

THE GEOLOGICAL SETTING OF Au–Ag–Te MINERALIZATION AT THE AUCOIN PROSPECT (NTS MAP AREA 13N/6) HOPEDALE BLOCK, LABRADOR

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ABSTRACT

The Aucoin gold prospect (NTS map area 13N/6), located 70 km west of Hopedale in the Archean Nain Province, is one of only two Labrador gold prospects that have been tested by drilling. It was discovered in 1995, during ground prospecting in the vicinity of a single, gold-in-lake sediment geochemical anomaly, obtained during a regional government survey. Trenching, sampling and diamond drilling have yielded samples up to 478 g/t Au and > 100g/t Ag and a drill interception of 12.4 g/t Au (14g/t Ag) over 1.05 m. The mineralized zone consists of an array of anastomosing, discontinuous, northeast- and north-west-trending white quartz veins (typically <20 cm wide) spatially associated with a strongly chlorite–ankerite–epidote±sericite+ talc-altered and sheared contact zone between massive to weakly foliated syenite and cogenetic monzodiorite. High gold assays occur in, and above, the contact zone and best correlate with elevated silver and tellurium, reflected by the presence of argentiferous electrum and Ag–Au telluride (petzite?) as inclusions in pyrite, minor chalcopyrite and rutile after ilmenite. Rare wire gold has been reported at the margins of the veins.

The age of the mineralization is unknown, but the syenite and monzodiorite host rocks are fresh alkaline intrusive rocks that may correlate with the ca. 1500–1420 Ma intermediate rocks of the Harp Lake Complex or, alternatively, of the 1350–1290 Ma Nain Plutonic Suite. If this inference is correct, then gold mineralization at Aucoin is also likely of Mesoproterozoic age. Further work is proposed to test this hypothesis, including geochronological studies of the host rocks and of alteration associated with mineralization.

INTRODUCTION

The Aucoin gold prospect (UTM 602424E 6136064N: all coordinates in NAD27, zone 20) is exposed on a sparse-ly tree-covered hillside, ca. 70 km west of the hamlet of Hopedale, Labrador (NTS map area 13N/6; Figure 1). Access to the area is *via* float plane or helicopter only. Remarkably, it is one of only 2 known gold prospects that have been drilled and yielded >1g/t gold in the entirety of Labrador. The other drilled gold mineralization, the VBE prospect, was explored in 1995–96 by Canalaska Resources and Columbia Yukon Resources and was subsequently documented by Skanes *et al.* (2004). The geological setting and nature of gold mineralization at the Aucoin prospect has, however, not received comparable government documentation.

The geology of this part of Labrador has been mapped at scales of 1:250 000 or 1:100 000 (Taylor, 1977; Hill, 1982; Thomas and Morrison, 1991; Ermanovics, 1993). Detailed geochemical and potential-field and induced-field data are largely lacking, although the region is covered by a

regional National Reconnaissance Program lake-sediment survey (one sample per 14–16 km²: Hornbrook *et al.*, 1978) and regional, 800-m line-spacing aeromagnetic data (Teskey *et al.*, 1982). Systematic mineral exploration in the area commenced with the 1994–1995 spike in activity in Labrador associated with the ‘Voisey’s Bay exploration boom’. Thus, a very sparse geoscience knowledge base exists for this remote region of central Labrador.

Available mineral-exploration industry assessment reports (Sandberg, 1995; Lehtinen and Weber, 1996; Lehtinen, 1997; Dyke and Hussey, 2003; Dyke, 2004; Hussey and Moore, 2005; 2006a, b) provide significant valuable new information about the geology of the area. The lack of modern baseline geological mapping available for the host rocks to the prospect has, however, led to somewhat conflicting geological interpretations. Careful evaluation of historical data, in conjunction with our own observations, helps to alleviate some inconsistencies and uncertainties. The genetic model presented in most of the mineral exploration reports interprets the elevated gold and silver at Aucoin as representing a mesothermal, or orogenic shear zone style of

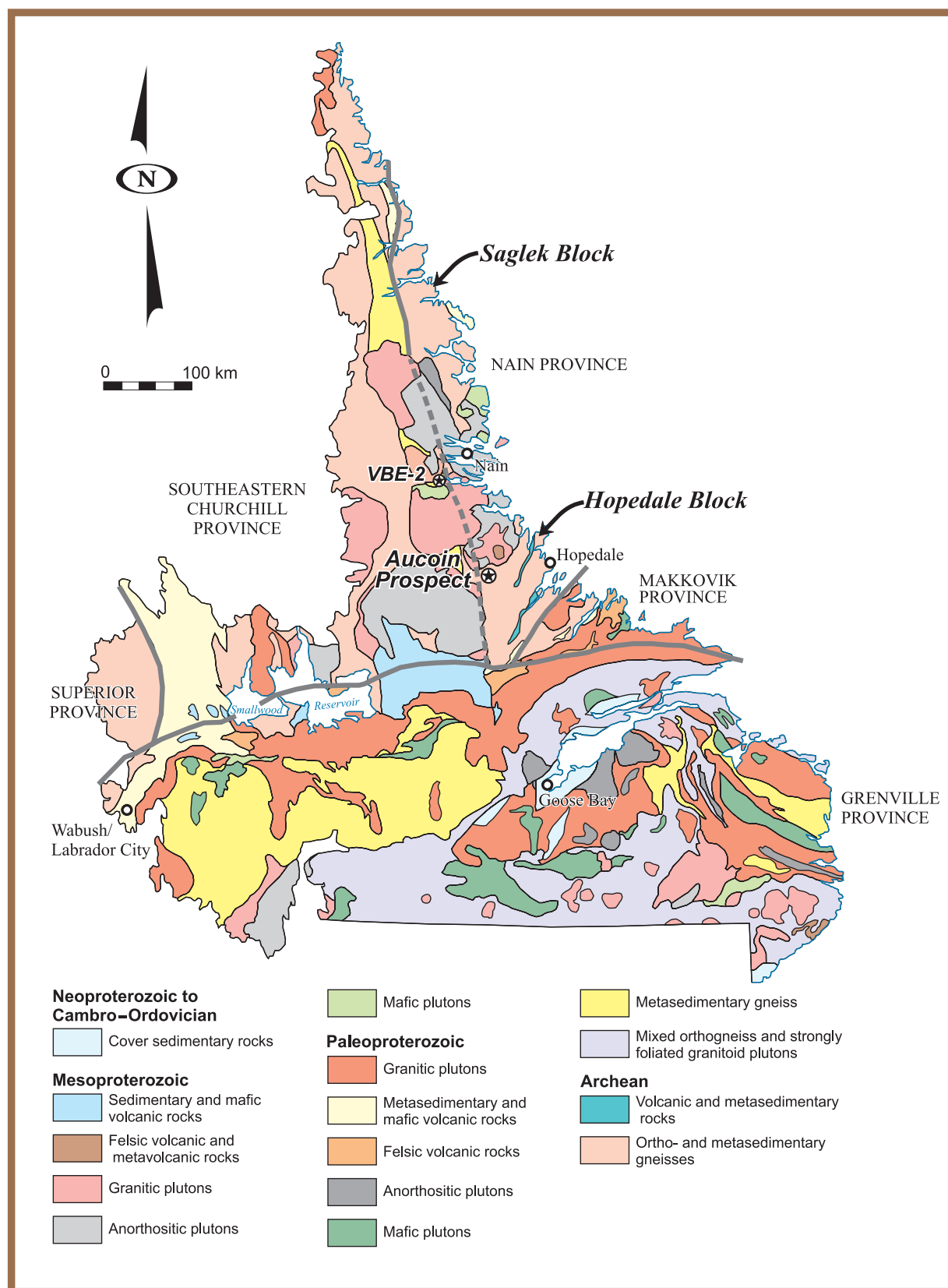


Figure 1. Simplified geological map of Labrador showing the location of the Aucoin prospect with respect to recognized major geological terranes.

mineralization, a conclusion based on that body of work. However, the exploration reports suggest that the Aucoin alteration and mineralization occur in a thickened portion of a northwest-trending gabbroic dyke, inferred to correlate with the Paleoproterozoic Kikkertavak dykes (Lehtinen and Weber, 1996). The rocks hosting the Aucoin prospect were previously described as *granitic* and *mafic gneiss*, of inferred Archean age, but here, we report and suggest that the rocks are petrologically distinct and may be significantly younger.

This contribution presents a compilation of regional (1:250 000 and 1:100 000 scale) government and more detailed (1:500, 1:1000 and 1:1250 scale) mineral-exploration industry geological data from the immediate vicinity of the prospect. A revised geological map of the Aucoin prospect area integrates these data with the results of the field work in 2010. This contribution discusses the current understanding of the geology of the prospect, describes the mineralization, the nature of alteration and, suggests a number of avenues for future research. A better understanding of the Aucoin gold prospect may provide improved exploration strategies for discovery of comparable auriferous mineralizing systems in under-explored Labrador. Cores collected as a result of the diamond-drilling program in 1995, have remained on site. As a result, most of the core boxes have deteriorated significantly and many box labels are missing. Eight representative boxes of core that retained identification tags were retrieved from storage at the Aucoin prospect and are now catalogued and stored at the Geological Survey of Newfoundland and Labrador core-storage facility in Goose Bay, Labrador.

REGIONAL SETTING

The Aucoin prospect lies *ca.* 12 km to the east of the tectonic boundary between the Hopedale block of the Archean Nain Province and the easternmost, Southeastern Churchill Province (Figure 1). The study area lies near the northwest boundary of the regional, 1:250 000-scale map of Ermanovics (1993); the north central boundary of the 1:100 000-scale map of Thomas and Morrison (1991) and; the south central boundary of the 1:100 000-scale geological map of the Flowers River igneous suite of Hill (1982). The geological setting of the Aucoin prospect has been briefly described in the regional 1:250 000-scale maps of Taylor (1977) and Ermanovics (1993). These earlier studies focused on the better exposed, and more readily accessible, eastern portions of the Hopedale block. As a result, the western Hopedale block is very poorly understood. The host rocks to the mineralization are described by Ermanovics (1993) as diverse, retrograde metamorphosed, relict granulite-facies granitoid rocks (his Unit A'Mgl) that are flanked on all sides by the heterogeneous Maggo tonalite

orthogneiss, which includes a number of well preserved (his Unit AM') and reworked (his Unit A'mg) variants. Ermanovics (1993) interpreted all large, intact bodies of amphibolite as remnant supracrustal rafts of Weekes amphibolite (his units A'Wab and A'Wan), which were inferred to represent dismembered remnants of the *ca.* 3000 Ma Hunt River belt exposed to the east, the oldest intact supracrustal rocks of the Hopedale block. These older rocks are crosscut by the typically northeast-trending 2235 ± 2 Ma Kikkertavak dykes (Cadman *et al.*, 1993). In the area of the Aucoin prospect, an array of north-northwest-trending vertical diabase dykes were interpreted by Ermanovics (1993) as likely being Kikkertavak dykes.

To the west of the Aucoin prospect, the boundary between the Southeastern Churchill Province and the Nain Province is stitched by the *ca.* 1460 Ma, anorthosite – mangerite – charnockite-granite association rocks (AMCG) of the Harp Lake Complex (Emslie, 1980). Along the northern portion of the Hopedale block, the Maggo gneisses are intruded by the AMCG rocks of the long-lived, *ca.* 1351–1292 Ma Nain Plutonic Suite (NPS; Hill, 1982; Ryan *et al.*, 1991; Thomas and Morrison, 1991; Ryan, 1998). To the northeast, the *ca.* 1293–1271 Ma Flowers River igneous suite (FRIS), consisting of peralkaline volcanic and granitic rocks, intrudes all other units (Hill, 1982; Brooks, 1982, 1983; Krogh, 1993; Thomas and Morrison, 1991). All of the rocks of the region, with the apparent exception of the FRIS are transected by the *ca.* 1273 Ma northeast-trending tholeiitic Harp dykes (Emslie, 1980; Hill, 1982). Cadman *et al.* (1993) suggested, on the basis of lithogeochemical comparisons, that the Harp dykes correlate with the *ca.* 1250–1224 Ma Naskaupi gabbroic sills that intrude the middle and upper sections of the Seal Lake Group, which are exposed *ca.* 100 km to the southwest (Romer *et al.*, 1995; van Nostrand, 2009; van Nostrand and Lowe, 2010).

The regional, 800-m-line spacing, 300 m elevation, airborne geophysical dataset that is available for the region (Teskey *et al.*, 1982) is extremely coarse with respect to the dimensions of the Aucoin prospect. When combined with the more detailed airborne and resistivity survey data of Ascot Resources Ltd. (Sandberg, 1995), the dataset then can be interpreted, and a number of significant features may be observed (Figure 2). The Aucoin prospect occurs on a prominent south-trending magnetic high that is bounded to the west by a distinct, curving, south-trending magnetic low and, to the east by a gradation into a broad region having a generally low magnetic susceptibility (Figure 2). The south-trending magnetic low is interpreted as a fault. The prominent magnetic high that underlies the prospect appears to consist of one of a number of arcuate positive magnetic features that project toward the southwestern margin of the FRIS (Figure 2). Mapping by Hill (1982) and Thomas and

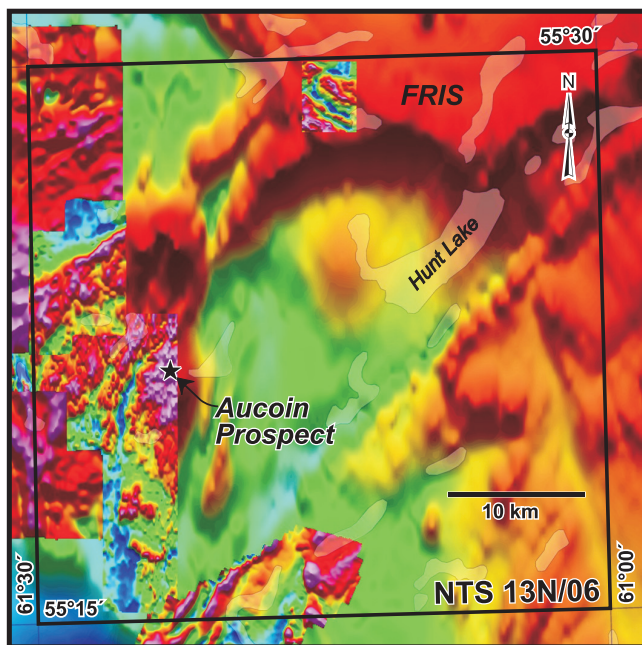


Figure 2. Total-field, compilation aeromagnetic map of NTS map area 13N/06. This is a composite image having high resolution sections over the Aucoin property and a number of other mineral exploration licences, along with lower resolution background comprising the regional 800-m-line-spacing data of the Geological Survey of Canada (<http://gdrdap.agg.nrcan.gc.ca/geodap/home>). FRIS = Flowers River igneous suite.

Morrison (1991) indicate that intermediate rocks of the NPS and the FRIS are both exposed immediately north of the Aucoin prospect.

HISTORY OF EXPLORATION

With the exception of regional, reconnaissance base-metal exploration undertaken by the British Newfoundland Exploration Ltd. (BRINEX) in the 1950s, very little mineral exploration was undertaken in this part of Labrador, prior to the large volume of work following the early 1990s staking that followed the discovery of the Voisey's Bay nickel deposit.

In May 1995, Ascot Resources Ltd. staked two mineral licences based on a single elevated gold in lake-sediment anomaly (Hornbrook *et al.*, 1978). The company then initiated prospecting traverses and airborne geophysical surveys and, by September of that year, had discovered the Aucoin showing (Sandberg, 1995). Initial results from prospecting and chip sampling yielded up to 7.62 g/t Au with a corresponding elevated value of 6.3 ppm Ag from a hand-trenched carbonate – chlorite-altered, quartz-veined monzodiorite. Sandberg (1995) recognized that the host rocks to the Aucoin showing are syenite and monzodiorite and sug-

gested, on the basis of their petrology, that the rocks are part of the Arc Lake adamellite (Emslie, 1980) rather than the Maggo gneiss as indicated by the mapping of Taylor (1977) and Ermanovics (1993). Sandberg (1995) also recognized that the monzodiorite sill trends northwest-southeast and infers a northeast dip.

Following the successful summer of 1995, Ascot Resources Ltd. established a detailed grid over the Aucoin showing. They then collected 370 soil samples and undertook ground-based, total field magnetic and VLF-EM surveys, geological mapping, prospecting and an eight-hole, diamond-drilling program totalling 461.7 m (Lehtinen and Weber, 1996). Rock samples collected from surface yielded a maximum of 8.49 g/t Au with 5 ppm Ag. The best intersection obtained through diamond drilling was in DDH AR96-2 where a 1.05 m segment of core yielded 12.43 g/t Au and 14 ppm Ag. Most of the gold mineralization intersected in drillcore occurred proximal to, and primarily within, a curvilinear shear zone defining and perhaps focussed along the contact between 'diorite' and 'granitic gneiss' trending at *ca.* 150° and dipping at 50° to the southwest. The shear zone was described as characterized by the alteration assemblage quartz + ankerite + chlorite ± epidote ± sericite, accompanied by abundant pyrite, less abundant galena and chalcopyrite and, rare visible gold. In drillcore and on surface, Lehtinen and Weber (1996) also noted two distinct types of apparently younger mafic intrusions, 'diabase' and 'mafic dykes'. Those termed 'diabase' are described as grainy, grey, salt and pepper rocks that are highly magnetic and are locally altered and cut by quartz veins. Those termed 'mafic dykes' are fine-grained, green to black, weakly magnetic and contain only calcite-epidote stringers. These two types of mafic rocks cut the 'granitic gneiss' but only the 'diabase' yielded anomalous gold concentrations. Lehtinen and Weber (1996) interpreted the mineralized monzodiorite-monzogabbro intrusion at Aucoin as being a thickened and differentiated Kikkertavak dyke.

In the summer of 1997, Ascot Resources Ltd. undertook further reconnaissance grid-based mapping, prospecting, soil and silt geochemistry over the Aucoin licences and, ground geophysical magnetic and VLF-EM surveys over the Aucoin prospect detailed grid (Lehtinen, 1997). A total of 28 rock samples were collected and yielded a maximum of 3.76 g/t Au with 1 ppm Ag. Of a total of 1355 B-horizon soil samples collected from the property, most yielded Au and Ag concentrations below detection (<5 ppb Au and 0.2 ppm Ag), with the exception of those collected directly over the Aucoin prospect, and a single 600 ppb Au anomaly (with 0.2 ppm Ag) occurring *ca.* 800 m to the north-northeast of the prospect (Lehtinen, 1997). To the best of our knowledge, this anomaly has not since been properly investigated. Thirty-six stream silt samples were also collected from the prop-

erty and most yielded Au concentrations below detection. One notable sample, collected 2.5 km due south of the Aucoin prospect, yielded a maximum of 80 ppb Au, but no detectable silver! No further work was conducted by Ascot Resources on the Aucoin prospect, and the mineral licences were dropped in 2000.

In 2002, prospectors Lloyd Hillier and Alex Turpin restaked the area around the Aucoin prospect and subsequently optioned the property to Cornerstone Resources Inc. (Cornerstone) in 2003. During 2002, Hillier and Turpin undertook prospecting on the property whereas Cornerstone conducted research and produced a compilation of the previous work by Ascot Resources Ltd. Of the 24 rock samples collected, the best assay yielded 49.1 g/t Au. No other elements were analyzed.

Cornerstone conducted a lake-sediment sampling program in 2003 along with prospecting and rock sampling. A total of 46 lake-sediment samples were collected and 15 of these yielded anomalous values between 1 and 12 ppb Au. Seventy-six rock samples (float and outcrop) were collected and 50 of these yielded assays of >5 ppb Au. The best result was 7.36 g/t Au and 3.6 ppm Ag from an outcrop of carbonate-altered diorite immediately north of the Aucoin prospect.

Work in 2004 by Cornerstone included follow-up prospecting of several gold-in-lake sediment anomalies that were generated during earlier work. Reconnaissance geological mapping of the Aucoin prospect and surrounding area was also undertaken and a total of 13 rock samples were collected. The best assay result, for a grab sample collected from the Aucoin prospect, was 478 g/t Au with >100 g/t Ag. This work also outlined a *ca.* 700-m-long, south-southeast-trending, altered and mineralized zone, culminating at its south end, with the newly discovered Turpin showing. The latter is a partially exposed quartz vein located approximately 600 m south of the Aucoin prospect. A grab sample from the vein yielded an assay of 0.91 g/t Au with 1.01 ppm Ag. For the first time, the element tellurium (Te) was determined by assay for the collected samples and Hussey and Moore (2005) noted correlations between Au, Ag and Te.

In 2005, Cornerstone focused on the newly discovered Turpin showing and, in order to expose the vein, undertook hand excavation. This proved difficult and had limited success. Along with detailed mapping of the exposed vein, nine rock samples were collected and of these, three yielded gold concentrations >1 g/t. The highest assay was 3.1 g/t Au with 0.7 ppm Ag and 0.5 ppm Te. One sample containing abundant visible galena and chalcopyrite yielded 2.8 g/t Au with 2.6 ppm Ag, 26.3 ppm Te and >1 % Cu and Pb.

In August of 2006, Cornerstone attempted dynamite blasting and further hand trenching of surficial materials overlying the Turpin showing. Although the work managed to expose more of the vein, it met with limited success in exposing the contacts with the host rocks. Four rock samples were collected and all yielded <1 g/t Au. The best result was 0.2 g/t Au with 0.3 ppm Ag and 0.3 ppm Te. Cornerstone has not since conducted exploration work on the property.

LOCAL GEOLOGY OF THE AUCOIN PROSPECT

Herein, we summarize observations from field work, petrographic observations and Visible/Infrared Reflectance Spectrometric (VIRS) data on 35 representative rock specimens. This information is supplemented by observations presented in the mineral assessment reports (Sandberg, 1995; Lehtinen and Weber, 1996; Lehtinen, 1997; Dyke and Hussey, 2003; Dyke, 2004; Hussey and Moore, 2005, 2006a, b).

The barren, prominent hills surrounding the Aucoin prospect (Figure 3) are underlain by four distinct rock types. Two widely separated localities, which are distal from the Aucoin prospect (6 and 3 km respectively), were visited and consist of grey, heterogeneous tonalite gneiss containing centimetre- to metre-scale screens and schlieria of fine- to medium-grained amphibolite (Plate 1A). Underlying the hills immediately surrounding the Aucoin prospect is a pink-, to buff-coloured, generally medium-grained, massive to weakly foliated or lineated, hornblende±clinopyroxene syenite (Plates 1B and 2A, B). Accessory phases include: abundant anhedral grains of ilmenite with magnetite intergrowths that are locally mantled by anhedral brown titanite (Plates 2A, B); abundant, anhedral large (≤ 1.5 mm) apatite and dispersed subhedral zircon. A common mineral in the syenite is a colourless, high-relief, low-birefringent phase (Plate 2A) that is anhedral and has been confirmed as apatite *via* energy dispersive electron microprobe analysis. The syenite locally varies to quartz syenite and commonly contains irregular patches and veins of quartz syenite pegmatite (*see* Hussey and Moore, 2005). At a number of localities, the syenite contains irregular, medium-grained, hornblende + clinopyroxene + magnetite-rich monzogabbroic to monzodioritic bands or layers that are interlayered with syenite (Plate 1C). The syenite is crosscut at numerous localities by generally thin (< 2 m wide) irregular, anastomosing dykes of fine-grained hornblende + clinopyroxene + ilmenite + magnetite monzodiorite (Plate 1D). These dykes lack chill margins, but have relatively abrupt, locally scalloped and feathered contacts with the host syenite. They consist of (Plates 1D and 2C, D): *ca.* 45% feldspar consisting of abundant untwinned or simple twinned potassium feldspar with less

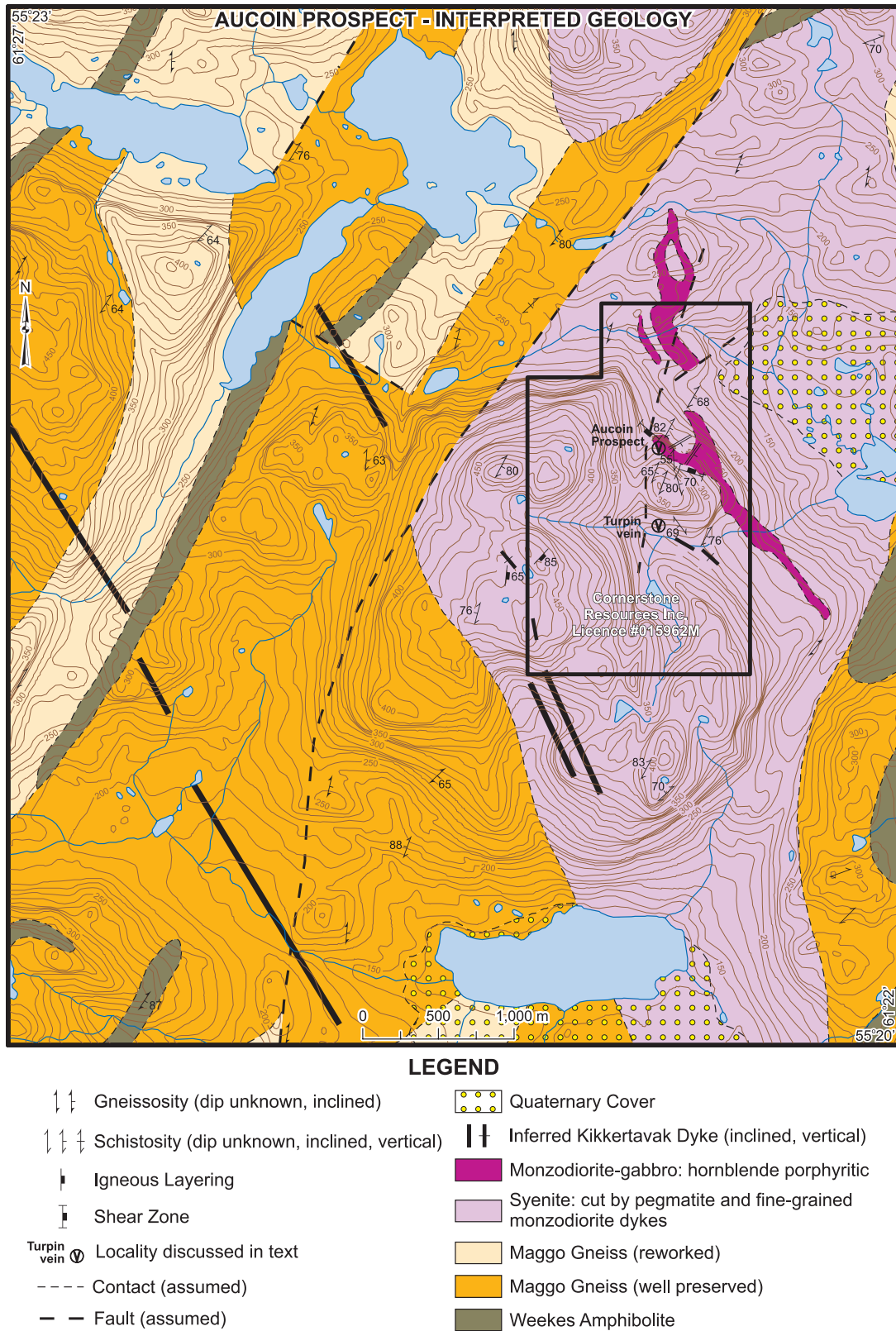


Figure 3. Simplified, compiled geological map of the area around the Aucoin prospect. Data sources include: Hill (1982); Thomas and Morrison (1991); Ermanovics (1993); Sandberg (1995); Lehtinen and Weber (1996); Lehtinen (1997); Dyke (2004); Hussey and Moore (2005, 2006a, b).

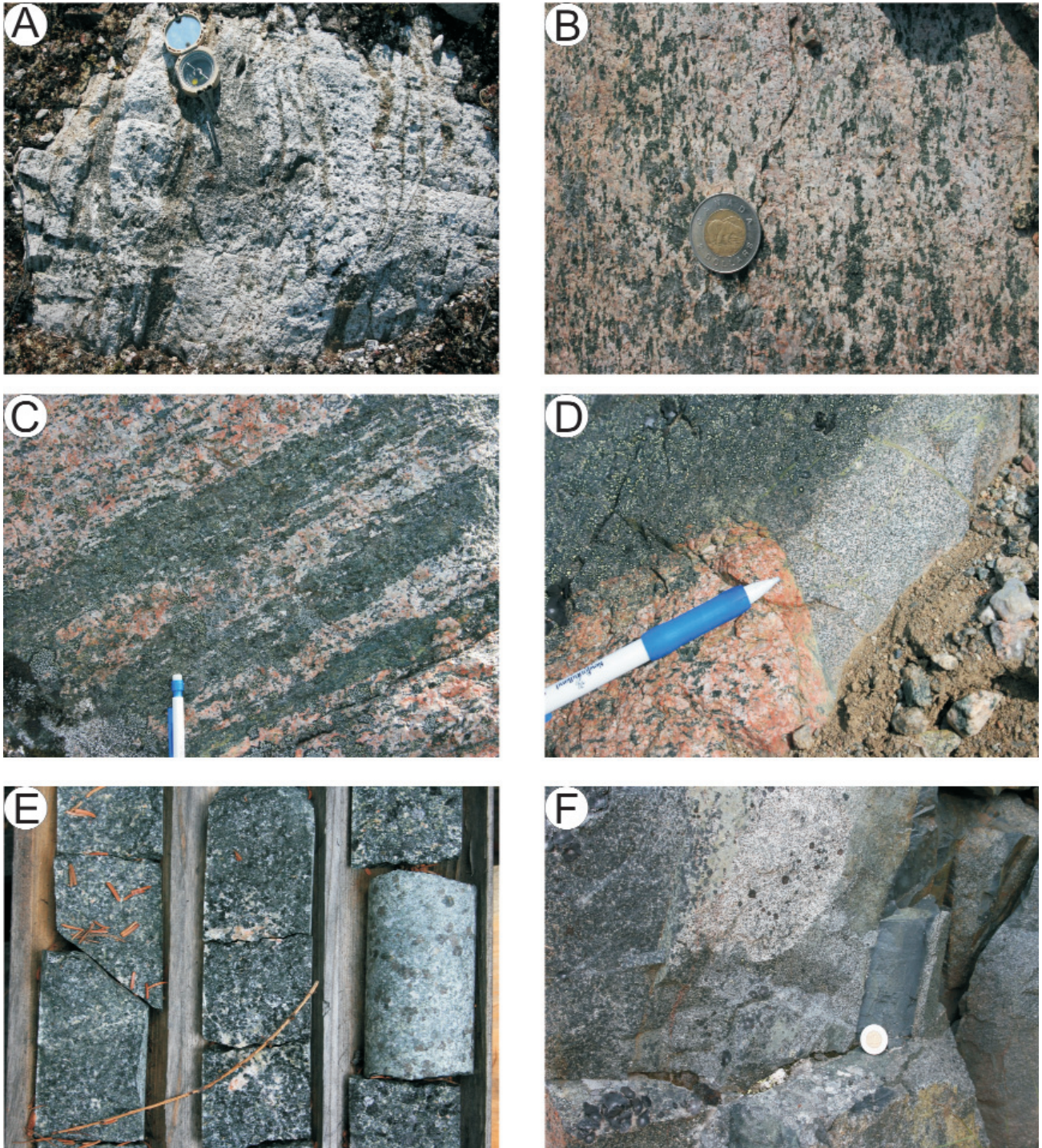


Plate 1. Photographs of representative fresh rock types exposed in the environs of the Aucoin property. A) Heterogeneous, amphibolite schlieren-bearing tonalitic Maggo orthogneiss exposed 3 km to the southeast of the Aucoin prospect (603466E, 6133247N). Brunton compass for scale is 15 cm in length. B) Weakly foliated, medium-grained hornblende $\pm$ clinopyroxene syenite (602373E, 6135855N). Two dollar coin is 28 mm in diameter. C) Medium-grained hornblende $\pm$ clinopyroxene syenite with hornblende $\pm$ clinopyroxene $\pm$ magnetite – rich lenses (601358E, 6135167N). Pencil is 14 cm long. D) Medium-grained hornblende $\pm$ clinopyroxene syenite cut by anastomosing irregular intrusions of fine-grained monzodiorite (601163E, 6134908N). Pencil is 14 cm long. E) Medium-grained hornblende porphyritic monzogabbro intersected in drillhole AR96-04, at 25 m depth (602423E, 6136069N). Core is 4 cm in diameter. F) Medium-grained syenite cut by fine-grained monzodiorite, both cut by a 6-cm-wide, black mafic diabase dyke having chill margins (602373E, 6135855N). Coin is 28 mm in diameter.

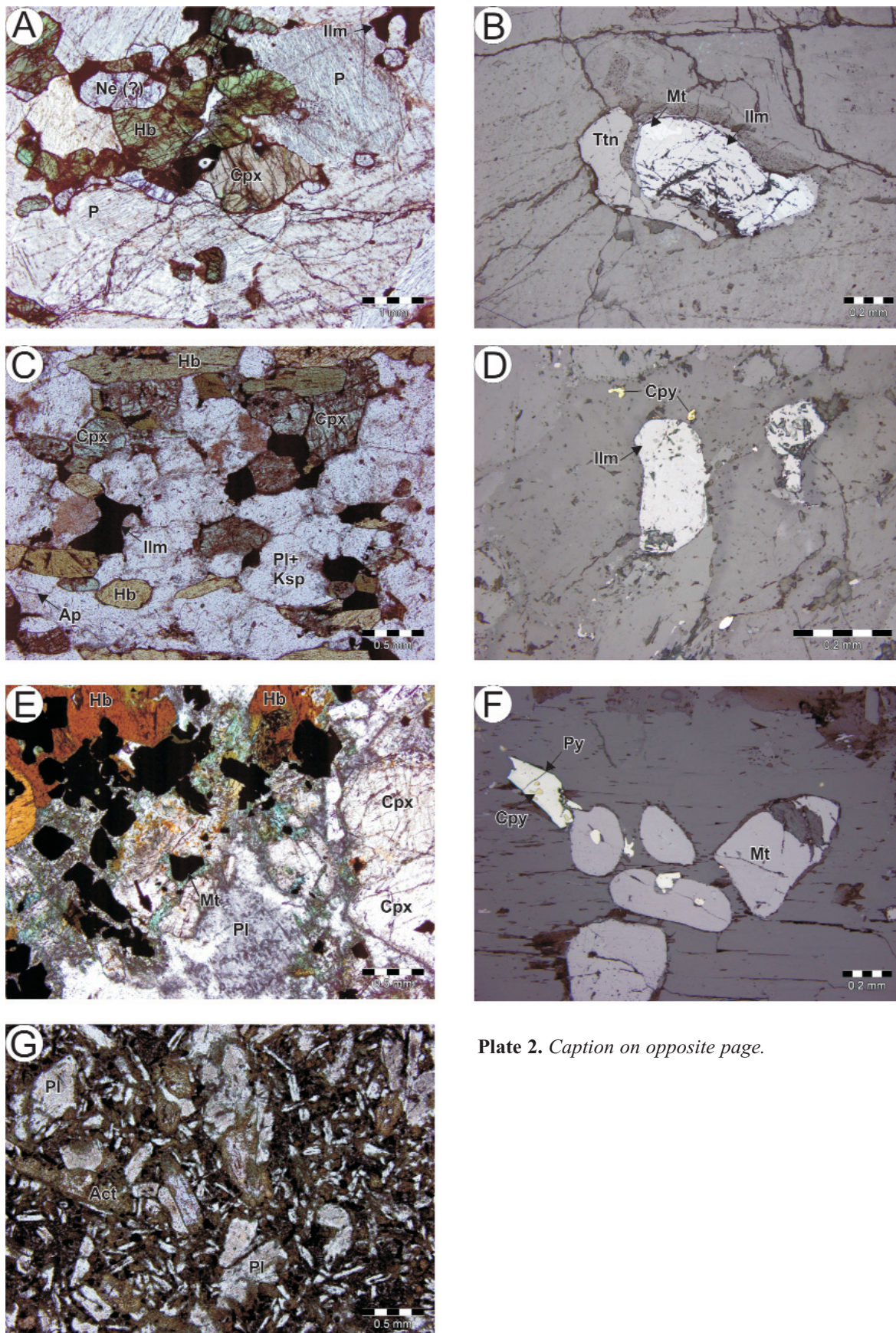


Plate 2. Caption on opposite page.

Plate 2. (opposite page) *Photomicrographs of representative rock types shown in Plate 1. A) Syenite in plane-polarized light (ppl) with abundant perthitic potassium feldspar (P), green hornblende (Hb), pink clinopyroxene (Cpx), magnetite-ilmenite (Ilm) and the high relief, low birefringent phase confirmed as apatite (Ap). B) Syenite in reflected light (rl) showing ilmenite (Ilm)- magnetite (Mt) intergrowth with a mantle of titanite (Ttn). C) Fine-grained monzodiorite in ppl with green clinopyroxene (Cpx), green-yellow pleochroic hornblende (Hb), and magnetite-ilmenite set in a matrix of intergrown plagioclase and potassium feldspar (Pl + Ksp). D) Fine-grained monzodiorite in rl showing ilmenite (Ilm)- magnetite intergrowth and small anhedral grains of chalcopyrite (Cpy). E) Monzodiorite in ppl with pophyritic, oikocrystic brown-green hornblende (Hb), finer grained equant pink clinopyroxene (Cpx), abundant magnetite (Mt), set in a fine-grained groundmass of plagioclase (Pl) and potassium feldspar. F) Monzodiorite in rl showing subhedral magnetite (Mt) grains with pyrite (Py) inclusions and subhedral pyrite with chalcopyrite (Cpy) inclusions. G) Fine-grained plagioclase (Pl) porphyritic diabase dyke in ppl with actinolite after clinopyroxene (Act).*

common lamellar-twinned plagioclase; *ca.* 20% elongate, euhedral, dark-green to pale-green, pleochroic hornblende; *ca.* 20% prismatic, pale-green to yellow clinopyroxene; *ca.* 10% anhedral grains of intergrown magnetite and ilmenite and; $\leq 5\%$ fine-grained, anhedral biotite. Short stubby apatite grains are the only obvious accessory mineral.

Immediately to the north and east of the prominent hill that hosts the Aucoin prospect and cropping-out at lower altitude is an irregular northwest-southeast-trending sill or sheet of medium-grained, green-black hornblende-porphyrritic monzodiorite grading to monzogabbro (Plates 1E and 2E, F). Large (≤ 6 mm) euhedral, poikilitic phenocrysts of brown-green hornblende have green mantles and are surrounded by a matrix consisting of euhedral, pink to pale-orange clinopyroxene (≤ 2 mm), abundant grains (≤ 2 mm) of subhedral magnetite, minor anhedral pyrite, trace chalcopyrite and, oikocrystic, lamellar-twinned plagioclase with less common potassium feldspar. Stubby euhedral apatite is the only other notable accessory phase. Examination of outcrops and drillcore indicate that the coarse-grained monzodiorite typically grades into the syenite. The contact zone between these two rock types contains the main quartz vein and chlorite + ankerite + epidote $\pm$ sericite alteration zone forming the Aucoin prospect.

All of the rock types discussed above are crosscut by two sets of green-black, near-vertical mafic dykes that have chilled margins (Plate 1F). The most prominent set of dykes trend south-southeast (*ca.* $150\text{--}120^\circ/90^\circ$) and consists of plagioclase porphyritic, actinolite (after clinopyroxene) + ilmenite + magnetite-bearing diabase (Plate 2G). These have been assigned to the Kikkertavak dyke swarm by Ermanovics (1993). A single southwest-trending ($230^\circ/80^\circ\text{NW}$) green dyke (≤ 25 cm wide) was noted by Hussey and Moore (2005), and suggests a probable second set of diabase dykes. The latter was not observed and whether these two distinct orientations of late dykes are contemporaneous is unknown.

In contrast to all of the other rocks described above, the contact zone between the syenite and monzodiorite is moderate to strongly schistose, trends $158/44^\circ\text{SW}$, and is characterized by abundant, generally schistosity-parallel, sigmoidal, white quartz veins (≤ 20 cm wide) that contain rare sulphides. The strongly altered and schistose unit containing most of the veins, and characterized by chlorite + ankerite + talc $\pm$ sericite assemblages was termed the chlorite-talc-sericite-carbonate schist by Ascot Resources Ltd. (CSSC: Sandberg, 1996; Lehtinen and Weber, 1996). The main alteration zone and comparable alteration occurs primarily within, but also above and below the CSSC and contains up to 10 to 15% disseminated euhedral pyrite along with minor chalcopyrite and galena. Rare visible wire gold has been reported from the sulphidic margins of some of these veins (Sandberg, 1995; Dyke, 2004).

MINERALIZATION AND ALTERATION

Most of veining and associated alteration occurs at or above the contact between the syenite and monzodiorite, in and adjacent to a schistose, fine-grained mafic rock unit (CSSC: Lehtinen and Weber, 1996). Alteration and minor veining also occurs in strongly carbonate-altered monzodiorite up to 10 m below the CSSC (Lehtinen and Weber, 1996). Using the depth and location data from the 8 drill-holes on the property, and on the basis of a three-point reconstruction, Lehtinen and Weber (1996) determined that the orientation of the CSSC is $158^\circ/44^\circ\text{SW}$. Lehtinen and Weber (1996) indicated that the CSSC was not exposed at surface, however, a strongly carbonate-altered, quartz-veined zone was observed at the surface, exposed *ca.* 100 m southeast of the Aucoin prospect (UTM 602477E, 6135905N). This zone trends *ca.* 288° and dips 76° north-east and may represent the surface exposure of the CSSC (Plate 3A), or alternatively a secondary shear zone. The difference in orientation between the projected CSSC unit of Lehtinen and Weber (1996) and the zone observed at surface may be an indication of a more complex, curvilinear geom-

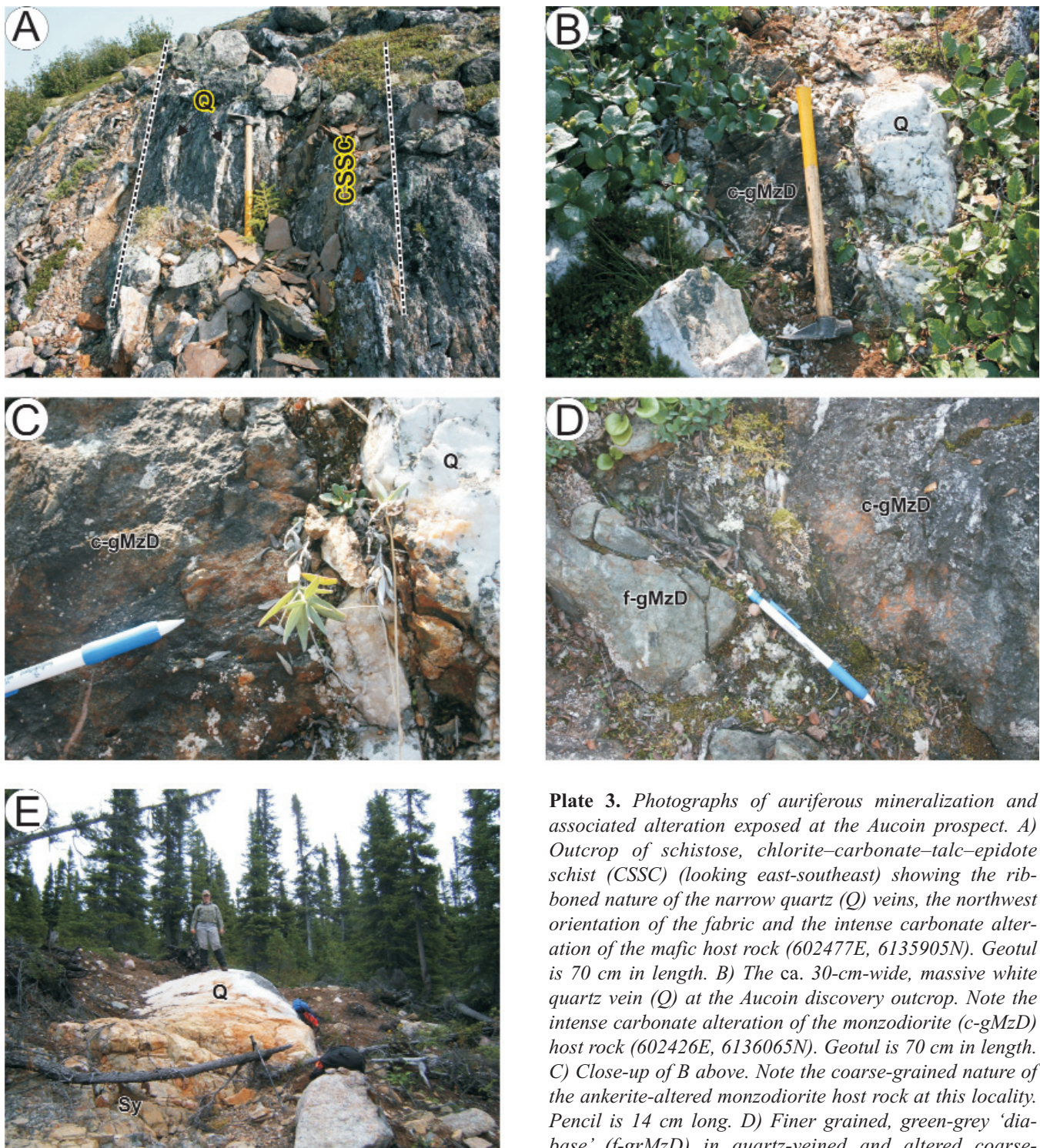


Plate 3. Photographs of auriferous mineralization and associated alteration exposed at the Aucoin prospect. A) Outcrop of schistose, chlorite-carbonate-talc-epidote schist (CSSC) (looking east-southeast) showing the ribboned nature of the narrow quartz (Q) veins, the northwest orientation of the fabric and the intense carbonate alteration of the mafic host rock (602477E, 6135905N). Geotul is 70 cm in length. B) The ca. 30-cm-wide, massive white quartz vein (Q) at the Aucoin discovery outcrop. Note the intense carbonate alteration of the monzodiorite (c-gMzD) host rock (602426E, 6136065N). Geotul is 70 cm in length. C) Close-up of B above. Note the coarse-grained nature of the ankerite-altered monzodiorite host rock at this locality. Pencil is 14 cm long. D) Finer grained, green-grey 'diabase' (f-grMzD) in quartz-veined and altered coarse-grained monzodiorite (c-gMzD). E) The partially exposed Turpin vein (Q) with syenite inclusions (Sy) looking north-east (602564E, 6135428N).

etry for the mineralized contact zone. Alternatively, it may represent a subsidiary, mineralized planar structure. Within the CSSC, are irregular, anastomosing, carbonate-altered, schistose, green-grey, locally salt and pepper coloured rocks (Plate 3D) that were interpreted as 'diabase' (Lehtinen and Weber, 1996). On the basis of examination of drillcore and a review of exploration drill logs, these are inferred to be fine-grained monzodiorite.

Quartz veins occur in 2 primary orientations. Deformed, thin (≤ 15 cm), discontinuous, ribboned and sigmoidal, white quartz veins generally parallel the northwest-trending fabric in the CSSC (Plate 3A). In contrast, wider (typically ≤ 60 cm) white and massive, north-northeast-trending quartz veins occur in syenite and monzodiorite to the southwest of the CSSC (Plate 3B, C). The host rock to the original Aucoin gold discovery is a strongly carbonate-altered and foliated monzodiorite. Petrography indicates that the schistose, fine-grained mafic rock (CSSC) noted at the Aucoin prospect and in drillcore is typically a schistose monzodiorite (Plate 4A, B). These samples are characterized by large (ca. 4 mm) anhedral, lamellar-twinned plagioclase grains having long recrystallized tails containing biotite, chlorite, plagioclase, ilmenite and carbonate (ankerite?). The ilmenite appears to be commonly altered to titanite and rutile. Groundmass minerals comprise mats of fine-grained, intergrown chlorite+carbonate+talc+ilmenite with common euhedral pyrite and trace chalcocopyrite. All are crosscut by curving, discontinuous and irregular quartz-carbonate veins, essentially mimicking relationships observed in outcrop. Precious metals occur as dispersed, tiny (≤ 30 μm) Ag-Au tellurides (petzite?: Ag_3AuTe_2) dispersed as inclusions in pyrite, chalcocopyrite or as minute grains (≤ 5 μm) of electrum in ilmenite altered to rutile (Plate 4C).

Irregular and anastomosing, discontinuous veins occur in syenite to the south and southeast of the Aucoin prospect and extend up to 600 m to the south-southeast. Adjacent to the veins, the syenite is typically reddened (hematized?) and intensely sericite + carbonate-altered and contains abundant euhedral pyrite with chalcocopyrite inclusions (Plate 4D, E). Sulphide minerals in the veins are typically restricted to the vein margins and the vein alteration haloes and comprise abundant pyrite (typically $\leq 10\%$) + chalcocopyrite $\pm$ galena.

Approximately 600 m to the southeast of the Aucoin prospect is the Turpin showing quartz vein (Figure 3, Plate 3E). Although the contacts with the country rocks have not been exposed, this vein is significantly wider than those at Aucoin as it is at least 2.5 m in width. Much of the Turpin vein is massive, bull-white quartz; however, pyrite, chalcocopyrite and galena concentrations locally occur immediately adjacent to altered syenite xenoliths. The xenoliths consist of strongly sericite + carbonate-altered syenite having

abundant anhedral pyrite and hematized magnetite (Plate 4F, G).

VISIBLE/INFRARED SPECTROMETRIC (VIRS) RESULTS

We have obtained VIRS results on 25 altered and unaltered rock samples from the Aucoin property. These are presented in Figure 4 and are discussed below in conjunction with petrographic observations. Background information on VIRS methods and their possible application in research are presented by Kerr *et al.* (*this volume*). Collectively, the composition of the alteration assemblage is variable and largely depends on the primary composition of the host rocks. Petrography indicates that alteration in syenite is dominated by sericite + ankerite $\pm$ chlorite $\pm$ epidote, whereas chlorite + ankerite + talc $\pm$ epidote assemblages predominate in the mafic rocks.

In Figure 4A, two distinct spectra are shown for quartz veins from the Aucoin prospect. Spectrum 'a' exhibits absorption features characteristic of carbonate minerals, whereas the more complex absorption patterns in spectrum 'b' indicate contributions from both carbonate and phengite. Figure 4B illustrates the differences in spectral absorption for fresh and altered monzodiorite samples. Spectrum 'a' shows only a minor Mg-chlorite response, whereas spectrum 'b' exhibits an absorption response from Mg chlorite and talc. Stacked spectra from variably altered syenite are displayed in Figure 4C and show a variation in the depth of absorption features at several diagnostic wavelengths. These wavelengths include ~ 1400 nm ($\text{H}_2\text{O}/\text{OH}$ feature), ~ 2200 nm (Al-OH feature: crystallinity of white mica), as well as ~ 2300 nm (Fe-Mg feature: reflection of chemical composition of chlorite, amphibole and epidote). The depths of these diagnostic absorption features are used in VIRS to identify the relative proportions of the main mineral constituents in a sample (Herrmann *et al.*, 2001). They can also be used to calculate alteration indices (van Ruitenbeek *et al.*, 2005) as vectors to mineralization, based on relative amounts of chlorite and white mica. A preliminary visual investigation of the stacked spectra illustrates a systematic variation in proportion of chlorites and white mica. This variation is also accompanied by the influence of the absorption features of calcium- and iron-bearing carbonate minerals. Whether this variation provides a 'proximity indicator' to mineralization, or is indicative of a broader alteration halo, remains to be seen.

DISCUSSION

The Aucoin prospect gold mineralization is hosted by hornblende $\pm$ clinopyroxene + ilmenite syenite, medium-grained, hornblende porphyritic, clinopyroxene + titanite +

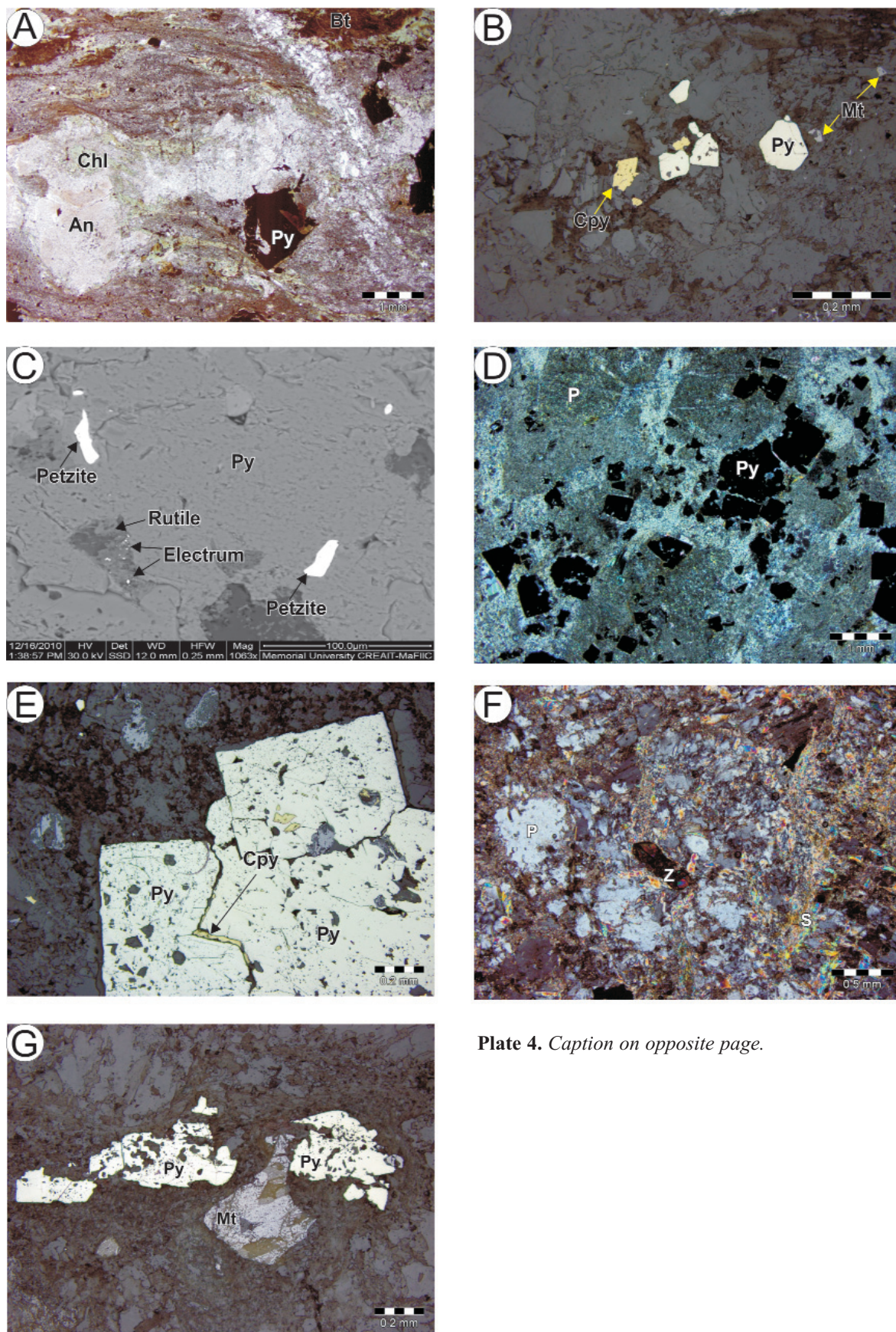


Plate 4. Caption on opposite page.

Plate 4. (opposite page) *Photomicrographs of mineralized samples. A) Altered monzodiorite host rock immediately adjacent to the vein in Plate 3B and C. Note the well-developed schistosity defined by biotite (Bt) and chlorite (Chl) along with subhedral pyrite (Py), set in a fine-grained matrix comprising chlorite + epidote + ankerite (An) + biotite. B) Euhedral pyrite and chalcopyrite in the altered monzodiorite. C) Backscatter electron image of a large pyrite with an inclusion of rutile after ilmenite. Note the ca. 30 μm Ag–Au–Te-bearing inclusions (petzite?) and minute (<5 μm) inclusions of electrum associated with rutile after ilmenite. D) Intensely altered syenite (602420E, 6026069N) in crossed nicols showing complete replacement of large alkali feldspar crystals (P) by sericite–ankerite and abundant euhedral pyrite (Py) and magnetite. The fine-grained groundmass comprises intergrown sericite + chlorite + ankerite. E) Large euhedral pyrite (Py) with chalcopyrite (Cpy) occurring as inclusions and along fractures. (F) Moderately sericite + carbonate + chlorite-altered syenite occurring as a xenolith in the Turpin vein (602564E, 6135428N). Note the large subhedral zircon (Z) at centre, remnant perthite (P) and abundant fine-grained sericite (S). G) Opaque minerals in reflected light comprise abundant anhedral, spongy textured pyrite (Py) and subhedral magnetite (Mt) that is locally altered to hematite (darker grey).*

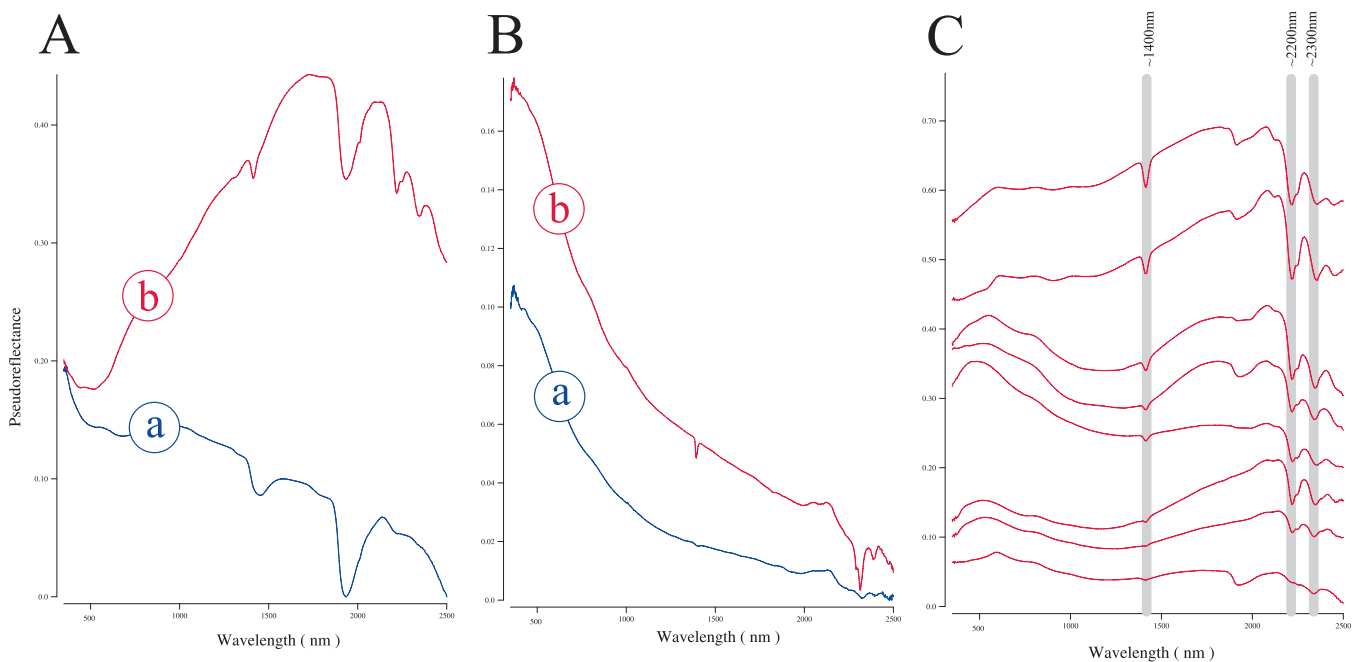


Figure 4: Representative VIRS spectra for rocks of the Aucoin prospect. A) Infrared spectra of quartz veins from the Aucoin area showing (a) carbonate absorption features and (b) mixed carbonate+phengite absorption features. B) Infrared spectra of fresh and altered monzodiorite from the Aucoin area showing Mg chlorite absorption features (a) in generally fresh versus Mg chlorite + talc absorption features (b) in altered monzodiorite. C) Infrared spectra of a range of altered syenite from the Aucoin area showing variation in the depth of absorption features at ~1400 nm wavelength (OH-H₂O), ~2200 nm wavelength (Al-OH) and ~2300 nm wavelength (Fe-Mg).

magnetite monzodiorite to gabbro and fine-grained hornblende + clinopyroxene + titanite + magnetite monzodiorite. In particular, mineralization and alteration is associated with a moderately schistose, chlorite + ankerite + talc $\pm$ epidote-rich, ribboned quartz vein-bearing, curvilinear contact zone between the syenite and medium-grained monzodiorite. The mineralized and sheared contact zone appears to trend south-southeast (158°) and to dip moderately to the south-southwest (44°; Lehtinen and Weber, 1996). The quartz veins exhibit two distinct orientations and styles: 1) thin (≤ 15 cm), numerous, southeast-trending, ribboned and sig-

moidal discontinuous quartz veins in the schistose mafic contact zone (CSSC) and; wider (≤ 60 cm), northeast-trending, massive white quartz veins that cut syenite, monzodiorite and schistose mafic rock of the CSSC. The simplest explanation for these vein systems involves the initiation of the northeast-trending, wider veins (060°/90°) as pinnate fractures in the hangingwall of the main CSSC shear zone (Hobbs *et al.*, 1976). These are filled with auriferous quartz, but continued shearing within the CSSC resulted in disruption of veins therein and the production of sinusoidal, dismembered and discontinuous veins in a strongly sheared

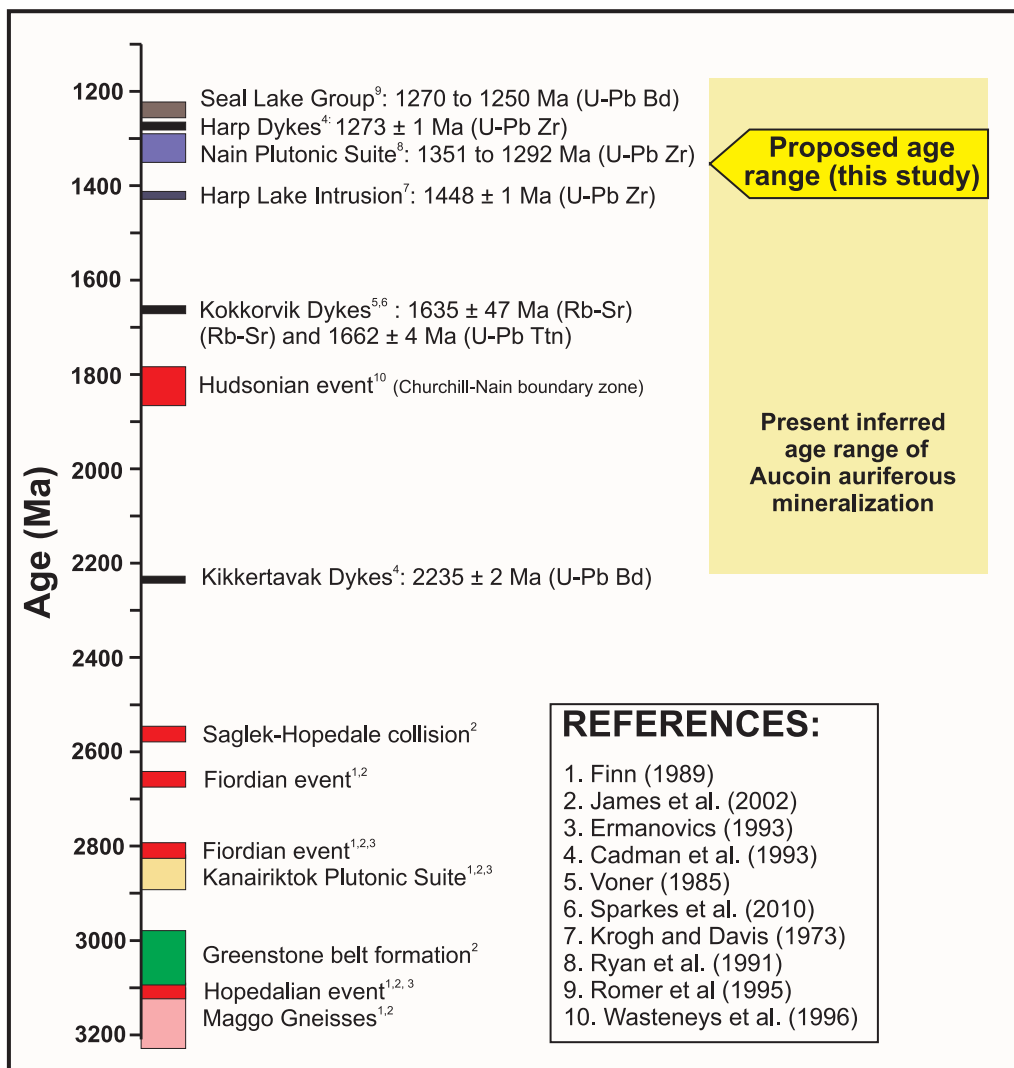


Figure 5. Geochronological summary diagram illustrating known constraints on crystallization ages and tectonothermal events recorded by rocks of the region. Inferred age ranges are based on the geological relationships described in the text. Key: Zr – zircon; Rb–Sr – rubidium–strontium whole-rock; Ttn – titanite; Bd – baddeleyite.

matrix. If this suggestion is correct, then this implies a component of dextral displacement along the CSSC, with the southwestward-lying syenite displaced to the northwest.

Elevated gold assay values are typically associated with sericite + chlorite + carbonate + pyrite alteration and sulphide-poor quartz veins cutting the syenite and, in an ankerite + chlorite + talc ± epidote-altered, pyritic and schistose mafic rock (CSSC) that is interpreted as altered and quartz-veined pyritic, hornblende porphyritic monzodiorite-gabbro (Sandberg, 1995). Alteration and anomalous gold concentrations are also reported from fine-grained, gabbroic bodies termed ‘diabase’ that were interpreted to be mineralized Kikkertavak dykes (Lehtinen and Weber, 1996; Lehtinen, 1997). Based on the geological observations and on the

description of the mineralized ‘diabase’ from drill-core (Lehtinen and Weber, 1996), this rock type is considered most probably to be fine-grained monzodiorite that is likely cogenetic with the syenite and medium-grained monzodiorite. Other fine-grained, green-black, weakly magnetic ‘mafic dykes’ described by Lehtinen and Weber (1996) are likely correlative with the planar, mafic dykes having chill margins, seen throughout the region, and inferred by others to correlate with the Kikkertavak dyke swarm (Cadman *et al.*, 1993; Ermanovics, 1993). A few northeast-trending planar diabase dykes have been noted (Lehtinen and Weber, 1996; Hussey and Moore, 2005) and may be members of the 1273 Ma Harp dyke swarm (Cadman *et al.*, 1993). Anomalous gold concentrations have been reported in quartz syenite pegmatite veins that crosscut the syenite (Hussey and Moore, 2006b). This observation may be particularly significant as it suggests more widespread elevated back-

ground Au, and perhaps a magmatic enrichment of gold (Hussey and Moore, 2005). This proposal will be tested using lithogeochemistry of representative altered and unaltered rocks from the property.

The age of mineralization at the Aucoin prospect is not known, however, a number of inferred geological and geochronological constraints, along with observations presented herein on the nature of the prospect, provide important considerations for further exploration in the region (Figure 5). The Aucoin mineralization was previously inferred to be hosted by Archean granitoid gneisses including the Maggo gneiss as well as younger Archean granodiorite and tonalite (Kanairiktok intrusive suite: Ermanovics, 1993; James *et al.*, 2002). These rocks range in age from *ca.* 3100

to 2850 Ma (Finn, 1989; Wasteneys *et al.*, 1996; James *et al.*, 2002) and are dominated by tonalite–granodiorite gneiss containing amphibolite inclusions and having polyphase tectonic and metamorphic fabrics. Archean granitoid rocks in the region are also typically strongly foliated (Taylor, 1977; Finn, 1989, 1991; Ermanovics, 1993; James *et al.*, 2002). These rock types are, however, petrologically distinct from the host rocks of the Aucoin prospect. The Archean gneissic granitoids are cut by 2235 Ma, vertical diabase dykes with chill margins that others have inferred to correlate with the regionally extensive Kikkertavak dyke swarm. Based on the presence of mineralized ‘*diabase dykes*’ the Aucoin mineralization was therefore inferred to be younger than the Kikkertavak dykes but likely Paleoproterozoic in age.

This contribution shows that the unaltered host rocks to the prospect are fresh, essentially pristine alkaline igneous rocks containing what appear to be alkali-element-rich igneous mineral phases. The syenite contains abundant perthitic alkali feldspar, common pale- to dark-green pleochroic hornblende and pink to pale-green clinopyroxene (aegerine–augite?) as well as common anhedral apatite. Medium- and fine-grained monzodiorite contains abundant brown-green hornblende, common pink to colourless clinopyroxene, plagioclase, potassium feldspar and abundant magnetite–ilmenite. The unaltered syenite locally preserves a weak foliation and/or lineation that might be a primary igneous fabric. This suggestion is supported by the presence of monzodioritic lenses and layers in the syenite (Plate 1C). The porphyritic monzodiorite–gabbro unit and the fine-grained monzodiorite are only foliated in proximity to intense ankerite + chlorite + epidote + pyrite alteration associated with the CSSC. These fresh alkaline host rocks more closely resemble the ‘*intermediate*’ diorite–monzonite–syenite assemblages of the NPS (Hill, 1982; Thomas and Morrison, 1991; Sandberg, 1995), examples of which are exposed only *ca.* 8 km to the north of the Aucoin prospect.

The age of the northwest-trending planar diabase dykes is critical to understanding the history of the Aucoin prospect as they crosscut the host syenite and monzodiorite. If these correlate with the Kikkertavak dyke swarm, then the syenite and monzodiorite must be older than 2235 ± 2 Ma (Cadman *et al.*, 1993). However, if these dykes are not correlative with the Kikkertavak dyke swarm, then they may be representatives of an unusually oriented set of Harp dykes, or a younger, previously unrecognized suite of dykes. The mafic dykes might be cone-sheet-like dykes associated with the Harp Lake Complex or perhaps distal radial dykes associated with the Seal Lake Group (Romer *et al.*, 1995). It is typically difficult to obtain precise U–Pb geochronological data for mafic dykes, and the syenite itself presents a more

obvious target for U–Pb geochronology. It is important to note, however, that whatever the age of the host rock, the auriferous quartz veins and their associated alteration occur in spatial and temporal relationship with a late, crosscutting, southeast- to northwest-trending quartz-veined and altered shear zone (CSSC). ^{40}Ar – ^{39}Ar age determinations on abundant white mica in altered syenite proximal to the veins could further provide a minimum age for the auriferous mineralization. The noted Au, Ag and Te association in mineralized samples, along with elevated gold in fractionated quartz syenite pegmatite veins, suggests a possible primary magmatic link between the mineralization and their alkaline host rocks (Zhang and Spry, 1994). It is hoped that documentation of the Aucoin prospect and further geoscientific studies may promote greater interest in exploring for gold in Labrador.

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REFERENCES

- Brooks, C.
1982: Third report on the geochronology of Labrador pertaining to sub-project 109. Newfoundland Department of Mines and Energy, Open File Labrador 519.
- 1983: U–Pb geochronological ages. A report to Energy Mines and Resources concerning contract No. 1. EMP-MMD-82-0052 and amendment No. 1. Open File Labrador 519.
- Cadman, A.C., Heaman, L., Tarney, J., Wardle, R. and Krogh, T.E.
1993: U–Pb geochronology and geochemical variation within two Proterozoic mafic dyke swarms, Labrador. Canadian Journal of Earth Sciences, Volume 30, pages 1490–1504.
- Dyke, B.
2004: Assessment report of lake sediment sampling,

- prospecting and rock sampling on Licences 8482M (2nd year), 9692M (1st year) and 9693M (1st year) Aucoin Property, NTS 13N/06, eastern Labrador, NL. NFLD 013N/06/0123.
- Dyke, B. and Hussey, A.M.
2003: First year assessment report on compilation, prospecting and rock sampling on the Aucoin project Licence 8482M, NTS 13N/06, eastern Labrador, NL. NFLD 013N/06/0121.
- Emslie, R.F.
1980: Geology and petrology of the Harp Lake Complex, central Labrador: an example of Elsonian magmatism. Geological Survey of Canada, Bulletin 293, 136 pages.
- Ermanovics, I.
1993: Geology of Hopedale Block, southern Nain Province, and the adjacent Proterozoic terranes, Labrador, Newfoundland. Geological Survey of Canada, Memoir 431, 161 pages.
- Finn, G.C.
1989: Rb-Sr geochronology of the Archaean Maggo gneiss from the Hopedale block, Nain Province, Labrador. Canadian Journal of Earth Sciences, Volume 26, pages 2512-2522.

1991: Major-, trace-, and rare-earth-element geochemistry of the Archaean Maggo gneisses, southern Nain Province, Labrador. Canadian Journal of Earth Sciences, Volume 28, pages 44-57.
- Herrmann, W., Blake, M., Doyle, M., Huston, D., Kamprad, J., Merry, N. and Pontual, S.
2001: Short wavelength infrared (SWIR) spectral analysis of hydrothermal alteration zones associated with base metal sulphide deposits at Rosebery and Western Tharsis, Tasmania, and Highway-Reward, Queensland. Economic Geology, Volume 96, pages 939-955.
- Hill, J.D.
1982: Geology of the Flowers River – Notakwanon River area, Labrador. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 82-6, 140 pages.
- Hobbs, B.E., Means, W.D. and Williams, P.F.
1976: An Outline of Structural Geology. John Wiley and Sons Inc., Toronto.
- Hornbrook, E.H.W., Maurice, Y.T. and Lynch, J.J.
1978: Regional lake sediment and water geochemical reconnaissance data, central Labrador (NTS 13N). Geological Survey of Canada, Open File 558.
- Hussey, A.M. and Moore, P.J.
2005: Assessment report of geology and lithogeochemistry on Licences 8482M (3rd yr.) and 9692M & 9693M (1st yr. supplementary), Aucoin Property, NTS 13N/06, Labrador. NFLD 013N/06/0129.

2006a: Fourth year assessment report of geology and geochemistry on mineral licence 8482M, Aucoin Property, NTS 13N/06, Labrador. NFLD 013N/06/0130.

2006b: Fifth year assessment report of geology and geochemistry on mineral licence 8482M, Aucoin Property, NTS 13N/06, Labrador. NFLD 013N/06/0131.
- James, D.T., Kamo, S. and Trogh, T.
2002: Evolution of 3.1 and 3.0 Ga volcanic belts and a new thermotectonic model for the Hopedale Block, North Atlantic craton (Canada). Canadian Journal of Earth Sciences, Volume 39, pages 687-710.
- Kerr, A., Rafuse, H., Sparkes, G., Hinchey, J. and Sandeman, H.
This volume: Visible/infrared spectrometry (VIRS) as a research tool in economic geology: Background and pilot studies.
- Krogh, T.E.
1993: Report on Labrador geochronology, 1992-93. Newfoundland Department of Mines and Energy, Geological Survey Branch, Open File Labrador 997.
- Krogh, T.E. and Davis, G.L.
1973: The significance of inherited zircons on the age and origin of igneous rocks – an investigation of the ages of the Labrador adamellites. Carnegie Institute of Washington Yearbook, Volume 72, pages 610-613.
- Lehtinen, J.
1997: Geological, geophysical, geochemical and prospecting report on mineral licences 3895M and 5637M, Labrador (NTS 13N/5 and 13N/6). NFLD 013N/06/0079.
- Lehtinen, J. and Weber, J.S.
1996: Geological, geophysical, geochemical and diamond drilling report on the Aucoin showing Ascot Property, Labrador (NTS 13N/05, 13N/06, mineral

- licence 3895M, 3896M & 4663M). NFLD 013N/06/0113.
- Romer, R.L., Scharer, U., Wardle, R.J. and Wilton, D.H.T.
1995: U-Pb age of the Seal Lake Group, Labrador: relationship to Mesoproterozoic extension-related magmatism of Laurasia. *Canadian Journal of Earth Sciences*, Volume 32, pages 1401-1410.
- Ryan, B.
1998: The Mesoproterozoic Nain Plutonic Suite in eastern Canada, and the setting of the Voisey's Bay Ni-Cu-Co deposit. *Geoscience Canada*, Volume 24, pages 173-188.
- Ryan, B. (*Compiler*), Krogh, T.E., Heaman, L., Schärer, U., Philippe, S. and Oliver, G.
1991: On recent geochronological studies in the Nain Province and Nain Plutonic Suite, north-central Labrador. *In Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch*, Report 91-1, pages 257-261.
- Sandberg, T.
1995: Report on prospecting program on map licences 3895M and 3896M, Labrador (NTS 13N/5 and 13N/6). NFLD LAB1147.
- Skanes, M., Kerr, A. and Sylvester, P.J.
2004: The VBE-2 gold prospect, northern Labrador: geology, petrology and mineral geochemistry. *In Current Research. Newfoundland Department of Mines and Energy, Geological Survey*, Report 04-1, pages 43-61.
- Sparkes, G.W., Dunning, G.R. and McNicoll, V.J.
2010: New U-Pb age constraints and potential implications for the genesis of the Kitts uranium deposit, Central Mineral Belt, Labrador. *In Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey*, Report 10-1, pages 93-109.
- Taylor, F.C. (*compiler*)
1977: Geology, Hopedale, Newfoundland. Map 1443A. Scale: 1:250 000. Geological Survey of Canada. Colour map. GS# 013N/0009.
- Teskey, D.J., Dods, S.D. and Hood, P.J.
1982: Compilation techniques for the 1:1 million magnetic anomaly map series. *In Current Research, Part A. Geological Survey of Canada, Paper 82-1A*, pages 351-358.
- Thomas, A. and Morrison, R.S.
1991: Geological map of the central part of the Ugjoktok River (NTS 13N/5 and parts of 13M/8, and 13N/6), Labrador (with accompanying notes). Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey Branch, Map 91-160.
- van Nostrand, T.S.
2009: Geology of the Seal Lake Group, central Labrador (Parts of NTS map areas 13K/5 and 6). *In Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey*, Report 09-1, pages 249-270.
- van Nostrand, T.S. and Lowe, D.
2010: Geology of the Seal Lake area, central Labrador (Parts of NTS map areas 13K/3, 4, 5 and 6). *In Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey*, Report 10-1, pages 351-371.
- van Ruitenbeek, F.J.A., Cudahy, T., Hale, M. and van der Meer, F.D.
2005: Tracing fluid pathways in fossil hydrothermal systems with near-infrared spectroscopy. *Geology*, Volume 33, pages 597-600.
- Voner, F.R.
1985: Crustal evolution of the Hopedale block, Labrador, Canada. Unpublished Ph.D. dissertation. Miami University, Oxford, Ohio, 136 pages.
- Wasteneys, H., Wardle, R., Krogh, T. and Ermanovics, I.
1996: U-Pb geochronological constraints on the deposition of the Ingrid Group and implications for the Saglek-Hopedale and Nain craton – Torngat orogen boundaries. *In Eastern Canadian Shield Onshore-Offshore Transect (ECSOOT). Compiled by R.J. Wardle and J. Hall. The University of British Columbia, Lithoprobe Secretariat*, Report 57, pages 212-228.
- Zhang, X. and Spry, P.G.
1994: Petrological, mineralogical, fluid inclusion, and stable isotope studies of the Gies gold-silver-telluride deposit, Judith Mountains, Montana. *Economic Geology*, Volume 89, pages 602-627.

