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INCOMPATIBLE BEHAVIOR OF SULFUR IN ULTRA-DEPLETED MORB

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ABSTRACT

The assumed presence of a sulfide phase in the residuum after melting of typical MORB is critical for an estimation of sulfur concentrations in the Earth's mantle and for balancing the abundances of platinum-group elements (PGE) in MORB. Also, this assumption is consistent with the fact that most MORB glasses are close to sulfur saturation (e.g. Jambon, 1994). However, almost all MORB glasses do not represent primary melts because of (1) extensive mixing on the way to the surface (Sobolev and Shimizu, 1993) and (2) significant fractional crystallization. It was shown (Sobolev and Shimizu, 1993; Sobolev, 1996) that ultra-depleted melts trapped as inclusions in high-magnesium olivine are better representatives of the compositions of instantaneous primary MORB melts. Here we present data on the composition of such melts from typical NMORB at 8° N, Mid-Atlantic Ridge, and at the Siqueiros F.Z., East Pacific Rise (Perfit et al., 1996).

The inclusions possess beautiful negative crystalline shapes of host olivine and consist of fresh glass with rare shrinkage bubbles. Major element and sulfur concentrations were measured on a Jeol Superprobe electron microprobe at Mainz University (Germany). Long counting times for sulfur peak and background lead to a precision of about 100 ppm with a detection limit of 60 ppm. Trace elements were measured by ims-4f ion probe in the Institute of Microelectronics, Russian Academy of Science (Yaroslavl, Russia) with relative accuracies better than 10%. All inclusions show moderate to minor crystallization of olivine on the cavity walls. This effect was corrected using the procedure of Sobolev and Shimizu (1993).

As is apparent from Fig. 1, the sulfur contents show strong positive correlations with highly incompatible elements, and they vary from 0 to 0.10 wt% (the latter is close to saturation level for low-Fe basaltic melts). This fact strongly suggests that sulfide melt was not present in the mantle sources of the ultra-depleted melts at the time of their separation and was probably consumed at lower degrees of melting. The modeling of critical melting of a MORB source suggests that S-undersaturated, ultra-depleted melts were produced at degrees of melting higher than 12% and up to 18% (Sobolev, 1996). This implies that the sulfide might be exhausted from the MORB mantle at degrees of melting higher than 10%, and typical NMORB primary melts were likely segregated from a sulfide-free restite. This result is not in contradiction with high S contents and near sulfur-saturated behavior of MORB because the degree of undersaturation of integral primary melts is relatively small and could be easily compensated by crystallization of 10-30% phenocrysts.

The potential importance of these observations is that they might eliminate one of the otherwise more plausible explanations for the extremely low abundances of platinum-group elements (PGE) such as osmium and iridium in MORB, namely that these elements are held back in the mantle by residual sulfides, which have very high partition coefficients for PGE.

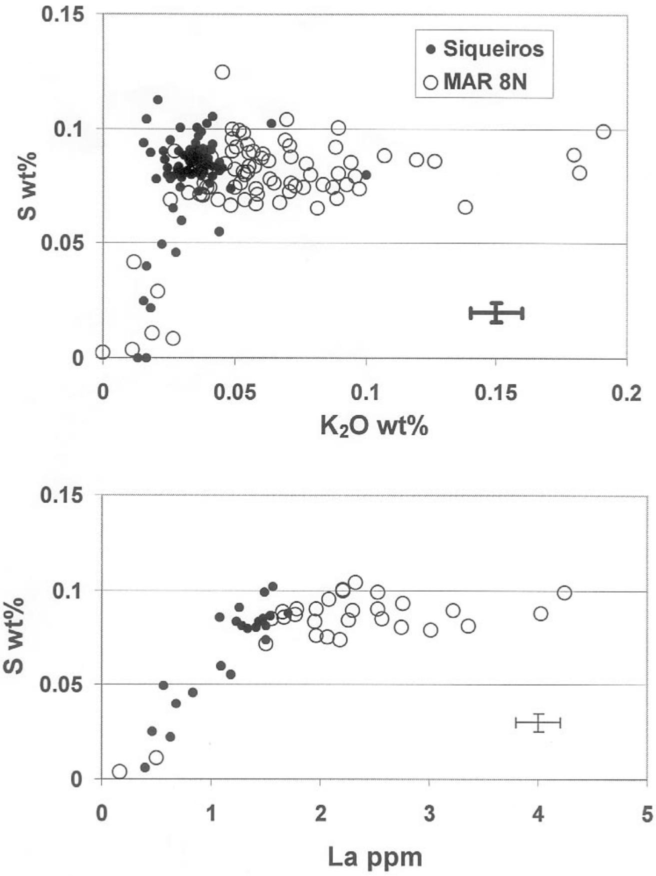

Fig 1. The compositions of melt inclusions in high-Mg olivines of NMORB.

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