Current Research (2012) Newfoundland and Labrador Department of Natural Resources
Geological Survey, Report 12-1, pages 85-102

U–Pb GEOCHRONOLOGY AND LITHOGEOCHEMISTRY OF THE HOST ROCKS TO THE REID GOLD DEPOSIT, EXPLOITS SUBZONE–MOUNT CORMACK SUBZONE BOUNDARY AREA, CENTRAL NEWFOUNDLAND

H. Sandeman, V. McNicoll[1] and D.T.W. Evans[2]
Mineral Deposits Section
[1]Geological Survey of Canada, 601 Booth St., Ottawa, ON K1A 0E8
[2]Golden Dory Resources Ltd., P.O. Box 940, Bishop's Falls, NL A0H 1C0

ABSTRACT

The Reid gold deposit of the Brady option exploration licences in NTS map area 2D/05 of central Newfoundland was discovered in 2002, through prospecting and sampling of arsenopyrite-bearing quartz-plagioclase porphyry float, in an area of extensive till cover, immediately north of the Northwest Gander River. Reid deposit mineralization is hosted in ophiolitic basalt, diabase dykes and trondhjemite of the Coy Pond Complex that likely occur in a series of thrust-bound slices, marking the boundary between the eastern Exploits Subzone (Dunnage Zone) and the ellipsoidal Mount Cormack Subzone, a tectonic window into the underlying Gander Zone. Trench and drillcore data indicate that the Reid deposit mineralization occurs as randomly oriented sericite–chlorite–Fe-carbonate–pyrite–arsenopyrite alteration, hosted mainly in silicified and quartz-veined, quartz-plagioclase porphyritic granitoid (Reid porphyry) and to a lesser extent, in basalt, diabase and microgabbro of the Coy Pond Complex. The porphyry both crosscuts, and is intruded by fine-grained diabase and basalt. Lithogeochemical data for the porphyry, diabase and lava indicate that these are all tholeiitic, trace-element depleted, supra-subduction zone rocks. The Reid (deposit) porphyry is a trondhjemite and likely represents the final product of fractional crystallization of strongly depleted tholeiitic mafic rocks of the ophiolite complex.

The U–Pb zircon geochronology indicates the Reid (deposit) trondhjemite crystallized in the Cambrian at 510 ± 4 Ma and the Coy Pond Complex is, therefore, the oldest known ophiolite fragment in the Appalachian–Caledonide orogen.

INTRODUCTION

The Reid gold deposit, the most significant mineralization on the Brady option exploration property, is located 50 km south of the Town of Grand Falls-Windsor, Newfoundland, in the Burnt Hill map area (NTS 2D/05; Figure 1). This part of central Newfoundland forms a peneplained flatland having little topographical relief (from 130–250 m asl), and a mature river system developed on thick hummocky terrain, ablation and basal till, with local alluvium and bogs (Liverman and Taylor, 1990). The thick glacial till blanket, in conjunction with the flat topography and younger fluvial deposits, make intact bedrock outcrop very scarce, typically <1%. Glacial flow indicators, of which there were very few, are dominantly bidirectional, but local unidirectional striae indicate ice flow from the north to the south (Proudfoot *et al*., 2005).

Prior to the construction of the Bay d'Espoir highway in the early 1970s, and systematic 1:50 000-scale geological mapping, little exploration or academic survey work had been completed. For a complete summary of survey investigations prior to 1985, the reader is referred to Colman-Sadd (1985), and all subsequent scientific work is summarized in Colman-Sadd *et al.* (1992), Valverde-Vaquero *et al*. (2006) and Zagorevski *et al.* (2007). After the release of a Provincial Government regional lake-sediment compilation (Davenport *et al*., 1994), the mineral exploration industry renewed its interest in central Newfoundland, and initiated a number of systematic grass-roots prospecting and soil sampling programs. In 2002, the discovery of auriferous, arsenopyrite and pyrite mineralized basaltic, ultramafic and porphyritic granitoid float north of the Northwest Gander River and west of the Bay d'Espoir highway, led to the acquisition of the Brady option exploration licences. Explo-

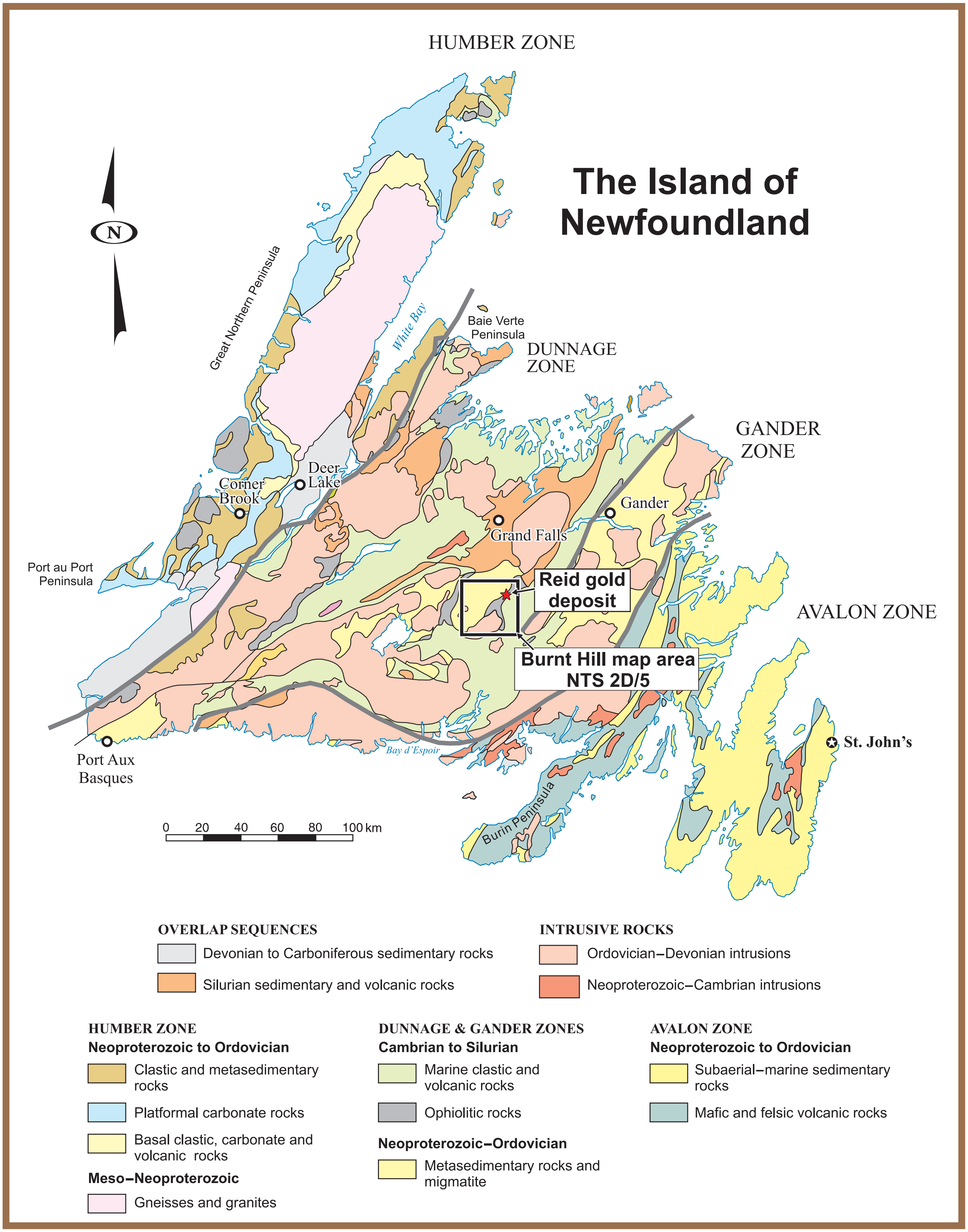

Figure 1. *Simplified geological map of the Island of Newfoundland showing the location of the Burnt Hill map area and the Reid gold deposit.*

ration at the Brady option property began with systematic prospecting and soil sampling of a detailed grid at the Reid Brook Zone, (now referred to as the Reid gold deposit) that occurs in till and alluvium covered areas, north of the Northwest Gander River (Figure 2). This was immediately followed by detailed ground geophysics (VLF-EM, magnetics, Induced Polarization (IP)), soil geochemistry, prospecting and trenching as well as diamond drilling (Dimmell, 2003, 2004); and more recently, extensive diamond drilling (Evans, 2010, 2011). Completed diamond drilling indicates that the Reid deposit contains an inferred resource of 5.99 million tonnes averaging 0.558 g/t Au for 107 461 ounces of gold at a cutoff of 0.30 g/t Au (Golden Dory Resources, Press Release, September 28, 2010).

Largely, because of the paucity of exposed bedrock, the geological and geochronological database for this part of central Newfoundland is sparse (Anderson and Williams, 1970; Colman-Sadd, 1985; Dunning *et al*., 1990; Colman-Sadd *et al*., 1992; Valverde-Vaquero *et al*., 2006) making interpretation of the geology and setting of the Reid gold deposit difficult. Robust lithogeochemical data are lacking for rocks hosting the deposit, and although there are a number of regionally significant U–Pb crystallization and metamorphic ages, none is directly pertinent to the rocks of this investigation. Herein are reported whole-rock lithogeochemistry for select rocks from the Reid gold deposit of the ophiolitic Coy Pond Complex, including mineralized and unmineralized samples. A new U–Pb (SHRIMP) zircon age determination for the quartz-plagioclase porphyry of the Reid deposit is also reported.

REGIONAL SETTING AND PREVIOUS WORK

In central Newfoundland, the late 1960s and early 1970s regional-scale aeromagnetic surveys and geological mapping by the Geological Survey of Canada (Anderson and Williams, 1970) were followed by 1:50 000-scale systematic mapping by the Newfoundland and Labrador Department of Natural Resources (Colman-Sadd, 1980a, 1985; Blackwood, 1982; Colman-Sadd and Swinden, 1984a, 1989; Swinden, 1988; Colman-Sadd and Russell, 1988). These regional mapping programs resulted in a series of investigations (Colman-Sadd, 1980b; Colman-Sadd and Swinden, 1982, 1984b; Colman-Sadd *et al*., 1992) that have greatly improved our understanding of the geodynamic evolution of the region.

The northeast portion of the Burnt Hill map area (NTS 2D/05) encompasses the southeastern margin of the elliptical Mount Cormack Complex, the southward-lying ophiolitic rocks of the Coy Pond and Great Bend (ophiolite) complexes and the felsic volcanic, volcaniclastic and fine-grained clastic sedimentary rocks of the Baie d'Espoir Group (Figures 2 and 3; Colman-Sadd, 1980a, 1985). The rocks of the Mount Cormack Complex are dominated by chlorite to biotite metamorphic zone, decimetre- to metre-scale bedded psammite and pelite of the Spruce Brook Formation. These low-grade rocks pass gradationally northwestward into sillimanite and K-feldspar-grade metamorphic gneisses and metasedimentary diatexite, along with minor mafic intrusions and the Middle Ordovician ($464^{+4}/_{-3}$ Ma) anatectic, garnet–tourmaline–muscovite Through Hills granite (Colman-Sadd, 1985; Colman-Sadd *et al*., 1992; Valverde-Vaquero *et al*., 2006).

Southeast of, and in structural contact with, the rocks of the Mount Cormack Complex and underlying the Northwest Gander River lowlands are the ophiolitic rocks of the Coy Pond and Great Bend complexes (Colman-Sadd, 1982, 1985; Colman-Sadd and Russell, 1988). North of Coy Pond (Figure 2), an almost complete ophiolite stratigraphy is preserved with peridotites exposed in the west and mafic dykes, lavas and sedimentary rocks exposed in the east. Thin-bedded black argillite, sandstone and polymict conglomerate conformably overlie mafic pillow lavas that are inferred to grade transitionally into diabase and gabbro (Colman-Sadd, 1985). Altered trondhjemite forms a large irregular intrusion that crosscuts gabbro and diabase, but is itself cut by mafic dykes. Gabbro and diabase pass gradationally westward into massive and layered pyroxenite, wehrlite and intermixed gabbro. These units are separated from a thick basal harzburgite by a thin unit of strongly sheared serpentinite and talc–magnesite schist. To the northeast, the ophiolite complex tapers into a narrow (~1 km wide) zone of brecciated and sheared peridotite. Contacts between the Coy Pond and Mount Cormack complexes are not exposed, but are interpreted to be faulted.

South and east of the Coy Pond Complex are clastic sedimentary, volcaniclastic and volcanic rocks of the North Steady Pond Formation of the Baie d'Espoir Group (Figures 2 and 3; Colman-Sadd, 1980a; 1985). The thickness and internal stratigraphy of the formation are not known because of the poor exposure, a lack of marker horizons and the presence of isoclinal folding. From north to south, the rocks include a sequence of felsic volcanic flows, tuffs and volcaniclastic sandstones also termed the Huxter volcanic belt (Colman-Sadd and Swinden, 1982); a discontinuous horizon of clast-supported polymict conglomerate containing argillite, siltstone, psammite, chert and felsic and mafic volcanic clasts and interbedded packages of thin- and medium-bedded arkosic sandstone, siltstone and phyllite. The contact between the North Steady Pond Formation and the rocks of the Coy Pond Complex is exposed at one locality, where a sheared serpentinite marks the trace of an easterly dipping normal fault. Elsewhere, the contact is assumed to be faulted.

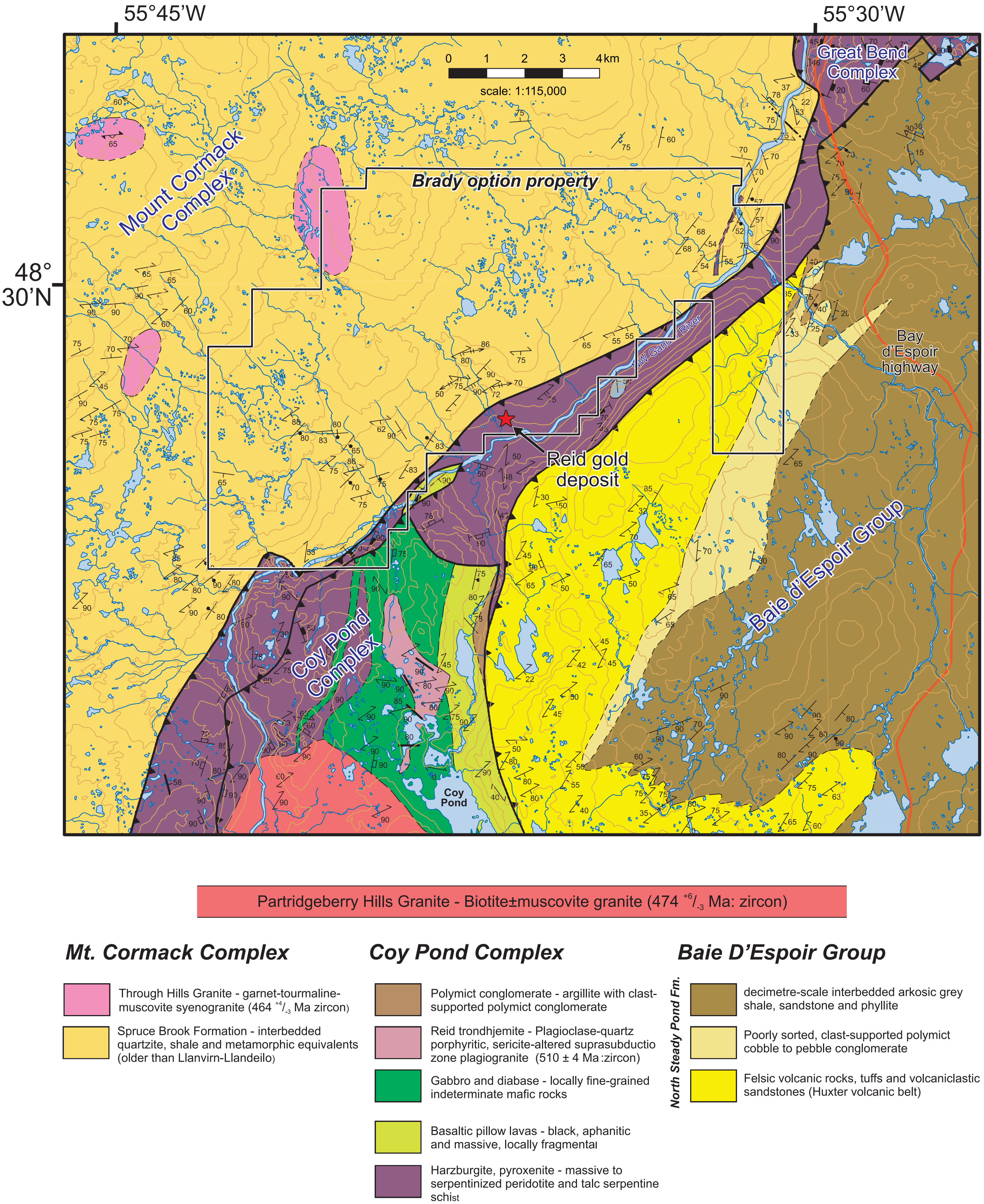

Figure 2. *Simplified geological map of the area around the Reid gold deposit adapted after Colman-Sadd (1985). All contacts are assumed.*

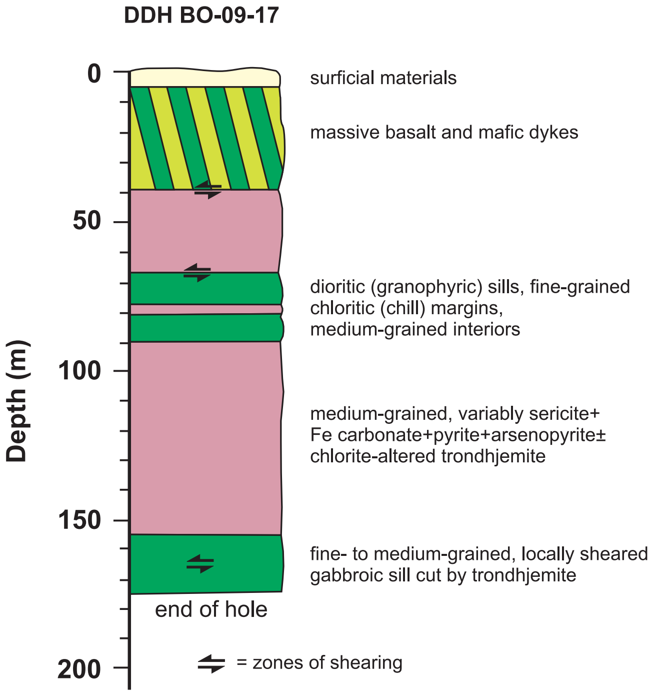

Figure 3: *Schematic representation of rock types encountered in diamond-drill hole BO-09-17 that intersected rocks of the Reid gold deposit of the Coy Pond Complex (adapted from Evans, 2010).*

Colman-Sadd and Swinden (1984b) and Colman-Sadd (1985) recognized that the quartz-rich, turbiditic sedimentary rocks of the Spruce Brook Formation of the Mount Cormack Complex, exhibited paleontological fauna and sedimentological characteristics similar to rocks of the Davidsville Group of the Gander Zone. The rocks encircling the Mount Cormack Complex, however, were noted to have lithological associations and faunal evidence of Exploits Subzone rocks. Colman-Sadd and Swinden (*op. cit*.) therefore proposed that the Mount Cormack Subzone represents Gander Zone rocks exposed in an upward-domed basement window, encircled by a structurally modified, tectonic klippe of intra-oceanic-arc and back-arc complexes of the eastern Dunnage Zone (Colman-Sadd and Swinden, 1984b). Subsequently, the Gander Zone of Newfoundland was divided into three distinct constituents, the Gander Lake, Meelpaeg and Mount Cormack subzones (Williams *et al*., 1988). Faunal provenance studies on graptolite-bearing black shale conformable at the top of the Coy Pond Complex indicate that the local rocks of the Exploits Subzone included oceanic crust that must have formed proximal to the Gondwanan eastern margin of Iapetus (Williams *et al*., 1992). These Upper Cambrian (*e.g*., Pipestone Pond Complex, *ca.* 494 Ma; Dunning and Krogh, 1985), eastern Dunnage Zone 'Penobscot' arc ophiolites were thrust eastward (present-day coordinates) over the Gander Zone margin (Colman-Sadd *et al.,* 1992; Zagorevski *et al*., 2007). Metamorphism and accompanying anatexis in the Mount Cormack Complex at *ca.* 464 Ma (Colman-Sadd *et al*., 1992; Valverde-Vaquero *et al*., 2006), and intrusion of the 'stitching', Partridgeberry Hills Granite (Middle Ordovician: 464 $^{+6}/_{-4}$ Ma) were interpreted to indicate that overthrusting of the eastern Exploits oceanic tract and concomitant doming and anatexis in the Mount Cormack window, must have finished by that time (Colman-Sadd *et al*., 1992). The origin of younger, normal faulted contacts between the Coy Pond and Mount Cormack complexes, and second-generation fabrics in the southern portions of the Partridgeberry Hills Granite and the adjacent Baie D'Espoir Group was described as uncertain by Colman-Sadd *et al*. (1992). Those authors suggested that these faults and fabrics may have resulted from further crustal shortening, or perhaps forceful intrusion of a semi-solidified granitic intrusion (*i.e*., Partridgeberry Hills Granite).

GEOLOGY OF THE REID GOLD DEPOSIT

The rocks hosting the Reid gold deposit are very poorly exposed, but sparse local outcrop and rubble-crop, along with trenching, indicate that the mineralization is hosted by massive to weakly deformed, block-faulted and likely thrust-imbricated ophiolitic rocks of the Coy Pond Complex (*e.g*., Colman-Sadd, 1985; Colman-Sadd *et al*., 1992; Dimmell *et al.*, 2003; Dimmell, 2004; Evans *et al*., 2007; Evans, 2010, 2011). Trenching at the Reid deposit was successful in exposing only sporadic, isolated outcrop and subcrop of quartz-veined and chlorite + Fe carbonate ± sericite ± epidote altered, arsenopyrite- and pyrite-bearing, fine- to medium-grained mafic volcanic, hypabyssal diabase (microgabbro) and rare quartz-plagioclase porphyry (Dimmell *et al.*, 2003). Diamond-drill hole data at the Reid deposit (Dimmell *et al.*, 2003; Dimmell, 2004; Evans, 2010, 2011), however, provide new insight into the orientations and spatial relationships of the rocks of the Coy Pond Complex and the Spruce Brook Formation of the Mount Cormack Subzone. The drillholes record the first clear and unambiguous relationships documented for the ophiolitic rocks at the Reid deposit and provide for material for lithogeochemistry and suitable siliceous granitoid U–Pb geochronology.

Anomalous gold at the Reid deposit occurs throughout the upper and middle parts of the drillholes and is hosted by basalt, diabase and quartz-plagioclase porphyry. Several diamond-drill holes, in particular the vertical BO-04-13 (Dimmell, 2004) and the inclined BO-09-17 (Evans, 2010, 2011) intersected thick sequences of ophiolitic stratigraphy. Diamond-drill hole BO-09-17 (Evans, 2010, 2011) yielded some of the highest and continuous gold assays so it was examined in greater detail, and representative, 20-cm-quartered core samples were taken throughout. Gold assays were determined for much of the drillhole and ranged from <5–5378 ppb Au in 1-m-wide, split core intervals (Evans, 2010). In basalt and diabase near the top of the drillhole, values ranged from <5–3146 ppb Au and in the quartz-plagioclase porphyry ranged from <5–5378 ppb Au. Other elements were not analyzed. Earlier auriferous drillhole intersections (Dimmell *et al.*, 2003; Dimmell, 2004), however, demonstrated that Au is strongly correlated with As and perhaps weakly correlated with Cu and Zn.

Examination of drillhole BO-09-17 (Figure 3) reveals that the upper parts contained about 40 m of generally fine-grained, massive chloritic basalt (sample BO-09-17_7.13 m, Plate 1) interlayered in repeated intervals with fine- to medium-grained gabbro and basaltic dykes exhibiting chill margins. Granitoid veins, herein interpreted as trondhjemite (the Reid quartz-plagioclase porphyry), and basaltic breccia zones occur locally in these basaltic rocks (Plate 2). The veins and breccia clasts exhibit chloritic margins and do not have distinct chill zones. All of the rock types had locally extensive disseminated pyrite, were quartz veined and yielded anomalous Au assays (*see* above; Evans, 2010, 2011). Below the upper mafic-rock-dominated horizon, is an interval (~28 m) of typically medium-grained (<5 mm) leucocratic quartz and plagioclase porphyritic biotite trondhjemite or tonalite (BO-09-17_60.95 m, Plate 3). The trondhjemite preserves diffuse, poorly developed chill margins against some basalt, but is also crosscut by basaltic dykes with well-developed chills. Some of this interval of the porphyritic granitoid was sericite + Fe carbonate altered, but only yielded anomalous gold where dissected by generally narrow quartz veinlets.

Plate 1. *Massive, fine-grained pyritic basalt from the top of drillhole BO-09-17 (sample BO-09-17_7.13 m). This intersection yielded an assay of <5 ppb Au. The $2 coin is 28 mm in diameter.*

Below the upper trondhjemite is a fine- to medium-grained gabbro varying to diorite (sample BO-09-17_69.39 m, Plate 4) that is inferred to represent an approximately 20-m-thick gabbro sill or dyke that crosscuts the trondhjemite.

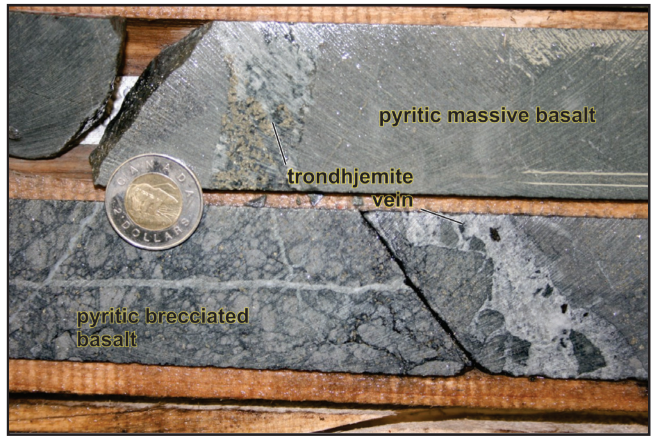

Plate 2. *Pyritic, massive and brecciated chlorite + Fe-carbonate + epidote-altered basalt cut by veinlets of medium-grained pyrite + arsenopyrite + sericite+ Fe-carbonate + chlorite-altered trondhjemite (sample BO-09-17_27.32 m). This intersection yielded an assay of 1694 ppb Au. The $2 coin is 28 mm in diameter.*

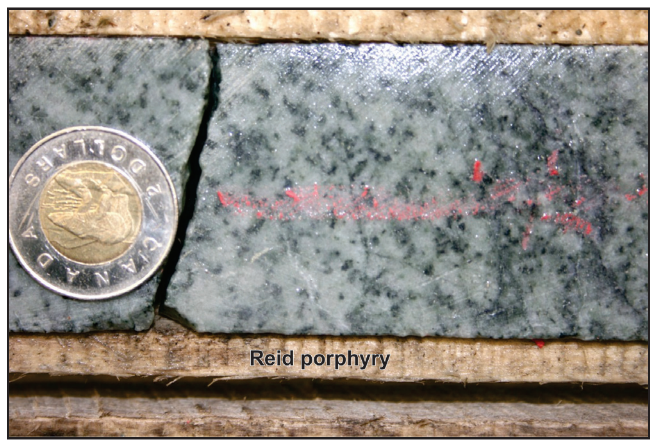

Plate 3. *Weakly chlorite–sericite–Fe-carbonate-altered quartz-plagioclase porphyry from drillhole BO-09-17 (sample BO-09-17_60.95 m). This intersection yielded an assay of <5 ppb Au. The $2 coin is 28 mm in diameter.*

This unit was poorly mineralized relative to the top and lower sections of the drillhole.

Immediately below the gabbro sill is the widest intersection of trondhjemite, corresponding to arguably the most anomalous mineralized section of the drillhole. This is a ~50-m-thick interval of commonly quartz-veined, strongly chlorite + Fe carbonate + sericite ± epidote-altered, arsenopyrite- and pyrite-bearing, typically medium-grained trondhjemite (sample BO-09-17_107.34 m, Plate 5; Evans, 2010, 2011). Mineralization consists of disseminated pyrite, less common chalcopyrite and abundant arsenopyrite that occurs in spatial association with pervasive, flooding-style alteration of the trondhjemite matrix. Alteration consists of

Plate 4. *Fine- to medium-grained chlorite+epidote-altered diorite of the Coy Pond Complex (sample BO-09-17_69.39 m). This intersection yielded an assay of 94 ppb Au. The $2 coin is 28 mm in diameter.*

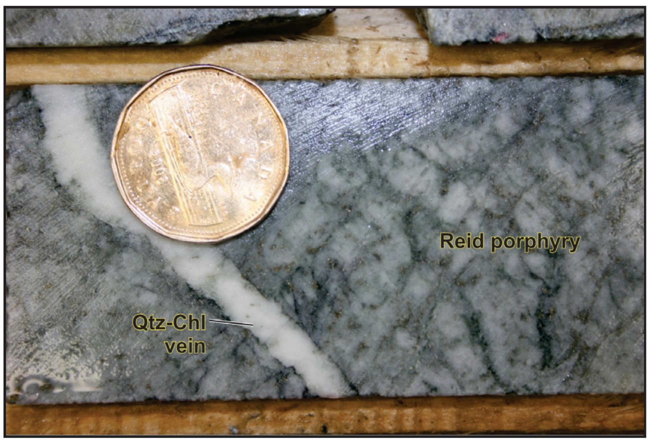

Plate 5. *Medium-grained moderately to strongly altered and quartz-veined quartz-plagioclase porphyry (sample BO-09-17_107.34 m). This intersection yielded an assay of 3036 ppb Au. The $1 coin is 25 mm in diameter. Key: Qtz = quartz; Chl = chlorite.*

anastamosing, millimetric chlorite + Fe carbonate + sericite + epidote veinlets that wrap around large remnant phenocrysts of quartz and saussuritized plagioclase (Plates 6 and 7). Quartz veining is sporadic and discontinuous throughout, with individual veins rarely exceeding 10 cm in width. Free gold has been observed as fracture coatings and as isolated tiny (≤ 10µm) grains in pyrite (Seymour, 2003; Plate 8). This lower trondhjemite interval is crosscut by a 1.5-m-wide, fine-grained basaltic dyke (sample BO-09-17_125.90 m, Plate 9) that has well-developed chill margins against the trondhjemite.

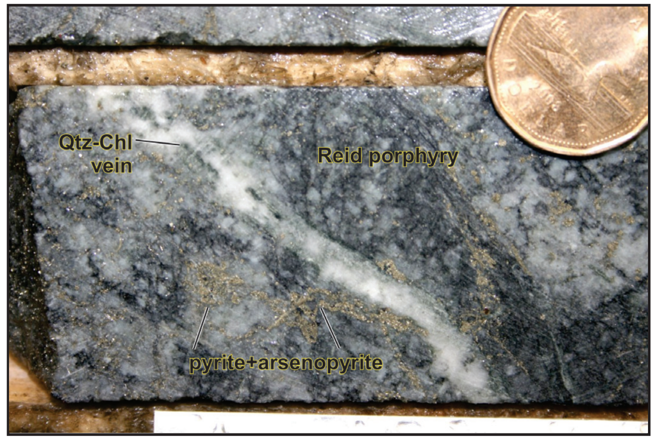

Plate 6. *Strongly pyrite–arsenopyrite–chlorite–sericite + Fe-carbonate-altered and quartz-veined and mineralized quartz-plagioclase porphyry (sample BO-09-17_150.72 m). This intersection yielded an assay of 2916 ppb Au. The $1 coin is 25 mm in diameter. Key: Qtz = quartz; Chl = chlorite.*

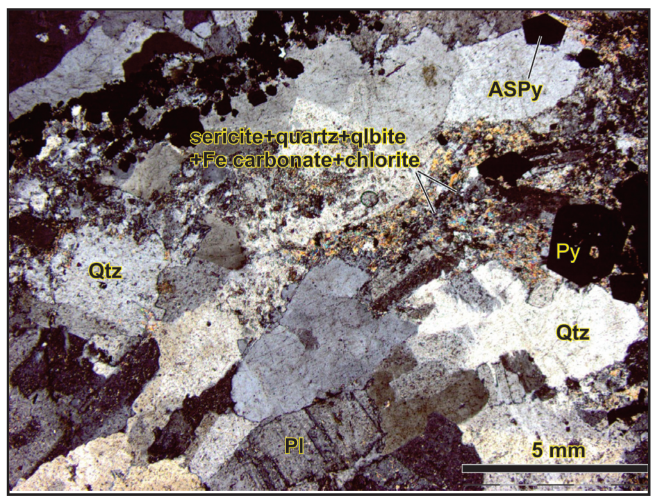

Plate 7. *Photomicrograph of quartz-plagioclase porphyry under crossed polars showing typically euhedral pyrite and arsenopyrite in a sericite + quartz + albite + Fe-carbonate + chlorite-altered matrix surrounding remnant interlocking grains of quartz and plagioclase feldspar (sample BO-09-17_107.0m). This rock yielded an assay of 3036 ppb Au. Key: Qtz = quartz; Pl = plagioclase; Py = pyrite; ASPy = arsenopyrite.*

The trondhjemite passes abruptly downward into generally weakly altered to massive, medium- to coarse-grained chloritized and serpentinized gabbro (Plate 10) and locally peridotite.

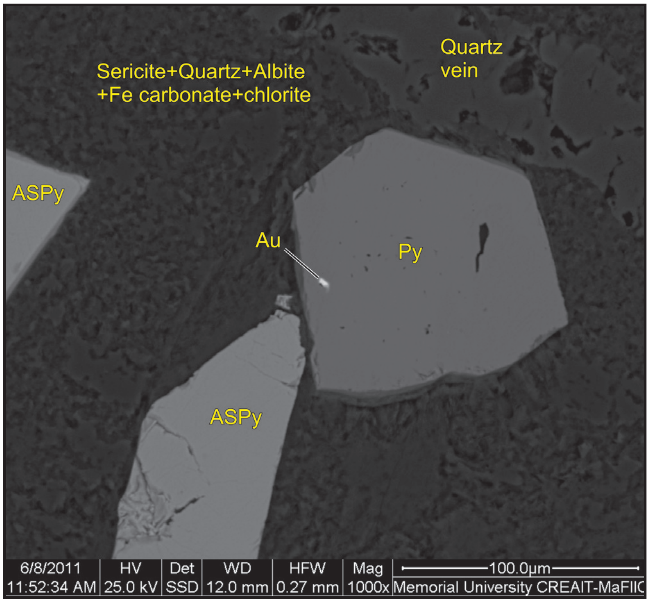

Plate 8. *Electron microprobe backscattered electron image of subhedral arsenopyrite and pyrite grains in a strongly sericite + quartz + albite + Fe-carbonate + chlorite-altered quartz-plagioclase porphyry matrix. Note the tiny gold inclusion in pyrite (sample BO-09-17_107.0 m). Key: Au = gold; Py = pyrite; ASPy = arsenopyrite.*

Plate 9. *Fine-grained diabase dyke with thin quartz veins crosscuts quartz-plagioclase porphyry in diamond-drill hole BO-09-17 (sample BO-09-17_125.9 m). Canadian $1 coin is 25 mm in diameter. The diabase was not assayed.*

ANALYTICAL METHODS

LITHOGEOCHEMISTRY

Five specimens of the porphyry along with 4 samples each of diabase-basalt and gabbro-diorite of the Coy Pond Complex were analyzed for their major, trace and rare-earth-element contents. These samples are all variably altered and mineralized. Samples were analyzed at the Department of Natural Resources, Government of Newfoundland and Labrador, Geochemical Laboratory (Howley Building, Higgins Line) for their major and selected trace elements (Ag, As, Be, Cd, Co, Cr, Cu, Li, Mo, Ni, Pb, Sc, V, Zn). Analytical methods for these elements are after Finch (1998). Fluoride was determined by ion specific electrode at the Howley Building geochemical laboratories. The samples were then analyzed for REE and other selected elements (Ba, Bi, Cs, Ga, Ge, Hf, Nb, Rb, REE, Sb, Sn, Sr, Ta, Th, Tl, U, W, Y, Zr) by ICP-MS, total digestion methods at XRAL Laboratories in Ancaster, Ontario using standard methods outlined on their website (http://www.actlabs.com/). Gold (in ppb) represents the fire assay results for 1m length sections of the core as reported in Evans (2010; 2011). Results are presented in Table 1.

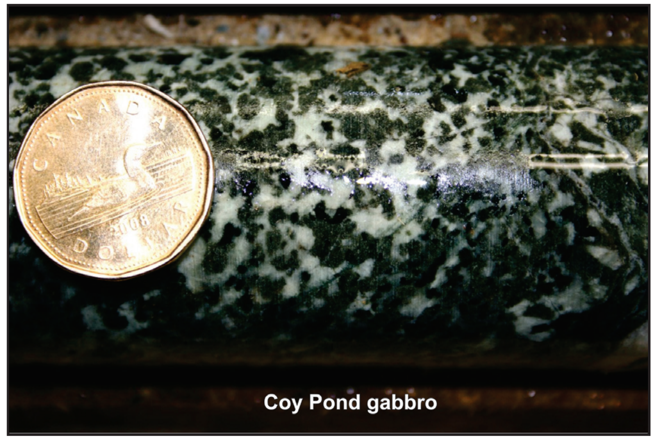

Plate 10. *Massive, medium- to coarse-grained gabbro near the base of drillhole BO-09-22 (sample BO-09-22_168.2 m). Canadian $1 coin is 25 mm in diameter. This section of core was not assayed.*

SHRIMP U–Pb GEOCHRONOLOGY

A sample of medium-grained, weakly mineralized, plagioclase porphyritic trondhjemite was collected for U–Pb geochronology from a section of NQ drillcore from the trondhjemite (sample BO-09-017-123.1-123.3 m; z10414) to provide the maximum possible age of the timing of that gold mineralization. The sample is visually, petrographically and geochemically identical to trondhjemite immediately above the sampled interval, which yielded ~3–4 g/t Au.

SHRIMP II (Sensitive High Resolution Ion Micro-Probe) analyses were conducted at the Geological Survey of Canada (GSC) using analytical and data-reduction procedures described by Stern (1997) and Stern and Amelin (2003) and briefly summarized here. Zircons from the samples and fragments of the GSC laboratory zircon standard (z6266 zircon, with $^{206}Pb–^{238}U$ age = 559 Ma) were cast in an epoxy grain mount (GSC mount IP587), polished with diamond compound to reveal the grain centres, and photographed in transmitted light. The mount was evaporatively coated with 10 nm of high-purity Au, and the internal features of the zircons were characterized with backscattered electrons (BSE) utilizing a scanning electron microscope (SEM). Analyses were conducted using an O^- primary beam projected onto the zircons with an elliptical spot size of 13 x 16 µm (K100). The count rates of ten isotopes of Zr^+, U^+, Th^+, and Pb^+ in zircon were sequentially measured with a single electron multiplier. Off-line data processing was accomplished using customized in-house software. The SHRIMP analytical data are presented in Table 2. Common-Pb-corrected ratios and ages are reported with 1s analytical errors, which incorporate an external uncertainty of 1.0% in calibrating the standard zircon (*see* Stern and Amelin, 2003). Isoplot v. 3.00 (Ludwig, 2003) was used to generate the concordia diagram, where the error ellipses are displayed at 2s. Analyses of a secondary zircon standard (Temora 2) were interspersed between the sample analyses to verify the accuracy of the U–Pb calibration. Using the calibration defined by the z6266 standard, the weighted mean $^{206}Pb–^{238}U$ age of the analyses of Temora 2 zircon on the grain mounts were determined to be 415.2 ± 3.4 Ma (IP587). The accepted $^{206}Pb–^{238}U$ age of Temora 2 is 416.5 ± 0.22 Ma, based on 21 isotope dilution fractions (Black *et al.,* 2005).

LITHOGEOCHEMICAL RESULTS

The quartz-plagioclase porphyry plots as a trondhjemite transitional to tonalite in the normative classification scheme of Barker (1979; Figure 4A) and exhibits Nb, Y and other high-field strength abundances characteristic of volcanic arc granitoids (Figure 4B: Pearce *et al*., 1984). The porphyry as well as the basalts, diabase and diorite of the Coy Pond Complex all belong to the low-K_2O arc tholeiite suite (Figure 5A), and they have Zr/Y versus Zr relationships typical of volcanic arc basalts (Figure 5B; Pearce and Norry, 1979). These observations all suggest that the Coy Pond Complex was formed in an intra-oceanic, depleted, tholeiitic island-arc setting. This conclusion is further substantiated by normal mid-ocean ridge basalt (NMORB; Sun and McDonough, 1989) normalized plots (Figure 6). The diorite–gabbro exhibits trace-element abundances lower than MORB for all elements except P and Th (Figure 6A). They have flat to weakly LREE-depleted rare-earth element patterns with strongly elevated Th and prominent Nb troughs. Three of 4 samples have Zr–Hf troughs whereas the fourth, containing significantly elevated MgO, Cr and Ni, is mafic to ultramafic and lacks a Zr–Hf trough. Basalt and diabase exhibit multi-element patterns similar to those for the diorite–gabbro where all element abundances are less than NMORB with the exception of Th (Figure 6B). They have flat to weakly depleted patterns with large negative Nb anomalies, variably positive and negative P anomalies and Zr–Hf troughs. The trondhjemite has multi-element patterns essentially identical to those for the basalt–diabase with flat, weakly LREE-depleted REE patterns, and prominent Nb, P, Zr–Hf troughs (Figure 6C). The Eu exhibits both minor positive and negative anomalies. The porphyry hosting mineralization at the Reid gold deposit appears to represent a siliceous, island-arc tholeiitic trondhjemite derived *via* fractional crystallization of strongly depleted mafic rocks of the Coy Pond Complex, perhaps comparable to gabbro sample BO-09-17_168.2 m (Figure 6A). Although the database is limited, gold appears to correlate best with Sb and W. Cadmium and As are typically elevated, but are not directly correlated with Au.

U–Pb RESULTS

A small number of poor-quality zircon grains were retrieved from the trondhjemite sample (BO-09-017-123.1-123.3 m, z10414), all of which have a high U content (Table 1). These zircon crystals display textures most likely resulting from alteration and radiation damage to the crystals (Figure 7). Although all of the zircon grains retrieved from the sample display these textures, most of these grains contain unaltered, undamaged portions that could be analyzed using *in-situ* analysis on the SHRIMP.

The U–Pb SHRIMP analyses result in a cluster of concordant, overlapping data (Figure 8, Table 2). A weighted average of the $^{206}Pb/^{238}U$ ages of these analyses is calculated to be 510 ± 4 Ma (MSWD=0.80, probability of fit = 0.55, n=6). Three analyses in the concordia diagram are younger than *ca.* 510 Ma and are slightly discordant. These analyzed zircons are interpreted to have undergone minor Pb loss and the data are not included in the age calculation. Six additional analyses on zircon grains from this sample had U contents greater than 2000 ppm. As these analyses are outside of the calibration range of the BR266 standard on the SHRIMP mount, they are also not included in the data table or the age calculation. The resultant Cambrian age of 510 ± 4 Ma is considered the crystallization age of the trondhjemite.

IMPLICATIONS OF THE NEW DATA

One of the major roadblocks to a better understanding of the geology of central Newfoundland is the lack of exposed bedrock. Detailed aeromagnetic and induced polarization studies, in conjunction with regional prospecting, trenching and drillhole data reveal critical, new information on the rock types, their gross orientations and their interrelationships in the area around the Reid gold deposit of the Brady option exploration property. This is particularly important as this prospect occurs near the contact zone between the metasedimentary rocks of the Spruce Brook Formation of the Mount Cormack Subzone and the ophi-

Table 1: Representative lithogeochemical data for the quartz-plagioclase porphyry, diabase and basalt and diorite-gabbro of the Coy Pond Complex

sample	**BO09-17_43.56**	**BO09-17_60.95**	**BO09-17_78.2**	**BO09-17_98.62**	**BO09-17_131.75**	**BO-09-17_7.13**	**BO-09-17_27.32**
Lab Number	**8940301**	**8940302**	**8940305**	**8940307**	**8940311**	**8940295**	**8940298**
rock-type	**Trondhjemite**	**Trondhjemite**	**Trondhjemite**	**Trondhjemite**	**Trondhjemite**	**Basalt**	**Alt Basalt**
UTM east	**602382**	**602382**	**602382**	**602382**	**602382**	**602382**	**602382**
UTM north	**5369098**	**5369098**	**5369098**	**5369098**	**5369098**	**5369098**	**5369098**
Prospect	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**
SiO_2	77.12	69.29	74.00	72.92	73.23	53.52	44.80
TiO_2	0.22	0.24	0.25	0.23	0.27	0.84	0.73
Al_2O_3	11.72	11.51	11.63	11.66	11.00	14.66	12.03
FeOT	4.04	4.27	2.56	2.37	3.06	12.38	8.34
Fe_2O_3	0.51	n.a.	0.27	0.37	0.55	2.51	n.a.
FeO	3.59	n.a.	2.32	2.04	2.57	10.13	n.a.
MnO	0.06	0.07	0.05	0.05	0.04	0.17	0.20
MgO	0.73	0.59	0.60	0.61	0.46	4.85	3.93
CaO	0.24	2.62	2.39	2.92	2.76	1.93	8.30
Na_2O	2.93	3.78	2.98	4.54	3.18	3.71	3.16
K_2O	1.18	0.59	1.25	0.54	0.87	0.28	0.69
P_2O_5	0.04	0.05	0.05	0.05	0.06	0.05	0.04
LOI	1.92	3.29	3.22	3.38	3.61	5.26	10.65
Mg#	24.27	19.78	29.44	31.59	21.13	41.13	45.65
F	62	54	76	45	197	141	109
Cr	< 1	< 1	< 1	< 1	< 1	8	2
Ni	< 1	< 1	< 1	< 1	< 1	8	2
Co	2	2	2	< 1	1	37	35
Sc	17.5	20.6	17.0	18.6	19.6	40.4	29.6
V	4	< 1	1	< 1	5	337	84
Cu	1	< 1	26	< 1	1	16	21
Pb	< 1	< 1	< 5	< 1	< 1	< 5	< 5
Zn	68	55	23	26	21	41	38
Ag	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Au (ppb)	47	<5	<5	13	13	<5	1694
As	59	7	8	10	15	15741	15170
Be	0.5	0.3	0.4	0.3	0.3	< 0.1	< 0.1
Bi	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cd	0.4	0.2	0.2	0.2	0.2	46.6	48.3
Cs	5.2	2.1	4.7	1.4	6.2	3.50	3.70
Ga	16	15	12	13	12	18	13
Ge	1.2	1.3	1	1	1.1	0.90	0.60
Li	17	22	13	14	12	36	16
Mo	< 1	< 1	< 2	< 1	< 1	< 2	< 2
Sb	0.6	0.2	0.4	0.3	0.4	0.30	11.20
Sn	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Tl	0.16	0.05	0.14	< 0.05	0.11	< 0.05	0.12
W	1.1	0.6	< 0.5	1.4	1.9	1.40	7.00
Ba	53	39	56	36	33	44	33
Rb	33	12	32	11	24	19	18
Sr	45	125	97	145	83	152	157
Hf	1.6	0.7	1.3	1.3	1	0.90	0.70
Ta	0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01
Nb	0.6	0.4	0.6	0.6	0.5	0.30	0.20
Y	22.4	17.7	27.6	28.7	25.6	17.10	15.70
Zr	54	25	40	40	30	27	21
Th	0.69	0.30	0.55	0.55	0.44	0.43	0.25
U	0.37	0.22	0.33	0.19	0.20	0.24	0.17
La	3.39	2.40	3.58	3.43	3.73	2.24	1.86
Ce	7.82	5.65	9.16	8.48	9.34	5.92	4.85
Pr	1.02	0.82	1.34	1.24	1.37	0.84	0.69
Nd	4.96	4.36	6.99	6.44	6.92	4.34	3.69
Sm	1.86	1.68	2.44	2.34	2.36	1.62	1.50
Eu	0.37	0.93	1	0.70	1.06	0.40	0.61
Gd	2.82	2.52	4.14	4.04	4.04	2.35	2.19
Tb	0.56	0.49	0.73	0.74	0.67	0.44	0.43
Dy	3.78	3.12	4.9	4.94	4.49	2.85	2.79
Ho	0.85	0.68	1.07	1.08	0.97	0.63	0.60
Er	2.66	2.06	3.33	3.37	2.95	1.94	1.74
Tm	0.44	0.32	0.517	0.52	0.45	0.31	0.27
Yb	3.06	2.25	3.36	3.37	2.97	2.11	1.80
Lu	0.54	0.37	0.556	0.55	0.50	0.34	0.28

n.a. = not analyzed
All trace elements in ppm except Au in ppb.
Major elements are in wt. %.
Mg# = molecular (MgO/MgO+FeOT)*100
< = concentration at or lower than detection limit

Table 1: *(Continued)* Representative lithogeochemical data for the quartz-plagioclase porphyry, diabase and basalt and diorite-gabbro of the Coy Pond Complex

sample	**BO-09-17_37.49**	**BO-09-17_125.90**	**BO-09-17_69.39**	**BO-09-17_74.10**	**BO-09-17_86.8**	**BO-09-22_168.2**
Lab Number	**8940299**	**8940309**	**8940303**	**8940304**	**8940306**	**8940313**
rock-type	**Basalt**	**Mafic Dyke**	**Diorite**	**Diorite**	**Diorite**	**Gabbro**
UTM east	**602382**	**602382**	**602382**	**602382**	**602382**	**602354**
UTM north	**5369098**	**5369098**	**5369098**	**5369098**	**5369098**	**5369037**
Prospect	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**	**Reid Zone**
SiO_2	42.82	49.16	60.82	61.23	60.64	40.78
TiO_2	1.09	0.61	0.98	0.93	0.90	0.08
Al_2O_3	14.06	14.31	12.13	11.71	11.89	11.67
FeOT	12.14	12.81	10.49	10.35	11.09	9.12
Fe_2O_3	n.a.	2.26	1.76	1.71	1.57	0.74
FeO	n.a.	10.77	8.91	8.82	9.67	8.46
MnO	0.17	0.17	0.14	0.20	0.19	0.18
MgO	4.06	3.18	2.10	1.88	2.97	12.36
CaO	5.62	5.68	1.50	2.62	1.83	8.91
Na_2O	2.11	3.89	3.30	3.29	2.94	0.76
K_2O	1.33	0.14	0.21	0.15	0.20	0.13
P_2O_5	0.03	0.06	0.30	0.25	0.27	0.00
LOI	11.19	7.19	3.44	4.22	4.10	13.14
Mg#	37.35	30.67	26.33	24.44	32.33	70.72
F	118	53	100	104	126	37
Cr	11	16	< 1	< 1	< 1	263
Ni	2	5	< 1	< 1	< 1	97
Co	29	34	14	15	14	62
Sc	42.2	51.4	48.3	53.8	49.0	48.2
V	345	437	20	29	25	150
Cu	3	84	< 1	7	< 1	35
Pb	5	< 5	< 5	< 5	< 5	< 5
Zn	34	115	97	92	105	51
Ag	< 0.1	< 0.1	< 0.1	< 0.1	0.20	< 0.1
Au (ppb)	1786	na	94	9	na	na
As	27488	40	19	36	10	29
Be	0.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bi	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cd	131.7	0.7	0.5	0.6	0.4	0.5
Cs	8.80	1.80	0.90	1.00	1.20	3.60
Ga	18	17	14	13	14	6
Ge	0.80	0.70	1.20	1.00	1.40	1.40
Li	40	60	55	52	55	64
Mo	< 2	< 2	< 2	< 2	< 2	< 2
Sb	20.40	1.00	0.90	0.60	1.00	1.20
Sn	< 1	< 1	< 1	< 1	< 1	< 1
Tl	0.27	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
W	32.90	2.20	3.10	1.90	1.00	< 0.5
Ba	61	18	14	13	20	9
Rb	62	4	9	4	4	6
Sr	121	97	59	63	76	81
Hf	1.10	0.40	0.40	0.40	0.50	< 0.1
Ta	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nb	0.40	0.02	0.02	0.02	0.30	0.02
Y	17.60	15.00	14.70	13.50	15.00	1.40
Zr	37	9	13	12	14	2
Th	0.48	0.16	0.25	0.24	0.32	0.04
U	0.30	0.17	0.27	0.33	0.24	< 0.01
La	2.44	1.33	1.31	1.58	1.58	0.07
Ce	6.65	3.08	3.50	4.19	3.80	0.20
Pr	0.96	0.45	0.54	0.62	0.54	0.04
Nd	5.04	2.45	2.91	3.44	2.90	0.20
Sm	1.79	0.97	1.25	1.37	1.11	0.10
Eu	0.80	0.52	0.52	0.54	0.57	0.04
Gd	2.54	1.91	1.96	2.10	2.16	0.18
Tb	0.48	0.33	0.40	0.40	0.37	0.04
Dy	3.18	2.35	2.54	2.45	2.51	0.25
Ho	0.70	0.54	0.55	0.51	0.54	0.05
Er	2.22	1.69	1.70	1.51	1.70	0.17
Tm	0.36	0.26	0.27	0.23	0.26	0.03
Yb	2.45	1.71	1.79	1.60	1.65	0.20
Lu	0.40	0.27	0.28	0.27	0.26	0.03

n.a. = not analyzed
All trace elements in ppm except Au in ppb.
Major elements are in wt. %.
Mg# = molecular (MgO/MgO+FeOT)*100
< = concentration at or lower than detection limit

Table 2: U–Pb SHRIMP zircon data for trondhjemite from the Reid gold deposit

BD-09-017-123.1m (GSC lab# z10414, GSC grain mount# IP587; UTM NAD27, Zone 21, 602382E - 5369098N)

Spot name	U (ppm)	Th (ppm)	Th/U	^{206}Pb* (ppm)	^{204}Pb/^{206}Pb	± ^{204}Pb/^{206}Pb	f(206)^{204}	^{208*}Pb/^{206*}Pb	± ^{208*}Pb/^{206*}Pb	^{207*}Pb/^{235}U	± ^{207*}Pb/^{235}U	^{206*}Pb/^{238}U	± ^{206*}Pb/^{238}U	Corr Coeff	^{207*}Pb/^{206*}Pb	± ^{207*}Pb/^{206*}Pb	Apparent Ages (Ma) ^{206}Pb/^{238}U	Apparent Ages (Ma) ±^{206}Pb/^{238}U	Apparent Ages (Ma) ^{207}Pb/^{206}Pb	Apparent Ages (Ma) ±^{207}Pb/^{206}Pb	Disc. (%)
10414-17.1	1080	651	0.60	77	-4.17E-6	-2.80E-5	-0.0001	0.1981	0.0041	0.661	0.009	0.0831	0.0008	0.7139	0.0577	0.0006	514	5.0	519	21.8	0.9
10414-2.1	1345	871	0.65	96	3.35E-5	1.32E-5	0.0006	0.2105	0.0039	0.644	0.008	0.0828	0.0009	0.8082	0.0565	0.0004	513	5.2	471	17.0	-9.3
10414-5.1	1594	1452	0.91	114	—-	—-	0.0000	0.2989	0.0042	0.660	0.008	0.0830	0.0008	0.8286	0.0577	0.0004	514	5.0	517	15.1	0.6
10414-17.2	1811	1699	0.94	122	2.44E-5	1.37E-5	0.0004	0.3073	0.0044	0.612	0.008	0.0782	0.0008	0.8155	0.0568	0.0004	485	4.8	483	16.0	-0.5
10414-6.1	784	453	0.58	55	5.32E-5	7.61E-5	0.0009	0.1925	0.0050	0.632	0.015	0.0811	0.0009	0.4500	0.0565	0.0012	503	5.3	471	48.0	-7.1
10414-10.1	757	421	0.56	53	2.73E-5	8.14E-6	0.0005	0.1868	0.0075	0.639	0.009	0.0817	0.0008	0.7393	0.0567	0.0005	506	5.1	481	20.9	-5.4
10414-10.2	606	304	0.50	41	3.86E-5	1.45E-5	0.0007	0.1700	0.0065	0.615	0.009	0.0778	0.0008	0.6893	0.0573	0.0006	483	4.8	502	24.0	3.9
10414-5.2	1774	1677	0.95	114	2.33E-5	1.11E-5	0.0004	0.3097	0.0044	0.590	0.007	0.0751	0.0008	0.8341	0.0570	0.0004	467	4.7	490	15.1	4.8
10414-10.3	800	447	0.56	56	-4.81E-5	-3.89E-5	-0.0008	0.1884	0.0052	0.659	0.011	0.0822	0.0008	0.6093	0.0581	0.0008	509	5.1	534	29.4	4.8

Notes (see Stern, 1997):
Spot name follows the convention x-y.z; where x = sample number, y = grain number and z = spot number. Multiple analyses in an individual spot are labelled as x-y.z.z
Uncertainties reported at 1sigma and are calculated by using SQUID 2.23.08.10.21, rev. 21 Oct 2008
f206^{204} refers to mole percent of total ^{206}Pb that is due to common Pb, calculated using the ^{204}Pb-method; common Pb composition used is the surface blank (4/6: 0.05770; 7/6: 0.89500; 8/6: 2.13840)
* refers to radiogenic Pb (corrected for common Pb)
Discordance relative to origin = 100 * ((207/206 age -206/238 age)/(^{207}Pb/^{206}Pb age))
Calibration standard 6266; U = 910 ppm; Age = 559 Ma; ^{206}Pb/^{238}U = 0.09059
Error in ^{206}Pb/^{238}U calibration 1.0% (included) (GSC mounts IP587)
Standard Error in Standard calibration was 0.34% (not included in above errors but required when comparing data from different mounts).

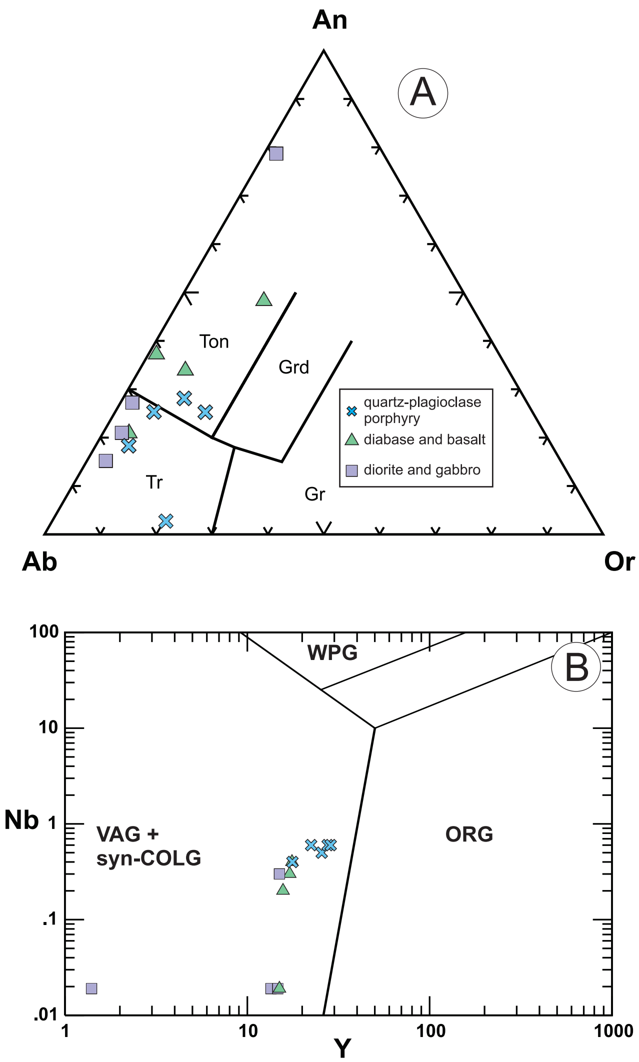

Figure 4: *Chemical classification of the porphyry exposed at the Reid gold deposit. A) CIPW normative classification diagram of Barker (1979) and; B) Nb* vs *Y tectonic discrimination plot after Pearce* et al. *(1984). Samples of the diabase, basalt and gabbro-diorite are shown for comparison only.*

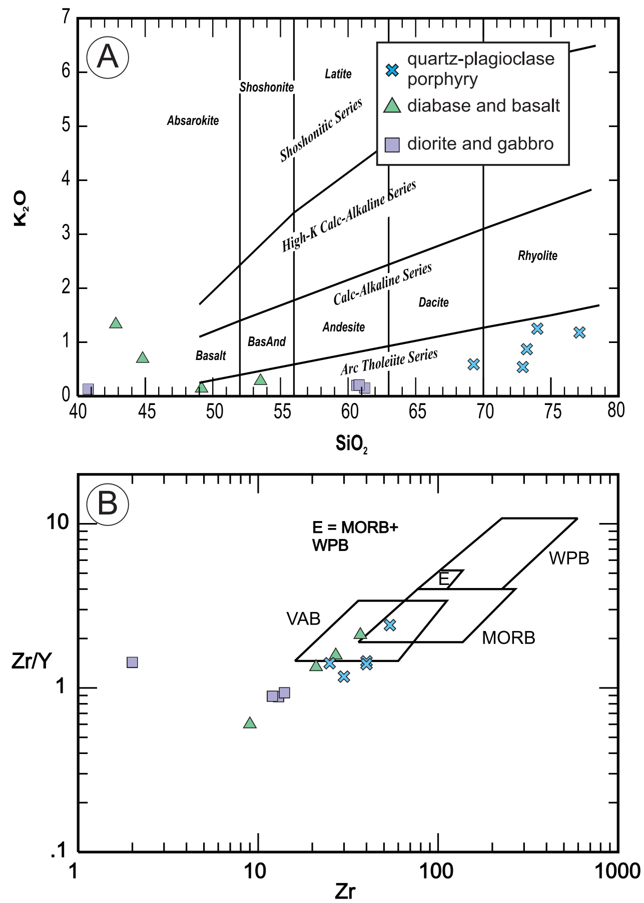

Figure 5: *Classification of the basaltic and gabbroic rocks of the Reid deposit. A) K_2O* vs *SiO_2 plot after Peccerillo and Taylor (1976) and; B) Zr/Y* vs *Zr plot after Pearce and Norry (1979). Samples of the Reid porphyry are shown for comparison only.*

olitic rocks of the Coy Pond Complex of the eastern Exploits Subzone (Colman-Sadd, 1985; Colman-Sadd *et al*., 1992).

The Reid deposit mineralization is hosted by ophiolitic rocks including massive basalt, diabase, gabbro and trondhjemite. Drillholes intersect massive mafic volcanic rocks and diabase dykes in their upper sections (~40 m), trondhjemite, diorite–gabbro and basaltic dykes in the middle sections (~110 m) and coarse-grained gabbroic and ultramafic rocks are typical in deeper parts of the holes. This suggests that the ophiolite complex exposed at the Reid gold deposit is right way up, inclined to the southeast and faces to the east and south away from the Mount Cormack Complex, as described by Colmann-Sadd (1985) for the main part of the Coy Pond Complex to the west and southwest of the Reid deposit. Mineralization consists of widespread disseminated pyrite and arsenopyrite (up to 15%) that is accompanied by minor quartz veining and chlorite + Fe carbonate + epidote alteration in mafic host rocks and quartz veining with sericite + Fe carbonate + chlorite ± epidote alteration in trondhjemite. Trondhjemite with remnant quartz and plagioclase crystals and extensive replacement of its matrix by arsenopyrite + pyrite + sericite + Fe carbonate ± chlorite, typically carries the highest gold assays. Gold occurs as free (≤10 µm) grains enclosed in pyrite (Seymour, 2003; *this study*).

The new U–Pb SHRIMP geochronological data for the mineralized trondhjemite exposed at the Reid gold deposit establishes that the ophiolitic Coy Pond Complex is Middle Cambrian, yielding a U–Pb SHRIMP zircon crystallization age of 510 ± 4 Ma. The Coy Pond Complex was originally correlated with the Pipestone Pond Complex (494 $^{+3}/_{-2}$ Ma;

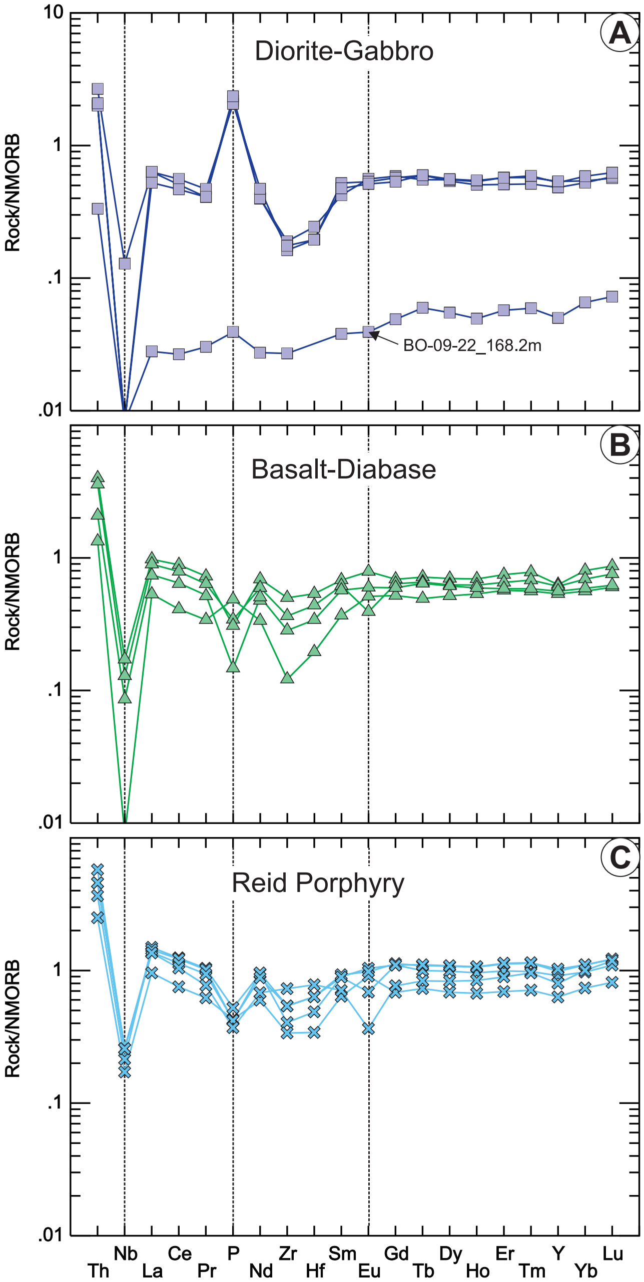

Figure 6: *Normal mid-ocean ridge basalt (NMORB: Sun and McDonough, 1989) normalized multi-element plots for rocks of the Reid gold deposit. A) diorite-gabbro; B) diabase-basalt and; C) Reid porphyry. See Figure 5 for key.*

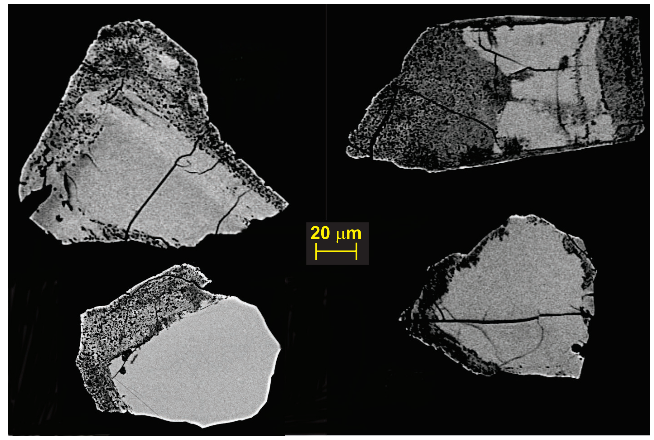

Figure 7: *BSE-SEM images of representative zircons from the Reid deposit trondhjemite.*

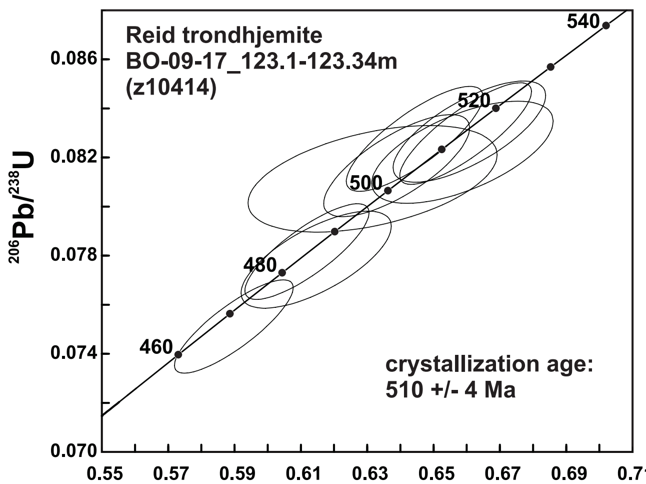

Figure 8: *Pb–U concordia diagram of SHRIMP zircon analyses from the Reid deposit trondhjemite.*

viz., Dunning and Krogh, 1985) but the new data establishes it as significantly older, in fact the oldest known ophiolite in the Appalachian–Caledonide orogen. Figure 9 depicts available precise U–Pb dates for ophiolites of the Appalachian–Caledonide orogen. Most of the ophiolites of the Appalachians cluster between 490 and 480 Ma (Bluck *et al*., 1980; Dunning and Krogh, 1985; Dunning *et al*., 1987; Dunning and Pederson, 1988; Spray and Dunning, 1991; Whitehead *et al*., 2000), with the Pipestone Pond Complex of eastern Exploits Subzone being somewhat older and comparable in age to the Shetland Islands ophiolite of Britain (Spray and Dunning, 1991) and the Karmoy and Leka ophiolites of Norway (Dunning and Pederson, 1988). The Coy Pond Complex of the eastern Exploits Subzone is clearly significantly older and does not overlap in age, within 2σ error, with any of the other ophiolites.

The porphyry occurring at the Reid deposit is trondhjemitic to tonalitic in composition, exhibits trace-element abundances characteristic of volcanic arc granites and is a sodic, highly fractionated, island-arc tholeiitic granitoid intrusion. The trondhjemite cuts and is crosscut by cogenetic, strongly depleted, island-arc tholeiite gabbro, diorite, basalt and basaltic dykes that form the major constituents of the ophiolitic Coy Pond Complex.

The maximum age of the mineralization at the Reid gold deposit is now constrained at < 510 Ma, but its mini-

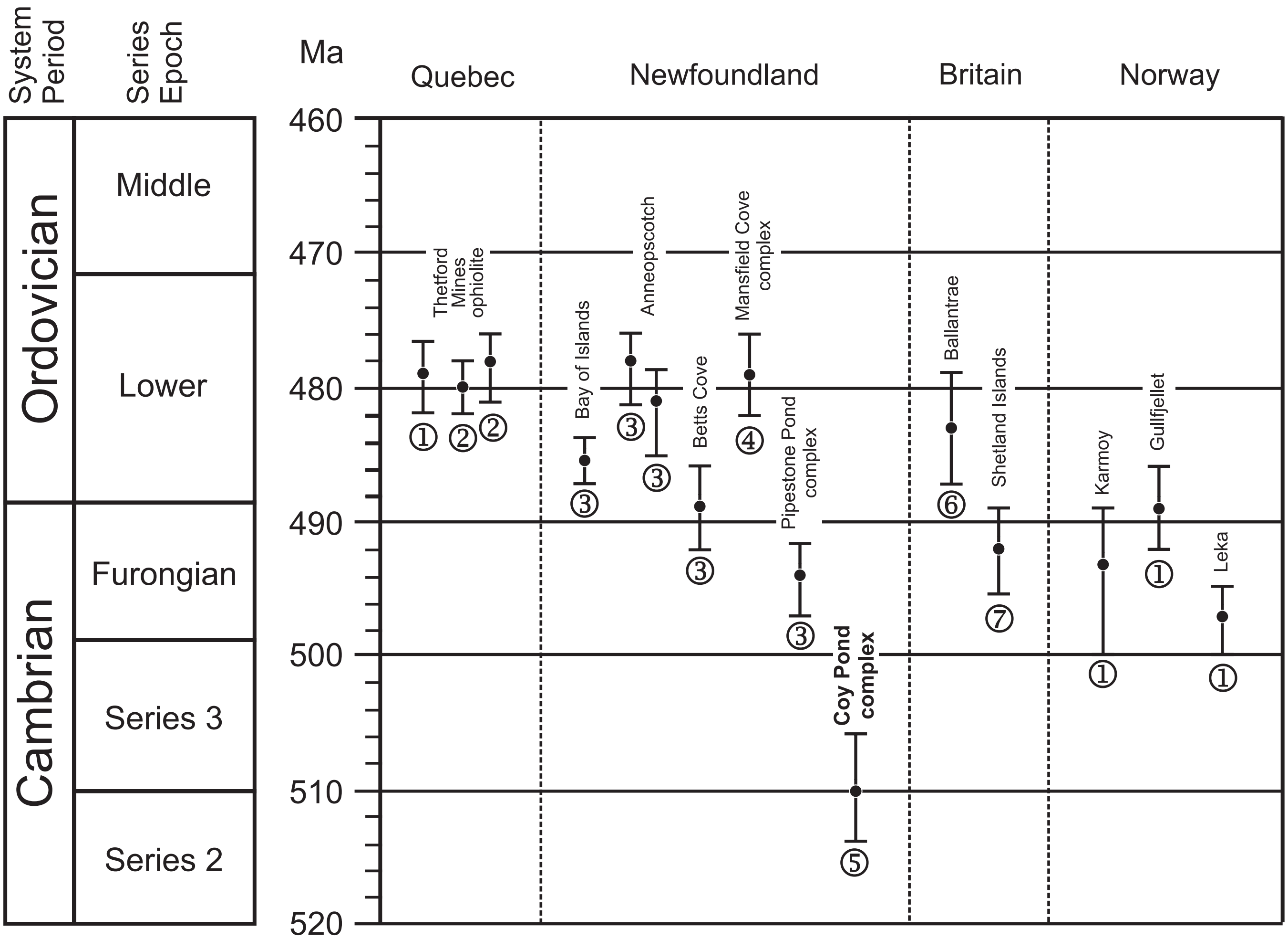

Figure 9: *Summary of geochronological data for ophiolites of the Appalachian–Caledonide orogen. Data sources: 1) Dunning and Pedersen (1988); 2) Whitehead* et al. *(2000); 3) Dunning and Krogh (1985); 4) Dunning* et al. *(1987); 5)* This study*; 6) Bluck* et al. *(1980); 7) Spray and Dunning (1991). Timescale from International Commission on Stratigraphy (2009).*

mum age is unconstrained. The ^{40}Ar–^{39}Ar thermochronology on randomly oriented, fine-grained sericite deposited with pyrite, arsenopyrite and gold in the Reid deposit will constrain the minimum age of that mineralization. The Sm–Nd analyses of the ophiolitic rocks will aid in their petrological interpretation and may further refine the antiquity of their magmatic sources and provide new data to better constrain tectonic interpretations of the eastern Exploits Subzone.

ACKNOWLEDGMENTS

Matt Minnett and Jonathon Hull provided capable assistance in the field while Gerry Hickey helped immensely with logistics and safety. The manuscript was improved by the helpful reviews of Bruce Ryan and Andy Kerr. Golden Dory Resources Corporation and Paragon Minerals Corporation are kindly thanked for permission to study the rocks on their mineral exploration properties and for sharing unpublished data.

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