenoran Orogeny (2480 million years). Minor periods of deformation have occurred later than the Kenoran Orogeny with minor effects on the rocks of the Abitibi Belt; these were the Hudsonian (1735 million years) and the Elsonian Orogenies (≈1300 million years). These deformation periods (primarily the Kenoran Orogeny) deformed the volcanic-sedimentary rock sequences into a series of broad, gentle folds with regionally east-west-trending axes generally plunging moderately to the east or west. The later minor deformation periods caused some cross-folding of variable orientations, faulting, and the intrusion of igneous bodies of various descriptions to further complicate the situation (Douglas, 1970).

The most pertinent regional structural feature relating to the gold mineralization and this study is the system of rather large-scale faults and shear zones that cross the region, such as those found at Destor-Porcupine, Larder Lake, Cadillac, Malartic, and Val d'Or. The entire length of this fault system covers hundreds of kilometers, it trends easterly and normally occurs at, or near, the synclines of the broad regional folds described above.

The rocks in the faults and shear zones exhibit strong dynamic metamorphism with primarily a chlorite-carbonate mineralogy, but this effect can only be detected for a few hundred metres away from the main shear planes. Lead isotope studies of the gold deposits related to this series of faults indicate initial deformation during the Kenoran Orogeny (Douglas, 1970).

METAMORPHISM

The rocks of the Abitibi Belt have been regionally metamorphosed during orogenic activity. The deformation effects on the rocks and the intensity of these effects seems to be differential depending upon the lithologic character and bedding characteristics of the basement rocks (Douglas, 1970).

The periods of deformation have regionally metamorphosed the rocks of the Abitibi Belt to greenschist facies with higher metamorphic grades, such as amphibolite facies and contact metamorphic hornfels in close proximity to the granitic intrusives. Locally the development of the metamorphism seems to be governed by the lithologic character of the rocks, regional stratigraphy, proximity to major faults or shears, and the proximity to intrusive igneous bodies (Price and Douglas, 1972).

CHAPTER 3

GEOLOGY OF THE STUDY AREA

The Beauchastel study area occupies the southern limb of a regional east-west-trending syncline, the axis of which lies immediately to the north. The basement rocks are a series of east-west-striking, northerly dipping (approximately 40° to 60°), lens-like volcanic flows of the Abitibi Greenstone Belt. These intermediate to felsic flows have been intruded by intermediate to basic igneous bodies of various descriptions. In the east-southeast section of the property, the volcanics (and intrusives ?) are uncomformably overlain by a late-deposited series of clastic sediments.

The volcanic pile is cut by at least two separate regional east-west trending shear zones. These shear zones are of prime interest to any geological investigation of this area because they provide the structural control for the gold ore.

The detailed geology of the three properties comprising the Beauchastel study area is shown in Figures 5 (Beauchastel 2-77; 6 (Beauchastel 1-78); 7 (Beauchastel 4-78) located in the rear pocket. It should be noted here that, due to the disconnected configuration of the three properties, it is nearly impossible to draw any major conclusions regarding the geology between them.

STRATIGRAPHY

The rocks exposed in the study area have been interpreted by previous workers to be of Archean or Proterozoic Age (Gunning and Ambrose, 1940; Wilson, 1962). The general stratigraphy worked out for the region is tabulated in Table 4, the simplest and most generally accepted stratigraphy used by most present workers in the region.

Keewatin Series, Blake River Group

The oldest and most abundant rocks in the Beauchastel study area are the volcanics of the Keewatin Series, Blake River Group. The volcanic flows of this group regionally strike approximately east-west. The dip of the flows is somewhat more difficult to ascertain, due to the poor exposure and lack of visible bedding. The contacts between the flows were either covered, or so gradational that no clean contact could be outlined. These observations are similar to those of others that have worked in the area. The regional dip of the flows, obtained from diamond drill data or from observations made within the mine workings when they were operational, average approximately 45° to 50° to the north.

The exposures of the discontinuous, apparently lens-like, interfingering volcanic flows of this group are sparse. The lack of continuous well-exposed outcrop combined with extreme variability in flow lithology both along the apparent regional strike, as well as stratigraphically, made the mapping and the correlation difficult and inconclusive.

Table 4. Formations in region including study area.

Era or period	Series or group	Lithologies
Cenozoic	Post-Glacial Glacial	Stratified clay, sand and gravel Boulders, gravel, sand and boulder clay
	Unconformity	
Proterozoic (Late Precambrian)		Quartz diabase-gabbro dykes Olivine diabase-gabbro dykes Quartz diabase-gabbro
		Intrusive Contact
	Cobalt Group	Conglomerate and greywacke
	Unconformity	
Archean (Early Precambrian)		Quartz diabase-gabbro ?
		Intrusive Contact
	Post-Timiskaming	Lamprophyre dykes Syenite porphyry dykes, sills and masses Potassic granite dykes and masses Albite granite dykes and masses Amphibolite Quartz diorite dykes, sills and masses Andesite and related rocks in dykes and sills Rhyolite (quartz-albite) porphyry dykes and sills
		Intrusive Contact

Era or period	Series or group	Lithologies
	Temiskaming Series Cadillac Group	Conglomerate and greywacke
	Unconformity	
		Amphibolite Quartz diorite dykes, sills and masses Andesite and related rocks in dykes and sills Rhyolite dykes and sills Rhyolite (quartz-albite) porphyry dykes and sills
		Intrusive Contact
	Pontiac Group	Mica schist, amphibolite, amphibolite-schist, andesite and andesite tuff
	Keewatin Series Abitibi Group	
	Blake River Group	Volcanic rocks
	Kewagama Group	Sediments
	Malartic Group	Volcanic rocks

Adapted from Gunning and Ambrose, 1940, and Wilson, 1962.

The different lithologies are described in order of decreasing abundance of exposure, not in stratigraphical order, due to the uncertain relationships (Figures 5, 6, and 7, in back pocket of report).

Andesites

The most common rock types encountered as outcrop in the study area are andesites (V_6) and related variables with basically andesitic composition (e.g., $V_6\sigma$ and $V_6\odot$). The outcrop morphology of the andesitic lithologies assisted in the identification in the field. The andesitic outcrops as a general rule exhibit considerably less shattering and fracturing due to their less competent nature compared to the more brittle felsic flows in the area. This differential hardness (soft, so it could be scratched by a good quality knife blade) as well as color and texture were the primary criteria used for macroscopic identification in the field. As a general rule the relative hardness of the rock would give an indication of relative quartz content. Obviously alteration by metamorphic or weathering could influence the hardness of the rock, but for the field identifications these factors were taken into consideration.

The andesites (V_6) in the study area are as a rule relatively soft, presumably indicating an intermediate quartz content. The colors of the andesites are variable ranging from a light to medium green. Grain size textrue varies from medium to fine with the greatest proportion falling in the former category. Microscopically, in general, the andesites contain significant quantities of magnetite ($\approx$10-15 percent), and major amounts of orthoclase, plagioclase, some free quartz, and amphiboles usually in the form of hornblende. Chlorite is very abundant in all samples, in general as the alteration product of the ferromagnesian minerals, influencing the darkness of the green color.

The lithologies of the andesitic flow units are subtly variable throughout the study area. The internal variations within the flow units cannot be traced over great distances.

Several of the more common, notable lithological variations of the andesites are listed below. No order of abundance is implied.

Silicified Andesite ($V_6\sigma$). These rocks bear a striking resemblance to the "normal andesite" with respect to color, texture, grain size, and texture. The major difference is that these rocks are very hard, similar to what one would expect to encounter with a more siliceous extrusive. These rocks, in field examination, appear to possess a higher quartz content. The question at the time was whether the higher quartz content was due to an initial greater silica content or due to post depositional alteration. The author assumes from observation and personal communication with other workers in the region that the rocks have been hydrothermally silicified. Microscopically the silicified andesites seem to be similar in composition to the "normal andesite", however, they have a much greater proportion of very fine-grained quartz, and a marginally greater proportion of chlorite.

Porphyritic Andesite (V_6D). These andesites are fairly typical except they contain small (4 mm) plagioclase feldspar prophyroblasts. Macroscopically, the feldspar porphyroblasts do not have any preferred orientation. No thin section was made of this lithology. Some of these fine-grained andesite porphyries exhibit microlitic and occasionally trachitic textures in the matrix.

Carbonatized Andesite ($V_6$3). The basic appearance of this rock type is again quite similar to that of the "normal andesite"; however, it seems to have been altered or penetrated with calcite. In addition, microscopically there seems to be a much greater proportion of alteration to chlorite, sericite and large (0.5 mm) fractured, crystalline pyrite. This carbonatized lithology was encountered only in the general vicinity of the Lake Fortune shear zone. It is therefore highly probable that the access for the carbonate to the rock was afforded by the channels formed by the shearing of the country rock. The thin section seems to indicate the rock has undergone a minor amount of shearing, because a poorly developed foliation of the chlorite and sericite and stretching of the pyrite in one direction is visible.

Amygdaloidal Andesite (V_6 ⊙). These rocks are more fine-grained than many of the other andesites encountered. Microscopically they have a higher plagioclase feldspar content and the laths exhibit microlitic textures. The small spherical or elongate amygdales are filled with finely crystalline, interlocking quartz grains, occasional large pyrite grains, and small chlorites. Chlorite alteration seems to be more strongly developed in the andesite near the margin of the amygdules.

Sheared Andesites ($V_6^{\times}$ or $V_6^{\checkmark}$). In outcrop these rocks appear quite different from the other andesites in the area. These rocks have been dynamically deformed to such a severe extent that they now have the extreme platy appearance of a phyllite or schist. The rocks in the shear zones weather so heavily on the surface that it is difficult to obtain a sizable sample because the rock splits readily into thin plates (Plate 4). Quartz veinlets between the foliation plates are common. Microscopically the rocks appear to be almost totally composed of quartz present both in the rock itself and in fine veinlets; chlorite, sericite, and carbonate in foliations; and disseminated opaque minerals, such as magnetite, pyrite, and hematite.

There is one other major andesite lithology present on the property. Its physical appearance is not related to its deposition but instead to its post-depositional deformation. These are the sheared andesites found in close proximity to the major shear zones traversing the study area.

The exact original composition of these rocks is not known; however, since many of the flows in the vicinity of the shear zones are of andesitic composition and the shear zones seem to trend sub-concordantly along the flow contacts (Malouf, 1941), it seems probable that the dynamically deformed rocks in the shear zones are originally of andesitic composition.

Plate 4. Platy appearance of sheared andesites where exposed in trench across Francoeur-Arntfield Shear Zone outcrop located on Beauchastel 2-77 property, Line 12E, 6 North.

The Ministère des Richesses naturelles du Quebec took two drill core samples from Noranda Explorations drill hole AR-78-1 which is located roughly in the center of the Beauchastel 2-77 property. The whole rock chemical analyses on both of these samples, which under the hand sample classification system used in this project would fall in the category of fine-grained, slightly porphyritic andesite (intermediate volcanic). The results of these analyses are shown in Table 5.

On the basis of average SiO_2 (silica) content, these rocks would fall chemically broadly in the category of intermediate volcanic rocks, which include andesites (Table 6). If these two samples were classified solely on the basis of their SiO_2 content, they would fall in the rhyodacite to dacite range (Table 7). While classifying these rocks solely according to their chemical content, it should be remembered that the rocks in this region are not fresh and essentially unaltered, as were the rocks in the tabulated analyses. The rocks of this region have been considerably altered and/or metamorphosed to varying degrees. It is likely, taking their alteration component into consideration, that the rock analyses do not reflect the true chemical character of the originally deposited rock but instead give an enriched value for SiO_2 if the rocks have undergone silicification or give a reduced value if the rocks have had their silica leached out.

Table 5. Whole rock chemical analyses of two rock samples from the AR-78-1 diamond drill hole, Beauchastel 2-77 property, Arntfield, Quebec.

Parameter	Depth in drill hole: 121 feet	Depth in drill hole: 771 feet
Major Element Oxides (wt. %)		
SiO_2	66.60	64.00
Al_2O_3	12.50	11.05
Fe_2O_3	2.25	3.15
FeO	2.90	2.45
MgO	1.13	0.85
CaO	2.60	4.65
Na_2O	6.50	3.30
K_2O	0.13	2.10
TiO_2	1.19	0.95
P_2O_5	0.18	0.14
CO_2	1.50	4.46
MnO	0.11	0.10
H_2O	1.40	2.20
S	0.03	0.02
Total	99.02	99.42
Minor Elements		
Au (oz./ton)	0.006	0.002
Ag (oz./ton)	0.018	0.002
Cu (ppm)	71	73
Zn (ppm)	70	37
Pb (ppm)	7	2
Ni (ppm)	Tr	Tr
Ti (ppm)	3	3
Ba (ppm)	28	220
As (ppm)	0.2	1
Classification when logged by Dr. W. A. Hogg	Trachyte	Syenite-Trachyte
Classification by this author in present project	Andesite	Andesite

Table 6. Average SiO_2 (silica) content in a general rock classification system.

ACID $SiO_2 > 66$ percent

Example: granites (average 72 percent); granodiorites (67 percent)

INTERMEDIATE SiO_2 52 to 66 percent

Example: andesites (average 57 percent); trachytes (62 percent)

BASIC SiO_2 45 to 52 percent

Example: basalts (average 48 to 51 percent

ULTRABASIC $SiO_2 < 45$ percent

Example: peridotites (average 41 to 42 percent); nephelinites (40 percent)

(Carmichael et al., 1974)

Table 7. Average composition (oxides, wt %) of five classes of volcanic rocks.*

Constituent	Rhyolite	Dacite	Andesite	Basalt	Phonolite
SiO_2	73.66	63.58	54.20	50.83	56.90
TiO_2	0.22	0.64	1.31	2.03	0.59
Al_2O_3	13.45	16.67	17.17	14.07	20.17
Fe_2O_3	1.25	2.24	3.48	2.88	2.26
FeO	0.75	3.00	5.49	9.05	1.85
MnO	0.03	0.11	0.15	0.18	0.19
MgO	0.32	2.12	4.36	6.34	0.58
CaO	1.13	5.53	7.92	10.42	1.88
Na_2O	2.99	3.98	3.67	2.23	8.72
K_2O	5.35	1.40	1.11	0.82	5.42
P_2O_5	0.07	0.17	0.28	0.23	0.17
H_2O	0.78	0.56	0.86	0.91	0.96
Total	100.0	100.0	100.0	100.0	100.0**

*From Nockolds (1954).

**Total includes 0.23% Cl and 0.13% SO_3.

(Carmichael _et al_., 1974)

Andesite Fragmentals

The second most common major volcanic rock division encountered in the study area is mapped under the heading of andesite fragmentals. This category was defined and adopted to include a wide range of fragmental rocks based more on composition than inferring depositional origin. The category of andesite fragmentals is defined to include all rocks containing major proportions of fragments of any size or composition in an andesitic matrix. To divide this category further to imply any sort of genetic mechanism would require a large amount of time and effort; thus, for the purposes of this mapping project, no attempt was made to subdivide them.

These andesite fragmentals (V_6f (type of fragments)) in the field generally have angular to subrounded fragments of rhyolite (V_2) or chert (Ch). The size of these fragments is variable from millimeters to several centimeters. The density of fragments in each flow unit is also variable from being very tightly packed autobreccia to widely spaced in flow breccias. Fragmental contacts with the matrix are generally fairly sharp, although on occasion the fragment margins appear to be heat altered, or conversely the matrix contact with the fragment is chilled.

These fragmental units were quite useful because they sometimes exhibited striking flow structures (Plate 5). These flow breccia units gave an indication of relative direction of flow from which one could infer at least a general strike direction.

Plate 5. Andesite flow breccia ($V_6f(V_2)$) with sub-angular rhyolitic fragments. Flow direction parallel to long axis of photograph. Outcrop is located on Beauchastel 2-77 property, Line 4 West, 14 South. Hammer handle is approximately 40 cm long.

Rhyolites

The rhyolite (siliceous) flow units as a general rule seem to alternate fairly regularly with the flow units with andesitic compositions though they are more common in the northern half of the study area. The outcrop morphologies also assisted in the field mapping in a similar way to the andesitic outcrops. The rhyolites and other more siliceous rocks are much harder and more brittle than the andesites, therefore the outcrops appeared to be much more shattered and fractured (Plate 6). Though converse to andesites, the hardness of these rocks contributed major criteria to the outcrop identification. The rocks were categorized as rhyolites if the blade of a good quality knife would not scratch them, using the assumption that the hardness could be used as a general indication of relative silica content.

The rhyolites (V_2) in the study area were, as a rule, very hard and tended to shatter in a brittle nature when struck with a hammer. The colors of the various rhyolite lithologies varied greatly from light green to black. All rhyolites are very fine-grained. Microscopically most of the rhyolites contain large proportions of fine-grained granular quartz, larger grains of orthoclase feldspar, some plagioclase feldspar, epidote, and chlorite. The chlorite appears to be the alteration products of ferromagnesian minerals, but it occurs also in the feldspar. Few opaque minerals seem to be present, although in some units considerable quantities of pyrite and magnetite were observed.

Plate 6. Shattered rhyolite outcrop (V_2). Site on line 8 West just north of the road crossing the Beauchastel 2-77 property from east to west.

The rhyolitic units on the property are almost as variable as the andesitic units with regard to lithology. Most lithological variations within flows could not be traced with any confidence over great distances. Only one major rhyolite lithological variation could be traced across the study area and accurately identified. The "rhyolite "marker" unit" is located in the north-central section of Beauchastel 2-77 near the north tie line. This flow is mainly massive in nature but becomes somewhat brecciated (in large fragments) towards the west of the property. In hand specimen, the rocks are light green in color with distinctive, small feldspar laths (0.1 mm) and small spherical, black quartz-eyes (1-2 mm) ($V_2$0Q).

Microscopically the rock is very fine-grained and is similar in composition to many of the rhyolites in the study area with quartz, feldspar, and chlorite as the major components. The spherical, black quartz-eyes take two forms, as individual quartz crystals or as tightly packed aggregates of 5 or 6 crystals. Alteration to chlorite or epidote often appears along crystal boundaries in the quartz crystal aggregates. Large feldspar crystals appear to be primarily orthoclase.

Rhyolite Fragmentals

The rhyolite fragmental category was defined in a manner similar to the andesite fragmental category. The basic assumption regarding size of fragments, shape, and genetic implication of origin are identical to those outlined in the description of the andesite fragmentals. The category of rhyolite fragmental was defined during mapping to include all rocks with major proportions of fragments of any size or composition in a rhyolitic or siliceous matrix.

The rhyolite fragmentals (V_2f (type of fragments)) tend to be quite variable in their lithologies relating to factors such as grain size, size and shape of fragments, composition of fragments, and fragment density. In general, these rocks have a "typical" rhyolitic matrix with a primarily cherty or rhyolitic fragments composition. The rocks are usually totally fine-grained with sharp fragment-matrix contacts.

The rhyolite fragmental flows were used in a manner similar to the andesite fragmentals to indicate the general strike direction of the flows in the volcanic pile.

Post-Keewatin Series - Pre-Cobalt Group Intrusives

Several types of intrusive rocks are present in the Beauchastel study area. The exact age of the emplacement of the intrusives is a matter of some controversy and seems to change from area to area in the region (Gunning and Ambrose, 1940; Malouf, 1941; and Wilson, 1962). Field relations indicate that some of the intrusives were possibly emplaced contemporaneously, but more likely the major proportion were emplaced post-deposition of the volcanics of the Blake River Group of the Keewatin Series. The intrusive bodies of compositions similar to those in the study area are not observed to penetrate the later deposited sediments of the Proterozoic Age Cobalt Group. Obviously the field relations indicate a probable wide period of intrusive emplacement between the early and late Precambrian. No conclusive field relations (i.e., cross-cutting relationships) relating timing the emplacement of the different intrusive phases were observed on the study area because the intrusive rock exposures are isolated.

The relative ages of the intrusive rocks are not known. As with the descriptions of the rocks of the Blake River Group, they will be described in order of decreasing relative abundance.

Diorite

Several dioritic intrusives are exposed in the study area. Two dioritic bodies have been mapped in the southern half of the study area (Beauchastel 4-78 and Beauchastel 1-78 properties). These bodies are located just to the south of Lake King of the North and Lake Mud. The major diorite bodies in this section seem to have a pluton-like appearance with somewhat sill-like concordant pods along the edges.

The northern half of the study area (Beauchastel 2-77 property) has four areas of major diorite exposure. The major "plutonic" body is located in the extreme north-west corner of the property. The second "plutonic" or sill-like body is located on the main road to the Arntfield Gold Mine south-east of the major tailings pond. An interpreted diorite dike with a general east-west trend is located in the north-west corner of the property. No surficial outcrop as evidence for the diorite was found during this mapping program but its approximate location is interpreted using old diamond drill logs, results of magnetic and induced polarization surveys, and topographic observations. Just to the north-east of this interpreted dike, a single outcrop of diorite was located. From this outcrop and the results of the magnetic survey, the presence of a sill-like body was interpreted (Figure 8 in back pocket).

The diorite outcrops seem to have a knoll-like rounded type of morphology. There does not appear to be any major jointing trends between the diorite outcrops; however, on individual outcrops the jointing is blocky in nature. No shearing is manifest in the diorite in the vicinities of the shear zones (structure will be discussed later), indicating the shearing and associated tectonic activity occurred either synchronously or before the emplacement.

In hand sample the diorites (2D) are massive and grey-green in color. The grain size tends to be variable from medium coarse-grained in the center of the plutonic bodies becoming marginally finer grained near the edges. No contacts with the country rock were located, therefore it is not known if the edges exhibit chilling as would be expected if the rocks intruded a cooled volcanic pile.

A typical diorite in thin section contains major amounts of large hornblende crystals (2.0 mm) to a great extent altered or altering to fine-grained (micrographic texture, 0.1 mm) chlorite, small laths of plagioclase feldspar, and scattered grains of magnetite and pyrite. There is little or no quartz in the rock. The variability in the shade of green exhibited in hand sample can be attributed to the degree of alteration to chlorite.

Quartz-Feldspar Porphyry

One large, fresh, sill-like, concordant to sub-concordant body of quartz-feldspar porphyry (1R) was mapped just north of the road on Line 8W on the Beauchastel 2-77 property. This sill-like intrusive is exposed for an area about 11 m (35 feet) wide and 61 m (200 feet) in length. Sharp contacts are visible both top and bottom of the proposed sill across much of the exposure.

A second exposure of the intrusive porphyry in a more rounded, less-well-defined body is located just east of the large tailings pond on the Beauchastel 2-77 property.

In hand specimen, the intrusive is somewhat pinkish in color. Distinctive, white-weathering, 0.60 cm, feldspar porphyroblasts are visible in a fine-grained matrix. No macroscopic preferred orientation of the feldspar porphyroblasts is apparent.

Under the microscope, the large, well-formed, complexly twined phenocrysts can be identified as plagioclase. The feldspar phenocrysts show considerable alteration to sericite, giving the crystals a finely poikilitic texture. A large proportion of the matrix of the porphyry consists of fine-grained quartz, feldspar, and sericite. Approximately 15 percent of the rock consists of small, poorly formed, laths or aggregates of hornblende. The hornblende is relatively fresh and only locally altered to chlorite. Opaque minerals such as pyrite and magnetite are present as disseminated grains scattered throughout the sample section.

Syenite Porphyry

One major, sub-concordant, pink syenite porphyry dyke was mapped on the Beauchastel 2-77 property. The dyke has an approximate northeast-wouthwest orientation and is locate near the north tie line on Line 4 east. The dyke has an apparent thickness of approximately 15 m (45 feet). True thickness is not known due to the fact that no dip measurement could be obtained.

Previous workers in this region, such as S. E. Malouf, noted the occurrence of several other intrusive bodies of similar syenitic character. They noted that the syenite is the youngest intrusive phase. However, clear cross-cutting relationships are not observed in this study.

In surficial exposure this dyke can be easily mapped due to its rather anomalous pink coloration and strongly porphyritic texture. The contacts of this dyke with the surrounding country rock (acid volcanics) are sharp although ragged. The ragged appearance of the contacts may be accounted for by the dyke stoping and incorporating pieces of the heavily fractured country rocks during its emplacement. Occasional angular xenoliths 5-30 cm in diameter can be seen in the outcropping dyke.

In thin section, the syenite porphyry is made up of approximately 40-50 percent coarse-grained (≈6 mm), subrounded, heavily altered feldspar phenocrysts. Most of the large phenocrysts are plagioclase feldspar though some orthoclase feldspar is present. The plagioclase feldspar is strongly sericitized. The matrix of the porphyry is a fine-grained aggregate of quartz, feldspar, sericite, chlorite, and opaque minerals such as pyrite and magnetite.

Cobalt Group

The sedimentary rocks of the Proterozoic (Late Precambrian) Age Cobalt Group are exposed on the eastern edge of the Beauchastel 1-78 property in the southern half of the study area. The rocks of this group form the major, east-west-trending topographic feature, the Kekeko Hills (Wilson, 1962).

The clastic sedimentary rocks of the group in the study area unconformably overlie both the intrusive rocks and the volcanic series of the Blake River Group (Wilson, 1962). Measurements taken of the bedding on the outcrops on the eastern shore of Lake Renaud and east of the highway indicate the rocks have a general east to northeast strike and a gentle dip (10-15^{o}) to the south or southeast. No direct field relationships between the sediments and the underlying volcanics and intrusives were observed since the outcrop exposures were separated by a great distance. However, a major unconformity can be inferred.

The rocks of the Cobalt Group were not examined in detail during this mapping program because they are considered younger than the Blake River Group rocks which host the gold mineralization and thus of lower priority.

The grey-green colored, clastic sedimentary rocks outcropping on the lakeshore and in the road cuts can be classified as greywackes. These coarse-to-fine-grained, poorly sorted greywackes exhibit massive and graded bedding but few other large-scale bedding structures. The cementation of the greywacke is very strong, because the rock is generally very hard and competent with large fragments which break through rather than around as one would expect to find in a poorly cemented rock.

Thin section analysis shows the greywackes have variable grain size from a maximum of approximately 2.0 mm to a minimum of 0.01 mm. Most of the clasts are angular to sub-angular with quite sharp boundaries. The rocks appear to have undergone little alterations, except a minor amount of chloritization. The composition of the monomineralic clasts are primarily quartz, plagioclase and orthoclase feldspar, and occasionally hypersthene. Some scattered opaque mineral grains are present, such as pyrite cubes and magnetite. Many larger, more rounded fragments of intrusive rocks or valcanics are present, many of these clasts exhibit alteration characteristics similar to those noted in the previous descriptions. The matrix and cement of the greywacke is extremely fine-grained and determination of its exact composition is difficult; however, it appears to be a mixture of ? sand grains and lithic fragments.

Cenozoic Age Deposits

The study area has undergone a period of glaciation. This period of glaciation left a thick mantle of pleistocene mixed boulder till over much of the area. In the northern extremities of the study area there are gravel deposits of glacio-fluvial origin. These glacio-fluvial deposits consist of alternating bands of cross-bedded clastic material. The material in the deposits is well rounded or sub-angular and ranges in grain size from sand to coarse gravel.

Many of the large outcrop exposures on the three properties exhibit a smooth, well rounded, knoll-like morphology (roches moutonnées). This morphology, at least in part, was developed by the passage of the glacial ice scraping clean, polishing and plucking the exposed bedrock. On several outcrops well-developed striae and grooves of glacial origin were observed and measured (Figure 9). The glacial striae measured ranged from 003° to 011° with an average direction of 008°. Regionally, the glacial movements appear to have been from the north.

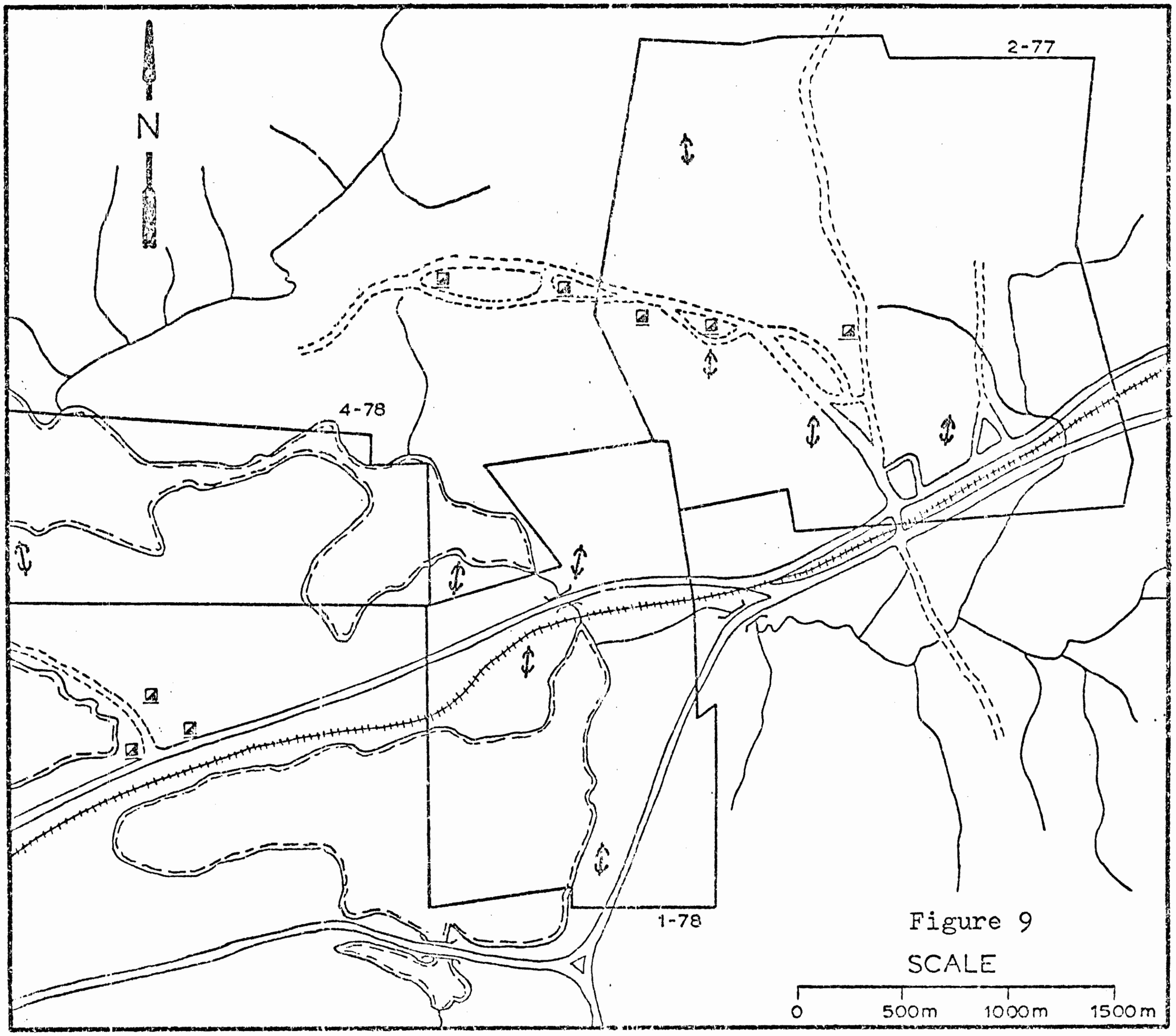
METAMORPHISM

The Arntfield study area can be, within limits, considered to be typical as compared to many other areas of the Abitibi belt with respect to the degree of metamorphism the rocks have undergone (Malouf, 1941; Wilson, 1962; and Douglas, 1970). The major metamorphic influence on the rocks in the study area has been regional in nature. Only extremely rarely, in the contact aureoles of some of the intrusive bodies in the area,

Figure 9. Map of major glacial striae measured on the Beauchastel study area, Arntfield, Quebec.

Explanation:

Glacial striation (direction unknown)


N
2-77
4-78
1-78
Figure 9
SCALE
0
500m
1000m
1500m

From general observations made of the rocks in hand sample and selected thin sections the rocks have undergone only a relatively low grade of regional metamorphism, quite probably only to greenschist facies (Barrovian Chlorite Zone). The main evidence leading to this conclusion is the presence of secondary minerals such as sericite, chlorite, some plagioclase and carbonate, in large quantities. These secondary minerals are considered to be indicative of greenschist facies metamorphism (Jolly, 1974; and Miyashiro, 1973). Malouf in 1941, after a considerably more detailed investigation of a suite of rocks from the area also arrived at a similar conclusion.

The dynamically metamorphosed rocks (V_6X or Z) associated with the shear zones in the study area are still only metamorphosed to greenschist facies. The major secondary mineral components are similar to those in the unsheared rocks except that the platy minerals such as chlorite and sericite appear to have been aligned to form foliation planes. These rocks from the most intensely sheared section of the shear zone could be classified as a well-developed phyllite or poorly-developed schist. The rock in hand sample appears to have a definite foliation, and the surfaces of the foliation have a shiny lustre, but no mica flakes are visible as would be expected in a well-developed schist (Moorhouse, 1959). In thin section some of the larger crystals of pyrite, quartz and feldspar ? seem to have been ground and fractured by the movements along the fault zone.

The shear zones have been a channel for the movement of hydrothermal solutions. The evidence supporting this theory is the presence of numerous quartz-carbonate veins between the foliation planes. In certain areas along the shear zones, primarily where they dilate, the quartz-carbonate veins of hydrothermal origin carry economic gold mineralization (Malouf, 1941).

CHAPTER 4

STRUCTURAL GEOLOGY OF THE STUDY AREA

The study area appears to be traversed by sections of at least two major, regional fault systems. These two fault systems do not however manifest themselves as individual straight, discrete fractures as one might expect to see in brittle rocks, but instead appear as broad sinuous shear zones. It has been recognized that the regional shear zones in this part of the Abitibi Greenstone Belt contain and control gold ore concentrations. Major gold deposits have been discovered and exploited in areas where major dilation occurs along the shear zones, for example the maximum ore concentrations for these structurally controlled ore zones have been found where the shear zones change both strike and dip (Boyle, 1979). During the past 60 years or so, many hundreds of feet of diamond drilling and surficial trenching have been done by both individuals and companies endeavoring to locate and analyse the behavior of these shear zones with hopes of finding economic gold ore concentrations.

There are two major shear zones surficially exposed in the Beauchastel study area. It is in these shear zones that the gold mines operated. Diamond drilling, surficial trenching, mapping and underground mining in the past has, at least in general terms, outlined the location and attitudes of the shear zones. Figure 10 shows the general location of the major fault (shear) structures in the vicinity of the study area.

Figure 10. General location plan of major fault structures in the Beauchastel study area, Arntfield, Quebec.

Explanation:

Faults observed in surface exposure

Faults observed in drill holes

Interpreted regional faults

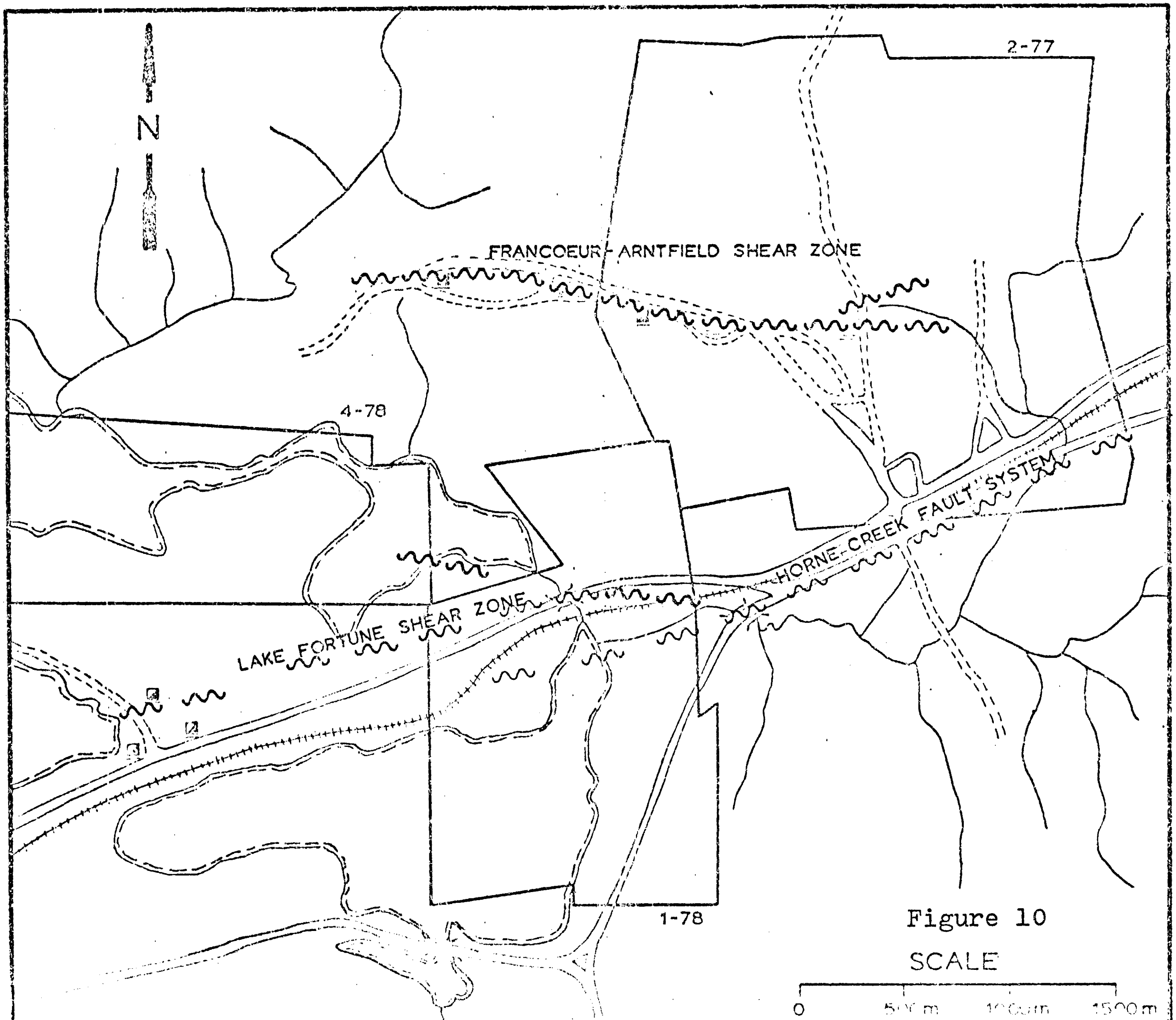

N
FRANCOEUR-ARNTFIELD SHEAR ZONE
2-77
4-78
LAKE FORTUNE SHEAR ZONE
HORNE CREEK FAULT SYSTEM
1-78
SCALE
0

Figure 10

FRANCOEUR-ARNTFIELD SHEAR ZONE

The most important structure examined is the Francoeur-Arntfield shear zone which represents a major ore control for gold mineralization in the area and the focus of interest that prompted this study. The shear zone hosts no less than seven separate mine shafts, with three of these shafts on the Beauchastel 2-77 property.

The shear zone trends in a gentle arc and lies approximately east-west across the middle of the Beauchastel 2-77 property. Just to the north of the Arntfield Number 3 shaft two distinct shear trends can be measured, indicating that the shear bifurcates, or alternatively it is crossed by another north-east trending fault. The branch seems to be of approximately the same intensity as the major shear and is therefore believed by the author to represent a bifurcation of the major shear.

The Francoeur-Arntfield shear zone tends to have an extremely variable dip and strike. The western end of the shear (near the Arntfield Number 1 shaft) dips between 51° and 81° to the north. The central section of the shear (near the Arntfield Number 3 shaft) dips between 68° and 80° to the north. The extreme eastern end of the exposed shear is somewhat anomalous in that it dips approximately 52° to the south. These present surficial observations as well as observations made underground lead to the belief that the shear zone follows the lava flow contacts in a sub-concordant manner (Malouf, 1941). This irregularity in the shear zone can be likened to a hanging cloth sheet, and appears to be consistent with a strike slip displacement for the structure (see below).

The surficial exposures of the Francoeur-Arntfield shear zone are very distinctive in appearance. The rocks in the center of the shear zone are very intensely deformed but the effects of the deformation die out as one moves away from the axis of the shear. The major effects of the shearing are only distinctly discernible at a maximum distance of 60 to 75 m (200-500 feet) away from the axis of the shear.

LAKE FORTUNE SHEAR ZONE

The Lake Fortune shear zone is the second ore hosting shear zone to cross the study area. This shear zone is again gently curved and east-west trending. It crosses the northern part of the Beauchastel 1-78 property to pass south of the Beauchastel 4-78 property (Figure 10).

The Lake Fortune shear zone is believed to be related to the regional Horne Creek fault system (Ambrose and Ferguson, 1945). These two fault zones have very similar trends, however their characteristics are somewhat different. The Horne Creek fault is not exposed on the surface in the study area, however, there is some faulting noted in a diamond drill hole in line with the fault trend and believed to possibly be the extension.

The Lake Fortune shear zone is exposed in several limited outcrops across the Beauchastel 1-78 property. It appears as a wide, strongly schistose zone with a high degree of carbonatization. Surficial exposures indicate a shearing with a general trend varying from 90^{o}Az to 120^{o}Az. The dip direction and the extent of the influence of the shear zone could not be readily determined from the surficial exposures.

The Lake Fortune shear zone may bifurcate with a branch trending slightly northwest to the shore of Lake Mud. The character of the shear exposed on the lakeshore appears to be very similar in character to the Lake Fortune shear zone, however the relationships of the shear exposures is not definitely known.

CHAPTER 5

SHEAR ZONE INVESTIGATIONS

INTRODUCTION

The shear zones of the Abitibi Region are important mineralization controls in the gold deposits of the area. Keeping the importance of these shear zones in mind, it is logical to analyse the available structural data to discover as much as possible of the genesis of the Francoeur-Arntfield shear zone. It was felt that the joint and related planar structures in the rocks in the study area might possibly be related to the formation of the shear zones.

As an integral part of the mapping program, major planar structural features were measured and noted on each outcrop. The planar features normally were in the form of joint sets and minor shears; in the major shear zones these directions were also noted. The joints were defined for this investigation as sets of parallel, sharp fractures with the distance between the fractures on the order of several centimeters. Minor shears were similar to the joint sets except the inter-fracture distance was less than 2 cm, for ease of nomenclature minor shears will be considered as joints also.

In order to standardize the measurements of the planar structures and make them statistically valid, certain procedures were followed and assumptions made. Each outcrop when mapped was examined carefully to discern individual sets of joints or discrete shears. One member of each set (joint or shear) was measured and assumed to show an average attitude for the feature. Repeating the procedure on each outcrop examined in the entire study area it can be assumed that statistically the measurements made indicate the orientation of joint set concentrations and give a general indication of the relative magnitudes of these concentrations.

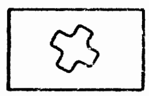
The attitudes of the planar structures measured in the field were plotted along with the other data on the preliminary geology map. Upon visual inspection there were no major trends to be noted except the shearing of the rocks in the identified shear zones. It was felt that another analytical method should be used to test the data for trends.

The planar structures were considered in terms of four domains determined by the Francoeur-Arntfield shear zone, since this is the major structural feature of interest in the study area and it is also believed to be the source of the strongest structural effects observed. The four domains were chosen to be (a) north of the Francoeur-Arntfield shear zone, (b) within the Francoeur-Arntfield shear zone, (c) south of the Francoeur-Arntfield shear zone, and finally (d) the entire study area (Figure 11).

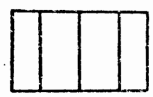
The structural data for each domain was analyzed and plotted using a standard stereographic projection program on the Dalhousie University computer. The program yielded contoured stereographic plots of poles to joint surfaces on a Schmidt Method lower hemisphere equal area projection.

Figure 11. General location plan of domains used in the structural analyses.

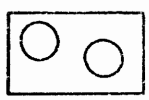
Explanation:



Domain (a)
North of the Francoeur-Arntfield shear zone



Domain (b)
Within the Francoeur-Arntfield shear zone



Domain (c)
South of the Francoeur-Arntfield shear zone

Domain (d)
Includes the above three domains

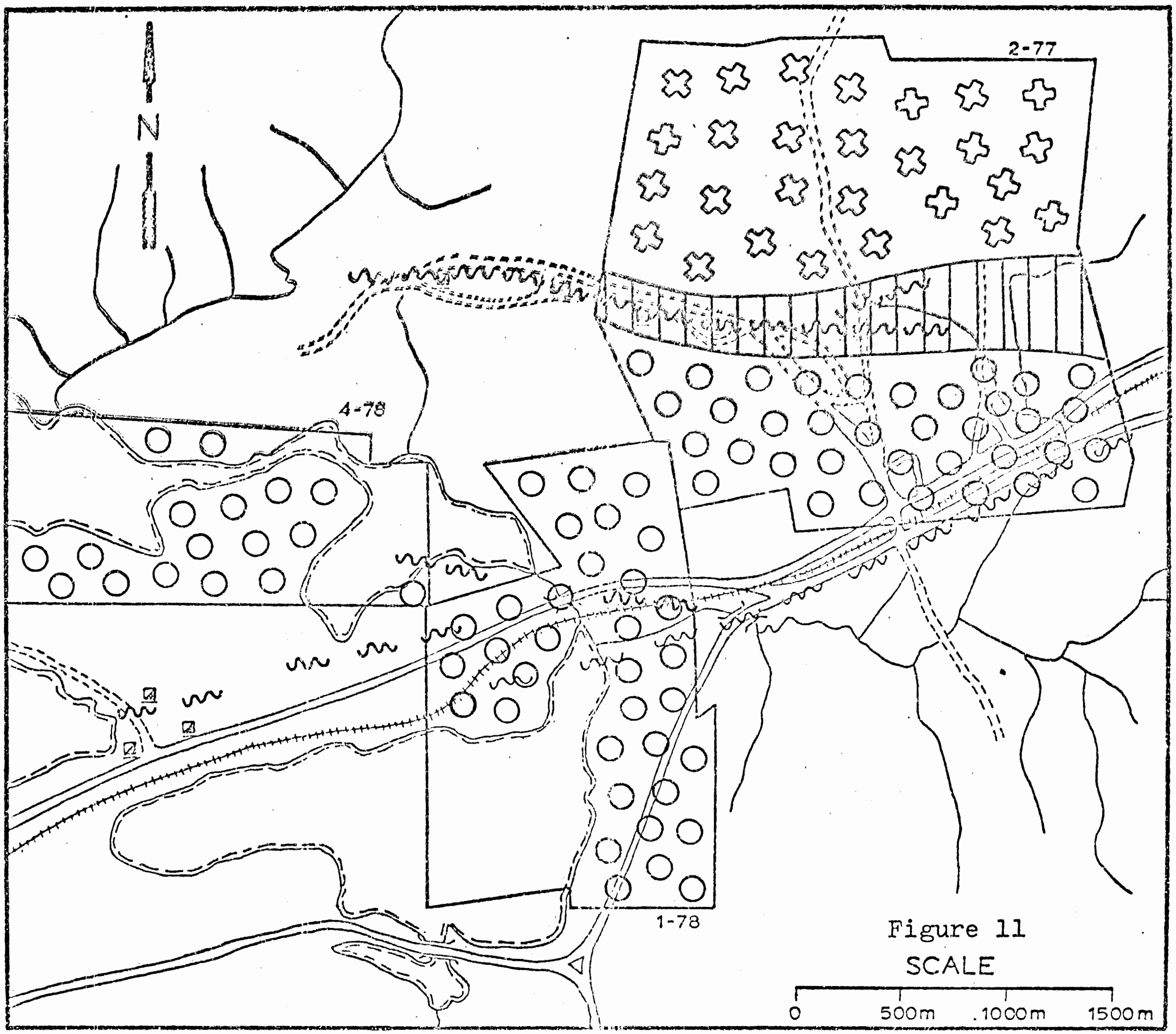


Figure 11

DATA AND OBSERVATIONS

Domain (a): North of the Francoeur-Arntfield Shear Zone

A total of 237 joints were measured in this domain. The domain was defined as the area on the Beauchastel 2-77 property north of any visible shearing effect on the rocks in the Francoeur-Arntfield shear zone.

The contoured stereographic projection plot of poles to joint surfaces is shown in Figure 12. From this diagram, there seem to be two well-defined "major" concentrations of poles and one "minor" (lower magnitude) pole concentration. The orientation of these pole concentrations, as well as the β representation of the plot are interpreted as follows:

"Major" Pole Orientations	Joint Plane Orientations	
(1) $018^{\circ}/22^{\circ}$	$108^{\circ}/68^{\circ}$S	
(2) $308^{\circ}/05^{\circ}$	$038^{\circ}/85^{\circ}$SE	
"Minor" Pole Orientation		$024^{\circ}/85^{\circ}$SE
(3) $279^{\circ}/05^{\circ}$	$009^{\circ}/85^{\circ}$	

Note: Concentrations 2 and 3 are treated as one.

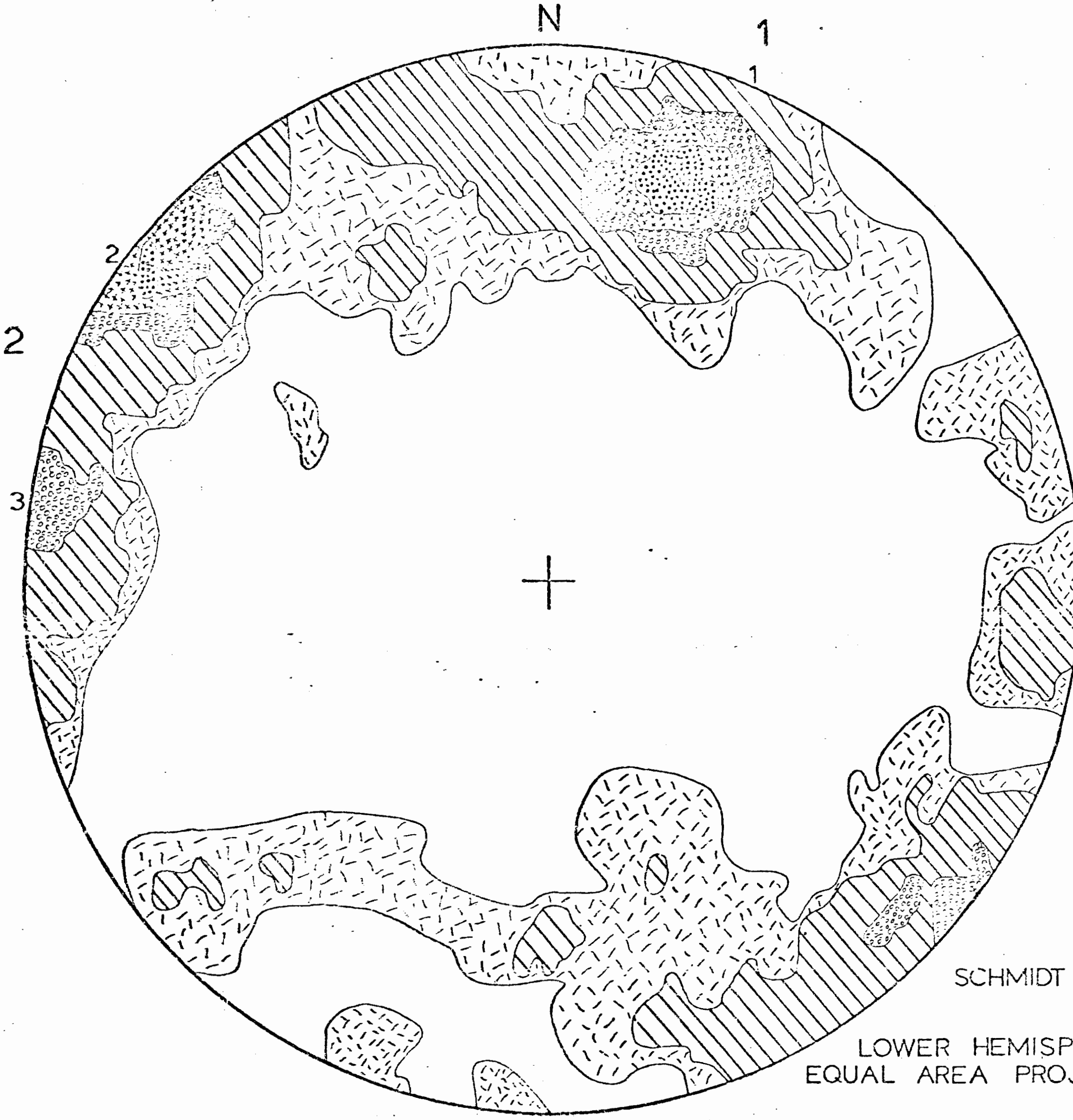
The stereographic projections of the joint planes represented by the pole concentrations are shown in Figure 13.

Domain (b): Within the Francoeur-Arntfield Shear Zone

A total of 66 joints were measured in this domain. The domain was defined as the area on the Beauchastel 2-77 property within which the strong effects of the shear zone were manifested in the rocks.

Figure 12. Contoured stereographic plot of poles to joint surfaces: Domain (a).

CONTOURED STEREOGRAPHIC PLOT OF POLES TO JOINT SURFACES
237 POLES OF JOINTS NORTH OF THE FRANCOEUR-ARNTFIELD SHEAR ZONE



SCHMIDT METHOD

LOWER HEMISPHERE
EQUAL AREA PROJECTION

DENSITY CONTOURS:

- 0-1 %
- 1-2 %
- 2-4 %
- 4-6 %
- 6-8 %
- 8-MAX 9.7 %

Figure 12

Figure 13. Stereographic projection of traces of joint planes represented by the pole concentrations on the complementary representation for Domain (a), north of the Francoeur-Arntfield shear zone.

(Schmidt method, lower hemisphere equal area projection)

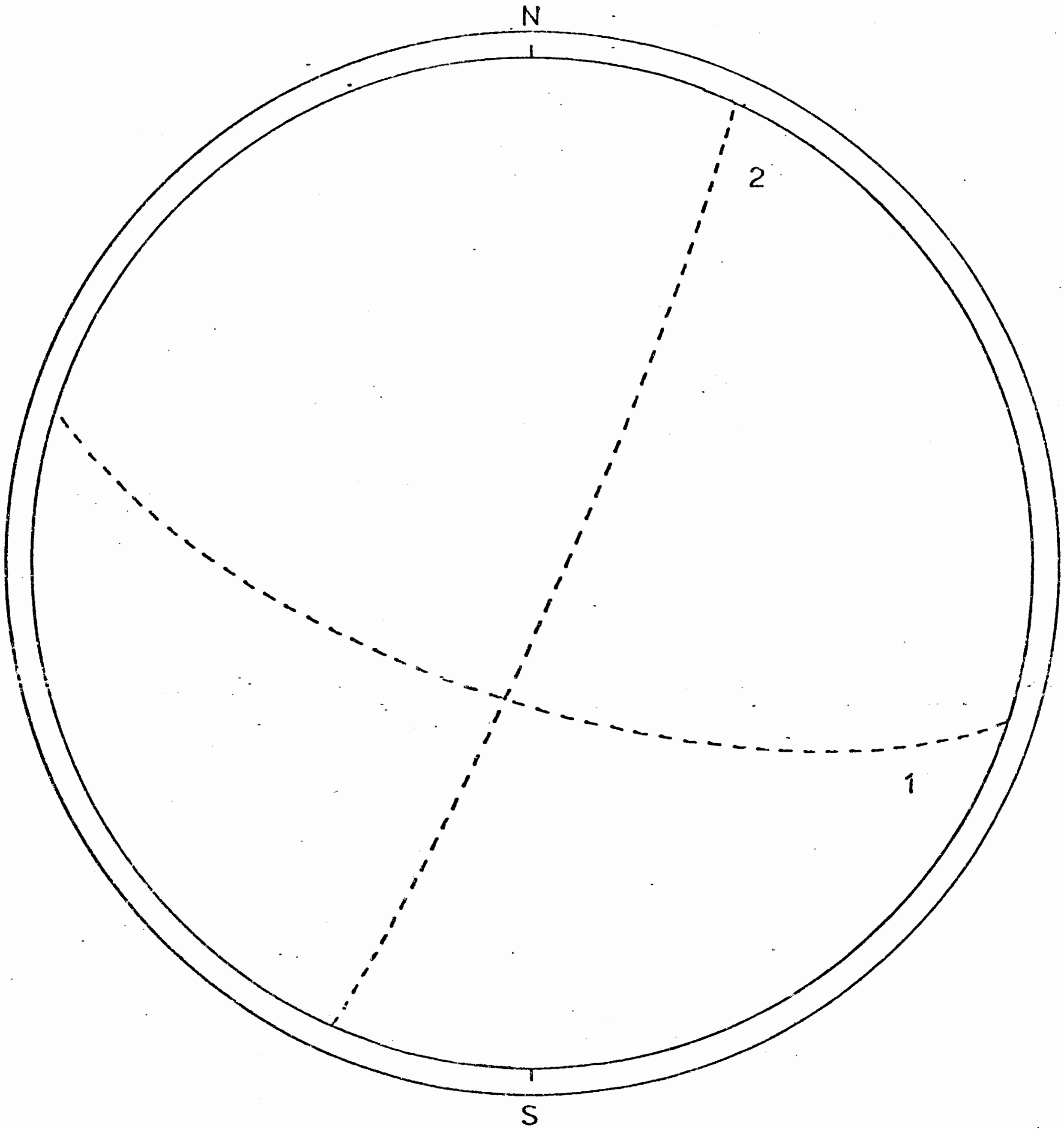


Figure 13

The contoured stereographic projection plot of poles to joint surfaces is shown in Figure 14. There are a total of seven pole concentrations visible in the diagram. The pole concentrations do not as a rule seem to be as compact and well defined as those noted in Domain (a). The reasons for this scatter are possibly attributable to the low number of measurements taken and the very complex infrastructure of the shear zone itself.

The pole concentrations have been divided on the basis of the magnitude of the concentration and the amount of scatter. The orientation of the pole concentration and the joint plane representations of the concentrations listed in decreasing order of magnitude are interpreted as follows:

"Major" Pole Orientation	Joint Plane Orientation
(1) $006^{\circ}/00^{\circ}$	$096^{\circ}/90^{\circ}$
"Minor" Pole Orientation	
(2) $332^{\circ}/10^{\circ}$	$062^{\circ}/80^{\circ}$S
"Sub Minor" Pole Orientation	
(3) $290^{\circ}/30^{\circ}$	$020^{\circ}/60^{\circ}$E

The stereographic projections of the joint planes represented by the pole concentrations are shown in Figure 15.

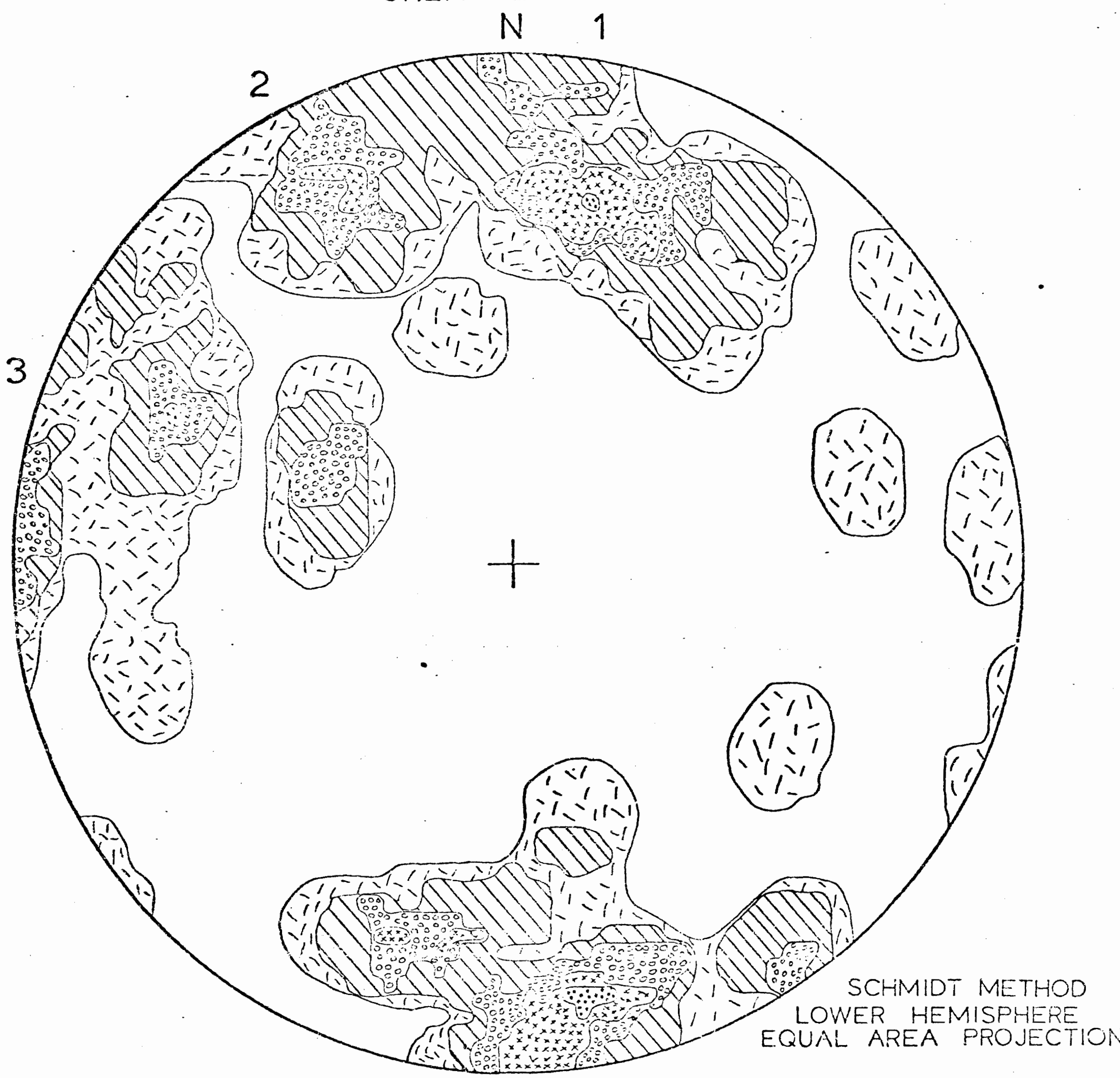
Domain (c): South of the Francoeur-Arntfield Shear Zone

A total of 102 joints were measured in this domain. The domain is defined as the Beauchastel 1-78 property, Beauchastel 4-78 property and the area of the Beauchastel 2-77 property south of any major visible shearing effects on the rocks in the Francoeur-Arntfield shear zone.

Figure 14. Contoured stereographic plot of poles to joint surfaces: Domain (b).

CONTOURED STEREOGRAPHIC PLOT OF POLES TO JOINT SURFACES.

66 POLES OF JOINTS MEASURED IN THE FRANCOEUR – ARNTFIELD SHEAR ZONE



DENSITY CONTOURS:

- 0-1 %
- 1-2 %
- 2-4 %
- 4-6 %
- 6-8 %
- 8-MAX 9.1 %

Figure 14

Figure 15. Stereographic projection of traces of joint planes represented by the pole concentrations on the complimentary representation for Domain (b), within the Francoeur-Arntfield shear zone.

(Schmidt method, lower hemisphere equal area projection)

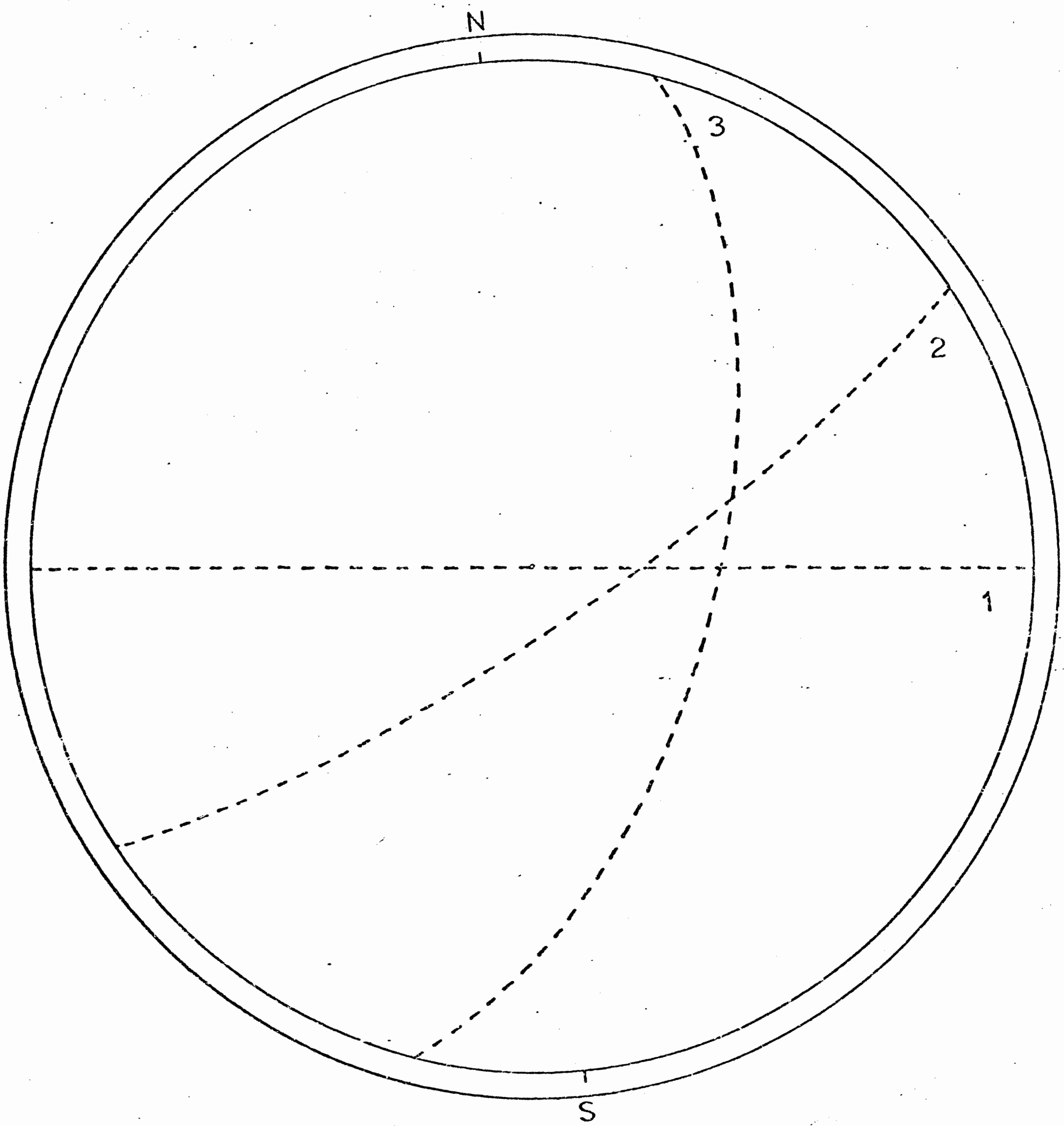


Figure 15

The contoured stereographic projection plot of poles to joint surfaces is shown in Figure 16. A total of four pole concentrations are clearly visible in the diagram. The pole concentrations generally seem to be well-defined.

The orientation of the pole concentration and the joint planes representation of the pole concentrations are interpreted as follows:

"Major" Pole Orientations	Joint Plane Orientations
(1) $176^{\circ}/03^{\circ}$	$086^{\circ}/87^{\circ}$N
(2) $038^{\circ}/08^{\circ}$	$128^{\circ}/82^{\circ}$SW
(3) $134^{\circ}/12^{\circ}$	$044^{\circ}/78^{\circ}$NW
"Minor" Pole Orientations	
(4) $089^{\circ}/44^{\circ}$	$079^{\circ}/46^{\circ}$W

The stereographic projections of the joint planes represented by the pole concentrations is shown in Figure 17.

Domain (d): Entire Study Area

A total of 405 joints was measured during the course of the mapping investigation. All measurements are included in this analysis. The domain is defined to include all three properties in the study area.

The contoured stereographic projection plot of the poles to joint surfaces is shown in Figure 18. A total of three well-defined although moderately scattered pole concentrations are visible in the diagram.

Figure 16. Contoured stereographic plot of poles to joint surfaces: Domain (c).

CONTOURED STEREOGRAPHIC PLOT OF POLES TO JOINT SURFACES.

102 POLES OF JOINTS SOUTH OF THE FRANCOEUR—ARNTFIELD SHEAR ZONE

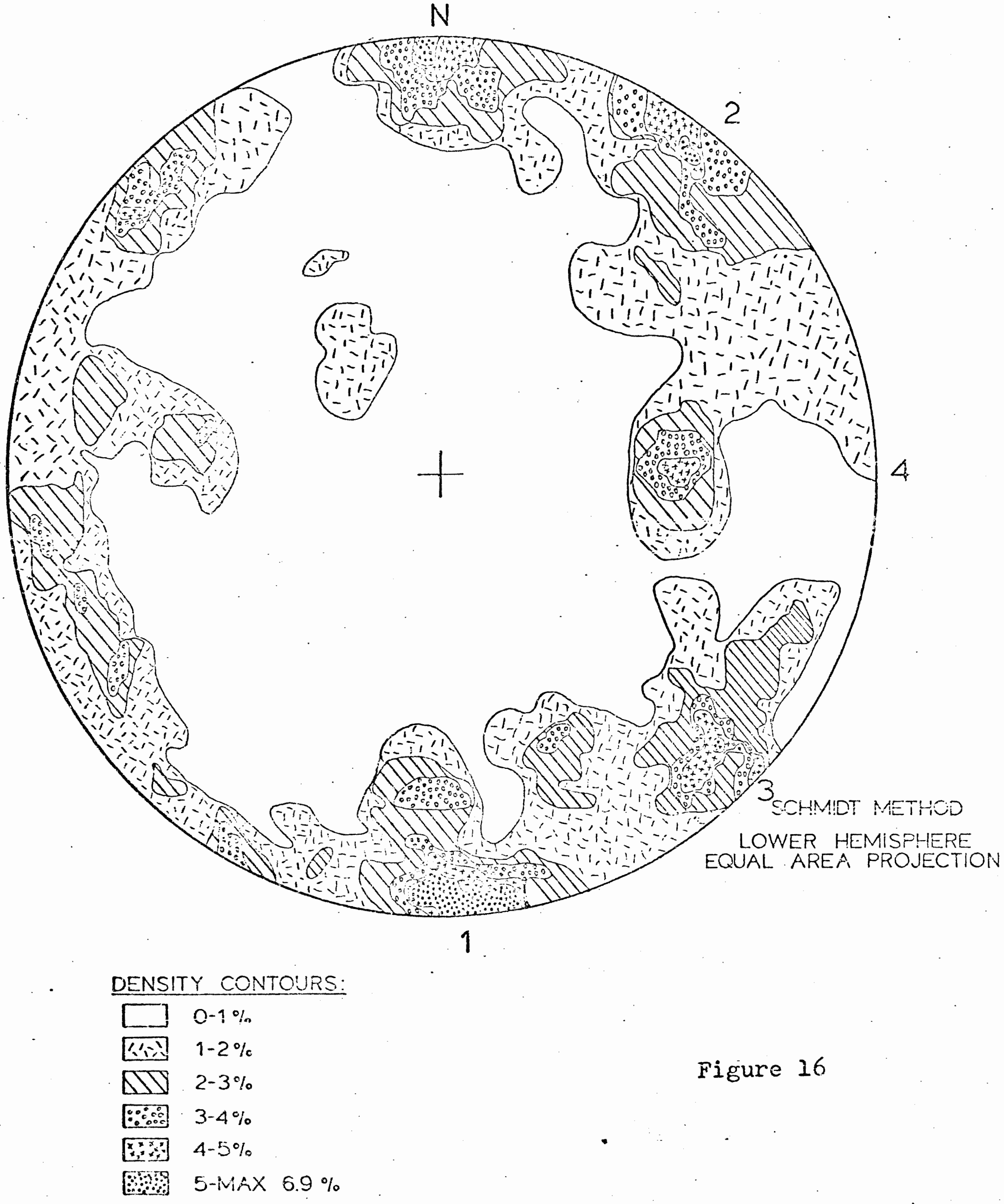


Figure 16

Figure 17. Stereographic projection of traces of joint planes represented by the pole concentrations on the complimentary representation for Domain (c), south of the Francoeur-Arntfield shear zone.

(Schmidt method, lower hemisphere equal area projection)

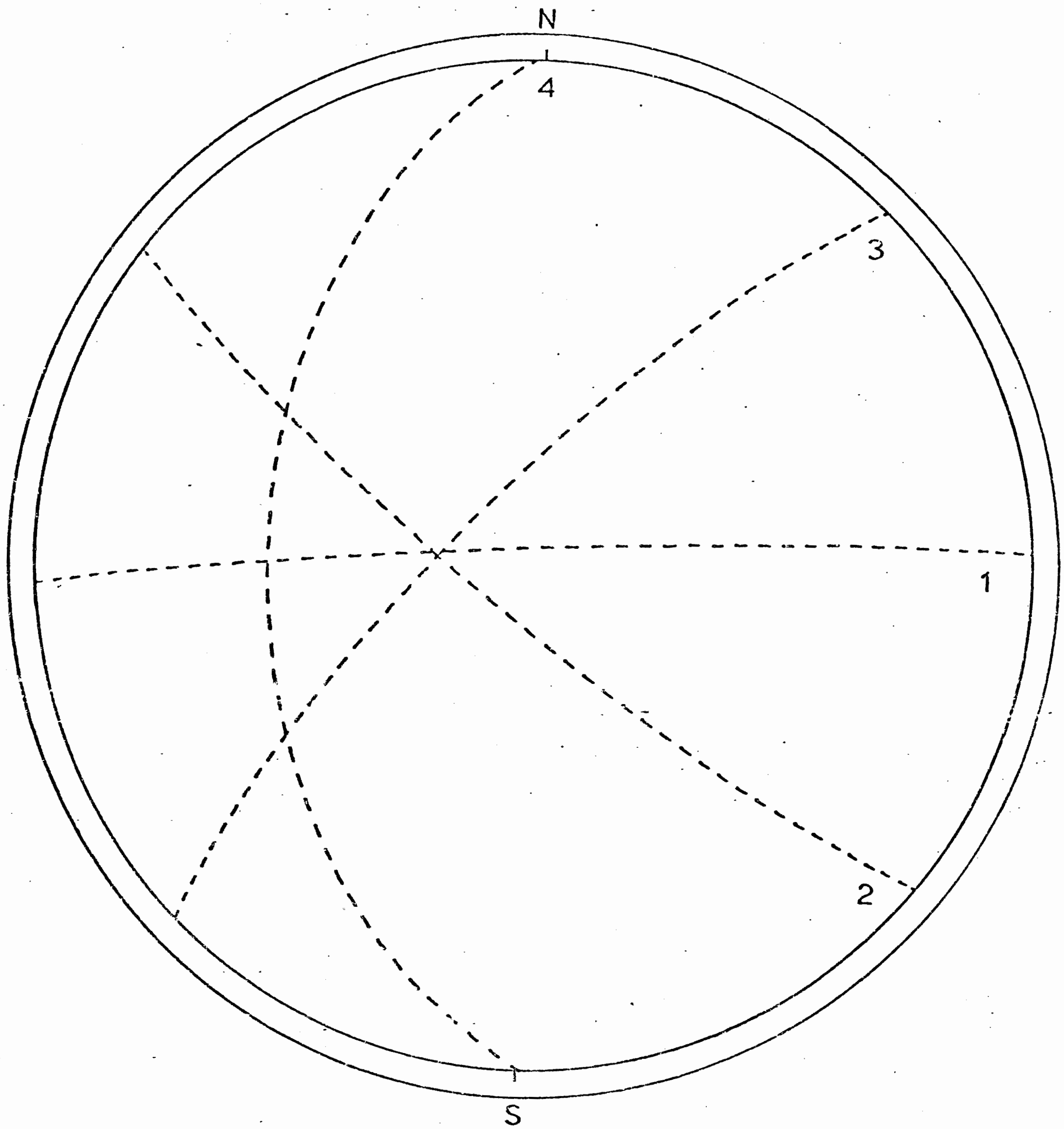


Figure 17

Figure 18. Contoured stereographic plot of poles to joint surfaces: Domain (d).

CONTOURED STEREOGRAPHIC PLOT OF POLES TO JOINT SURFACES

POLES OF ALL 405 JOINT SETS MEASURED IN STUDY AREA

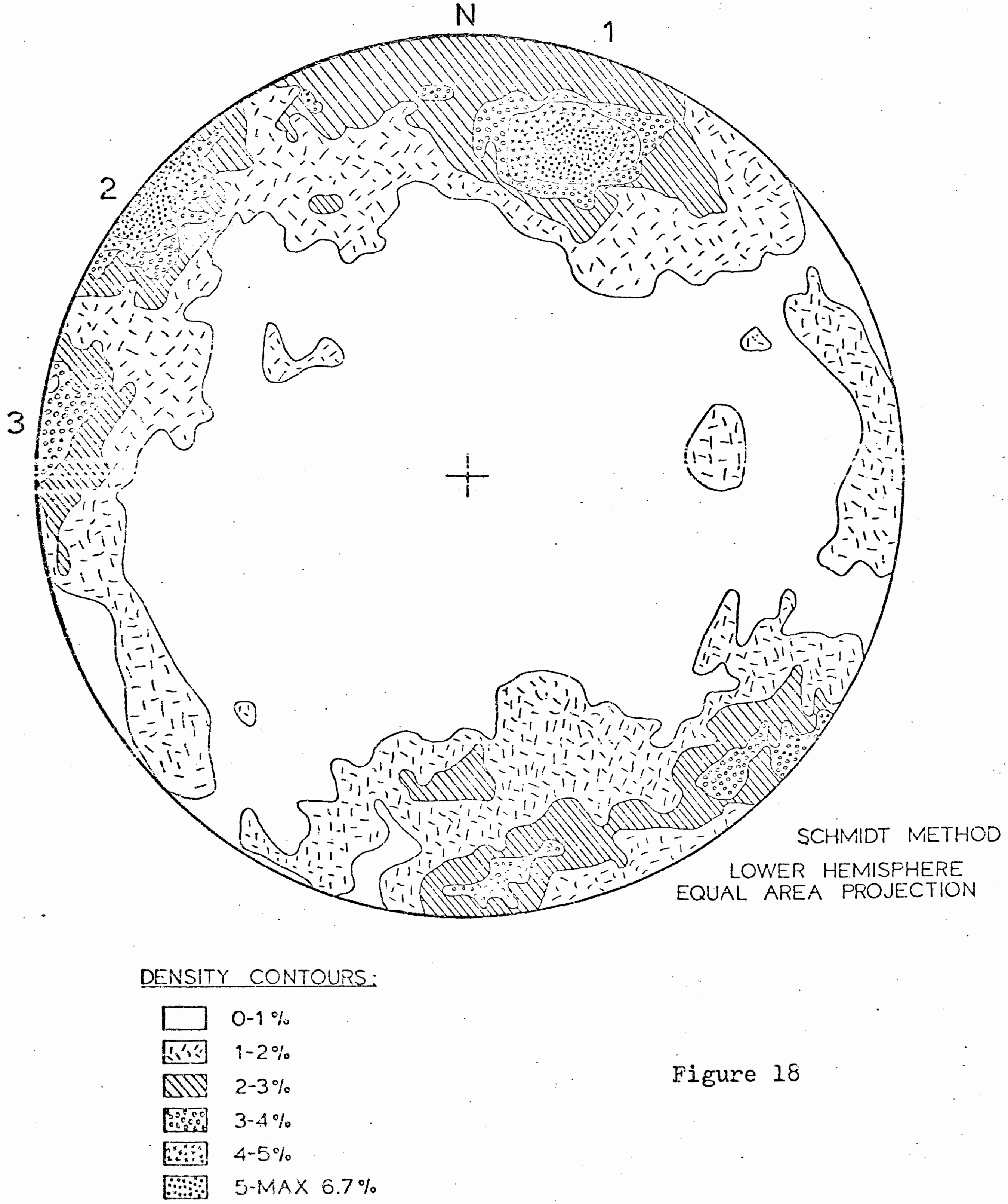


Figure 18

The orientations of the pole concentrations and the joint plane representation of the pole concentrations are interpreted as follows:

"Major" Pole Orientations	Joint Plane Orientations
(1) $018^{\circ}/21^{\circ}$	$108^{\circ}/69^{\circ}S$
(2) $310^{\circ}/03^{\circ}$	$040^{\circ}/87^{\circ}E$
"Minor" Pole Orientations	
(3) $277^{\circ}/02^{\circ}$	$007^{\circ}88^{\circ}E$

The stereographic projection of the joint planes represented by the pole concentration is shown in Figure 19.

Upon examination and comparison of the domains several general trends can be noted. Some of these trends are obvious, others poorly defined. Some of the general trends are:

(1) At least one generally east-west trending preferred joint direction.

(2) All domains have at least one roughly northeast to north-northeast preferred joint direction.

(3) All domains have one preferred joint direction trending approximately north-south.

These similarities in the pointing directions only hold true with respect to the strike directions. The magnitude and direction of dip of the joint planes do not correlate particularly well. For simplicity, since most joint planes are nearly upright, the precise dip value will not be considered in the discussion to follow.

Figure 19. Stereographic projection of traces of joint planes represented by the pole concentrations on the complimentary representation for Domain (d), the entire study area.

(Schmidt method, lower hemisphere equal area projection)

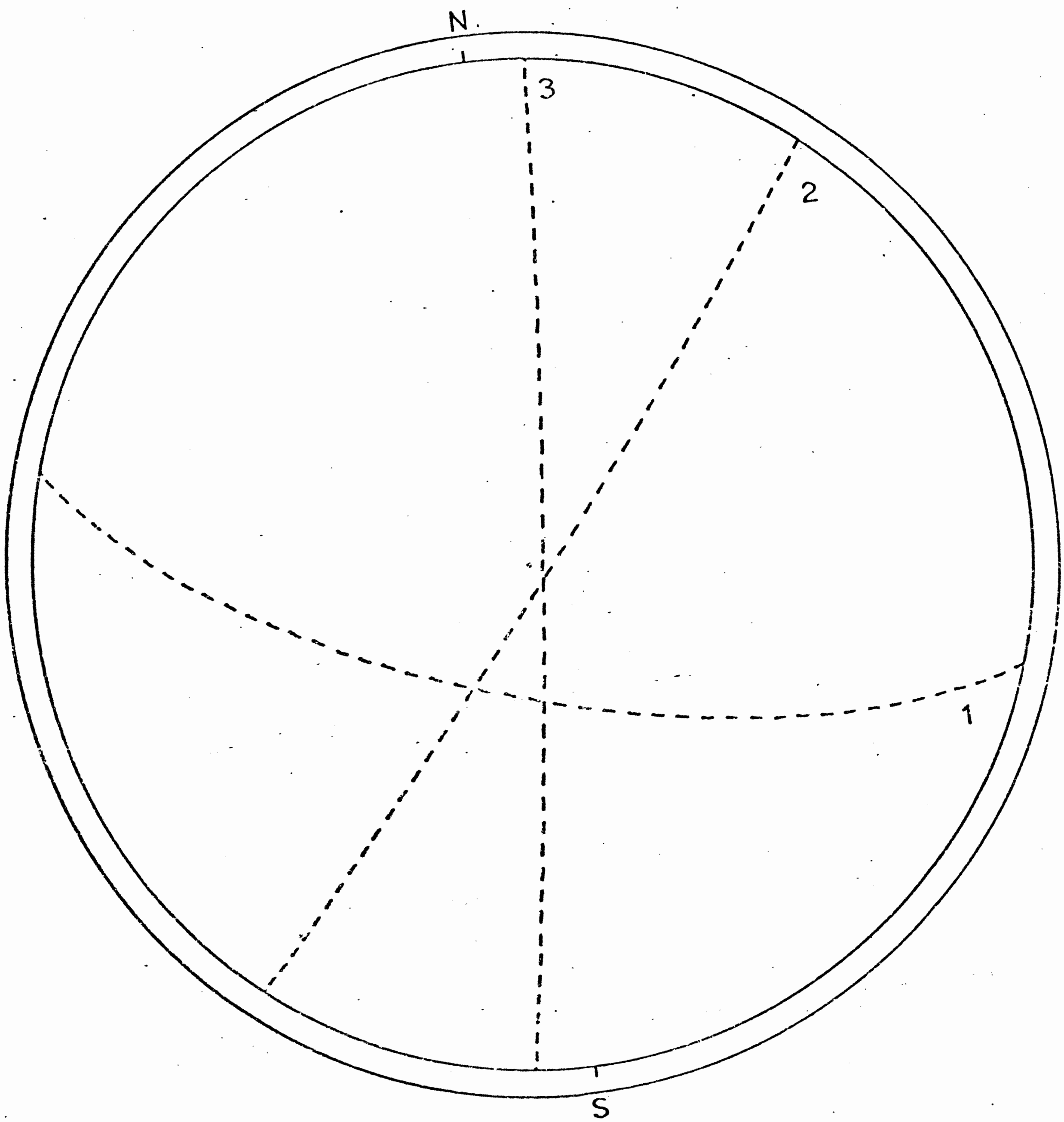


Figure 19

DISCUSSION OF JOINT DATA

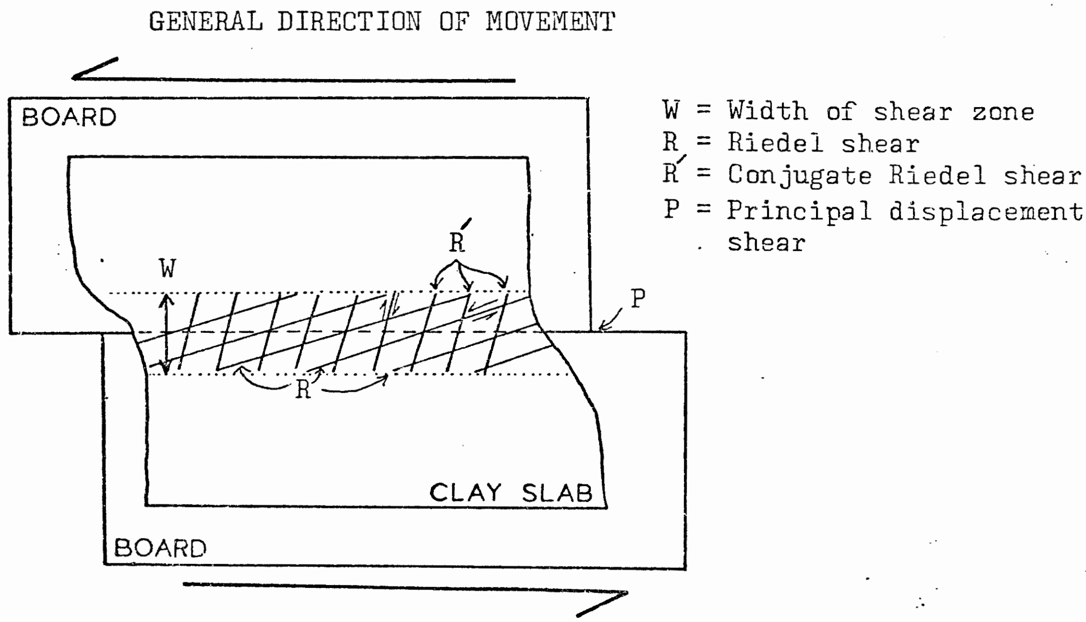
The theory of the development of shear zones and their associated structures has been the subject of many scientific investigations. The structures have been investigated on many different magnitudes, from microscopic to regional large-scale fault systems.

Tchalenko (1970) reported on experimentally produced joint sets related to a model shear zone, and compared these with joint patterns found in actual shear zones in the field.

In general terms he found that when stress is applied to a medium, the material does not immediately release the stress by sharply fracturing (faulting) when the stress has reached the fracture strength but instead will slowly yield and deform by a series of minor slippages along joint and shear planes in a "regular" predictable pattern.

Tchalenko repeated an experiment first described by Riedel (1929). In this experiment Riedel placed a slab of clay (plastic) material in a horizontal position on two adjoining boards making sure the material adhered firmly to the surface. He then proceeded to increase the shear stress to which the slab was subjected by horizontally sliding the boards one past the other. It is believed that within experimental bounds this apparatus approximates geologic conditions.

In the experiments performed with this apparatus researchers found that as the shear stress applied to the clay slab was slowly increased and approach the shear strength of the material a regular pattern of low displacement joints and shears appeared in the clay slab. The pattern appeared roughly as follows:



(Tchalenko, 1970)

The first set of joints to appear form at a high angle to the direction of the applied shear stress. This first set of low displacement joints Riedel called "conjugate Riedel shears" or (R′). As the shear stress increased further, a second set of joints appeared at a lower angle to the shear stress, these Riedel called "Riedel shear" or (R). With a yet further increase in shear stress to near the failure point of the material the "Riedel shears" deform further by extension and slight rotation. At this point, just before structural failure of the material, as the Riedel shears became interconnected to form another type of shear termed by Riedel as "P shears". As the material finally fails all deformation movement occurs along one "principal displacement shear" (P) which forms in the experiments along the contact between the two boards (Tchalenko, 1970).

Upon close examination very similar deformation structures were observed with relation to a much larger scale example. The example examined was the Dasht-e Bayaz earthquake fault which occurred in Iran on August 31, 1968. The deformation structures mapped with relation to the regional fault system are shown in Figure 20(Tchalenko, 1970).

Very similar jointing trends can be observed with relation to the regional Francoeur-Arntfield shear zone. The trends and their relationships are not exactly "text-book" in nature because of variables in the geologic environment such as curves in the east-west shear zone and the presence of a second shear zone in the southern part of the study area, the Lake Fortune shear zone. The evidence appears to be conclusive enough to lead the author to believe the theory that the joints observed in the rocks in the study area are directly related to the deformation period which formed the Francoeur-Arntfield shear zone.

The general trends in the jointing pattern observed in the domains of the study area have direct analogies with the jointing patterns observed in the Riedel experiments performed by Tchalenko. The author believes the following analogies to be valid.

(1) The east-west trending set of joints noted in the domains represent the main shear zones present in the area. These joints can be

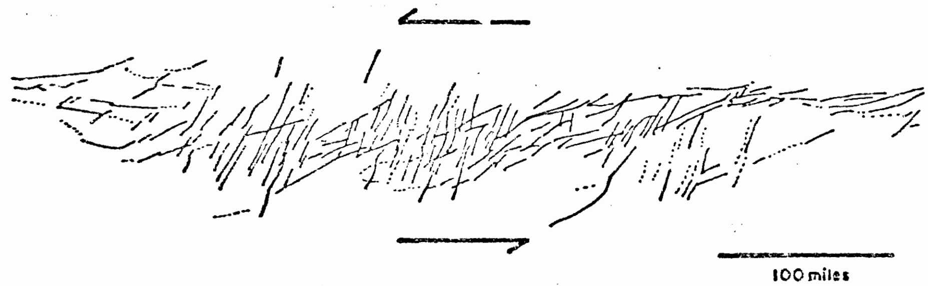
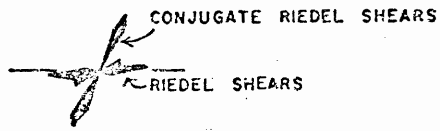


DIAGRAM OF PEAK STRUCTURE IN THE
DASHT-E BAYAZ EARTHQUAKE FAULT



ROSE DIAGRAM SHOWING RIEDEL AND CONJUGATE
RIEDEL SHEAR DIRECTIONS

(TCHALENKO 1970)

Figure 20. Deformation structures mapped with relation to the Dasht-E Bayaz Earthquake Fault in Iran.

correlated directly with the "P shears" or "Riedel shears" (R) observed in Tchalenko's experiments depending upon at what stage of development the shear reached.

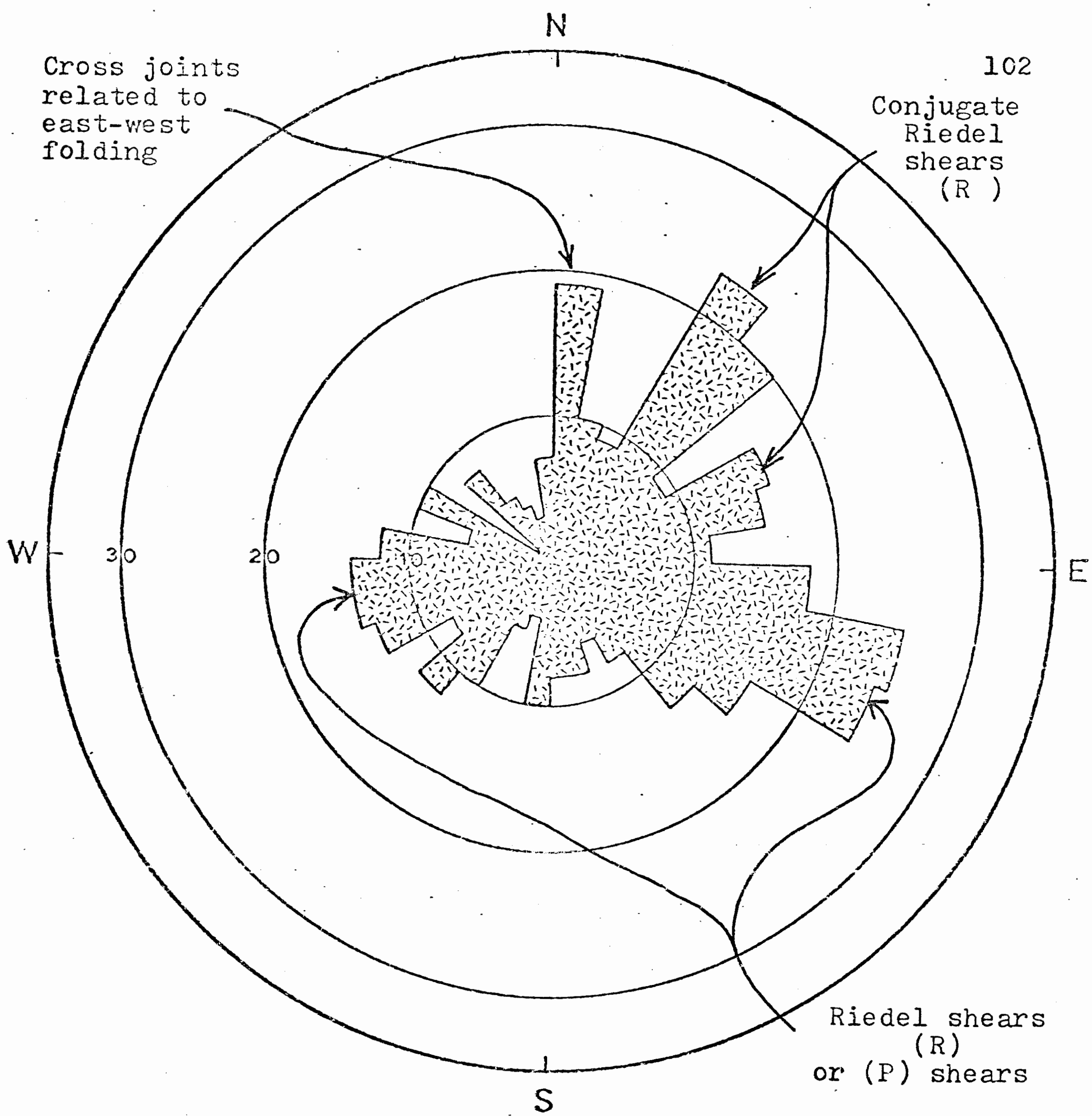
(2) The second joint trend observed in the domains is the generally northeast trending set of joints. These joints the author believes to be analogues to the "conjugate Riedel shears" (R´) observed in Tchalenko's experiments.

(3) The final set of joints observed in the domains trend roughly north-south approximately perpendicular to the direction of the east-west shear force. These joints may represent: a) a further deformation stage of the "conjugate Riedel shears" (R´) as they rotate or b) cross joints developed as the result of the gentle regional east-west folding the rocks have undergone. The present author prefers the second interpretation.

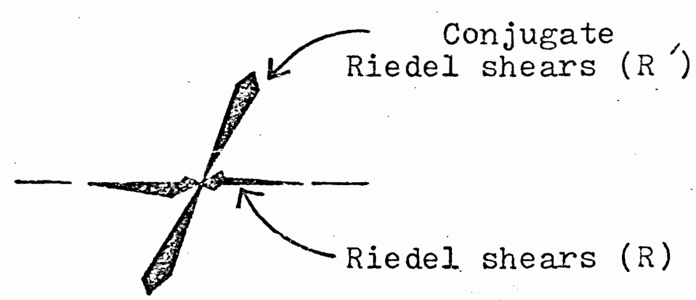
Figure 21 illustrates these general trends and the experimental analogues believed to correlate with them.

The dynamic metamorphism manifested as cleavage or foliations in the rock is only well-developed within or in close proximity to the shear zone. The noticeable lack of dynamic metamorphic effects at distance from the shear is evidence of a definite strain/stress gradient. Obviously,

Figure 21. General jointing trends observed in Arntfield study area domains compared with experimental analogues from Riedel experimental results and observations by Tchalenko (1970).



Rose diagram of 400 joint sets, Arntfield study area, Quebec.
(Note: Joint data all in dip-to-the right form)



Rose diagram showing Riedel (R) and conjugate Riedel (R′) shear direction Dasht-E Bayaz Earthquake Fault, Iran.
(Tchalenko, 1970)

Figure 21

the magnitude of the shear stress to which the rock was subjected would decrease with distance from the zone of major dynamic effect (Ramsay *et al.*, 1970).

The general situation appears to be typical of the observations one would expect to note as the result of sinistral (left lateral) shear stress. In this situation of the Francoeur-Arntfield shear the northern side of the shear zone appears to have moved toward the west with respect to the southern side, no estimation of the relative strike slip movement has been made. Due to the relatively clear relationship between the three general jointing trends in the domains of the study area it can probably be concluded that the movement on the Francoeur-Arntfield shear zone was the result of one continuous period of deformation, if there had been more than one deformation period there would be likely a more complex jointing pattern represented in the rocks.

CHAPTER 6

SUMMARY AND CONCLUSIONS

From the results of the observations made during this field oriented geological survey of the area in the vicinity of the gold mines on the regional Francoeur-Arntfield shear zone there are several preliminary conclusions that could be brought forward. These are:

(1) The study area is underlain by an Archean Age series of interfingering volcanic lava flows belonging to the Blake River Group of the Keewatin Series. These lavas are very diverse in lithology and range in composition from felsic to intermediate. No mafic volcanics were encountered in the study. There is a high proportion of fragmental rocks with matrix compositions of both felsic and intermediate classifications. The flow structures visible in these lava units indicate a generally east-west flow direction in the moderately north dipping volcanic pile. The high proportion of felsic flows seem to indicate a volcanic center fairly close to the study area because due to the viscous behavior of the flows when they were extruded it is likely they did not flow far from the source. The volcanic center was not located in this study.

(2) The volcanic series has been deformed into a series of broad folds. The study area lies on the southern limb of an east-west trending syncline, the axis of which lies just to the north of the study area. The volcanic flows strike generally east-west and dip between 45^{o} to 50^{o} to the north.

(3) The volcanic pile has been intruded by a number of intrusive bodies of varying morphology and composition. The largest proportion of the intrusives on the property are of dioritic composition. The dioritic intrusives generally take the form of small plutons or sub-concordant sill-like bodies. There are also dykes present of syenite and quartz-feldspar porphyry. The absolute ages of these intrusives are not known. Relative ages for the bodies are also not positibely known as there does not seem to be any cross-cutting relationships visible in surficial exposures. The relationships of the intrusives to the shear deformation described later is not known, however it can be hypothesized that the emplacement was either synchronous or after the deformation event because diorite bodies in the vicinity of the major shear zones show no evidence of shearing.

(4) The volcanic pile has been dynamically deformed by at least two east-west trending, sub-concordant regional shear zones. The Francoeur-Arntfield shear zone crosses the northern part of the study area (Beauchastel 2-77 property) and the Lake Fortune shear zone crosses the southern half of the study area (Beauchastel 1-78 property and just to the south of the Beauchastel 4-78 property). These regional shear zones are extremely important as they host the gold mineralization in their dilations. Analyses of the joint systems believed to be related to the major Francoeur-Arntfield shear zone lead to the conclusion that the shear is of the "Riedel Type". The Francoeur-Arntfield shear is sinistral

(left-lateral). This implies that the northern side of the shear zone appears to have moved toward the west with relation to the southern side. There has been no estimation made of the magnitude of the strike slip movement. The gold mineralization in the deposits in this area are definitely related to the original formation of the shear zone. These are exploration implications in that there may be more economic gold mineralization "pods" found where there are joint concentrations. A further benefit may be gained from this joint system analysis in that,if other areas in the region along strike with the regional shear zones have no outcrop exposure of the shear zones,it may be possible to "remotely detect" the position or presence of the shear zones by analysis of the joint sets mapped in the rock exposures.

(5) The gold mineralization, as stated before, is found in economic quantities in the deposits of the area in locations where the shear zone changes both strike and dip. The factors dealing with the genesis, paragenesis, or emplacement of the gold ore were not examined in this paper because all mineralization left behind is in the sub-surface. The study area has had its surface exploited both when the mine was operational, and by prospectors and interested individuals in the forty years or so since the mine closure, therefore there is no "ore" of any description left on the surface. The literature indicates the gold in these deposits is found not as visible native gold but instead occurs as tellurides in quartz-carbonate-pyrite veins of hydrothermal origin. These

deposits also host some silver mineralization. It has been hypothesized with relation to some of the other gold deposits of this type in the area that the origin of the hydrothermal solutions may be the diorite intrusions which always seem to be found in the vicinity of the deposits. No evidence to either substantiate or disprove the hypothesis regarding the genesis of the mineralizing fluid was found in this study.

(6) The area is unconformably overlain by a series of clastic metasediments of the Proterozoic Age Cobalt Group. These rocks were not directly related to the gold deposits around which this program was designed therefore they were afforded very little attention. The rocks appear to be a poorly sorted greywacke with very angular and asserted fragments.

(7) All the rocks encountered on the property have been regionally metamorphosed to greenschist facies. With few exceptions the rocks exhibit varying degrees of chloritization which gives all the rocks a greenish tinge. Other forms of alteration noted in the rocks of the area seem to indicate that during their history the rocks have been permeated by hydrothermal solutions.

(8) The entire area has been glaciated in the Pleistocene. The evidence for this is the presence of a thick mantle of drift covering a large proportion of the area and many glacial striae and grooves on the polished surfaces of outcrops. The orientation of the grooves indicate the glacial ice moved in a north-south direction.

RECOMMENDATIONS FOR FUTURE WORK

This study was designed to provide a general synthesis of the geological setting of the area in the vicinity of the Francoeur-Arntfield shear zone. This project is far from conclusive with respect to many topics, and there are a multitude of studies that could be undertaken to expand the scientific knowledge regarding the geology of the area as well as assist in the exploration for larger gold ore reserves. Some possibilities would be:

(1) Detailed petrologic and lithogeochemical studies to examine and investigate the rocks in the vicinity of the shear zone as well as at distance from it to decipher the chemical effects of hydrothermal alteration. Comparisons with similar studies carried out at other mines in the region could prove fruitful in determining alteration gradients helpful in locating the major structures.

(2) Detailed compilation of the underground geology found in the diamond drill logs and the maps of the underground workings to obtain a three dimensional view of the area to gain an understanding of the behavior of the volcanic flows and the erratic shear zone. With this information the outlining of the ore zone below the 1075-foot level in the Arntfield Gold Mine, Number 2 shaft, through the use of surficial diamond drilling may be possible.

(3) If samples of the ore from the mines in the area could be obtained from government agencies, university collections, or private individuals, an investigation of the

paragenesis of the gold mineralization would be useful to develop a well-defined genetic model for the gold deposits in the area.

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APPENDIX I

JOINT AND SHEAR DATA USED FOR COMPUTER ANALYSIS

DOMAIN (a) NORTH OF FRANCOEUR-ARNTFIELD SHEAR ZONE
(BEAUCHASTEL 2-77 PROPERTY)

Joints

068/65S	314/84NE	013/85E	101/70S
040/88SE	180/80W	122/51S	025/50E
328/80NE	300/43NE	235/85NW	070/90
078/78S	265/57N	176/53W	260/50N
036/85S	131/43SW	318/70NE	113/59SW
085/64S	065/37SE	032/90	100/90
030/79SE	238/73NW	085/84S	295/58N
040/80SE	165/87SW	092/78S	060/60SE
130/72SW	161/75SW	035/75SE	110/72SW
100/85S	039/41E	325/79NE	042/74SE
208/70NW	277/56N	230/76NW	105/58S
070/54SE	223/61NW	016/83E	140/90
030/68SE	250/88N	020/74E	106/68S
110/75SW	036/90	353/87E	084/71S
048/82SE	249/42N	230/86NW	206/63W
104/63S	195/81W	101/74SW	084/68S
004/70E	059/53S	006/90	312/43NE
112/85SW	274/60N	245/83NW	115/60SW
140/60SW	284/59N	154/80W	108/57SW
290/20N	007/75E	013/86E	006/74E
340/54E	184/87W	052/75SE	060/52S
070/74SE	354/68E	090/52S	173/53W
243/55N	060/83SE	310/60NE	084/55S
244/82N	032/90	158/82W	186/84W

Domain (a) Joints (continued)

262/56N	265/62NE	052/84S	145/31SW
015/90	113/51SW	319/83NE	110/78S
070/46S	030/60S	045/90	010/90
090/62S	150/67W	350/79E	170/84W
045/66E	073/79S	213/75NW	096/63S
107/68S	259/71W	185/86W	049/90
260/73N	337/66E	067/90	033/83E
185/71W	310/58NE	270/83N	114/90
295/80NE	043/82S	220/84NW	040/87SE
045/90	292/76N	155/64SW	095/57S
215/82W	188/80W	000/90	009/90
120/86SW	110/72S	060/90	030/80E
255/81N	042/90	082/84S	250/72N
115/78SW	114/72	136/75SW	120/75SW
095/67S	115/48S	035/72SE	029/76SE
110/69S	038/79S	070/77S	163/90
185/76W	120/73S	072/86S	125/76SW
056/62S	353/86E	074/83S	108/80S
311/71NE	132/65S	040/75S	226/73NW
243/79NW	345/84NE	215/84NW	213/78NW
098/90	108/54S	040/86S	260/75N
220/75NW	206/65NW	115/82SW	040/90
008/83E	233/78NW	322/66NE	104/66S
110/27SW	075/83S	248/76NW	288/85N

Domain (a) Joints (continued)

104/65S	248/57NW	106/70S	112/65S
104/66S	115/64SW	118/66S	210/84W
038/45SE	134/71SW	226/77NW	036/90
105/74SW	228/87NW	088/67S	249/42N
077/63S	003/78E	003/80E	112/81W
030/90	050/90	017/73E	228/77N
109/67S	141/80SW	100/68S	210/85NW
090/74S	224/85NW	038/87E	005/57E
154/60SW	042/90	105/60S	

Shears

310/90	111/75SW
242/63N	240/60N
245/37NW	100/75S
294/51NE	103/80S
007/83E	050/73S

DOMAIN (b) WITHIN THE FRANCOEUR-ARNTFIELD SHEAR ZONE
(BEAUCHASTEL 2-77 PROPERTY)

Joints

069/60S	020/90	066/76S	106/61W
214/54NW	108/56S	084/84S	060/90
094/67S	073/90	098/78S	030/63E
005/65E	005/89E	000/90	062/76S
234/80NW	076/40S	020/58E	062/60S
020/64E	095/87S	030/90	165/61W
255/70N	175/85W	111/65S	295/70NE
273/68N	236/80N	090/71S	058/69S
012/33E	110/70S	125/74SW	100/62S
034/74S	255/75N	040/84E	022/72SE
345/67NE	145/86SW	009/81E	120/76SW

Shears

263/86N	290/69NE
267/76N	120/52S
275/57N	255/72W
275/90	265/79N
270/82N	095/58S
282/68NE	256/42N

Glory Hole Data

Joints		Shears
038/40SE	070/79S	285/60N
024/31E	262/53N	259/82N
128/62SW	075/67S	
030/38SE	130/51SW	

DOMAIN (c) SOUTH OF THE FRANCOEUR-ARNTFIELD SHEAR ZONE

Beauchastel 2-77 Property

Joints

255/88N	015/68S	177/45W	223/82N
061/41S	253/48N	040/78SE	146/62W
129/70SW	132/90	280/45N	230/73NW
336/73NE	123/77S	146/78W	185/46W
112/67S	335/80E	055/80S	264/80N
100/64S	055/25SE	131/76SW	009/54E
016/54E	274/56N	266/82N	045/90
092/75S	338/77E	170/90	268/84N
004/40E	358/80E	205/82W	168/46W
091/80S	065/89S	062/74S	163/79W
082/82S	175/90	320/81E	215/73NW
098/36S	281/87N	048/87S	120/83SW
214/53NW	045/81SE	005/49E	009/72E
051/30S	042/54S	171/45W	180/46W
207/74NW	299/32NE	226/65NW	020/90
271/66N	114/90	290/70N	133/53W
250/75N	123/90	228/83NW	273/63N

Shears

128/90

350/78E

DOMAIN (c) CONTINUED

Beauchastel 1-78 Property

Joints

244/60N

086/90

137/80W

354/72E

100/84S

242/60NW

214/65W

Shears

085/5S

091/90

Beauchastel 4-78 Property

Joints

132/50SW	296/80N	195/74W	280/79N
063/55SE	197/52NW	227/72NW	250/55NW
224/80NW	252/76N	275/64N	137/66SW
273/80N	161/67SW	138/90	090/74S
160/58SW	015/75E	033/81E	
267/84N	122/90	324/74SW	

Shears

094/90


LOT 9
LOT 10
LOT 11
LOT 12
L8W
L4W
0
L4E
L8E
L12E
L16E
L20E
L24E
L28E
L32E
L36E
L40E
L44E
L48E
Range VI
Range V
TL 27+00N
N
BL0+00 AZ. 90°
TL 20+00S
TAILINGS
Town
Arntfield
LOCATION PLAN OF BEAUCHASTEL 2-77
Scale 1" = 2640'
DASSERAT
BEAUCHASTEL
LEGEND
VOLCANIC ROCKS
V2 Rhyolite
V2F Rhyolite Fragmental (Cherty Fragments)
V3 Trachyte
V4 Dacite
V6 Andesite
V6F Andesite Fragmental (Cherty Fragments)
V9 Tuff
V10 Agglomerate
METAMORPHOSED ROCKS
M Indeterminated Metamorphic Rocks
M1 Schist
M3 Hybrid Rocks
M5 Migmatite
M7 Gneiss
M8 Amphibolite
INTRUSIVE ROCKS
1S Syenite
1R Quartz Feldspar Porphyry
2D Diorite
2L Indeterminated Lamprophyre
I Indeterminated felsic intrusive
SUFFIXES FOR STRUCTURE & TEXTURE
Porphyry
Porphyritic
Amygdaloidal
Sheared
Brecciated
Fragmental
Pillowed
Banded
ALTERATION
Amphibolitized
Silicified
Pyritized
Chloritized
Sericitized
Carbonatized
COMPOSITION
Felsic
Mafic
Ultramafic
ORIGIN
Sedimentary
Volcanic
Intrusive
SUFFIXES FOR METALS
Ag Silver
Cu Copper
Fe Iron
Au Gold
SUFFIXES FOR ECONOMICAL MINERALS
Cp Chalcopyrite
Ch Chert
Gp Graphite
Hem Hematite
Mt Magnetite
Mo Molybdenite
Po Pyrrhotite
Py Pyrite
Q Quartz eye
Qv Quartz vein
Sp Sphalerite
STRUCTURAL SYMBOLS
Joints
Geological Contact (Observed & Assumed)
Strike and Dip
Strike and Top (Pillows)
Strike, Dip and Top (Pillows)
Fault
Glacial Striae
Schistosity (Inclined, Vertical & Horizontal)
Lineation (Direction Unknown)
E.M. Conductor axis V.L.F.
Diamond drill hole
Outcrop
Trench
Building
Mine shaft (Abandoned)
I.P. Anomaly
Claim post
Underground workings
SCALE
0 25 50 100 150 200 250
metres
(1:5000)
REVISED
BEAUCHASTEL 2-77
GEOLOGICAL SURVEY
PROJECT ARNTFIELD
PROJ. NO.
N.T.S: 32-D-3
DWG. NO.
8355
SURVEYED BY: Dean R. Cutting
DATE: JUNE / 79
DRAWN BY: M.P. P.Mo.
SCALE: 1" = 200'
NORANDA EXPLORATION CO. LTD.
OFFICE: NORANDA QUÉ.

Figure 5

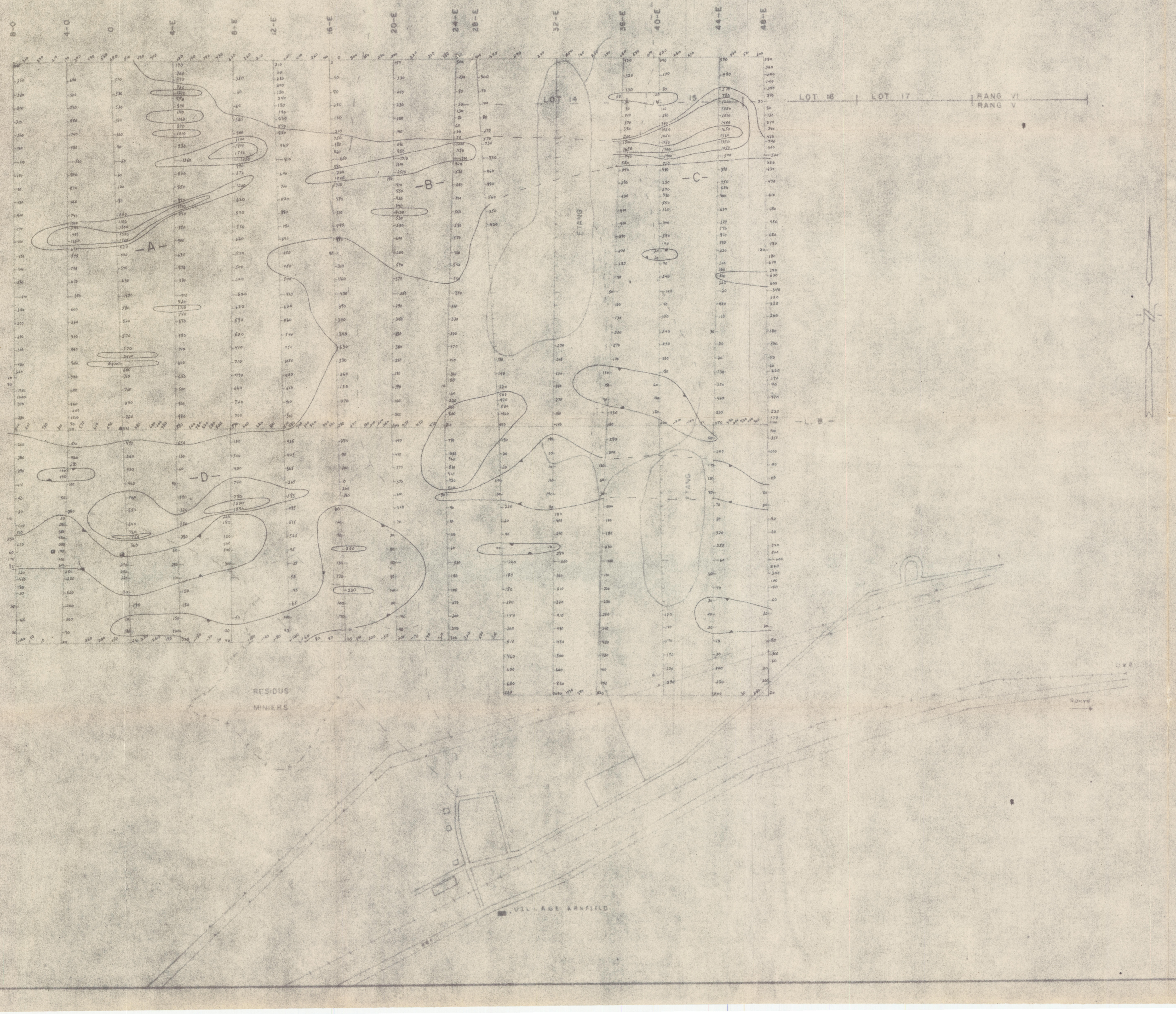

LOCATION PLAN OF BEAUCHASTEL 1-78
KING OF THE NORTH LAKE
MUD LAKE
RENAUD LAKE
FORTUNE LAKE
TAILINGS
TAILINGS
RENFORT GOLD MINES
TRANSMISSION LINE
Cat-Tail Swamp
Low Ground
Cabin
Camps
ARNTFIELD
CREEK
DASSERAT
BEAUCHASTEL
9000 N
8000 N
7000 N
6000 N
5000 N
4000 N
3000 N
2000 N
1000 N
0000
1000 S
2000 E
3000 E
4000 E
5000 E
6000 E
7000 E
8000 E
9000 E
10000 E
11000 E
12000 E
13000 E
NOTE: Grid on map taken from RENFORT GOLD MINES
LEGEND
V2 RHYOLITE
V4 DACITE
V6 ANDESITE
V9 TUFF
S1 CONGLOMERATE
S3 GRAYWACKE
S5 QUARTZITE
2D DIORITE
1S SYENITE
PORPHYRITIC
AMYGDALOIDAL
SHEARED
BRECCIATED
SILICIFIED
EPIDOTIZED
CHLORITIZED
CARBONITIZED
Cp CHALCOPYRITE
Mt MAGNETITE
Hem HEMATITE
Py PYRITE
Po PYRRHOTITE
STRIKE & DIP OF SCHISTOSITY
GLACIAL STRIATION (Direction Unknown)
JOINTS (Horizontal, Inclined, Vertical)
FAULT (Known)
FAULT (Assumed)
GEOLOGICAL CONTACT (Known, Assumed)
BEDDING ATTITUDE
MINE SHAFT (Abandoned)
TRENCH
DIAMOND DRILL HOLE
SCALE
0 50 100 200 300 400 500
metres
REVISED
GEOLOGICAL SURVEY
BEAUCHASTEL 1-78
PROJECT ARNTFIELD
PROJ.NO.
N.T.S.
DWG.NO.
SURVEYED BY: D.CUTTING DATE: JULY 79
DRAWN BY: M.P. SCALE: 1" = 400'
NORANDA EXPLORATION CO.LTD.
OFFICE:

Figure 6

KING OF THE NORTH LAKE
FORTUNE LAKE
MUD LAKE
RENAUD LAKE
RENFORT GOLD MINES
TRANSMISSION LINE
Mixed Hardwood (Birch)
Low Ground
Cat-Tail Swamp
Low Ground
Mixed Forest
No. 3 SHAFT
No. 2 SHAFT
No. 1 SHAFT
DASSERAT
BEAUCHASTEL
9000 N
8000 N
7000 N
6000 N
5000 N
4000 N
3000 N
2000 N
1000 N
0000
1000 S
2000 E
3000 E
4000 E
5000 E
6000 E
7000 E
8000 E
9000 E
10000 E
11000 E
12000 E
13000 E
LOCATION PLAN OF BEAUCHASTEL 4-78
LEGEND
V2 RHYOLITE
V4 DACITE
V6 ANDESITE
V9 TUFF
PORPHYRITIC
AMYGDALOIDAL
SHEARED
BRECCIATED
S1 CONGLOMERATE
S3 GRAYWACKE
S5 QUARTZITE
SILICIFIED
EPIDOTIZED
CHLORITIZED
CARBONITIZED
2D DIORITE
1S SYENITE
Cp CHALCOPYRITE
Mt MAGNETITE
Hem HEMATITE
Py PYRITE
Po PYRRHOTITE
STRIKE & DIP OF SCHISTOSITY
GLACIAL STRIATION (Direction Unknown)
JOINTS (Horizontal, Inclined, Vertical)
FAULT (Known)
FAULT (Assumed)
GEOLOGICAL CONTACT (Known, Assumed)
MINE SHAFT (Abandoned)
TRENCH
DIAMOND DRILL HOLE
CLAIM POST
SCALE
0 50 100 200 300 400 500
metres
REVISED
GEOLOGICAL SURVEY
BEAUCHASTEL 4-78
PROJECT ARNTFIELD
PROJ. NO.
N.T.S.
DWG. NO.
SURVEYED BY: D. CUTTING
DATE: JULY '79
DRAWN BY:
SCALE:
NORANDA EXPLORATION CO. LTD.
OFFICE:

Figure 7

PLAN DE LOCALISATION
BEAUCHASTEL 2-77



LEGENDE

- Lectures en gammas
- Contours magnétique
- Station de base
- Conducteur E M
- Poteau de claim (localisé approx.)

Figure 8

LEVE: MAGNETIQUE
BEAUCHASTEL 2-77

CANTON BEAUCHASTEL Index 2F
PROJET Nº 510
OPÉRATEUR R. MOYLE DESSINATEUR
APPROUVÉ DATE MAI 1979 REVISÉ
FILIÈRE S.N.R.C. 32-D-3 ÉCHELLE 1:40

EXPLORATIONS NORANDA LTÉE

BUREAU Noranda, Québec