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GEOLOGICAL REPORT
GIANT COPPER BRECCIA
SKAGIT RIVER AREA
HOPE DISTRICT, B.C.

for

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by

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Table 1. **LEGEND**

5 **Overburden, glacial deposits, talus**

Late Faults (East-Northeast to Northeast)
Left-lateral displacement common; includes Giant Fault and several small faults which may offset the AM Breccia slightly; may be genetically associated with major faulting along the Hozameen and Chuwanten (Pasayten) Faults; possibly minor migration of precious metals into faults.

4 **Felsic Dikes**

- 4a very fine grained, porphyritic (plagioclase and quartz phenocrysts)
- 4b aphanitic

Major Hydrothermal Sequence of Events

Late Silver-Lead-Zinc Veins associated with NE-ENE faults,

Main Stage Mineralization (breccia matrix): sulfides (pyrite, pyrrhotite, chalcopyrite, arsenopyrite, minor sphalerite, galena, molybdenite, scheelite); gangue: chlorite, quartz, calcite, feldspar, tourmaline; minor replacement of host rock (chert-carbonate-sericite alteration)

Early Stage: quartz-tourmaline veins and replacement (in part consisting of Subunit 3T)

Brecciation: in pipes near contact of Invermay Stock; breccia zones commonly bounded by faults; possibly controlled by intersection of northeast-trending structures and veins with northwest trending arm of Invermay Stock; possibly associated with brecciation is major rotation of sedimentary blocks. * Note: Formation of AM-breccia may precede intrusion of Invermay Stock

3 **Invermay Stock** (Cretaceous or Tertiary): quartz diorite, diorite, minor granodiorite intrusion; possibly accompanied by block faulting and rotation of metasedimentary rocks bordering the stock.

- 3a medium grained, equigranular to slightly porphyritic
- 3b porphyritic: plagioclase-(hornblende) phenocrysts in very fine grained groundmass
- 3T tourmaline-magnetite-pyrite-(chalcopyrite) replacement body and veins, possibly skarn on contact of roof-pendant of quartzite of Subunit 1e; some brecciation of quartz diorite.
- 3x Pass Breccia: intrusive breccia, with minor to abundant fragments of metasedimentary rocks in a groundmass of Subunit 3b.

Major Regional Deformation (Cretaceous): tight folding along north-northwest-trending subvertical axial planes, axes commonly plunge moderately to the northwest; metamorphism in the greenschist facies.

2 **Mafic Sills**, minor dikes (Upper Jurassic-Cretaceous): mostly intruded parallel to bedding, some possibly along early faults. Note: A few sills may be later than the major hydrothermal event.

2a andesite, fine grained diorite
2b medium grained gabbro, diorite
2c coarse grained hornblende pyroxenite, hornblendite

1 **Dewdney Creek Group** (Upper Jurassic)

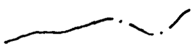
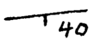
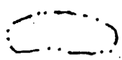
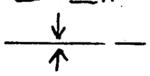
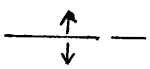
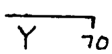
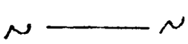
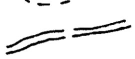
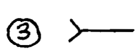
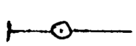
metasedimentary and minor felsic metavolcanic rocks:

1a siliceous argillite and minor siltstone, commonly finely laminated, strong color contrast between layers
1b black argillite, gradational to Subunit 1a
1c sandstone, greywacke; thickly bedded
1d fine felsic tuff (associated with Subunit 1c)
1e quartzite

Suffixes (not all used on maps)

F feldspar-rich
h hornfelsed
L limonite-altered hornfels
P chlorite-carbonate-(actinolite-sericite) (propylitic)
Q silicification
S sulfide-rich
T tourmaline alteration, veins
x breccia
Y chlorite-rich (propylitic)
Z quartz-sericite-(pyrite) alteration

Table 2. **SYMBOLS**

	outcrop border (outcrops examined in this study)
	(outcrops from previous studies, not examined in this study)
	geological contact: defined, approximate/assumed
	bedding
	outline of zone of unusual bedding attitudes (Figure 2)
	fold axis: syncline
	anticline
	vein and/or fracture set (mineralization of veins noted: see list of suffixes for vein type)
	fault, major
	minor
	linear feature, possible fault
	outcrop seen from distance only
	road
	adit
	grid station or drill hole; segment of grid line
	creek or valley

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1.0 Introduction

In June and July, 1989, six field days and six and one-half office days were spent studying the Giant Copper Breccia property. The purpose of the examination was to determine the structural setting of the breccia zones and their relations to the Invermay pluton, to determine structural controls of mineralization, and to recommend regions for additional exploration based on these conclusions.

The examination involved detailed traverse-mapping of the surface geology of much of the core of the property at 1:2400 scale, traverse-mapping of some outlying regions at 1:6000 scale, and a brief examination of the underground workings on the #10- and #15-levels of the AM Breccia Deposit. For surface mapping, control was by topographic map and altimeter. Data obtained in this study were compiled with those from previous studies for regions not examined in this study. For the brief underground examination, control was from previous maps.

Office time was spent reviewing pre-existing data, discussing the geology with officials of Bethlehem Resources Corporation, and compiling and interpreting the data. No attempt was made in this report to summarize or incorporate the details of the abundant drill-hole data in the AM Breccia or the less extensive underground workings and drilling in the Invermay Showing.

Much geological data exists for the property; geological units are defined as closely as possible to conform to classifications of previous studies. Surface data from previous studies are of varying degrees of quality. For example, some maps show inferred contacts but not outcrops, and on many maps, structural data is limited. No maps were available for the part of the #15-Level near the adit.

In this study, the 1:2400 map (Figure 1) is incomplete, in that some outcrops were not examined, most contacts were not traced on the ground in detail, and because in some areas outcrop data is too sparse to allow contacts to be outlined or the structure to be understood adequately enough to make an overall synthesis. The 1:6000 map (Figure 2) contains traverses outside the limits of Figure 1 and generalized and interpreted features for the area covered by Figure 1. Tables 1 and 2 show the legend and symbols used for Figures 1 and 2.

2.0 Geology

2.1 Regional and General Geology

A belt up to several km wide of steeply dipping and tightly folded metasedimentary rocks of the Jurassic Dewdney Creek Group forms a structural block between the northwesterly trending Hozameen and Chuwanten thrust faults, along both of which older rocks are thrust from the west over younger rocks to the east. The Hozameen Fault separates rocks of the Dewdney Creek Group of Jurassic age from Carboniferous argillite, slate, and phyllite of the Hozameen Group to the west. The Chuwanten (or Pasayten Fault) separates rocks of the Dewdney Creek Group from Cretaceous arkose, siltstone, argillite, and conglomerate of the Pasayten Group to the east. The Giant Copper property is near the western side of the block of rocks of the Dewdney Creek Group.

The sedimentary rocks of the Dewdney Creek Group were intruded by abundant, mainly mafic to locally ultramafic sills of uncertain age, probably Jurassic/Cretaceous. Most of the sills are conformable to bedding and were folded with the sedimentary rocks.

The Invermay Stock, an elongate diorite to quartz diorite to locally granodiorite body of Cretaceous or Tertiary age was intruded into the older rocks, more or less along the northwest-trending axis of the sedimentary rocks.

Zones of potential economic interest include replacement bodies, breccia pipes and veins, almost all of which are near the contact of the metasedimentary rocks with the intrusive body, and which have been considered historically to have been related in origin to the intrusive body.

The Giant Fault, a major northeast-trending fault, truncates the south end of the AM Breccia and may offset it up to 1000 metres to the northeast to the site of the anomaly north of #10-Portal.

2.2 Property Geology: Lithologic Units

2.2.1 Dewdney Creek Group (Unit 1)

Metasedimentary rocks of the Dewdney Creek Group are dominated by finely laminated sequences of argillite, siltstone, and minor greywacke. These commonly are strongly color banded from pale greenish grey and grey to medium to dark brownish grey and greenish grey (**Subunit 1a**). Southeast of Giant Fault, rocks of Subunit 1a become blacker and more uniform in color and texture, and grade into black argillite (**Subunit 1b**).

Less abundant are intervals of thickly and poorly bedded greywacke and fine to coarse felsic tuff, which are pale to light bluish to greenish grey in color (**Subunit 1c**). The coarsest layers, which are of minor abundance, consist of angular to subangular fragments of sedimentary and/or volcanic rocks averaging 3- 7 mm in size in a sparse argillitic matrix (**Subunit 1d**).

Near the Invermay Showing in the Invermay Stock is an inclusion a few hundred metres long of orthoquartzite, which shows a weak fabric which may represent original bedding (**Subunit 1e**).

2.2.2 Mafic/Ultramafic Intrusions

Intrusive into the Dewdney Creek metasedimentary rocks are abundant sills and minor dikes which range in composition from diorite to mafic gabbro and less commonly hornblende pyroxenite and hornblendite. Intrusions are from one metre to a few tens of metres wide. Commonly wider sills are zoned, with border zones of aphanitic diorite grading inwards to fine grained diorite (**Subunit 2a**), then to coarser grained diorite/gabbro (**Subunit 2b**), and in the cores to medium to coarse grained mafic gabbro and/or hornblende pyroxenite and hornblendite (**Subunit 2c**). Over 95% of the intrusions have contacts parallel or subparallel to bedding in the metasedimentary rocks. Most contacts are tight, and some are along small faults; some of the faults probably were formed during regional deformation.

Previous studies state that primary minerals include labradorite plagioclase and minor pyroxene. Most of the latter was replaced by secondary actinolite/ tremolite with minor phlogopite. Some sills contain interstitial quartz, and most contain minor opaque.

The high magnetic anomaly at the south end of Line 120E probably is due to a topographic effect a steep cliff of slightly magnetic diorite/gabbro.

On the south spur of Silverdaisy Mountain, three main diorite to mafic gabbro sills were folded around the nose of a major syncline. This and other similar but less prominent examples indicate that the great majority of the mafic sills were intruded prior to regional deformation and metamorphism.

2.2.3 Breccia (Subunit 1x/2x)

Breccia bodies contain fragments of metasedimentary rocks and mafic sills in a variable groundmass, in part containing abundant sulfides. They were formed prior to intrusion of the Invermay Stock, possibly as an early, explosive phase of that event.

2.2.3.1 AM Breccia

The AM breccia is an ovate, semi-vertical plug 400 metres long by up to 150 metres wide, with a northwest elongation. The contacts of the breccia are along major, steeply dipping faults, which truncate bedding in the surrounding metasedimentary rocks. These are zones of original strong vertical movement associated with the brecciation event. Subsequent to mineralization of the breccia, many of these were reactivated.

The breccia is composed of fragments of sedimentary rocks of the Dewdney Creek Group (**Subunit 1x**) and much fewer fragments of the mafic sills (**Subunit 2x**). Most breccia zones contain fragments from several mm to several cm in size. In general, sedimentary rocks were more strongly fragmented than mafic sills. Scattered to locally abundant blocks averaging 50 cm to a few metres in size commonly are of mafic sills, and locally are of sedimentary rocks. No fragments of the Invermay pluton have been reported.

Previous studies state that locally clusters of coarse fragments of mafic sills have only been slightly disturbed relative to each other. In places on the #6- and #10-levels, sedimentary fragments have been reported to be oriented with subhorizontal bedding.

The matrix of the breccia generally comprises from 10-25%, and locally over 50% of the total mass. Commonly it is dominated by chlorite, with much less epidote, amphibole, and tourmaline. In places it also contains patches and blebs of sulfides; these zones commonly are concentrated along the south and north ends of the breccia body adjacent to the bounding faults. In general, the percentage of sulfides and grade of copper, silver, and gold are highest in rocks with a high percentage of matrix. In zones of potential economic interest, the groundmass is dominated by sulfides, commonly associated with one or more of calcite, quartz, tourmaline, and feldspar. Sulfides occur in patches up to a few decimetres in size, and are dominated by one or more of pyrite, arsenopyrite, and chalcopyrite. Sphalerite, pyrrhotite, and galena are less abundant, and molybdenite, scheelite, and magnetite are minor. Patches rich in sulfides, quartz, calcite, or feldspar commonly are vuggy and medium to coarse grained. On the #10-level, feldspar is concentrated in a few areas, mainly in fractures surrounding fragments of mafic sills. Calcite commonly is concentrated in the western part of the breccia in the #6- and #10-Levels. Sulfides, probably of a later age, are concentrated in veins in faults (see Section 2.2.6).

2.2.3.2 Camp Breccia

The Camp Breccia is an equant body about 100 metres across. On the east and north it is bordered by the Invermay Stock, and probably is underlain by the pluton at a depth of less than 200 metres. The bedding in the outcrop of argillite bordering the south end of the breccia dips gently to the northeast, and strikes at a large angle to the regional trend. Angular fragments are dominated by rocks of Subunit 1a and average 3 mm to 15 cm in size. The matrix comprises from 5-10% of the breccia, is dominated by feldspar and chlorite, and commonly has an igneous appearance. Minor blebs of pyrite, pyrrhotite and chalcopyrite occur in the breccia and nearby Invermay Stock, mainly associated with chlorite.

2.2.3.3 New Breccia

A small body up to a few decametres across occurs on the ridge 800 hundred metres west of the AM Breccia. Much of it was covered by snow at the time of examination. The exposed part consists of a fine breccia similar to the Camp Breccia, with a moderate limonite stain on the weathered surface. The breccia is cut by a dike of Unit 4. Nearby is a mixed zone of rocks of Units 4, 2, and 1 in which the geology is unclear.

2.2.4 Invermay Stock (Unit 3)

The stock is mainly a massive, medium grained diorite to quartz diorite with minor gradations to granodiorite (**Subunit 3a**). It is composed of slightly to moderately zoned andesine plagioclase, with about 10% hornblende, minor to 25% quartz, and minor biotite. Previous studies indicate that plagioclase is altered variably to sericite and kaolinite; hornblende is altered to actinolite/tremolite and minor chlorite; and biotite is replaced by chlorite and muscovite. Granodiorite contains K-feldspar in the groundmass, and minor to moderately abundant accessory tourmaline.

Border zones of the stock commonly are finer grained and porphyritic, with phenocrysts dominated by strongly zoned andesine plagioclase and minor hornblende (**Subunit 3b**).

The body is elongated subparallel to the regional north-northwest trend, and has several apophyses. The upward emplacement of the magma probably was guided by the folded structure of the metasedimentary rocks.

In a contact metamorphic aureole about the stock up to a few decimetres across, metasedimentary rocks of Unit 1 are contact metamorphosed to hornfels with a dense, siliceous character, and with minor to moderately abundant, disseminated pyrite/pyrrhotite. The sulfides weather to give a weak to strong limonite stain on abundant fractures. Hornfelsed metasedimentary rocks are denoted by a suffix "**h**", and those hornfelsed rocks containing abundant limonite are denoted by a suffix "**L**".

The Pass Breccia (**Subunit 3x**)is an poorly defined, irregular intrusive breccia body up to 50 metres across containing zones of sparse to abundant angular to subrounded fragments of metasedimentary rocks enclosed in the fine grained border phase of the Invermay Stock. Some metasedimentary fragments are metasomatised moderately. Locally where fragments are abundant, the texture and weathered surface of the breccia resemble those of the AM and Camp Breccias. In these zones, limonite is moderately abundant. Two drill holes encountered minor pyrite, pyrrhotite, and tourmaline, but negligible values in copper, silver, and gold.

2.2.5 Tourmaline-(Sulfide-Magnetite) Replacement (Subunit 3T) and Quartz-Tourmaline Veins

Scattered through the Invermay Stock and concentrated along its borders and in adjacent metasedimentary rocks are zones with moderately abundant to abundant tourmaline as disseminated rosettes, as veins with quartz, and as replacement bodies. Further from the stock, possibly similar veinlets commonly contain chlorite with or without minor pyrite/pyrrhotite.

The largest replacement body is at the Invermay Showing. It may be a skarn at the contact of the stock and a roof-pendant of banded quartzite, which outcrops a few decametres southeast of the tourmaline-rich zone.

An irregular zone up to a few decametres across is replaced moderately to completely by extremely fine to very fine grained tourmaline and less magnetite, with or without sulfides, mainly pyrite and pyrrhotite with minor chalcopyrite. The content of chalcopyrite increases with that of tourmaline. Tourmaline commonly occurs in rosettes averaging 0.3-1 cm in diameter.

At the southeast corner of the replacement body is a finely banded vein-like zone up to 2 metres thick of alternating layers of quartz-feldspar-(tourmaline) and tourmaline, the latter with or without minor to abundant patches and bands of pyrite. The feldspar-rich bands locally are fragmented and rotated slightly. The vein-like zone has an unusual orientation, striking east-west and dipping moderately to the north.

The replacement zone contains patches of altered quartz diorite, and locally has a breccia texture resulting from replacement of the quartz diorite by tourmaline outwards from a network of fractures. On the borders of the replacement zone, several veins and shear zones extend into relatively unaltered quartz diorite; veins contain abundant patches and lenses very fine to fine grained tourmaline and lenses and pods of pyrite and of quartz. At the northwest end of the replacement body, the strongest vein and a subparallel shear zone 10 metres to the west strike north-south and dip steeply to the west. The replacement body has a strong magnetic dipole, whose axis strikes east-west, with the positive end of the dipole at the east end.

Previous studies state that surrounding the replacement body, the intrusive rocks are altered moderately to strongly to chlorite-sericite-actinolite. In places the intrusive body is altered more strongly to quartz-sericite-(tourmaline); the distribution of these zones is not reported.

On the #10-level in the Invermay Stock a few tens of metres away from the contact with the AM Breccia are a few zones of tourmaline, including one irregular replacement lens up to 30 cm wide, and several subparallel veinlets and veins. The tourmaline replacement and vein zones appear to be unrelated to the AM Breccia.

At several localities, some not close to the outcrop zone of the Invermay Stock, the metasedimentary rocks and mafic sills are cut by irregular, strongly brecciated veins or pebble dikes less than 30 cm wide dominated by quartz and less tourmaline. The orientation of these is variable. They probably are related in origin to the other veins of quartz-tourmaline.

2.2.6 Late Silver-Lead-Zinc Veins

Veins containing abundant sphalerite and galena, and with high contents of silver occur in two main localities, the Invermay Vein, and in the AM Breccia. The former, and probably the latter are low-temperature veins which were emplaced after intrusion of the Invermay Stock. The high silver content is partly in galena and partly in Ag-bearing sulfosalts.

The Invermay Vein occurs along a northeast-trending fault. It consists of lenses up to 30 cm wide and several decametres long of massive sulfides dominated by galena, sphalerite, and less pyrite, pyrrhotite, and minor chalcopyrite and jamesonite.

In the AM Breccia on the #15-level near the southern end of the northern mineralized zone, pods up to a few decimetres long of medium to coarse grained sulfides (sphalerite, pyrite, chalcopyrite, and galena) intergrown with medium to coarse grained quartz and calcite are enclosed in a strong fault gouge. The pods are interpreted as being part of a segmented vein, which had been emplaced along the border of the breccia body, and then was disrupted by late faulting along the same zone. It probably is of a later age than the main mineralization stage in the matrix of the breccia, and may be of the same age as the mineralization in the Invermay Vein. In another fault, local very high gold values probably indicate at least moderate hydrothermal migration and concentration of metals from earlier veins or breccia matrix, rather than introduction of late primary hydrothermal gold.

2.2.7 Northeast-Trending Vein Sets

In several areas, metasedimentary rocks and mafic sills are cut by closely spaced sets of veins and fractures, which trend 035-075 and dip steeply northwest. Two main zones are as follows:

1) from just east of the Pass Breccia northeast to the cliffs at the north end of the mapped area, and
2) in the Twenty-Six Mile Creek geochemical anomaly

In the former, veins are dominated by chlorite with locally minor to moderately abundant pyrite/pyrrhotite. Locally vein stockworks are present, with abundant veins in various other orientations as well as the main set. Limonite is common in the cliff face. The Cliff geochemical anomaly (Zn,As,Ag) downslope and east of the cliffs probably was derived from these veins.

In the latter, fractures and small faults containing abundant limonite cut strongly fractured and limonitic rocks of Units 1 and 2. The Twenty-Six Mile Creek geochemical anomaly, which contains zones high in Cu, Zn, Ag, and As, overlaps and extends downslope from this this zone, and most probably was derived from sulfides in the faults and fractures. The zone of fractures and limonitic alteration extends to the northeast into a series of cliffs. It was not mapped higher on the slope towards the AM Breccia. South of the AM-breccia an small outcrop zone of strongly limonitic metasedimentary rocks has similar weathering characteristics. These vein sets may be of similar origin to the northeast-trending veins in the Invermay Showing and the AM breccia.

The major breccia zones (AM and Camp) occur roughly at the intersection of these vein and fracture sets with the northwest trending arm of the Invermay Stock. This intersection may represent a fundamental structural control to the mineralization events on the property.

2.2.8 Felsic Dikes and Sills (Unit 4)

These may be a late phase of the Invermay magmatic event. They occur in metasedimentary rocks near the pluton, and commonly form sills. They range from very fine grained and porphyritic (pale to medium grey in color), with phenocrysts dominated by plagioclase and locally quartz (**Subunit 4a**), to aphanitic (pale to dark grey in color) (**Subunit 4b**). Some of the porphyritic phases are identical in texture and composition to Subunit 3b of the Invermay pluton. Some contain minor disseminated pyrite, and some are bleached moderately. Dark, aphanitic varieties are similar to hornfelsed, massive argillite. Dikes do not contain tourmaline mineralization, and probably are later than the main tourmalinization event.

2.2.8 Late Ultramafic-Mafic Dike (?)

Some reports describe a large body of amphibolite which cuts the AM breccia underground, and contains blocks of metasedimentary rocks and of breccia. It is reported to grade to a lighter green, fine grained diorite. The description is similar to that of the mafic sills of Unit 2, and alternately to this being a late intrusion, it may be an unusual occurrence of rocks of Unit 2.

3.0 Structure

3.1 Cretaceous Deformation

Regional deformation occurred during a major, Late Cretaceous(?) event prior to intrusion of the Invermay Stock and after emplacement of at least most of the mafic sills. In the section along Highway #3 northwest of the property, beds trend north-northwest and dip steeply, mainly to the northeast, and no folds are obvious.

In most outcrops on the property, beds are planar, and no folds are obvious or suspected. The regional orientation of bedding strikes 160-140 degrees and dips steeply southwest or northeast. On the scale of several decametres to a few hundred metres, tight folds are suggested by the presence of zones or blocks of ground which internally show consistent bedding attitudes with dips in one direction, and adjacent zones or blocks which have similar strikes with dips in the opposite direction. Such folds are indicated on the ridge east of the AM Breccia and on the south spur of Silverdaisy Mountain. On the scale of one to several metres, local moderate warps in bedding attitudes suggest the presence of tight folds, even though generally no fold noses were recognized.

Macroscopic and mesoscopic fold noses were mapped in several outcrops. The largest of these, on the south spur of Silverdaisy Mountain, is a tight syncline nose up to a few decametres wide. Away from the fold nose, limbs are subparallel to the regional trend and steeply dipping.

In the #10-level near Station 10.09, a drag fold consists of an anticline to the northeast and a syncline to the southwest. These folds are a few metres in width and amplitude. The sense of the drag fold suggests a major anticlinal axis to the southwest. Just west of and north of the AM Breccia, similar drag folds are outlined on surface; these plunges moderately to the northwest. Some drag fold axes are relatively flat, and a few dip steeply to the northwest.

Conflicting attitude orientations from surface and underground workings directly beneath indicate that folding is complex, and that warping and other types of distortion of primary folds may have occurred, probably associated with the intrusion of the Invermay Stock.

Just northwest of the AM Breccia, in a zone up to 300 metres long by 200 metres wide, the attitude of beds strikes 90-120 degrees and dips steeply. The northern border of the block is marked by a major east-west fault, near which beds and mafic sills are folded and dip anomalously south at a moderate angle. Because the attitude of the beds in this block is inconsistent with the regional pattern of folding, the block probably was rotated by faulting, rather than being on the limb of a regional fold. Several smaller zones of consistent bedding attitudes do not fit the regional trend. This block and possibly some others may have been rotated during formation of the AM Breccia pipe and other pipes. Others blocks may have been rotated during intrusion of the Invermay Stock. Less commonly, local variations in bedding orientation are due to movement along late faults.

3.2 Faults

Faults are of two main types: those associated with breccia pipes, and late regional faults. Minor faults are in various orientations; some of these probably were formed during late regional faulting.

3.2.1 AM-Breccia Faults

Bordering the AM Breccia are strong faults which truncated bedding in the surrounding metasedimentary rocks, and which were major zones of movement during formation of the breccia pipe. Faults are curved, indicating a predominantly vertical movement. Some of these faults contain veins of sulfides-quartz-calcite, which themselves were fragmented during later movement, possibly related to regional Tertiary faults.

3.2.2 Tertiary Faults

Tertiary faults are of two main sets.

A northeast-trending set includes the regional Giant Fault and numerous smaller ones. The Giant Fault extends along the Canam Creek Valley, over the AM Pass, and down a steep valley to the southwest, and continues along a major valley southwest of Twenty-Six Mile Creek.

Left-lateral displacement of about 1000 metres was determined from the offset of the arm of the Invermay Stock in the center of the property. Northwest of the fault, the stock extends from near the AM Breccia to just northeast of Camp #6. Southwest of the fault it was seen in the #15-level and in Canam Creek just above the #15-level portal. The most recently discovered zone of sulfide mineralization north of #10-portal (#10-North Anomaly) probably is on the southeast side of the Giant Fault, and in the reconstructed, pre-fault model, would be adjacent to the AM Breccia.

One previous interpretation of the AM Breccia body shows it to be cut by several northeast-trending faults with minor left-lateral displacement on each. These faults are subparallel to the Giant Fault, and may be of the same age. On the #15-Level, one such fault contains brecciated fragments of a sulfide-rich vein (see Section 2.2.7).

The Invermay Fault and Vein have a similar orientation to that of the Giant Fault. Late movement along the fault may have produced a left-lateral offset of up to a few tens of metres of the tourmaline-pyrite replacement zone. From the descriptions of the discontinuous nature of the Invermay Vein, it is probable that it was segmented by late movement along the fault.

Several Tertiary faults trend east-west and dip steeply. Displacement on these faults is uncertain, but probably is small. One may truncate the band of metasedimentary rocks north of Invermay Pass. Another truncates the zone of east-west bedding northwest of the AM Breccia.

Most gullies along ridge crests are occupied by small faults in various orientations. A major east-west trending fault cuts the ridge west of the AM Breccia in a region of moderate to tight folding of the metasedimentary rock and mafic sills.

4.0 Economic Geology

1. The most probable interpretation of the AM and Camp Breccias is that they were formed shortly before the intrusion of the Invermay Stock by explosive release of gases. The outline of the AM Breccia is marked by strong, curved faults, whereas that of the Camp Breccia, a much weaker breccia system, is more diffuse. No detailed structural control is obvious for the position of emplacement of either breccia body. Their locations may have been controlled partly by the intersection of a zone of northeast-trending fractures and faults with the northwest-trending structures defined by folds in the metasedimentary rocks and mafic sills. Veins in the northeast-trending fractures probably were formed at the same time as hydrothermal activity in the breccias. The age of sulfide mineralization is uncertain; it probably occurred shortly after the explosive event, and probably was associated with hydrothermal activity following intrusion of the Invermay Stock is unknown.

2. In the AM Breccia, zones of highest-grade sulfides are concentrated in regions near the northern and southern borders of the breccia pipe. This may be because such zones were more permeable than elsewhere in the breccia pipe, possibly because brecciation was more intense there than in the interior of the breccia pipe.

3. Tourmaline-pyrite-(chalcopyrite) replacement bodies and veins were formed shortly after intrusion of the Invermay Stock, probably at moderate to high temperature.

4. Veins rich in silver, zinc and lead were formed after intrusion of the Invermay Stock, as indicated by the Invermay Vein, and possibly by the veins which occur in faults in the AM Breccia. Later movement on northeast faults disrupted breccia bodies and veins. Migration of gold may have occurred from earlier-formed mineralization into some faults at this time.

5. The left-lateral displacement of the Giant Fault suggests that the mineralized zone north of the #10-level portal may be the offset continuation of the AM Breccia zone. It has a similar geochemical signature as does the AM Breccia. Economic potential may exist further southeast along this trend beneath the west side of the broad valley of Canam Creek. However, if the Invermay Stock outcrops on the creek just northeast of the #10-Portal, the zone of economic potential north of that would be small. Additional ground of possible economic potential would occur in the southeast extension of this contact of the Invermay Stock and the metasedimentary rocks southeast of #10-Portal. This zone is covered by overburden, and would be difficult to test.

6. The relationship of the northeast-trending vein sets to zones of possible economic mineralization is unclear, but may indicate zones of structural weakness, whose intersection with northwest-trending features, may have helped localize the explosive activity which produced the breccia pipes.

5.0 Conclusions

1. Because of the lack of fragments of rocks of the Invermay Stock in the AM Breccia, the latter may have formed well prior to intrusion of the Stock. More probably it formed at an early, explosive stage in the intrusive event. Sulfide mineralization probably was a late-stage event, associated with hydrothermal activity at the end of the Invermay intrusive event.

2. The AM breccia and the Camp Breccia occur along the contact of the Invermay Stock where it is intersected by a major set of discontinuous, northeast-trending fractures, veins, and minor faults of uncertain, but probably similar age to the main-stage mineralization in the breccias. These structures are not obvious in country rocks adjacent to the stock or the AM Breccia, but occur in metasedimentary rocks and mafic sills up to a few hundred metres away from and on both sides of the Invermay Stock, where they cause the Twenty-Six Mile Creek and Cliff geochemical anomalies.

3. Two types of sulfide mineralization are present in the AM Breccia; an earlier, probably higher-temperature assemblage of pyrite-pyrrhotite-chalcopyrite-arsenopyrite-(tourmaline) in the breccia matrix and a later, probably lower-temperature assemblage of sphalerite-galena-pyrite-chalcopyrite-quartz-calcite in faults which border and cut the breccia.

4. At the Invermay showing, an early, high-temperature event is represented by the tourmaline-pyrite-magnetite-(chalcopyrite) replacement body and associated veins, and a later, lower-temperature event is represented by the silver-lead-zinc veins in and parallel to the Invermay Fault. The main-stage (matrix) mineralization in the AM Breccia and the tourmaline-pyrite-magnetite replacement bodies at the Invermay Showing probably occurred at about the same time.

5. Major offset of the southeast continuation of the trend of the AM Breccia along the Giant Fault suggests that the target zone north of the #10-Portal is an extension of the AM Breccia, and suggests that the southwesterly extension of this zone beneath the Canam Creek Valley has potential for similar deposits.

6. As well as the breccias, other zones of structural complexity in the metasedimentary rocks and mafic sills may have provided channels for emplacement of hydrothermal fluids. Margins of large rotated blocks and major faults in such blocks may be exploration targets for precious-metal-vein mineralization. The most important such block is just northwest of the AM Breccia.

7. The arm of the Invermay Stock southeast of Giant Fault probably ends in the broad valley of Canam Creek, which probably formed because the intrusive rocks were more strongly altered and easily eroded than the diorite sills and metasedimentary rocks. Much less probably, the arm of the stock may have been offset further northeast along another branch of the northeast-trending, left-lateral fault system which intersects Canam Creek several hundred metres higher than does the Giant Fault. The second possibility suggests a low-priority region for exploration further northeast down the Canam Creek valley.

8. The zone of strong limonite alteration in metasedimentary rocks on the ridge south of Invermay Pass suggests that the rocks form a thin cover on the Invermay Stock. The valley to the west of this ridge containing a small lake is along the projected extension of the intrusive contact, and is a low-priority exploration target.

6.0 Recommendations

1. Exploration should continue on the #10-North Anomaly. #10-Portal. As part of this continuing study, polished thin section examination of chips from percussion drilling should be done to help determine the nature of the host rock type, alteration, and sulfide mineralogy. Detailed mapping of proposed trenches should help to determine the exact location of the Giant Fault, and provide more evidence to test the model presented in this study of significant left-lateral offset along it.

2. The southeast extension of the southwestern contact of the arm of the Invermay Stock southwest of the Giant Fault should be tested southeast of the #10-Portal. Much of this region is in the broad valley of Canam Creek and is covered by thick overburden. Nevertheless, geochemical and geophysical studies might produce targets for high-risk drilling.

3. The geology should be mapped in more detail in the following regions:

1) in and around the 26-Mile Creek geochemical anomaly,
2) in the region between the 26-Mile Creek anomaly and the AM Breccia, and
3) on the westerly facing cliffs northwest of the AM Breccia, to outline more accurately the zone of east-west bedding and tight folding.

Attention should be focussed on zones of structural complexity, important faults, northeast-trending fractures and zones of strong limonite alteration.

4. Any geochemical anomalies discovered in present studies north of the Cliff anomaly and southeast of Canam Creek should be followed by geological examination of the surrounding rocks. Preliminary geochemical studies could be made along the assumed contact of the Invermay Stock and metasedimentary rocks in the major valley northwest of the AM Breccia in the region 8000-9000E/12000-13000N.

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