Fractionated REE in EL chondrites

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Refractory lithophile elements in chondrites are unfractionated relative to CI [1]; the sole exception appears to be the enstatite chondrite EL group whose falls have a mean La/Sm abundance ratio of 0.89×CI [2]. However, all EL falls are highly recrystallized (petrologic type-6) rocks. Despite the fact that many EL6 chondrites appear to have been shocked and brecciated, all presently have silicates indicative of a low shock stage (S2), consistent with these rocks having undergone post-shock annealing [3]. Although refractory lithophile abundances are generally inferred to reflect nebular conditions, in view of the complex parent-body history of EL6 chondrites, it seems possible that their fractionated REE abundances resulted from processes on their parent asteroid.

We examined this possibility by analyzing two EL3 (MAC88136 and PCA91020) and one EL4 (Grein 002) chondrite by neutron-activation analysis. EL3 and EL4 chondrites seem to be members of the same chondrite group as EL6: relative to EH enstatite chondrites they all have large-diameter chondrules (~550 vs. ~220 µm), low Si in metallic Fe-Ni (0.5-1.7 vs. 2.6-3.5 wt.%) and contain ferroan alabandite {(Mn,Fe)S} instead of niningerite {(Mg,Fe)S}. We found that the mean La/Sm abundance ratio of the EL3 and EL4 chondrites is essentially unfractionated, i.e., 0.97×CI. With the exception of Eu in plagioclase, the main carrier of REE in EL6 chondrites is oldhamite (CaS), which has a mean La/Sm ratio of 0.73×CI and a significant negative Eu anomaly (Eu/Sm = 0.28×CI) [4].

We suggest that all EL chondrites started off with unfractionated REE abundances, but those rocks that became EL6 were partly shock melted. The occurrence of a chondrule-free, oldhamite-rich melt vein in EL6 Jajh deh Kot Lalu [3] indicates that temperatures were high enough to melt oldhamite. Silicates would also have melted during this event; plagioclase has a low impedance to shock compression and is readily melted and mobilized during impacts. Plagioclase is enriched in LREE [4]. Minor loss of plagioclase would deplete the whole-rock in LREE, Eu and Al. This is consistent with the lower CI-normalized ratios of La/Sm (0.89 vs. 0.97), Eu/Sm (1.04 vs. 1.35) and Al/Mg (0.84 vs. 0.90) in EL6 falls relative to EL3 and EL4 chondrites.

References

[1] Wasson J. and Kallemeyn G. (1988) *Phil. Trans. R.S.L.* **325**, 535-544.
[2] Kallemeyn G. and Wasson J. (1986) *GCA* **50**, 2153-2164.
[3] Rubin A. et al. (1997) *GCA* **61**, 847-858.
[4] Floss C. and Crozaz G. (1993) *GCA* **57**, 4039-4057.

Dielectric properties of lunar material and its microwave penetration depth

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Interest in the microwave dielectric properties of lunar regolith occurring at the lunar surface is based on potential applications in active and passive microwave remote sensing. Knowledge of the penetration depth is also required in passive microwave remote sensing to estimate the effective emission temperature in case of a temperature gradient within the emitting layer on the one hand and for modeling volume scattering on the other. China has planed to using microwave radiometry to explore the depth of lunar regolith and estimate helium-3 resource on the moon. But quantitative information of the electromagnetic properties of lunar surfaces and penetration depth at different frequency is largely missing. The present contribution helps to fill this gap. The paper analyzed all data published of dielectric properties of lunar material sampled during Apollo and Luna program. We found, both ε′ (relative dielectric permittivity) and tgδ (loss tangent) of lunar rocks and soil increase with increasing density. ε′ of lunar soil is 1.66~ 4.45, average is 2.68. tgδ of lunar soil is 0.001~0.025, average is 0.0074. ε′ of lunar rocks is 4.17~11, average is 6.80,tgδ is 0.0002~0.21, average is 0.042. But there is difference of dielectric properties existed in different landing sites. Average ε′ and tgδ of lunar soil sampled at Apollo 11, 12, 14, 15, 16,17 and Luna 16, 20 are respectively (2.53, 0.0169), (2.28, 0.0138), (2.97, 0.0074), (2.97, 0.0066), (2.44, 0.0031), (2.81, 0.0086), (3.31, 0.0124), (2.91, 0.0054)。On the other hand, ε′ and tgδ of lunar rocks at Apollo 11~17 landing sites are respectively (8.02, 0.089), (8.32, 0.099), (5.92, 0.019), (5.87, 0.0086), (6.35, 0.0065), (6.55, 0.0479). Dielectric properties of lunar soil and rocks at Apollo 11, 12 landing sites are obviously different from the others. Neglecting influence of frequency for dielectric properties of lunar material, the author estimated microwave penetration depth at 1~40GHz with these data at these sites. They are respectively 3.55m, 4.58m, 7.49m, 8.39m, 19.72, 6.62m, 4.23m, 10.37m in 1.0 GHz and 1.18m, 1.53m, 2.50m, 2.80m, 6.57m, 2.21m, 1.41m, 3.45m in 3 GHz at Apollo11~17 and Luna16, 20 landing sites. Comparing the penetration depth estimated by the author with thickness of lunar regolith at these sites published in literatures, thickness of lunar regolith at Apollo11~17 landing sites are respectively 4.4 m, 4.8m, 5.8m, 5.0m, 12.5 m, 14m, we found that we can estimate depth of lunar regolith by using microwave radiometry working at some frequencies and polarization.

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