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THE KATIE PROSPECT AND THE POTENTIAL FOR VOLCANOGENIC MASSIVE SULPHIDES IN THE BAIE D'ESPOIR GROUP, SOUTH-CENTRAL NEWFOUNDLAND: A METALLOGENIC AND LITHOGEOCHEMICAL STUDY

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ABSTRACT

The Huxter Pond volcanic belt is a felsic to intermediate volcanic sequence, seemingly formed in an island-arc-type setting, which may be a favourable environment for the deposition of volcanogenic massive sulphides. Regionally, the Huxter Pond volcanics are situated in the Exploits Subzone of the Dunnage Tectonostratigraphic Zone, and apparently represent the easternmost example of arc volcanism in the subzone. Locally, these rocks belong to the Middle Ordovician North Steady Pond Formation of the Baie d'Espoir Group, which comprises repetitive sequences of volcanogenic arkose, argillite, conglomerate, and transitional to calc-alkaline volcanic rocks consisting mainly of intermediate to felsic tuff.

Volcanic rocks in the western Exploits Subzone of the Dunnage Zone, such as those in the Tulks Hill and Tally Pond volcanic belts, are recognized as hosts to significant VMS depositional environments and are similar in age and lithology to the Huxter Pond volcanic belt. Rock types and sulphide mineralization at the Strickland VMS deposit in the Hermitage Flexure of the southwestern Exploits Subzone also resemble those in the Huxter Pond volcanics, particularly in the vicinity of the Katie Prospect. The Strickland deposit is predominantly zinc rich and hosted by Ordovician felsic volcanic rocks interpreted to have erupted near the Gondwanan continental margin. This study was designed to determine if the Huxter Pond volcanics are genetically related to volcanism in the western half of the Exploits Subzone and their potential for base-metal enrichments.

Geochemical data define the presence of two different igneous suites in the vicinity of the Katie Prospect, viz.; *a calc-alkaline rhyodacite to dacite suite (the so-called normal felsic volcanic suite) and a tholeiitic to transitional high-level granite–granite breccia–tuff suite. The granite–granite breccia–tuff suite itself appears to be at least, in part, bimodal, being further subdivided into andesite and rhyodacite groups. Sulphide-enriched samples are solely felsic volcanic and exhibit significantly different geochemical signatures than the normal suite including the immobile elements. Lead isotope data for a galena separate from the Katie Prospect resemble those for galenas from Victoria Mine, Tulks and Tulks Hill deposits of the Victoria Lake supergroup.*

Recognizing and documenting the metallogenic potential of the Huxter Pond volcanics with respect to other deposits in the Exploits Subzone, and to the overall geological development of the Iapetus Ocean may be of considerable importance for understanding the metallogenic development of the entire volcanogenic massive sulphide district in central Newfoundland.

INTRODUCTION

During the summer of 2001, a study commenced to determine the significance of base-metal enrichments in the Huxter Pond volcanics of the Ordovician Baie d'Espoir Group at the Katie Prospect (Figure 1). Of primary importance to this study is the evaluation of petrological and geochemical similarities between the Huxter Pond volcanic belt and other known volcanic-arc environments from the Dunnage Zone, in the context of a volcanogenic massive sulphide (VMS)-type setting. These include the Tally Pond and Tulks Hill belts in the western Exploits Subzone and the Strickland deposit in the southwestern portion of the Exploits Subzone, Dunnage Zone. To date, work on the volcanic sequence has involved mapping and lithological sampling followed by derivation of whole-rock major- and trace-element geochemical data and lead-isotope data for galena separates.

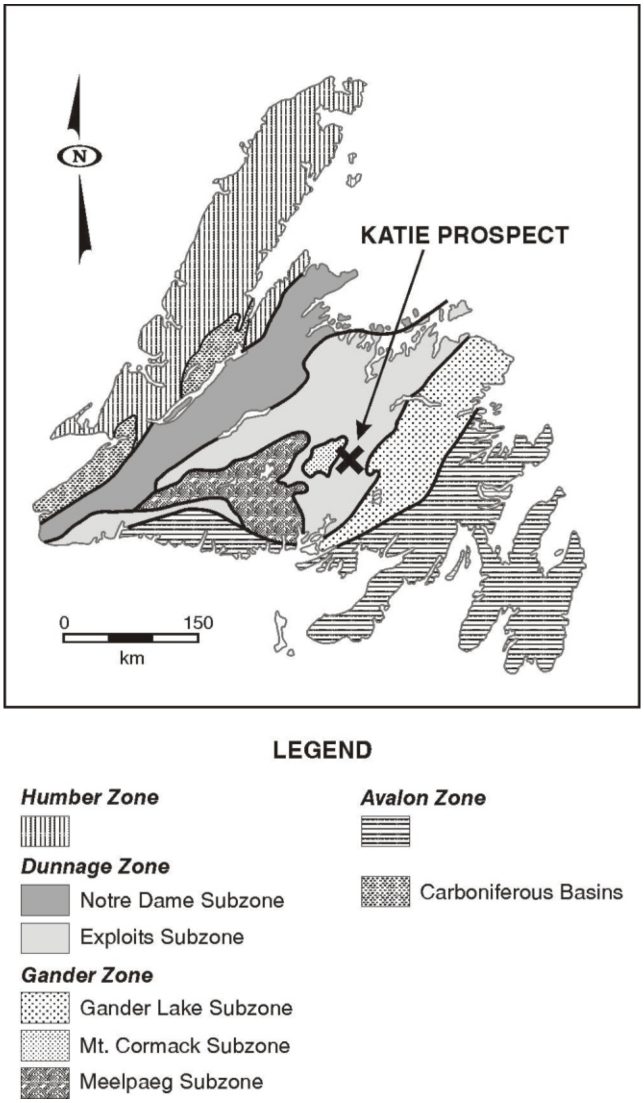

Figure 1. *Tectonostratigraphic subdivisions of the Newfoundland Appalachians (after Williams* et al., *1988) and location of the Katie Prospect.*

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LOCATION, ACCESS AND PHYSIOGRAPHY

The Katie Prospect of the Huxter Pond volcanic belt is located on the Burnt Hill NTS map area 2D/5, in south-central Newfoundland, approximately 75 km south of the town of Grand Falls–Windsor, and about 8 km west of the Baie d'Espoir Highway (Figure 1). Access to the Katie Prospect is obtained via a series of woods roads using truck or all-terrain-vehicles. The terrain in the vicinity of the prospect is essentially flat lying to gently sloped having an average relief of < 30 m, and comprises large areas of open bog and low till hummocks. Maximum elevation is about 245 m above sea level. Poor drainage and an extensive glacial debris cover give poor bedrock exposure (< 1 percent) and generally characterizes the entire region. Bedrock is generally confined to stream beds and isolated rocky knolls. To the north and south of the Katie Prospect, outcrop exposures are best reached by helicopter.

PREVIOUS WORK

Colman-Sadd (1985) reported that the earliest recorded geological observations in the Burnt Hill map area were made by Cormack (1823) and Jukes (1842), who documented the presence of ultramafic rocks that are presently recognized as constituents of the Pipestone Pond Complex. From 1870 to 1876, Alexander Murray made a number of geological observations during a series of expeditions along the Northwest Gander River, including the discovery of the Coy Pond complex and the northeastern end of the Partridgeberry Hills Granite (Murray and Howley, 1881).

Mineral exploration in the region began with an assessment of ultramafic rocks in the Coy Pond complex and, in particular, the Pipestone Pond Complex for potential chromite deposits (Willis, 1901; Moore, 1930). Subsequent work by Snelgrove (1934) on ultramafic rocks of both the Coy Pond and Pipestone Pond complexes derived geochemical analyses and petrographic descriptions. Grady (1953) mapped the ultramafic portion of the Coy Pond complex, and completed reconnaissance mapping of what are now recognized as the Huxter Pond volcanics.

Anderson and Williams (1970) produced a 1:250 000-scale map of the area. The Burnt Hill region was also the focus of regional geochemical studies including the lake-sediment study of Butler and Davenport (1978), the Baie d'Espoir granite project (Elias and Strong, 1982), and the 1:50 000-scale mapping project detailing the geology of the Burnt Hill area (NTS 2/D5; Colman-Sadd, 1985). Swinden (1988) derived geochemical data for North Steady Pond Formation rocks about 40 km to the west of the Katie Prospect in the Pipestone Pond area.

In 1981, an airborne geophysical survey by St. Joe Canada Incorporated (Huxhold, 1982) defined a number of MAG and AEM anomalies to the east and south of Bruce Pond. Follow-up soil geochemical surveys also defined Cu and Zn anomalies, some of which were coincident with the geophysical anomalies (Huxhold, *op. cit.*).

Following identification of felsic volcanic rocks in the region by Colman-Sadd (1985), Rio Algom Exploration Inc. geologists undertook an exploration program over what they termed the Huxter Pond volcanics. Their exploration rationale and target were potential base-metal sulphide deposits of the so-called volcanogenic massive sulphide (VMS) type. Their initial regional-scale work in the Bruce Pond region (MacGillvray, 1987) identified, 1) outcrops of felsic volcanic rock having intense silica and sericite alteration, and pyrite–pyrrhotite mineralization, 2) a number of geophysical anomalies, and 3) stream and soil sediment, and groundwater-seep geochemical anomalies in As, Cu, Pb and Zn. Stream sediments southeast of Bruce Pond contained up to 1179 ppm Zn, 596 ppm Pb and 527 ppm Cu.

In 1986, Rio Algom discovered outcrops containing stratabound pyrite hosted in massive felsic to intermediate crystals tuffs (Bonham, 1988a). Follow-up work by Rio Algom, consisted of horizontal loop Max-Min II and magnetometer surveys over six grids associated with prospecting, geological mapping, till geochemistry and diamond drilling (Bonham, *op. cit.*). The grids covered airborne geophysical anomalies and bedrock sulphide occurrences. The drilling and mapping confirmed the presence of felsic volcanic rocks having extensive sericitic alteration and associated stockwork pyrite and/or pyrrhotite. Rio Algom drilled 14 holes over six grids in the Bruce Pond–Katie region (Bonham, 1988b). Bonham (*op. cit.*) also reported a boulder near Bruce Pond that contained up to 30 percent pyrite and another lithic-crystal tuff boulder that returned an isolated anomalous mercury value of 14 ppm.

In 1993, geologists with BHP Minerals Canada Limited established a grid to the southeast of Bruce Pond in the area of AEM and soil geochemical anomalies as defined by St. Joe Canada Incorporated. BHP's interest in the region was sparked by their observations (Williamson, 1994) that there were, 1) a number of untested AEM anomalies, 2) outcrops containing pyrite and pyrrhotite mineralization in the area, 3) unexplained zinc anomalies in lake-bottom sediments, and 4) boulders having quartz–sphalerite, pyrite–galena, chalcopyrite and arsenopyrite. Their exploration program included 13 trenches and eight short NQ diamond-drill holes (Williamson, 1994). The BHP geologists concluded that the sulphide mineralization was related to granite intrusion into the felsic volcanic rocks.

Gallery Resources Limited (2000 to 2001) has re-investigated the potential for massive sulphide-bearing horizons with claim staking, prospecting and diamond drilling in an area of the Huxter Pond volcanics, just to the east of Bruce Pond, referred to as the Katie Prospect. The best assays for grab samples from four boulders in the region (Figure 3) were (1) 25.6% Zn, 3.5% Pb, 1.66% Cu, 4.4 oz/t Ag and 0.11 oz/t Au, (2) 20% Zn, 2.32% Pb, 0.82% Cu, 1.8 oz/t Ag and 0.06 oz/t Au, (3) 5.88% Zn, 1.57% Pb, 1.63% Cu, 1 oz/t Ag and 0.06 oz/t Au, and (4) 5.73% Zn, 0.39% Pb, 0.10% Cu, 0.5 oz/t Ag and 0.03 oz/t Au (Gallery Resources, unpublished data, 2001). Based on his petrographic analyses of these boulders, Payne (2000) suggested that some of the Zn-rich boulders represent exhalative style mineralization, typical of VMS systems. Although the diamond drilling has been relatively unsuccessful in discovering mineralization, numerous felsic volcanic boulders have been mapped and sampled with high-grade (up to 25 percent) sphalerite, notable chalcopyrite and galena as well as anomalous Ag values.

REGIONAL GEOLOGICAL SETTING

The Island of Newfoundland defines the northeast terminus of the Appalachian Orogen. Williams (1979) subdivided the island into four tectonostratigraphic zones that are, from west to east, the Humber, Dunnage, Gander and Avalon zones (Figure 1). The Newfoundland Dunnage Zone can be further subdivided into the Exploits and Notre Dame subzones on the basis of geochemical, geochronological, geophysical, paleontological and metallogenic criteria and is separated by an extensive fault system, the Red Indian Line (Williams *et al.*, 1988). Hall *et al*. (1998) proposed that the Exploits and Notre Dame subzones formed on opposite sides of the Iapetus Ocean and were not juxtaposed until the late Llanvirn–early Llandelio.

The Burnt Hill map area of south-central Newfoundland (Colman-Sadd, 1985) is located within the southeastern portion of the Exploits Subzone (Figure 1). The area (Figure 2) has a complex geology comprising separate sequences of ophiolitic, volcanic and sedimentary rocks that are all intruded by posttectonic Silurian or Devonian granite intrusions (Colman-Sadd, 1985). Rocks of the North Steady Pond Formation form a northeast- to southwest-trending felsic volcanic package southeast of the ophiolitic Coy Pond complex and are a constituent of the Middle Ordovician Baie d'Espoir Group (Colman-Sadd, 1985). The main posttectonic intrusive in the region is the perthitic Partridgeberry Hills Granite (Colman-Sadd, *op. cit.*).

Colman-Sadd (1985) formally divided the Baie d'Espoir Group into five formations but only one of these, the North Steady Pond Formation, is present in the area of the Katie property. The descriptions of this unit have been derived from Colman-Sadd (1985). Rocks of the North Steady Pond Formation (NSPF) have been further subdivided into three separate units on the basis of lithology, distribution and petrography (Colman-Sadd, 1985). Interbedded sandstone, siltstone and phyllitic siltstone, or interbedded siltstone and phyllitic siltstone, comprise the first subdivi-

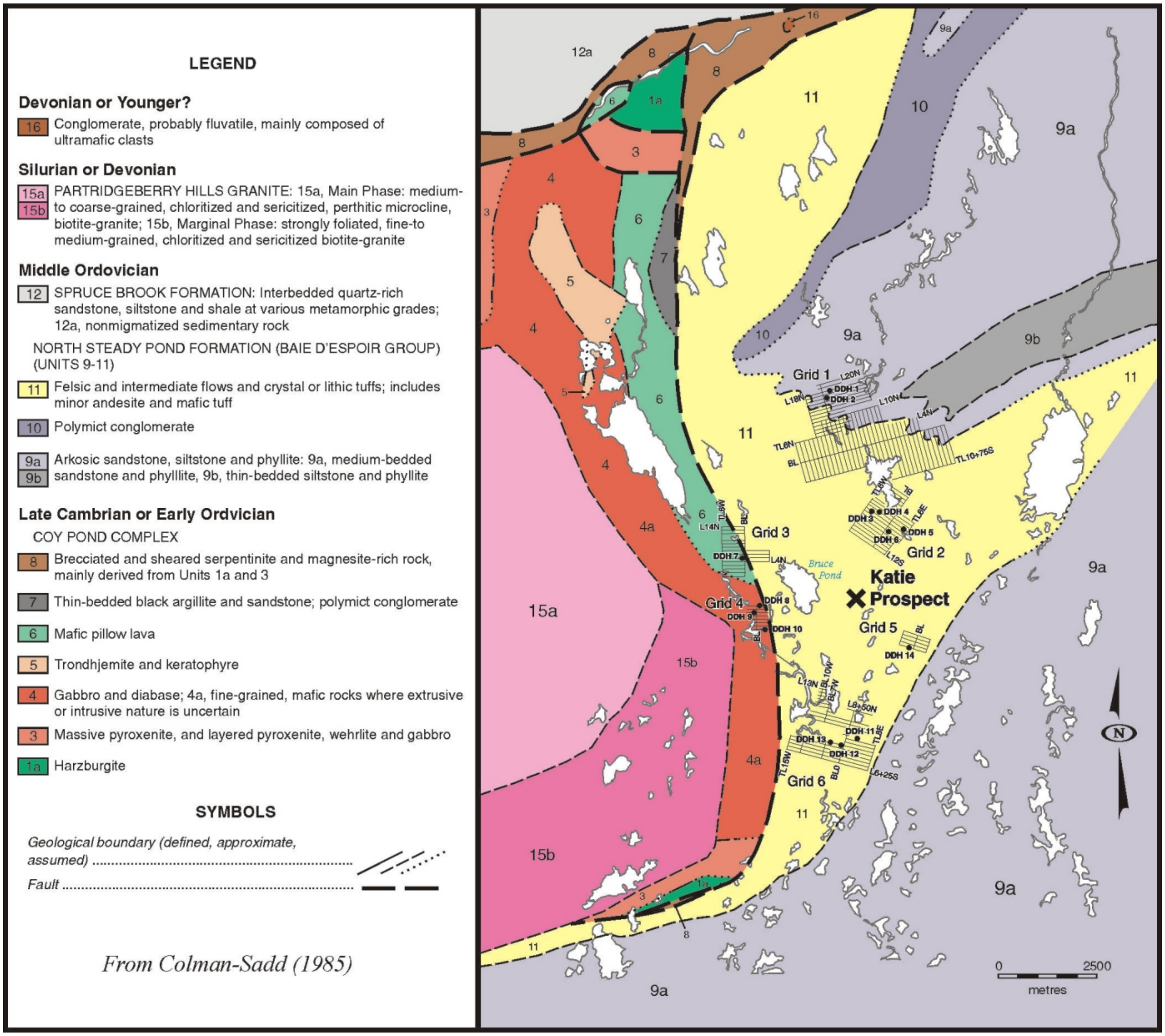

Figure 2. *Geological map showing distribution of major geological units in the eastern half of Burnt Hill (NTS 2D/5), south-central Newfoundland (from Colman-Sadd, 1985). Also showing location of Katie Prospect and Rio Algom exploration grids (from Bonham, 1988a).*

sion within the NSPF. Colman-Sadd (1985) described the sandstone as consisting of graded beds of arkose or lithic arkose.

Conglomerate in the Burnt Hill area constitutes the second subdivision within the NSPF (Colman-Sadd, 1985). According to Colman-Sadd (*op. cit.*) clasts within the conglomerate comprise sedimentary (argillite, siltstone, chert), igneous (felsic and mafic), and metamorphic (?) (psammite) along with mineral grains (calcite, quartz, feldspar and epidote).

As mapped by Colman-Sadd (1985), the NSPF volcanic rocks are of felsic to intermediate compositions, and lesser mafic tuff. In general, the volcanic rocks occur as flows and crystal tuffs with rare occurrences of lithic tuff, the latter with fragments up to 3 cm in diameter (*op. cit.*).

LOCAL GEOLOGY

Volcanic rocks within the proximity of the Katie property (i.e., the Huxter Pond volcanics) commonly exhibit greenschist-facies metamorphism and often have well-defined foliation and/or moderately developed cleavage (Figure 3). Sedimentary units also have moderate- to well-developed cleavage and, in addition, display at least two generations of folding, thus indicating multiple regional-scale deformations within the NSPF. Outcrop and drill core indicate that there is a diversity of rock types within the Huxter Pond volcanic belt near the Katie Prospect. These predominantly include varieties of felsic to intermediate flows and crystal to crystal-lithic tuffs and minor or singular occurrences of andesites, dacites, rhyolites and granites in addition to polylithic debris flows (Plate 1) and/or conglomerate, volcaniclastic and graphitic argillite rocks.

The intermediate to felsic flows and tuffs are typically aphanitic, usually containing phenocrysts/crystals of quartz, quartz-feldspar and plagioclase feldspar from 0.5 to 2 cm in diameter (Plate 2). The groundmass ranges in composition from rhyolite to dacite or andesite and, in some instances, exhibits varying amounts of sericite and/or chlorite alteration. Andesites are typically light green to dark grey and may contain blocky plagioclase phenocrysts in a plagioclase-rich matrix. Dacites are similar in appearance to andesite, i.e., dark grey, but are distinguished by the presence of subrounded quartz and blocky plagioclase phenocrysts in a plagioclase-rich matrix and accessory biotite. Rhyolites are characteristically red–brown having an alkali feldspar-rich matrix, and subrounded quartz as well as, rare, blocky plagioclase phenocrysts (Plate 3). Phenocrysts in all rock types range from approximately 0.5 to 2 cm in diameter. These rocks are locally massive but more commonly have a penetrative cleavage which deflects around subrounded and augen-shaped quartz and quartz-feldspar and blocky to flow-oriented plagioclase crystals, suggesting a significant amount of post-volcanic deformation. At numerous localities, quartz and subordinate carbonate veins trend parallel to the cleavage orientation.

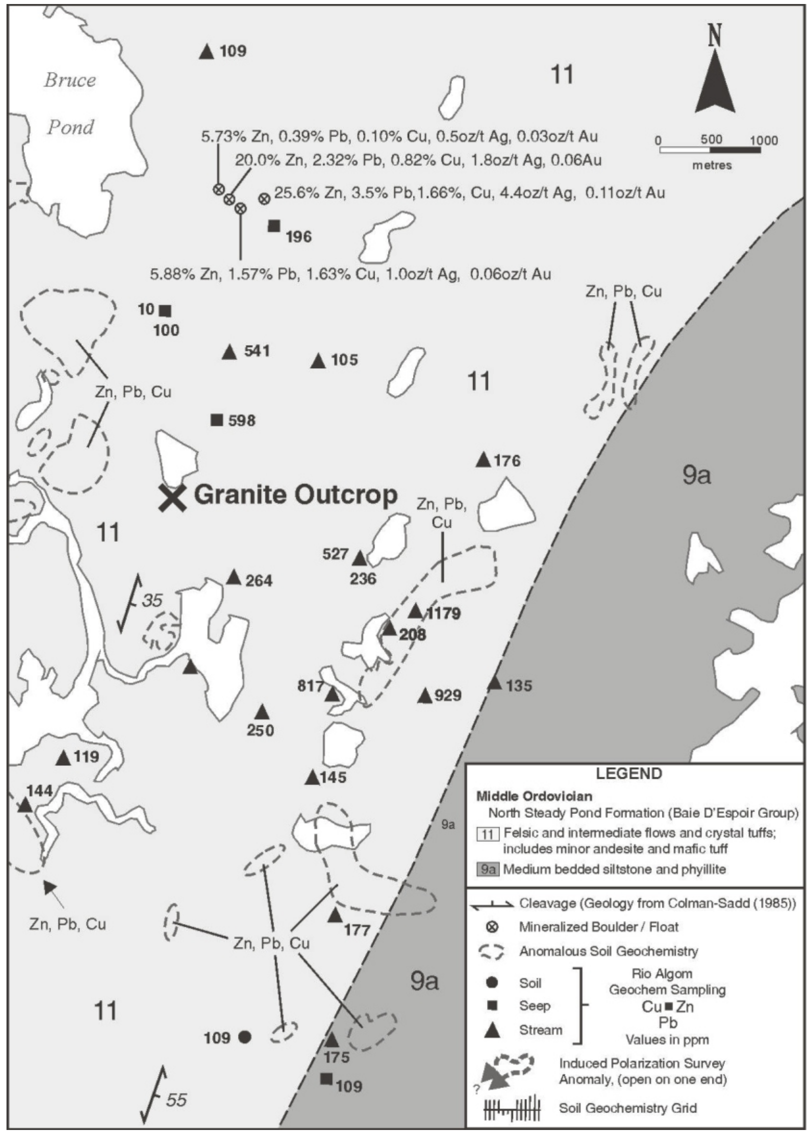

Figure 3. *Geology of the Katie Prospect, and location of Katie boulder zone and Rio Algom geochemical anomalies (from Wilton, 2001b, after Bonham, 1988b).*

Exposures of granite are rare and noted by a single outcrop in the western half of the map region. The granite is massive, white to buff and equigranular, containing medium- to coarse-grained quartz and feldspar. Muscovite, which is slightly to moderately altered to sericite, is the only notable accessory phase.

Significant sulphide mineralization was noted in boulder float at the Katie Prospect and, although most prevalent in felsic–intermediate crystal tuff, is apparently not restricted to any one rock type, including sedimentary sequences. Sulphide compositions are varied and include chalcopyrite, sphalerite, galena, pyrrhotite, pyrite and arsenopyrite. Both sphalerite and galena are strongly associated with pervasive silica alteration (Plate 4). Chalcopyrite, which is locally associated with sphalerite and galena, does not necessarily display a tendency to co-exist with pervasive silicification elsewhere and is present to some degree in most altered rock types. In other locations, chalcopyrite occurs as isolated sul-

Plate 1. *Clasts (up to 15 cm in diameter) of granite and porphyritic rhyolite in debris flow with felsic volcanic matrix (subcrop; sample MD01-044).*

Plate 2. *Chlorite-altered, quartz-feldspar lithic tuff.*

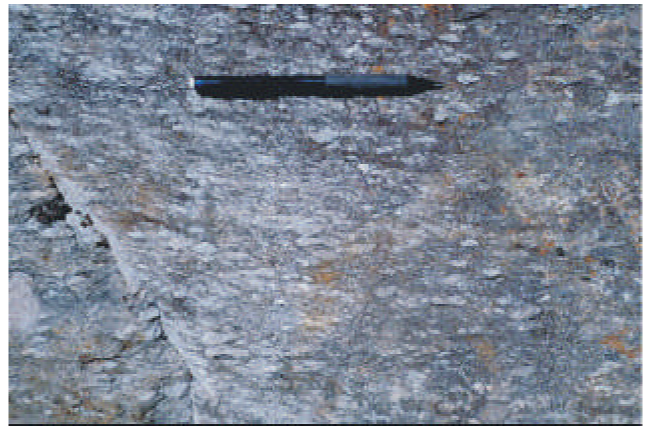

Plate 3. *Sericite-altered, felsic porphyry containing crystals of both quartz and feldspar (sample MD01-048).*

Plate 4. *Strongly silicified and sericite-altered, quartz crystal-tuff boulder float containing semi-massive band of pyrite, sphalerite ("blackjack") and trace galena (MD-01-03).*

phide 'blebs' or co-exists with pyrrhotite. Rare instances of arsenopyrite are associated with extreme sericite alteration (Plate 5), whereas other sulphide minerals such as pyrite and pyrrhotite occur irregularly throughout all rock types.

Lithological information obtained from diamond-drill core within the Huxter Pond volcanics at the Katie Prospect, indicates that the local subsurface geology is nearly identical to that defined for the poorly exposed surface geology. Rock types present dominantly include felsic to intermediate flows and crystal to crystal-lithic tuffs as well as granite and granite–granite breccia–tuff. Minor rock types include andesites, dacites, rhyolites and polylithic debris flows. Other units including volcaniclastic and graphitic argillite rocks are relatively widespread, generally share gradational contacts with tuffaceous horizons and display interlayering with all volcanic units throughout the drill core, relationships typical of an active VMS system (e.g., Ohmoto and Skinner, 1983; Ohmoto, 1996). Additionally, minor intervals of sulphide mineralization were observed that are similar to the surface exposures (especially the sphalerite–silica associations) and once again include chalcopyrite, sphalerite, galena, pyrrhotite, pyrite and arsenopyrite.

The granite to granite–granite breccia–tuff phase (Plate 6) is the only rock type prevalent in drill core that was not observed in outcrop. The granite is white to buff and equigranular with some clearly visible graphic intergrowths of medium- to coarse-grained quartz and feldspar. Minor muscovite and chlorite, typically altered to sericite and chlorite respectively, are the only accessory phases. Local occurrences of non-preferentially oriented, ductile shearing with discrete C–S planar fabrics and chlorite–sericite alteration

Plate 5. *Strongly silicified and sericite-altered quartz crystal-tuff outcrop containing semi-massive concentrations of pyrite and minor arsenopyrite (MD-01-02).*

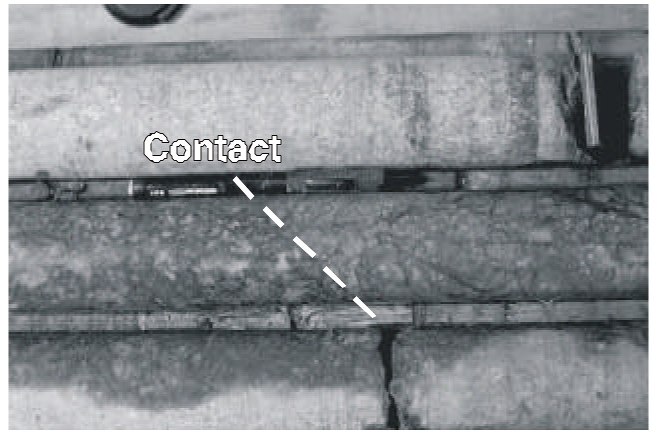

Plate 6. *Contact in drill core between chlorite–sericite-altered quartz-feldspar tuff (left) and granite breccia (right).*

are evident throughout the granite. In some instances, shearing and deformation are pervasive enough to give the granite a brecciated or granulated, possibly tuffaceous, appearance, the latter with subangular to subrounded clasts in chlorite- and/or sericite-altered, schistose matrix. The deformed granite also contains subangular to subrounded quartz-feldspar clasts, up to 4 cm in diameter, in a non-schistose but predominantly chlorite- (with lesser sericite) altered matrix.

GEOCHEMISTRY

Of the 240 whole-rock samples collected from the vicinity of the Katie Prospect, 72 have been analyzed for major- and trace-element contents using X-ray fluorescence techniques. These samples were analyzed at the Department of Earth Sciences, Memorial University of Newfoundland, following the procedures outlined by Longerich (1995). Samples used in the preliminary analyses were collected exclusively from drill core and include 31 intermediate to felsic crystal tuff, 15 tuffaceous andesites to dacites, 14 mixed granite–granite breccia–tuff, 9 intermediate to felsic flows and 3 lithic-crystal tuff. These subdivisions were based solely on textural and/or mineralogical features visible in hand specimen. The geochemical data are listed in Table 1.

Rocks of the Huxter Pond volcanic belt have been metamorphosed to the greenschist facies and subjected, locally, to extensive hydrothermal alteration and thus have a significant probability for remobilization of typically mobile elements in the various protolithic compositions. To address this mobility problem, only selected trace elements that are known to be immobile in typical water-rock reactions are considered in the primary rock classifications. Immobile trace elements that exhibit this behaviour include the high-field strength elements (HFSE): Ti, Zr, Hf, Nb, Ta, P and Y; and the low-field strength element (LFSE): Th (Rollinson, 1993).

Some of the samples analysed were sulphide-rich as indicated by Figure 4; sulphide-enriched samples are defined as those that contained in excess of 1% (or 10,000 ppm) S. In general, most non-sulphide-enriched samples contained < 1% Fe_2O_3, whereas sulphide-enriched samples ranged from 0.33 to 5.69% Fe_2O_3. Only 8 sulphide-enriched samples contained > 100 ppm Zn; in contrast most of the sulphide-enriched samples contained at least 10 ppm Pb (up to 3.6% Pb), whereas in most of the low-sulphur samples, Pb contents were below detection limit.

One final important point to note from these diagrams is that none of the granite–granite breccia–tuff samples contained sulphide enrichments. All of the other rock types did have some samples that contained > 1% S.

According to the Winchester and Floyd (1977) Nb/Y vs. Zr/TiO_2 discrimination diagram (Figure 5), most Huxter Pond volcanic samples have andesite/basalt to andesite to rhyodacite/dacite signatures. Distinct groupings are conspicuous on the Nb/Y vs. Zr/TiO_2 discrimination diagram. In general, there are three groups, including a high Nb/Y-moderate Zr/TiO_2 group (intermediate-felsic crystal tuff, rhyodacite–rhyolite and tuffaceous andesite–dacite) prominently in the rhyodacite–dacite field (termed the "normal" group), a low Nb/Y-moderate Zr/TiO_2 group (mixed granite–granite-tuff-GT-1 (**G**)) in the lower rhyodacite–dacite and upper andesite fields and a low Nb/Y-low Zr/TiO_2 group (mixed granite–granite breccia–tuff-GT-2 (**O**)) in the andesite–basalt field. Numerous samples not belonging to either of

Table 1. X-Ray Fluorescence whole-rock geochemical data for outcrop and drill-core samples, Katie Prospect, Huxter Pond volcanics, Baie D'Espoir Group, central Newfoundland

Sample Name	Rock Type	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	FeO %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	Cr ppm	Ni ppm	Sc ppm	V ppm
MD-01-124	Granite-Tuff	73.25	0.19	13.08	0.26	1.31	0.03	1.87	0.50	6.34	0.26	0.01	19	0	11	16
MD-01-125	Rhyolite(Alt)	73.31	0.46	18.58	0.33	1.70	0.02	1.85	0.41	1.63	3.78	0.11	19	0	10	45
MD-01-127	Granite-Tuff	69.73	0.23	13.29	0.37	1.90	0.07	2.99	1.21	5.12	0.59	0.02	10	0	6	19
MD-01-135	Rhyolite (Min)	64.10	0.66	13.75	1.10	5.60	0.02	0.61	6.71	2.11	2.41	0.10	9	0	15	29
MD-01-136	Xtal Tuff(Dacitic)	62.40	0.65	19.83	0.74	3.75	0.06	2.18	3.31	1.31	5.20	0.13	18	0	19	70
MD-01-137	Xtal Tuff(Semi Min)	33.96	0.25	6.91	3.61	18.38	0.18	2.48	5.80	1.02	2.34	0.07	20	0	1	34
MD-01-139	Xtal Tuff(Semi Min)	22.38	0.19	3.87	2.27	11.59	0.33	0.15	38.77	0.27	1.39	0.03	6	0	20	32
MD-01-140	Xtal Tuff(Dacitic)	63.92	0.64	16.17	0.86	4.37	0.10	2.28	2.81	1.57	5.11	0.13	14	0	17	64
MD-01-141	Xtal Tuff(Andesitic)	65.51	0.67	16.90	0.70	3.56	0.17	2.35	3.21	1.17	4.75	0.13	14	0	13	59
MD-01-142	Xtal Tuff(Rhy Alt)	70.59	0.56	16.24	0.36	1.83	0.09	1.20	1.03	2.00	4.87	0.12	14	0	11	39
MD-01-143	Xtal Tuff(Andesitic)	66.06	0.65	16.90	0.76	3.90	0.11	2.00	2.36	1.96	4.87	0.13	13	0	18	55
MD-01-144	Xtal Tuff(Min)	65.00	0.59	15.39	0.81	4.14	0.05	0.62	1.87	4.01	3.66	0.14	68	0	7	58
MD-01-149	Xtal Tuff(Dacitic)	65.46	0.67	21.01	0.58	2.97	0.14	2.28	1.70	0.41	5.27	0.09	39	0	19	74
MD-01-150	Xtal Tuff(Min)	65.04	0.53	18.18	1.28	6.52	0.05	1.62	1.19	0.22	4.70	0.10	27	18	8	58
MD-01-061	Granite-Tuff	64.83	0.41	15.71	0.56	2.87	0.04	4.08	0.45	4.19	1.56	0.08	13	0	37	87
MD-01-063	Granite-Tuff	62.67	0.52	16.41	0.59	3.03	0.07	5.32	0.88	5.85	0.90	0.12	6	0	22	89
MD-01-064	Granite-Tuff	73.78	0.18	12.90	0.29	1.46	0.06	2.48	1.08	6.13	0.29	0.02	0	0	7	29
MD-01-065	Granite-Tuff	63.06	0.54	17.87	0.71	3.63	0.09	4.23	1.35	3.64	2.31	0.13	5	0	23	93
MD-01-067	Xtal Tuff (And)	65.44	0.53	17.81	0.71	3.60	0.08	4.09	1.69	2.03	3.18	0.11	29	1	14	52
MD-01-070	Granite-Tuff	64.21	0.52	17.54	0.60	3.07	0.09	4.84	1.79	3.16	2.53	0.12	6	0	22	93
MD-01-071	Rhyolite (Alt)	74.18	0.39	17.18	0.26	1.35	0.06	1.63	1.51	0.84	3.83	0.08	15	0	13	42
MD-01-077	Granite-Tuff	70.16	0.20	14.52	0.33	1.66	0.05	2.25	0.93	4.99	1.06	0.03	0	0	7	15
MD-01-079	Tuffaceous Dacite	33.47	0.10	17.05	1.32	6.74	0.09	24.91	2.98	2.12	0.28	0.00	815	141	47	96
MD-01-084	Xtal Tuff (Dacite)	63.88	0.69	17.15	0.70	3.57	0.10	3.20	2.73	2.16	3.87	0.12	33	0	19	64
MD-01-086	Tuffaceous Andesite	49.34	1.17	22.68	1.14	5.81	0.13	5.52	3.33	0.68	6.14	0.08	463	63	52	306
MD-01-089	Granite-Tuff	68.58	0.32	13.52	0.51	2.61	0.08	4.64	2.27	4.12	0.75	0.06	0	0	25	48
MD-01-091	Xtal Tuff (Andesite)	65.78	0.72	15.97	0.75	3.82	0.07	3.26	2.31	2.36	2.58	0.15	47	1	13	76
MD-01-093	Granite-Tuff	70.71	0.26	14.62	0.44	2.27	0.06	2.84	1.12	5.81	0.62	0.05	2	0	11	38
MD-01-095	Tuffaceous Dacite	71.85	0.42	20.10	0.27	1.38	0.01	1.93	0.21	1.70	4.02	0.09	17	0	10	46
MD-01-096	Tuff Dacite(Min)	58.49	0.33	13.02	1.91	9.76	0.16	1.95	2.26	1.41	2.73	0.08	39	0	8	42
MD-01-101	Granite-Tuff	62.66	0.65	18.12	0.75	3.82	0.09	4.58	2.20	1.57	3.22	0.10	43	0	16	74
MD-01-102	Xtal Tuff (Dacite)	69.71	0.23	17.43	0.47	2.40	0.01	0.83	0.14	3.15	3.20	0.04	22	0	12	27
MD-01-103	Xtal Tuff(Min)	67.43	0.53	16.61	0.96	4.89	0.04	1.96	0.97	0.36	4.19	0.05	145	16	18	93
MD-01-105	Xtal Tuff (Dacite)	62.74	0.64	20.39	0.70	3.57	0.09	4.43	2.52	0.58	4.43	0.10	38	2	13	74
MD-01-106	Tuffaceous Dacite	69.47	0.54	16.27	0.33	1.70	0.01	1.28	0.34	0.92	3.63	0.04	175	20	18	99
MD-01-109	Tuffaceous Dacite	64.99	0.65	15.81	0.82	4.20	0.05	5.20	1.31	3.87	1.39	0.12	59	9	18	80
MD-01-110	Granite-Tuff	73.32	0.20	14.55	0.20	0.99	0.02	1.25	0.48	6.31	0.80	0.05	15	0	17	23
MD-01-111	Tuffaceous Dacite	60.77	0.72	16.94	0.96	4.90	0.17	5.18	5.34	0.21	3.60	0.09	59	5	18	81
MD-01-112	Xtal Tuff (Dacite)	66.31	0.63	16.86	0.73	3.70	0.04	3.19	0.89	2.29	2.76	0.11	38	0	17	61
MD-01-113	Xtal Tuff (Dacite)	68.54	0.48	15.98	0.58	2.96	0.04	1.97	0.78	2.73	3.12	0.11	21	0	14	48
MD-01-114	Tuffaceous Dacite	70.33	0.48	23.07	0.10	0.53	0.02	1.30	0.53	0.25	5.47	0.11	25	0	16	58
MD-01-116	Xtal Tuff (Dacite)	65.66	0.65	21.05	0.48	2.45	0.03	2.22	0.34	0.96	4.48	0.10	30	0	14	64
MD-01-119	Tuffaceous Dacite	48.89	1.30	18.08	1.62	8.28	0.16	7.44	5.46	0.09	3.40	0.47	126	53	20	197
MD-01-120	Rhyolite	70.82	0.44	20.00	0.21	1.06	0.01	1.78	0.21	0.40	5.14	0.11	25	0	14	58
MD-01-121	Xtal Tuff (Dacite)	67.24	0.52	16.88	0.65	3.32	0.06	2.63	0.61	3.42	3.07	0.11	30	0	12	56
MD-01-122	Granite Tuff	70.83	0.24	13.39	0.29	1.46	0.08	2.69	2.57	3.16	1.82	0.05	15	0	15	27
MD-01-155	Xtal Tuff (SM Min)	45.98	0.33	10.44	3.66	18.67	0.12	1.33	5.09	1.29	2.70	0.07	1	5	12	34
MD-01-156	Xtal Tuff (Andesite)	61.45	0.78	17.61	0.92	4.70	0.08	3.41	4.35	1.45	4.30	0.13	19	0	19	125
MD-01-157	Xtal Tuff (Andesite)	64.02	0.79	13.65	1.00	5.10	0.10	3.16	3.90	3.74	1.45	0.13	30	0	12	112
MD-01-158	Xtal Tuff (Andesite)	58.43	0.72	19.33	1.08	5.50	0.12	3.37	4.14	1.54	3.78	0.13	23	0	22	139
MD-01-161	Rhyolite	75.77	0.22	15.94	0.27	1.36	0.02	0.90	0.60	2.07	4.75	0.02	2	0	9	11
MD-01-162	Rhyolite	72.39	0.24	18.44	0.32	1.65	0.05	1.76	0.81	0.20	4.60	0.02	3	0	10	13
MD-01-163	Lithic Tuff (Sm Min)	27.67	0.08	4.04	5.69	29.04	0.17	0.16	6.27	0.09	1.09	0.03	5	2	16	17
MD-01-164	Lithic Tuff (Ands)	64.75	0.27	16.34	0.86	4.39	0.09	3.84	3.75	0.15	3.57	0.05	1	0	25	10
MD-01-165	Lithic Tuff (Sil-Mn)	73.93	0.25	15.05	0.35	1.78	0.03	2.12	0.83	1.02	3.45	0.05	2	0	16	3
MD-01-199	Xtal Tuff (Rhyolite)	77.23	0.14	14.20	0.18	0.94	0.01	0.65	0.40	3.49	2.15	0.01	1	0	10	5
MD-01-200	Xtal Tuff (Dacite)	65.67	0.68	16.02	0.67	3.40	0.08	3.20	1.51	2.59	3.32	0.12	31	0	12	74
MD-01-201	Tuff Andesite(Min)	62.62	0.11	2.57	2.30	11.74	0.06	2.94	1.47	0.41	0.35	0.01	14	10	6	45
MD-01-202	Xtal Tuff(Min)	65.65	0.16	10.32	0.58	2.98	0.06	1.05	7.53	4.28	1.12	0.03	3	0	14	20
MD-01-203	Andesite (Sm Min)	47.17	1.03	10.37	2.66	13.54	0.28	8.24	5.02	2.10	1.54	0.30	51	29	33	520
MD-01-204	Xtal Tuff (Dacite)	66.91	0.57	20.01	0.41	2.09	0.06	2.41	2.71	1.46	3.68	0.13	32	0	12	63
MD-01-205	Xtal Tuff (Dacite)	64.00	0.73	17.48	0.82	4.20	0.07	3.23	1.59	1.89	4.86	0.12	34	0	17	69
MD-01-206	Granite-Tuff	69.62	0.26	14.91	0.30	1.51	0.04	2.05	0.62	5.09	1.17	0.03	13	0	13	10
MD-01-208	Tuffaceous Andesite	63.20	0.56	20.82	0.44	2.27	0.09	4.46	2.67	0.66	4.55	0.10	33	0	18	60
MD-01-209	Xtal Tuff (Strg Min)	63.86	0.12	3.29	2.35	11.97	0.18	3.05	5.61	0.04	0.64	0.02	17	44	8	34
MD-01-211	Rhyolite (Po Min)	70.25	1.78	16.28	0.72	3.65	0.01	1.03	0.51	3.21	2.61	0.19	7	24	26	205
MD-01-213	Xtal Tuff (Dacite)	63.02	0.34	15.73	0.78	3.99	0.12	3.96	4.20	2.23	2.27	0.03	50	5	21	107
MD-01-215	Xtal Tuff (Sm Min)	50.22	0.05	3.35	2.08	10.63	0.08	0.48	2.42	3.71	0.88	0.01	17	48	13	32
MD-01-216	Xtal Tuff (Andesite)	56.97	0.40	16.36	0.90	4.59	0.14	5.22	3.63	2.37	2.60	0.04	66	7	26	109
MD-01-218	Tuffaceous And-Alt	38.39	2.12	14.13	2.21	11.25	0.13	17.32	3.38	2.19	0.58	0.25	367	107	44	393
MD-01-168	Alt Andesite	61.53	0.48	21.77	1.12	5.69	0.28	3.22	0.35	0.44	4.88	0.08	88	17	16	111
MD-01-225	Rhyolite (Alt-Min)	68.61	0.58	16.67	0.00	0.00	0.08	1.32	2.25	2.63	4.65	0.12	15	0	14	64

Table 1. (Continued)

Sample Name	Cu ppm	Pb ppm	Zn ppm	S ppm	As ppm	Rb ppm	Ba ppm	Sr ppm	Ga ppm	Nb ppm	Zr ppm	Y ppm	Th ppm	U ppm	Ce ppm	Cl ppm
MD-01-124	0	0	0	535.90	7.53	6	29	61	9	1.5	134	20	2.24	3.32	20.21	96.05
MD-01-125	7	18	0	8657.83	60.06	94	127	21	16	13.5	242	31	10.06	3.01	72.13	149.78
MD-01-127	0	0	0	378.33	3.91	13	37	54	11	0.6	99	12	2.31	1.80	0.00	120.10
MD-01-135	7	3	28	42475.63	74.04	81	333	127	13	13.1	199	23	8.70	2.83	78.81	17.18
MD-01-136	5	0	28	464.85	18.69	146	676	112	21	17.0	275	42	7.62	2.83	69.96	11.53
MD-01-137	27	353	0	173121.20	707.84	51	223	96	10	6.6	108	17	0.98	0.00	17.63	69.03
MD-01-139	2	33	469	87584.98	148.69	31	174	368	6	4.7	60	23	1.53	0.00	17.94	153.70
MD-01-140	6	0	14	214.01	4.03	169	581	54	18	14.2	225	38	8.26	0.00	32.66	91.45
MD-01-141	3	0	1	1128.89	0.00	134	525	63	15	14.5	228	36	8.72	2.58	76.71	162.87
MD-01-142	4	0	0	5086.56	2.06	110	519	35	17	14.4	214	34	9.49	3.59	73.81	85.11
MD-01-143	13	0	22	172.60	17.08	159	600	59	17	16.0	236	39	9.32	2.06	62.73	146.76
MD-01-144	13	31	0	21064.34	0.00	74	478	53	17	15.1	236	38	13.22	1.74	53.73	69.94
MD-01-149	2	0	38	1593.31	30.04	129	296	26	20	16.5	227	32	9.59	4.22	62.96	152.27
MD-01-150	102	143	242	29712.37	50.45	113	214	18	17	13.5	188	27	10.59	3.26	45.12	159.17
MD-01-061	23	0	8	4464.22	6.76	39	74	24	14	2.4	32	51	2.97	1.34	32.95	244.48
MD-01-063	0	0	27	1951.03	0.00	29	58	84	14	2.3	52	33	0.70	0.26	0.00	99.26
MD-01-064	5	0	0	269.53	2.71	7	21	46	7	1.8	125	18	1.83	0.42	6.57	80.80
MD-01-065	31	0	4	842.17	23.12	56	191	59	14	1.2	37	17	0.00	0.00	28.65	50.33
MD-01-067	9	0	10	2024.08	92.96	88	256	49	20	15.7	259	33	7.71	4.16	85.30	53.39
MD-01-070	7	0	9	4585.46	0.00	63	84	34	13	1.6	35	17	2.11	1.48	24.37	69.66
MD-01-071	0	0	0	5093.12	93.48	85	85	19	16	12.1	181	22	8.87	2.23	67.50	42.60
MD-01-077	0	0	0	805.31	0.00	27	68	61	11	2.0	102	36	0.00	0.00	16.07	60.16
MD-01-079	1	0	14	105.33	19.92	8	30	58	12	0.3	3	2	0.84	0.36	0.00	45.35
MD-01-084	6	0	19	461.64	1.22	136	328	35	20	15.7	212	33	9.32	4.40	97.89	57.60
MD-01-086	38	0	73	6541.72	0.00	228	1192	40	20	4.8	133	25	0.00	1.15	10.16	132.20
MD-01-089	2	0	0	162.68	6.76	39	85	44	10	2.0	34	26	1.23	0.56	0.00	63.51
MD-01-091	12	0	10	1266.52	0.00	94	301	61	20	16.1	224	33	11.55	1.69	114.31	70.38
MD-01-093	2	0	0	2934.71	4.48	16	82	78	12	1.4	78	19	0.36	0.00	12.14	72.23
MD-01-095	5	0	13	2519.62	340.28	120	232	18	20	15.7	243	37	11.06	2.63	85.88	55.99
MD-01-096	74	1099	211	33507.95	26.57	69	117	32	15	10.1	172	23	11.22	0.00	36.03	76.51
MD-01-101	14	0	19	869.72	14.98	83	191	30	17	15.8	224	34	11.13	0.00	46.36	53.96
MD-01-102	120	0	0	16249.33	171.82	77	232	33	13	2.5	93	51	0.00	0.00	13.81	119.61
MD-01-103	49	194	0	23978.34	219.36	92	188	20	14	7.0	110	26	8.47	0.00	44.16	68.58
MD-01-105	9	0	13	1007.98	4.02	113	169	27	19	15.4	210	34	9.63	0.55	41.11	3.27
MD-01-106	44	8954	10344	15533.81	9421.91	80	96	18	43	4.5	79	13	0.00	0.00	617.42	64.71
MD-01-109	28	0	15	738.68	16.19	41	95	52	18	14.2	196	29	10.42	3.37	49.58	132.44
MD-01-110	0	0	0	1983.63	1.08	15	45	55	9	1.9	71	30	0.12	0.00	22.87	260.96
MD-01-111	7	0	23	404.28	20.10	160	522	73	17	16.2	227	36	10.43	0.00	40.58	803.18
MD-01-112	1	0	20	249.43	15.96	92	408	27	18	15.0	214	34	10.63	3.44	59.53	144.92
MD-01-113	9	4	21	1479.10	177.08	105	599	43	18	15.2	239	34	12.35	1.37	90.26	94.26
MD-01-114	0	0	0	57.44	38.93	129	161	20	17	15.3	264	36	11.39	2.95	66.49	19.93
MD-01-116	0	0	19	539.70	11.34	117	287	21	19	15.7	215	30	11.39	2.44	63.79	99.58
MD-01-119	41	0	48	779.30	11.39	189	159	152	19	20.5	283	30	3.70	0.00	51.90	140.59
MD-01-120	1	0	0	1333.42	5.27	122	357	15	17	14.3	236	28	10.91	1.71	51.65	71.06
MD-01-121	17	0	18	1158.25	4.84	100	333	35	17	15.4	264	35	10.39	2.55	55.65	51.80
MD-01-122	53	1	55	3802.80	7.84	40	93	40	10	4.8	109	45	5.07	0.00	44.24	103.37
MD-01-155	112	44	9	129117.00	12.49	66	261	94	10	9.5	140	21	7.01	5.73	9.94	36.92
MD-01-156	15	0	38	1061.31	14.84	136	627	84	20	14.7	223	36	8.32	4.11	69.59	240.56
MD-01-157	5	0	29	606.31	18.09	69	261	203	18	15.8	230	38	10.60	1.69	66.98	118.90
MD-01-158	9	0	34	533.75	6.67	109	497	88	20	16.1	243	41	9.87	5.05	46.68	168.93
MD-01-161	0	0	0	154.17	8.44	136	535	24	16	12.2	201	38	12.54	5.81	80.54	196.66
MD-01-162	1	0	3	1918.62	0.00	132	403	27	18	12.2	213	37	13.92	7.81	68.57	17.95
MD-01-163	481	264	0	219300.41	1285.51	22	21	53	1	1.3	16	10	5.40	6.18	0.00	93.36
MD-01-164	3	0	25	343.85	0.00	72	161	47	13	1.5	53	26	0.00	0.75	0.00	25.42
MD-01-165	0	202	4057	3982.80	13.57	68	86	18	22	1.9	57	42	0.00	0.75	0.00	299.57
MD-01-199	0	0	2	1852.14	2.94	33	313	35	9	3.1	134	48	2.93	2.00	6.84	11.02
MD-01-200	22	0	13	1588.67	0.00	88	440	52	20	16.3	218	33	10.19	4.73	101.27	76.71
MD-01-201	2880	36564	7737	89042.34	27.20	16	12	8	90	0.0	0	0	354.19	0.00	187.74	75.63
MD-01-202	149	370	173	11720.96	2.87	28	198	48	9	2.9	112	32	8.82	0.49	51.31	45.90
MD-01-203	323	0	90	40323.44	1.87	54	166	86	15	2.0	53	34	0.54	4.28	0.00	207.90
MD-01-204	5	0	12	1402.23	20.81	112	442	56	21	17.2	278	37	11.41	2.54	74.96	51.66
MD-01-205	11	0	18	139.39	5.28	149	639	44	18	16.2	234	33	8.01	0.79	41.51	39.70
MD-01-206	0	0	0	480.54	0.22	21	83	55	13	3.2	68	19	1.67	0.00	17.32	49.80
MD-01-208	0	0	1	120.79	11.67	120	180	27	22	15.6	274	30	9.55	4.21	86.33	147.94
MD-01-209	184	454	37	78231.04	9.85	16	10	46	5	2.8	16	6	31.01	0.00	0.00	137.03
MD-01-211	42	167	0	20308.77	190.14	79	99	28	17	14.6	228	30	5.07	0.00	41.80	56.60
MD-01-213	13	0	10	747.51	10.07	56	161	52	13	2.7	77	22	0.00	0.00	20.42	41.58
MD-01-215	84	261	108114	127438.40	31.05	20	23	30	57	1.5	12	3	1.30	0.00	0.00	15.21
MD-01-216	24	0	51	1262.62	21.94	54	150	47	13	3.0	68	23	0.86	0.00	5.46	56.64
MD-01-218	23	0	56	182.06	2.25	16	52	143	22	18.4	162	23	1.55	0.00	5.16	115.74
MD-01-168	34	0	33	4437.15	9.42	165	645	38	24	14.0	99	19	9.18	3.04	56.59	30.89
MD-01-225	4	0	0	6171.16	0.00	145	610	82	18	15.4	230	38	8.41	3.54	49.80	211.34

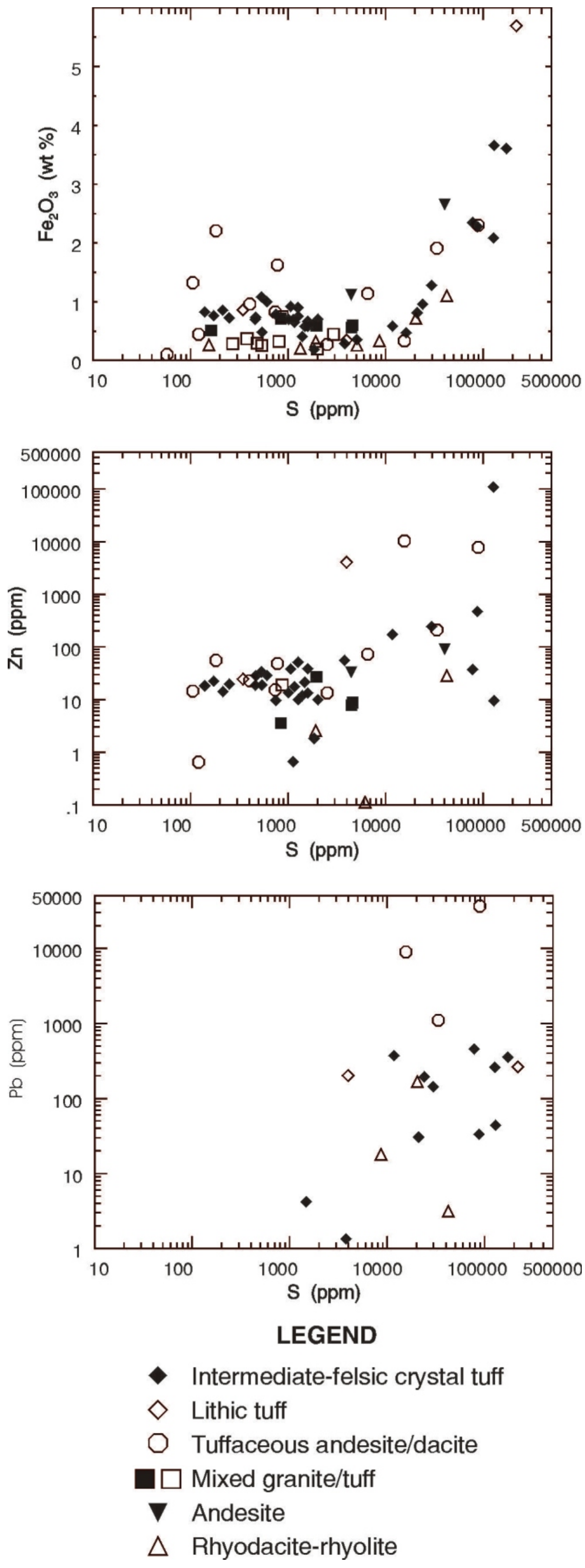

Figure 4. *Variation diagrams of Fe_2O_3 (wt. %), Zn (ppm) and Pb (ppm) vs. S (ppm) for samples from the Huxter Pond volcanics, Katie Prospect.*

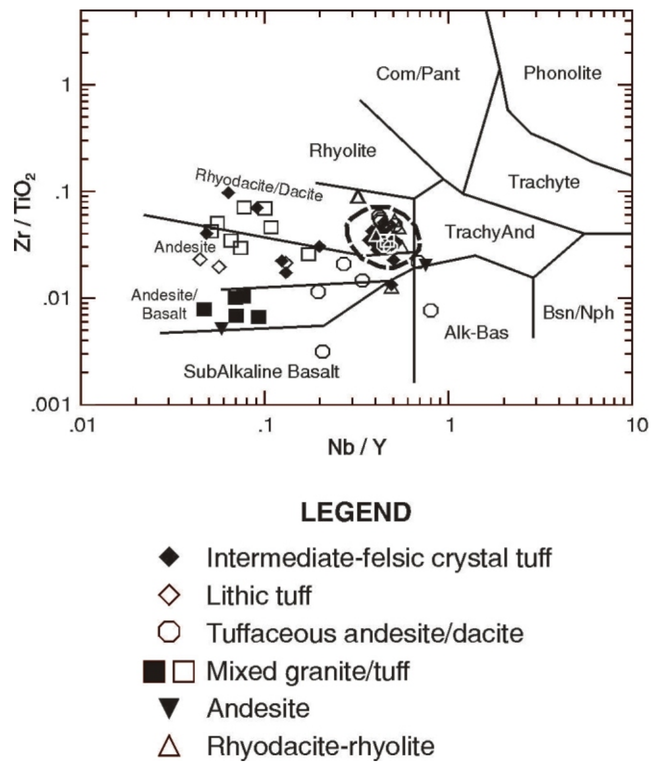

Figure 5. *Zr/TiO_2 vs. Nb/Y discrimination diagram (from Winchester and Floyd, 1977) for felsic volcanic rocks of the Huxter Pond volcanics, Katie Prospect ("normal" felsic group is outlined).*

these groups also plot indiscriminately on the diagram and this scattering is explained, for the most part, by either carbonate alteration and/or, most significantly, sulphide mineralization.

The two distinct classifications for the mixed granite–granite breccia–tuff suggest a bimodal distribution for at least one magmatic assemblage in the Huxter Pond rocks. The major-element chemistry for these samples explicitly suggests a higher silica nature for GT-1 vs. a lower silica nature for GT-2 even though these 'bimodal' rocks are texturally very similar and have definitive felsic constituents such as alkali feldspar and quartz. The mixed granite–granite breccia–tuff phase (GT-2) represents a suite of samples from a single drillhole, whereas the (GT-1) phase is widespread throughout all drillholes at variable depths. Harker

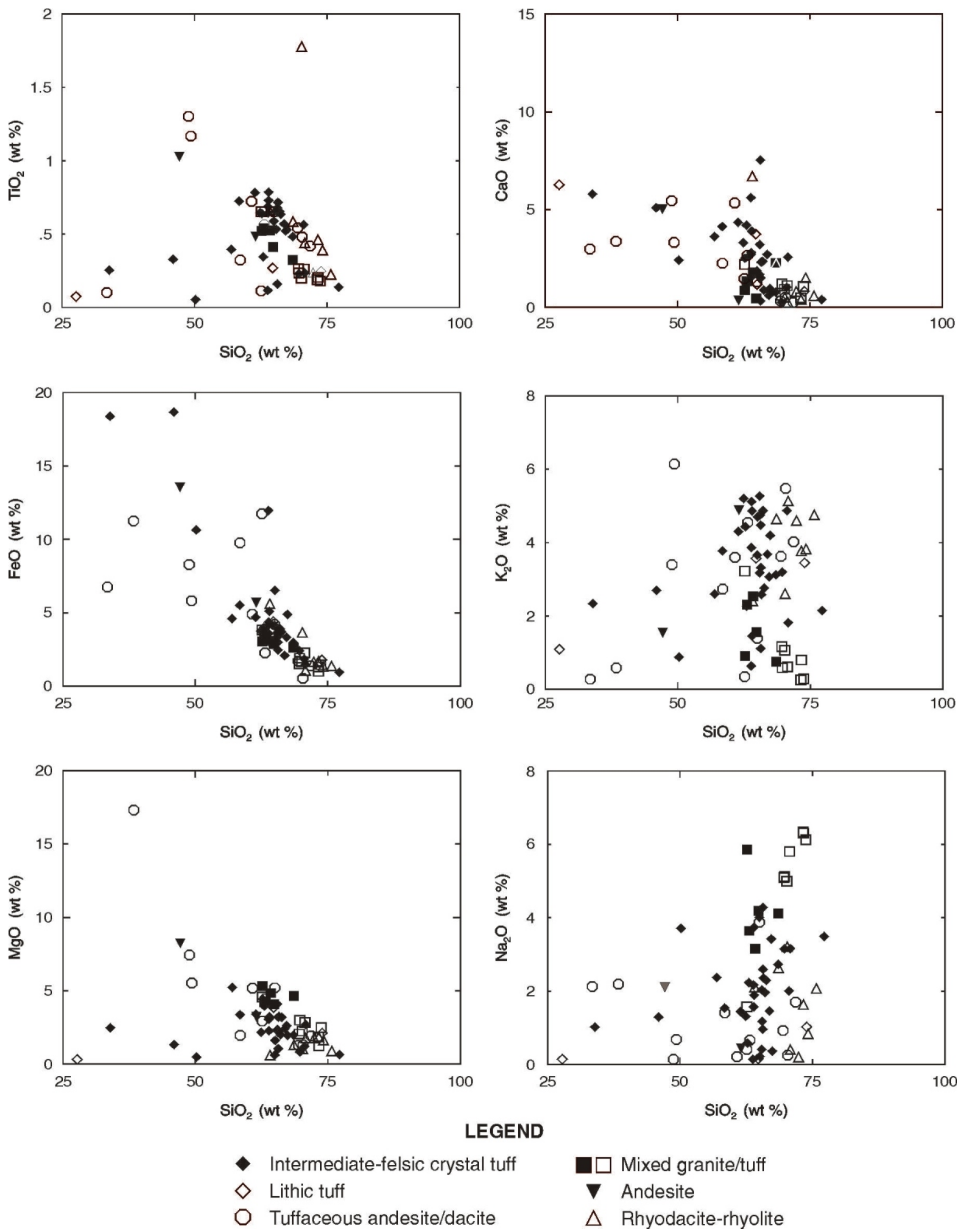

Figure 6. *Harker variation diagrams (vs. SiO_2) for felsic volcanic rocks of the Huxter Pond volcanics, Katie Prospect.*

diagrams (Figure 6) plotted for all samples from the region surrounding the Katie Prospect also suggest that the GT-2 phase reflects an increasingly mafic chemistry relative to the GT-1 phase. For example, the GT-1 samples have definitively lower TiO_2, FeO, MgO and CaO contents with respect to GT-2, indicative of an initial felsic protolithology.

Alkali enrichments in the more felsic GT-1 are conflicting, as an increase in Na_2O was observed in conjunction with slightly depleted K_2O relative to GT-2. The K_2O depletions in the GT-1 phase probably result from element substitution between K and Na, possibly induced by metasomatism, as a K_2O–Na_2O diagram (Figure 7) suggests a linear and thus potentially transferable relationship between these mobile, low-field strength elements. The K_2O–Na_2O plot also indicates that sulphide-enriched samples appear to be associated with moderate to strong depletions in K_2O and/or Na_2O. For some samples, this alkali depletion is not solely a function of mass gain through the addition of sulphur (Figure 8).

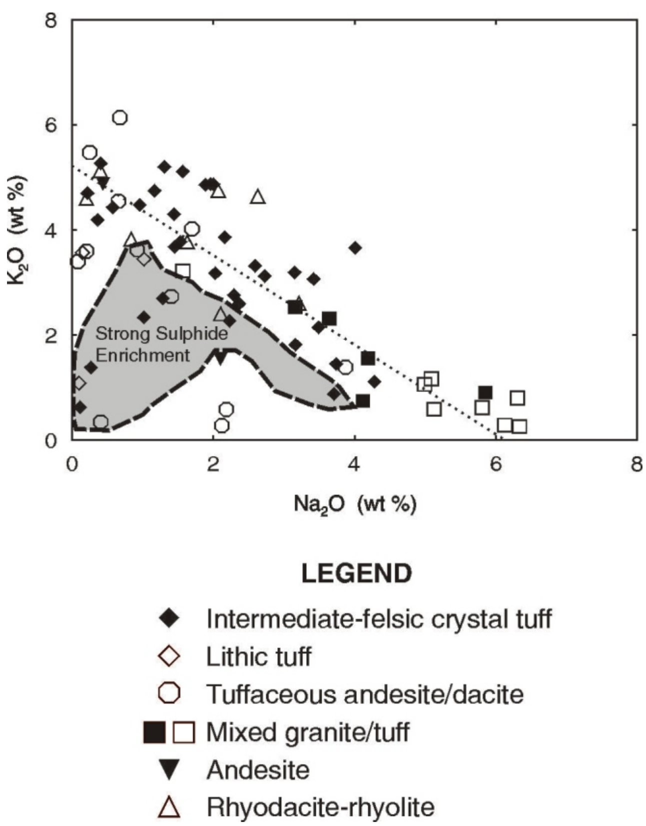

Figure 7. *K_2O vs. Na_2O variation diagram for felsic volcanic rocks of the Huxter Pond volcanics, Katie Prospect.*

A Zr–Y ternary diagram, based on the formulations of Barrett and Maclean (1994), allows for the subdivision of volcanic samples into relative tholeiitic, transitional and calc-alkaline affinities (Figure 9). It is important to note that the defined tholeiitic-transitional-calc-alkaline fields are arbitrary and should not be used as a definitive designation of primary volcanic geochemistry. The primary use of the Zr–Y diagram is as a comparative tool for identification of sample groups within geological settings and whether these groups share similar geochemical signatures. True tholeiite

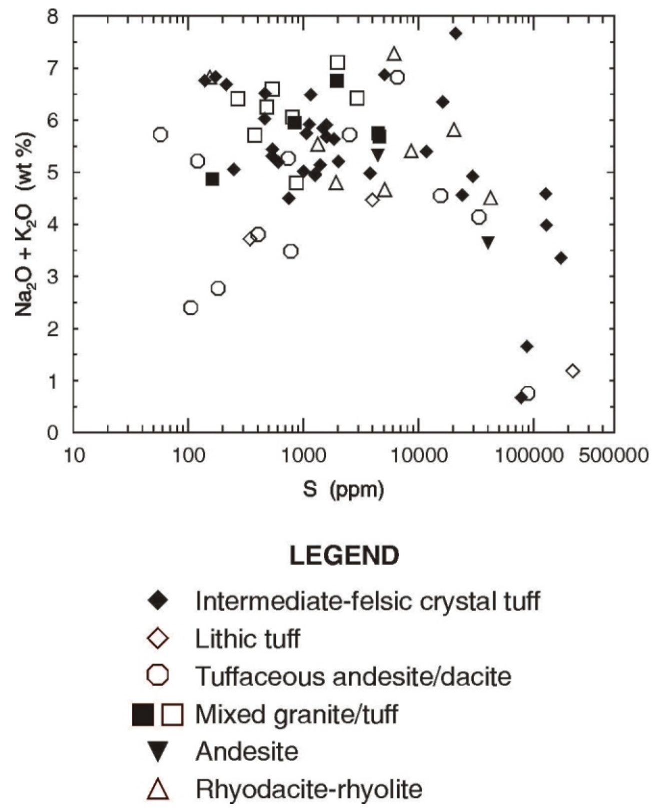

Figure 8. *Total alkalis (K_2O+Na_2O) vs. S variation diagram for felsic volcanic rocks of the Huxter Pond volcanics, Katie Prospect.*

vs. calc-alkaline classification reflects two independent igneous lines of fractionation descent from two distinctly different tectonic environments, based on extensive geochemical analyses including the application of rare-earth-element geochemistry (Wilton, 2001a).

Individual affinity designation is determined on the basis of Zr/Y ratios wherein samples with Zr/Y ratios of < 4.5 are defined as "tholeiitic" and those with Zr/Y ratios > 7 are "calc-alkaline," whereas samples plotting intermediately are recognized as "transitional" (*after* Barrett and Maclean, 1994). Once again, the three distinct groupings are developed on the diagram including the "normal" cluster of felsic-intermediate crystal tuffs, lithic tuffs, andesites–dacites and rhyodacite–rhyolite, as well as both mixed granite tuffs: GT-1 and GT-2. The GT-1 mixed granite–granite breccia–tuff samples plot in a wide range from calc-alkaline through to the tholeiitic field whereas the mixed GT-2 samples plot as a tholeiitic to highly tholeiitic set. The sulphide-enriched samples plot as either tholeiitic-transitional, or as low Zr–Y calcalkaline.

The Nb–Y diagram of Figure 10a also indicates the three member grouping, within which samples with the

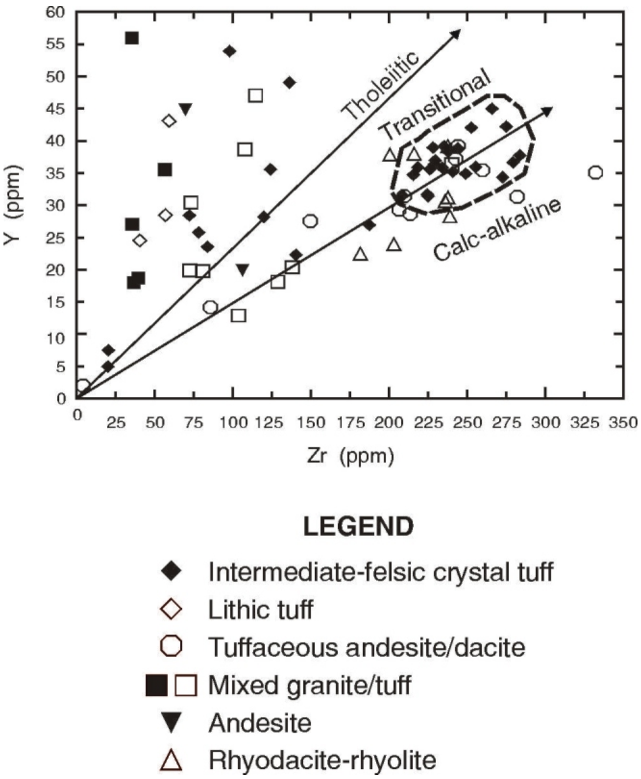

Figure 9. *Y vs. Zr variation diagram for felsic volcanic rocks of the Huxter Pond volcanics, Katie Prospect; tholeiitic, transitional and calc-alkaline fields from Barrett and Maclean (1994) ("normal" felsic group is outlined).*

"normal" felsic volcanic signature have higher Nb than either the GT-1 and GT-2 groups which have a larger range in Y. The sulphide-enriched samples plot away from the "normal" felsic volcanic group. The TiO_2 –Zr diagram (Figure 10b) also define the three groups with GT-1 having lower TiO_2 and low Zr, GT-2 exhibiting higher TiO_2 along with lower Zr, and the "normal" felsic volcanic rocks with highest Zr and TiO_2. The sulphide-bearing samples are again scattered away from "normal" suite, but not necessarily in terms of simple mass gain (i.e., there is no correlative depletion in both immobile elements). Compared to Swinden's (1988) data for the North Steady Pond Formation felsic volcanic rocks at Pipestone Pond, the "normal" felsic volcanic rocks at the Katie Prospect have similar ranges in TiO_2 and Zr, but with lower Y contents (i.e., in Swinden's samples, Y contents were 46-77 ppm).

The Pearce *et al.* (1984) Nb–Y bivariate plot (Figure 11) provisionally indicates that most mixed granite–granite breccia–tuff rocks from the vicinity of the Katie Prospect lie in, or at the boundary of, the volcanic-arc + syn-collisional granite field. With the exception of a single anomalous sample, the mixed granite–granite breccia–tuff indicates a small variation in Nb (1 to 8 ppm) relative to a larger spread in Y

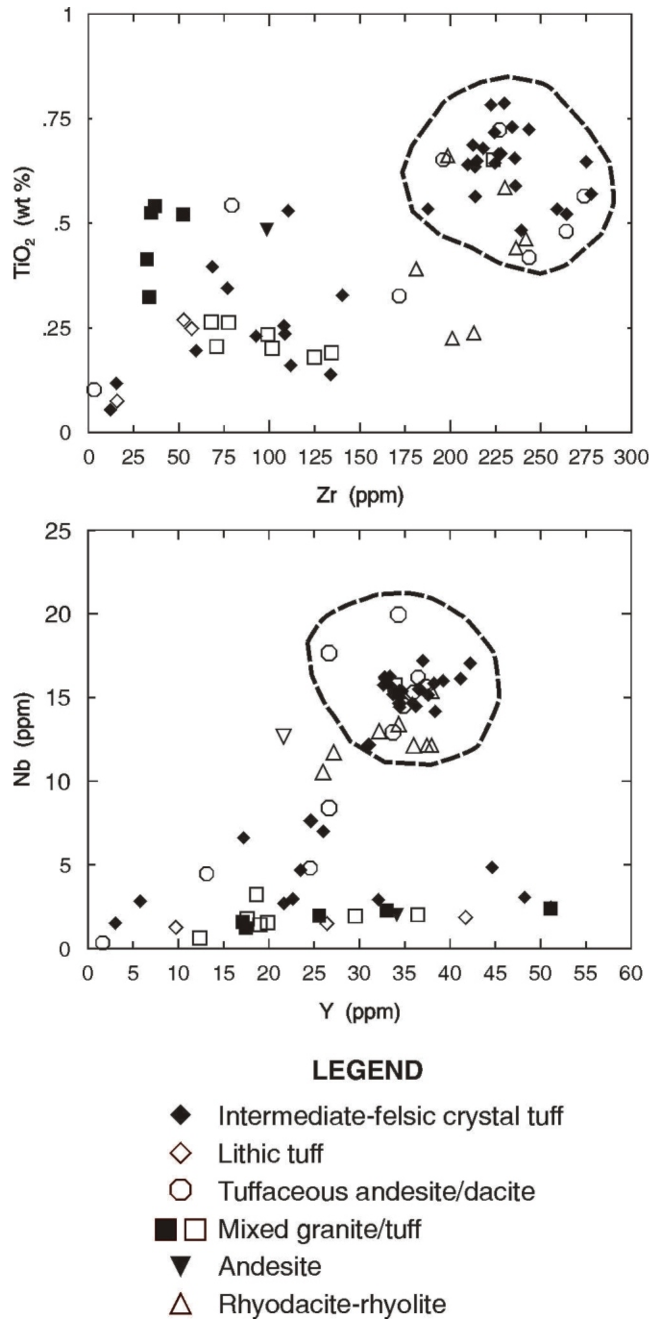

Figure 10. *Nb vs. Y and TiO_2 vs. Zr variation diagrams for felsic volcanic rocks of the Huxter Pond volcanics, Katie Prospect ("normal" felsic group is outlined).*

(20 to 55 ppm). There is not much distinction between the GT-1 and GT-2 samples in terms of these immobile elements.

The GT samples are distinctly different from data reported by Colman-Sadd (1985) for the post-tectonic Partridgeberry Hills Granite. In particular, the GT samples have lower concentrations of Rb, Ba, Pb, Y, K_2O, CaO, TiO_2, much lower Nb, and higher concentrations of Na_2O and Sr.

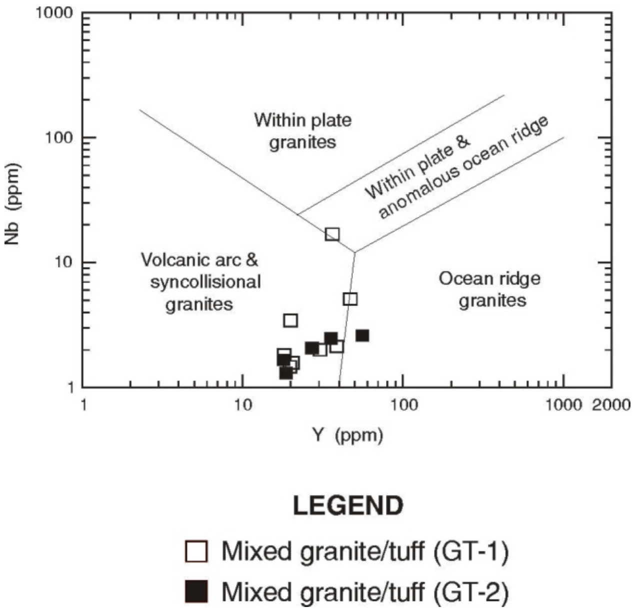

Figure 11. *Nb vs. Y discrimination diagram (from Pearce* et al., *1984) for mixed granite/tuff samples of the Huxter Pond volcanics, Katie Prospect.*

Zr is depleted in the GT-2 compared to the Patridgeberry Hills Granite.

LEAD-ISOTOPE GEOCHEMISTRY

The lead isotope ratios in a single galena separate from a sulphide-bearing boulder at the Katie Prospect were analyzed at the GEOTOP laboratory, Université du Québec à Montréal (UQAM). The ratios were: $^{206}Pb/^{204}Pb$ = 18.190, $^{207}Pb/^{204}Pb$ = 15.599 and $^{208}Pb/^{204}Pb$ = 37.976. The derived data (Figure 9) are quite similar to those reported by Swinden and Thorpe (1984) for galena separates from volcanogenic massive sulphide deposits in the Victoria Lake supergroup (Evans and Kean, 2002), western Exploits Subzone of the Dunnage Zone, including the Victoria Mine, Tulks Hill and Tulks deposits. The data are also very similar to those reported by Pollock and Wilton (2001) from the Duck Pond deposit in the Tally Pond belt of the Victoria Lake supergroup. These similar isotopic ratios suggest a possible common Pb source for the Huxter Pond and Tulks Hill/Tally Pond volcanic belts. The Katie Prospect galena sample is much less radiogenic than galena from the Strickland deposit at the southwestern edge of the Exploits Subzone (Swinden and Thorpe, 1984), but much more radiogenic than lead from the Buchans VMS deposit in the Notre Dame Subzone (Winter and Wilton, 2001; Cumming and Krstic, 1987). The full metallogenic significance of Pb isotope data in the Huxter Pond volcanics will be further examined with more analyses during this study.

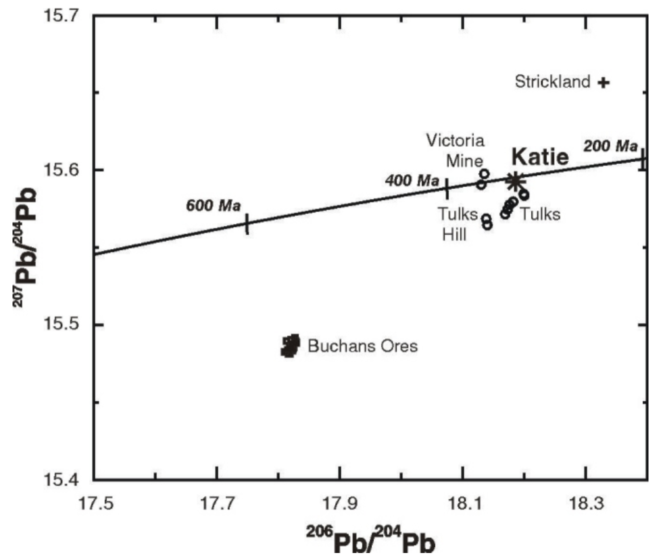

Figure 12. *Lead-isotope diagram for galena separates from the (1) Katie Prospect, (2) Tulks Hill, Tulks, Victoria Mine and Strickland deposits, Exploits subzone (from Swinden and Thorpe, 1984), and (3) Buchans deposits, Notre Dame subzone (from Cumming and Krstic, 1987; Winter and Wilton, 2001).*

DISCUSSION

Swinden (1996) suggested that VMS mineralization within the Exploits Subzone represents the products of at least four different systems. These systems include: (1) deposits in the Tally Pond volcanics, Victoria Lake Group, including the Boundary and Duck Pond ore bodies, (2) deposits in the Tulks Hill volcanics, Victoria Lake Group, including the Daniel's Pond and Tulks East occurrences, (3) deposits in the Baie d'Espoir Group, the Barasway de Cerf Deposit, and the Bay du Nord Group, the Strickland Deposit, along the southern extremities of the subzone (the Hermitage Flexure), and (4) deposits in the Wild Bight Group, including the Point Leamington ore deposit.

Swinden (1996) stated that Type 1 VMS are polymetallic and hosted by bimodal calc-alkaline basalts and rhyolites and arc tholeiites. Type 2 (Swinden, *op. cit.*) VMS are also polymetallic but are hosted by felsic volcanic rocks. Type 3 are zinc-rich and hosted solely by felsic volcanic rocks (Swinden, 1996), and Type 4 occurrences are copper–zinc and hosted by mafic arc tholeiites (Swinden, *op. cit.*).

When explicitly compared to VMS mineralization in the Exploits Subzone, it appears that the Zn-rich sulphide mineralization at the Katie Prospect in the Huxter Pond volcanics is most similar to the VMS settings within the Hermitage Flexure (i.e., Swinden's (1996) Type 3). In both instances, the volcanic rocks are dominantly felsic and sulphide compositions are dominated by the presence of Zn having lesser amounts of Cu, Pb and Ag. In particular, the Strickland Deposit with up to 260 000 tonnes of ore at > 5 percent lead and zinc (Wynne and Strong, 1984; Swinden, 1996).

Despite the fact that lithological distributions and mineralization within the Huxter Pond volcanics superficially resemble those from the Strickland Deposit, it would be unwise at this point to link these two VMS settings without more fully evaluating VMS deposition elsewhere in the Exploits Subzone in the Victoria Lake supergroup (Tally Pond and Tulks Hill volcanics). Preliminary Pb isotope data for galena from the Katie Prospect more closely compare with samples from the Tulks Hill deposit rather than those from the Strickland Deposit, which is much more radiogenic (Swinden and Thorpe, 1984). Volcanic rocks in the Huxter Pond belt are also comparable to selective rocks in the Tally Pond belts in that sulphide mineralization is predominantly hosted by felsic volcanic horizons where unaltered and that have transitional to calc-alkaline geochemical affinities (Evans *et al.*, 1990; Pollock and Wilton, 2001).

CONCLUSIONS

The Huxter Pond volcanics at the Katie Prospect exhibit a number of features suggesting potential to host volcanogenic massive sulphide (VMS) mineralization. These include: 1) large, angular (i.e., presumably locally derived) boulders with base-metal sulphide concentrations, 2) lithological intersections in drill core similar to the rock types present in the boulders, (3) a range of felsic volcanic and associated high-level intrusive rocks in drill core and outcrop which is indicative of a high-energy submarine volcanic depositional environment, and 4) Pb-isotope systematics similar to those of VMS deposits in the Victoria Lake Group.

Geochemical data suggest the presence of two main primary groups of magmatic rocks. The dominant group is composed of felsic volcanic rocks and the data suggest that they are calc-alkaline rhyodacites–dacites. Altered and sulphide mineralized samples of these felsic volcanic rocks do not have the same geochemical signatures as the normal group and the differences cannot be solely linked to mass gain (i.e., they also vary in immobile trace-element concentrations and ratios).

The other group comprises two varieties of mixed granite–granite breccia–tuff; one set is transitional to tholeiitic low Nb/Y rhyodacite–dacite to andesite, whereas the second group consists of tholeiitic andesite–basalt. The two groups define a bimodal distribution, and neither group has > 1% S.

The mixed granite–granite breccia–tuff and "normal" felsic volcanic rocks appear to be distinctly different from each other and are not related to each other by fractionation. The two groups (i.e., granite/tuff vs. "normal" felsic volcanic rocks) may define a volcanic stratigraphy in the Katie Prospect, but documentation of stratigraphic relationships will require further work. The granite–granite breccia–tuff samples are geochemically different from the posttectonic Partridgeberry Hills Granite and thus may represent a magmatic event unrelated to regional granite plutonism.

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