Downhole trace and major element chemostratigraphic patterns relating to igneous fractionation processes in the Golden Mile Dolerite, Western Australia

T. O'Connor-Parsons and C. R. Stanley
Department of Geology, Acadia University, Wolfville, NS, B4P 2R6
<070875o@acadiau.ca> <cliff.stanley@acadiau.ca>

The largest gold mine in Australia is the Fimiston Superpit, located in the Golden Mile Camp, Kalgoorlie, Western Australia. This mesothermal gold mine is jointly owned by Barrick Gold Corp. and Newmont Mining Corp. through Kalgoorlie Consolidated Gold Mines. The main host to mineralization is the differentiated Golden Mile dolerite: a sill up to 940 m thick. Previous research has subdivided the Golden Mile dolerite into ten units based on mineralogy, primary igneous texture and iron/titanium oxide mode and morphology. The area is structurally complex and boasts several deformational events. Zones of intense hydrothermal alteration with concurrent obliteration of primary igneous textures are common. These factors have made chemostratigraphic studies of the intrusion important for determining stratigraphic position within the sill during deep exploration drilling.

Distinct downhole geochemical patterns in both major and trace elements using molar element ratios have constrained a set of igneous differentiation processes responsible for the mineral mode and textural diversity of the sill. (Al/2+Na/2)/Zr and (Ca/2+Fe/2+Mg/2-Al/4+Na/4)/Zr molar ratios that specifically track the addition or loss of plagioclase and pyroxene, exhibit patterns that allow recognition of pyroxene cumulates in the lower units of the sill, despite the textural ambiguity created by subsequent hydrothermal alteration.

A major lithological discontinuity associated with the introduction of magnetite to the liquidus assemblage occurred at the base of Unit 6. Differences in shapes of the Ti/Zr and V/Zr downhole patterns give insight into the chemical controls that influenced the distribution of these elements in the magma chamber. V has a higher magnetite-melt partition coefficient than Ti. The steeply-decaying V/Zr downhole pattern reflects the rapid depletion of V from the magma chamber as it strongly partitioned into the fractionating magnetite. The 'box'-shaped downhole depletion pattern observed for Ti/Zr is a result of the coupled substitution of Ti with ferrous iron in the magnetite-ulvospinel phase. Additionally, the downhole plots of base metals (Cu/Zr, Zn/Zr and Ni/Zr) exhibit enrichments that coincide with magnetite saturation. However, detectable concentrations of these elements are not observed in magnetite. They reside in anomalous concentrations of disseminated sulphide minerals (chalcopyrite and pyrite) in the magnetite-bearing portion of the sill. The presence of these co-occurring sulphide minerals with magnetite likely resulted from liquid immiscibility of a sulphide melt triggered by the saturation of magnetite in the magma chamber.

In summary, chemostratigraphic patterns observed in ratios tracking the material transfers of major elements and igneous minerals, and ratios responding to trace element partitioning of V, Ti, Cu, Ni and Zn into magnetite and an immiscible sulphide liquid, reveal new information about the igneous evolution of the Golden Mile dolerite. These patterns facilitate confident recognition of stratigraphic level in deep exploration drill cores, despite subsequent hydrothermal alteration effect.