The formation of vanadium deposits of the Archean Bell River Complex, Quebec: Insights from Fe-Ti oxide chemistry

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Vanadium deposits in layered mafic intrusions (LMI) occur as variably thick layers rich in Fe-Ti oxide minerals such as magnetite and ilmenite, in which vanadium is primarily concentrated in Ti-rich magnetite. While LMIs are a fairly common feature on Earth, not all contain economically significant concentrations of vanadium, and among those that do, multiple models exist to explain the formation of layering and vanadium mineralization. Examples of these include the late-stage, closed-system fractionation model typified by the Bushveld Complex, whereas multiple injections of primitive magma near the base of the Panzhihua intrusion of China have been proposed to have formed its Fe-Ti-V deposits. The 2.72 Ga Bell River Complex (BRC) is a layered intrusion situated in the Matagami mining camp in the northern Abitibi greenstone belt, Quebec. The BRC consists of interlayered massive Fe-Ti oxides and variably oxide-rich gabbros and pyroxenites (± olivine) that have been metamorphosed to amphibolite facies, and is host to the prospective “Iron-T” vanadium deposit. Electron microprobe analysis and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) have been conducted on magnetite and ilmenite grains collected from various depths of the BRC in order to examine variations in the chemostratigraphy for trace elements such as Cr and V. These elements are highly compatible into magnetite and should therefore reflect whether or not fractionation during Fe-Ti oxide mineralization occurred within a closed magma chamber. Both of these elements show initial upward-depletion trends in magnetite from the lowermost 50 m of the profiles, while remaining relatively consistent over the remaining 250 m, including across the massive oxides of the central layered series. Host rock type appears to have little influence on the chemistry of Fe-Ti oxides, with the exception of metagabbroic samples in which primary oxides are only a minor constituent of the modal mineralogy. Most of the metagabbroic samples contain little to no relict primary magnetite, which appears to have been replaced by chlorite and/or hornblende (± biotite). Elevated Cr and V concentrations in Fe-Ti oxides from these samples may therefore be the result of the diffusion of these elements into ilmenite due to the alteration of magnetite during metamorphism. Consequently, there is no clear evidence of Fe-Ti oxide mineralization being related to multiple magma injections during the emplacement and cooling of the BRC.