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GOLD AND MASSIVE SULFIDE MINERALIZATION IN THE TULKS HILL VOLCANICS, VICTORIA LAKE GROUP, CENTRAL NEWFOUNDLAND

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ABSTRACT

The Victoria Lake Group, a thick sequence of volcanic, volcaniclastic and epiclastic rocks, was deposited during the development of an early to middle Ordovician island arc. The volcanic rocks occur within two principal volcanic units, informally termed the Tulks Hill and Tally Pond volcanics, both of which represent major time-stratigraphic units of volcanism. The volcanic rocks consist of intercalated mafic and felsic rocks that are predominantly pyroclastic. Mafic pillow lava is more common in the Tally Pond volcanics than in the Tulks Hill volcanics. The felsic volcanic rocks occur as laterally extensive sheets of crystal and crystal-lithic tuff, breccia and minor flows. Sedimentary rocks consist of sandstone, siltstone, shale, argillite, chert and minor interbedded conglomerate. The clastic sedimentary rocks appear to be derived from the adjacent and underlying volcanic rocks of the Victoria Lake Group.

There are approximately 130 documented mineral occurrences and prospects in the Victoria Lake Group. Most are volcanogenic sulfide type and occur in hydrothermally altered felsic volcanic rocks of the Tulks Hill and Tally Pond volcanics. Pyrite, chalcopyrite, sphalerite, galena and trace to minor amounts of precious metals are generally present.

A number of gold occurrences and prospects have been discovered recently in the Tulks Hill volcanics. One of the more significant of these prospects is the Midas Pond gold prospect. The gold occurs in pyritiferous quartz veins in a ductile shear zone. The shear zone is developed in pyrophyllitized, silicified and sericitized Tulks Hill volcanics. The alteration and mineralization are interpreted to have formed in an epithermal alteration system; however, its temporal and genetic relationships to the base-metal hydrothermal systems in the Tulks Hill volcanics are not known.

INTRODUCTION

Metallogenic studies of the pre-Caradocian volcanic sequences of central Newfoundland were begun in July, 1984, concentrating on the Tally Pond volcanics (Kean, 1985). In 1985, studies began on the Tulks Hill volcanics. These studies involved regional rock geochemistry and detailed stratigraphic, structural and geochemical studies in the areas of known mineralization. A regional rock-sampling program for gold was also carried out over the Victoria Lake Group. The field component of this project was completed during the 1986 field season.

Access to the area is provided by woods roads from Millertown and Grand Falls. The area is characterized by a heavily forested, gently undulating topography covered by extensive glacial till. Consequently, bedrock exposure is poor except for Tulks ridge, which extends from Tulks Valley to Victoria River.

Previous Work

Parts of the field area have been mapped in detail by mineral exploration companies, including ASARCO, Abitibi-Price, BP-Selco and Noranda. The first systematic geological mapping was done at a 1:250,000 scale by the Geological Survey of Canada (Riley, 1957; Williams, 1970). The Newfoundland Department of Mines and Energy has done 1:50,000 scale regional mapping of the King George IV Lake (12A/4), Victoria Lake (12A/6), Star Lake (12A/11E), Lake Ambrose (12A/10), Noel Paul's Brook (12A/9), Buchans (12A/15), Badger (12A/16) and Grand Falls (2D/13) map areas (Kean, 1977, 1979a, b, 1983; Kean and Jayasinghe, 1980, 1982; Kean and Mercer, 1981).

Brown (1952) proposed the name 'Victoria River Series' for the volcanic and sedimentary rocks in the Lake Ambrose–Victoria River area. Riley (1957) proposed the name 'Strides Group' for similar rocks in the western half of the Red Indian Lake map area. Kean (1977) abandoned these names and proposed and defined the 'Victoria Lake Group' to include all the area's pre-Caradocian volcanic and sedimentary rocks (Figure 1).

Volcanogenic sulfide mineralization in the rocks presently assigned to the Victoria Lake Group was first discovered near the mouth of the Victoria River in the early 1900's and is known as 'Victoria Mine' or the Victoria prospect. A number of other significant, volcanogenic, base-metal prospects and gold occurrences were subsequently discovered.

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The volcanogenic sulfide mineralization at Victoria, Jacks Pond, Tulks East, Tulks Hill, Tally Pond (Boundary), Burnt Pond, two prospects of confidential status, and the gold occurrence at Midas Pond were studied as part of this project (Kean, 1985; Kean and Evans, 1986; Evans and Kean, 1986). The Jacks Pond prospect was studied as part of an Honors B.Sc. program (Evans, 1986). The Midas Pond gold prospect forms part of a proposed M.Sc. study by D. Evans.

Regional Geology

The Victoria Lake Group underlies that part of the Dunnage Zone (Williams, 1979) of central Newfoundland that extends from Grand Falls in the northeast to King George IV Lake in the southwest, and from Red Indian Lake in the north to Noel Paul's Brook in the south.

The Ordovician geological development of the Dunnage Zone is recorded in three very broad geologic sequences:

1) *ophiolitic rocks that are interpreted to have formed as oceanic crust.* Where contacts are preserved, these rocks always form the stratigraphically lowest units, and they are believed to represent basement to most of the younger rocks in the Dunnage Zone.

2) *tholeiitic and calc-alkaline volcanic and subvolcanic rocks, and related volcaniclastic rocks.* These rocks stratigraphically overlie the ophiolites in some areas, and range up to 8 km in total thickness. The volcanic units consist of mafic and felsic, dominantly submarine, volcanic and volcaniclastic rocks, and are generally interpreted to represent the remains of early to middle Ordovician island arcs and back-arc basins.

3) *post-island-arc shale and chert, and a flyschoid sequence of argillite, graywacke, and conglomerate.* These rocks stratigraphically overlie many of the island-arc sequences and are in part derived from them. The sedimentary rocks range in age from Middle Ordovician to Early Silurian, and are succeeded by younger Silurian rocks consisting of subaerial, mainly felsic, volcanic rocks and terrestrial sedimentary rocks.

In the south-central part of the Dunnage Zone, the ophiolitic sequences are represented by the King George IV Lake, Annieopsquotch, Star Lake and Shanadithit Brook complexes. The King George IV Lake and Annieopsquotch complexes are faulted against the early to middle Ordovician island-arc sequences of the Victoria Lake Group to the southwest of Red Indian Lake, but are interpreted to have been originally in stratigraphic continuity (Herd and Dunning, 1979).

In the northeast, the Victoria Lake Group is conformably overlain by Caradocian black shales and cherts, which in turn are conformably overlain by Middle Ordovician to Early Silurian flysch, argillite and conglomerate. Siltstone and tuffaceous sandstone of the Harbour Round Formation overlie the Victoria Lake Group in the Red Indian Lake area. This assemblage of rocks is in fault contact to the northwest with the Buchans Group and the Southwest Brook Complex along the Lloyds River–Red Indian Lake fault system.

The Rogerson Lake Conglomerate unconformably overlies the Victoria Lake Group along the group's southern and southeastern boundary. The contact, however, is generally fault modified. A fault also separates the Rogerson Lake Conglomerate along its southeastern boundary from mafic volcanic rocks of the Pine Falls Formation and unnamed volcanic, sedimentary and metamorphic rocks south of Noel Paul's Brook.

Rocks of the Victoria Lake Group occupy a regional northeast-trending anticlinorium (Victoria Anticlinorium). Regionally, the sequence youngs northwesterly on the north limb and southeasterly on the south limb; however, there are many first-order and second-order folds resulting in variable facing directions. Unfortunately, poor exposure generally precludes deciphering detailed structure.

GEOLOGY OF THE VICTORIA LAKE GROUP

The Victoria Lake Group can be divided into two regional lithological facies (Figure 1):

1) volcanic rocks in the southwest (Tulks Hill volcanics) and along the group's southeastern margin (Tally Pond volcanics), comprising approximately 60 percent of the group, and

2) a predominantly sedimentary facies in the northeast that is laterally equivalent to, and derived from, the volcanic rocks.

Limestone lenses near the top of the sedimentary facies and Tulks Hill volcanics have yielded late Llanvirn to early Llandeilo conodonts (Kean and Jayasinghe, 1982), and a U–Pb zircon age of $462\pm^{4}_{2}$ Ma has been obtained on a subvolcanic rhyolite (Dunning, 1986). A preliminary U–Pb zircon age of 517 ± 5 Ma on the Tally Pond volcanics suggests it is much older than the Tulks Hill volcanics (Dunning, 1986). The sedimentary sequence is also conformably overlain by Caradocian graptolitic shale and chert (Kean and Jayasinghe, 1982). The thickness of the Victoria Lake Group cannot be estimated with any degree of certainty because of folding and poor exposure.

The Victoria Lake Group has an inhomogeneously developed, regional penetrative foliation defined by chlorite, sericite, flattened clasts and crystal augen. This foliation is axial planar to tight to isoclinal folds. The rocks have been metamorphosed to the lower greenschist facies.

Volcanic Rocks

Volcanic rocks predominate in the southwestern part of the Victoria Lake Group, as well as along its southeastern margin. Two principal volcanic units, informally termed the Tulks Hill volcanics in the north and the Tally Pond volcanics in the southeast, occupy the north and south limbs of the Victoria Anticlinorium respectively. Both units are characterized by linear belts of predominantly felsic volcanic rocks in particular pyroclastics. Mafic flows are common in the Tally Pond volcanics but minor in the Tulks Hill volcanics. Both represent significant time-stratigraphic units of volcanic

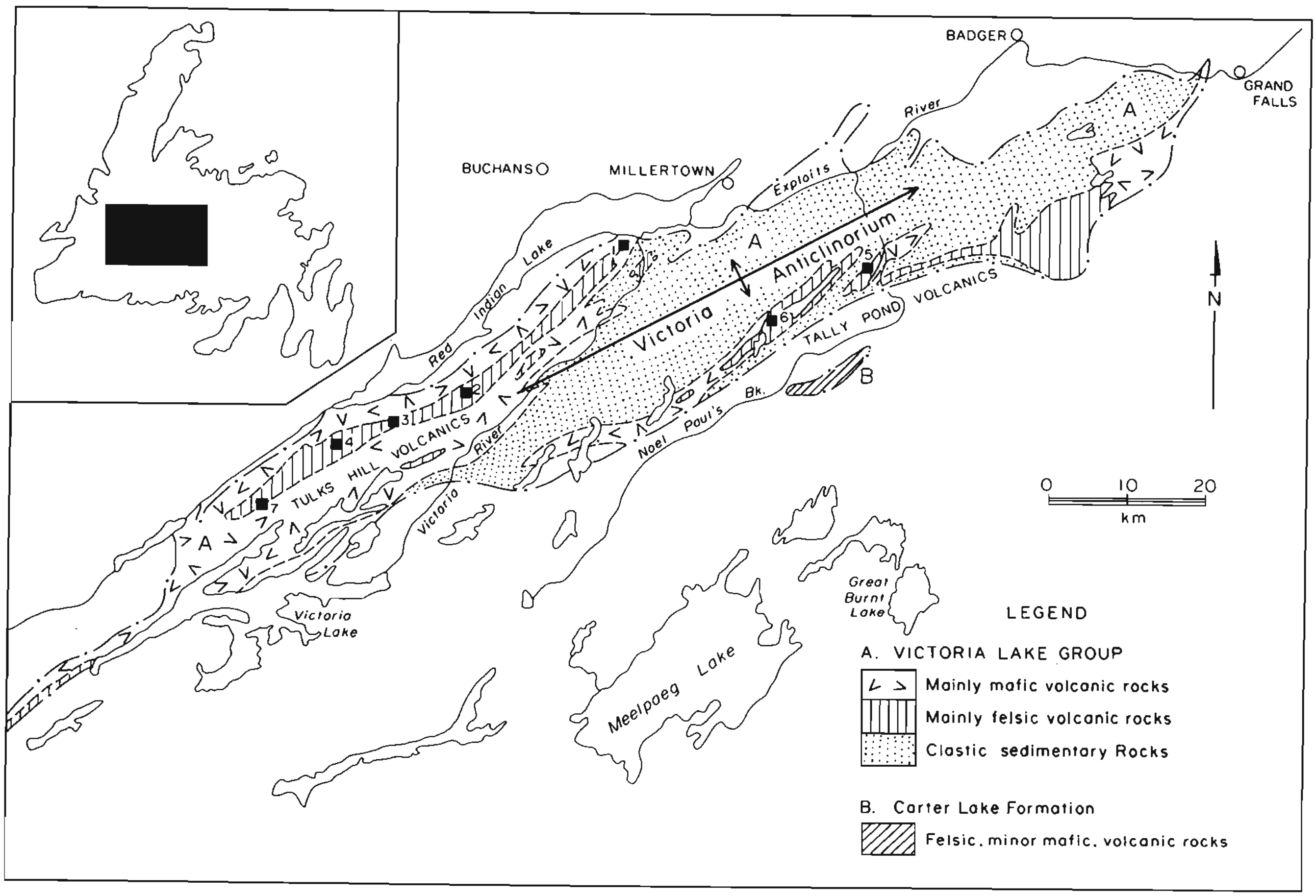

Figure 1: *Early to Middle Ordovician volcanic-dominated sequences and associated mineralization (solid squares) in central Newfoundland (modified after Swinden and Thorpe, 1984). 1. Victoria Mine; 2. Jacks Pond; 3. Tulks East; 4. Tulks Hill; 5. Burnt Pond; 6. Tally Pond; 7. Midas Pond.*

activity with associated hydrothermal alteration and mineralization. Small intercalations or lenses of volcanic rocks also occur within the clastic sedimentary rocks of the Victoria Lake Group to the northeast.

Tulks Hill volcanics. The numerous bands and lenses of volcanic and volcaniclastic rocks that occur in a belt extending from Pat's Pond in the Victoria Lake map area to Victoria River on the southeastern shore of Red Indian Lake in the Lake Ambrose map area were defined by Kean and Jayasinghe (1980) as the Tulks Hill volcanics. The best exposures of these volcanic rocks occur at Tulks Hill in the Star Lake area. The Tulks Hill volcanics consist of predominantly felsic pyroclastic rocks and minor mafic volcanic rocks that are intercalated with well bedded, mafic to silicic, volcaniclastic rocks (including epiclastic–sedimentary rocks).

The felsic volcanic rocks occur as laterally extensive sheets of crystal and crystal-lithic tuff, breccia, porphyritic flows and shallow intrusives. The silica content of most of these rocks place them in the high dacite–low rhyolite range, and they are generally Na_2O enriched relative to K_2O by a factor of approximately 3 to 1 (unpublished chemical analyses, Newfoundland Department of Mines and Energy). Grayish, green and white quartz-crystal and crystal-lithic tuff predominate. The quartz crystals range up to 1 cm across and are commonly blue. Locally, feldspar crystals are present. Flow-banded rhyolite occurs in places, especially west of Bobby's Pond. Locally, in the Jacks Pond area, the rocks have a superficial granitic appearance, and contain quartz, plagioclase, minor potassium feldspar, and a chloritized mafic mineral.

Pyroclastic breccias are also well developed in the felsic volcanic rocks. They contain angular to subrounded clasts of green felsic volcanic, rare mafic volcanic, and sedimentary rock, ranging from 0.5 to 45 cm in length. Fine grained, greenish felsic tuff constitute the matrix to the clasts. Locally the matrix is chloritic and has an intermediate composition.

The mafic volcanic rocks are mainly pyroclastic, comprising mafic to intermediate aquagene tuff, lapilli tuff, agglomerate and breccia. Mafic lavas are mostly pillow lavas that generally exhibit small, commonly flattened pillows with thin selvages and minor interpillow material. Pillow breccia occurs locally. Massive unpillowed lavas are rare; some rocks interpreted as such may actually be sills. The lavas are vesicular, contain calcite amygdules, and locally are variolitic; minor feldsparphyric phases are also present.

The host to these felsic and mafic volcanic rocks is a well-bedded sequence of volcaniclastic rocks. The unit consists of bedded, waterlain, reworked, mafic to silicic tuff, tuffaceous sandstone, argillite and shale.

The Victoria, Jacks Pond, Tulks East and Tulks Hill deposits are hosted by the felsic pyroclastic rocks of the Tulks Hill volcanics. These areas of mineralization are marked by zones of silicification, K_2O enrichment, and Na_2O depletion, as a result of hydrothermal alteration associated with the sulfide mineralization (Evans, 1986).

Tally Pond volcanics. The Tally Pond volcanics were defined by Kean and Jayasinghe (1980) as a belt of intercalated mafic and felsic volcanic rocks that extend from Quinn Lake in the southwest to Sandy Lake in the northeast. The mafic volcanic rocks comprise vesicular and amygdaloidal, generally pillowed flows, and mafic to andesitic tuff, agglomerate and breccia. Mafic pillow lava is more common in the Tally Pond volcanics than in the Tulks Hill volcanics. The pillows are generally small and have minor interpillow material; the latter consists of mafic tuff (probably hyaloclastite) and minor green chert. The breccias contain mafic volcanic rock fragments that range up to 20 cm across. Some of the breccias contain pillow fragments, and are interpreted as pillow breccias.

The felsic volcanic rocks, which host the Tally Pond deposit and Burnt Pond prospect, consist of tuff, lapilli tuff and breccia. Flow-banded rhyolite and rhyolitic breccia are locally present. Black, subvolcanic, quartz–feldspar porphyries are common. The lapilli tuff consists of angular to rounded clasts of white, gray and green dacite and rhyolite, locally flow banded, in a fine grained to locally vitric, tuffaceous matrix. The breccias contain angular felsic volcanic fragments, ranging from 3 to 45 cm in length, in a tuffaceous matrix. Locally, gas breccias are developed that consist of flow-aligned, gas-brecciated clasts in an aphanitic to vitric, siliceous matrix.

Sedimentary Rocks

Clastic rocks constitute most of the northeastern sedimentary facies of the Victoria Lake Group (Kean and Jayasinghe, 1982). This facies consists of sandstone (graywacke) and interbedded siltstone, shale, argillite, conglomerate and rare limestone. Siliceous siltstone and chert are more common near the top of the sequence. Thin intercalations of mafic volcanic rocks are present locally.

The sedimentary sequence generally displays cyclic bedding. A typical cycle has a lower unit of conglomerate and pebbly sandstone, constituting approximately 40 percent of the cycle, which has erosional bases marked by scour and fill structures, load casts and flame structures. The lower unit grades upward into sandstone, which forms about 50 percent of the cycle. The sandstone grades from coarse at the bottom to fine toward the top, where faint laminations, cross-laminations or convolute laminations are locally developed. The sandstone layer is overlain by thinly laminated siltstone, argillite or shale. The contact between the siltstone and underlying sandstone is sharp and free of erosional features. The cycles mainly include ABCE and ABE Bouma divisions and locally CE divisions (Bouma, 1962).

The clastic sedimentary rocks contain abundant volcanic detritus. The amount and coarseness of pyroclastic and epiclastic material increase toward the volcanic rocks of the Victoria Lake Group to the southwest. This suggests that the clastic sedimentary rocks were derived from the adjacent and underlying volcanic rocks of the group.

Intrusive Rocks

The Victoria Lake Group is intruded by linear bodies of medium grained quartz monzonite, minor granite and granodiorite, interpreted to be related to the volcanism (Kean and Jayasinghe, 1980, 1982). Fine to medium grained diorite and gabbro, including rare coarse grained phases, occur as small plugs and large bodies throughout the Victoria Lake Group.

ECONOMIC GEOLOGY

Approximately 130 mineral occurrences and prospects have been documented in the Victoria Lake Group (MODS file, Newfoundland Department of Mines and Energy), and new occurrences and prospects are regularly being discovered. The mineralization occurs mainly in felsic volcanics of both the Tulks Hill and the Tally Pond volcanics.

The mineralization is predominantly of volcanogenic type associated with hydrothermal alteration of the host volcanic rocks. It includes both stratiform-exhalative and stockwork sulfides with the most common consisting of disseminated and stringer pyrite with minor chalcopyrite. Subeconomic, exhalative, volcanogenic sulfide deposits at Tulks Hill, Tulks East, 'Victoria Mine', Tally Pond and Burnt Pond contain significant sphalerite, chalcopyrite and galena. Precious metals are generally present in minor to trace amounts.

A number of gold occurrences and prospects are present in the Tulks Hill volcanics. They are generally associated with quartz veins in high alumina and potassium alteration systems, e.g., Midas Pond. These showings generally contain only trace amounts of base metals.

Midas Pond Gold Prospect

A study of the Midas Pond gold prospect was undertaken as part of a proposed M.Sc. study by D. Evans. This study will examine the general geology and geochemistry, including the style and nature of the alteration and its relationship to mineralization. Mapping was conducted in the vicinity of Midas Pond on a 1:13,320 scale using the BP-Selco grid, and in more detail on nineteen trenches through the mineralized sequence along the south side of Midas Pond. A detailed study of drill core from the prospect was also carried out.

The Midas Pond gold prospect was discovered by BP-Selco personnel in 1985. The prospect is hosted by altered, intermediate to mafic and felsic crystal tuff, lapilli tuff, tuff and breccia of the Tulks Hill volcanics that have been cut by a northeast-trending and northwest-dipping ductile shear zone. Extensive zones of pyrophyllitization, sericitization and silicification are associated with the mineralization. Combined with the shearing, this alteration all but obliterates the original rock textures. The mineralization consists of pyritiferous quartz veins carrying assay gold and trace silver values. Gold content ranges from 5 ppb up to 7300 ppb (J.G. Thurlow, personal communication, 1986; see also Table 1). Only trace amounts of base metals are present. No estimate of tonnage is possible at this stage.

Table 1. Assay gold values from the Midas Pond gold prospect

Sample Number	Sample Description	Au ppb
DE-86-116A	Felsic volcanic	145
DE-86-116B	Quartz vein	1100
DE-86-116C	Quartz vein	770
DE-86-116D	Quartz vein	1350
DE-86-117B	Quartz vein	465
DE-86-117C	Quartz vein	90
DE-86-118A	Felsic volcanic	720
DE-86-118B	Quartz vein	235
DE-86-118C	Quartz vein	140
DE-86-118D	Quartz vein	20
DE-86-119A	Felsic volcanic	230
DE-86-119B	Quartz vein	140
DE-86-119D	Quartz vein	145
DE-86-120A	Felsic volcanic	160
DE-86-120B	Quartz vein	15
DE-86-120C	Quartz vein	485
DE-86-125B	Quartz vein	105
DE-86-134B	Quartz vein	25
DE-86-140B	Quartz vein	700
DE-86-141B	Quartz vein	10
DE-86-142B	Quartz vein	5
DE-86-144B	Quartz vein	5
DE-86-144C	Quartz vein	5
DE-86-145C	Quartz vein	1150
DE-86-147A	Felsic volcanic	85
DE-86-148B	Quartz vein	5
DE-86-225A	Felsic volcanic	5
DE-86-225B	Quartz vein	5

In the general area of the Midas Pond gold prospect, the host Tulks Hill volcanics consist of approximately 40 percent mafic and 60 percent felsic volcanic rocks. These volcanic rocks occur as interbedded, interfolded and probably structurally interleaved sequences of fine grained tuff, white-weathering, felsic, crystal-lithic, lapilli tuff, and fine grained, green-gray, mafic to intermediate, feldspar-crystal tuff and breccia.

The host rocks can be locally divided into seven units on the basis of rock types and alteration (Figure 2); these subdivisions do not necessarily represent stratigraphic units. The mineralized quartz veins generally occur in a silicified zone adjacent to, and intimately associated with, a structural footwall unit of banded mafic rock of probably tuffaceous origin. The structural hanging wall to the mineralized unit is characterized by a highly cleaved zone of extensive pyrophyllitization and minor silicification. The banded mafic rocks of the structural footwall (Unit 4), the mineralized zone, the alteration zone in the structural hanging wall, and the shear zone will be discussed here.

Banded mafic unit. The structural footwall to the mineralization consists of a banded mafic unit that has a strike length of approximately 700 m and a maximum width of approximately 30 m. The unit consists of dark-green, fine grained, chloritic, locally feldsparphyric bands and sugary-textured, felsic, rusty-weathering lenses or clasts containing abundant limonite. These lenses or clasts generally range from 1 to 2 mm in width, but locally are 1 to 2 cm wide, and on average are 1 to 30 cm long. Cloudy, blue quartz crystals are locally developed and occur as aligned, slightly flattened augen in the felsic lenses. The banded mafic unit is variably cleaved and contains narrow localized sericitic zones that exhibit intense shearing. The protolith of the unit is interpreted to have been either interbedded, mafic and felsic tuff, or mafic breccia containing felsic blocks that have been flattened and boundinaged.

The banded mafic unit becomes slightly more siliceous upward, and the contact with the structurally overlying mineralized zone is generally gradational. Quartz veining is common throughout; however, the intensity of veining increases upward toward the mineralized zone. Within the mineralized zone there are rafts of the banded mafic unit caught up in the veining.

Pyrite is a common constituent, both as fine grained anhedral to euhedral disseminations and coarse grained patches containing assay gold values. It is generally present in amounts ranging from 1 to 2 percent (average for rocks of the Tulks Hill volcanics), but in siliceous zones near the top of the unit up to 5 percent coarse grained pyrite is present.

Mineralized zone. The host to the mineralized quartz veins varies from fine grained, gray to grayish-green, sheared and silicified, felsic volcanic rock to variably silicified banded mafic rock. The zone has an estimated strike length of 800 m and an approximate width of 12 m. Pyrite is common throughout both rock types, but appears to be much more abundant in the banded mafic unit, where coarse grained pyrite may reach up to 5 percent of the rock. The host rocks commonly contain thin pyrophyllite seams, and are variably sericitic.

There are possibly three generations of quartz veins within the mineralized zone. The oldest vein system is approximately parallel to the main shear fabric and forms well developed boundins in the fabric planes. These veins contain coarse grained, milky-white quartz and minor rusty-orange carbonate. A penetrative foliation defined by sericite is commonly developed within the boudins. The vein system is interpreted to have formed either prior to or during the early development of the shear zone.

The second- and third(?)- generation quartz veins consist of milky-white, coarsely crystalline quartz exhibiting comb structures. These veins cut both the first-generation quartz veins and the main shear fabric. This suggests that they

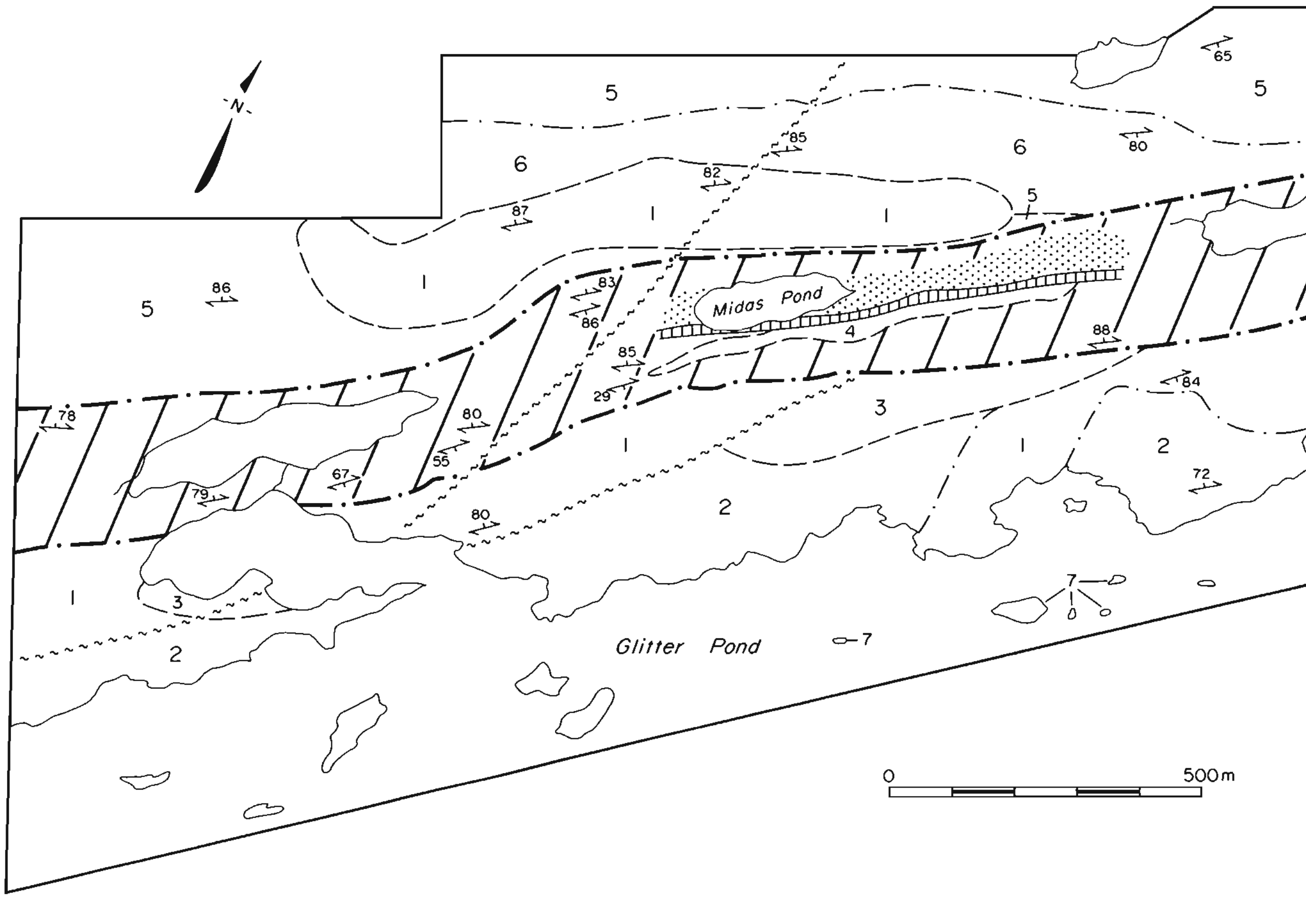

Figure 2: *Geology of the Midas Pond gold prospect.*

formed in a relatively strain-free environment either after or late in the shear-zone development, i.e., dilational veins. The veins may reach up to 1 m in width but are generally much smaller, usually less than 1 cm wide in the profusely veined zones.

Large patches of dolomite, pyrite, chlorite, amorphorous pale-green paragonite, and tourmaline are common in the second- and third-generation quartz veins. Pyrite occurs as fine grained disseminations, coarse grained patches and single euhedral crystals up to 1 to 2 cm across. The pyrite content of the quartz veins ranges from 0 to 5 percent in areas of coarse grained pyrite. Initial assays suggest anomalous gold values in all three quartz-vein generations. The gold, however, appears to be restricted to those veins containing coarse grained pyrite.

Main Alteration zone. The main alteration zone forms the structural hanging wall. It consists of pyrophyllitized, sericitizied and silicified felsic volcanic rocks. This zone is not exposed at surface and can only be studied in drill core. Similar alteration assemblages are present throughout the shear zone, but are most prevalent in the vicinity of the mineralized zone where the alteration zone has an estimated strike length of 800 m and an approximate width of 70 m.

The altered rocks are generally buff to gray, fine grained, felsic, crystal-lithic, lapilli tuff. They are generally strongly foliated. Cloudy quartz crystals are abundant throughout the zone and range from 1 mm up to 3 mm across. Small white feldspar crystals that have brownish kaolinized(?) rims are locally developed. Alteration of these rocks appears to increase toward the mineralized zone. Waxy, green to orange-brown pyrophyllite that first occurs as thin seams increases to about 40 to 60 percent of the rock just above the mineralized zone. Abundant quartz–dolomite veining is common throughout, locally containing coarse grained pyrite and patches of chlorite and paragonite. Thin purple fluorite veinlets up to 1 to 2 mm wide are scattered throughout the alteration zone. Pyrite content is generally 1 to 2 percent, but locally reaches up to 5 percent coarse grained pyrite. Minor, narrow stringers of pyrite are also locally developed. Silicified zones occur sporadically and contain a moderately developed anastomosing cleavage marked by fine grained pyrophyllite and sericite. These zones are generally textureless, but locally have a brecciated appearance of probable tectonic origin. The main shear fabric appears to overprint the alteration, suggesting the alteration zone developed either prior to or during the earlier stages of shearing.

LEGEND

7 *Fine grained, green-gray gabbro*

6 *Yellow to bluish-gray, highly silicified felsic tuff*

5 *Light green-gray, locally sericitic, felsic crystal tuff*

4 *Banded mafic rock consisting of fine grained, dark-green chloritic bands, and white, sugary-textured, locally limonitic, felsic bands*

3 *Cream- to buff-weathering, sericitic, locally siliceous, felsic crystal tuff and minor breccia*

2 *Coarse, angular, locally flattened breccia consisting of felsic blocks in a matrix of fine grained, green, intermediate to mafic, locally feldsparphyric, tuff*

1 *Dark-green, fine grained, intermediate to mafic, feldspar-crystal tuff and minor breccia*

Anastomosing shear zone consisting of interbanded felsic crystal tuff, lapilli tuff and fine grained, mafic, crystal tuff variably pyrophyllitized and silicified

Extensively pyrophyllitized and locally silicified, felsic crystal tuff and lapilli tuff

Mineralized zone consisting of pyritiferous quartz veins cutting silicified felsic rocks and in part the banded mafic rocks of Unit 6

SYMBOLS

~~~~~~~~ *Fault (assumed)*

—— —·— *Geological contact (approximate, gradational)*

Cleavage (inclined)

Shear zone. The northeast-trending, northwest dipping, ductile shear zone extends beyond the study area (approximately 2 km), has a width of approximately 200 m, and exhibits gradational contacts with the host rocks. The zone is a system of ductile, anastomosing shears. In the shear zone most of the rocks are highly cleaved, but the more competent, usually silicified rocks are less cleaved. The main shear fabric is developed subparallel to the regional, penetrative foliation. The general absence of *C–S* planes in the shear zone may indicate the main shear fabric represents *C* planes (K. Green, personal communication, 1986). Intense shear strain within the system may have rotated the *S* planes into parallelism with the *C* planes or shear direction. A dextral shear sense is indicated by the observation of possible *C–S* planes in three places.

Intensely cleaved zones locally contain S- and Z-shaped, asymmetric, kink folds that crenulate the shear-zone fabric. These may represent kink or shear bands, which are commonly developed in shear zones. A prominent fracture set is discontinuously developed, generally axial planar to the crenulations. There is no evidence of shearing along these fractures since they do not offset the cleavage.

Conclusions. The Midas Pond gold prospect exhibits alteration and mineralization styles somewhat similar to epithermal gold systems (Berger and Eimon, 1983). However, due to extensive shearing within the ductile shear zone, further work is needed to ascertain the genetic origin of the prospect. The hydrothermal alteration system is presently interpreted to have formed prior to or during early development of the shear zone. The age and nature of the mineralizing episode is difficult to establish. The gold may have been deposited during the formation of the alteration system, in which case, the gold associated with the post-deformation, second- and third-generation, pyritiferous quartz veins may have been remobilized during the shear-zone development. Conversely, the shear zone may have provided pathways for later movement of gold-bearing fluids. Either the shear zone or a large, nearby, subvolcanic quartz monzonite body may have acted as a heat source for the fluids. The temporal and genetic relationships of this gold-mineralizing system to the base-metal hydrothermal systems is not established.

Volcanogenic Sulfides

The Tally Pond, Tulks Hill, Tulks East, and Jacks Pond volcanogenic sulfide prospects have previously been described (Kean, 1985; Kean and Evans, 1986; Evans and Kean, 1986; Evans, 1986). During the 1986 field season, the 'Victoria Mine' prospect and two prospects of confidential status were examined; the 'Victoria Mine' prospect will be briefly discussed here.
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The 'Victoria Mine' prospect consists of high-grade, volcanogenic Cu–Zn–Pb, massive sulfide showings located at the northeast end of the Tulks Hill volcanics, near the mouth of Victoria River. The showings were discovered in outcrop in the early 1900's, and since then have been the subject of several exploration efforts. However, no economic concentrations have been discovered. Three exploration development shafts were sunk on these showings–one at the brook prospect and two others in the area of the main showings.

The prospect consists of a number of small lenses containing a few hundred thousand tonnes of ore. No reliable grades are available; however, Douglas *et al.* (1940) reported copper values of 5 to 10 percent. Grab samples from the dumps give values of up to 7.5 percent Cu, 2.4 percent Zn, 1.5 percent Pb, 140 ppb Au and 12 ppm Ag.

The mineralization occurs within altered felsic pyroclastics of the Tulks Hill volcanics. The felsic pyroclastics occur as lensoid units within volcaniclastic rocks consisting of both pyroclastic and tuffaceous sedimentary rocks. The pyroclastic rocks consist of intermediate (andesitic to dacitic) tuff, lapilli tuff and breccia, and local feldsparphyric phases. The tuffaceous sedimentary rocks are generally bedded or laminated siltstone, sandstone and graywacke containing clasts of volcanic rocks. A maroon matrix and maroon and red chert(?) and siltstone clasts are locally well developed in the rocks in the area of the Victoria prospect.

The host rocks to the mineralization are schistose, altered, dacitic to felsic tuffs. They are generally sericitic, greenish-gray, locally grayish-white, lithic, lapilli tuff. Quartz eyes occur locally. Whitish, altered rhyolite clasts are common in places. Brown-weathering, carbonate-rich rocks containing galena, sphalerite and pyrite overlie these felsic volcanic rocks in places.

Sericitic, chloritic and carbonate alteration, and disseminated and stringer pyrite–chalcopyrite is developed throughout the host sequence, but is most strongly developed in the footwall. The carbonate (dolomitic?) alteration occurs both as quartz–carbonate veins and as disseminated carbonate in the hanging wall and footwall, persisting well beyond the limits of mineralization. Chlorite alteration is developed in the footwall and is commonly associated with pyrite-chalcopyrite. The alteration zone appears to peter out with depth, i.e., no pipe-like structure can be delineated.

Aside from the disseminated and stringer sulfides developed in the alteration zone, the mineralization is stratiform–exhalative type. The sulfides are generally fine grained, equigranular and banded. The mineralization varies from predominantly pyritic to pyrite–chalcopyrite and pyrite–sphalerite–galena–chalcopyrite. In the latter, the chalcopyrite content increases with depth. Dolomite(?) occurs in places as disseminations and veins within the sulfides, locally forming massive to bedded units containing high-grade lead–zinc. The lenses pinch out down dip, and the extension of the mineralized zone is characterized by disseminated pyrite and base metals, including a few discontinuous high-grade lenses (Thurlow, 1978).

SUMMARY AND CONCLUSIONS

The Tulks Hill volcanics represent a major volcanic complex within the Victoria Lake Group. Felsic volcanic rocks of the Tulks Hill volcanics represent a signficant time-stratigraphic unit of extensive felsic volcanic activity within a dominantly mafic to intermediate volcaniclastic sequence. The felsic rocks appear to have been deposited near a number of volcanic edifices located along a fissure or fault-controlled lineament.

This volcanic activity was accompanied by hydrothermal activity, which resulted in deposition of metallic elements, mainly Zn, Pb and Cu, near the stratigraphic top of the felsic volcanic rocks. This mineralization occurs both as exhalative-stratiform sulfides and as disseminations and stringers in a stockwork or alteration pipe. This alteration is usually characterized by the development of sericite, chlorite and silica, reflected by a general K_2O-enriched, Na_2O-depleted aureole around the mineralization.

The felsic volcanic rocks of the Tulks Hill volcanics also have associated gold mineralization, e.g., the Midas Pond gold prospect. It generally occurs in quartz veins in volcanic rocks characterized by high-alumina and potassium alteration. This alteration is reflected by the development of pyrophyllite, sericite and silica. The relative ages and genetic relationship of the two alteration systems have not been established.

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