STRUCTURAL AND STRATIGRAPHIC SETTING OF SULPHIDE DEPOSITS IN ORDOVICIAN VOLCANICS SOUTH OF KING'S POINT, NEWFOUNDLAND

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by

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View of King's Point from the south shore of Southwest Arm.

ABSTRACT

The study area, located north of Springdale, Newfoundland, is underlain by basic volcanic rocks of the Ordovician Little Bay Head section of the Lush's Bight Group. From the base of the section to the top a general lithologic gradation (with considerable interdigitation of units) is present as follows: close-packed pillowed lavas, isolated pillow breccia, broken pillow breccia, coarse aquagene tuff, fine aquagene tuff.

The section comprises the south limb of an anticline whose axial plane dips steeply northward and whose horizontal axis strikes east-northeast. Within the section discontinuous schist zones are approximately parallel to the volcanic layering. These are the result of inhomogeneous strain and are characterized by the presence of a strain-slip fabric, so that there are two fabrics in the zones and only one, an S or LS tectonite fabric outside. The schist zones are apparently pretectonic to the major anticline. Subsequent to the development of these structures, the rocks were disturbed by block-faulting and thrust-faulting from the north, and were finally folded again into an open flexure whose axial plane strikes north-south and whose axis plunges steeply northward.

Sulphide mineralization is economically significant only in the schist zones, and chalcopyrite seems to be enriched in the hinges of the latest folds. It is postulated that the suplhides are stratabound by the volcanics, are pretectonic to the development of the schist zones, and were later remobilized in the schist zones during the folding episode(s).

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I. INTRODUCTION

A. LOCATION OF AREA, ACCESS, AND CONDITIONS OF TRAVEL

The study area of about ten square miles is located north of Hall's Bay, Newfoundland, approximately between longitudes $56^{\circ}07'$ and $56^{\circ}12'$ west and latitudes $49^{\circ}31.5'$ and $49^{\circ}35'$ north (see maps). The area is bounded on the west by the King's Point road and on the north by the Jackson's Cove road; these provide ready access to much of the countryside. For convenient geographical reference, the study area is identified in the body of this dissertation as the King's Point Area.

A helicopter leased by British Newfoundland Exploration Limited (Brinex) for the summer of 1970 gave the writer considerable assistance in examining all parts of the map-area with minimal expenditure of effort. Numerous bogs and an old winter road linking the towns of King's Point and Springdale facilitate travel by foot in the area. Pace-and-compass traversing was the principal means of travel employed between the bogs since the rest of the area is thickly wooded.

B. PHYSIOGRAPHY

The area has undergone Pleistocene glaciation and is at present largely covered with ground moraine. Outcrops tend to be small and rounded, and amount to about one percent of the surface area underlain by pillow breccia, and less than half that elsewhere in the map-area. There is practically no exposure to the northwest near the junction of the King's Point and Jackson's Cove roads.

The pillow breccias form an undulating plateau with an elevation of about 550 feet. The less resistant tuffs, pillow lavas, and flows underlie the lower ground.

C. GENERAL GEOLOGY

1. REGIONAL SETTING

The King's Point area is underlain by part of the Little Bay Head section of the Lush's Bight Group consisting of volcanic flows, pillows and their derived breccias, and aquagene tuffs. This section comprises part of the central Palaeozoic mobile belt of the Appalachian orogen (Williams, 1964), though the structural and stratigraphic relation of the section to the surrounding rocks is not certain. The Little Bay Head section is generally considered to be Lower Ordovician in age (see p. 11).

At the northern boundary of the map-area the Little Bay Head section is separated from red sandstones and shales by the east-west trending South Brook fault, stated by McLean (1947, p. 13) to be strike-slip and sinistral on the basis of a few drag folds. The southern boundary is marked by the Catcher's Pond fault (apparently a northward offset of the Lobster Cove fault) where the Little Bay Head section abuts the Springdale Group of conglomerates, sandstones and intermediate to acid volcanics. These are generally considered to be Silurian in age because of their resemblance to the fossiliferous Botwood Group to the east.

Where the Lobster Cove fault zone is visible some 3000 feet west of Springdale (McLean, 1947, p. 11) it dips 60° northward and was interpreted by McLean to be a reverse fault. Later workers, notably Kay (1967, p. 594), have interpreted the fault to be a dextral strike-slip fracture on regional considerations.

2. LOCAL STRUCTURE

Between these bounding faults the Little Bay Head section apparently comprises the south limb of an anticline which is overturned to the south and whose axial plane strikes east-northeast. The axis is approximately horizontal and was located somewhere to the north of the study area. Schist zones are abundant in the Ovals Brook-Harry's Brook vicinity in the map-area. These structures are disrupted by later block-faulting and thrusting from the north, and by the development of the bounding faults discussed above. All these structures are folded into an open synform about an axis plunging 65° north in the vicinity of the Rendell-Jackman mine showings.

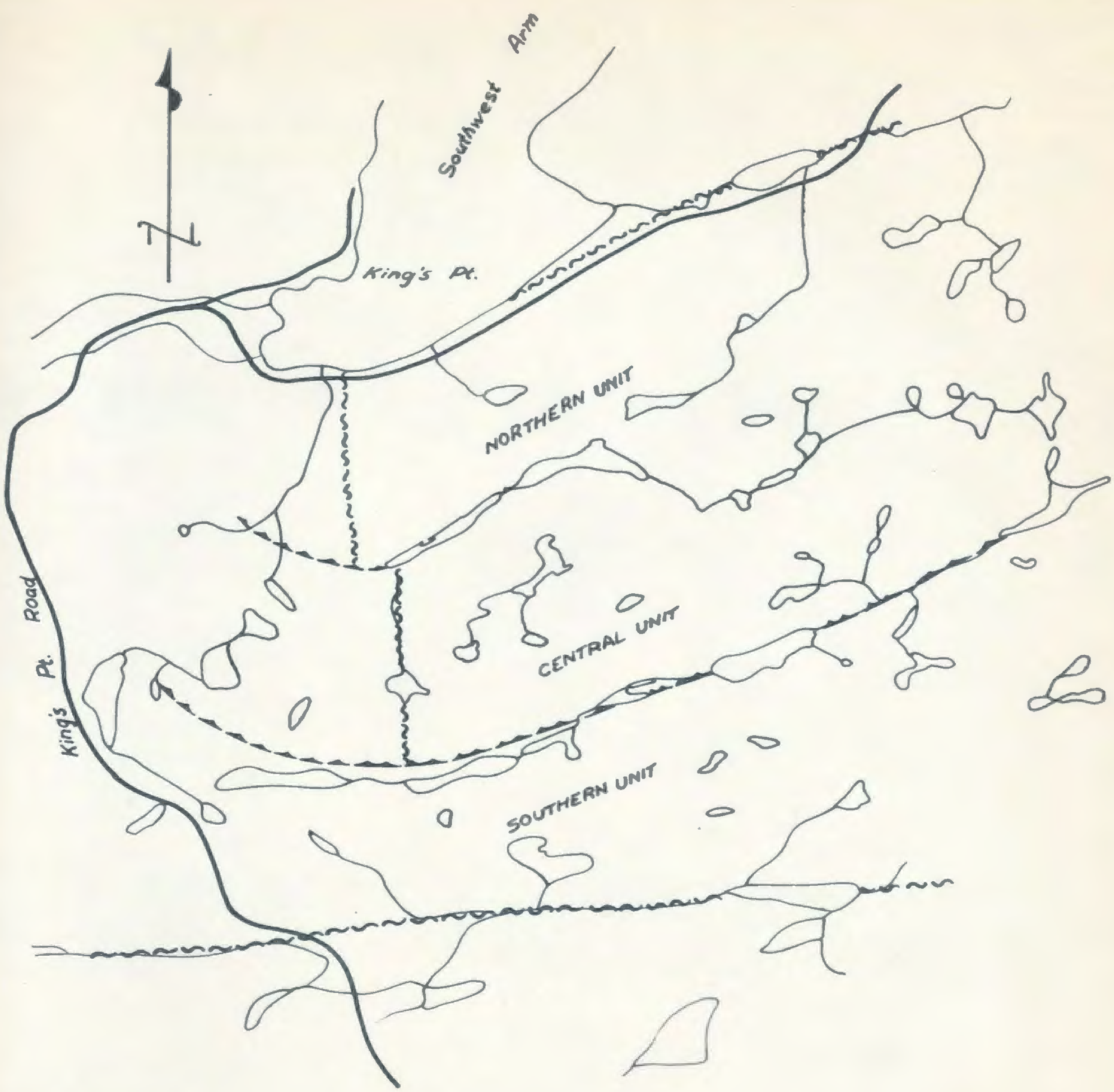
3. LOCAL STRATIGRAPHY

Despite the structural complications, broad stratigraphic gradations can be recognized in the Little Bay Head section of the map-area. From the base (north) to the top (south) of the section the sequence of units is as follows: close-packed pillowed lavas, isolated pillow breccia, broken pillow breccia, coarse aquagene tuff, fine aquagene tuff (these terms are fully discussed in Section II.A.1.). The same sequence, with considerable interdigitation of units, is present from east to west. Massive flows become abundant towards the top of the section. Pretectonic gabbro dykes and sills intrude all the units.

Only one definite top determination was made (plate IV), in a well-graded tuff bed north of Bean Pond (see map). Here the beds were overturned, tops being to the south. Poorly-developed graded bedding was present near Harry's Brook (plate III) and at a few other locations. Pillowed lavas and pillow breccia could not, for the most part, be relied upon to provide top information with any degree of confidence. Bedding always dips to the north more steeply than schistosity where both can be observed. The consistent sense of cleavage-bedding intersection and the general lithologic gradation towards more abundant and finer pyroclastics southwards (see p. 20) supports the interpretation that the beds face southwards everywhere in the map-area.

A convenient Lithologic division of the Little Bay Head section into the northern (close-packed pillows dominant), central (pillow breccia dominant), and southern (flows and aquagene tuff dominant) units can be made in the map-area (see table of formations and figure 1). All these units undergo a lateral facies change into close-packed pillowed lavas towards the eastern boundary of the area, so that these divisions can probably not be applied elsewhere in the Little Bay Head section.

Each unit is faulted at its base and top, so that only minimum thicknesses can be assigned to them. Thrust faults separating the northern and central, and the central and southern units remove an unknown part of the section.



SYMBOLS

FAULT; APPROXIMATE.

THRUST FAULT; APPROXIMATE, INTERPRETED; TEETH IN DIRECTION OF DIP.

SCALE: 1 MILE = 1 INCH

Figure 1: Map of the King's Point area showing the locations of fault-bounded stratigraphic units in the Little Bay Head section.

TABLE OF FORMATIONS

<table>
<tr><th>ERA</th><th>PERIOD</th><th colspan="2">FORMATION AND THICKNESS (FEET)</th><th>LITHOLOGY</th></tr>
<tr><td rowspan="9">PALAEOZOIC</td><td>SILURIAN</td><td colspan="2">SPRINGDALE GP.
(approx. 13,000')</td><td>sandstone, conglomerate, volcanic flows and breccia.
Southwest Arm Section: fine-to-medium grained red quartz sandstones, locally feldspathic and micaceous; rare limestone interbeds; locally cross-bedded.</td></tr>
<tr><td colspan="4">UNCONFORMITY ?</td></tr>
<tr><td rowspan="5">ORDOVICIAN</td><td rowspan="5">LUSH'S BIGHT GROUP
LITTLE BAY HEAD SECTION</td><td>SOUTHERN UNIT
(4,400'+)</td><td>aquagene tuffs interdigitating to east with massive, medium green flows which pass eastward into close-packed pillowed lavas.</td></tr>
<tr><td colspan="2">FAULT</td></tr>
<tr><td>CENTRAL UNIT
(5,400'+)</td><td>isolated and broken pillow breccia predominating over close-packed pillowed lavas and tuffs.</td></tr>
<tr><td colspan="2">FAULT</td></tr>
<tr><td>NORTHERN UNIT
(3,700'+)</td><td>close-packed pillowed lavas predominating over pillow breccias and tuffs.</td></tr>
<tr><td colspan="3">INTRUSIVE ROCKS:</td><td></td></tr>
<tr><td colspan="3">DEVONIAN (?)
ORDOVICIAN (?)
ORDOVICIAN (?)</td><td>rhyolite porphyry
serpentinized peridotite
gabbro sills and dykes</td></tr>
</table>

D. ECONOMIC SIGNIFICANCE

A number of pyrite and chalcopyrite occurrences in the map-area make it economically interesting. One of these, the Rendell-Jackman showing, has been extensively drilled, and some mining was done in the early part of this century though no ore was shipped.

Two producing copper mines, the Whalesback and Little Deer mines operated by Brinex, are located in the Little Bay Head section a few miles to the northeast of the map-area. In addition to these another operation, the Little Bay mine owned by the Atlantic Coast Copper Corporation, has been in production near the town of St. Patricks; and development of a property near Colchester Pond north of the Jackson's Cove road is being undertaken by Cerro Mining Company.

The association of copper mineralization with what most investigators have termed "chlorite shear zones" has long been known. However, no regional synthesis has yet been made which illustrates the features common to all occurrences and which adequately explains the controls for sulphide mineralization in the Little Bay Head section. It was possible to do this in the King's Point area because of the lithologic variety of the country rocks and the distribution of the several showings in the area (see chapter IV). It is the writer's opinion that certain of these controls are operative throughout the Little

Bay Head section and that these controls can be a worthwhile consideration in further exploration efforts.

E. PREVIOUS WORK

1. GENERAL STATEMENT

The area was first investigated by Murray and Howley (1881) as part of a regional geological survey. Murray noted (p. 473) the potential importance of the town of King's Point as a centre for the copper mining industry, which he stated in his report for 1878 was "nearly established and settled." He was aware of the association of the ores at Little Bay with what he termed (1881, p. 499) "an exceedingly ferruginous mass of chloritic slate rock." From the writer's standpoint the most useful previous work in the area remains that of H. J. McLean (1947). Though his record lacks the detail provided by later writers, McLean's interpretation of the structural relations within the Little Bay Head section is in substantial agreement with that of the writer and at variance with those of most other workers.

Unpublished work by Dr. E. R. W. Neale, who mapped the King's Point East area in the summers of 1959 and 1961 under the auspices of the Geological Survey of Canada was unquestionably helpful for its discussion of Lush's Bight Rocks in a more regional context. Other published map sheets which are of importance with regard to the writer's map-area were produced by Espenshade (1937), Kalliokoski (1953), and Neale and Nash (1962).

Numerous geologists have written reports relating directly or indirectly to problems encountered in the map-area. These are listed in the Bibliography, and the more important of them are discussed in some detail in the following subsections.

2. CORRELATION OF THE LITTLE BAY HEAD SECTION WITH OTHER ROCK UNITS

The original Lush's Bight section was described by Espenshade (1937, p. 13) as the upper part of the so-called Pilley Series, the type section being located on Long Island. Espenshade interpreted the Lush's Bight Group as conformably overlying the Cutwell Group of intermediate volcanics, and minor clastics and carbonates. Williams (1962, p. 6) showed that in fact the Cutwell Group is actually faulted against the Lush's Bight Group and that the conformable succession designated the Pilley Series does not exist as originally stated. McLean (1947, p. 5) tentatively equated the Lush's Bight section on Sunday Cove Island with the Hall's Bay Head section along strike to the west. This in turn he correlated with the Western Arm Section on the basis of lithological similarity. Interpreting the contact between the Western Arm and Little Bay Head sections as gradational, he suggested that the latter also be designated "Lush's Bight." Marten (1971) has re-examined the relationships between the Western Arm and Little Bay Head sections and supports McLean's interpretation. The relationship between the two sections is not conclusively established, however. In fact, McLean seriously considered renaming the Little Bay Head section as a separate formation (D. A. Bradley, personal communication). Because the rocks of the Little Bay Head section in the King's Point area face south, and the rocks of the Western Arm section and part of the Little Bay Head section (Marten, 1971) face north, it is the writer's opinion that until the structural relations between these areas are clearly established the exact relationship of the two sections must remain in doubt. Marten (1971) has formally proposed that the Western Arm section be renamed the Western Arm Group.

The Lush's Bight Group was stated by McLean (1947, p. 4) to be Lower Ordovician (Canadian) in age on the basis of a single fossil brachiopod of the subfamily Acrothelinea and genus discotreta found in the Western Arm section. The Lithologic similarity of the Little Bay Head section to the Western Arm section, and to Ordovician volcanics elsewhere in Newfoundland (notably the Snooks Arm Group to the north - see regional map), suggests a Lower Ordovician age for the Little Bay Head section as well, though the stratigraphic relationship of the section with the other volcanic rocks in the area is largely unknown.

At the northern boundary of the map-area the Little Bay Head section is separated from a section of red sandstones and shales by the east-west trending South Brook fault. At the southern boundary, the Catcher's Pond fault separates the Little Bay Head rocks from the Springdale Group of conglomerates, sandstones, and intermediate to acid volcanics.

The rocks south of the Catcher's Pond fault were originally named the "Springdale Formation" by Espenshade (1937, p. 11) who intended the unit to include only the red sandstone and conglomerate portions of the present section around the town of Springdale. McLean (1947, p. 6), who changed the name to "Springdale Group", and Kalliokoski (1953) extended the section to include some 10,000 feet of volcanic rocks south of Indian Brook, bringing the total thickness to about 13,000 feet.

The Springdale Group is generally considered to be Silurian in age. The group bears a lithological similarity to the fossiliferous Botwood Group of eastern Notre Dame Bay (McLean, 1947, p. 7) which is Silurian. The available magnetic evidence indicates that the Springdale Group rocks south of the town of Springdale are copolar with those of the Botwood Group (Neale, 1962, unpublished manuscript, from Black, 1962).

Joseph (1962) has equated the Springdale section near the town of Springdale with the section of red beds exposed at the head of Southwest Arm because of close similarities in composition, grain size distribution, and poles of remanant magnetism.

3. PREVIOUS PETROGRAPHIC WORK ON THE LITTLE BAY HEAD SECTION

The rocks were first described in detail by H. J. McLean who concluded that they were olivine basalts on the basis of one published chemical analysis (1947, p. 15). He noted that the lavas were non-vesicular, and in places markedly variolitic, usually in "a 1-to-3 inch zone around the periphery of the pillow" (1947, p. 15). McLean found little evidence of original textures and structure, though in a few cases he recognized original trachytic flow structure and intergranular texture.

E. R. W. Neale (1962, unpublished manuscript) recognized the same textures as McLean, and further considered that "in all except highly altered varieties, traces of the original textures remain." On the basis of two additional chemical analyses, he concluded that the rocks were best classified as being restricted "to the andesite-basalt range." In addition, Neale recognized that the "agglomerates" described by McLean are in fact pillow breccias in the sense that Henderson (1953) used the term (equivalent to the term "isolated pillow breccia" as used in this dissertation).

Papezik and Fleming (1967) carried out a detailed petrographic and chemical study of the Little Bay Head section rocks in the vicinity of Whalesback pond to the northeast of the map-area. They concluded that there are two distinct and fairly readily separable groups of basic lavas in the area. These they designated the Whalesback and St. Patrick types. The former are "light greenish-grey pillow lavas, relatively high in Ca, which are classified as tholeiitic basalts", and the latter are "dark greenish-grey rocks relatively rich in Na which are classified as spilites on the basis of comparison with an average of 105 analyses of spilitic rocks" (Papezik and Fleming, 1967, p. 181). Some seventeen analyses were added to those already published. Analyses of average Whalesback and St. Patrick volcanics, and an average spilite as calculated by Papezik, are presented in table 1. The authors believed that the types could be separated in the field and that such a separation could assist in elucidating the structure in the area. No such separation was attempted in the King's Point area by the writer.

	A	B	C
SiO_2	50.83	53.13	49.73
TiO_2	0.75	1.13	1.55
Al_2O_3	15.54	15.07	15.92
Fe_2O_3	3.11	2.94	3.79
FeO	6.94	8.92	6.48
MnO	0.17	0.17	----
MgO	7.30	5.27	5.00
CaO	9.33	5.60	6.44
Na_2O	2.70	4.15	4.30
K_2O	0.12	0.06	1.24
P_2O_5	0.12	0.18	0.39
CO_2	0.30	0.57	2.20
H_2O (total)	2.79	2.81	2.96

Table 1: average compositions of (A) "Whalesback volcanics", (B) "St. Patrick volcanics", and (C) spilites (105 analyses calculated by V. S. Papezik). After Papezik and Fleming, 1967, p. 188.

4. PREVIOUS STRUCTURAL WORK IN THE LITTLE BAY HEAD SECTION

McLean (1947, p. 3) acknowledged that "the stratigraphy and structure of the [Lush's Bight] group are not clear." He stated (1947, p. 9) that the rocks are "northeastward trending, steeply dipping, closely folded ... with overlying basins of gently folded Silurian (?) sediments and volcanics." The structural sections accompanying his report illustrate the Little Bay Head section rocks as homoclinal sequences dipping steeply to the northwest. The writer assumes, therefore, that McLean considered the scale of the structures to be very large.

McLean recognized the presence of abundant faulting within the Little Bay Head section, and the presence within each fault slice of "numerous lenses of chlorite schist, which die out along strike." He considered that in fact these were shear zones "produced by differential movement between the flows, which controlled the direction of shearing" (1947, p. 9). McLean noted further that these schist zones were absent in the Western Arm section and in the Springdale Group.

Kalliokoski (1953), who mapped the Springdale area south of the writer's map-area, did not investigate the Little Bay Head section but noted the simple structural style of the neighbouring Ordovician (?) rocks of the Roberts Arm Formation, stating that "the structure of the ... rocks appears to be homoclinal with the oldest beds to the east" (1953, p. 3).

Neale and Nash (1962) included all of the writer's map-area in their map of the Sandy Lake (east half) area. They concluded that "the Lush's Bight Group is tightly folded and there has been more repetition of beds than recognized by McLean" (Neale and Nash, 1962, p. 11). Their published map includes a number of synformal and antiformal fold axial plane traces in the Little Bay Head section, which trend east-northeast. These were defined on the basis of top directions derived from pillow structures (E. R. W. Neale, personal communication).

Neale's investigation of the King's Point East area in 1959 and 1961 included part of the Little Bay Head section and all of the writer's map-area. He maintained the same conclusions as regards the internal structure of the section. In addition, he noted a structural discordance across some of the faults cutting the section, and suggested some amount of rotation across the fault planes as an explanation for this (E. R. W. Neale, 1962, unpublished manuscript).

F. PURPOSE AND SCOPE OF PRESENT INVESTIGATION

The map-area was investigated during the summer of 1970 at the suggestion of Brinex for the purpose of clarifying the structural and stratigraphic relationships within the Little Bay Head section. The King's Point area was chosen because it contains a thick clastic section and good outcrop distribution compared with much of the rest of the area underlain by Little Bay Head section rocks. This dissertation is a general structural, stratigraphic, and, to a lesser extent, petrological description of that area.

G. ACKNOWLEDGEMENTS

The writer gratefully acknowledges the assistance of Drs. M. J. Kennedy and E. R. W. Neale of Memorial University during their visits in the field and in subsequent discussions; and the constructive interest taken in the project by Mr. H. R. Peters and Dr. D. A. Bradley of Brinex.

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The writer is also indebted to the technical staff of Memorial University. Foster Thornhill, Lloyd Warford, and Albert Morgan prepared the thin and polished sections used in the study. Wilfred

Marsh produced the photographic plates presented in this dissertation.
Mrs. G. Andrews performed the analyses presented in table 2.

II. PETROLOGY OF ROCK UNITS

A. LITTLE BAY HEAD SECTION

1. DISCUSSION OF TERMINOLOGY

The writer's interpretation of the manner of deposition of the Little Bay Head section rocks in the King's Point area draws heavily on the work of D. Carlisle (1963) who investigated similar volcanics of Triassic age on Quadra Island, British Columbia. Carlisle recognized repeated successions in the rocks there, from ordinary pillowed lava at the base up to isolated pillow breccia and then to broken pillow breccia at the top; the successions being up to 600 feet thick and commonly followed by massive flows.

Carlisle defines "ordinary pillow lava" as "the typical close-packed or fairly close-packed accumulations of unbroken pillows - a rock generally with less than ten per cent matrix" (Carlisle, 1963, p. 49). Pillow breccias are rocks which are "in part pillow or pillow derived and in part cogenetic basic tuff or lapilli tuff" (ibid., p. 48). Where the distinction between pillow breccia and pillowed lava is not clear, the rock is classified as the former if the matrix amounts to more than ten per cent of the rock. Isolated pillow breccia is that kind in which "irregularly shaped but unbroken pillows are widely separated from each other by tuff-aceous matrix" (ibid., p. 49). Broken pillow breccia "consists largely of disaggregated fragments of pillows set in the matrix" (ibid., p. 51).

The matrix is termed aquagene tuff, a genetic term implying that the tuff "has been produced through globulation or granulation through quenching, or both ... entirely beneath water or when lava has flowed into water or beneath ice" (ibid., p. 61). "Aquagene tuff" is distinguished from "subaqueous tuff", a term generally applied to water-lain subaerial tuff. Carlisle stated (1963, p. 67) that the matrix material, which is very homogeneous, sometimes grades directly upwards through loss of clasts into well-laminated aquagene tuff which may show excellent graded bedding.

The case which Carlisle described is representative of a typical depositional mode of submarine volcanics. For this reason the writer has used Carlisle's general observations as a guide for the interpretation of the Little Bay Head section in the King's Point area. Metamorphism has obscured, for the most part, the microscopic features of the tuffs and pillow breccia matrices, so that the rocks have had to be named on macroscopic considerations alone. Thus the writer considers a pillow breccia to be one in which recognizable pillows or pillow fragments are set in a matrix consisting of over ten per cent of the rock unit in question, whatever the present appearance of that matrix may be. The tuffs are considered to be aquagene because of their lateral facies relationship with pillowed lavas and pillow breccias, which are taken to be submarine in origin.

2. LITHOLOGY OF THE LITTLE BAY HEAD SECTION

a) NORTHERN UNIT

The northern unit (see figure 2) lies between the South Brook fault to the north and an interpreted thrust fault of unknown displacement which passes through Bean Pond to the south.

The unit is dominantly one of medium-green close-packed pillowed lavas. Most of the pillows are lenticular and are now enclosed within individual shells of schist as the result of deformation (plate Ia). This schist masks the nature of the skins and interstices of the pillows, and makes top determinations generally impossible. In a few places the pillows seem relatively undeformed, and show well-defined chilled margins up to 1/2 inch thick, concentric arrays of amygdules which are more abundant towards the margins, and, locally, crude concentric jointing (plate Ib). The pillows vary in size up to maximum dimensions of about three feet by four feet.

In thin section the pillows are for the most part composed of unoriented to poorly oriented laths of clinochlore and grains of epidote, which are commonly turbid as the result of patches of finely granular sphene. Fibrous actinolite is present in minor quantities. Less common are original clinopyroxene grains which have been corroded and partly replaced by clinochlore, epidote and feldspar; and, in places,

a: Intensely deformed pillow in northern unit. Hammer scale.

b: Undeformed pillow in northern unit. Brunton scale points north.

relict plagioclase grains which exhibit a variolitic tecture. Pyrite is universally present in small amounts as euhedral to subhedral grains. Quartz is rare.

The amygdule fillings are generally fibrous actinolite, though clinozoisite, calcite, and feldspar were also observed (plate II).

The unit contains an isolated pillow breccia with approximately 30 per cent matrix component. A few bands of aquagene tuff, locally with graded bedding (plates IIIa and IIIb) occur near the top of the section. These tuffs seem more abundant towards the west, suggesting a lateral facies change in that direction, but this remains uncertain because of scarcity of exposure in that area.

b) CENTRAL UNIT

This unit is composed almost entirely of medium to light green pillow breccias, with a poorly defined gradation from isolated pillow breccia (plate IVa) near the base of the section to broken pillow breccia (plate IVb) near the top. In places the matrix of the isolated pillow breccia is itself a broken pillow breccia (plate Va). The tuffaceous matrix is generally more resistent to weathering than the pillow component. Joint sets which are consistent from pillow to pillow are sometimes indistinct or nearly lacking in the matrix (plate Vb). The pillows generally have pale green amygdaloidal chilled margins about 1/2 inch thick. In places the amygdules are arranged in poorly developed concentric rings about the core of the pillows. The percentage of matrix component is variable but is generally greater near the top of the section.

The lithic fragments in the matrix generally occur as fine-grained mosaics of turbid epidote with small amounts of accessory minerals. The matrix is composed of chlorite minerals and rare relict feldspar laths, with small amounts of fibrous actinolite, turbid epidote, and leucoxene. Clastic pyroxene crystals are rare. Pyrite is present as scattered euhedral to subhedral grains, and calcite occurs as a vein mineral.

Thin, poorly-bedded tuff bands are located near the south shore of Icepack Pond and the west shore of Octopus Pond. Aquagene tuffs appear to become more abundant westward, indicating a lateral facies change from pillow breccias in the east.

The pillow breccias undergo a lateral facies change eastwards into pillowed lavas near the eastern boundary of the map-area. The central unit is thrust-faulted against the southern unit. Where it was observed, the fault zone dips 28° north and is a zone of cataclasis approximately ten feet thick.

Photomicrograph - Amygdules of clinozoisite and calcite in pillow. X nicols. 192x

PLATE III

a: Graded bedding in tuff north of Bean Pond. Hammer handle scale points south; tops are to the south.

b: Graded bedding in tuff near Harry's Brook. Hammer handle scale.

a: Isolated pillow breccia from central unit. Hammer handle scale points north.

b: Broken pillow breccia from central unit. Lens cap scale.

PLATE V

a: Isolated pillow breccia with broken pillow breccia matrix from central unit. Hammer scale.

b: Isolated pillow breccia from central unit; jointing well-developed in pillows but absent in matrix. Brunton scale points north.

c) SOUTHERN UNIT

In the western part of the map-area, the southern unit is composed of aquagene tuffs. These interdigitate eastwards with massive medium-green flows, which in turn interdigitate with pillowed lavas (similar to those of the northern unit) near the eastern boundary of the map-area.

The original subvariolitic textures of the flows can be seen in thin section because the plagioclase laths, although turbid as the result of alteration, are generally preserved. The mafic components are virtually completely altered to epidote, chlorite minerals, and leucoxene. One thin-section shows a number of epidote grains with common extinctions which are apparently pseudomorphing a pyroxene crystal.

The original nature of the clasts comprising the tuff is obscured by their small size and the low-grade metamorphism of the rock. In some outcrops the tuffs are uniform in appearance with only faint laminations to mark bedding. Ellipsoidal sand-size clasts can be distinguished on the weathered surfaces of these and amount to up to 30 per cent of the rock. In thin section these are irregular, equidimensional patches of fibrous actinolite, prehnite, and epidote in varying proportions, and are interpreted to represent completely altered clasts of pyroxene, relicts of which can be seen in a few places (plate VI). Feldspar crystal fragments are also present here and there. For the most part, the tuffs have been entirely recrystallized into turbid epidote, chlorite minerals, fibrous actinolite, and leucoxene.

More commonly the tuffs are thinly but irregularly banded with rare lenses of grey magnetic chert or red argillite (plate VII) seldom exceeding one foot in length or one inch in thickness. In places bombs (?) are found in the tuffs, and slumping features are visible in some beds (plates VII and VIII), the chert and argillite lenses being broken and slightly displaced in their beds. Graded bedding with respect to altered pyroxene (?) crystal clasts is present in a few places, but is never well developed.

Magnetite-rich tuffs are fairly common. One outcrop in the western part of the unit contains an inch-thick band of magnetite crystal tuff (plate IX). The magnetite bed is in sharp contact with the surrounding beds of magnetite-feldspar-pyroxene crystal-lithic tuff. Whether the magnetite grains, which comprise about 80 per cent of the bed, are the result of an episode of magnetite volcanism or of sorting during sedimentation is not certain from textural evidence. The grains are poorly sorted up to a maximum dimension of 0.01 mm. and are subangular. Surfaces reminiscent of crystal faces are only rarely visible (plates Xa and Xb).

It is doubtful whether any of the tuff beds can be used as a stratigraphic marker because rapid lateral facies changes are to be expected in tuffs of an aquagene nature. In addition, the scarcity of outcrop would make any thin marker horizon difficult to follow.

B. SPRINGDALE GROUP

Rocks of the Springdale Group are exposed to the north of the map-area and in the Catcher's Brook - Indian Brook area.

South of Catcher's Pond the Springdale Group comprises a broad syncline plunging gently to the southeast (McGonigal, 1971, in preparation). The section is dominantly one of welded volcanic conglomerates, followed in stratigraphic order by sedimentary conglomerate, intermediate to basic lavas, and pyroclastics. At the head of Southwest Arm the section contains coarse conglomerate and sandstone grading upwards into cross-bedded sandstone and siltstone with interbedded thin calcareous units, the total thickness being about 2500 feet (Joseph, 1962, pp. 12-14).

Photomicrograph - Relict pyroxene clasts in aquagene tuff from southern unit. X nicols. 192x

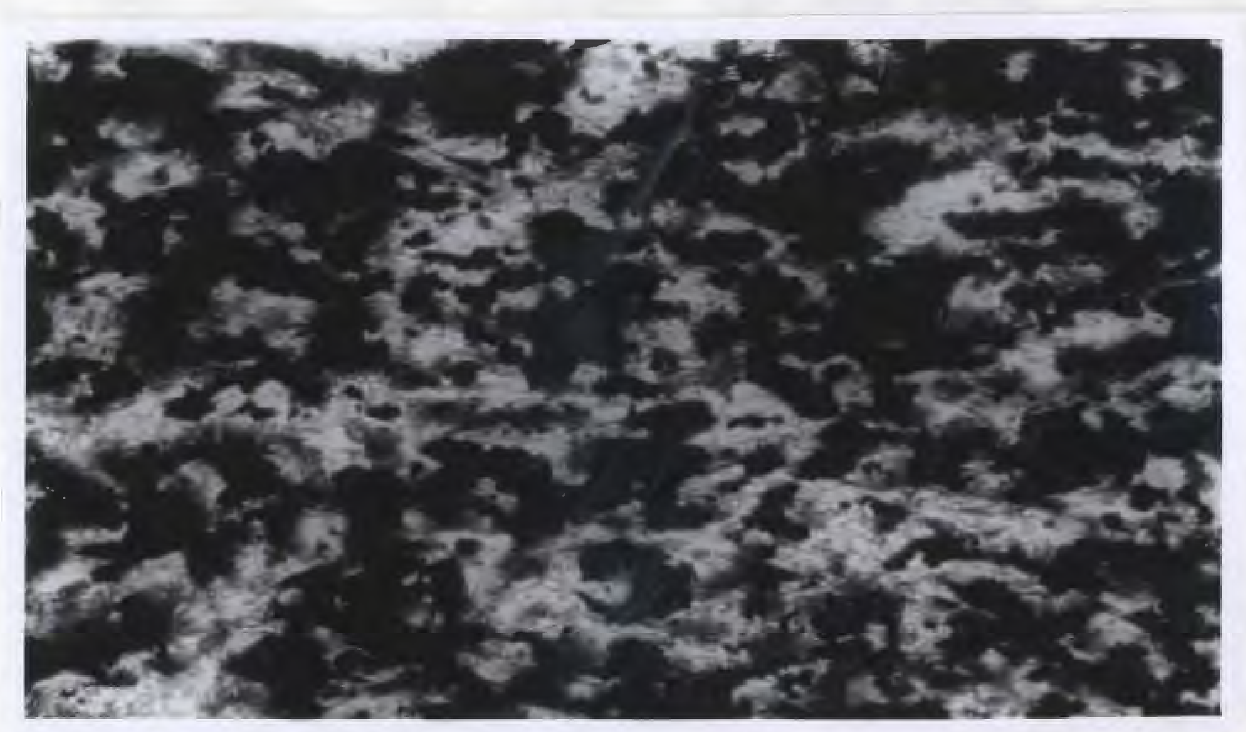
Aquagene tuff with bombs (?) of volcanic rock. Lenses of grey chert located just above and to left of Brunton scale, which points north.

PLATE VIII

Close-up of bombs (?) in aquagene tuff (Plate VII) to show slumping features. Lens cap scale.

Layer of magnetite crystal tuff in aquagene crystal-lithic tuff.
Brunton scale points north.

a: Photomicrograph - Magnetite crystal tuff (Plate IX) showing depositional layering. Plane light. 150x.



b: Photomicrograph - Magnetite crystal tuff. Plane light. 2385x.

C. INTRUSIVE ROCKS

The Little Bay Head section in the map-area has been intruded by gabbroic dykes and sills, by a small ultrabasic pluton, and by a number of small bodies of rhyolite porphyry.

1. GABBRO

The gabbroic intrusions are now largely altered to greenschist facies minerals and are similar to the flows of the southern unit in most respects except grain size. Pyroxene grains are generally preserved and the feldspar is extensively altered to (?) epidote. The freshest gabbros show a relict hypidiomorphic granular texture in thin-section. Alteration is similar to the flows with turbid epidote, fibrous actinolite, sphene, and lesser amounts of chlorite as the alteration minerals. Very small quantities of quartz were observed in some thin-sections. Three analyses were made of the intrusives by atomic absorption spectroscopy using specimens from the map-area. The results (see table 2) compare well with Papezik's and Fleming's (1967) average "Whalesback volcanics" (table 1) and supports their identification of the gabbro intrusions with the tholeiitic pillowed lavas (Papezik and Fleming, 1967, p. 185).

	A	B	C
SiO_2	49.2	48.5	47.6
TiO_2	0.77	0.72	0.93
Al_2O_3	13.2	15.6	16.8
Fe_2O_3	11.7	8.9	11.9
MnO	0.19	0.14	0.19
MgO	8.52	8.73	6.43
CaO	9.27	10.00	9.57
NaO_2	2.29	2.43	1.97
K_2O	0.13	0.32	0.31
loss on ignition	3.91	3.63	3.43
TOTAL	99.18	98.97	99.13

Table 2: Analyses of representative samples of gabbro intrusions from King's Point area:

A (sample JRD-70-6) approximately 200 feet south and 500 feet west of the west end of Bean Pond.

B (sample JRD-70-19) approximately 3300 feet north of the middle of East End Pond.

C (sample JRD-70-97) approximately 2200 feet southeast of the east end of Icepack Pond.

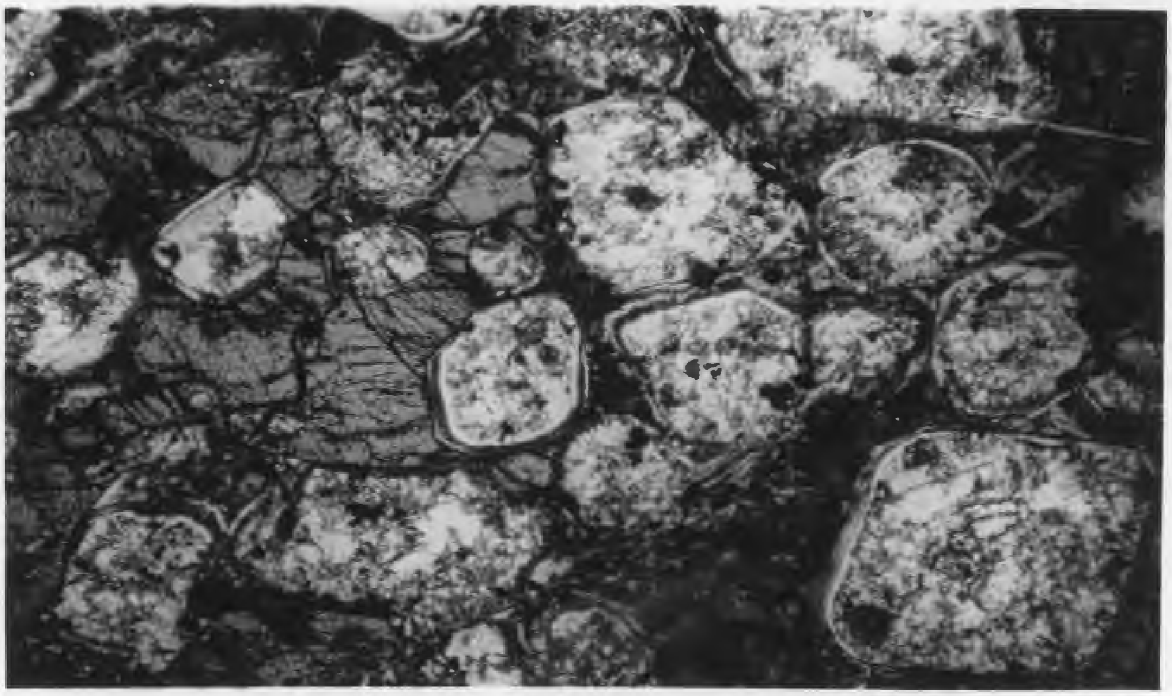
Analyses performed by Mrs. G. Andrews of Memorial University using a Perkin-Elmer 303 atomic absorption spectrophotometer.

The smaller dykes are aphanitic, and a continuous gradation in grain size is present up to the medium-grained rocks of the larger plutons. A weak tectonic fabric is present. Where contacts could be observed the regional foliation was always penetrative into the dyke rock.

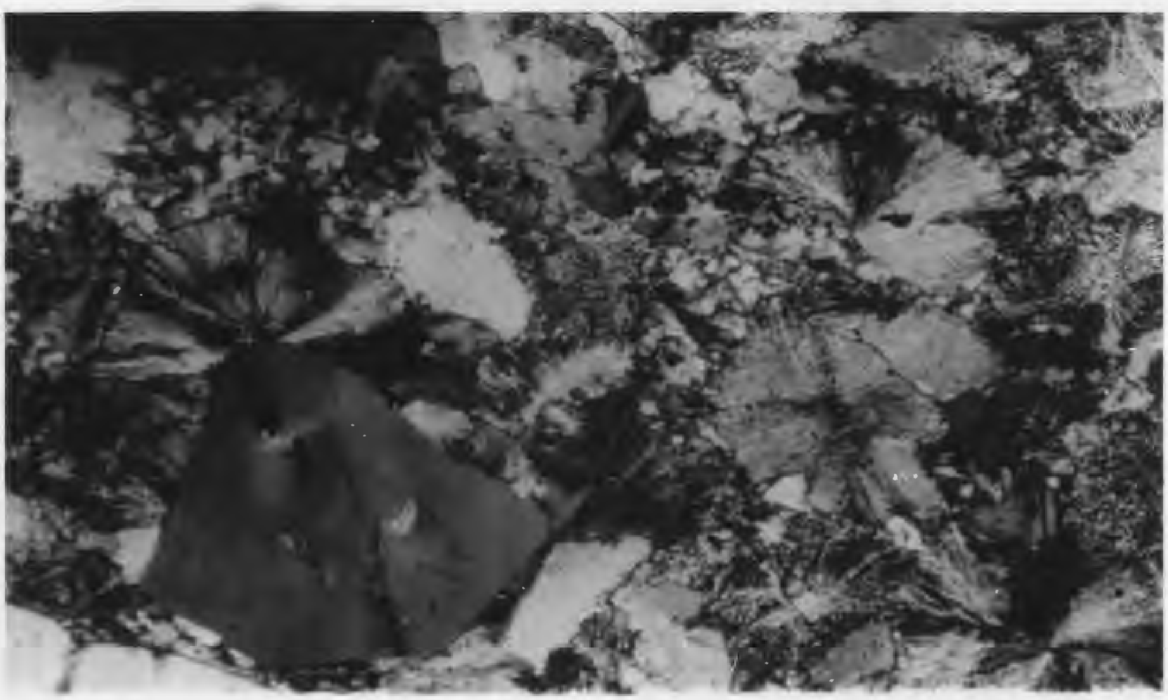
2. PERIDOTITE

A small plug of magnetite-rich peridotite is located on the east shore of Pit Pond. Only two exposures are present and the contacts of the pluton with the country rock are not visible.

Equidimensional, well-rounded olivine grains up to 1 mm. in diameter comprise about 50 per cent of the rock. These are now almost entirely altered to serpentine and have been apparently mechanically rounded (plate XIa). The olivine grains crystallized first in the cooling history of the rock and yet crystal faces are almost entirely absent in their well-preserved outlines. No cumulate layering was visible in outcrop or in thin section. The grains are set in a matrix of clinopyroxene and orthopyroxene in unknown proportion which are largely altered to turbid epidote. Magnetite is an abundant primary and secondary accessory mineral. No tectonic fabric is apparent. Table 3 is an interpreted modal analysis of the rock:



a: Photomicrograph - Serpentinized peridotite from intrusion on east shore of Pit Pond. X nicols. 150x.



b: Photomicrograph - Variolitic texture in groundmass of rhyolite porphyry. X nicols. 240x.

olivine + alteration products	55.2%
pyroxene + alteration products	35.7%
magnetite (in part secondary)	9.1%
TOTAL	100.0%

Table 3: Modal analysis of ultrabasic pluton in interpreted unaltered state.

3. RHYOLITE PORPHYRY

The tuffs of the southern unit are intruded by a number of quartz - feldspar porphyry bodies. These are mineralogically unaltered and totally lacking in tectonic fabric. They must have been emplaced before the development of the Catcher's Pond fault since that structure truncates and brecciates one of the porphyry bodies (see map).

Subhedral quartz phenocrysts with maximum dimensions of up to 2 mm. comprise approximately 20 per cent of the rock. Subhedral orthoclase and plagioclase (An 35) phenocrysts up to 2 mm. across comprise about 10 per cent. The groundmass is in part variolitic with respect to feldspar (plate XIb) and is almost entirely a very fine-grained mosaic of quartz and feldspar. Hornblende is a minor accessory mineral.

III. STRUCTURAL GEOLOGY

The Little Bay Head section in the King's Point area has undergone three major deformations which have produced mesoscopic structures or fabrics, though it is rare for all three to be identifiable in any one exposure. For shorthand purposes these will be designated D, S, and F (deformation, schistosity, and fold) followed by subscripts 1, 2, and 3 (first, second, and third).

A. STRUCTURES RELATED TO REGIONAL SCHISTOSITY

In all exposures of Little Bay Head section rocks a penetrative fabric can be identified, at least in thin section, as a chlorite LS or S fabric (Flinn, 1965).

Both the schistosity and the bedding dip to the north, and everywhere in the map-area the former dips less steeply than the latter. This supports the interpretation that the section faces southward everywhere in the map-area and that there has been no repetition of section by folding. Cleavage and bedding have approximately the same strike, and no precise conclusion as to the inclination of their line of intersection was reached.

If the regional foliation is assumed to be axial planar to folds, then the Little Bay Head section in the King's Point area comprises the south limb of a southward-facing anticline whose axial plane dips steeply northward. Small folds related to the same fabric in the Little Bay Head rocks of the Colchester area to the northeast (U. A. Sayeed, 1970) are apparently parasitic to the major structure. No other limbs of the major fold have been positively identified as yet, and they may have been at least partly removed by faulting. The rocks of the Western Arm Group face north (Marten, 1971), and may be on the northern limb of the fold.

B. STRUCTURES RELATED TO SCHIST ZONES

1. DESCRIPTION OF SCHIST ZONES

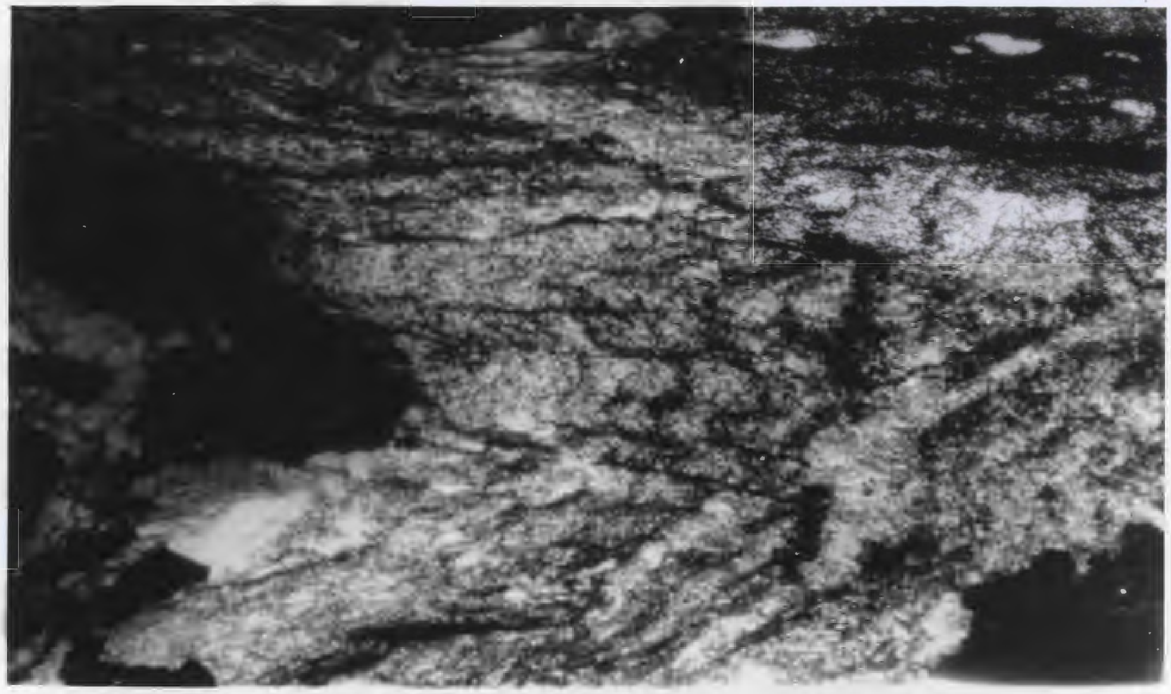
The portions of the section which the writer has designated "schist zones" occur in apparently long lenticular bands approximately parallel to bedding (see map). Where Fleming (1971) mapped similar zones to the northeast of the map-area in detail, he showed them to be slightly sigmoidal in plan and to pinch out along strike over the space of a few hundred feet.

In thin-section the fabric is a strain-slip schistosity intersecting an earlier preferred mineral orientation fabric. Where the strain-slip schistosity is well developed (in the mineralized schist zones), the transposition of the preferred mineral orientation into the strain-slip bands is apparent. Both symmetrical and asymmetrical folding of the earlier fabric have been observed in thin-section (plate XII), resulting in the development of minor folds in a few places. Magnetite is concentrated along the strain-slip planes.

Where the strain-slip cleavage is weakly developed, it is seen as a series of epidote-magnetite bands approximately 1 mm. apart (though not regularly spaced) which cross the weakly developed pre-existing foliation at angles of not more than about ten degrees and without apparently folding it (plate XIII). The sense of intersection of the two foliations is not clear because their relative orientations are variable. Similar fabric relations have been observed at a few localities outside the major schist zones where weakly developed strain-slip bands pass through rock which is otherwise typical of the regionally foliated Little Bay Head section.

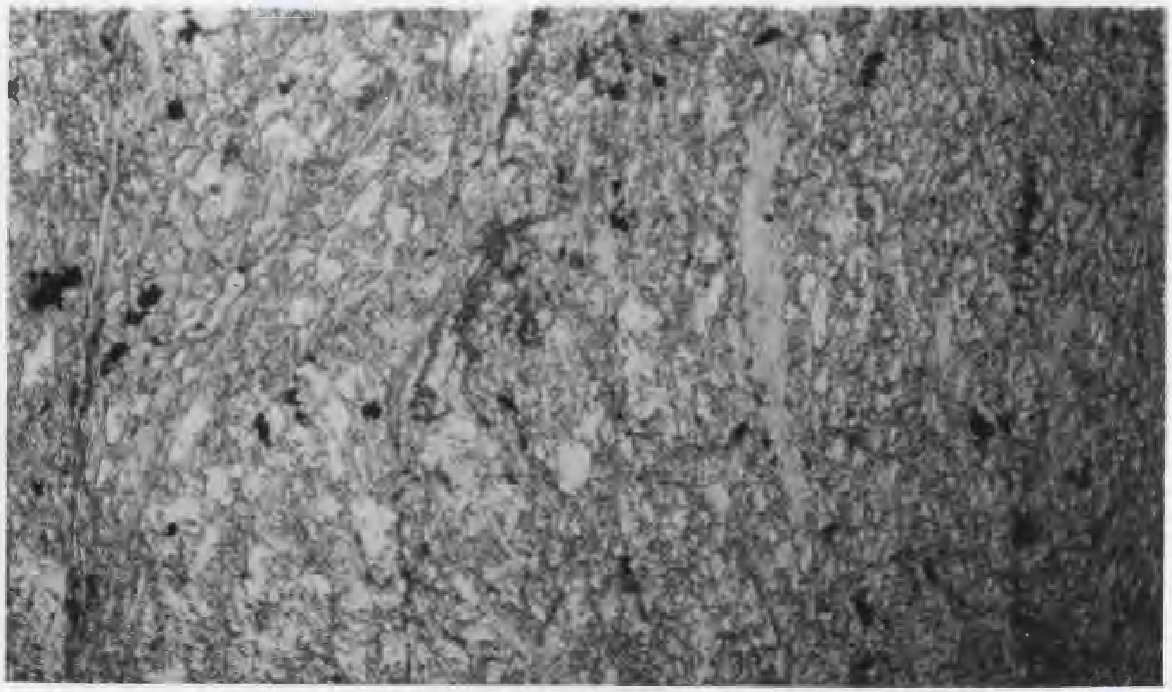
2. STRUCTURAL SIGNIFICANCE OF SCHIST ZONES

The schist zones are zones of inhomogeneous strain. This is

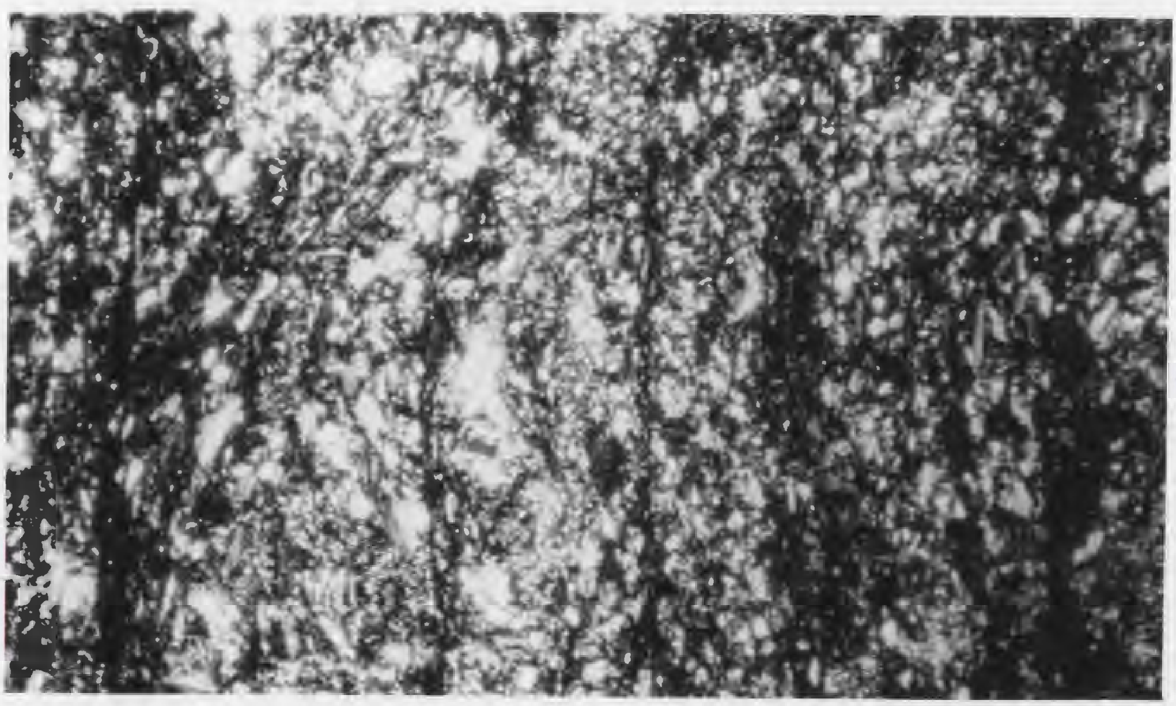


a: Photomicrograph - Symmetrical and asymmetrical folding of early schistosity with axial planar strain-slip schistosity. Plane light. 378x.

b: Photomicrograph - Same as plate XIIa: X nicols.



a: Photomicrograph - Fabric relations in unmineralized schist zone. Plane light. 240x.



b: Photomicrograph - Same as plate XIIIa; X nicols.

apparent because they are characterized by the presence of two fabrics - hence two deformations - while the surrounding rock has only one. One of the fabrics in the zones can be considered equivalent to the regionally developed fabric, while the other must represent an episode of inhomogeneous strain. Planar zones of this type that localize high strain states are termed "shear belts" (Ramsay and Graham, 1970, p. 786). These are structures which represent deformation by simple shear, but which are distinct from faults in that the textures in the zones are produced by flattening rather than by shear (Flinn, 1962, p. 483; Ramsay and Graham, 1970, p. 803).

In the case of a shear belt developed in unfoliated rock, the schistosity which defines the shear shows that the plane of flattening is not parallel to the walls of the shear. The schistosity is inclined to the shear belt at about 45 degrees at the margins. Towards the centre of the shear it becomes stronger and makes an angle of less than 45 degrees with the walls, approaching parallelism with the walls at large strains (Ramsay and Graham, 1970, p. 803). Shear belts are better considered, therefore, as zones of deformation or "ductile faults" (ibid., p. 799) rather than as faults in the traditional sense of the word.

In the King's Point area, the schist zones are the result of two deformations rather than only one, but can still be considered shear belts because they meet the above criterion - that is, they are planar zones which localize high strain states. A preferred mineral orientation fabric is developed regionally, and within the zones a preferred mineral orientation fabric is folded between strain-slip planes. What must be determined is the ages of the fabrics inside the zones relative to that outside.

The schist zones are D_2 relative to the regional schistosity if the earlier fabric within them is equivalent to that outside. If this were the case the shear belts would have developed subsequent to the development of a regional mineral orientation fabric. The rock would then have been structurally inhomogeneous before shearing, and the texture produced in the development of the shear belts would have been a strain-slip schistosity with the pre-existing mineral orientation schistosity folded between the strain-slip planes.

The schist zones are D_1 relative to the regional schistosity if the earlier fabric within them predates the fabric outside the zones. If this were the case, subsequent deformation would have affected the foliated rocks of the shear belts differently than the unfoliated rocks outside, and the strain-slip schistosity within the schist zones would be related to the same deformation as the mineral orientation fabric outside.

No convincing argument for either case is provided by the known presence of a rare, weakly-developed strain-slip schistosity in the foliated country rocks. This could be explained either as the presence of incipient D_1 shear belts or as the incipient refoliation of the regional preferred mineral orientation fabric. More detailed work would be necessary to determine which is the case from field evidence.

While the orientations of the zones relative to the regional foliation is not in general well-known, it has been observed that the strain-slip schistosity in the zones has the same trend as the fabric outside. This is consistent with the zones being D_1 and not with their being D_2. Rotation of strain-slip planes developed during deformation of a rock with a pre-existing preferred mineral orientation fabric is into a plane perpendicular to the principal stress direction (Turner and Weiss, 1963, p. 465). This orientation is shared by the schistosity developed in unfoliated rock during the same deformation. If, on the other hand, the strain-slip schistosity had been imposed on an already regionally foliated rock, the later fabric would necessarily be inclined at an angle of up to 45 degrees to the regional mineral orientation schistosity (see figure 2). This is apparently not the case, and the evidence available therefore supports the interpretation that the schist zones represent first deformation shear belts. It must be emphasized, however, that these shear belts are more complex than those discussed by Ramsay and Graham (1970) because they have had a subsequent deformation superimposed upon them.

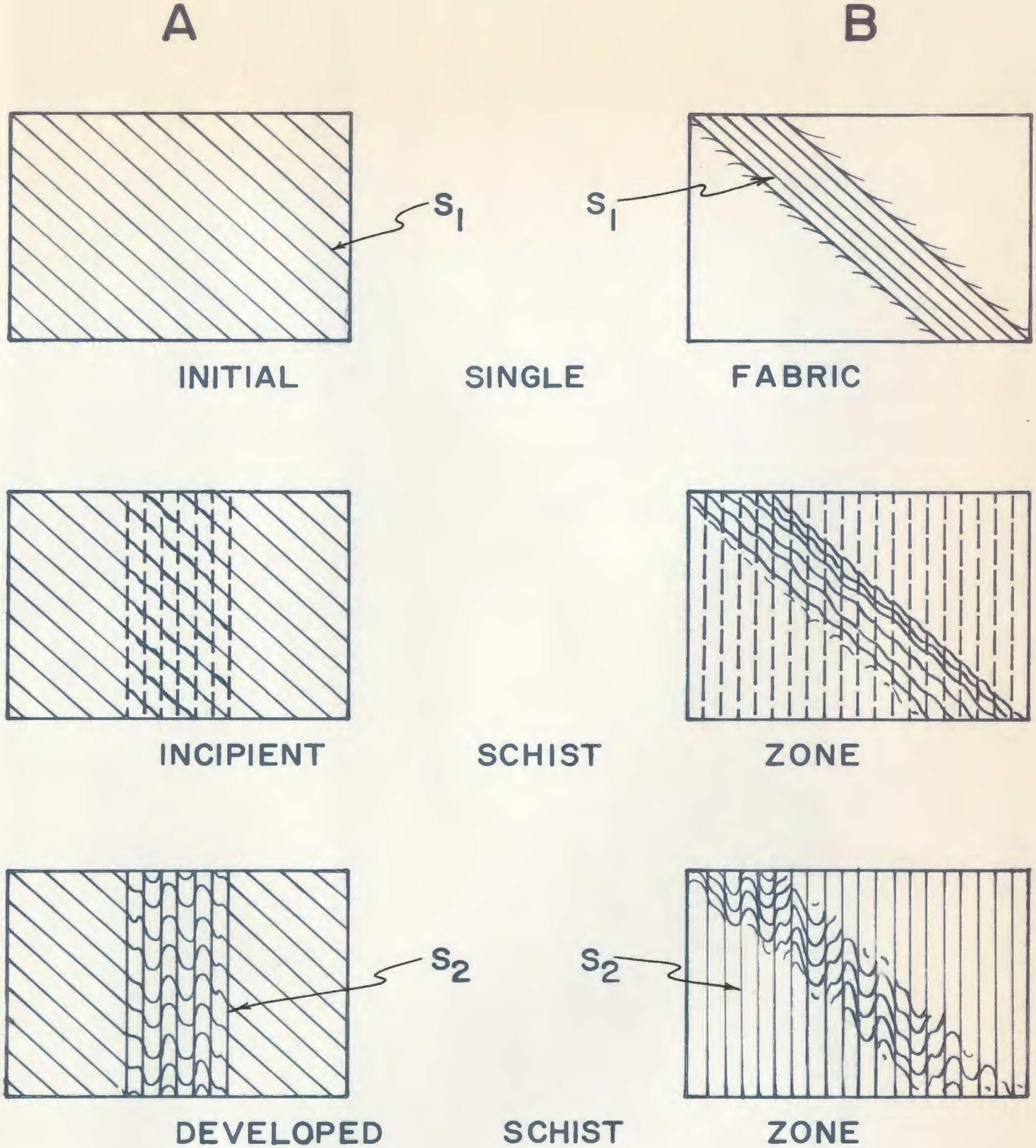


Figure 2: Fabric relations to be expected in the development of schist zones if (A) the zones are D_2 and (B) the zones are D_1. First and second schistosities indicated as S_1 and S_2 respectively for each case.

C. POST D_2 - PRE D_3 STRUCTURES

Subsequent to the development of the schist zones, north-south trending faults were developed, one of which apparently truncates the schist zones in the vicinity of Ovals Brook and displaces the section there about 500 feet sinistrally. The dip-slip component of displacement is not known; no fault planes were observed directly.

Truncating the air-photo linears marking these faults are two east-northeast trending thrust faults which pass through Bean Pond to the north and through East End Pond to the south. Where the thrust fault plane of the southern fault was observed just west of Young Pond it was a zone of cataclasis about ten feet thick and dipping 28° north. The trace of the fault appears to be folded by later (F_3) structures. The northern fault is interpreted as being present and a thrust because the well developed air-photo linear which marks it shares the same strike as the one to the south, and because in the vicinity of Bean Pond there is an abrupt change in rock type across the linear, but without apparent strike-slip displacement of rock units.

In one place in Ovals Brook, fine, flat-lying crenulations with flat axial surfaces were observed which fold both pre-existing foliations in a schist zone. These are assumed to be pre D_3 in age, though this remains unproven since their intersection with D_3 kink bands was not observed.

D. D_3 STRUCTURES

An open synform with a vertical axial plane and an axis plunging 65° north is located in the western part of the map-area (see map). Related minor structures are a coarse, poorly-developed axial planar fracture cleavage, kink bands, and tension gashes, though these were not investigated in detail. The fold axis is defined on a stereonet plot of poles to regional foliation (figure 3).

Smaller folds of the same orientation and age are known underground at the Little Deer mine to the northeast (J. E. James, personal communication), and there is some evidence of an antiformal closure of the F_3 fold in the King's Point area to the west of the map-area as the result of mapping carried out by J. Cant of Brinex in the summer of 1970. Microscopic F_3 folds with associated kink bands were seen in thin-sections from mineralized schist zones within the map-area (plate XIV). The writer therefore interprets the major fold as being related to a major regional straining episode.

E. POST D_3 STRUCTURES

At least three sets of post D_3 faults are known in the schist zones to the northeast at Little Deer (J. E. James, personal

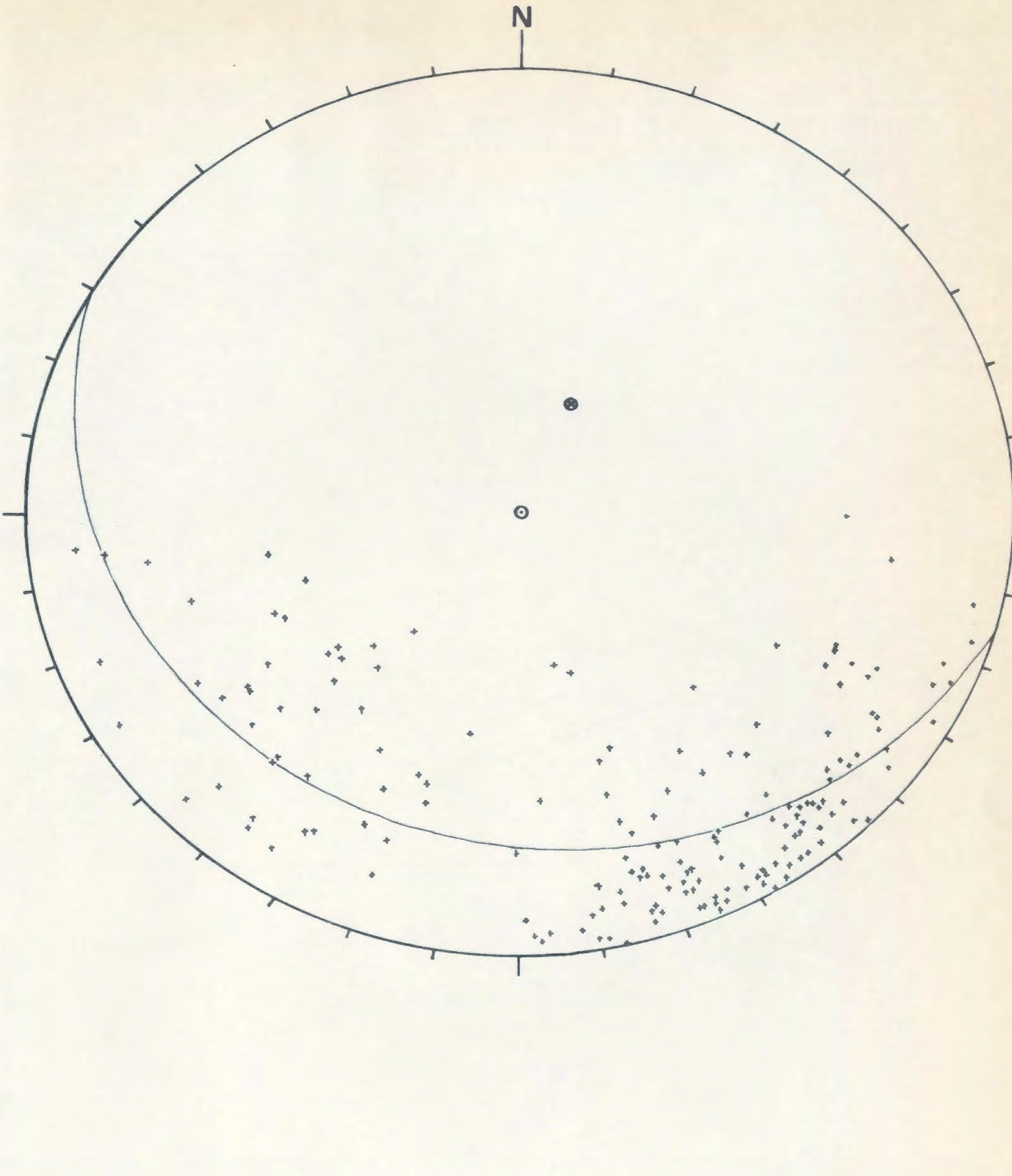


Figure 3: Stereonet plot of poles to regional foliation in northern unit; axis of F_3 fold indicated (⊗). Left uncontoured because of irregular distribution of measurements.

Photomicrograph - F_3 fold in mineralized schist zone. Plane light. 150x.

communication). The South Brook and Catcher's Pond faults (see page 31) were developed subsequent to the deposition of the Springdale Group and the intrusion into the Little Bay Head section of small rhyolite plugs.

F. STRUCTURAL HISTORY OF THE LITTLE BAY HEAD SECTION IN THE KING'S POINT AREA (TABULAR SUMMARY)

STRUCTURE PRODUCED	ASSOCIATED FABRIC	STRAIN
D_3 folds	fracture cleavage, kink bands, tension gashes	ENE-WSW shortening
crenulations	crenulations	vertical shortening
thrust faults	cataclasis in fault zones	shortening from north-northwest
north-south trending faults	?	?
D_2 schist zones	S_2 strain-slip foliation	?
D_1 anticline	S_1 axial planar schistosity	NNW-SSE shortening
OR		
D_2 anticline	S_2: strain-slip foliation in schist zones; axial planar schistosity in country rock	NNW-SSE shortening
D_1 schist zones	S_1 schistosity	?

IV. ECONOMIC GEOLOGY

A. DESCRIPTIONS OF SULPHIDE OCCURRENCES IN MAP-AREA

1. RENDELL-JACKMAN MINE SHOWINGS

(a) LOCATION AND HISTORY OF INVESTIGATION

The Rendell-Jackman showings are located north of Mine Pond within the Rendell-Jackman fee-simple mining grant which is currently being maintained by Brinex.

The showings were discovered early in this century by Esau Burt of King's Point and since then the area has been subject to numerous geological, geophysical, and geochemical investigations. Their association with zones of chlorite schist was known early and no record is available of the first to make this observation. Two ore "lenses" (see figure 4) were gradually defined on the basis of geophysics, diamond drilling, and direct subsurface exploration.

The first shaft was sunk in the northern lens in April, 1910, to a depth of 132 feet, with two short drifts being run along strike. By October, 1912, some 1600 tons of ore had been brought to the surface, 600 of them hand-picked and estimated to contain four per cent copper (J. R. Stewart, 1912). Proven reserves in the northern lens amounted to 11,081 tons at an unspecified grade. The two shafts in the south lens were sunk in the 1930's, and some drifting was done though no detailed records are available. Six rock dumps from the three shafts contain some 2100 tons of rock with an average grade of slightly over one per cent copper, and minor values of silver and gold (G. S. W. Bruce, 1952).

Three diamond drilling programs were carried out in the vicinity of the showings. The Geological Survey of Newfoundland drilled five holes in 1939, Kontiki Mines Ltd. drilled ten in 1955, and Brinex drilled four in 1967. For the most part the holes were drilled south from the hanging wall side of the ore lenses, and served to define the size and shape of the lenses.

The area was investigated geochemically twice. In 1959 the Rendell-Jackman property was included in a Brinex-Anglo American joint regional survey, and anomalous copper concentrations were found in stream sediment samples at the showings and at the mouth of Ovals Brook. In 1966 a Brinex soil survey on a 100-foot grid showed copper concentrations of over 1000 ppm over each showing.

Records are available for three geophysical surveys over the showings. In 1966 Brinex completed a Self Potential survey on a 100-foot grid, the crossover points of which confirmed the presence of the sulphide bodies. In the same year an Induced Polarization survey

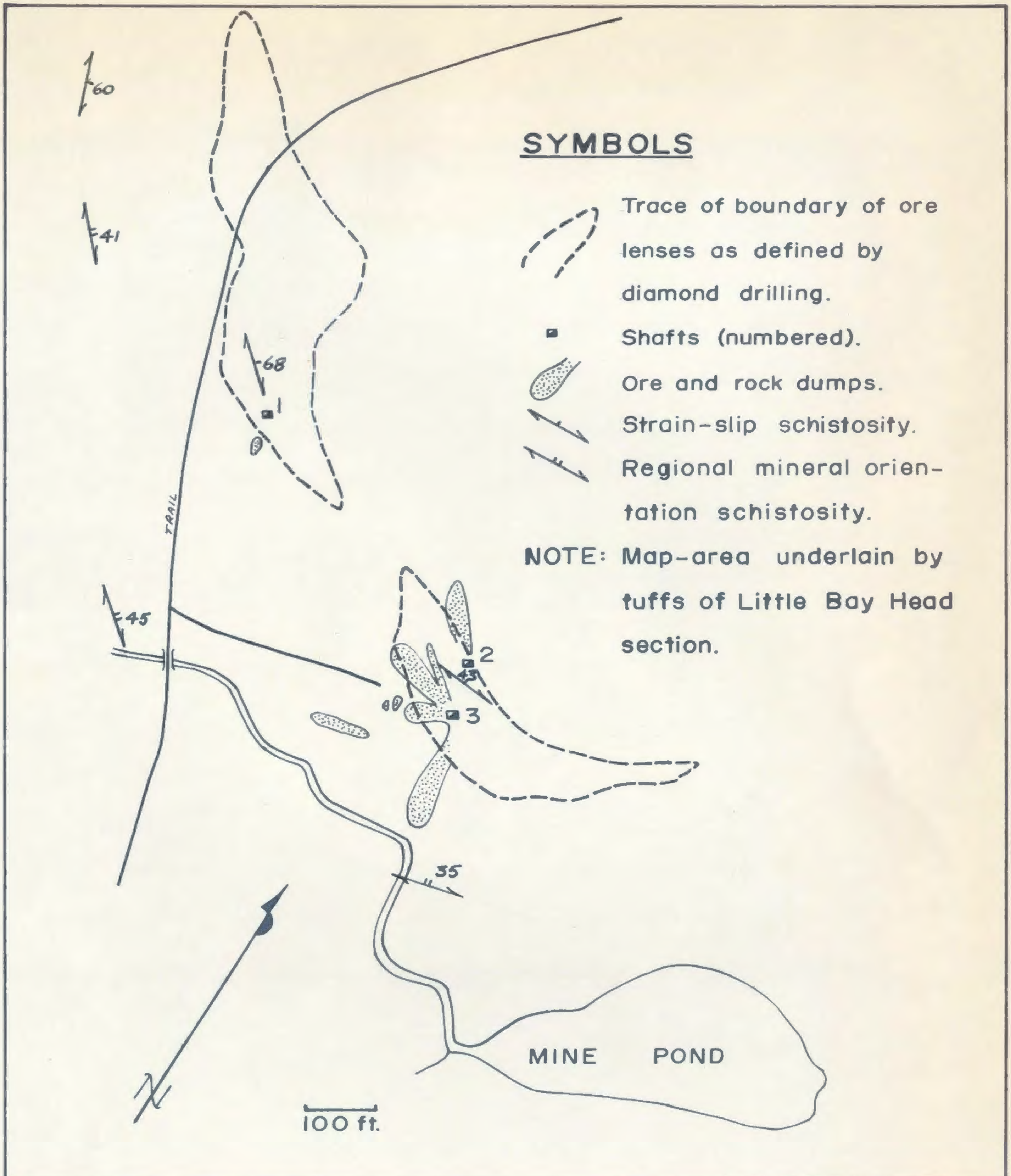


Figure 4: Map of the Rendell-Jackman mine showings.
(after Nfld. Geol. Surv. map, 1938, unpub.)

made by Brinex over the entire fee-simple grant on a 1000-foot grid showed an anomaly over the showings, and on a line some 4000 feet north of Ovals Pond. (The latter was explored by diamond drilling and massive pyrite of no economic interest was intersected.) A magnetometer survey conducted by Brinex in 1967 on a 500-foot grid over the showings showed anomalies over both lenses. H. J. McLean (1947, p. 26) stated that during the summers of 1935 and 1936, Hans Lundberg Ltd. of Toronto conducted a geophysical survey (of a type he did not specify) of the property and the adjoining area.

While the distribution of the ore in two lenses and its association with chlorite schist was known practically from the start of exploration, the first recorded speculation as to the origin of the ore and the controls for its location was not made until 1940, when H. J. McLean (Douglas, Williams, and Rove, 1940) stated that the mineralization was located in shear zones. "The ... system of shears, one of which contains the copper deposits, is considered to be a shear-fault zone, striking approximately north and south and dipping about 45 degrees east, and is a subsidiary feature on the south flank of a major fault which is postulated to extend along the valley of South Brook and westward passing just south of King's Point" (ibid., p. 89). By 1947 (N. G. S. bull. 22) McLean had extended his interpretation to all the sulphide bodies in the Lush's Bight Group and considered them to have a common origin. He suggested (1947, p. 21) that all the sulphide deposits were shallow mesothermal bodies and were related to the same period of mineralization which was a replacement of chlorite schists during late stages of faulting. McLean (ibid.) also concluded that there might be a genetic relationship between the sulphides and the granodiorite intrusions in the area. "The ore solutions may have travelled, part way at least, up from depth along the flanks of the granodiorite bodies in zones of weakness at their contact with sheared country rock. Also, the solutions may have travelled up along the major fault zones before filtering out and depositing in smaller subsidiary pockets of schist on the flanks of the faults."

G. S. W. Bruce (1952) stated that he considered the ore to be a disseminated to massive replacement of the schist. B. Relly (1959) considered the Rendell-Jackman "shear" to be "a subsidiary synclinal structure in the broader synclinal structure that lies between the Rendell-Jackman prospects and Catcher's Pond and that plunges 45° northeast." F. J. Nolan considered this synformal structure to result "from the thrusting of the King's Point-South Brook fault to the north."

The most valuable contribution from the writer's standpoint was that of S. Roderick (1960) who considered the massive pyrite-chalcopyrite mineralization at the showings to be a replacement of layered tuff bands, and stated that he could see all stages of replacement in the ore bodies. He suggested that the mineralization was controlled by a shear zone and/or a fold in the banded fragmental rocks and summarized the possible sets of controls of mineralization as follows:

1. The shear is the dominant structure and favourable mineralization occurs in the zone where:

   (a) it intersects the nose of a synclinal fold;
   (b) it intersects tuffaceous rocks;
   (c) combinations of (a) and (b) are found;
   (d) it is deflected by the fold;
   (e) it is deflected by the fold into tuffaceous rocks.

2. The fold is the dominant structure with favourable mineralization:

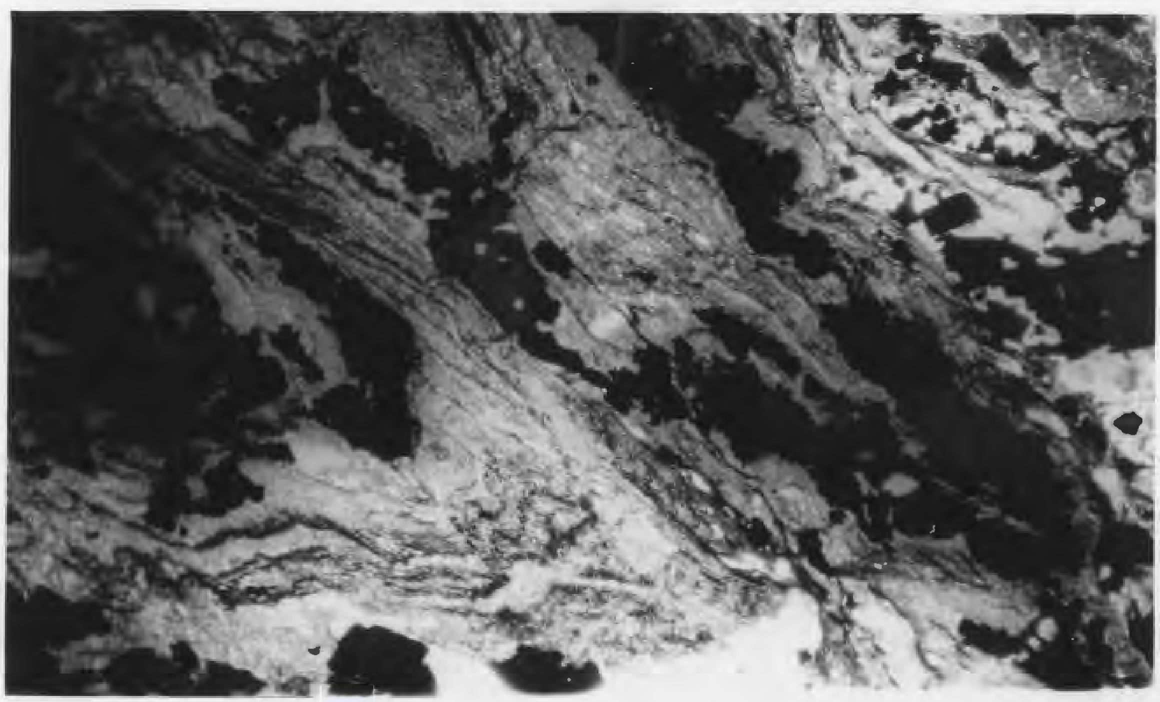
   (a) at the nose and mainly controlled by plunge;
   (b) following the tuff beds along the limbs and down dip.

3. Combinations of 1 and 2.

The writer assumes that Roderick used the term "shear" in the classical sense as a fault zone rather than to describe a "shear belt" in the sense that Ramsay and Graham (1970) used the term.

Roderick noted two types of mineralization. Massive banded pyrite-chalcopyrite was characteristic around shafts 2 and 3 (south ore lens). "Nodular" massive chalcopyrite and minor pyrite was found around shaft 1. Roderick offered the explanation that the two distinct types represent separate but interrelated occurrences.

a: Boudinized jasper band in massive banded pyrite ore from Rendell-Jackman showings. Boudins indicated by "b".



b: Photomicrograph - Folded pyrite bands with axial planar strain-slip schistosity. Plane light. 150x.

(b) DESCRIPTION

The Rendell-Jackman showings are located in schist zones, and the shapes and relative positions of the ore lenses as defined by diamond drilling suggest that they are in the same schist zone. The southerly body is located in the hinge of the major F_3 fold in the map-area and is apparently folded by it. Stratigraphically the mineralization is in a section of tuffs. This is inferred from the laminated appearance of the massive sulphides, the presence of rare apparently boudinized lenses of jasper in the mineralized zones (plate XVa), and the presence of a section of tuffs both above and below the schist zone.

Macroscopically the sulphides are laminated on a scale of 1 cm. or less with respect to sulphide concentration and grain size, and in that respect superficially resemble the surrounding tuffs. In polished section no sedimentary features are visible and in fact the pyrite bands appear to be isoclinally folded into minor structures to which the strain-slip schistosity is axial planar. Pyrite and sphalerite apparently precede chalcopyrite in the sulphide paragenesis.

2. YOGI POND SHOWING

The showing is located in a schist zone in the bed of a stream about 1000 feet south of Yogi Pond. The discoverer of the showing is not known. It was investigated geochemically by Brinex and found to contain anomalous amounts of nickel, but not copper, and to disappear (geochemically) within 400 feet along strike in either direction. No further work has been done on the showing.

The schist zone is about 30 feet wide and strikes east-west, dipping steeply northward at its only exposure in the stream bed. Mineralization is almost entirely pyrite in disseminated bands reminiscent of depositional textures, and the walls of the schist zone are both of tuff. In thin-section the pyrite is poorly banded and follows poorly-defined fold patterns to which the strain-slip schistosity is axial planar (plate XVb). F_3 folds with associated kink bands are present on a microscopic scale (plate XIV) and do not appear to affect the distribution of sulphide mineralization.

3. NOLAN SHOWING

The Nolan showing is located near the east end of Young Pond on the trail between King's Point and Springdale. The original discoverer is unknown; it was first discussed by F.J. Nolan (1960) who described it as "a zone a few feet thick [in which] fairly massive bands of pyrite occur in a massive (?) andesite." One trench was made across the showing in the summer of 1970.

The mineralization is in a schist zone which strikes approximately east-west. The zone is about six feet thick, and the strike length of the showing is unknown. The mineralization is almost entirely massive banded pyrite with minor magnetite occurring as rare discrete bands about ¼ inch thick. The showing is surrounded by a fine-grained gabbro which is apparently part of a larger intrusion, but the actual contacts of the showing with the surrounding rock were not observed.

B. COMPARISONS WITH OTHER SHOWINGS IN THE LITTLE BAY HEAD SECTION OUTSIDE THE MAP-AREA

Trenches over the Little Deer mine, showings north of Little Deer Pond, and trenches in the vicinity of Colchester Pond were visited by the writer. The textures of the mineralized rocks are macroscopically identical to those of the schist zones described in the King's Point area.

At each of these localities the rocks are in close assoc-iation with tuffaceous or fragmental volcanic rocks, though the local stratigraphy is not well-known at any of them. At the Whalesback and Little Bay mines, however, the association of the sulphide bodies with volcanoclastic rocks is not established, and in fact structures reminiscent of pillows have been observed in the schist zones there (H.R. Peters, personal communication).

Folding identifiable as F_3 is present in the Little Deer mine. There, F_3 folds with orientations similar to the one in the Rendell-Jackman mine area deform the schist zone. Chalcopyrite is more concentrated at the hinges of this than on the limbs (J.E. James, personal communication). In the trenches over the mine isoclinal folding of pyrite bands was observed, with the strain-slip schistosity axial planar.

C. REGIONAL CONTROLS FOR SULPHIDE MINERALIZATION

In the writer's opinion the sulphide showings in the Little Bay Head section show sufficient common features that they can be considered cogenetic and to have similar structural histories. The factors used in constructing a regional synthesis are listed as follows:

1. Significant mineralization is invariably in schist zones, though a wide barren schist zone passes through pillow lavas and pillow breccias north of the Rendell-Jackman showings.

2. Mineralization is most commonly in volcanoclastic

rocks (with the important exceptions of the Little Bay and Whalesback mines, where it seems to be in pillows).

3. Most of the showings are very small, the only large sulphide occurrences being at the Little Bay, Whalesback, and Little Deer mines.

4. The strain-slip schistosity is apparently axial planar to folded pyrite bands in at least three places (the Rendell-Jackman and Yogi Pond showings, and the Little Deer mine).

5. Chalcopyrite mineralization is enriched at the hinges of F_3 folds in at least one place (the Little Deer mine). Chalcopyrite appears to postdate pyrite in the sulphide paragenesis, suggesting that the former has been remobilized into the hinges of the F_3 folds as openings developed during folding.

6. Under conditions of regional metamorphism chalcopyrite is more mobile than pyrite, and will move readily in response to directed stress recrystallizing to leave no evidence in the texture (J. E. Gill, 1965, p. 995).

Taking all these considerations together, the following speculation regarding the regional significance seems reasonable: all the above showings are stratabound by volcanoclastic rocks with the exception of the Little Bay and Whalesback mines. These may be metamorphosed primary bodies as indicated by their relatively large size and their association with pillowed lavas (Hutchinson, 1965, and personal communication, 1971). The smaller showings along strike in the tuff sections may also be primary and sedimentary, and related to the sulphide emplacement processes going on in the vicinity of the main ore bodies. This conclusion was anticipated by Williams (1963, p. 41) as part of his general set of conclusions regarding base metal mineralization in volcanic rocks in northeastern Newfoundland. All the sulphide bodies have been subject to deformation and partial remobilization after emplacement. The apparent sulphide paragenesis (see p. 51) at the Rendell-Jackman showings supports the interpretation that the chalcopyrite was remobilized and redeposited in F_3 fold hinges during deformation. Certainly the bodies have been deformed as indicated by folding of pyrite bands with strain-slip schistosities axial planar, and, of course, the invariable association of the bodies with schist zones.

If the sulphide deposits are in fact primary, then the schist zones must not be considered as "controls" for mineralization. Rather, they would be shear belts (see section III.B.2.) which began at loci of greatest mechanical weakness - commonly the sulphide bodies. Thus the control for the localization of sulphide mineralization would be stratigraphic, and the control for chalcopyrite enrichment, structural (F_3 folding). The presence of a barren schist zone in a favourable stratigraphic horizon could be considered an indication that a sulphide deposit might lie in the zone along strike.

V. CONCLUSION

The rocks of the Little Bay Head section in the King's Point area have been shown to comprise part of the south limb of an anticline whose axial plane strikes east-northeast and dips steeply northward, and whose axis is approximately horizontal. The section as it is exposed is reminiscent of the type sequences of submarine volcanics which Carlisle (1963) described. Detailed stratigraphic mapping in the area will probably not be possible because of the lack of exposure.

The structural significance of the schist zones in the area has not been conclusively established, and more detailed petrographic work will be required to do so. However, the invariable association of mineralization with the structurally identical schist zones has been demonstrated, as has the common association of sulphides with sections of tuffaceous rock. The indication is that sulphide enrichment with respect to chalcopyrite is to be expected at the hinges of F_3 folds in mineralized schist zones. These three considerations should prove a useful guide in further exploration for sulphides in the Little Bay Head section.

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