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REGIONAL SETTING OF GOLD MINERALIZATION AT THE VIKING PROPERTY, SOUTHERN WHITE BAY, NEWFOUNDLAND

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ABSTRACT

The Viking property of southern White Bay contains a significant new gold prospect that comprises quartz-sulphide-bearing auriferous veins and associated sericite-carbonate alteration, hosted in the Main River pluton, a granitoid complex that intrudes the Long Range Inlier of western Newfoundland. The veins range from 1 cm to 2 m in width, are steeply dipping, locally folded, and are arranged in complex networks. Primary host rocks to the quartz–sulphide veining are extensively iron-carbonate, sericite and chlorite altered. Sulphides associated with gold in the quartz veins include pyrite, galena and chalcopyrite, and lesser amounts of sphalerite, whereas pyrite and magnetite are typically found disseminated throughout the altered and unaltered host rocks. The high-grade Thor vein is the main target for gold mineralization on the property and includes narrow intercepts grading 218.79 g/t Au over 0.5 m but also with wide intercepts of 2.0 g/t Au over 41.4 m. To date, 45 drillholes have been completed in an effort to better define the economic potential of the property.

The Viking prospect appears to be an intrusion-hosted orogenic gold deposit, however, the timing and detailed nature of the mineralization remains unconstrained. Future investigations will target the mineralogy of the deposit, the lithogeochemistry of altered and unaltered host rocks and the age of alteration to better constrain the origin of the gold mineralization.

INTRODUCTION

The study area is located 50 km north of Deer Lake, and 12 km west of White Bay along the eastern margin of the Great Northern Peninsula in western Newfoundland. The Viking property is 9 km^2 in size and lies within NTS map sheets 12H/10 and 11. Previously, access to the property was by a rugged forest road that passes within 1.5 km of the western claim boundary. Travel times from the base camp were in excess of 6 hours per day to and from the property, so, in 2009, a new road was constructed from Route 420, 1 km westward to the main area of mineralization. This provides significantly quicker access to the property (Figure 1). Rugged topography with a total relief of over 500 m, coupled with extensive, thick forest cover characterizes the property. Mature forests of large birch and evergreen trees cover the hillsides and, with increasing elevation, these forests are transformed into barren uplands with low shrubs and tuckamore. Valleys between hills contain many lakes, ponds, and bogs. Viking Pond and North Viking Pond are kilometre-scale ponds that run northeast along a prominent geographic lineation within the property, just west of the main Viking showing (Figure 1).

High-grade mineralization at the Viking property is hosted within quartz–sulphide veins, containing varying amounts of iron-carbonate. These veins, which range in size from millimetre to metre scale, are arranged in complex networks, are locally folded, steeply dipping, and are associated with brittle–ductile shear zones. The main high-grade gold vein (the Thor vein) is located 500 m west of the eastern claim boundary, situated at the 440 m contour within a weakly forested upland.

The rock types observed vary from fine-grained sedimentary rocks to medium- and coarse-grained felsic and mafic intrusive rocks. The purpose of this study is to provide preliminary documentation of the regional geology of the area and describe the setting and characteristics of the Thor vein. A M.Sc. research project, to be completed at Memorial University of Newfoundland by the senior author, will include a more detailed geochemical and petrologic study of the rocks and mineralization of the Viking property. A brief note on the future aims of this research is also presented.

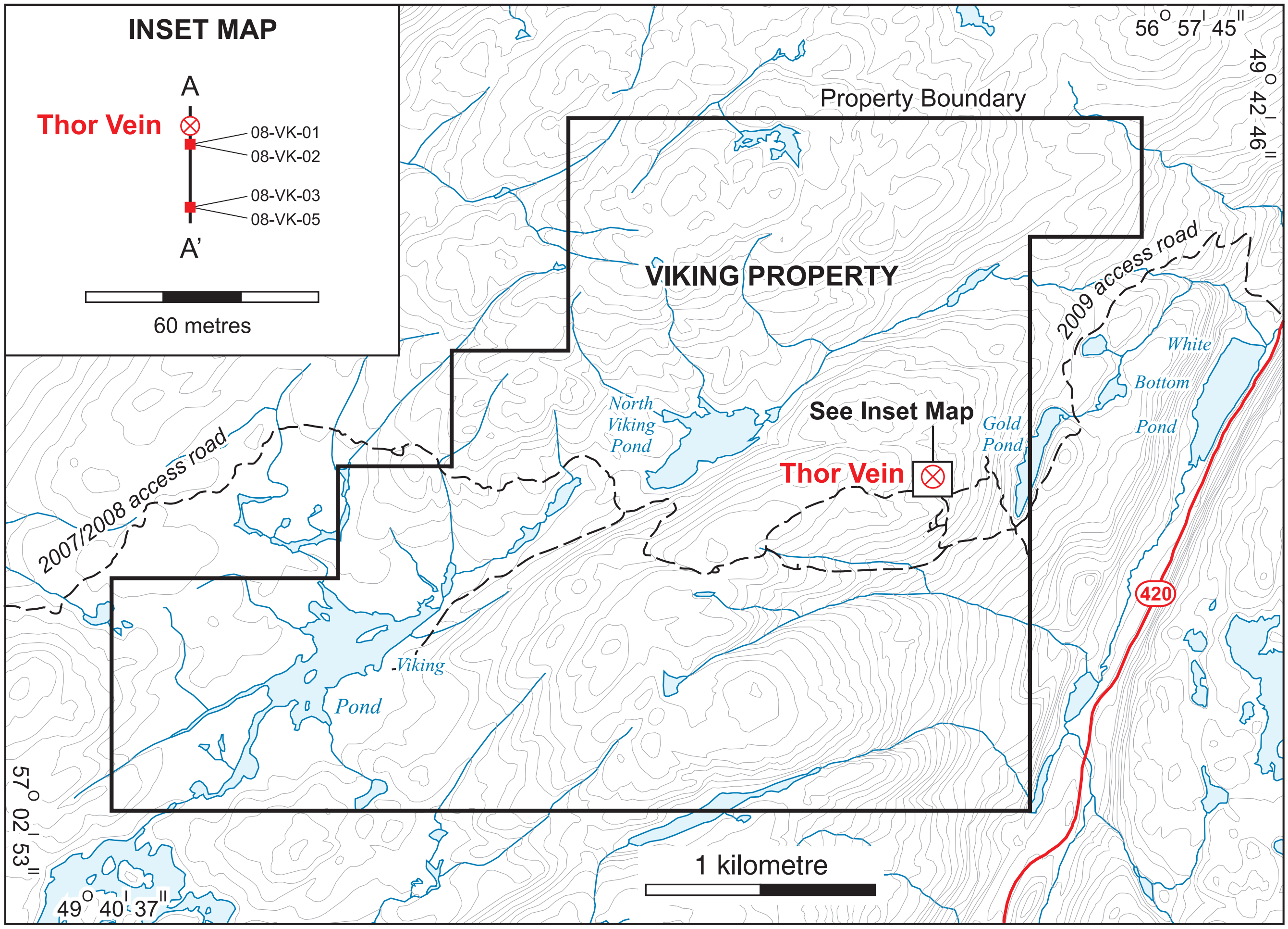

Figure 1. *Map of the Viking property. The location of the Thor vein is highlighted by a red-circled cross. Inset map shows north–south, A–A' cross-section through the Thor vein. Drillholes (marked by red square in inset map) are oriented toward north (*see *Figure 4).*

REGIONAL GEOLOGY

The Viking property is located within the Humber Zone of the Appalachian Orogen (Figure 2). This zone represents the ancient margin of Laurentia that has been extensively reworked during Appalachian orogenesis (Williams, 1979). The Long Range Inlier is the largest exposure of basement rocks in western Newfoundland (Heaman *et al.*, 2002) and contains the largest and most diverse assemblage of mid-Proterozoic rocks known on the Island (Owen and Erdmer, 1988). Rocks of the inlier comprise a series of *ca.* 1500 Ma granitoid gneisses that have been intruded at two distinct intervals, *ca.* 1025 and *ca.* 1000 Ma, by a series of granitoid plutons. These rocks preserve three distinct metamorphic events, the latter two of which correspond to the two intervals of magmatism (Heaman *et al.*, 2002). All rocks of the inlier are crosscut by the late Precambrian (~615 Ma) Long Range dykes (Heaman *et al.*, 2002; Kerr, 2006b). The eastern margin of the inlier was intruded by the Silurian Devils Room granite (425 ± 10 Ma) and also by the Silurian Taylors Brook gabbro (430.5 ± 2.5 Ma: Heaman *et al.*, 2002).

The host to the mineralization at Viking is the Main River pluton (Figure 3), a potassium-feldspar megacrystic to augen granodiorite that has been correlated with the *ca.* 1036 Ma Apsy Granite lying to the north (Heaman *et al.*, 2002). The Main River pluton is cut by variably textured, monzogranite sheets–sills and is transected by many well-developed topographic lineations, a number of which preserve mylonitic granitoids. Many of these linear features are known or inferred to represent fault zones. The fault zones appear to be spatially associated with much of the gold and related base-metal mineralization, and have been inferred to have formed in response to protracted, strike-slip movement along the Doucer's Valley Fault System (DVFS; Dearing, 1989). The DVFS is a prominent north-trending structural lineament that juxtaposes the eastern margin of the Long Range Inlier, with eastward-lying Palaeozoic oceanic and

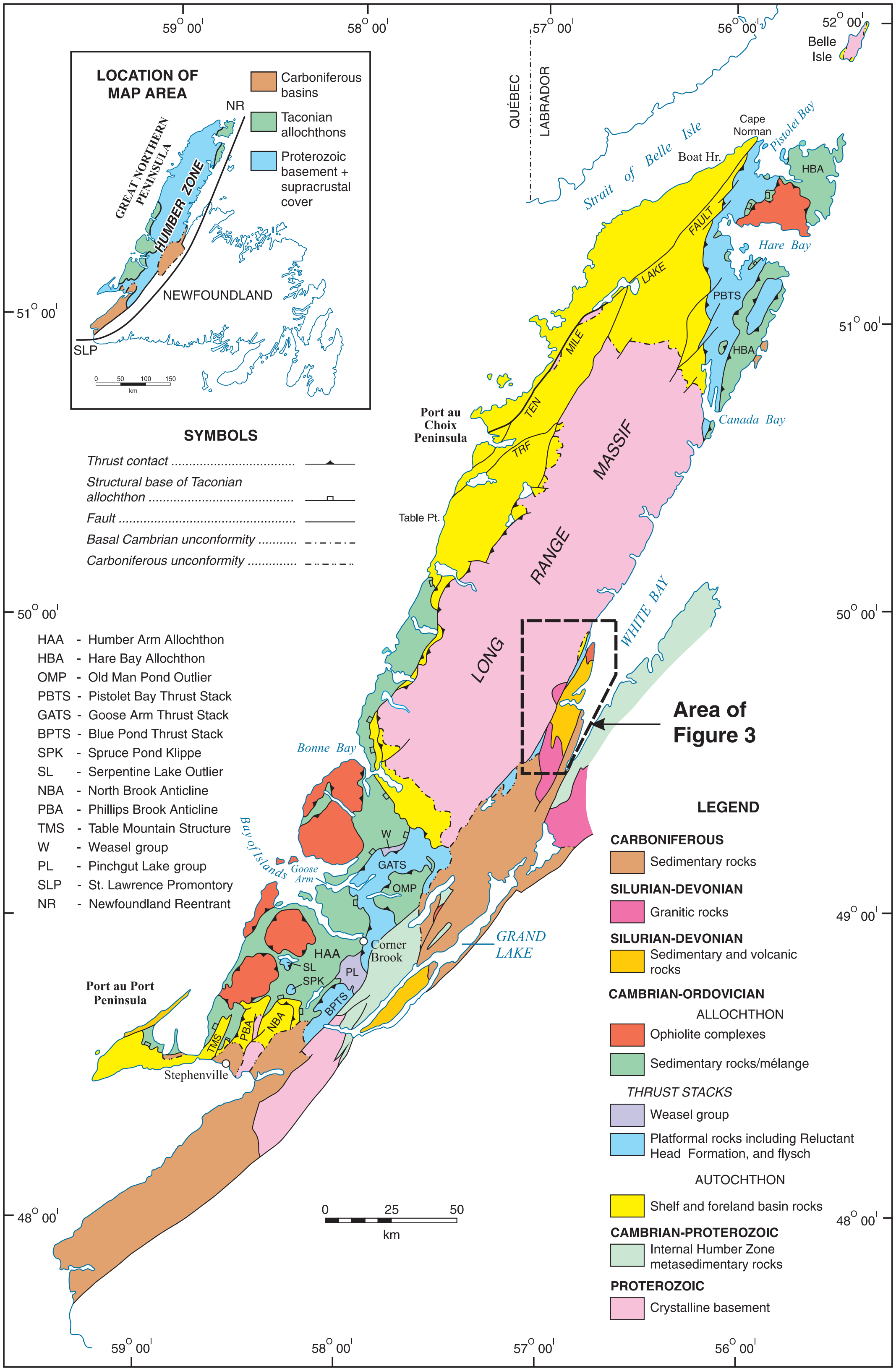

Figure 2. *General geology and tectonic elements of the Great Northern Peninsula, northwestern Newfoundland. Location of the study area is highlighted and regional geology is presented in Figure 3 (Knight, 2007).*

continental, volcanic and sedimentary terranes (Kerr and Knight, 2004; Figure 2). Numerous accessory splays and faults occur along the DVFS, some of which were inferred to have been favourable environments for the passage of Au-enriched fluids and Au deposition (Sparks and MacDougall, 1991). This fault zone has a complex history of reactivation throughout the Paleozoic and, therefore, marks a major tectonostratigraphic break in the Appalachian Orogen (Tuach, 1987).

Lying immediately east of the Long Range Inlier, is a thin, linear belt of deformed autochthonous, Cambro-Ordovician, clastic and carbonate rocks belonging to the Labrador Group, which dip steeply to the east and show tight, isoclinal folding of both S and Z asymmetry. This shelf sequence is composed of three major lithological groups, the Labrador, Port au Port, and the St. George groups (Kerr and Knight, 2004). For the purpose of this study, only the Labrador Group will be discussed in more detail. The Bradore and Forteau formations comprise the Lower Cambrian rocks of the Labrador Group and are dominated by sandstone, quartzite, and phyllite, with thin lenses of dark limestone, dolostones and siltstone. Conformably overlying the Bradore and Forteau formations is the Hawke Bay Formation, consisting of well-preserved, mixed siliciclastic and carbonate rocks. This sequence reflects the response of sedimentation to repeated long-term cycles of marine transgression and regression across the shallow shelf (Kerr and Knight, 2004). Sedimentary rocks of similar age are located along the west coast of Newfoundland, but are relatively undeformed.

To the east of the DVFS is a disrupted Taconic allochthon, termed the Southern White Bay allochthon (Kerr and Knight, 2004). This Cambrian to Ordovician allochthon includes the Taylors Pond formation, Maiden Point Formation, Murray's Cove schist, and the Coney Head complex. The Taylors Pond formation is a narrow belt of dark, graphitic and pyritic slate and phyllite. The formation is characterized by laminated limy argillites and abundant quartz veins and pods. Fine- to medium-grained, green, schistose greywacke and slate make up the Maiden Point Formation and are overlain by the Murray's Cove schist. These greywackes are characterized by blue quartz grains and interbedded minor quartz pebble conglomerates typical of the type of formation at Hare Bay (Smyth and Schillereff, 1982). The next highest slice of the allochthon, the Murray's Cove schist, consists of polydeformed and metamorphosed mafic tuffs and breccias, and rare, thin, calcareous tuffs, red chert and metagabbro pods. These rocks are locally intruded by rare, pre-tectonic, grey feldspar porphyritic felsic dykes (Smyth and Schillereff, 1982). Last, the Coney Head complex refers to a dominantly trondhjemite and tonalite intrusive sequence that also includes gabbro, biotite microgranite and minor muscovite leucogranite. A zone of intrusion breccia into the above rock types is cut by mafic to silicic dyke swarms (Smyth and Schillereff, 1982). This package is interpreted to have structurally overlain the autochthonous clastic carbonate rocks described above (Kerr *et al.*, 2004) and represents the vestiges of Iapetus Ocean that were obducted westward across the ancient continental margin of North America during the Ordovician Taconic Orogeny (Williams and Stevens, 1974).

The eastern part of the area is dominated by the Silurian Sops Arm Group (Figure 3). The rocks of the Sops Arm Group are mostly east dipping and east younging, suggesting that the oldest formations lie to the west and become progressively younger to the east. This is not necessarily the case, however, as two distinct lithostratigraphic units, the western and the eastern sequences, are separated by the Long Steady Fault, a significant reverse fault characterized by highly schistose zones (Kerr, 2006a). The western sequence comprises the Pollards Point, Jackson's Arm, and Frenchman's Cove formations and consists of a lower package of felsic volcanic and pyroclastic rocks, lesser mafic volcanic rocks and conglomerates, overlain by a fining-upward sequence of terrestrial to fluviatile sedimentary rocks (Kerr, 2006a). The eastern sequence consists of the Simms Ridge and the Natlins Cove formations, comprising two packages of rocks that are thought to be in stratigraphic continuity. The base consists of variably calcareous siltstones, locally with thin fossiliferous limestone units (Simms Ridge Formation). This has then been overlain by the sandstone-dominated sequence of the Natlins Cove Formation. The Sops Arm Group is considered to have been deposited unconformably on the southern White Bay allochthon, but definitive contact relationships are observed only in one location, and typically the contacts are faulted (Kerr, 2006a). The present architecture of the Sops Arm Group mainly records Salinic and/or Acadian deformation of Silurian to Devonian age, as the fossils preserved in the group indicate it is Silurian (Heyl, 1937; Kerr, 2006a). These rocks are known to contain numerous gold occurrences (*e.g.*, the Browning Mine), as well as stratabound lead mineralization occurring in brecciated dolostones (Saunders, 1991).

PREVIOUS INVESTIGATIONS

The western White Bay area has been the subject of more than a century of geological study. The first geological investigations were conducted by Murray (1881). Howley (1918) continued further investigation, with follow up provided by Snelgrove (1935), who studied the gold mineralization of the area. Heyl (1937) proposed the earliest nomenclature for stratigraphic units in the region and produced the first geological map of the area; mapping and

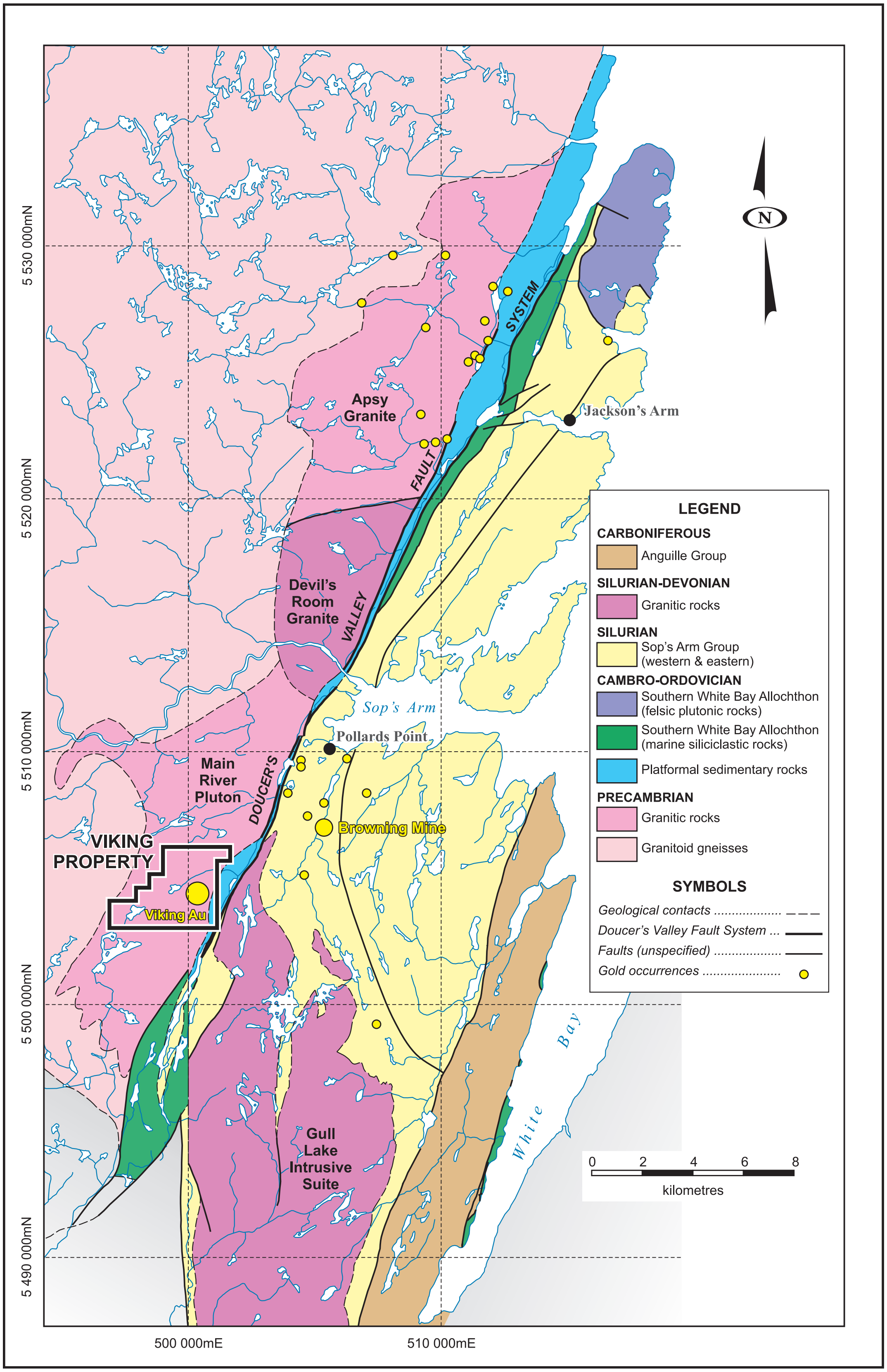

Figure 3. *Regional geology of the western White Bay area, showing the distribution of rock types and the locations of some other significant gold prospects (gold circles). Modified after Churchill and Voordouw (2006).*

stratigraphic correlation were continued by Betz (1948). Lock (1969, 1972) identified the Taconic structure separating the Silurian sequence from the Cambro-Ordovician sequence. Williams (1977) observed the unconformable contact of these Silurian strata relative to their igneous basement.

The Geological Survey of Newfoundland and Labrador (GSNL) has conducted many projects in the area, most notably Smyth and Schillereff (1982), who published 1:25 000 scale maps and summarized the regional geology. Tuach and French (1986) and Tuach (1986, 1987) completed metallogenic studies in the region, subsequent to the discovery of gold mineralization in granitic rocks of late Grenville age to the west of Jackson's Arm in 1983. Saunders (1991) completed a detailed compilation of the gold occurrences of the region. A 1:250 000-scale geological map was compiled by Owen (1991) and concentrated on rocks of the Grenville Inlier. The Silurian rocks of the Sops Arm Group to the east of the DVFS have been extensively studied in recent years by Kerr (2006a, b), and documentation of much of the gold mineralization was presented by Kerr (2006b). The stratigraphy and structure of the Cambrian and Ordovician rocks in the Coney Arm and Jackson's Arm area have been studied by Kerr and Knight (2004). The geochemical and metallogenic characteristics of the Devonian Gull Lake intrusive suite, and related Devils Room Granite, were studied by Saunders and Smyth (1990). Those authors concluded that both the Gull Lake intrusive suite and Devils Room Granite have low potential for significant granitophile element mineralization, however, the former, which is inferred to be cogenetic with the Sops Arm Group, was suggested as a priority exploration target for gold.

Prior to 1987, there is no record of industry-supported mineral exploration in the area of the Viking property. The property, as it is today, consists of one package (014079M) made up of 36 claims. Preceding this, it consisted of three licenses (12734M, 010935M, and 08878M), which have been amalgamated, through changing of property ownership. A detailed report of the major industry activity in the area is given in Churchill and Voordouw (2006).

Noranda Exploration Company Limited (Noranda) staked two claim blocks in 1986. These were immediately adjacent to BP Resources Canada Limited (BP) claims to the east near White Bottom Pond (Figure 1). The Noranda claims eventually became known as the Viking property, which is named after the gold showing discovered therein. Noranda's 1987 work program included a total of 220 km of reconnaissance grid-work comprising prospecting, mapping, soil sampling, and mag/VLF-EM surveys carried out under contract by Shear Exploration Limited. The result of this work identified a series of high-priority gold anomalies, which are now known as the Viking trend. This is a 6.5-km-long zone, with widths of up to 100 m, that follows a prominent northeast-trending linear topographic low. Grab samples along the trend returned values of 5.15 g/t Au, 21 g/t Ag, 0.74% Pb, and 0.62% Zn, and soil sampling identified several target areas with soil values of greater than 1000 ppb.

In 1988, based upon the results from the previous year, a series of detailed surveys were completed by Noranda. A grid totalling 46.4 km in length with a 4 km baseline was cut along the trend of the main gold anomaly. The B-horizon soil samples collected from this grid defined four separate gold anomalies. A follow-up soil-sampling program in 1989 yielded marginal results. Lake-bottom sampling proved more successful, and resulted in a maximum assay value of 55 ppb Au. Diamond drilling was completed during 1989 and returned altered granite with 0.56 g/t Au over 5.3 m. The results from outcrop, float, and inferred subcrop sampling yielded a maximum of 6.95 g/t from a total of 179 samples. A total of 218 B-horizon soil samples were collected with results of a maximum of 500 ppb Au. In 1990, a series of sampling surveys again returned less than expected results and a recommendation for no further work on these claims was suggested.

BP also completed exploration work in the area during the same period as Noranda. A line-cutting and soil-sampling program in 1987 in the area directly west of White Bottom Pond (Figure 1) yielded a broad, moderate gold-in-soil anomaly. In 1988, BP established a new tieline, as well as 3.8 km of flagged lines, over the area. A soil-sampling program, along with grid mapping and prospecting, was completed, and 267 samples were taken, which coincided with a helicopter-borne magnetic and VLF-EM survey. The results of these efforts included a 200 by 500 m gold-in-soil anomaly with elevated Pb–Mo–P concentrations.

Deep Reach Exploration Inc. (DREX) staked portions of the northeastern part of the Viking trend in 2002, with 14 claims. These were subsequently optioned to Messina Minerals in 2002 (Churchill and Voordouw, 2006). Messina Minerals surveyed and collected 24 samples on the northeast end of the Viking grid; these returned values of up to 18.4 g/t Au in stockwork veined, argillic-altered granite. Messina optioned one of three licences back to DREX and subsequently acquired an additional 16 claims before optioning the current Viking property to Altius Resources Inc. in 2006. Northern Abitibi Mining Corporation (NAMINCO) entered into an option agreement with Altius Resources Inc. in July 2007 to acquire an interest in the Viking property. Since then, NAMINCO has completed trenching, diamond drilling, and systematic assay sampling to delineate and define the economic potential of the Viking property.

GEOLOGY

The dominant rock types of the property include potassium-feldspar megacrystic granodiorite of the Main River pluton, monzogranite sheets and sills, a series of diorite–diabase sills and dykes and, sporadic, irregular carbonate-altered mafic dykes. Subsurface relationships between these rock types and their relationships to the Thor vein will be discussed in later sections.

Potassium-Feldspar Megacrystic Granodiorite

The potassium-feldspar megacrystic granodiorites of the Viking property are, typically, moderately deformed and exhibit either weak planar foliations or moderately developed feldspar-stretching lineations. The foliation is anastamosing and has variable trends, although it most commonly strikes northeast–southwest unless disrupted by local structures, such as folds or shear zones. Lineations are locally well developed, in particular where foliations trend east–west. At sparse locations, xenolith trails and remnant layering in the Main River pluton indicate that it is openly folded by moderate-shallow, S-plunging folds. It is proximal to these fold hinges where linear fabrics are best developed.

The granodiorite is typically mesocratic and is variably textured (Plate 1A). Major topographic lineaments are inferred to be high-strain zones, where the granodiorite exhibits protomylonitic to mylonitic textures (Dearing, 1989). Shear zones are thought to be brittle–ductile and the alteration assemblage present is characteristic of lower to middle greenschist-facies metamorphism.

Retrograde metamorphism is manifested by chlorite, epidote, and albite overgrowths. Fine-grained biotite crystals define a fabric around medium- to coarse-grained K-feldspar megacrysts (orthoclase) and are commonly altered to chlorite. The K-feldspar megacrysts show internal strain fabric, whereas quartz typically exhibits sutured grain boundaries, all features generated by deformation and metamorphism. Feldspars are commonly replaced by sericite ranging in intensity from weak to very strong (>25% sericite; Plate 1B). Pyrite and trace amounts of chalcopyrite are disseminated in the groundmass along with fine-grained titanite, a phase that is suitable for radiometric dating.

Monzogranite

The Main River pluton is intruded by a series of monzogranite sheets and/or sills and dykes. The monzogranite is typically salmon-pink to beige and exhibits a heterogeneously developed foliation (Plate 2A). The rock is also texturally heterogeneous, ranging from moderately foliated and fine-grained, to massive and coarser grained with pods of syenogranite pegmatite developed locally. Both the monzogranite and its host granodiorite are locally cut by 20- to 30-cm-thick pegmatite veins.

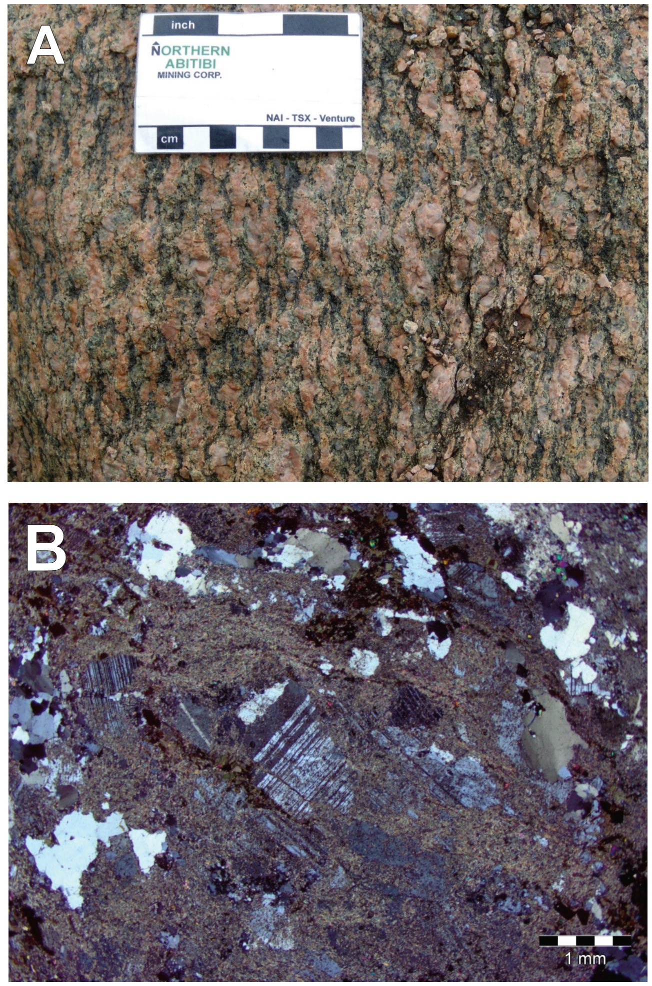

Plate 1. *A) Representative sample of moderately foliated, mesocratic potassium-feldspar megacrystic granodiorite of the Main River pluton displaying cm-scale potassium-feldspar megacrysts or augen in a fine-grained chlorite-sericite altered matrix. B) Photomicrograph of the same granodiorite showing intense sericitization of plagioclase feldspars and groundmass (cross-polarized light).*

The monzogranite is characterized by fine- to medium-grained plagioclase, fine-grained salmon-pink K-feldspar, and over 20% medium-grained anhedral quartz crystals having sutured grain boundaries. Fine-grained microcline, typically with plagioclase exsolution lamellae and fine-grained orthoclase are also visible in thin section (Plate 2B). These minerals are moderately to intensely replaced by sericite. The unit ranges from biotite-rich (>10%) to biotite-free and the former contain abundant chloritized biotite. Epidote is present in minor amounts and fractures contain limonite. Magnetite and pyrite are locally present.

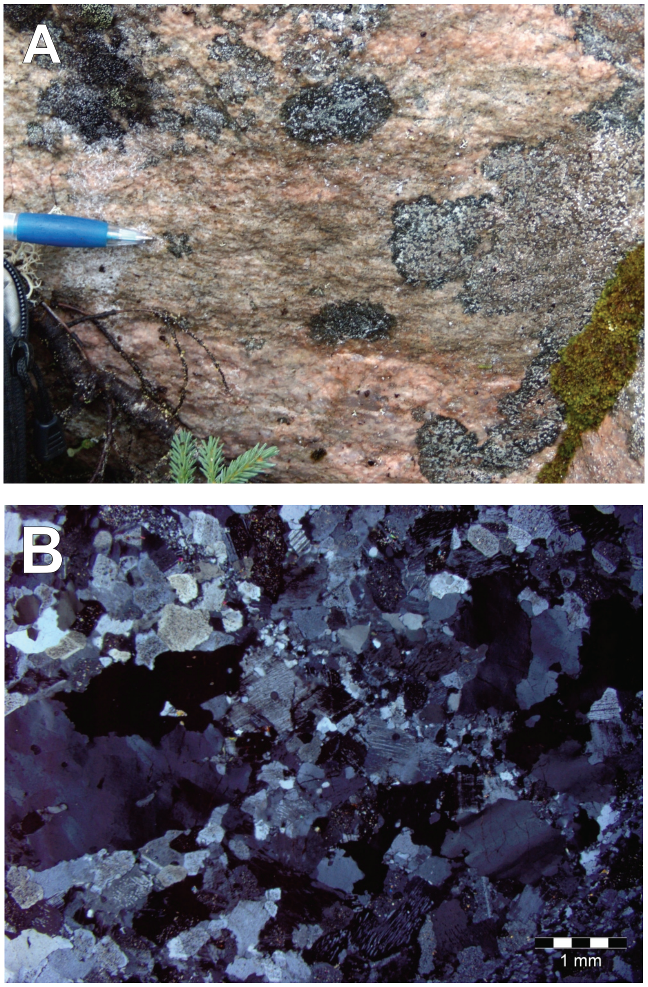

Plate 2. *A) Outcrop photograph of a moderately foliated variant of salmon-pink monzogranite with pen for scale. B) Cross-polarized light photomicrograph of the monzogranite unit, displaying sutured grain boundaries and plagioclase exolution lamellae.*

Mafic Intrusions

Mafic intrusions consist of both melanocratic, fine- to medium-grained, diabase or diorite dykes, and sills and, bleached, carbonate-altered mafic dykes. The diabase–diorite dykes are inferred to be Precambrian Long Range dykes; however, no radiometric dating has been carried out to test this hypothesis.

The diabase dykes are characterized by abundant plagioclase feldspars (>40 modal %) that are fine-grained and sericitized. Together with pleochroic, green to beige, fine- to medium-grained amphibole (hornblende), these provide a salt and pepper mottled appearance (Plate 3A). Approximately 10% recrystallized quartz is present. Accessory phases include very fine-grained apatite and epidote, and carbonate locally occurs in veinlets. Magnetite was identified in reflected light microscopy. The unit is moderately chloritized, as well as sericitized. Fine-grained pyrite is observed with very fine-grained anhedral gold, but the presence of gold needs confirmation. Trace amounts of fine- to very fine-grained chalcopyrite are associated with pyrite and magnetite.

Carbonate-altered mafic dykes are observed to crosscut the granodiorite and monzogranite, and are older than gold mineralized quartz-sulphide veins. The dykes are greenish tan and typically bleached in appearance, and locally exhibit a porphyritic texture. Like the diabase dykes, plagioclase feldspar is the dominate mineral, and in this case, is present as phenocrysts and as tabular laths in the matrix (Plate 3B). Amphibole and pyroxene are strongly altered by sericite and carbonate (Plate 3C). These dykes are assumed either to comprise part of the Long Range dykes, or are associated with a younger, possibly Silurian–Devonian intrusive event.

SUBSURFACE RELATIONSHIPS

Upon completion of NAMINCO's 2009 drilling program, a total of 4187.6 m of core had been drilled in 45 drillholes on the property. For this project and report, the four 2008 drillholes (08-VK-01, 08-VK-02, 08-VK-03, and 08-VK-05) were examined. These holes intersected high-grade gold mineralization, as well as wider zones of low-grade gold mineralization that are potentially bulk mining targets. Figure 4 illustrates the subsurface distribution of units and the location of the Thor vein in holes 08-VK-01 to 08-VK-03 and 08-VK-05.

Drillhole 08-VK-01 was drilled at a −45° angle to a final depth of 89.5 m from a collar position of 5504442N, 500582E, at an elevation of 441 m above sea level (asl) toward north. This drillhole intersected three major rock types, and was the first drill intersection of the Thor vein (graded 218.79 g/t Au over 0.5 m). Foliation in the Main River granodiorite ranges from 20 to 55° to core axis (TCA; Plate 4a), whereas contacts with other rock types range from 40 to 80° TCA. These contacts are irregular, intensely altered, and locally sheared. Monzogranite intervals are characteristically salmon-pink, contain quartz and potassium feldspar and, are locally silicified and quartz veined. Gold mineralization in quartz-sulphide veins parallels a shallowly dipping, carbonate-altered, mafic dyke. A zone of sheeted quartz veins returned 0.73 g/t Au over 33.3 m from 6.7 to 40 m depth (Northern Abitibi Mining Corporation website, 2009).

Drillhole 08-VK-02 was drilled at a −60° angle toward north to a depth of 55.0 m and at an elevation of 441 m asl. This hole was drilled from the same collar as Hole 08-VK-01. The rock types intersected were similar to those

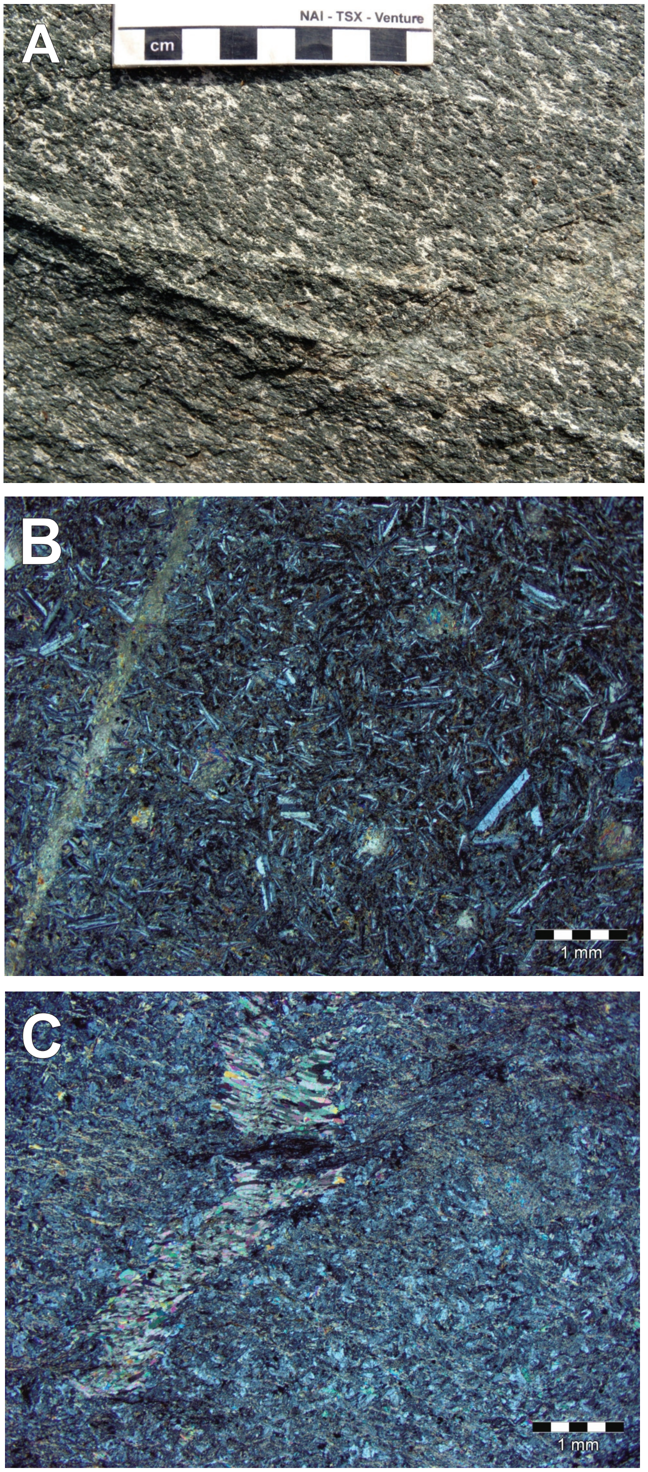

Plate 3. *A) Close-up, outcrop photograph of typical hornblende diorite exhibiting "salt and pepper" texture. B) Photomicrograph of the mafic dyke showing plagioclase laths comprising the matrix with porphyritic texture and a sericite–chlorite–epidote veinlet (left) (cross-polarized light). C) Carbonate- and sericite-altered matrix of the mafic dyke occurring in the Thor vein area (cross-polarized light).*

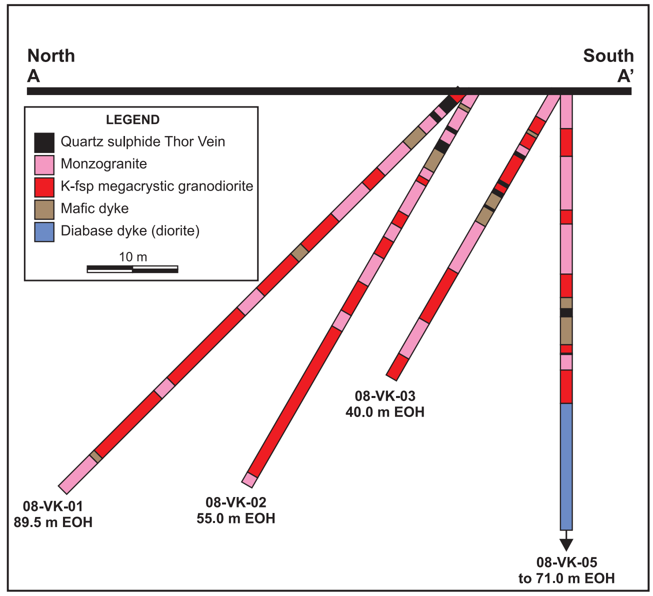

Figure 4. *Schematic cross-section through the Thor vein displaying drillholes 08-VK-01, 08-VK-02, 08-VK-03, and 08-VK-05. Location of the cross-section is shown as A-A' on Figure 1 inset map. Note that the high-grade quartz veins (black) cut and parallel a shallowly south-dipping carbonate-altered mafic dyke. Please note that the core logs are schematic as they represent all contacts as perpendicular to the core axis.*

observed in Hole 08-VK-01, and foliation measurements fall within a similar range. Medium-grained sericite-altered monzogranite (Plate 4b) crosscuts the foliation of a strongly chloritized granodiorite. A zone of sheeted quartz veins, similar to that in Hole 08-VK-01, returned 2.88 g/t Au over 4.2 m (from 1.8 to 6.0 m depth) in the hanging wall of the Thor vein and, 0.93 g/t Au over 5.2 m in the footwall (from 13.6 to 18.8 m depth). The lower part of the hole contains variable gold grades ranging from weakly anomalous to 7.02 g/t, and the last interval sampled returned 2.05 g/t gold over 1.3 m (from 50.0 to 51.3 m depth) (Northern Abitibi Mining Corporation website, 2009).

Drillhole 08-VK-03 was spotted a few metres south of holes 08-VK-01 and 08-VK-02 from a collar position of 5504431N, 500582E. This hole was drilled at a −60° angle toward north to a depth of 40.0 m. The elevation of the hole was 441 m asl. This hole was drilled to test the southerly down-dip extension of the Thor vein and intersected a 23.0 m interval from 1.3 to 24.3 m depth, grading 5.12 g/t Au, including a 0.5 m interval grading 176.20 g/t Au and a 0.3 m interval grading 23.41 g/t Au (Northern Abitibi Mining Corporation website, 2009). This hole intersected a number of thin intersections of the Thor vein, and observed lithological contacts and foliation orientations are comparable to those in the first two holes. A bleached greenish mafic dyke com-

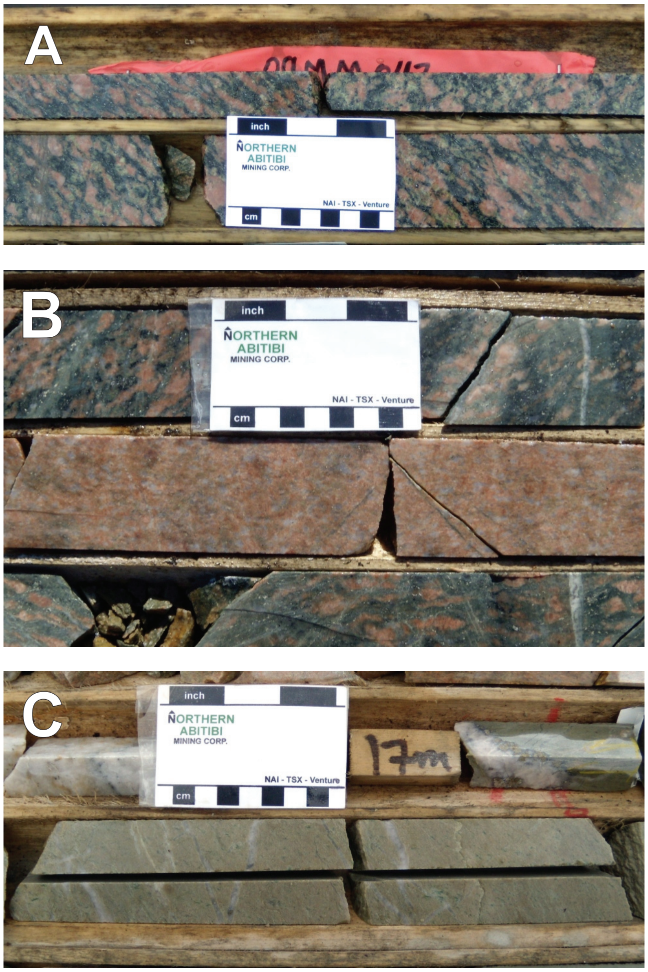

Plate 4. *Photographs of rock types in drillcore from Viking. A) Foliated chlorite–epidote–sericite-altered granodiorite in hole 08-VK-01 (58.75 to 59.15 m depth). B) Medium-grained, pink, silicified monzogranite crosscutting a strongly chlorite-altered and quartz-veined granodiorite (28.8 to 30.5 m depth). C) Bleached, quartz-veined and carbonate-altered mafic dyke from hole 08-VK-03 (18.2 to 18.5 m depth), which is cut by cm-scale quartz-sulphide veinlets (top right).*

parable to that observed at surface, crosscuts the granodiorite and monzogranite (Plate 4c) and is subparallel to quartz sulphide veins.

Drillhole 08-VK-05 was drilled vertically to a total depth of 71.0 m from the same collar location as Hole 08-VK-03. It intersected the Thor vein at greater depth and returned a 16.8 m interval (from 9.0 to 25.8 m depth) from the hanging wall of the vein grading 1.54 g/t Au, and a 0.9 m intersection of the Thor vein that returned 119.65 g/t Au (Northern Abitibi Mining Corporation website, 2009). This was the first hole to intersect the major diabase dyke at 37.22m (shown in hole 08-VK-05 in Figure 4).

GOLD MINERALIZATION

High-grade gold mineralization is associated with en echelon (pinch and swell) quartz-sulphide veins of variable thickness, whereas lower grade, bulk mineralization is associated with a number of host rock types. The mineralization is epigenetic, found in veins and disseminations throughout the surrounding host rocks. Gold grains vary in size from sub-millimetre to two mm in both drillcore (Plate 5a) and outcrop (Plate 5b). Gold-bearing veins display complex geometries and, by and large, are openly folded, fractured, and associated with steeply dipping brittle–ductile shear zones. East–west-trending veins appear to contain the highest Au concentrations, whereas sets of northeast–southwest- and northwest–southeast-oriented veins have also been noted to contain anomalous gold.

There are two styles of gold mineralization found on the Viking property. The first, exemplified by the Thor vein, comprises quartz veins containing 5 to 10% sulphides (dominantly pyrite, galena, and chalcopyrite and minor spha-

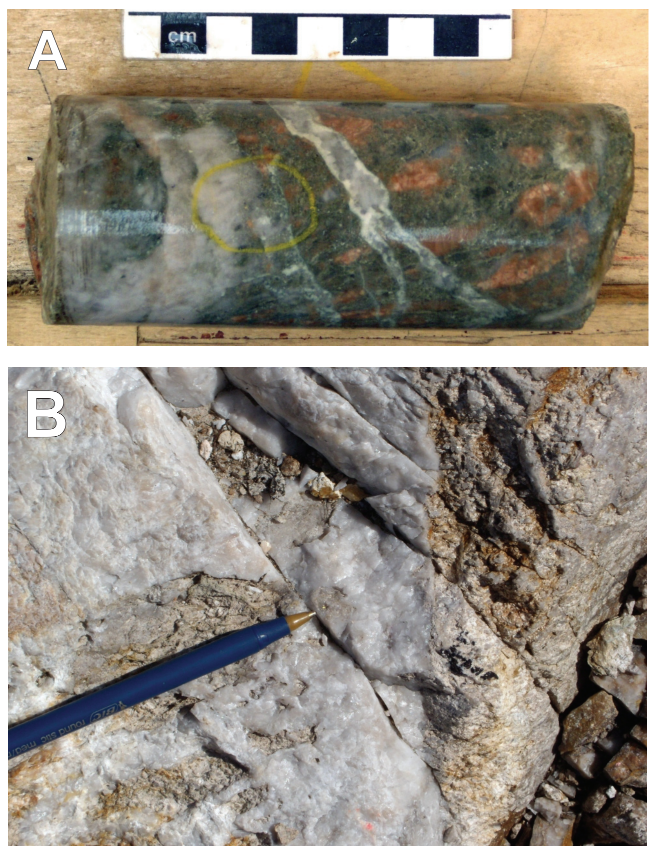

Plate 5. *A) Drillcore photograph with visible gold and galena in cm-scale quartz-carbonate veinlets that cut a strongly chlorite–sericite-altered granodiorite. B) Pen pointing to visible gold in outcrop just a few metres west of the Thor vein.*

lerite) along with rare visible gold. These veins range from centimetres up to two metres in width. Gold assays returned a spectrum of grades from <1 g/t up to 335 g/t (Ebert, 2008). The second style of mineralization consists of a low-grade halo around the major sulphidic-quartz veins and comprises sericite + pyrite-altered, and locally carbonate-altered, granodiorite and monzogranite with cm-scale quartz veins.

The Thor vein crosscuts all rock types and is composed of quartz and iron-carbonate along with pyrite, galena, chalcopyrite and minor sphalerite and trace visible gold. The vein returned an assay high of 218.8 g/t Au over 0.5 m, a low of 8.7 g/t Au over 1.3 m, and an average of 39.1 g/t Au over 2.82 m. Examples of high-grade gold intercepts in drillcore include 3.7 m grading 50.05 g/t Au and a 0.5 m interval grading 218.79 g/t Au. Wider, low-grade intervals have been encountered in drilling and outcrop channel sampling and include; 27 m grading 7.9 g/t Au, 23.0 m grading 5.12 g/t Au, 57.4 m grading 2.6 g/t Au, and 41.4 m grading 2.0 g/t Au (Northern Abitibi Mining Corporation website, 2009). The estimation of an accurate gold grade is problematic owing to the nugget-style, disseminated nature of the gold mineralization at Viking. Selected samples from the property taken by NAMINCO were re-analyzed using a larger sample size and realized a 27.8% increase in gold concentrations, confirming that grade calculations must be undertaken using bulk-sampling methods (Northern Abitibi Mining Corporation website, 2009b).

DISCUSSION

At this early stage of the investigation, the style of mineralization observed at the Viking property can be described as an intrusion-hosted, orogenic gold deposit. Epigenetic intrusion-hosted, quartz-carbonate vein deposits, with economic amounts of gold and other sulphides, typically occur in faults and shear zones located within structurally deformed terranes that are commonly metamorphosed to greenschist and locally amphibolite facies (Dubé and Gosselin, 2007). All of these characteristics are present at the Viking deposit. Analogues to the Viking-style of gold mineralization are the gold systems at the Val-d'Or and Rouyn-Noranda camps that also include the Renabie, Ferderber, Pierre Beauchemin, and Silidor deposits.

A major problem in deformed and metamorphosed terranes, such as at the Viking property, is that many primary characteristics have likely been obscured by later deformation and metamorphic overprinting (Dubé and Gosselin, 2007). This being said, many of the textures that are associated with late syn- to post-regional metamorphic events, such as gold mineralization and related fluid alteration, are readily visible at Viking. Structurally controlled mineralization is spatially related to structural breaks, formed, in part, by tectonic shortening, on second- and third-order compressional features. Such features are observed on the Viking property in the form of moderately to steeply dipping, brittle–ductile shear zones and faults.

On a regional scale, there is an apparent spatial relationship between the DVFS and gold mineralization in the western White Bay area (Saunders, 1991), a conclusion that likely applies to Viking. Large gold camps are commonly associated with curvatures along major compressional fault zones, which create dilational zones that allow for migration of hydrothermal fluids (*cf.*, the Porcupine-Destor fault in Timmins: Dubé and Gosselin, 2007).

High-grade gold mineralization occurred with the emplacement of quartz veins that cut all rock types. The diorite–diabase dykes and sills are the youngest intrusions in the area and are crosscut by gold-bearing quartz veins. Therefore, the diorite sill will provide a maximum age for mineralization. The diorite sill near the Thor vein is approximately 100 m thick at surface, strikes east–west and dips roughly 30° north (Thor vein dips south). This unit locally exhibits a weakly developed planar fabric near its margins, but it is unclear if it is the same fabric as that observed in the potassium-feldspar megacrystic granodiorite of the Main River pluton. If the diorite-hosted fabric is the same as the fabric observed in the granodiorite, then the diorite most likely represents a sill that is cogenetic with the Precambrian Long Range dykes. Acquisition of a definitive U–Pb age on the granodiorite and diorite sill will better constrain the timing of their emplacement and facilitate further interpretation of the complex relationships observed in the study area.

FUTURE WORK

Further research on the samples collected in 2009 will be the focus of a Master of Science thesis by the senior author at Memorial University of Newfoundland (MUN). The goals of the study are: to document the gold mineralization and related sulphides; complete a petrographic and geochemical study of all rock types and associated alteration; determine the origin and nature of the ore-forming fluids and; pinpoint the timing of key geological events that may be associated with the formation of the ore deposit. These goals will be accomplished using the following techniques:

- Microthermometric fluid-inclusion analysis on the Linkam THMSG600 at MUN will be completed on selected quartz-sulphide veins, including both gold mineralized and barren veins, to determine the composition and source of gold mineralizing fluids.
- ^{40}Ar–^{39}Ar geochronology, on biotite from a sample

from the Labrador Group (phyllite) will provide a minimum age of mineralization via determining the time of final peak (*ca.* 250°) metamorphism. This technique will also be used in an attempt to constrain the age of alteration and the formation of the sericitic alteration halo.
- Attempts will be made to determine a U–Pb zircon date on a sample of monzogranite, and a diorite sill in close proximity to the Thor vein. This will provide a maximum age of mineralization.
- Scanning electron microscopy will be undertaken to verify the presence and interrelationships of gold and other sulphides, and provide essential information on textural relationships between ore and gangue minerals.
- Cathodoluminescence will be used to map vein textures and to compare barren and mineralized quartz-carbonate veins.
- Whole-rock lithogeochemistry will permit regional-scale correlation of map units. Outcrop samples were collected from other granitoid plutons in the area (Devils Room Granite, Apsy Granite, Gull Lake intrusive suite; Figure 3) for geochemical and petrographic comparison to the Main River pluton and the younger monzogranite.

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