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The Composition and Distribution of Trapped Melt in the Kiglapait Layered Intrusion

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The Kiglapait Intrusion, Labrador, is a classic layered body that crystallised under closed, or near-closed, conditions [1]. The Lower Zone is dominated by troctolites with cumulus plagioclase (An_{66-52}) and olivine (Fo_{68-60}) and intercumulus clinopyroxene (cpx), orthopyroxene (opx), amphibole, biotite and oxides. The intercumulus phases record the crystallisation of trapped residual liquids within the cumulus pile. In order to characterise the composition of these liquids and their spatial/textural characteristics we have undertaken a laser-ablation ICP-MS study of minerals in Lower Zone samples from Port Manvers Run. Samples representing 1, 10, 22, 44, 60, 70 and 82% solidified (PCS) were studied.

In all samples cumulus plagioclase shows zoning in major and trace elements. The zoning patterns are subtle, but complex, typically with a normally zoned core and thin reverse-zoned outer rim [2]. For example at 22PCS the zoning sequence is from An_{61} to An_{59} (core) to An_{75} (outer rim). There is a concomitant change in trace elements. For example La increases from 1-3ppm in the core and then falls slightly in the outermost rim, while Ba increases from 110-180ppm and then falls to 140ppm. Sr, which is compatible in plagioclase, shows the opposite behaviour. A curious exception is Rb and K which, although incompatible, fall slightly from core to rim, as previously observed for K by Morse & Nolan [2]. In general the extent of major and trace element zoning decreases up-section. In a single plagioclase at 82PCS we observed a 100 micron diameter trace element-depleted core. There is a modest fall in plagioclase Sr contents with increasing PCS, in excellent agreement with that previously observed from mineral separate data [3].

Cumulus olivine occasionally shows zoning towards rims slightly poorer in Ni, e.g. 800-500ppm at 22PCS, suggestive of some growth from more evolved intercumulus liquids. In stark contrast cpx shows extreme compositional variation, both within grains and across a single thin section. For example at 22PCS Zr in cpx varies from 40 to 1220ppm with a concomitant increase in other incompatible trace elements, such as Sr and LREE. The highest concentrations are observed in the centres of elongate interstitial crystals. The least enriched cpx have trace element compositions in equilibrium with cumulus plagioclase cores.

The overall pattern of incompatible trace element enrichment in cpx crudely mirrors that in the up-sequence changes in whole-rock chemistry. These observations are best reconciled in terms of crystallisation from evolved trapped melts similar in composition to those which precipitated cumulates at higher stratigraphic levels. The fact that cpx shows the greatest enrichment is largely a consequence of its higher partition coefficients than plagioclase and olivine for almost all incompatible trace elements and its smaller grain size. The heterogeneous distribution of trace element-enriched cpx within a single thin section suggests that pockets of variously evolved melt were effectively trapped and isolated in the solidifying crystal pile. The limited extent of trace element zoning in plagioclase and the extreme enrichment of Sr (3-51ppm) in some cpx, suggest that plagioclase played a relatively minor role in crystallisation of the intercumulus melt.

The presence of trapped melt may also be evinced by the presence of rounded polymineralic aggregates associated with olivine grain boundaries throughout the Lower Zone. The aggregates, up to 1.5 mm across, comprise concentrically zoned arrangements of (from core to rim) opx, amphibole, biotite, plagioclase, oxides and zeolites. Plagioclase, amphibole and opx form symplectite intergrowths on a scale of a few microns. Some aggregates are associated with radiating veins filled with chlorite or serpentine where they traverse olivine. Where they traverse plagioclase grain boundaries they are associated with the thin, irregular high-An rims. These textures are suggestive of a trapped melt phase crystallising in situ and so elevating dissolved water content until the point that it is expelled.

We conclude that a combination of petrography and LA-ICP-MS provides an optimal tool for the characterisation of trapped melt in cumulates.

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