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GEOLOGY OF THE TIE-FIRTH AREA

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INTRODUCTION

This report describes the results of mapping and core logging conducted in the 1983 field season in the area between Grun and Firth.
The purpose of the work was to define the structure in this area to clarify the relationship of Firth to Grun and to help direct further drilling of the down plunge extension of the Grun deposit.
This work is intended to be the start of a program of remapping which in the next two field seasons should be extended over the entire Vangorda Plateau.
The authors have contributed equally to this study; they are listed alphabetically. The first author, however, accepts responsibility for shortcomings of the text.

LOCATION & GEOLOGIC SETTING

The Tie-Firth area is located at the northwest edge of the Vangorda Plateau between the turnoff of the Blind Creek road from the mine access road and the Grun Deposit, Figure 1.
The regional geologic setting of the area is shown in Figure 2 and a schematic stratigraphic section for the area in Figure 3. Figure 4 shows some of the structural features of Vangorda Plateau.
The Tie-Firth area has long been a geologic "trouble spot" where the metamorphic rocks of greenschist facies of the Vangorda Plateau pass northwest into the amphibolite facies rocks of the Rose Creek Valley.
This study shows that a major extensional fault separates these two portions of the terrain. There are preliminary indications of several similar faults elsewhere; furthermore, a cataclastic marginal phase of the Anvil Batholith indicates, probably related, large scale extensional strain. These findings strongly suggest that large displacement extensional faults will play an increasingly important role in the structure of the Anvil District.
Further discussion of the geology and ore deposits of the Anvil District can be found in Jilson 1984.

Figure 1 - The ~~First~~ Tenth Area Scale 1:250,000

Figure 2 - Generalized Geological Map of Anvil Lead-Zinc District

Legend for Figure 2

Figure 3 - Mappable SubDivisions

Deposition

fig 4

LITHOLOGY

In the area of interest Unit 5 equates to the Vangorda Formation and Unit 3 to the Mt. Mye Formation. This equation is not valid for the district as a whole; thus statements about map units in this report should not be extrapolated to the districtwide formations.

Unit 3

Unit 3 is used to refer to a group of amphibolite facies metamorphic rocks on the footwall side of the Tie Fault Zone. Two major divisions are present, a) marbles (3F) and calcsilicates (3D) and b) pelites (3G). The unit is not well exposed; thus the relationships of units are not well known and only brief lithologic summaries will be given.

3D

Rocks that comprise this sub unit are calcsilicates commonly associated with marble. The calcsilicates are dense, fine grained, homogenous to well banded, generally well foliated rocks. Green amphibole rich, grey, and purplish brown biotite rich bands are common. In comparison to Unit 3D at the mine these calcsilicates are less conspicuously banded and phyllitic and have fewer biotite rich purplish brown bands. The calcsilicates in this area are associated with more abundant relatively pure marble and may represent a different unit than 3D at the mine. Best exposures are in the "guts" just northwest of the Tie Fault Zone at the northern edge of the map area.

3F

Subunit 3F consists of light grey to off-white, well foliated, medium crystalline, calcite marble with bands and clots of biotite and locally garnet rich silicates.

Good exposures are found just northwest of Tie Fault near the main road.

3G

A sequence of deep rusty brown weathering, medium grained, biotite, muscovite ± minor garnet schists. The rocks are soft and not particularly quartzofeldspathic but have a distinctive 1-2 mm thick banding parallel to S_2 marked by alternating quartzose and mica rich bands. The banding imparts a strong colour lamination to the weathered surface. Thicker (1-5 cm) greenish grey (probably actinolite bearing) quartzose ± calcite layers also occur sparingly.

These rocks are coarser and more schistose than Unit 3G normally is but are not sufficiently like the Faro schists to be called 1D or 1C.

Best examples are from the large area of schist within Unit 10 AB at the northern edge of the map area.

Also included in Unit 3G are fine grained, non-calcareous phyllites. These rocks do not crop out in the map area but are intersected by the deep drill holes shown on the accompanying sections. The phyllites are medium to dark grey and commonly contain quartzose metasiltstone bands. While these rocks are generally non-calcareous they are associated with local calcareous, carbonaceous phyllite (3G39) and carbonaceous limestone (3F9). These 3G phyllites appear to be at the top of the Mt. Mye Formation and may stratigraphically overlie the above mentioned biotite schists.

Modifiers are used, mainly in detailed drill logs, to indicate deviations from the normal Unit 3G medium grey, non-calcareous phyllite (i.e. 3G0). The commonly used modifiers are:

0	normal	
1	siliceous	(i.e. hard= difficult to scratch with nail)
3	calcareous	
4	altered	(i.e. light grey or lighter)
6	sulphide bearing	
8	chloritic	(i.e. olive greenish grey)
9	carbonaceous	(i.e. dark medium grey to very dark grey)

Unit 4

The ore types of the Anvil District are described in detail elsewhere.

In the area of interest most sulphides intersected to date are low grade quartzose disseminated lithofacies which are the distal equivalents of the Grum ore layers.

Of the three Firth holes FAGA 097, FAGA 098 and FAGA 101 only #98 and #101 intersected what are normal Anvil District ore lithofacies, both of which appear to be thin overturned Anvil Cycles with grades in the 3 to 6% Pb + Zn range. The sulphides in these holes are associated with altered and unaltered phyllites, and together the sulphides and phyllites appear to be blocks, slices or horses in the Fault Zone.

The last Firth hole (#97) cut a sequence of chlorite rich and calcite + dolomite bearing altered phyllites locally with very heavily disseminated pyrrhotite (up to 50%) with minor magnetite, galena, sphalerite and chalcopyrite. These unusual ore types are a little reminiscent of the upper horizons at Grum but may relate to late hydrothermal sulphide mobilization within the Tie Fault zone.

Sulphides intersected on section 108W may be partly truncated by a late fault and not totally representative of the mineralization there, but results to date are consistently biased toward low grade, distal, quartzose, disseminated ore types, only minor massive sulphides were encountered.

Unit 5

The major subdivision and characteristic lithology of Unit 5 is a medium grey phyllite which is generally calcareous, Unit 5B. Unit 5 has interlayered within it metabasite or greenstone (5C), chloritic phyllite (5D) and graphitic phyllite (5A). A brief description of each of the major lithologies encountered in the Tie-Firth area follows:

5BO

This subunit is a light silvery grey to tan weathering medium grey thinly banded calcareous, phyllite. The rock consists of light coloured, thinly laminated, quartz + calcite bands alternating with darker, more homogenous and generally thinner non-calcareous muscovite, chlorite and "graphite" rich bands on a scale of one to several cm. These contrasting bands are intricately folded and a crenulation clevage is developed parallel to the axial plane of the folds imparting the characteristic lithon structure of Unit 5BO. The qualifying features are medium grey colour and calcite content which must be sufficient to cause the majority of the light coloured bands to fizz readily in 10% HCl. Deviations from this normal phyllite are indicated by a system of modifiers.

1 siliceous (not generally used for $B)
2 carbonaceous, i.e. dark grey
3 even more calcareous than normal
4 altered, i. e. light grey
6 non calcareous
8 chloritic, i.e. light green or grey green but having structure of $B
9 sulphide bearing - but not an ore facies @, $, * carbonate species other than calcite: ankerite, dolomite, unknown ± (& in computer files) patchily developed or interlayered on fine scale.

The major modifiers in use are 2, 3 and 6 which describe poorly defined subdivisions of a gradation of phyllite properties as indicated below:

	graphitic phyllite (5A)				very dark grey to black
increasing "graphite" (2)	5B26	$B26 ± 0 $B20 ± 6	$B20	$B23	dark grey
	5B6 ± 2		$B0 ± 2	$B3 ±2	
	5B6	$B6 ± 0 or $B0 ± 6	$B0	$B3	medium to dark medium grey
		increasing calcite (3 and 6)			
	No fizz	Weak fizz form a few bands	Most bands fizz readily	Fizzes violently	

Another major modifier used for Unit 5B is 8; this signifies that the phyllite is texturally and structurally like $B0 but the micaceous bands are not their usual medium grey colour but are light olive green. The meaning of this "greening" is controversial but it may be due to a carbon destructive alteration overprint, with or without addition of chlorite, or it may indicate a tuffaceous addition to the phyllites.

Where carbonates other than calcite are present they are indicated by use of the modifiers @, $ or *. All other subdivisions of Unit 5 (i.e. A,C,D, etc.) use the same modifiers.

5B6

As noted above Unit 5B6 is a medium grey phyllite that is non-calcareous. A large area of such phyllite occurs near the main road just east of the Tie Fault. The phyllites there have sparsely developed light coloured bands and those present are not generally calcite bearing.

5DO

Unit 5D is a medium olive green, chlorite rich phyllite which is characteristically calcite bearing. Several varieties occur including laminated, mottled and "gritty" appearing examples but well defined subdivisions are not worked out. A characteristic feature of this rock type is the presence of quartz calcite bands that differ from those of 5BO in that their internal grain size is coarse and the bands pinch and swell irregularly. These rocks may have originally been tuffs but the presence of apparent amygdules in some and the similarity of 5D to foliated fine grained margins of metabasites suggests some flows or small intrusive bodies could be included.

5C

Unit 5C is also known in the district as metabasite or greenstone. The term metabasite is used to refer to a metamorphosed basic igneous rock whose origin is not implied.

A typical specimen of 5CO is a fine to medium grained, green rock with a relict ophitic igneous texture. The relict texture shows itself in green and off-white speckling or mottling on a cut or broken surface. The typical 5C body is massive, homogenous and little foliated in its interior but has strongly foliated margins. Volcanic structures such as pillows are not present but amygdaloidal margins have been noted.

5C is derived from a mafic igneous parent but the proportion of extrusive to intrusive material involved is unknown.

Metabasite is not an important component of the section in the Tie Firth area. One outcrop occurs just south of the main co pad near DDH ~~79-Tie-01~~ EA-79-T01. The metabasites, however, appear to be the source of fragments of what appear to be carbonated, highly altered, fuchitic horses in the Tie Fault Zone.

A large horse of well foliated, dark green, amphibolite is noted as 5C in the Tie Fault Zone. This rock appears to be a more strongly metamorphosed version of the metabasites.

5A

Unit 5A is not mapped separately but occurs within the Tie Fault Zone. In the district 5A is a black variably siliceous and generally slightly calcareous carbonaceous phyllite. In the current area the most important occurrence of 5A is in the Tie Fault Zone. There it is a highly sheared fault rock with augen and horses of quartz and carbonated mafic rocks. At DY a similar rock has been called 5A* (however current usage of * indicates a carbonate mineral). In drill holes away from the Tie Fault, 5A is much less sheared and comes in two basic varieties. The first is a dark grey to black, fairly soft to very hard, pervasively S_2 foliated but not well banded rock with minor disseminated pyrite or pyrrhotite and minor dolomite or calcite. This rock when hard and siliceous and containing sulphides is part of a gradation from 5A to 4A that occurs around the ore deposits. The second major type consists of light grey quartz ± dolomite ± calcite siltstone bands separated by relatively soft, black phyllite and is the dark coloured analog to Unit 5BO. As with Unit 5B, modifiers are used to denote other carbonate species than calcite thus 5AO is variably calcareous, 5AO$ contains both calcite and dolomite and 5A6$ looks like 5AO but contains only dolomite.

Unit 10 - Intrusive Rocks

Unit 10AB

This unit consists of foliated biotite-muscovite quartz monzonite or granodiorite. A typical specimen consists of 1 cm diameter somewhat flattened Kfeldspar augen around which wraps a strong foliation defined by ribbon quartz and micas. A typical outcrop is blocky and weathers a slight orange tinged grey.

A marginal phase of the batholith seen locally on the surface and in drill holes is a very fine grained light grey to off-white rock consisting of quartz, feldspar and muscovite. A good quartz foliation is present and ghosts of relict feldspar can be seen locally.

The foliated granitic rocks and the marginal phase are both cataclastic rocks. Additionally, thin zones of mylonite similar to the marginal phase cut through the main foliated granitic rocks.

At several localities, especially near the granite contact, two foliations are apparent in these rocks. The main foliation is paralleled by ribbon quartz and micas and compositional banding; the other is marked by slickensided surfaces that cut the main foliation. The effect is similar to that of a widespaced crenulation clevage. At five localities the slickensided surface dips about 10° more steeply toward the south or southwest than the main foliation. These two foliations are S and C bands (Simpson and Schmid, 1983). The S bands parallel the main foliation and the C bands are the slickensided surfaces. Such bands can be used to define the kinematics of a shear zone, the sense of shear they indicate here is consistent with the offset on the Tie Fault.

10F

Little fractured, unsheared, slightly greenish beige, quartz, feldspar, biotite porphyry dykes cut the Tie Fault Zone near the Firth showing. These dykes do not crop out but have been intersected by drill holes. The dykes are similar to 10F at Faro as well as the ~~Dixon~~ Dickson Creek dyke swarm and related dykes at DY.

STRUCTURE

General aspects of the structure of Anvil district are covered elsewhere (Jilson, 1984) and need not be repeated here. The effect of fold deformations in the map area is not well known; thus discussion will be restricted to the Tie Fault Zone, the dominant structure of the area.

Mapping and logging in the Tie-Firth area defined a large fault zone which strikes N 65^{o} E and dips approximately 45^{o} southeast. The fault has been traced for 1.5 km along strike and intersected in 5 diamond drill holes which show the fault extends at least 1 km down dip. The fault zone can be traced by a prominent electromagnetic anomaly which allows the fault to be projected another 1-2 km southwest along strike and confirms the fault's dip. The northeast extension requires further study to determine if the fault passes into the Anvil Batholith.

The fault zone was first noted in drill core where it is manifested by intervals of highly sheared generally dark coloured graphitic phyllite. These sheared zones are intact coherent rocks as opposed to the gouge zones that commonly mark faults at Grum. The irregular anastamozing foliation of the sheared rocks is commonly slickensided and wraps around augen or "horses" of vein quartz and carbonated metabasite. Intervals of less sheared but highly fractured and veined altered phyllites are included.

A characteristic of this fault zone is that it separates lower metamorphic grade hanging wall from higher metamorphic grade, and probably older, footwall. The shear zones comminute S_2 foliated rock and the fault itself truncates D_2 fold structures. The direct relationship to the mylonitic border phase of Anvil Batholith is not known but unfoliated and unsheared quartz porphyry dykes intruded the fault zone. Elsewhere in the district such porphyry dykes are spatially related to the batholith and are thought to be a late phase of intrusive activity. If this is true then timing of fault movement is post D_2 and perhaps synchronous with final emplacement of Anvil Batholith during which its marginal shear zone may have formed.

The Firth showing consists of massive and unusual disseminated sulphide occurrences within the fault zone. These mineralized bodies may be slices of the down plunge extension of the Grum deposit and would thus imply dip slip movement of over 1 km.

This fault is significant on several counts. First, the magnitude of displacement suggests that this is a major structural element of the district. Secondly, the fault zone explains the connection between the amphibolite facies portion of the terrane and the greenschist facies portion; it delimits the northwest end of the normal Grum fold structure and explains how Grum connects with Firth. The most significant aspect of this fault is, however, its implication for the map pattern on the rest of the Vangorda Plateau. The distinctive sheared rock of the Tie fault has been encountered elsewhere. These occurrences suggest that other major faults comparable to the Tie fault remain to be recognized and mapped.

5

Figure 14 - all sulphide lithofacies

CONCLUSIONS AND RECOMMENDATIONS

A major extensional fault, cutting across all older trends of the Anvil District, separates the amphibolite and greenschist portions of the terrane in the area of the Firth showing. The Firth showing appears to represent small dismembered portions of the Grum deposit in this fault zone. The cataclastic marginal phase of the Anvil Batholith records large scale strain of a similar extensional nature. These relationships suggest that more such faults will prove to be present. There are preliminary indications that such a fault is present at Dy and maybe one of the factors delimiting are there. At least two additional similar faults perhaps with large displacement underly and terminate Grum at its southeast end. A Similar structure underlies Swim.
Continued study of this large scale extensional fault pattern is instrumental to the understanding of the overall structural picture of Vangorda Plateau. In conjunction with what is known of ore controls in the Anvil District such knowledge will greatly assist further exploration on the Plateau.

It is recommended that the Vangorda Plateau be remapped at 1:5000 scale and most available drill holes not actually in the ore deposits be relogged. Detailed closely spaced cross-sections should be constructed to define a consistent subsurface structure to which the ore deposits must relate. A new series of maps at the same scale showing relevant geophysics, geochemistry and drill hole distribution should also be compiled.

A coherent structural picture is of obvious value for exploration but such understanding will also help define logical shapes and trends of deposits which will assist interpretive definition and extraction of ore in the known deposits. For logistic and geologic reasons the Vangorda Plateau represents a high priority exploration target for Cyprus Anvil. We believe that a commitment to this next stage in the evolution of the geologic picture of the district will help enhance the return from exploration dollars by refining priority targets.

REFERENCES

Jilson, G. A., 1984, Summary of the geology and ore deposits of the Anvil Range, unpublished report for Cyprus Anvil Mining Corporation, March 1984.

Pigage, L.C., 1983, Field logging manual, Diamond Drill Hole Data Base System, unpublished report for Cyprus Anvil Mining Corporation, February, 1983.

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APPENDIX I

The following pages give computer summary logs of drill holes logged by CAMC in the Tie-Firth area. All holes but 456-75-09 and EA-79T01 were relogged by the authors during the 1983 field season. EA-79T01 was checked to insure that the Tie Fault was intersected. Original field logs are available at both Faro and Vancouver offices.

Two features are worthy of special note in conjunction with the drill holes. First, in EA-79T01 (also known as Tie-79-01) the Grum ore horizon(s) was cut out by the Tie Fault Zone. Second, hole EA65T01, a 1965 rotary hole, has been relocated. This hole was drilled to test an EM anomaly and chips stored at the Faro Core racks show that it intersected medium grey to black phyllites. Its original location is surrounded by granite outcrops, yet there were no granite chips recovered. The original site shows no evidence of a drill hole yet other 1965 vintage drill sites show much evidence of the presence of a drill. The hole is relocated as best as possible to a site on the hanging wall side of the Tie Fault just south of the original access road, the site has since been destroyed by further road construction.

To facilitate translation of the summary logs a lithologic code is provided. The interested reader is referred to the Diamond Drill Hole Database Field logging manual (Pigage, 1983) for detailed explanation of these drill log formats.