EPSL **77,** 165–175. (3) Armstrong J. T. (1989) *Lunar Planet Sci. Conf.* **20,** 23–24. (4) MacPherson G. J. (1985) *Meteoritics* **20,** 703–704.

Zone sequences, widths and compositions of olivine coronas in mesosiderites.

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Olivine coronas in thin-sections of the Emery (AMNH 4441-2, 4441-4) and Morristown (AMNH 305-1) mesosiderites were studied by optical and SEM microscopy to place constraints on the kinetic parameters and metamorphic conditions that prevailed during the formation of these coronas. All isolated olivine grains in these mesosiderites are surrounded by coronas. The coronas in both meteorites contain an optically distinctive orthopyroxene + chromite inner zone adjacent to olivine. In Emery, this inner zone is surrounded by fine-grained zones that are rich in orthopyroxene, merrillite and plagioclase; clinopyroxene exsolution lamellae and blebs are concentrated in the outermost portion of the corona adjacent to matrix. In Morristown these additional zones appear to be present but are difficult to discern from matrix. On flat portions of the coronas in Emery, the inner zone is typically 20–40% of the total thickness of the corona. One dunite clast was found in Morristown but it lacks an obvious corona, suggesting that the coronas (at least in Morristown) were formed *before* the final incorporation of olivine into mesosiderite matrix.

The modal compositions of various corona zones on the two largest olivine grains (Object 1: ~1 × 2 mm; Object 7: ~0.5 × 2.9 mm) in Emery 4441-4 were determined from backscattered-electron images of 5–11 representative areas from each zone on the flat edges of each object. Image processing of these areas enabled all phases except ortho- and clinopyroxene to be readily distinguished and the modes to be determined to an estimated precision of better than ±0.5 vol.% within each imaged area. The coronas on both objects are similar. The distinctive inner zone (~0.2–0.3 mm thick) is rich in pyroxene (~70–85 vol.%) and chromite (~3–20%), but also contains minor (<5%) merrillite and ilmenite, and rare (generally <1%) metal, sulfide, and plagioclase. An intermediate or middle zone (~0.2–0.3 mm thick) is rich in merrillite (~9–22%), pyroxene (~54–62%) and plagioclase (~9–28%), contains less chromite than the inner zone (<10%), and has minor ilmenite, metal, and sulfide. Plagioclase and merrillite abundances tend to vary inversely in this zone, and a thin (<0.1 mm thick) plagioclase-free, merrillite-rich zone is locally present immediately adjacent to the inner zone. An outer zone (~0.3–0.5 mm thick) adjacent to matrix is generally similar to the middle zone except that it contains less merrillite (~7–10%), and more metal (to a few %) and sulfide.

The layer sequence and zone compositions of the coronas in Emery are consistent with a 5-component (MgO-$AlO_{3/2}$-CaO-SiO_2-$PO_{5/2}$) steady-state kinetic model that assumes reaction and diffusion between olivine and a mesosiderite-like, silicate-phosphate assemblage (1). The coronas formed during thermal metamorphism after (and in Morristown possibly also before) brecciation episodes in the respective parent bodies. A comparison of model and actual coronas in Emery suggests that the diffusivities of MgO, CaO, SiO_2 and $PO_{5/2}$ during metamorphism were generally similar to one another, but that the diffusivity for $AlO_{3/2}$ was especially low. Moreover, the presence of merrillite in the outer zone of the coronas suggests that an additional source of $PO_{5/2}$ was added to the coronas besides that now present in the matrix; most likely this source was an earlier generation of P-rich metal that was initially present in mesosiderites. References: (1) Ruzicka A. and Boynton W. V. (1990) *Meteoritics* **25,** 403.

Plagioclase, ilmenite, lunar magma oceans, and mare basalt sources.

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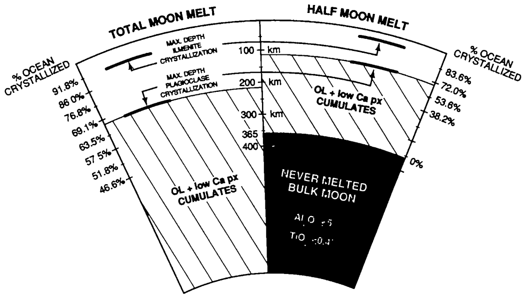
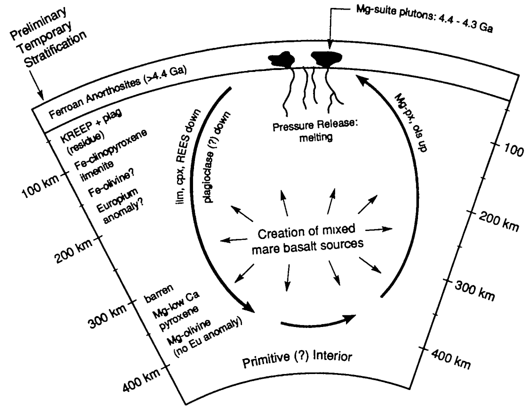
Lunar mare basalt source depletions in both europium and alumina are consensually attributed to complementary plagioclase floating from a magma ocean. However, the connection cannot be simple or direct: in contrast to the magma that crystallized to produce the mare basalt sources, the ferroan anorthosite parent magma was *more evolved* by virtue of its lower Mg/Fe ratio and Ni abundances, although *less evolved* in its poverty of clinopyroxene constituents, flat rare earth patterns, and lower incompatible element abundances (*e.g.,* (1, 2)). To crystallize plagioclase requires about 15% Al_2O_3 in a magma. Starting from a bulk Moon with less than about 5% Al_2O_3 requires crystallization of 70% Al-free phases before plagioclase can crystallize: even a whole-Moon melt would be less than 200 km deep before plagioclase could crystallize (Fig. 1); a half-Moon melt would be as shallow as 100 km before anorthosites would be forming. Some mare sources, and their contained europium anomalies, are inferred (from phase equilibria experiments) to be at depths of 400 km, too deep to have been directly influenced by plagioclase crystallization; nearly all mare sources are inferred to be deeper than 200 km. Ilmenite, also required in some mare sources, would not have crystallized until a whole-Moon ocean was little more than 50 km deep.

Global overturn of a hot, gravitationally unstable mantle following crystallization of a magma ocean would have carried down clinopyroxene, ilmenite, and phases with fractionated rare earths with Eu anomalies. These would have mixed with deeper olivines to form mare sources ((1, 2); Fig. 2). Upward-moving magnesian mafic minerals, decompressing, would have melted to be the prime component, with assimilated plagioclase, of the ancient Mg-suite that intruded the crust (Fig. 2). Mechanical mixing of a once stratified lunar interior creates considerable ambiguity and free parameters in numerical chemical modelling of supposed igneous processes of mare evolution. References: (1) Ryder G. (1982) *Trans. Am. Geophys. Un.* **63,** 785–787. (2) Ryder G. (1989) *Lun. Plan. Sci.* **20,** 554–555.





Mineralogical study of metals in MAC88177 with reference to S-type asteroids.

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MAC88177 was described as "carbon-free" ureilite by Mason (1). Prinz *et al.* (2) proposed that it may be a new type of achondrites on the basis of oxygen isotope and Takeda et al. (3) emphasized its link to primitive achondrites-lodranite.

We investigated metallic grains in MAC88177,17 polished thin section using electron probe microanalyser (EPMA) and scanning electron microscope (SEM) equipped with EDS with chemical map analysis (CMA) utilities.