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Advances in Exploring for Ni and V Ore Deposits Using Magnetite as an Indicator Mineral

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Mafic-ultramafic intrusions are important sources of Ni sulfide and V-rich magnetite deposits worldwide. Exploration in the northern hemisphere is challenging due to the thick cover of glacial till. However, indicator minerals, recovered as detrital grains from till, can help vector towards mineralisation. Trace element chemistry better fingerprints the source (deposit type, rock type) of indicator minerals. For magmatic ore deposits, magnetite is a useful indicator mineral because it is common in both mineralisation and host intrusion and easily recovered from till. However, magnetite is common in many other igneous rocks, including felsic rocks.

In this study, the trace element chemistry of magnetite, determined by laser ablation ICP-MS, is reviewed from a variety of Ni and V deposits and intrusions (mafic and felsic) from a range of tectonic settings. Through a better understanding of igneous processes that control trace elements in magnetite, a suite of discrimination diagrams is proposed to assist mineral exploration.

First, igneous magnetite is identified from hydrothermal magnetite using a Ti vs. Ni/Cr diagram. Second, igneous magnetite is divided into mafic and felsic origin using an Mg/V vs. V diagram; mafic magnetite has higher Mg-V than felsic magnetite. Third, the Mg/V vs. V diagram also distinguishes V mineralisation (oxide-rich) from unmineralized (oxide-poor) parts of mafic intrusion based on higher Mg/V. Fourth, mafic magnetite can be used to evaluate the fertility of mafic intrusions, to host Ni sulfide deposits at depth, using Ni depletion on the Ni-Cr diagram. Finally, the chemistry of magnetite from massive Ni sulfide ore is distinct from magnetite from mafic rocks. Therefore, this study advances the use of magnetite as an indicator mineral for the exploration of Ni and V deposits using detrital grains in till, not only in identifying a signature of the ore, but also to widen the footprint to prospective mafic intrusions.