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Crustal assimilation in basalt and jotunite: Constraints from layered intrusions

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To constrain the amount and rate of crustal contamination of basaltic and jotunitic magma, and to cast light on the physical processes of assimilation in crustal magma chambers, we have modelled published Sr and Nd isotopic data from three Norwegian layered intrusions. The basis of the modelling is that *F*, the mass fraction of magma remaining in the chamber, can be estimated from the thicknesses of well-exposed layered sequences showing no evidence of magma recharge. This allows model curves for concurrent assimilation and fractional crystallization to be fitted to the isotopic data by varying ***r***, the ratio of the mass assimilated to the mass crystallized. The results show that ***r*** is nearly constant in 800 to 2000 metre thick sequences of cumulates displaying continuous up–section decreases in anorthite content of plagioclase, increases in whole-rock Sr_0 (initial $^{87}Sr/^{86}Sr$) and decreases in whole-rock eNd_0.

Innumerable country rock xenoliths occur in all three layered intrusions and played a crucial role in the assimilation process. The xenoliths spalled off the roofs of the chambers during filling or recharge and their initial temperature and compositions relate to ***r***. In the Hasvik Intrusion (***r*** = 0.27), the temperature of the country rocks was ~450°C and the xenoliths were fusible metasediments and therefore produced a high fraction of partial melt that could be assimilated. In the Bjerkreim–Sokndal Intrusion (***r*** = 0.20), the country rocks were initially at 640–880°C but included both refractory massif–type anorthosite and fusible but dry quartzofeldspathic gneisses. In the Fongen–Hyllingen Intrusion (***r*** = 0.12), the country rocks were cooler (~300°C) and the xenoliths include refractory metabasalt (dominant) and fusible metapelite. We argue that refractory xenoliths acted mainly as heat sinks, resulting in reduced ***r***–values.

Heating of refractory and fusible xenoliths, and melting of fusible xenoliths absorbed heat from the magma. Surprisingly, energy–balanced modelling shows that up to 75% of the heat available was absorbed by xenoliths within the magma chambers, promoting higher rates of cooling and crystallisation than would have resulted from loss of heat to the country rock envelope alone. The high ***r***–values reflect the large amount of heat absorbed by melting country rock within the magma chambers themselves, and their constancy reflects the ready availability of fusible xenoliths.

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Sm-Nd isotopic evidence for mineral disequilibrium from the Merensky pegmatoid, Bushveld Complex, South Africa

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Introduction

Processes including magma mixing, crustal contamination, and secondary remobilisation have been suggested to explain reef-type mineralisation in layered mafic intrusions, based on mineralogical, textural, geochemical and isotopic evidence. Although most studies have emphasized silicate-sulphide/oxide relationships, isotopic disequilirbium in silicates from syn-crystallisation contamination has been demonstrated from the Rum intrusion [1] and mixing-induced disequilibrium from the Skaergaard Layered Series [2], for example.

Sm-Nd isotopic results from the Merensky Reef and its immediate footwall suggest that orthopyroxene and plagioclase are not in isotopic equilibrium with one another, such that plagioclase is enriched in radiogenic Nd relative to a Bushveld-aged reference isochron passing through the pyroxene and whole-rock data. The whole rocks and orthopyroxenes give ε_{Nd} values at 2.06 Ga between –7.46 and –8.46, which are broadly consistent with existing data (Maier *et al.*, 2000). However, the plagioclases have ε_{Nd} values of –1.13 to –3.37. The evident disequilibrium between feldspar and pyroxene can best be interpreted in terms of the derivation of the Merensky Cyclic Unit through assimilation-fractional crystallisation-accumulation mixing processes. The orthopyroxene was derived from a liquid affected by pre-emplacement crustal contamination, and settled by density-driven accumulation into a liquid-crystal mush dominated by plagioclase, derived from a relatively uncontaminated previous liquid. Isotopic constraints on the potential contaminant favour pre-emplacement contamination by late Archaean granitoids, and also require that orthopyroxene preceded plagioclase on the liquidus of the incoming magma. The presence of isotopic disequilibrium suggests that isotopic compositions of whole-rock samples in cumulus rocks must be interpreted with caution.

References

[1] Tepley III, F.J. and Davidson, J.P. (2003) *CMP* **145,** 628-641.
[2] McBirney, A.R. and Creaser, R.A. (2003) *J. Pet.*, **44**, 757-771.