5.4.12

Insights into the evolution of the crystal mush from textural observations: The Rum Layered Intrusion, Scotland

M.B. HOLNESS

Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ (marian@esc.cam.ac.uk)

The evolution of the crystal mush at the base of a magma chamber is controlled by a variety of processes from compaction to infiltration and metasomatism. Once the cumulate is fully solidified, however, it is difficult to constrain this evolution adequately using the usual discriminants such as mineral composition, grain size and orientation. I present a new discriminant which can provide information on thermal history.

The last phase to crystallise in troctolites of the Rum Layered Intrusion was clinopyroxene (cpx). Optical measurement of cpx-plag-plag dihedral angles, or Θ_{cpp}, using a universal stage, demonstrates that cpx pseudomorphed the last melt-filled pores, even in rocks containing cumulus cpx. The difference between the actual median value of the population of measured Θ_{cpp} values and that of a completely equilibrated cpx-plag rock constrains the rate of cooling in the sub-solidus. This gives a direct indication of the rate at which the solidification front moved upwards in the accreting mush. High angles denote slow upwards movement, and lower angles result from more rapid solidification. Profiles of Θ_{cpp} across individual troctolite horizons demonstrate that the rate of solidification was generally such as to result in a Θ_{cpp} in the range 87-92˚., intermediate between values expected for a melt (< 60˚) and those of a fully equilibrated solid (114˚).

In detail, the profile of median Θ_{cpp} tends to show steep increases of 4 – 5˚ followed by a slower decrease over ~ 5 m. This pattern is mimicked by both average Fo and Ni of the olivine. I suggest it is linked to repeated minor replenishment events, which promoted sinking of hotter magma into the mush with a consequent cessation of movement of the solidification front. Continued fractionation resulted in gradual acceleration of solidification until the next replenishment event.

Infiltration events marked by excursions of olivine composition at the base and/or top of troctolite horizons are also reflected in Θ_{cpp}. Angles generally increase significantly within a few metres of the top, due to the excess heat provided by the overlying hotter replenishing liquid. Angles are often lower at the base of units, due either to late-stage infiltration from underlying compacting horizons, or to an initially high solidification rate.

5.4.13

A mass balance approach to the differentiation of the Skaergaard intrusion, East Greenland

T.F.D. NIELSEN

Geological Survey of Denmark and Greenland (GEUS, Østervoldgade 10, DK-1350 Copenhagen K, Denmark (tfn@geus.dk)

Ever since the earliest descriptions of the Skaergaard intrusion has it´s differentiation process been debated. Despite all the data, significant uncertainty remains regarding the bulk composition, the shape and structure, and the origin of the Fe-enrichment trend and the lack of residual granophyre melt. The intrusion is now suggested to be a box-like, fault-controlled, 300 km^3, magma chamber (11x7.5x4 km) with an onion-type internal structure and a bulk com-position similar to evolved (Mg# 0.45), Fe-rich, contem-poraneous plateau basalt [1].

Traditionally, the gabbros were divided into the Upper Border Series (UBS), the Marginal Border Series (MBS) and the Layered Series (LS). LS is suggested to constitute 2/3, UBS 1/6 and MBS 1/6 of the total mass[1]. Previous attempts to model the fractionation are based on an assumed bulk composition and the cumulates of LS, mostly neglecting UBS and MBS.

The revised differentiation model assumes enhanced cooling and crystallisation of liquidus phases below the roof. Olivine (later joined cpx and Fe-Ti oxides) and evolved melt descended, while plagioclase stayed below the roof to form UBS. The melt from which LS crystallised was through out the crystallisation enriched in Fe-Mg liquidus minerals and evolved Fe-rich melt from the top of the magma chamber.

Liquid immiscibility is likely to evolve in Fe-rich basaltic liquids [2]. Similar to a descending liquidus front, a front of liquid immiscibility would descent through the plagioclase rich UBS mush below the roof. The Fe-rich immiscible melt would sink, but the Si-rich immiscible melt would stay be-hind in UBS. Immiscible Fe-rich droplets are inferred in a PGE mineralisation in LS (upper Middle Zone) and the UBS is rich in interstitial granophyre.

The assumed bulk, Fe-rich fractionation trend is, in part, an artefact of the crystallisation processes and the distribution of components in the intrusion. The lack of a significant volume of residual granophyre melt is due to the continuous extraction of such a melt. Future fractionation models should operate with bulk cumulates composed of LS cumulates mixed with appropriate proportions of UBS and MBS cumulates corrected for intercumulus crystallisation and granophyre contained in UBS.

References

[1] Nielsen T.F.D. (2004) *Journ. Petrol.* (in press).
[2] Naslund, R.H. (1976) *Carnegie. Yb.* **75**, 592-597.
[3] Nielsen, T.F.D. (2003) *GEUS Report* 2003/48.