Geological Setting of Mineral Occurrences in the Second Gold Brook Area, Southwestern Cape Breton Highlands, Nova Scotia

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Introduction

The area around Second Gold Brook (Fig. 1) has been a focus of mineral exploration and gold mining activity since the late 1800s, but reports derived from this work provide conflicting information about the nature of the occurrences and their host rocks (e.g. DeMont, 1996; Grant, 1997). The lack of geological information makes the economic potential difficult to assess. Metasedimentary and metavolcanic rocks in the area were assigned to the Precambrian George River Group by Milligan (1970) and Delahay (1979), and later to the Silurian Sarach Brook Metamorphic Suite by Jamieson and Doucet (1983) and Barr et al. (1992). Subsequent mapping in the southwestern highlands by Horne (1995) and O'Neill (1996) did not include the Second Gold Brook area.

Hence, a study of the Second Gold Brook area was undertaken as a B.Sc. Honours thesis project (Chew, 2017) with the goals of better characterizing the rock types and investigating their relation to other units in the southern Cape Breton Highlands. The study also aimed to investigate the mineral occurrences in the area, especially in the area around the mine site on Second Gold Brook.

Methods

During the current study, rivers and brooks in the study area were systematically traversed and outcrops examined. About 150 samples were collected, of which 85 were thin sectioned for petrographic study. Twenty-one igneous and meta-igneous samples were analyzed by X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) at Bureau Veritas Commodities Canada Ltd., Vancouver, B.C. In addition, all samples were analyzed using a Reflex portable XRF unit to obtain a larger chemical database focused mainly on elements of economic interest.

Geological Setting

The study area is mostly underlain by interlayered metavolcanic and clastic metasedimentary rocks. Following previous workers, including O'Neill (1996) who mapped in the MacDonald Brook area to the south (Fig. 1), these rocks are assigned to the Sarach Brook Metamorphic Suite (Fig. 1). The Silurian age for the Sarach Brook Metamorphic Suite is based on a U-Pb zircon date of 433 +7/-4 Ma from rhyolite in the central Cape Breton Highlands (Barr and Jamieson, 1991). The Sarach Brook Metamorphic Suite in the study area is bounded on the north by higher grade metamorphic rocks of the Middle River Metamorphic Suite (Fig. 1). An abrupt increase in metamorphic grade and abundance of pegmatite, aplite, and granodiorite indicate that the contact is a fault, as also suggested by previous workers (Delahay, 1979; Jamieson and Doucet, 1983).

In the eastern part of thee study area the Sarach Brook Metamorphic Suite is intruded on the east by granite assigned to the Devonian Bothan Brook pluton (O'Neill, 1996). The Devonian age for the pluton is based on a U-Pb (zircon) date of 376 ± 3 Ma from the central highlands reported by Horne et al. (2003). South of MacDonald Brook (Fig. 1), the Sarach Brook Metamorphic Suite is in sheared contact with dioritic and granitic rocks of the Devonian or older Gillis Brook diorite and Leonard MacLeod Brook plutonic suite (O'Neill, 1996).

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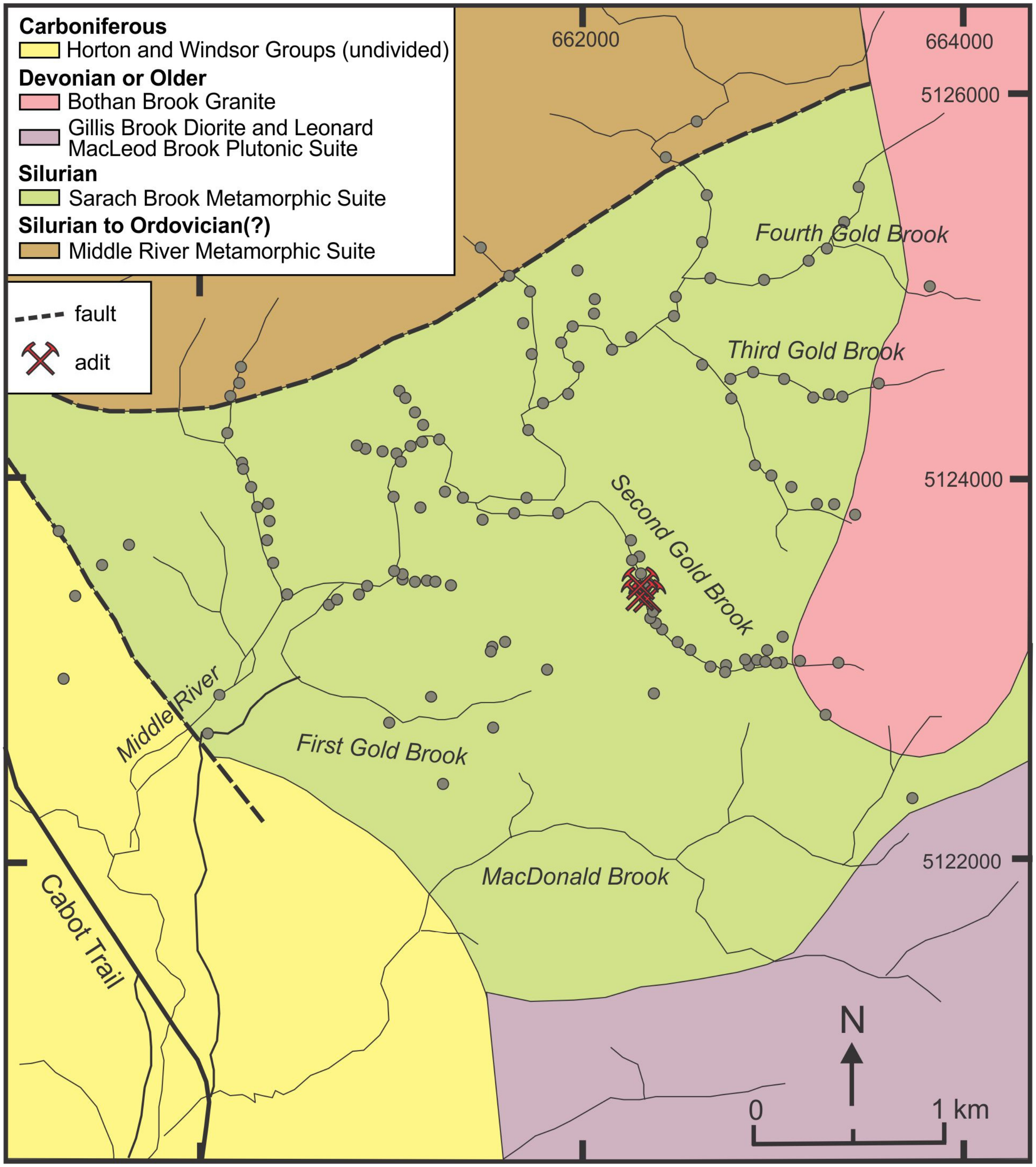

Figure 1. Geological map of the Second Gold Brook area after Jamieson and Doucet (1983), O'Neill (1996), and the present study. Circles indicate sample locations.

Carboniferous sedimentary rocks unconformably overlie or are in faulted contact with the older rocks on the west and southwest. This study focused on the Sarach Brook Metamorphic Suite and the Bothan Brook pluton (Fig. 1).

Sarach Brook Metamorphic Suite (SBMS)

The metavolcanic rocks in the SBMS are mainly mafic, and increase in abundance relative to metasedimentary rocks from southeast to northwest across the map area. Felsic metavolcanic rocks are minor and consist of rhyolitic tuff.

Metasedimentary rocks include fine- to medium-grained quartzite, slate, phyllite and schist. Metamorphic grade generally increases from southeast to northwest across the area, as indicated by increasing grain size and abundance of amphibole in mafic rocks and biotite and garnet in metasedimentary rocks, consistent with the petrographic observations of Delahay (1979). Bedding and foliation are generally parallel, and foliation is typically better developed in metasedimentary than in metavolcanic units, which appear more massive. The bedding and foliation trends are mainly northeast - southwest with moderate dips to the northwest.

Primary igneous features are not generally preserved, but because the metavolcanic rocks are interlayered with metasedimentary rocks, their protoliths are assumed to have been mainly basaltic flows and tuffs, but some were fine-grained gabbroic sills that in places preserve evidence of relict chilled margins. Individual mafic layers vary from less than 1 m to tens of metres in thickness. Dominant minerals in mafic rocks are amphibole, plagioclase and biotite in a finer-grained matrix of recrystallized plagioclase, quartz and magnetite. Some tuffaceous rocks locally preserve primary layering and contain elongate basaltic lithic fragments and feldspar crystals; fine-grained rocks may represent metamorphosed mafic ash deposits.

Interlayered phyllite and slate make up most of the metasedimentary rocks. Both are thinly laminated and cleavage is typically crenulated. Less abundant feldspathic quartzite to quartzite is fine- to medium-grained and weakly foliated parallel to bedding. The quartzite consists predominantly of quartz (75% – 95%) with varying amounts of feldspar and chlorite. Some samples from the northern part of the study area contain biotite and garnet. Metaconglomerate occurs rarely throughout the study area but the thickest layer is near the Second Gold Brook mineral occurrences where conglomerate forms a 15 m-wide bed (e.g. Delahay, 1979). Clasts include elongate quartzite, feldspathic quartzite, phyllite and slate, together with abundant quartz and feldspar crystals in a fine-grained muscovite-rich phyllitic matrix. In other places the metaconglomeratic beds are thinner (<1 m) and clasts are dominated by elongate banded rhyolite and basalt. The clasts appear to have been locally sourced and hence the conglomerate layers are likely intraformational.

Chemical characteristics of the mafic metavolcanic rocks indicate that they are tholeiitic and display both MORB and volcanic-arc signatures. Their chemical signatures combined with abundance of interlayered quartz-rich sedimentary rocks suggests that they may have formed in a back-arc setting with access to continental sediment sources. A felsic metavolcanic sample has chemical characteristics of a within-plate tectonic setting. The chemistry is similar to that of mafic and felsic volcanic rocks in the SBMS farther north (Barr and Jamieson, 1991; Lister, 1997).

Bothan Brook Pluton

The Bothan Brook pluton in the study area is pinkish-red, coarse-grained monzogranite, dominated by approximately equal amounts of alkali feldspar (orthoclase), quartz and plagioclase. Texture is allotriomorphic granular, with interstitial granophyre in some samples. Biotite forms <10% and is partly altered to chlorite. The quartz shows undulatory extinction with some evidence of recrystallization. Five analyzed samples are chemically similar to samples from the main body of the pluton in the central highlands to the north (O'Beirne-Ryan and Jamieson, 1986). The granite was emplaced in a volcanic-arc to syn-collisional tectonic setting.

Mineralization

Historical work in the area included panning and sluicing, which led to the development of five adits and one shaft on Second Gold Brook (DeMont, 1996). According to the Nova Scotia Department of Natural Resources drillhole database, 30 holes have been drilled in the area; logs are available for 24 holes but no core samples. Overall, the core was described in the logs as consisting of metasedimentary rocks (phyllite, slate, schist, quartzite, conglomerate and metagreywacke) and meta-igneous rocks (altered diorite, porphyry and granite), with little sulphide mineralization and only minor gold and copper (Holbrook, 1962; Johnson, 1982; Morris, 1986; Johnson, 1998). One occurrence of massive mineralization was reported, a thin vein of pyrrhotite in a rock described rather enigmatically by Holbrook (1962) as “an altered diorite to talc, serpentinized biotitic schist”.

Documentation of mineral occurrences was intended to be a significant component of the present study; however, little evidence was observed for such occurrences. No gold was observed in either quartz veins or host rocks and sulphide minerals are a minor component, both as observed in the field and in slabbed hand samples. Two massive sulphide samples containing pyrrhotite, chalcopyrite, pyrite, pentlandite, sphalerite and galena were found in mine waste piles in Second Gold Brook near the southernmost adit (Fig. 1), but none were found in outcrop. Analysis of the two samples with the portable XRF showed low SiO_2 (average 5.6%) and high FeO^t (73.7 % and 55.8%), consistent with the high content of sulphide minerals. Both samples have somewhat elevated Cr (272 and 254 ppm). One of the samples revealed 7886 ppm Ni, 18 140 ppm Cu, 677 ppm Pb and 770 ppm Zn. The second sample is more weathered and has lower metal abundances. Although potentially of economic significance, the geological setting of these samples is unknown.

Analyses of 150 samples representing all rock types in the study area by portable XRF showed low background levels of Cu, Pb, Zn, and Ni in the metavolcanic and metasedimentary rocks as well as in quartz veins and plutonic units. The highest levels were obtained in samples from the area of historical mining, drilling, and exploration in Second Gold Brook, which may suggest that the economic mineralization is confined to that area.

Samples from an altered diorite dyke(?) in Second Gold Brook may represent the altered diorite previously described as hosting massive sulphides but samples contain only minor disseminated pyrrhotite, pyrite, chalcopyrite, pentlandite and sphalerite, and generally low metal levels (538 ppm Cu and 211 ppm Ni). Hence, little evidence was found for earlier interpretations that the altered diorite plays a significant role in mineralization in the Second Gold Brook area.

Eleven quartz vein samples were analyzed using the portable XRF, of which only four (all from the area of historical mining activity) have elevated (over 250 ppm) metal concentrations, with Cu up to 3632 ppm, Pb up to 3147 ppm, and Zn up to 1121 ppm.

Regional Correlations

This study corroborated the observation by Barr and Jamieson (1991) that the SBMS in the Second Gold Brook area consists mainly of metasedimentary and interlayered metabasic rocks, in contrast to the main part of the unit to the northeast which is dominated by felsic crystal-lithic tuff, epiclastic volcanogenic sedimentary rocks, and minor flow-banded rhyolite. Lister (1998) confirmed that pyroclastic rocks are dominant in the eastern area, with dacitic tuff most abundant, as well as fine-grained, light pink, finely layered rhyolitic tuff. Basaltic to andesitic flows are subordinate. Interbedded metasedimentary rocks are dominantly metasiltstone with minor amounts of black slate and biotite schist; overall, the metasedimentary rocks seem finer grained than in the study area, where quartzite to feldspathic quartzite is a significant component. Hence the relationship between rocks in the study area and the main part of the SBMS remains to be investigated.

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