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STRATIGRAPHIC IMPLICATIONS FOR MINERALIZATION: PRELIMINARY FINDINGS OF A METALLOGENIC INVESTIGATION OF THE TALLY POND VOLCANICS, CENTRAL NEWFOUNDLAND

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ABSTRACT

Preliminary investigation of volcanogenic massive sulphide occurrences within the Tally Pond volcanics, suggests mineralization is intimately associated with a sequence of quartz-phyric, high-silica rhyolite flows and epiclastic sedimentary rocks. These mineralized rocks are hosted within a bimodal volcanic pile, where correlation as a single magmatic event cannot be confirmed but the available age-date determinations suggests the correlation of at least one widespread mineralizing event. This is demonstrated by identical U–Pb (zircon) dates (513 ± 2 Ma) obtained by previous workers, from similar quartz-phyric volcanic rocks from the Duck Pond–Boundary deposit area and the Lemarchant prospect.

Based mainly on observations of drill core from the Duck Pond and Boundary deposits, the internal stratigraphy of the Tally Pond volcanics appears to attest to a prolonged period of mafic volcanism, punctuated by several felsic volcanic episodes. The oldest felsic volcanic event is recorded as a thick sequence of flow-dominated aphyric to feldspar-phyric dacitic to rhyolitic volcanic rocks having textures indicative of a lobe-hyaloclastite flow volcanic regime. This sequence is conformably overlain and possibly locally intercalated, with an apparently less voluminous sequence of high-silica, quartz-phyric, rhyolite and epiclastic turbidites that host, and is chronologically and perhaps genetically, linked with volcanogenic massive sulphide mineralization.

Based on a review of available geochemical, geochronological and isotopic data, the Tally Pond volcanics are interpreted to have formed in an ensimatic-arc environment, as originally proposed by previous workers. However, it is further proposed that this arc formed adjacent to the Gondwanan continental margin as evidenced by characteristic highly radiogenic Pb-isotopic signatures, observed from massive sulphides within the Tally Pond volcanics and the Victoria Lake supergroup. Tectono-magmatic models, proposed for pre- and post-Arenig volcanic rocks of similar tectonic affinities, within the Wild Bight and Exploits groups elsewhere in the Exploits Subzone, may apply to arc-related volcanic rocks of the Victoria Lake supergroup, including the Tally Pond volcanics, suggesting further links between these two metallogenically important areas.

INTRODUCTION

The objective of this project is to characterize volcanogenic massive sulphide mineralization within the Tally Pond volcanics. As defined by Evans and Kean (2002), these volcanics are host to two major VMS deposits and several lesser occurrences and prospects. Of these, the Duck Pond and Boundary deposits are the only occurrences known to host a reserve inventory and are estimated to contain aggregate proven and probable reserves of 5.48 million tonnes grading 3.3% Cu, 5.8% Zn, 0.9% Pb, 59 g/t Ag and 0.8 g/t Au (Thundermin Resources Inc., press release, May 16, 2001).

The 2002 survey program included detailed investigations of the Duck Pond and Boundary deposits, while only preliminary reviews were completed at the Lemarchant and Burnt Pond prospects. Emphasis was placed on the Duck Pond and Boundary deposits in an attempt to characterize these important mineralizing systems as a benchmark for comparison to other prospects within the Tally Pond volcanics.

Work was facilitated by the examination of archived exploration drill core and the review of available outcrop. Careful attention was given to contact relationships and stratigraphic-facing directions, in an attempt to place the deposits in stratigraphic context and perhaps begin to define an internal stratigraphy within the Tally Pond volcanics. This approach bears particular merit as mapping by previous workers was hampered by limited outcrop exposure and significant structural complications that prevented definition of stratigraphic relationships (e.g., Kean and Jayasinghe, 1980).

REGIONAL GEOLOGY

The Appalachian Dunnage Zone of central Newfoundland (Figure 1, inset), comprises at least two tectonostratigraphic subzones separated by an extensive fault system known as the Red Indian Line (Williams *et al*., 1988). Dunnage Zone rocks west of the Red Indian Line (Notre Dame and Dashwoods subzones) are believed to have formed on the Laurentian side of the Iapetus Ocean (Williams *et al*., 1988; van Staal, 1994); whereas, Arenig and older Dunnage Zone rocks east of the Red Indian Line (Exploits Subzone) are considered to have originated in peripheral regions of Iapetus, adjacent to Avalonia and the main Gondwanan continent (Neuman, 1984; Colman-Sadd *et al.*, 1992). The Tally Pond volcanics (Figure 1) occur within the Exploits Subzone and represent vestiges of one of possibly several bimodal Cambrian to Ordovician volcanic arcs, which together with adjacent volcanic and sedimentary rocks of various tectonic affinities, collectively make up the Victoria Lake supergroup (Evans and Kean, 2002).

The Victoria Lake supergroup (Evans and Kean, 2002) is defined as encompassing all pre-Caradocian volcanic, volcaniclastic and sedimentary rocks that extend from Grand Falls–Windsor in the northeast to King George IV Lake in the southwest, and from the Red Indian Line in the north to the Noel Paul's Line in the south. Evans and Kean (*op. cit.*) subdivide the Victoria Lake supergroup into a northern and southern terrane, separated by the Rogerson Lake Conglomerate, and place the Tally Pond volcanics on the southern edge of the northern terrane (Figure 1), where it is reported to be unconformably overlain by the Rogerson Lake Conglomerate (Mullins, 1961). The latter is Middle Ordovician or younger (Kean and Jayasinghe, 1980) to perhaps Silurian age (Kean and Evans, 1988; Pollock *et al*., 2002b). The northern boundary of the Tally Pond volcanics is marked by a regionally extensive, although discontinuously exposed, unit of graphitic shaley sediments defined by a regionally defined electromagnetic conductor detected by airborne geophysical surveys (Evans and Kean, 2002). This unit can be traced from Victoria Lake in the south to the Noel Paul's Brook area in the north (e.g., Oneschuk *et al*., 2001).

LOCAL GEOLOGY

Evans and Kean (2002) define the Tally Pond volcanics as consisting of volcanic and sedimentary subunits that are distinguished by geographic distribution and lithology. These include felsic volcanic rocks that extend the length of the belt, composed of felsic breccia, tuffs, quartz porphyry, crystal tuff, and flow-banded rhyolite, as well as intercalated and adjacent mafic volcanic rocks subdivided into two sequences known as the Lake Ambrose and Sandy Lake basalts. The basalt sequences are considered to be correlative with one another and are essentially defined as occurring on opposite sides of the Precambrian (565 +4/-3 Ma, Evans *et al*., 1990) Crippleback Lake plutonic suite (Figure 1), which is itself believed to lie in structural contact with the Tally Pond volcanics (Evans and Kean, 2002).

Trace-element lithogeochemical investigations of the Tally Pond volcanics have documented compositional variants including relatively primitive-arc tholeiites to variably light rare-earth-element-enriched tholeiitic and/or calc-alkalic basalts (± basaltic andesites) and rhyolites (Dunning *et al.*, 1991) from samples of the Lake Ambrose basalts and adjacent quartz-phyric felsic volcanics. Evans and Kean (2002) have demonstrated that rocks of the Sandy Lake basalts exhibit island-arc tholeiitic signatures similar to those of the Lake Ambrose basalts, however, the former appear to be more depleted with respect to overall rare-earth-element concentrations. Dunning *et al.* (*op. cit.*) further determined that the quartz-phyric rhyolitic volcanic rocks possess arc affinities and are interpreted to represent high-silica rhyolites produced by partial melting of amphibolite-facies material in basal-arc crust. Pollock and Wilton (2001) also confirmed the variably depleted to enriched arc-tholeiitic nature of the Lake Ambrose basalts while also demonstrating that aphyric to feldspar-phyric felsic volcanic units also exhibit arc signatures similar to those identified by Dunning *et al*. (1991) for the quartz-phyric felsic volcanic rocks.

The Tally Pond volcanics are further defined by Evans and Kean (2002) as hosting at least two units of sedimentary rocks of uncertain age. The Burnt Pond sediments extend from the Tally Pond area northward to Noel Paul's Brook, bisecting the Tally Pond volcanics in the Noel Paul's Brook area (Evans *et al*., 1994a). The Stanley Waters sediments occur on the west flank of the volcanics and extend from Victoria Lake northward to the Quinn Lake area (Evans *et al.*, 1994b). Based on the distribution of potentially correlative graphitic units, the Stanley Waters sediments may extend farther north to Trout Pond, approximately 1.5 km north-northwest of Tally Pond (Evans *et al.*, 1994a, b). Airborne geophysical surveys also map potentially correlative conductive horizons beyond Trout Pond as far as the Noel Paul's Brook area (Oneschuk *et al.*, 2001).

Evans and Kean (2002) interpret the Burnt Pond sediments to be intercalated with and lateral equivalents of the Tally Pond volcanic sequences. The Stanley Waters sediments are less understood although Evans and Kean (*op. cit.*) suggest they may be correlative with the regionally

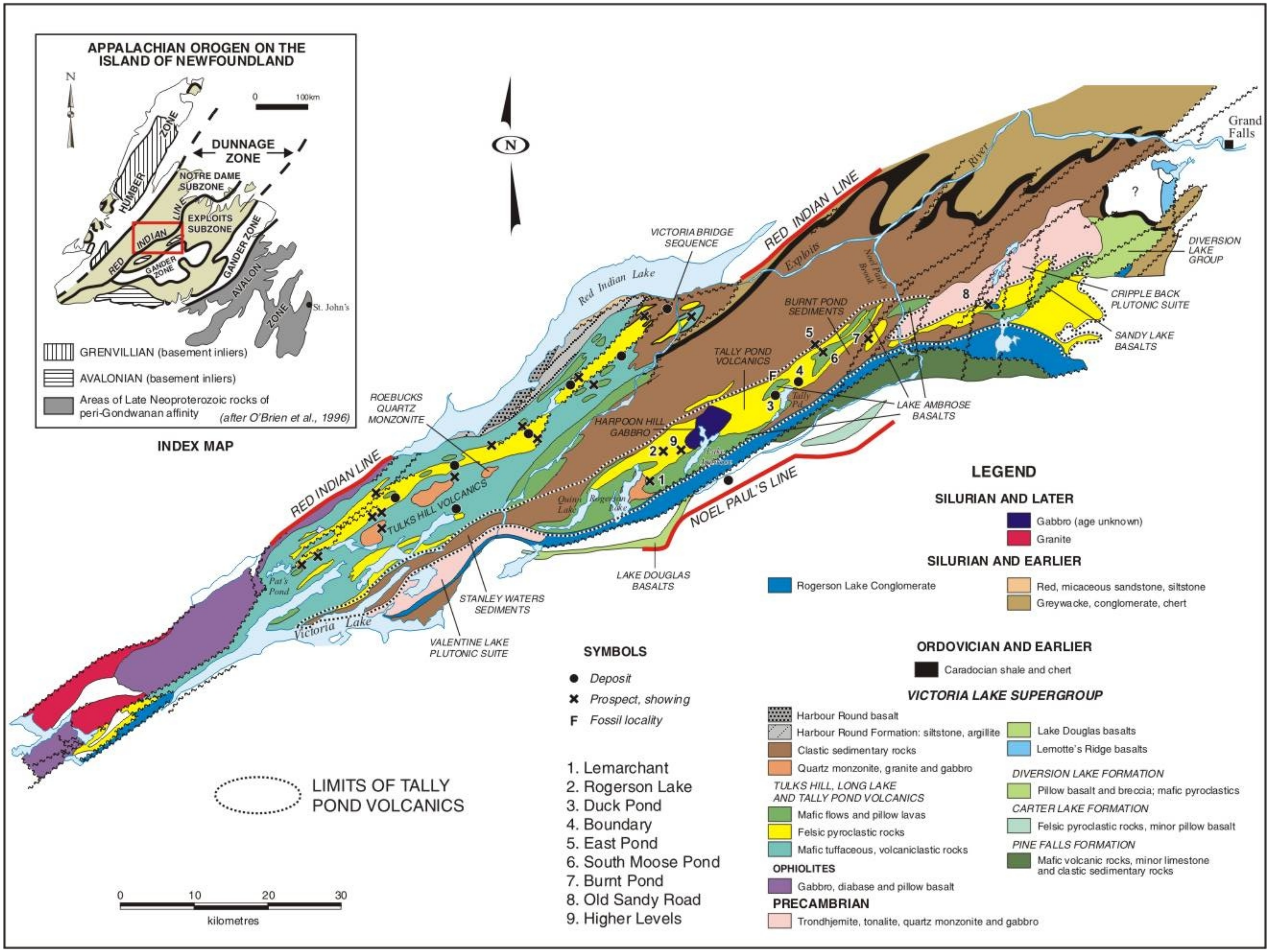

Figure 1. *Simplified geology map of the Victoria Lake supergroup showing the location of the Tally Pond volcanics and associated volcanogenic massive sulphide occurrences (modified after Evans and Kean, 2002). Depicted fossil locality is Caradocian graptolite occurrence (see text for explanation).*

extensive Caradocian black shale sequence located on the northern margin of the Victoria Lake supergroup (Figure 1). This suggestion is supported by identification of Caradocian/early Late Ordovician graptolites of the Lawrence Harbour Formation (Figures 1 and 2) within an outcrop of black shales, 2 km northwest of Tally Pond (S.H. Williams personal communication, 2002; Brace *et al.*, 2001). Assuming the Burnt Pond sediments are coeval with the Cambrian Tally Pond volcanics, as suggested by Evans and Kean (*op. cit.*), it could be said that they are significantly older than the Stanley Waters sediment, however, insufficient mapping control and dating information exists to constrain the age limits of either sequence.

The Tally Pond volcanics are intruded by a variety of intrusive rocks of unknown age that have been interpreted as ranging from Ordovician to Siluro-Devonian (Figures 1 and 2). These rocks include, fine- to medium-grained diorite and gabbro (e.g., Harpoon Hill intrusion) assumed to be Silurian (Evans and Kean, 1994b) to Siluro-Devonian age (Evans and Kean, 2002), as well as other gabbroic to diabasic bodies known to intrude the Tally Pond volcanics in the Duck Pond deposit area (Figure 2) presumed to be Ordovician and earlier (Squires *et al*., 2001). The age of the gabbro to diabasic bodies is inferred based on the observation that they are cut off and locally penetratively deformed by thrusting. Though the timing of thrusting in the Victoria Lake supergroup is not well constrained, it is assumed to be syn- to post-Caradocian to Early Silurian, based on disruption of Caradocian black shales and overlying Badger Group rocks (C.R. van Staal, personal communication, 2002). Colman-Sadd *et al*. (1992), suggested thrusting was active as early as the late Arenig elsewhere in the Exploits Subzone of central Newfoundland, based on inferred contact relationships that imply obduction of ophiolites prior to intrusion of the Partridgeberry Hills granite. This granite yielded an U–Pb zircon age of 474 +6/-3 Ma and is noted to have inheritance of Precambrian zircon. This observed inheritance has been suggested to provide evidence of involvement of peri-Gondwanan continental crust during magmatic evolution of the Exploits Subzone as far back as the Arenig (Colman-Sadd *et al*. *op. cit*.).

In addition to the intrusive bodies mentioned above, Kean and Jayasinghe (1980) and Evans and Kean, (1994b) have mapped a presumed composite body of gabbro and quartz monzonite centred on the northern half of Rogerson Lake (Figures 1 and 2), which may correlate with a body of granite mapped on the southern half of the same lake (Colman-Sadd, 1987). This body(s) remains undated but has been inferred by Colman-Sadd (1987), based on metamorphic assemblages (chlorite present) to be Ordovician or older; perhaps being related to the Valentine Lake quartz monzonite (Colman-Sadd, 1988). In contrast, Evans and Kean (1994b) presume the body(s) to be Siluro-Devonian.

As absolute ages of the various intrusive units are unknown; the possibility that some of the bodies are in part coeval with the volcanic rocks cannot be dismissed. It is perhaps important to note that intrusive bodies of quartz monzonite have been mapped and dated within the Tulks Hill volcanics of the Victoria Lake supergroup (Figure 1) where they have been shown to be essentially coeval with surrounding felsic volcanic rocks (e.g., 495 ± 2 Ma Roebucks quartz monzonite, Evans *et al*., 1990). Similarly, it should be pointed out that the initial mapping in the region inferred the Crippleback Lake and Valentine Lake quartz monzonite bodies to intrude the Tally Pond volcanics (e.g., Kean and Jayasinghe, 1980); however, subsequent U–Pb age dating demonstrated the bodies to be older (i.e., 565 +4/-3 Ma and 563 ± 2 Ma, respectively), whereby contacts are now inferred to be structural (Evans *et al*., 1990). The maximum age of the Tally Pond volcanics is not known, as thick sequences of felsic and possibly mafic volcanic rocks of undetermined age conformably underlie the dated (513 ± 2 Ma) units. In the absence of this critical data, relationships between the Tally Pond volcanics and the various intrusive rocks including the Precambrian Valentine Lake and Crippleback Lake plutonic suites remain unclear.

Internal stratigraphic subdivision of the Tally Pond volcanics is not defined and stratigraphic correlation and comparison to other volcanic sequences within the Victoria Lake supergroup is based on three U–Pb age dates of a conspicuous unit(s) of quartz-phyric, felsic volcanic rocks that returned dates ranging from 513 ± 2 Ma (Evans *et al.*, 1990) to 509 ± 1 Ma (Pollock *et al.*, 2002a; J.C. Pollock and V. McNicoll, personal communication, 2002). The two 513 ± 2 Ma dates of Evans *et al.* (*op. cit*.), were collected from two localities of rhyolite porphyry separated by about 23 km and located near the Lemarchant and Duck Pond massive sulphide occurrences, respectively (Figure 2). The 509 ± 1 Ma age date of Pollock *et al.* (*op. cit*.) was obtained from a felsic tuff, which conformably overlies the Southeast zone of the Boundary South zone massive sulphide deposit (Figures 2 and 5), about 1.5 km northeast of the Duck Pond date of Evans *et al*. (*op. cit*.). Zircons from all three localities show no evidence of Precambrian inheritance (Dunning *et al*., 1991; V. McNicoll, personal communication, 2002). The lack of inheritance and trace-element lithogeochemical evidence led Dunning *et al.* (1991) to propose that the Tally Pond volcanics were formed in an oceanic (ensimatic) arc setting.

Based mainly on spatial distribution and the limited age dating discussed above, Evans and Kean (2002) separate the Tally Pond volcanics from other bimodal volcanic sequences of the Victoria Lake supergroup including the Tulks Hill volcanics (498 +6/-4 Ma, Evans *et al*., 1990), and the Victoria Bridge sequence (minimum age of 462 +4/-2 Ma, Dunning *et al*., 1987), but have not proceeded to define

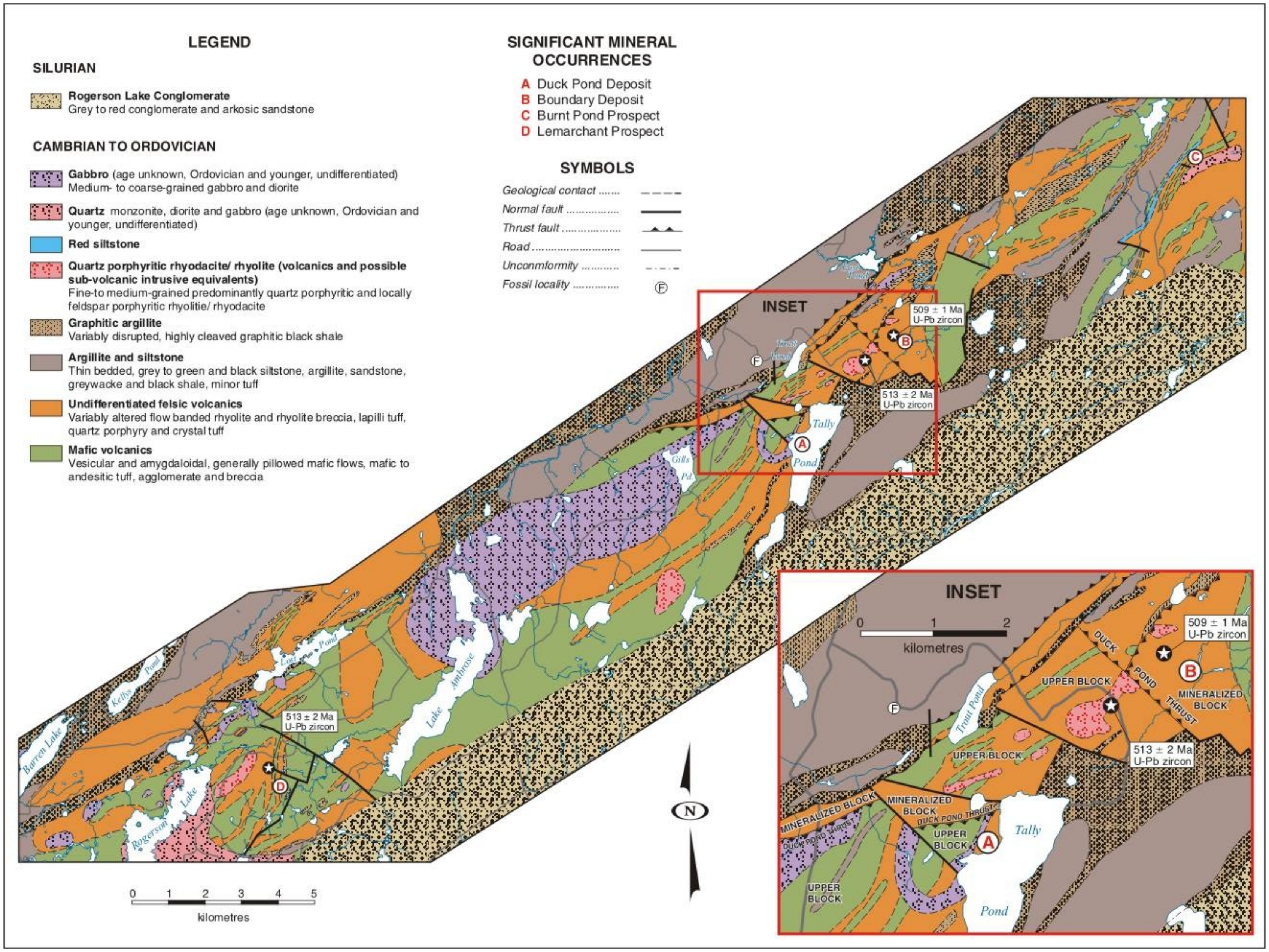

Figure 2. *Sketch map of the Tally Pond volcanics for the segment extending between the Burnt Pond and Lemarchant prospects (modified after Squires* et al., *2001; Pollock* et al., *2002a; and Evans* et al., *1994b). Depicted fossil locality is Caradocian graptolite occurrence (see text for explanation).*

groups and formations under the stratigraphic hierarchy of the informally proposed supergroup classification. In the absence of defined stratigraphic relationships between the mapped sequences described within the Victoria Lake supergroup and more particularly, within the Tally Pond volcanics, it would appear premature to formally subdivide the supergroup or its volcanic sequences into stratigraphic subdivisions at this time. This position is supported by Dunning *et al.* (1991) who argue that the division of the Tally Pond volcanics from those of the Tulks Hill volcanics could be oversimplified as these sequences could represent older and younger parts of a single, long-lived arc system having a minimum age difference of about 7 Ma.

REGIONAL TECTONICS

Comparison of Pb-isotope data for VMS prospects from the Notre Dame and Exploits subzones in Newfoundland, including the Tally Pond deposit, indicate deposits of the Victoria Lake supergroup are consistently more radiogenic than those of the Notre Dame Subzone (Swinden and Thorpe, 1984). Based on this relationship, Pb found in the different subzones was derived from different sources (Williams *et al*., 1988), providing one of the significant pieces of evidence for the existence of the Red Indian Line as a significant geological boundary dividing the two subzones.

Nd-isotopic and trace-element geochemical data for arc-related volcanic rocks associated with massive sulphide deposits of the Notre Dame Subzone, suggest that these rocks have been variably affected by continentally derived sediments and continental lithosphere likely sourced from Laurentia (Swinden *et al*., 1997). This relationship fits well with observations of Bell and Blenkinsop (1981) who had previously shown Pb-isotopic data from the Buchans ores to have evolved from a region of relatively low U–Pb, a characteristic of Pb deposits in the Grenville Province (Fletcher and Farquhar, 1977). At present, no Nd-isotopic data is known to have been collected from volcanic rocks of the Victoria Lake supergroup; and in the absence of confirmed Precambrian inheritance from U–Pb zircon dating, a continental influence from Avalonian continental crust can only be speculated upon at this time.

It should be pointed out, however, that the more radiogenic nature of Pb from massive sulphide deposits within the Exploits Subzone appears to be somewhat incongruous with the ensimatic origin proposed for the host volcanic sequences. Possible subduction of pelagic sediments may, however, offer one explanation for the more radiogenic character of the Exploits Subzone volcanic rocks as has been proposed for other arc systems (e.g., Barreiro, 1983); particularly where the sediments may have been, in part, derived from continental material having high U–Pb and Th–Pb values. Such an explanation does not require partial melting of and/or direct contamination by continental crust and therefore may explain the apparent lack of inheritance from U–Pb zircon dating studies (e.g., Dunning *et al*., 1991) of the more primitive, older (pre-Arenig) arc-related rocks of the Exploits Subzone.

Tectonomagmatic models have been proposed for the older (pre ~484 Ma) primitive and depleted arc rocks of the Wild Bight Group of the Exploits Subzone of Notre Dame Bay (MacLachlan, 1998). These models propose the existence of a pre-Arenig, westward-dipping subduction zone outboard of the adjacent Gondwanan continental margin, above which, Arenig and older arc-volcanic rocks of the Wild Bight Group were deposited. A similar model could similarly apply to the, Tremadoc and older, arc-related volcanic rocks of the Victoria Lake supergroup.

Some of the younger, post-Arenig, calc-alkaline volcanic rocks of the Victoria Lake supergroup, such as those of the Victoria Bridge sequence of Evans and Kean (2002), may represent arc-related volcanic rocks, where Precambrian continental crust may have been involved, as suggested by Dunning *et al.* (1987), and based on the apparent inheritance of a zircon component, yielding a minimum age of 919 Ma. Although Dunning *et al*. (1987) suggest the evidence for inheritance is somewhat inconclusive, if valid, the relationship would draw another gross correlation with Arenig and younger (~474 to 465 Ma), calc-alkalic volcanic rocks of the Wild Bight Group, which MacLachlan (1998) suggests received contribution from continental crust or continentally derived sediments. Based on these data, MacLachlan (1998) proposed that these rocks were produced on, or immediately, adjacent to thinned continental crust of the Gondwanan margin, above a post-Arenig, east-dipping subduction zone (i.e., subduction beneath the continental margin and possibly continental crust). Evans and Kean (*op. cit.*), similarly suggest that the calc-alkaline nature of basaltic rocks of the Victoria Bridge sequence of the Victoria Lake supergroup may provide additional evidence that post-Arenig volcanic sequences of the supergroup formed in a similar environment, possibly involving Avalonian (i.e., Gondwanan) continental crust; a relationship that fits well with the contention of Colman-Sadd *et al.* (1992) that post-Arenig sequences were deposited on composite crust composed of Gondwanan continental basement and allochthonous oceanic rocks. The 919 Ma inheritance described for the Victoria Bridge sequence may have been derived from several sources including Baltica or Laurentia, whereas Gondwana is not known to possess crustal material of this age within the Appalachian Orogen of northeastern North America (S.J. O'Brien, personal communication, 2002). It should be pointed out, however, that given the noted questionable quality of the inheritance data, the issue remains contentious.

MINERALIZATION

The Tally Pond volcanics host several occurrences of volcanogenic massive sulphide mineralization including the Duck Pond and Boundary deposits, and the less explored Lemarchant, South Moose Pond, and Burnt Pond occurrences, as well as several showings including the East Pond, and Old Sandy Road showings (Evans and Kean, 2002). Collins (1992) also reports a significant pyritic massive sulphide occurrence informally known as the Higher Levels occurrence, where diamond drilling intersected a sequence of massive, finely laminated, pyritic sulphides containing minor sediments over a drilled width of 18.5 m (Figures 1 and 2).

Only the Duck Pond and Boundary deposits are known to host a defined mineral resource. Of the lesser occurrences and showings, only Lemarchant, Burnt Pond and East Pond are known to host massive sulphide mineralization of potentially significant base-metal grades, comparable to the Duck Pond and Boundary deposits. With the exception of Old Sandy Road, which is reported to be hosted by basalts of the Sandy Lake basalts (Evans and Kean, 2002), all of the occurrences mentioned above are reported to be hosted by, or in contact with, altered felsic volcanic rocks (Collins, 1992; Evans and Kean, *op. cit.*).

Duck Pond and Boundary Deposits

The Duck Pond and Boundary deposits are located about 18 km south-southeast of Millertown and are separated from one another along the strike of the belt by a distance of 4 km (Figures 1 and 2). The geology of the Duck Pond and Boundary deposit area is best described by Squires *et al.* (1991, 2001) who incorporate decades of data acquired by exploration diamond drilling, detailed mapping, geophysical surveys and lithogeochemical analyses. Squires *et al.* (1991, 2001) describe the area as being underlain by a series of variably deformed, folded and structurally complicated panels or blocks composed of bimodal submarine volcanic sequences and lesser sediment. The immediate area of the deposits is predominantly underlain by volcanic rocks flanked to the west and east by Ordovician graphitic, argillaceous and siliciclastic sediment, considered to be in thrust contact with the volcanics (*op. cit.*). Squires *et al.* (2001) speculate the current distribution of the volcanics in this area is that of an eroded, folded thrust, whereby structurally overlying sediments have been eroded in the core of an antiform, exposing the volcanic rocks. Basement to the volcanic rocks is not known, however, diamond drilling in the area of the Duck Pond and Boundary deposits suggests the volcanic rocks lie in structural contact upon underlying graphitic argillaceous sediments (G.C. Squires, personal communication, 2002). The volcanic rocks are interpreted to also be internally disrupted by numerous block and thrust faults as evidenced by numerous shears and deformation zones identified from extensive diamond drilling conducted in the area (Squires *et al.*, 2001). These structural complications affect the Duck Pond deposit, which consists of several structurally dislocated lenses or zones referred to as the Upper Duck, Lower Duck and Sleeper zones, respectively (not displayed on accompanying figures).

Of the three lenses, the Upper Duck is the largest and accounts for greater than 85% of the proven, probable and inferred mineable reserves quoted in Thundermin's 2001 feasibility study for the combined Duck Pond and Boundary deposits (5.48 million tonnes grading 3.3% Cu, 5.8% Zn, 0.9% Pb, 59 g/t Ag and 0.8 g/t Au; Thundermin Resources Inc., press release, May 16, 2001). Thundermin (*op. cit.*) describes the respective lenses as follows. The Upper Duck lens is tabular in shape having a shallow dip, is 600 m long, 100 to 400 m wide and 18 m thick and occurs at a depth from 220 m to 420 m below surface. The Lower Duck lens is a shallow-dipping lens and is interpreted to be the down-faulted extension of the Upper Duck. It occurs between 700 and 800 m below surface and is not included in the 2001 feasibility reserve (Thundermin, *op. cit.*). The Sleeper zone occurs as a series of four shallow-dipping, 6- to 30-m-thick lenses that lie approximately 50 m below the Upper Duck. Squires *et al.* (2001) estimate that prior to its structural dismemberment, the Duck Pond deposit formed a single body up to 60 m thick and over 1 km long, exceeding 10 million tonnes of both pyritic and base-metal-rich massive sulphides. It is further interpreted (Squires *et al.*, *op. cit.*) that the deposit was exposed to erosion on the seafloor as indicated by massive sulphide debris-flow material on the north flank of the Upper Duck lens, informally known as the Serendipity zone (C.G. Squires, personal communication, 2002), suggesting the deposit may have been significantly larger.

The Boundary deposit contains three sub-cropping to shallow zones referred to as the North, South and Southeast zones (not shown on accompanying figures) and is described by Thundermin (press release, May 16, 2001) as follows. The North zone is the largest, measuring 275 m long, 25 to 50 m wide and up to 25 m thick. The South zone is 115 m long, 75 m wide and ranges in thickness from 15 to 25 m. The Southeast zone represents a southeastern extension of the South zone and is excluded from the 2001 feasibility global reserve.

The three zones of the Boundary deposit occur within an area measuring 300 by 600 m with the North and South zones' lenses separated by as much as 200 m. Squires *et al.* (2001) speculate the North and South zones either represent separate occurrences each with their own feeder alteration pipe, or structurally offset portions of the same linear vent. Direct correlation of these zones is prevented as the stratigraphic package hosting the two zones appears to have been eroded off between the zones, leaving room for speculation that the Boundary deposit(s) may have been significantly larger prior to its partial exhumation.

At the deposit scale, the geology of the Duck Pond and Boundary deposits can be simplistically described in the context of two structural panels or blocks separated by a moderately to gently south-dipping structure referred to as the Duck Pond Thrust (Squires *et al*., 2001). These blocks, referred to as the Upper and Mineralized blocks respectively (Squires *et al., op. cit.*), are defined as a structurally overlying, essentially barren sequence of bimodal volcanic rocks (Upper Block) and a structurally underlying, predominantly felsic sequence of mineralized and altered volcanic rocks that host the Duck Pond deposit (Mineralized Block). Prior to this investigation, no common stratigraphy had been correlated between the Upper and Mineralized blocks (Squires *et al.*, 2001). The U–Pb zircon age dates collected from an outcrop of extrusive quartz-phyric rhyolite porphyry within the Upper Block and felsic tuffaceous material overlying the Southeast zone of the Boundary deposit within the Mineralized Block (Evans *et al.*, 1990 and Pollock *et al.*, 2002a, respectively) returned similar ages of 513 ± 2 Ma and 509 ± 1 Ma, respectively, from lithologically similar units (Figure 2). These dates are interpreted here to provide initial evidence for the likelihood of stratigraphic correlation between the blocks.

Squires *et al*. (2001) describe the stratigraphic setting of the Duck Pond deposit in the context of the Mineralized Block, which is reported to be almost entirely composed of a thick sequence of aphyric felsic flows and autobreccias overlain by a mixed tuffaceous-sedimentary unit that hosts, and has been selectively replaced by, alteration and mineralization associated with the Duck Pond and Boundary deposits. The footwall rocks to the massive sulphides are described (Squires *et al., op. cit.*) as an up to 900-m-thick, flat-lying, variably altered and mineralized sequence of flow-banded, aphyric to feldspar-porphyritic, autobrecciated, dacitic flows stratigraphically overlain by an 85-m-thick sequence of interbedded quartz-phyric felsic tuffs and graphitic argillites that host massive sulphides of the Upper Duck lens.

Prior to this study, the interbedded quartz-phyric sequence was considered to be only rarely preserved and limited to the north end of the Upper Duck lens where it undergoes a facies change to the north into a 120-m-thick volcaniclastic sedimentary sequence consisting of deep-water, graphitic argillite lacking appreciable tuffs and locally containing base-metal sulphide debris-flow beds (Squires *et al.*, 2001). Based on their clastic and porphyritic nature, this tuffaceous sedimentary sequence has been interpreted (Squires *et al., op. cit.*), as identifying a change in the character (and timing?) of the volcanics from those of the aphyric footwall. The apparent lack of preservation of the porphyritic clastic tuffaceous rocks, within the Upper and Lower Duck lenses, prevented appreciation of their potentially widespread stratigraphic significance, with respect to the timing of mineralization at deposit and regional scales. Inspection of the latter reworked/erosional facies rocks during the course of this study indicates that these rocks locally contain abundant detrital volcanic quartz, confirming erosion took place after volcanism had changed from predominantly aphyric/feldspar-phyric to quartz-phyric.

Mineralization within the Boundary deposit is reported to be hosted by a sequence of volcaniclastic sediments and tuffs that stratigraphically overlie a variably altered and mineralized, flat-lying sequence of aphyric felsic flows, autobreccias and lapilli tuffs up to 500 m thick (Squires *et al.*, *op. cit.*). A bedded sequence of quartz porphyritic, felsic ash tuffs is interpreted to conformably overlie the mineralized volcaniclastic and tuffaceous volcaniclastic sequence, which Squires *et al*. (2001) propose may have acted as an "impermeable caprock" that facilitated replacement of more porous sections of the underlying host tuffaceous volcaniclastic sequence. They correlated the overlying quartz-phyric tuffs at the Boundary deposits with those hosting mineralization within the Upper Duck lens at the Duck Pond deposit.

Lemarchant

Located 20 km southwest of the Duck Pond deposit (Figures 1 and 2), this prospect hosts base-metal-rich, laminated massive sulphides assaying up to 4.5% Cu, 0.33% Pb, 5.70% Zn, 272.5 g/t Ag and 1.06 g/t Au over a drilled width of 0.3 m (Hole LM-92-07, Collins, 1993). The mineralized horizon is located along an inferred conformable contact between predominantly aphyric, locally mineralized, felsic volcanic flows and fragmentals interpreted to be conformably overlain by mafic flows and cut by numerous diabase dykes (Collins, 1992).

The geology of the prospect area is described by Collins (1992) as follows. Stratigraphy is reported to be upright, striking north–south, and dipping gently to the east. Stratiform massive sulphides occur along a mafic–felsic volcanic contact locally marked by graphitic argillite and banded pyritic argillaceous sediments. Felsic volcanic rocks occurring beneath the mineralized horizon are reported to be variably altered and mineralized including local chloritization and widespread sericitization. Mineralization within the felsic volcanics is described as consisting of stringer to disseminated sulphides with accompanying baritic alteration and locally returns whole-rock analyses of up to 10.1% Ba (Collins, 1992).

The lateral extent of the massive sulphide and stringer mineralization is not known. Mineralization is reported to remain open down dip and in both strike directions, with narrow, less than 1-m-thick, sections of pyritic sediments to massive, base-metal-bearing sulphides intersected along the favourable mafic–felsic contact over a strike length of 900 m (Collins, 1993). The extents of the footwall mineralization and alteration also remain unconstrained at this time (*op. cit.*).

Burnt Pond

Located 13 km northeast of the Duck Pond deposit (Figures 1 and 2), this prospect hosts base-metal-rich, laminated, massive sulphides assaying up to 0.79% Cu, 24.0% Pb, 25.8% Zn, 791.1 g/t Ag and 1.6 g/t Au over a drilled width of 0.37 m (Hole BP-2001-03, Volcanic Metals Exploration Inc., April 6, 2001 press release).

The prospect is reported to be underlain by a northeast-striking, subvertical to overturned intercalated sequence of felsic and mafic volcanic rocks that grade upward to the west into a transitional sequence of thinly bedded graphitic argillaceous sediment and interbedded felsic tuffs (Collins, 1991). These units are in turn reported (*op. cit.*) to be overlain by fine-grained, grey - green tuff–siltstone and an upper sequence of deep-water marine sediments and lesser intercalated mafic volcanics marked at the base by a distinctive mauve-red siltstone. Collins (1991) interprets these rocks to comprise a conformable sequence; however contacts between each of the sequences are consistently described in drill logs as being sheared and faulted.

Massive sulphide mineralization is reported to be hosted by the transitional sequence of graphitic argillaceous sediments and interbedded felsic tuffs associated with the contact with underlying felsic volcanics (Dimmell, 1986; Collins, 1991). Mineralization is reported to consist of narrow bands, up to 40 cm wide, of stratiform massive sulphides within the tuffaceous–sedimentary sequence, and as stringer to disseminated sulphides within sericitized to locally chloritized felsic volcanic rocks to the east (e.g., Dimmell, 1986; Collins, 1991). The stratiform mineralization is reported to have been intersected intermittently along the transitional sedimentary felsic volcanic contact for a strike length of 500 m (Dimmell, 1986).

Dimmell (1986) proposes the mineralization to be associated with late-stage hydrothermal activity during the waning stages of island-arc volcanism.

PRELIMINARY RESULTS

DUCK POND AND BOUNDARY DEPOSITS

Massive sulphide mineralization of the Duck Pond and Boundary deposits appears to be spatially and stratigraphically associated with a sequence of quartz-phyric felsic volcanic rocks composed of fragmental to epiclastic–volcaniclastic material (Figures 3, 4 and 5). These rocks are correlative with quartz-phyric tuffaceous and sedimentary rocks described by Squires *et al.* (2001) as locally hosting the Upper Duck lens of the Duck Pond deposit as well as conformably overlying massive sulphide mineralization within the Boundary deposit. In contrast to Squires *et al.* (2001), these rocks have now been essentially correlated throughout the Upper Duck lens as well as within the Lower Duck lens and Boundary deposit. Based on this lateral continuity and correlation with mineralization in different zones and deposits, it is proposed that these quartz-phyric epiclastic rocks represent a unit of significant metallogenic importance and is likely directly linked to the timing and genesis of volcanogenic massive sulphide mineralization. As it is not known if these rocks occupy a unique stratigraphic position, they are informally referred to here as the “mineralized sequence” as opposed to a specific formation or member of the Victoria Lake supergroup or Tally Pond volcanics.

The mineralized sequence (Figures 3, 4 and 5) is, in part, conformably overlain by, hosts, and underlain by massive sulphides at the Duck Pond deposit (Upper and Lower Duck lenses), and, in part, hosts and conformably overlies massive sulphide mineralization at the Boundary deposit (e.g., Boundary South zone). These rocks are conformably underlain by a thick sequence of altered and mineralized, aphyric to feldspar-phyric, footwall felsic flows at both deposits (Figures 4 and 5). The latter exhibit textural facies and flow morphologies indicative of a lobe-hyaloclastite flow volcanic regime as defined by Gibson *et al*. (1999). These textural–facies variations include abundant, locally thick (>100 m) proximal flows with flow-banded and brecciated margins lacking significant volumes of hyaloclastite beneath the Upper Duck lens of the Duck Pond deposit and perhaps more distal flows containing more abundant interflow hyaloclastite and breccias beneath the Boundary South zone deposit.

Identification of a mineralized sequence is demonstrated by correlation of intercalated and variably sulphide-replaced, quartz-phyric, epiclastic sediments within thicker portions of the Duck Pond and Boundary deposits (Figures 4 and 5). Laminated to banded sulphides interpreted to rep-

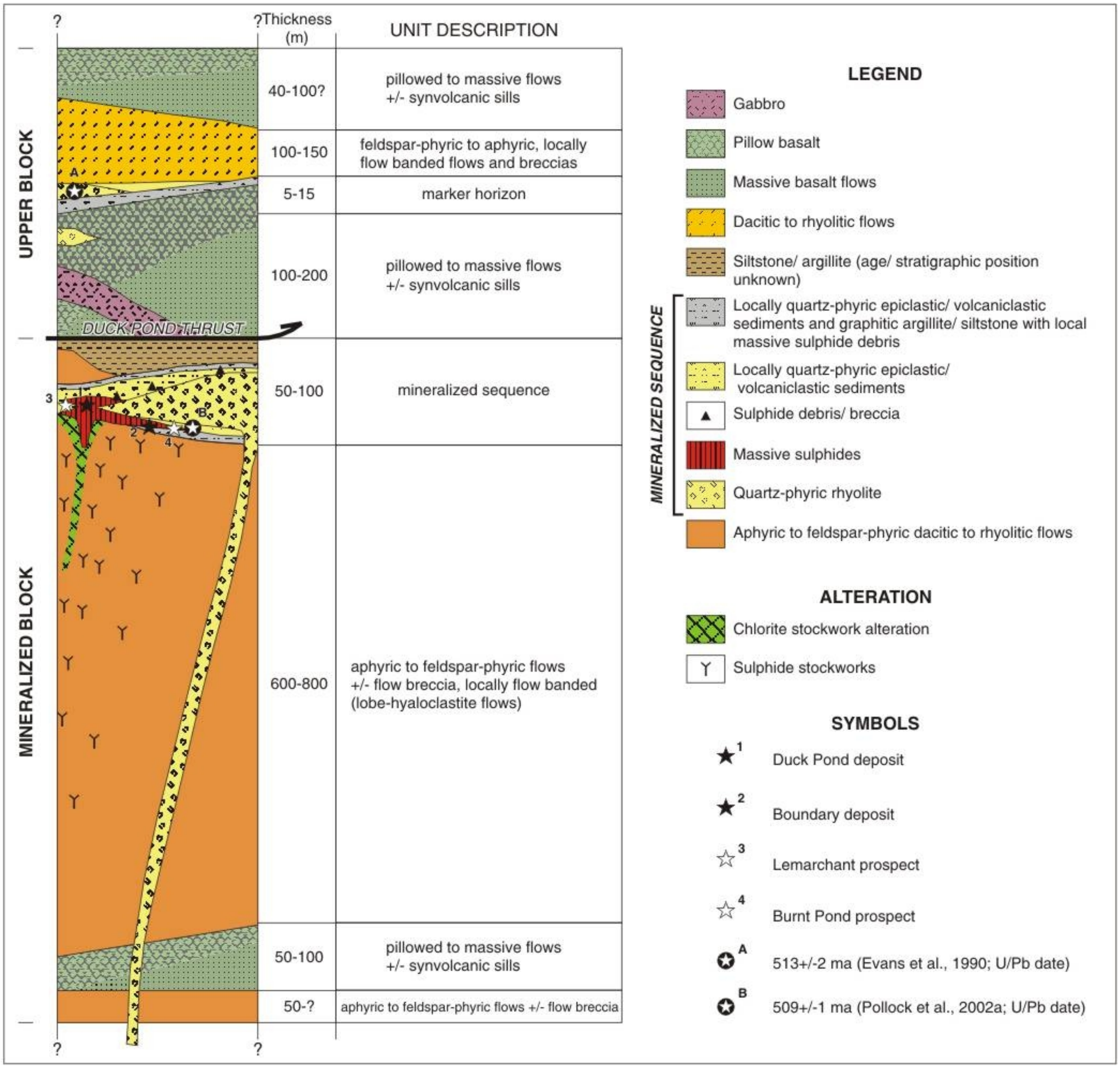

Figure 3. *Schematic stratigraphic column showing position of volcanogenic massive sulphide prospects within the Tally Pond volcanics based on geology of the Duck Pond and Boundary deposit areas. (Error limits for the Pollock* et al.*, (2002a) U–Pb date after J.C. Pollock and V. McNicoll, personal communication, 2002).*

resent intercalated and variably replaced quartz-phyric mineralized sequence rocks are correlated over 400 m down dip throughout the Upper Duck lens and are intercalated with variably sulphide-replaced, laminated, quartz-phyric, epiclastic turbidites within the Lower Duck lens and Boundary deposit (e.g., Boundary South Zone). The stratigraphic significance of this horizon is highlighted by the absence of laminated, quartz-phyric, epiclastic sediments in the stratigraphic footwall to the Duck Pond and Boundary deposits, which are consistently composed of aphyric to feldspar-phyric dacitic to rhyolitic flows and autoclastic breccias. The intimate stratigraphic and spatial association of quartz-phyric felsic volcanic rocks with the Duck Pond and Boundary deposits suggests a quartz-phyric volcanic event is likely genetically related to the mineralization.

Graphitic argillaceous sediments are locally observed within mineralized sequence rocks of the Upper Duck lens (Figures 3 and 4) and suggest a hiatus in volcanism may have locally followed deposition of quartz-phyric mineral-

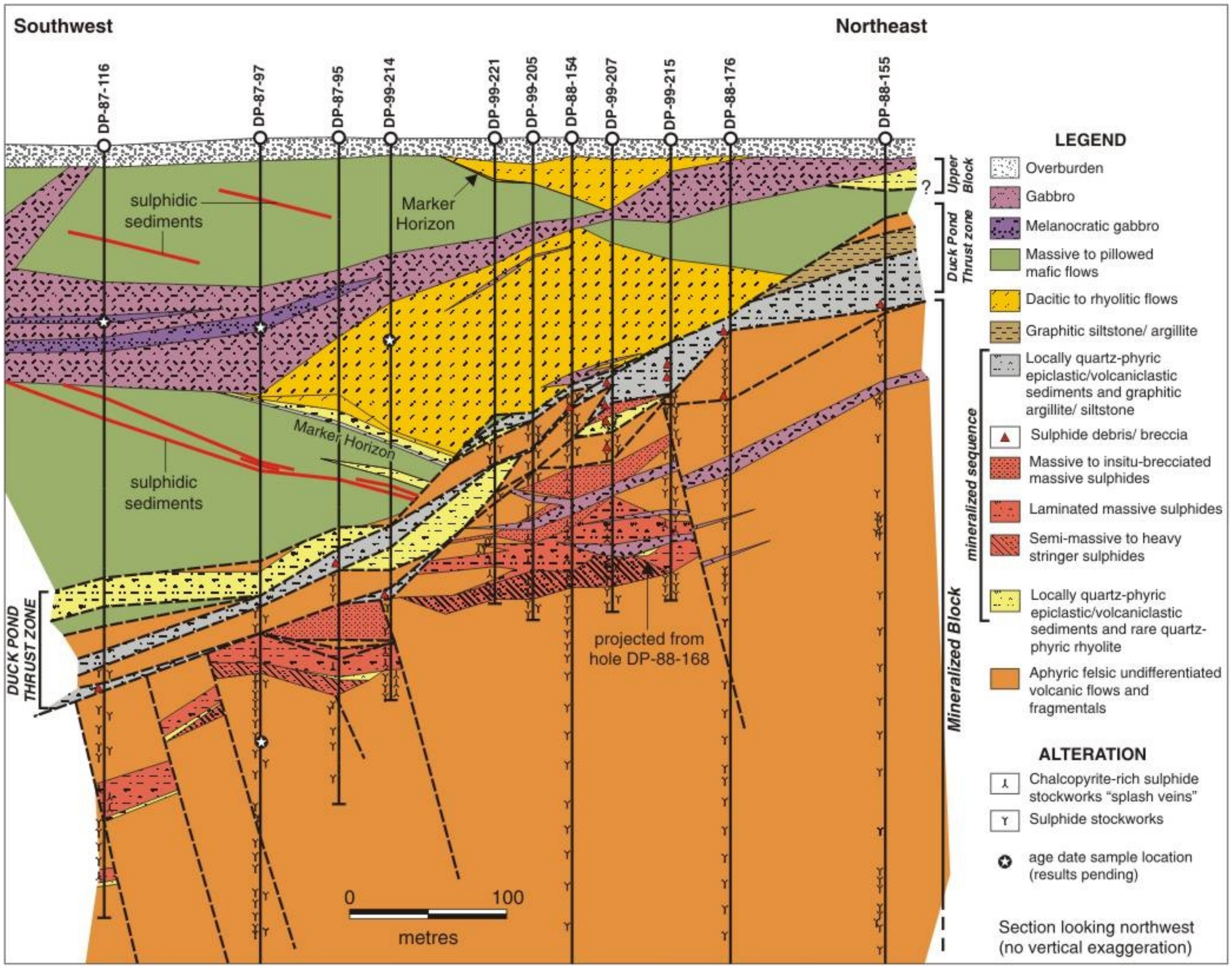

Figure 4. *Long section through the Upper Duck lens, Duck Pond deposit (modified after Squires* et al.*, 2001).*

ized sequence rocks. It is important to note, however, that mineralized sequence rocks are reported to be locally overlain by mineralized aphyric rhyolite similar to that observed in the footwall to the mineralized sequence (Squires *et al*., 2001). This relationship (e.g., drillhole DP-87-116, Figure 4) suggests the quartz-phyric volcanic event may have overlapped with the waning stages of an aphyric to feldspar-phyric felsic volcanic event responsible for the accumulation of large volumes of flow-dominated felsic volcanic rocks in the stratigraphic footwall to the Duck Pond and Boundary deposits.

Age dates obtained from the quartz-phyric units considered correlative to the mineralized sequence near the Duck Pond and Boundary deposits range between 509 ± 1 Ma (Pollock *et al*., 2002a; V. McNicoll, personal communication, 2002) and 513 ± 2 Ma (Evans *et al*., 1990). The underlying aphyric to feldspar-phyric suite remains undated and a sample has been collected as part of this study in an attempt to determine its age. This aphyric to feldspar-phyric suite locally contains intercalated mafic volcanics and the stratigraphic basement to the footwall volcanic sequence is not known. In the area of the Boundary deposit, the footwall felsic volcanic sequence is structurally underlain by a greater than 300-m-thick sequence of graphitic argillite with significant shearing noted at the contact in several drillholes (Squires *et al.*, 2001; C.G. Squires, personal communication, 2002).

The stratigraphic hanging wall to the quartz-phyric felsic volcanic sequence is locally composed of graphitic argillaceous sediments and siltstone; however, primary stratigraphic contacts are often not preserved as these sedimentary units are typically affected by the Duck Pond Thrust (e.g., Squires *et al.*, 1991, 2001). This structure is evident in drill core as a 50- to 80-m-thick inhomogeneous composite fault zone ranging from cataclastically disrupted graphitic argillaceous sediments to mylonitized basalt flows

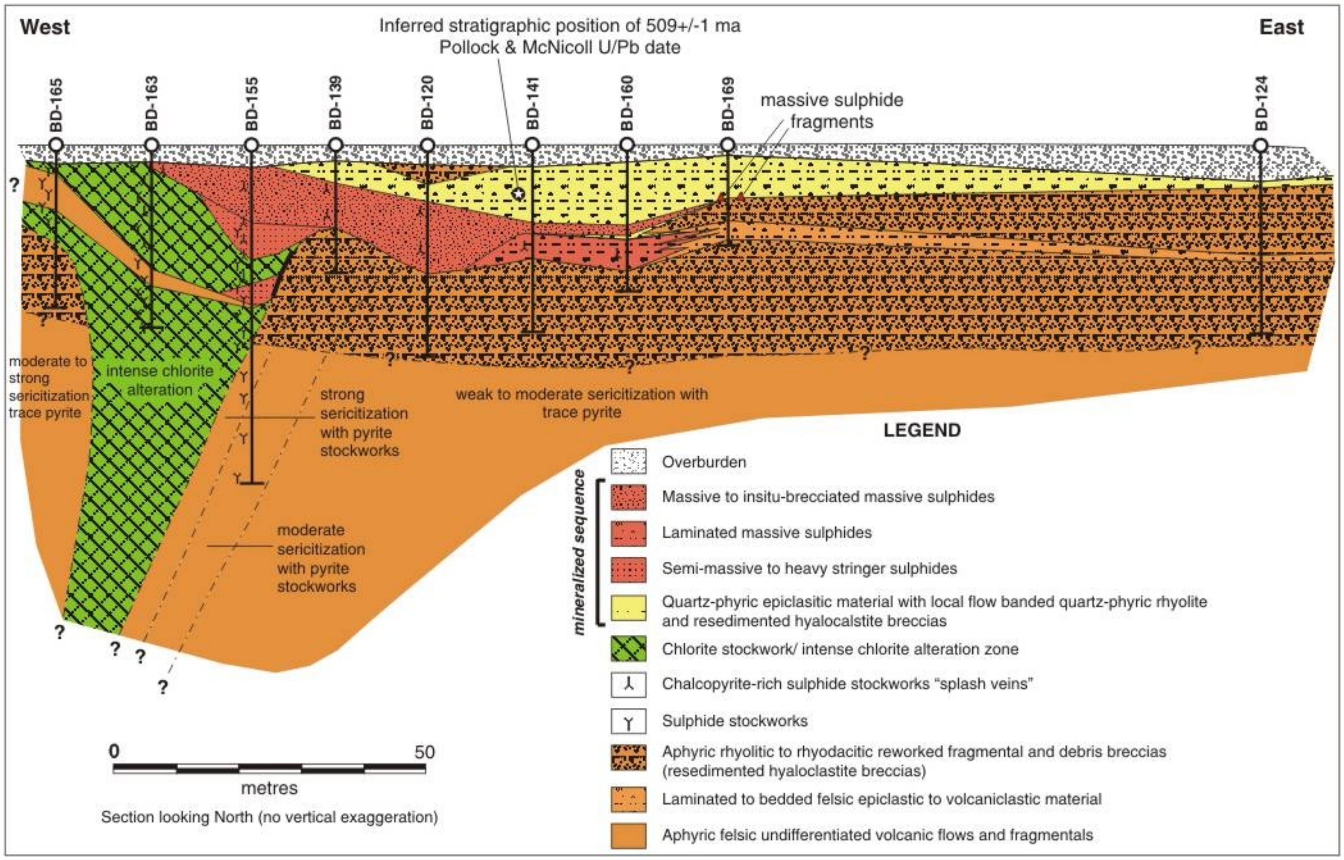

Figure 5. *Section through the South Zone, Boundary deposit.*

and sheared and brecciated felsic volcanics (Figure 4). The amount of displacement along this feature is not known and it is classified as a thrust because of its low angle relative to stratigraphy and its large lateral extents (e.g., Squires *et al*., 1991). The style of deformation noted within the fault zone appears to be controlled by the rheological properties of the rocks affected, whereby graphitic sediments are often strained and sheared throughout with penetrative cleavage development and cataclastic textures, whereas basaltic and rhyolitic rocks tend to develop foliation fabrics and brittle brecciation, respectively; whereby strain increases as sheared contacts are approached.

Overlying the Duck Pond Thrust sits a panel of relatively undeformed volcanics and sediments termed the Upper Block (e.g., Squires *et al.*, 2001). This panel (Figures 3 and 4) was previously described as being predominantly composed of felsic (aphyric to feldspar-phyric) and massive to pillowed mafic flows and lesser sediments (Squires *et al*., *op. cit*.). Included within this panel is a conspicuously thick sequence of mafic flows overlain by graphitic and sulphidic argillaceous sediments, felsic fragmentals and massive feldspar-phyric rhyolitic flows. This assemblage is correlated in numerous drillholes and is a reliable stratigraphic marker (C.G. Squires, personal communication, 2002). Observations made during this study document the quartz-phyric nature of the felsic epiclastic to fragmental unit immediately overlying graphitic argillaceous sediments within this assemblage. Based on this observation, it can be speculated that the quartz-phyric epiclastic to fragmental unit may represent a distal stratigraphic equivalent to the mineralized sequence hosting the Duck Pond and Boundary deposits.

Speculation of a correlation with the mineralized sequence is supported by the high sulphide content of the argillaceous sediments in the marker unit that locally reaches up to 50 percent pyrite. Observations made during this study also document a $\leq$5-m-thick, epiclastic to reworked unit of quartz-phyric felsic volcanic material or subaqueous pyroclastic flow approximately 15 to 25 m below the marker horizon (e.g., holes DP-87-95 and DP-99-214, Figure 4). The occurrence of this lower quartz-phyric unit suggests mafic volcanism was continuous and episodic during felsic volcanism as the unit is overlain and underlain by mafic flows.

A thick sequence of aphyric to feldspar-phyric rhyolite flows conformably overlies the marker horizon, and has been sampled for whole-rock lithogeochemical analyses and

U–Pb zircon age date determinations in an attempt to unravel its stratigraphic and structural position (Figures 3 and 4). This unit is, in turn, conformably overlain by massive to locally brecciated and pillowed basaltic flows.

A provisional correlation of the marker horizon and the mineralized sequence, implies that rocks of the Upper Block represent structurally duplicated stratigraphic equivalents to those hosting the Duck Pond deposit. Thus, the marker horizon may represent a distal equivalent to the mineralized stratigraphic package, whereby the absence of a large accumulation of aphyric to feldspar-phyric flow-banded rhyolite correlative to that observed in the footwall to the Duck Pond and Boundary deposits could be explained by either being due to the rocks being extruded beyond the flanks of the rhyolitic dome complex, or boundaries of a primary graben within which the footwall rhyolites accumulated. These possibilities remain conceptual and it is hoped that lithogeochemical analyses and age-date determinations generated by this study will better constrain the significance of the marker horizon and its implications to the volcanogenic and stratigraphic setting of the Duck Pond and Boundary deposits. It should be reiterated here, however, that similar age-date determinations of 513 ± 2 Ma and 509 ± 1 Ma from potentially correlative quartz-phyric rhyolitic and tuffaceous material by Evans *et al.* (1990) and Pollock *et al*. (2002a), from the Upper Block and Mineralized Block, respectively, are interpreted here to suggest correlation of the marker horizon (Upper Block) with the mineralized sequence (Mineralized Block) is likely.

LEMARCHANT

Drill core, examined from the prospect, support the interpretation of Collins (1992) that stratiform massive sulphide mineralization occurs at the top of a felsic volcanic sequence conformably overlain by mafic volcanics, and that the mineralized horizon is intruded by multiple mafic sill-like bodies and or dykes. Outcrops examined in the field display fragmental quartz-phyric flows at the same stratigraphic position, less than 400 m north along strike of stratiform massive sulphide mineralization intersected by diamond drilling. This quartz-phyric rhyolite is considered to be equivalent to quartz-phyric rhyolite that returned an U–Pb zircon date of 513 + 2 Ma (Evans *et al*., 1990; Dunning *et al*., 1991). Though the precise location of the dated outcrop is not known, it is reasonably estimated to be located less than 300 m west of the observed quartz-porphyritic rhyolite outcrops (i.e., presumed footwall).

Preliminary review of the prospect confirms that the occurrence is a volcanogenic massive sulphide prospect occurring conformably above an altered and mineralized sequence of largely aphyric rhyolitic flows and fragmentals. As quartz-phyric flow material has been mapped along strike on the inferred continuation of the mineralized stratigraphic horizon, it is speculated that the mineralization may occur within a similar stratigraphic horizon or be associated with a quartz-phyric volcanic episode similar to and coeval with mineralized sequence rocks hosting the Duck Pond and Boundary deposits.

BURNT POND

Relogging of archived drill cores confirm the mineralization at the Burnt Pond prospect consists of stratiform massive sulphides hosted by a subvertical to steeply east-dipping, overall west-facing, locally overturned, sequence of fine-grained, graphitic, felsic epilclastic sediments as had been reported by Collins (1991). The mineralized epiclastic sediments are, however, noted to contain abundent detrital volcanic quartz and lie in sheared contact with a sequence of unusual mauve-red to green-weathering siltstones to the west. The sheared contact between these units is marked by cataclastically deformed graphitic argillite and may represent a significant structural break. Host quartz-phyric epiclastic sediments are inferred to be conformably underlain by adjacent altered aphyric dacitic to rhyolitic fragmentals and flows located to the east. Where observed, the contact between host quartz-phyric epiclastic sediments and presumed conformably underlying felsic volcanics was noted to be either sheared or a potentially strain-modified conformable contact. The inferred conformable nature of this contact is supported by the proximal relationship between stratiform massive sulphides within the epiclastic sequence and alteration and mineralization within felsic volcanics to the east. The latter rocks are noted to also contain intercalated mafic to possibly dacitic massive amygdaloidal flows and possibly sills. Host quartz-phyric epiclastic rocks as well as the inferred footwall felsic volcanics and dacitic units are themselves highly disrupted by shearing and often possess sheared internal contacts, some of which display textures approaching mylonite.

Based on this preliminary review, it is possible that the Burnt Pond prospect may occur within a similar stratigraphic horizon associated with a quartz-phyric volcanic episode similar to that observed at the Duck Pond and Boundary deposits. Unlike the Lemarchant prospect, however, no age-date information is available for rocks in the area of the occurrence.

Dimmell (1986) and Collins (1991) report intersecting rock types correlative with the Crippleback Lake plutonic suite within the presumed footwall felsic volcanic sequence. Inspection of several of the reported intervals identified variably sericitized, chloritized and pyrite mineralized fine-grained phaneritic to quartz and feldspar-porphyritic felsic rocks. These rocks are observed to be in sheared contact with adjacent aphyric felsic volcanic rocks and contacts are marked by narrow shears measuring less than 1 cm in width, lacking appreciable penetrative deformation in adjacent rocks. The age of the unit is not known, although the observations suggest these rocks may have strain-modified intrusive contacts with the adjacent volcanic rocks. A potentially coincident weak positive magnetic anomaly defined by airborne geophysical surveys (e.g., Oneschuk *et al.*, 2001) led Evans *et al.* (1994a) to interpret this body to be an apophysis of the Crippleback Lake plutonic suite, which is associated with a positive, prominent, magnetic anomaly (D.T.W. Evans, personal communication, 2002).

Correlation of the aforementioned phaneritic, granitoid rocks with the Crippleback Lake plutonic suite is equivocal. Alternative interpretations include the possibility that these rocks represent syn-volcanic intrusive rocks related to adjacent felsic volcanics. This possibility is presented in Figure 2. Lithogeochemical analyses may help to resolve its correlation.

DISCUSSION AND CONCLUSIONS

Investigation of four key volcanogenic massive sulphide occurrences within the Tally Pond volcanics has yielded several geological similarities between each of the occurrences of potential regional metallogenic significance. First is the identification of a quartz-phyric felsic volcanic event (mineralized sequence) associated with stratiform massive sulphide mineralization. Likewise, at each occurrence, rocks of this sequence appear to be conformably underlain by a sequence of aphyric to feldspar-phyric felsic flows and breccias of unknown age. While correlation of the mineralized unit has not been confirmed, and the possibility of several mineralizing quartz-phyric volcanic events cannot be ruled out, available age-date determinations suggest correlation of a least one widespread mineralizing event is likely.

Based primarily on observations made from drill cores from the Duck Pond and Boundary deposit areas, the internal stratigraphy of the Tally Pond volcanics appears to consist of long-lived mafic volcanism punctuated by several felsic volcanic episodes. The oldest felsic volcanic event is a thick sequence of flow-dominated aphyric to feldspar-phyric dacitic to rhyolitic volcanics having textures indicative of a lobe-hyaloclastite flow volcanic regime. This sequence is conformably overlain, and possibly locally intercalated, with an apparently, less voluminous sequence of high-silica, quartz-phyric rhyolitic volcanics and epiclastic units, which hosts and is chronologically, and perhaps genetically linked with, key volcanogenic massive sulphide deposits and occurrences within the Tally Pond volcanics.

Correlations with similar quartz-phyric rocks in structural contact with the host stratigraphic sequences (i.e., Upper Block, Duck Pond deposit) suggest the mineralized quartz-phyric volcanic sequence is overlain by a second series of aphyric to feldspar-phyric felsic volcanic rocks. These relationships remain tentative at present. Whole-rock lithogeochemical analyses and U–Pb age-date determinations may help resolve the stratigraphic position of these rocks.

Based on the review of geochemical, geochronological and isotopic data collected by previous workers, the Tally Pond volcanics are considered to have formed within an ensimatic-arc environment as originally proposed by Dunning *et al*. (1991). Further, it is proposed that this arc formed adjacent to the Gondwanan continental margin as evidenced by the characteristic highly radiogenic Pb-isotopic signatures observed from massive sulphides within the Tally Pond volcanics and the Victoria Lake supergroup. Tectonomagmatic models proposed for pre- and post-Arenig (~490 to 485 Ma, and ~484 to 465 Ma, respectively) volcanic and plutonic rocks of similar tectonic affinities within the Wild Bight and Exploits groups of the Exploits Subzone (MacLachlan, 1998) may apply to arc-related volcanic rocks of the Victoria Lake supergroup and the Tally Pond volcanics, suggesting further links between these two important metallogenic areas.

IMPLICATIONS FOR EXPLORATION

Exploration for volcanogenic massive sulphides within the Tally Pond volcanics, should consider several key points in exploration strategy. These include:

- Visually discernible variations in phenocrysts populations, and in particular recognition of quartz as a phenocryst phase, provide a potentially effective tool in recognizing a key stratigraphic horizon associated with mineralization within the Tally Pond volcanics.

- Graphitic argillaceous sediments are intimately intercalated with base-metal-rich, pyritic massive sulphides at Duck Pond, Lemarchant, and Burnt Pond. Previous airborne and ground electromagnetic surveys have defined several regionally extensive conductive units inferred to be correlative with graphitic sedimentary units of various ages including those correlative with mineralization as well as younger black shales of Caradocian age (e.g., Oneschuk *et al*., 2001; Dimmell, 1986; Collins, 1991, 1992, 1993). These relationships should be taken into account when testing conductive targets, as conductive black shale horizons could be prematurely "written off", without proper assessment of adjacent volcanic rocks for alteration, mineralization and stratigraphic position.

$ Extensive alteration is visually discernible as abundant pyritic stockworks containing chlorite, silica and carbonate within footwall volcanics rocks to the Duck Pond deposit. This alteration can be traced for several hundreds of metres into the footwall at Duck Pond (>400 m) and appears to have similar lateral extents as the massive sulphides (e.g., Upper Duck lens, Figure 4). This relationship increases the effective footprint of a large massive sulphide deposit and should aid identification of target areas. Caution should be exercised; however, as structural complications could dismember a large footwall alteration zone from its associated massive sulphide mineralization.

FUTURE RESEARCH

The northeastern segment of the Tally Pond volcanics east of Noel Paul's Brook, and more particularly east of the Crippleback Lake plutonic suite, remains poorly understood. The rocks lack critical age-date determinations and stratigraphic correlations with the volcanics southwest of Noel Paul's Brook. This area is mapped as being underlain by significant accumulations of potentially prospective felsic volcanics east and west of the Sandy Lake basalts. Age-date determinations and lithogeochemical trace-element investigations should be undertaken to help resolve the stratigraphic and metallogenic significance of this area.

Further work is required to investigate the timing of intrusive activity in the area and assess the possibility of links between intrusive activity, volcanism and mineralization.

Consideration should be given to characterizing alteration associated with massive sulphide mineralization with a view toward helping explorationists identify and assess target areas. The Upper Duck lens and Boundary deposits represent excellent case-study areas in which to conduct such an investigation.

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