The formation of meteoritic basalts: Constraints from metal-silicate partition coefficients

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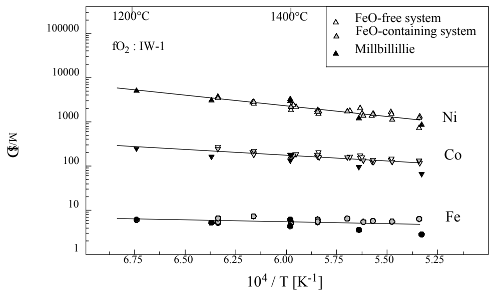
Stolper [1] suggested that eucrites are partial melts from a chondritic parent body. The incompatible behavior of W in eucritic melts excludes, however, the presence of metal in their source region [2], favoring crystallization models.

To study metal/silicate partitioning under realistic conditions metal/silicate partitioning experiments with aliquots of the eucrite Millbillillie as starting silicate composition were performed. The new results for Fe, Ni, and Co metal/silicate partition coefficients $D^{M/S}$ (closed symbols in the Figure) fit with older data (grey shaded symbols; data are taken from [3]) allowing precise prediction of the contents of Fe, Ni and Co in partial melts in equilibrium with chondritic metal at any given T, fO_2, and metal and silicate composition. At a given Fe-$D^{M/S}$, both Ni-$D^{M/S}$ and Co-$D^{M/S}$ decrease with increasing temperature.



A low degree partial melt with 19 % FeO would in equilibrium with H-chondrite metal have 7 ppm Ni and 5 ppm Co. While Co would fit for eucrites, Ni is a factor 5 too high. Fractional crystallization models produce even higher Ni contents in the melts as they require higher temperatures at which partition coefficients are lower.

These results and additional results on W and Mo indicate that the siderophile element abundances in eucritic meteorites cannot be easily explained, neither by varying degrees of partial melting nor by simple fractional crystallization. More complex models as proposed by e.g., [4] and [5] seem to be more likely hypotheses to explain the eucritic siderophile element abundances. We will present additional constraints on eucrite formation scenarios that are derived from the predicted siderophile element concentrations in eucritic melts.

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Light noble gases in the lithospheric mantle of the Red Sea region

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Intracontinental and rift related volcanism is usually ascribed to diapirs originating from a mantle plume or asthenospheric source, adding volatiles via fluid/melt migration in the overlying subcontinental lithospheric mantle (SCLM). Interactions between these mantle reservoirs can be studied using (light) noble gases as tracers since these reservoirs differ in isotopic composition. The MORB-source contains a lower contribution of primordial isotopes with a lower $^3He/^4He$ ratio of 8±1 R_A (atmospheric units) and more nucleogenic ^{21}Ne compared to primitive mantle plume sources. However, most studies on SCLM-rocks showed, that the He isotopic composition is more radiogenic ($^3He/^4He$=6±1 R_A). Only few studies deal with the Ne isotopic composition of SCLM. Frequently decoupling of He and Ne isotope systematics is observed (e.g. Niedermann et al.), indicating that Ne-isotopes better reflect a possible contribution of plume-related volatiles. Hence, we aimed to obtain high precision Ne data in this study.

We performed crushing experiments on ultramafic rocks from several locations of the Red Sea SCLM, 700-2500 km distant to the Afar-plume which is situated in the South of the Red Sea. The Afar-plume is characterized by high $^3He/^4He$-ratios of 20 R_A (Marty et al.). Interaction with the Red Sea MORB-source is displayed by a continuous decrease in $^3He/^4He$-ratios with increasing distance to Afar (Moreira et al.). Therefore a similar interaction with the SCLM should be observable. We obtained $^3He/^4He$-ratios of 6.1-8.1 R_A, variable for the same location and without dependence on geographic position. We observe a small contribution of plume-like Ne, indicated by mixing lines slightly steeper than the MORB-line in a Ne 3-isotope plot. Only one sample showed a more nucleogenic composition connected with a low $^3He/^4He$ of 6.3 R_A possibly reflecting the initial composition of the SCLM. $^{40}Ar/^{36}Ar$ ratios usually are lower than 12000, with the notable exception of one clinopyroxenite reaching 25000.

The results suggest a small scale mixing in various proportions of migrating plume-like volatiles with local fluids typical of the SCLM.

References

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