INDICATOR MINERAL AND GEOCHEMICAL SIGNATURES ASSOCIATED WITH THE SISSON W-Mo DEPOSIT, NEW BRUNSWICK, CANADA

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Introduction

The undeveloped Sisson W-Mo deposit in eastern Canada was used to test and demonstrate modern surficial exploration methods for intrusion-hosted W-Mo deposits. The study was carried out as part of the Geological Survey of Canada's (GSC) Targeted Geoscience Initiative 4, a collaborative federal geoscience program with a mandate to provide industry with the next generation of geoscience knowledge and innovative techniques for more effective targeting of buried mineral deposits. It was a collaborative effort between the GSC, the New Brunswick Department of Energy and Mines (NBDEM), Northcliff Resources Ltd., Hunter Dickinson Inc., and Laurentian University. This abstract provides an overview of the mineralogical and geochemical studies of surficial media collected around the deposit. The focus of the study was indicator minerals and till geochemistry, with additional information provided by a small suite of stream sediment and stream water samples.

Geology

The bedrock geology of the Sisson deposit area is summarized below from Nast and William-Jones (1991), Marr (2009), Fyffe et al. (2008, 2010), Rennie et al. (2013) and Bustard et al. (2013). The deposit occurs at the eastern contact of the Nashwaak Granite and Howard Peak Granodiorite plutons (Fig. 1) with Ordovician volcanic and sedimentary rocks and Cambro-Ordovician sedimentary rocks to the east. The Sisson deposit is a bulk tonnage W-Mo intrusion-related deposit that consists of four wide and steeply dipping zones of vein and fracture-controlled W and Mo mineralization that straddle the strongly sheared eastern contact of the Howard Peak Granodiorite. Mineralization is likely related to the presence of a buried granitic stock at depth, which was the heat source for a hydrothermal system and metals. The deposit has elevated concentrations of Cu, Zn, Pb, Bi, and As that are directly related to late quartz-scheelite and sulphide-rich veins. Ore minerals in the deposit include scheelite, molybdenite, and minor wolframite. A small high-grade Pb-Zn-Ag-Sb occurrence (Fig. 1), the Nashwaak occurrence, subcrops under thin till ~900 m east of the Sisson deposit and has been interpreted to be a vein-type showing related to the Sisson mineralizing system.

Bedrock outcrops in the Sisson area are rare due to the locally thick and continuous cover of till that varies from <2 m to 20 m in thickness. Surface till in the area is a sandy Early Wisconsinan lodgement till likely deposited by southeast glacial flow, and possibly reworked by south-southwest glacial flow during the Middle to Late Wisconsinan (Escuminac Phase). A discontinuous and thin (0.2 to 2.5 m) very loose and very sandy till, deposited by westward flowing ice during the Younger Dryas, overlies the Early Wisconsinan till in a few places (Seaman & McCoy 2008; Fyffe et al. 2010; Stea et al. 2011). Previous reconnaissance-scale till geochemical surveys in the region identified a 40 km long glacial dispersal train trending southeast from the deposit that was best defined by W, As, Bi, Cd, Cs, Cu, In, Mo, Sn, and Zn in till (Snow & Coker 1987; Lamothe 1992; Seaman & McCoy 2008; Seaman 2012). Regional scale stream sediment surveys were conducted over NTS map sheets 21J/07 and 21J/06 by the GSC which includes the Sisson deposit area and these show obvious elevated values of W and Mo in stream silt samples immediately downstream of the Sisson deposit (Friske et al. 2002; Pronk et al. 1997).

Methods

Sample locations, site descriptions, photographs, and sample depth information are reported in McClenaghan (2013a,b). A total of 61 surface till samples were collected from freshly dug trenches, road cuts, and hand-dug holes around and within the first 14 km of the known glacial dispersal train to optimize the chances of sampling metal-rich till at varying distances down ice. At each site, three till samples were collected: (1) 8 to 15 kg sample for recovery of indicator minerals; (2) 3 kg sample for geochemical analysis of the till matrix, till textural determinations and archiving; and, (3) 200 g sample for in-field testing using a portable XRF to help guide till sampling on a daily basis. The indicator mineral content of mineralized and host rocks were examined in polished thin section and heavy mineral concentrates to determine their potential mineral contributions to the till.

A limited number of stream sediment and stream water samples were collected around the deposit to compare with signatures in till. At each of the 16 sites, three samples were collected: (1) a 9 to 14 kg stream sediments for the recovery of indicator minerals; (2) a 200 g fine grained (silt+fine sand) stream sediment to be sieved to <0.177 mmm for geochemical analysis and archiving; and, (3) a 60 ml filtered stream water sample for geochemical analysis.

Detailed descriptions of till, stream sediment and stream water analytical methods, monitoring of analytical accuracy and precision and data listings are reported in McClenaghan et al. (2013b, in press). The <0.063 mm fraction of till was analyzed using 1:1 aqua regia/ICP-MS on 0.5 g, and lithium metaborate/tetraborate fusion followed by nitric acid digestion/ICP-ES, ICP-MS on 0.2 g. To provide a regional context in which to interpret the new till geochemical data for the Sisson area, the archived <0.063 mm fraction of 39 till samples, previously analyzed by NBDEM as part of their regional surveys, were re-analyzed as part of this study. The <0.177 mm fraction of stream sediment was analyzed using INAA on a 30 g aliquot and 1:1 aqua regia/ICP-MS on a 0.5 g aliquot. Filtered water samples were acidified and analyzed at GSC for trace elements by ICP-MS and major elements by ICP-ES.

Bedrock, till, and stream sediment heavy mineral samples were processed at a commercial lab to recover the heavy mineral fraction and determine the abundance of indicator minerals in each sample. Prior to processing, bedrock samples were disaggregated using an electric pulse disaggregator to preserve natural grain sizes, textures, and shapes. The <2.0 mm fraction of each bedrock, till, and stream sediment sample was processed to produce a non-ferromagnetic heavy mineral concentrate for selection of indicator minerals using tabling and heavy liquid (SG 3.2) using procedures outlined in McClenaghan et al. (2013a,c, 2014a, in press). The 0.25-0.5, 0.5-1.0, and 1.0-2.0 mm non-ferromagnetic heavy mineral fractions of samples were then examined. Potential indicator minerals of W-Mo mineralization were counted and some grains removed for detailed study. In collaboration with the commercial heavy mineral lab, a systematic method was developed to examine individual heavy mineral concentrates inside a black box using short wave ultraviolet light to rapidly and efficiently determine their scheelite content. Using visible light, scheelite has an unremarkable pale yellow colour, but under short wave ultraviolet light it has a diagnostic bright bluish white fluorescence.

Results

Till geochemistry

Till geochemical data are reported in McClenaghan et al (2013b; 2014b) and results are summarized as follows. The term ‘indicator element’ is used here to refer to an element that is an economically valuable component of the ore being sought and which may be used to detect an orebody and the term ‘pathfinder element’ is used here to refer to non-ore elements associated with the orebody that may be used to detect the orebody (Rose et al. 1979). Indicator elements for the Sisson deposit include W (total digestion) (Fig. 1) and Mo and pathfinder elements include Cu, Zn, Pb, Ag, Bi, In, As, Cd, Zn, and Te. This suite of elements is more extensive than the few elements (W, Mo, Cu, As, and F) that Snow & Coker (1987), Lamothe (1992) and Seaman & McCoy (2008) identified in their earlier studies of the deposit. The <0.063 mm fraction of till sampled in this study confirms the metal rich nature of the first 14 km of the southeast-trending glacial dispersal train reported in earlier studies.

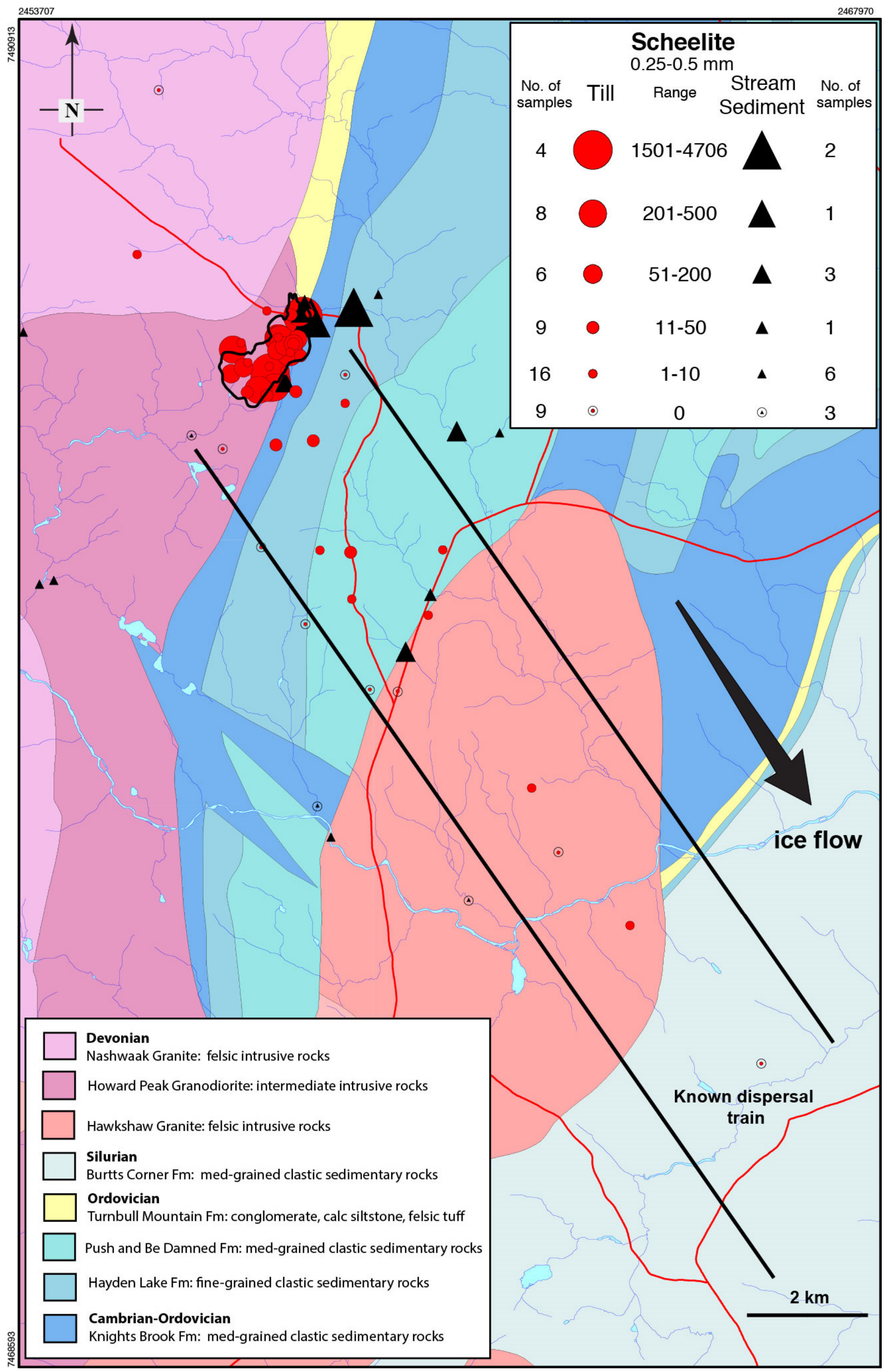

Figure 1. Local bedrock geology and normalized (10 kg) abundance of scheelite grains in the 0.25-0.5 mm fraction of till (red dots) and stream sediments (black triangles) around the Sisson W-Mo deposit (black outline). Modified from McClenaghan et al. (in press).

The unexpected elevated concentrations of Ag, As, Cu, In, Pb, Te, and Zn in till east and northeast of the Sisson deposit may reflect (1) glacial dispersal from a more distal expression of the intrusion that formed the Sisson deposit, such as the as Nashwaak occurrence, or (2) glacial dispersal from metal-rich Silurian-Ordovician Tetagouche Group sedimentary rocks to the north and east that are unrelated to the intrusion-related mineralizing system. These elevated metal concentrations may warrant further investigation to determine their bedrock source.

Stream sediment and water geochemistry

Geochemical data for stream sediments and water are reported in McClenaghan et al. (in press). Indicator/pathfinder elements in the <0.177 mm fraction of stream sediment downstream of the Sisson deposit include W (INAA), Mo, Ag, As, Bi, Cd, In, Tl, Cu, and Zn. This suite of elements is more extensive than those (W, Cd, Pb, Ag, Zn) identified in earlier regional stream sediment surveys (Friske et al. 2002; Pronk et al. 1997). Indicator/pathfinder elements in stream waters around the Sisson deposit include W, Mo, As, Cd, Cu, Cs, and Zn.

Indicator minerals

Indicator mineral data for bedrock, till, and stream sediment around the Sisson deposit are reported in McClenaghan et al. (2013a,c, 2014a, in press). Sisson ore indicator minerals include scheelite, wolframite, and molybdenite. They are heavy minerals that are visually distinct and easily recovered by the most common surficial sample processing method of tabling + heavy liquids (McClenaghan, 2011). Additional indicator minerals of the deposit include chalcopyrite, Bi-rich minerals (joseite, native Bi, bismutite, bismuthinite), galena, sphalerite, arsenopyrite, pyrrhotite, and pyrite. Indicator minerals are most abundant in the 0.25-0.5 mm fraction of till and stream sediments and are present at least 10 km down ice and 5 km downstream (Fig. 1). Coarse (0.5-2.0 mm) indicator minerals are present only in till and stream sediments proximal (<4 km) to the deposit.

Discussion

The use of indicator minerals and till geochemistry for W exploration in glaciated terrain is well documented (e.g. Brundin & Bergstrom 1977; Toverud 1984; Petersen & Stendal 1987; Salminen & Hartikainen 1986; Peuraniemi et al. 1984). The use of stream sediments for W exploration globally is well documented (e.g. de Smeth et al.1985; Steenfelt 1987; Özcan & Çağatay 1989; Fernández-Turiel et al. 1992; Mikulski & Wierchowiec 2013). However, most published literature dates back to the 1970 and 1980s when heavy mineral methods were variable and not available in commercial labs and W geochemical methods were time consuming and expensive. Analytical and processing methods have improved significantly in the past 30 years such that determination of the W content in till, stream sediment, and water is now routine and inexpensive, and indicator mineral processing/recovery methods are now well established and available at commercial labs (e.g., McClenaghan 2011). This case study demonstrates the use of these modern methods and provides examples of signatures at varying distance down ice or downstream.

Conclusions

The study reported here is among the first detailed indicator mineral studies of till and stream sediment around a major W deposit in glaciated terrain. Indicator minerals identified in the 0.25-0.5 mm fraction of mineralized bedrock, till, and stream sediment include ore minerals scheelite, wolframite, and molybdenite as well as several sulphide minerals and native Bi which reflect the polymetallic nature of the deposit. Indicator minerals are present in the coarse (0.5-2.0 mm) HMC fraction of till samples that are proximal to the deposits, thus indicator mineral size can provide some insights into glacial transport distance and proximity to the bedrock source.

Under short wave ultraviolet light, scheelite has a diagnostic bright bluish white fluorescence. A systematic method to rapidly and efficiently determine the scheelite content of heavy mineral concentrate using this fluorescence has been developed and is now commercially available. This method will provide consistent and comparable scheelite counts for till and stream sediment samples within, and between projects.

This study is one of the first modern geochemical studies of till, stream sediment, and stream water around a major W deposit in glaciated terrain. The suite of indicator/pathfinder elements is more extensive than earlier geochemical studies of the Sisson deposit, and reflects the polymetallic nature of the Sisson deposit as well as the broader suite of elements that is now available using modern ICP-MS and ICP-ES techniques. A total analytical method is required to report the total concentration of W in till or stream sediment. Aqua regia is suitable for determining the other indicator and pathfinder elements.

The Sisson case study also identified an area of elevated metal content in till northeast and east of the Sisson deposit overlying Ordovician rocks that warrants further investigation. The bedrock source of the elevated metal contents may be related to a known intrusion-related polymetallic occurrence east of the Sisson deposit or other unknown metal-rich rocks in the area.

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