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ANVIL DISTRICT GEOLOGY

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INTRODUCTION

The area investigated is a narrow belt, about 10-15 miles wide, and 40 miles long. It is located on the east side of the Pelly River (Tintina Trench) in the Anvil Range and includes a number of known lead-zinc deposits, one of which is the Anvil Mine.

A period of about 3 to 4 weeks was spent by the writer and an assistant in mapping sections across the belt. The plan was to first map in the regions of known mineralization (Faro and Vangorda orebodies) and then to extend the mapping to the northwest in order to better evaluate the newly staked ground in that area.

The purpose of the exercise was to try to discover any simple geologic features which may have been responsible for ore deposition at Faro and Vangorda and then to use this information as a guide during mapping to the northwest. The two main features emphasized were stratigraphy and structure.

The investigation of the Faro-Vangorda-Swim Lakes area indicated that: 1) a simple stratigraphic section of sedimentary and volcanic rocks exists across the belt, 2) the rocks have suffered at least 3 phases of deformation during a period of folding and regional metamorphism, 3) the known mineral deposits are located at the same level of the stratigraphic section, 4) the largest dimensions of both the Faro and Vangorda ore bodies are coincident with the trends of the first phase lineations in both areas and 5) that the stratigraphic horizon containing the ore deposits is unique in that it contains a proliferation of early phase structures.

Mapping in the area to the northwest of Faro revealed that: 1) the stratigraphy from the Faro-Vangorda region could be lithologically correlated to this region, 2) the effects of thermal metamorphism from the proximity of nearby granitic intrusions over printing regional metamorphism has produced large areas of hornfels and 3) the claim groups Lorna, Roto, and Gran all cover regions which are stratigraphically and structurally favourable for mineralization.

ROCK TYPES

For the purpose of mapping on a regional scale, the metamorphic rocks in the area were divided into three simple units greenstones, phyllites and schists. The 'greenstones' consist of schistose meta-basalt, chlorite-talc-amphibole schist, amphibolite and meta-ultra-mafic rocks. They are most common on the southwest side of the belt. The phyllites consist predominantly of a mica-quartz phyllite which is often graphitic, other members of the unit are sericite-quartz phyllite, black slate, phyllitic quartzite and chlorite phyllite. The schists include mainly mica-quartz-schist and mica-schist with minor intercalations of garnet-biotite-schist and biotite granite gneiss. The schists mainly outcrop along the north-eastern margin of the belt and flank the intrusions which core the Anvil range. The phyllites occupy the centre.

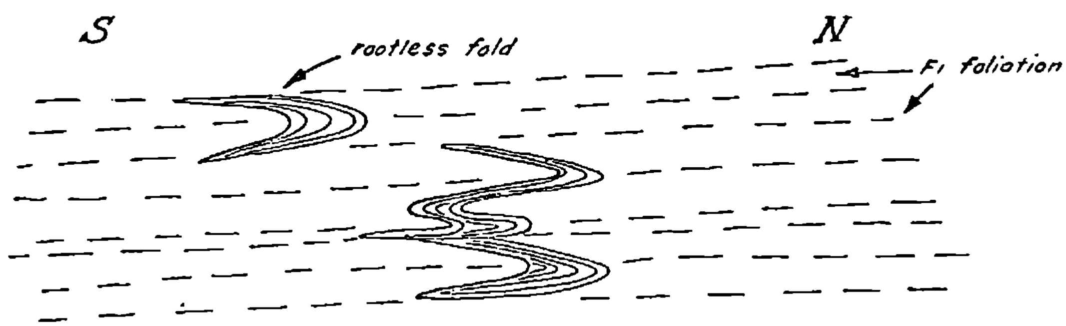
Intruding this sequence is a large mass of granitic rocks ranging from granite to granodiorite in composition. In general they carry no mineralization, however, at Faro a biotite-quartz monzonite in contact with the ore body contains an appreciable amount of pyrrhotite and minor chalcopyrite. Also a granite dike in the Anvil Creek area (see map) contains about ½% pyrrhotite and minor chalcopyrite.

For more detailed description of these rock types, the reader is referred to Fairley, 1965. For the purpose of this report, it suffices to realize that the rocks which were deformed and metamorphosed and later were hosts to ore solutions were of three unique types which behaved quite differently and often independently of each other.

STRUCTURAL GEOLOGY

The observations and measurement of major and minor structures has revealed that at least three phases of deformation have affected the geometry of the sedimentary-volcanic sequence. These phases occurred during a period of deformation accompanying low-grade regional metamorphism which pre-dated the intrusion of the granitic rocks, and the brittle deformation associated with movements along the Tintina fault system. Common minor structures observed were foliations, lineations and parasite folds.

PHASE 1: The most obvious and pronounced foliation in all the rocks is a penetrative planar element which is nearly parallel to original bedding and is the surface along which the rocks tend to break. This foliation is gently dipping to nearly horizontal along the whole length of the belt; its general trend is NW-SE with dips to the SW (see map). Associated with this foliation are minor parasite folds which are characteristically tight, similar and recumbent in habit and are often found as rootless or as isolated fold cores bound by foliation surfaces. The axial surfaces of these folds is the phase 1 foliation. Typical phase 1 parasite folds are depicted below:



Common Phase 1 linear elements are quartz rodding and mineral alignment. Measurement of these features and axis of minor folds indicates a phase 1 linear trend at NW-SE with gentle plunges in both directions (see map).

PHASE 2: The most common phase 2 minor structure observed is a linear element outlined by mineral alignment or by axis of minor folds. Measurement of such elements indicate that the general trend of folding during this phase was about an axis, dipping gently to the west (see map).

Other minor phase 2 structures are open similar folds which in general have rounded hinges and fold the phase 1 foliation surface. Such folds occur on a larger scale as well; an example is the synformal structure of Vangorda Creek.

Associated with the phase 2 folding is a non-penetrative strain-slip cleavage which is generally difficult to detect; where it has been measured it indicates an east-west trend with nearly vertical dip.

PHASE 3: Minor structures which appear to deform all earlier structures are found on some outcrops. In general these structures are a weak strain-slip cleavage and a wrinkle lineation resulting from the intersection of this cleavage with the phase 1 foliation. Also very open, concentric phase 3 folds have been observed.

The effects of this phase were minor and did little to change the geometry of the rocks; its importance is considered insignificant for this study and will not be discussed any further.

VANGORDA-FARO OREBODIES & PHASE 1 STRUCTURES

Both the Faro and Vangorda ore bodies are elongated, flat and rounded with their long dimension much greater than the other two dimensions (see Chisholm, 1959). The trend of the longitudinal axis of the orebody at Faro is about 15° in a 160° direction. The trend at Vangorda Creek is a very gentle plunge to the northwest. Phase 1 lineations measured in mica-quartz-schist and phyllite adjacent to the ore body at the Faro pit have trends similar to the orebody. Also,at the original showing in Vangorda Creek, a phase 1 parasite fold is exposed whose core is filled with massive sulfides and is outlined by quartz and quartzite. Quartz rodding along the axis of the fold indicates a phase 1 linear direction of $320/15^{\circ}$. The elongation of the orebodies is also suggested by the elongation of the airborne EM anomalies over them as indicated in figure 1. Note the coincidence with the phase 1 linear direction. Thus, the coincidence of Phase 1 lineations and the longitudinal axis of the orebodies in both cases is precise and is a fundamental indicator that structures developed during that early phase controlled ore deposition.

Furthermore, mapping during this project, and earlier work

(Chisholm, 1959), indicates that the orebodies are located at similar levels in the stratigraphic sequence. This level appears to be within the lower parts of the phyllite or at the phyllite-mica-quartz-schist contact. This horizon, in the phyllite unit especially, is quite unique in that it invariably contains abundant phase 1 parasite folds outlined and cored by quartz and/or calcite. An excellent example of this horizon is exposed in cliffs on the Tie claims on the north side of the road to Vangorda Creek, about ¼ mile east of the turn-off. A similar section outcrops in Faro Creek just below the Anvil Mine. In both areas, the folding of strata into parasite folds with accompanying metamorphism, resulted in calcite and quartz remobilization. These minerals were relocated in dilatent areas produced during folding - these areas generally being the cores of the minor folds.

No large single phase 1 fold or fold set was recognized at either Faro or Vangorda. Thus it is the writers impression, that the conditions (P,T, etc.) during phase 1 deformation were such as to allow the development of numerous parasite folds, particularly in the phyllitic horizon near the phyllite-mica-quartz-schist contact. Calcite and quartz remobilized in the folds provided relatively easy material for replacement during ore deposition.

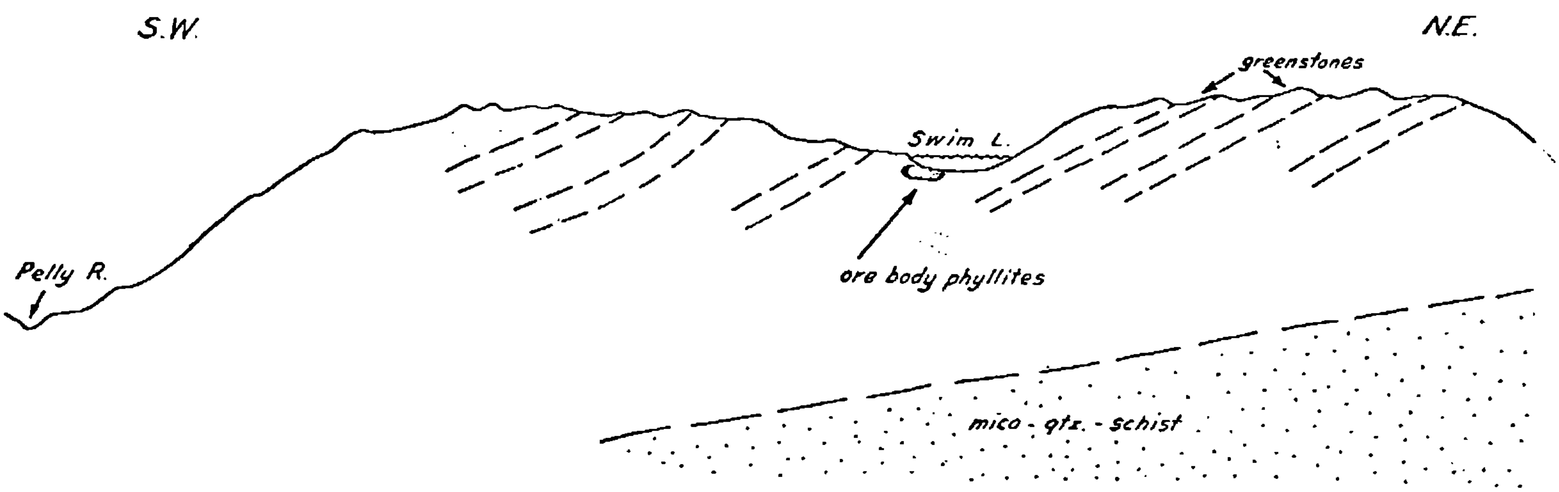
CROSS SECTIONS

SWIM LAKES

In the Swim Lakes area, only greenstones and phyllites are exposed. Outcrop exposure is generally poor with usually greenstone standing up as hills and the valleys underlain with black, graphitic phyllite.

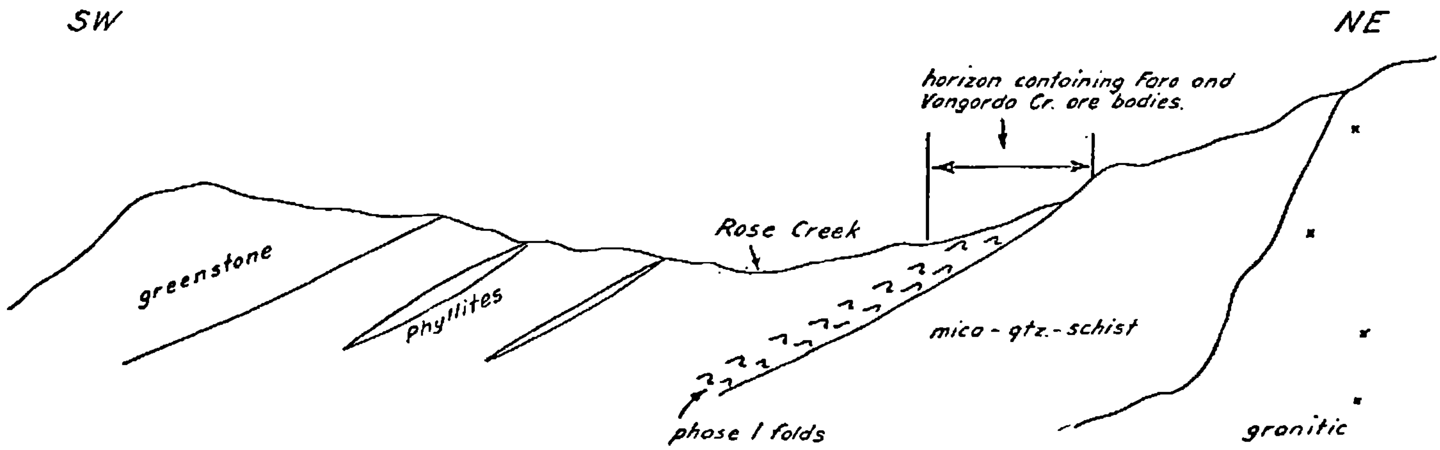
The writer spent about 3 days in the area both mapping and studying core at the Kerr-Addison and Anvil drill camps.

It appears that the area in general is underlain by rocks higher up in the stratigraphic section than in the Faro-Vangorda area. The ore deposits as well, appear to be higher up and well within the phyllite unit. A schematic cross section of the Swim Lakes area is illustrated below:



FARO - VANGORDA

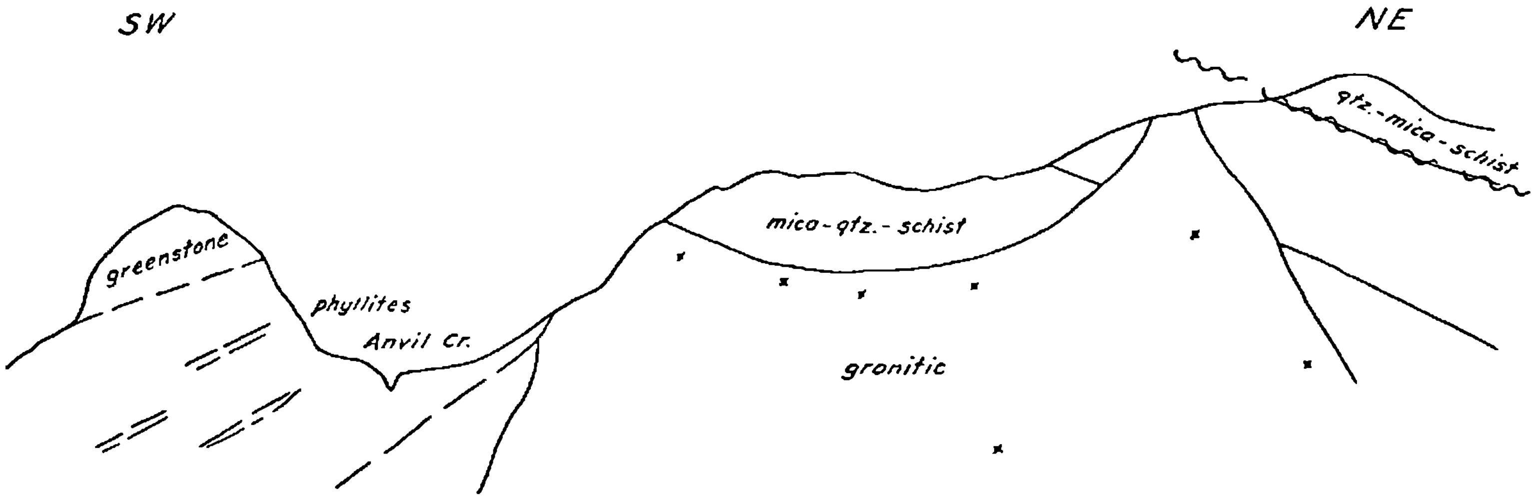
All three rock units are exposed in this area. A schematic section is shown below:



ANVIL CREEK

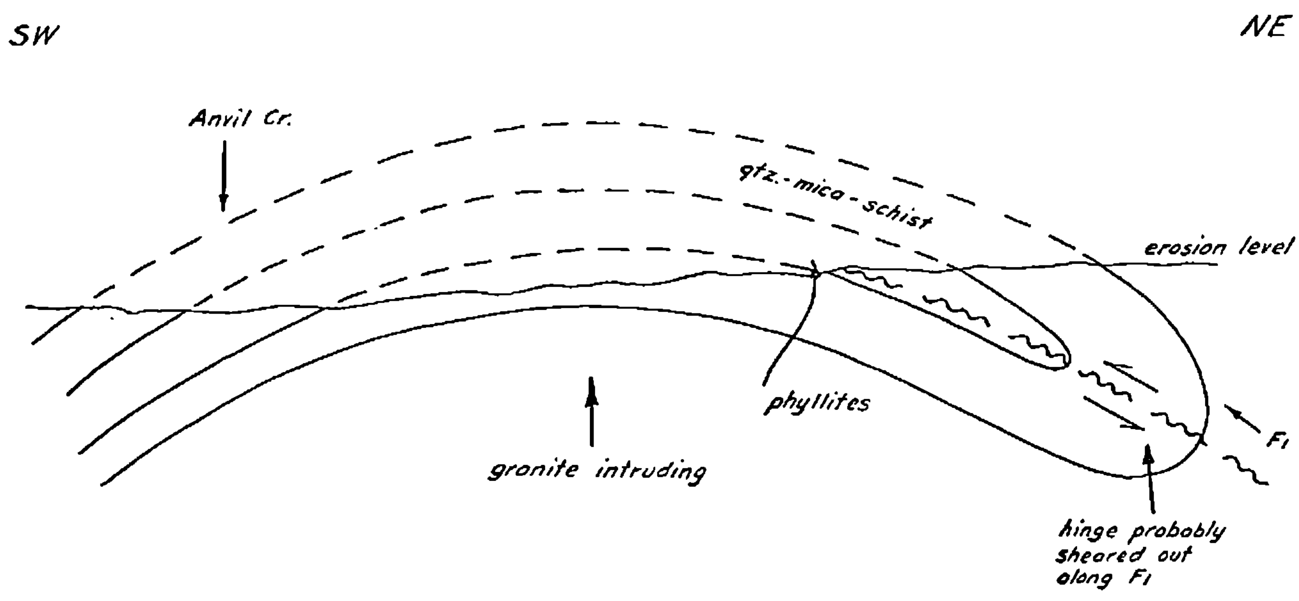
The same rock units can be traced northwestward into the Anvil Creek area. The only change is that due to the proximity of the granitic intrusions, the phyllites in many places have been metamorphosed into a tough, purplish, banded hornfels which invariably contains about ½% pyrrhotite. The large distribution of hornfels in the Anvil Creek area suggests that granite may actually underly a larger area at a shallow depth.

A cross section through Anvil Creek is illustrated below:



While mapping along the length of the belt, the mica-quartz-schist was always found underlying the phyllites. However, as is shown above in the Anvil Creek area, as mapping was carried on into areas of northeasterly - dipping foliation, the section of mica-quartz-schist was found overlying the phyllites. This area, designated as 'A' on figure 2, was investigated in detail due to the presence of coincident EM and Mag anomalies (see fig. 2). Structures and rock types mapped indicated that the phase 1 lineations were coincident with the elongation of the anomaly and that the anomaly outlined the phyllite unit in contact, and wrapped around a granite intrusion. About ½% pyrrhotite in the phyllite is common along the contact and may be the cause of the magnetic anomaly. The conductivity contrasts between the granite and the phyllite may well explain the EM anomaly as well, however, there may be a more conductive body present.

The repetition of the mica-quartz-schist unit over the phyllite is indicative of an early phase structure. This region appears to be the site of the hinge of an early large-scale recumbent antiform which is cored with phyllite. A schematic cross-section of the structure is shown below:



From this cross section it appears that the large-scale structures developed during phase 1 were recumbent antiformal nappes which were later folded and intruded by granite.

Area 'A' was prospected and mapped (see map) and soil samples were taken across the anomalies. Although the area was geologically favourable, the results of the geochem survey indicate no anomalous values of lead, zinc or copper in the soils overlying the area.

PROPERTIES IN THE ANVIL CREEK AREA

Favourable areas overlying EM and Mag anomalies were staked along Anvil Creek and gravity, ground mag and soil sampling conducted on them. These groups are the Roto, Lorna, Gran, and Jean. All groups are located in the Anvil Creek valley and are covered with glacial overburden; very little bedrock is exposed.

ROTO GROUP

Three days were spent on this group. Bedrock is exposed only in the northern part, where massive horizons of amphibolite alternating with phyllite outcrop periodically. The stratigraphy dips gently to the south, and under the main part of the claim group. Mineralization is confined to a few specks of pyrrhotite in the phyllite. The amphibolite is quite magnetic and its ubiquity in the area could explain the broad mag anomalies. A strange metallic mineral was found in massive amphibolite on line E32 at station 1300N; it is not unlike galena, however, its presence in amphibolite leaves some doubt about its identity. In general, the crystals are too minute to see with a hand lens. The mineral is metallic, has a black streak and a hardness of about 4. It makes up about 1-2% of the whole rock.

LORNA GROUP

This group, located on the south side of Anvil Creek, is underlain by southerly-dipping black phyllites and mica-quartz schist intercalated with minor amphibolite horizons. No mineralization apart from some pyrrhotite and specks of galena in quartz was found on the group. Sericitic alteration in the mica-quartz-schist as well as alteration in greenstones were observed along the cliffs outcropping on Anvil Creek. Stratigraphically and structurally, the Lorna is well located; it overlies the phyllite-mica-quartz-schist contact and also the horizon of abundant phase 1 parasite folds.

GRAN GROUP

No outcrop was observed on this group except for granite just north of it. Mapping to the southwest and north of the group suggests that the Gran is probably underlain partly by granite in possible contact with mica-quartz-schist and/or phyllites. If this is so it too is favourably located.

JEAN GROUP

No outcrop was observed on this group either. However, mapping was done along strike to it and it appears to be underlain mainly by phyllites. The proximity of the mica-quartz-schist contact is unknown, however, it appears that the group may be too 'high' up in the phyllites.

FAULTING ASSOCIATED WITH TINTINA FAULT

The whole belt is dissected by numerous fault systems which appear to cut and displace stratigraphy, earlier folded structures, intrusive bodies and ore bodies (see map). It is the feeling of the writer that the main mineralization was quite unrelated to these structures. The only relationship that the ore bodies have to the Tintina Trench is that they follow a linear which parallels the trench and thus represents a fracture along which ore minerals were tapped from deep in the crust or the upper mantle.

SEQUENCE OF EVENTS

1. Sediments and volcanic suite deposited on oceanic (?) crust.
2. Section regionally deformed and metamorphosed.
3. Intrusion of granitic batholith.

4. Ore deposition.
5. Faulting associated with Tintina fault system.

DISCUSSION

The general geometry of the sedimentary-volcanic sequence of the Anvil Range is that of a doubly-plunging, canoe-shaped, dome. The rocks were intensely deformed during phase 1, at which time large, recumbent nappe structures were thrust to the north-east. Conditions of metamorphism were such as to produce greenschist mineral assemblages. The style of folding was similar with much movement concentrated along phase 1 foliation surfaces. This phase gave way to a less intense phase of cross-folding (east-west) which warped and reshaped the earlier geometry.

The intrusion of granitic rocks appears to have been, at least partly, controlled by the geometry of the country rocks. This is suggested by the fact that the contact rocks to the granite are usually the same unit, the mica-quartz-schist.

PARAMETERS FOR EXPLORATION

This investigation has revealed that the lead-zinc replacement deposits in the Anvil area were at least partly, if not totally,controlled by structures developed during the earliest phase of folding. These bodies have a geometry which coincides with the phase 1 linear trends and thus indicates replacement along minor and/or major fold cores. If some remote sensing technique could be used which outlines bodies in rocks which have elongated geometries, then knowing the trend of the phase 1 lineation, one could better make a decision about the importance of such an anomaly. The EM anomalies over Faro and Vangorda are examples; however, in area 'A' the anomaly is outlined by the trend of the conductive graphitic phyllite unit as well as by the phase 1 lineations. In such a case, only detailed ground EM may pick out conductivity contrasts between the phyllite and any more conductive bodies which it may contain.

Another possible remote sensing tool is false colour photography which could outline possible ore bodies which could be checked out against the known structures in the area.

Geologic mapping in the Anvil district with the idea of finding ore bodies, should carefully outline first phase structures especially in areas underlain by the phyllites and phyllite-mica-quartz-schist contact. In the Swim Lakes area and farther to the SE, it appears that the most favourable stratigraphic level is at some greater depth and that the small deposits so far outlined may be only superficial off-shoots of a much larger body. These small bodies are located in rather 'tight' graphitic phyllites which lack the more dilatent phase 1 structures found at Faro and Vangorda.

Further exploration to the east and southeast of Swim Lakes should be concentrated in areas closer to the granite intrusions. Around these intrusions, the phyllite-mica-quartz-schist may be closer to the surface than it is near Swim Lakes.

Respectfully submitted,

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