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Exploration in glaciated terrain for rare earth elements using indicator minerals: a case study from the Strange Lake deposit

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Introduction

Indicator minerals recovered from till samples is an established exploration tool in glaciated terrain for gold (e.g. Averill, 2001; McClenaghan and Cabri, 2011), diamonds (e.g. McClenaghan and Kjarsgaard, 2007) and base metals (McClenaghan et al., 2015; Plouffe and Ferbey, 2017). The use of rare earth element (REE) indicator minerals, however, is relatively rare. The undeveloped Strange Lake peralkaline complex in eastern Canada is one of the world's largest deposits of Zr, Y, and heavy rare earth elements (Miller et al., 1997; Kerr and Rafuse, 2013; Kerr, 2013; Gowans et al., 2014; Zajac, 2015). It is an ideal test site for REE indicator mineral methods because it is a glacial landscape covered by till of varying thickness. At Strange Lake, streamlined landforms were carved out by fast glacial flow from an ice stream that flowed toward the east-northeast (Paulen et al., 2017). A glacial dispersal train trending east-northeast from the deposit for at least 50 km was defined using airborne gamma-ray spectrometry, lake sediment and till geochemistry (Geological Survey of Canada, 1980; Batterson 1989; Batterson and Taylor, 2009; Zajac, 2015), thus REE-rich till was available for sampling.

Methods

Mineralized bedrock and till samples were collected around and down-ice of the Strange Lake deposit in 2015. Selected unprocessed till samples from the Geological Survey of Canada archives were also used. The <2.0 mm material of each sample was processed using tabling and heavy liquid methods described by McClenaghan et al. (2017) to produce a non-ferromagnetic heavy mineral concentrate (HMC) (>3.2 specific gravity (SG)) and a mid-density (3.0–3.2 SG) mineral concentrates for examination of indicator minerals. Potential indicator minerals were identified using a binocular microscope and counted. The visual identification of some mineral species was verified using a scanning electron microscope or electron microprobe analysis.

Results and Conclusions

Arfvedsonite and aegirine in till samples are indicators of the presence of sodic alkaline rocks and fluorite indicates F-rich igneous rocks. Indicators of the Strange Lake REE mineralization include elevated counts of the following minerals in till down ice: thorite/thorianite, pyrochlore, monazite/rhabdophane, chevkinite, parisite, gittinsite, zircon, allanite, bastnaesite, kainosite, and komarovite. Colour photographs of some of the minerals recovered from bedrock and till samples are shown in Figure 1.

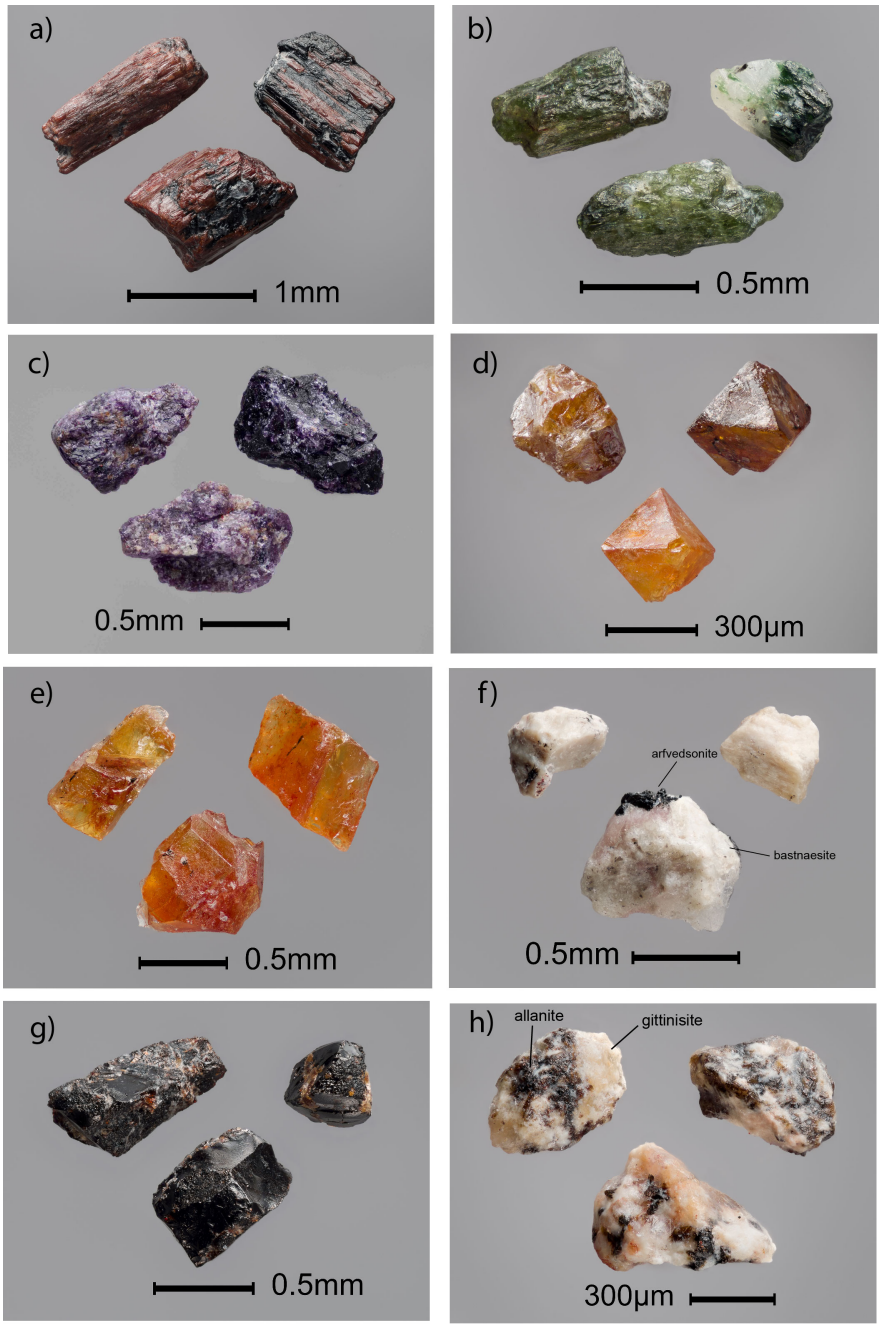

Figure 1. Selected indicator minerals from bedrock or till samples overlying and down-ice of the Strange Lake deposit: a) reddish brown to black fibrous arfvedsonite from till; b) dark green acicular aegirine from till; c) dark purple fluorite from bedrock; d) orange-brown octahedral pyrochlore from bedrock; e) orange monazite from till; f) white bastnaesite from till; g) black chevkinite from till; and h) dark brown allanite intergrown with white gittinsite from till. Digital photography by Michael J. Bainbridge Photography.

Indicator minerals are most abundant (100s to 1000s of grains) in till samples directly overlying the Strange Lake intrusion and between 2 and 5 km down-ice. Grains of pyrochlore, gittinsite, bastnaesite, and chevkinite were detectable in till up to 35 km down-ice, and a few grains of rhabdophane, parasite, and allanite were recovered from till 50 km down-ice.

The Strange Lake study is the first detailed investigation of the indicator mineral signature of a major REE deposit in glaciated terrain. The purpose of the study was not to redefine the glacial dispersal train; instead, this study demonstrates that that REE indicator minerals can indeed be recovered from till and are a viable exploration tool. The results offer a guide to contents in till that might be expected proximal and distal to REE mineralization. These minerals can be also recovered from the same till or stream sediment sample that is collected for diamond, precious, or base metal exploration.

A second phase of this research will include examination of the <0.25 mm HMC using Mineral Liberation Analysis (MLA) to identify additional indicator minerals and focused mineral chemistry studies to further advance the use of REE indicator mineral methods in glaciated terrain. Similar indicator mineral case studies of other types of critical metal deposits will improve this exploration method.

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