

Can the Eu oxygen barometer be applied to QUE 94201?

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QUE 94201 (QUE) has special significance among basaltic shergottites because (1) it likely represents a Martian melt composition and thus can provide valuable clues to magma petrogenesis on Mars; (2) it may be the most reduced of all basaltic shergottites (e.g. Herd *et al.*, 2002); and (3) its isotopic characteristics are the most primitive among basaltic shergottites (e.g., Borg *et al.*, 1997). Variation in oxidation state among the Martian meteorites, combined with systematic isotopic variations, may have important implications for the redox state of the Martian crust and mantle and the overall differentiation of Mars. Thus it is important to use multiple means to corroborate evidence that QUE is reduced.

One approach to determining oxidation state is through measuring the depth of the Eu anomaly in the REE patterns of near-liquidus minerals using SIMS (e.g., McKay *et al.*, 1994). In applying this approach to basaltic shergottites, Wadhwa (2001) assumed that the near-liquidus pyroxene crystallized from melt having the REE pattern of the bulk rock. This assumption is only valid if there is minimal fractionation of Eu from other REE prior to the crystallization of the volume of pyroxene analyzed by SIMS.

In the case of QUE, our experimental crystallization studies bear strongly on the validity of this assumption. QUE pyroxene is complexly zoned. Typical grains have Mg-rich pigeonite cores mantled by Mg-rich augite that abruptly begins to evolve towards more Fe-rich compositions. At the same point where iron enrichment begins, Al/Ti drops precipitously. Such Al depletions are generally thought to reflect plagioclase crystallization.

Dynamic crystallization experiments on synthetic QUE confirm the inference from Ti/Al: The drop in pyroxene Ti/Al and the commencement of Fe enrichment coincide and correspond to the onset of plagioclase crystallization. Because the potential of pyroxene to fractionate Eu is small, little fractionation can occur during crystallization of the initial Mg-rich pyroxene cores, only becoming significant after plagioclase entry. Thus, if SIMS analyses are of the Mg-rich pyroxene cores, little prior Eu fractionation can have occurred, and the assumption that the REE pattern of the melt was that of the bulk rock is valid. Provided appropriate partition coefficients are used, the Eu oxygen barometer can be applied to QUE.

References

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 Herd *et al.* (2002) *GCA* 66, 2025.
 McKay *et al.* (1994) *GCA* 58, 2911-2919.
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Bridging geochemistry and microbiology through ocean drilling

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In Jules Verne's adventure story, *Journey to the Center of the Earth* (1864), his heroes, while descending deep into the Earth's interior, discover a vast ocean teeming with pre-historic life. In the last 15 years, Verne's scientific fantasy has taken on new meaning within the context of the Ocean Drilling Program (ODP). Indeed, a major achievement of ODP has been the discovery of a sub-seafloor ocean comprising fluids moving through sub-seafloor formations in a wide variety of settings. Forming a continuum with the overlying ocean, this massive and dynamic plumbing system cycles the entire volume of the ocean through the seafloor every one million years, greatly influencing the chemical composition of the oceans. And, similar to the subterranean oceanic environment described by Jules Verne, this sub-seafloor ocean provides a unique habitat in which an extensive microbial population is active over a surprisingly broad range of temperatures, pressures and depths. Thus, another major achievement of ODP has been the recognition of the existence of a deep sub-seafloor biosphere, which may constitute as much as one-third of the living biomass on Earth. Together, the sub-seafloor ocean and the microbial communities therein are an important element coupling the biosphere with the geosphere.

Linking the biosphere and the geosphere provides a more realistic approach to delineate biogeochemical processes inducing carbonate biomineralization in marine sediments. Ocean drilling enables *in situ* studies of these biogeochemical processes associated with the deep biosphere, which, in turn, contribute to our interpretation of the evolution of marine sediments. For example, a combination of geochemical and microbiological analyses of samples, secured with recent ocean drilling during ODP Leg 201 on the Peru Margin, validates microbial mediation of dolomite precipitation in deep-sea sequences, providing tantalizing clues to understand the process of carbonate biomineralization under anoxic conditions. Geochemical signals incorporated into the microbial dolomite are a reflection of metabolic activity and document or confirm a microbial origin. The application of molecular biological techniques illustrates the intimate relationship between microbes and the *in situ* precipitation of dolomite. This geomicrobiological approach clearly demonstrates that microorganisms are instrumental in the modification and diagenesis of marine sediments. Future investigations of the biogeochemical interactions occurring within the sub-seafloor environment will undoubtedly provide new and exciting discoveries, as we continue to probe the oceanic depths with modern technologies and impending ocean-drilling campaigns within the framework of the Integrated Ocean Drilling Program (IODP).