**TERRESTRIAL ALTERATION OF LUNAR METEORITES DAR AL GANI 262 AND 400.** Christine Floss and Ghislaine Crozaz, Laboratory for Space Sciences and Dept. of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130, USA (floss@howdy.wustl.edu; gcw@wuphys.wustl.edu).

**Introduction:** Among the increasing number of meteorites that have been recovered from hot desert environments are rare specimens of particular interest for laboratory investigation, such as the lunar meteorites Dar al Gani (DaG) 262 and 400 [1, 2]. However, a growing body of evidence indicates that meteorites collected from hot deserts suffer from significant terrestrial alteration effects that include both mineralogical and chemical changes [e.g., 3-7]. Most recently, Crozaz and Wadhwa [7] investigated the paired shergottites DaG 476/489 from the Libyan Sahara and found variable degrees of terrestrial alteration in both meteorites. Ca-phosphate and feldspathic glass compositions did not appear to be altered, but minerals with low LREE concentrations, like olivine and pyroxene, typically showed LREE enrichments and Ce anomalies, accompanied by enrichments of Sr and Ba that were attributed to terrestrial contamination. However, not all grains were affected, and these authors noted that, despite the alteration, it is possible to obtain petrogenetic information about hot desert meteorites by using measurement techniques such as SIMS that can obtain data on pristine individual grains [e.g., 8].

In this study we continue to investigate the effects of terrestrial alteration on meteorites from hot deserts by examining the Saharan lunar meteorites, DaG 262 and DaG 400. Our goals are to compare the alteration effects in these meteorites with those observed in DaG 476/489 and to obtain petrogenetic information about these meteorites from uncontaminated phases.

**Experimental and Results:** Both DaG 262 and DaG 400 are anorthositic highland breccias [1, 2] with affinities to ferroan anorthosites (FANs). Plagioclase compositions are highly anorthitic and pyroxenes have intermediate mg# [molar Mg/(Mg+Fe)] although more Mg-rich compositions are also present [9, 10]. Although the two meteorites are similar, they are not paired with each other [11]. We used the ion microprobe to measure the rare earth elements (REE) and other trace elements in various minerals and clasts from both meteorites.

Because of the anorthositic nature of these meteorites, we were only able to find one olivine grain (in DaG 400) and one low-Ca pyroxene grain (in DaG 262) that were large enough to measure. However, like Crozaz and Wadhwa [7] we find that both phases exhibit evidence of terrestrial alteration. The LREE abundances in the olivine grain are distinctly elevated (Fig. 1) and the low-Ca pyroxene grain is also LREE-enriched compared to its counterparts from ferroan anorthosites [12]. Both minerals also have Eu abundances that are higher than typically observed in these phases. Furthermore, Sr and Ba concentrations are as much as 3 orders of magnitude higher in the DaG grains than in olivine and low-Ca pyroxene from the FANs.

We were able to measure one high-Ca pyroxene grain from DaG 262. It has REE abundances that fall within the range observed for FAN high-Ca pyroxene (Fig. 2), although its Sr and Ba concentrations are elevated. Similarly, six plagioclase grains have REE patterns similar to those of FAN plagioclase (Fig. 2). Sr abundances in DaG plagioclase are also within the range for FAN plagioclase, but two out of the six grains have elevated Ba concentrations. One analysis of impact melt glass from DaG 262 shows a flat REE pattern at about 5 – 8 x CI and Sr and Ba abundances of 115 and 18 ppm, respectively.

We also measured 17 clasts from both meteorites. Most of these are feldspathic fine-grained to microcrystalline melt breccias, but mafic-rich granulitic clasts and cataclastic anorthosites were also analyzed. REE patterns are generally flat, with abundances that vary from ~1 – 30 x CI, consistent with trace element data obtained for clasts from DaG 400 by laser ablation ICP-MS [13]. Most clasts have positive Eu anomalies, but one has a negative Eu anomaly and three others have essentially no Eu anomalies. A comparison with REE data for lunar highlands rocks [14] shows that REE compositions for the DaG clasts fall between those of ferroan anorthosites and rocks from the Mg-suite. Sr and Ba concentrations are variable, but tend to be higher than those observed in DaG plagioclase, the main carrier of these elements among the silicate phases.

![REE pattern for olivine from DaG 400.](image-url)
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Figure 2. REE patterns for high-Ca pyroxene and plagioclase from DaG meteorites. Shaded areas show ranges for ferroan anorthosites (FAN) from [12].

Terrestrial Alteration: The chemistry of the DaG 262 and 400 lunar meteorites has clearly been affected by terrestrial alteration, just as Crozaz and Wadhwa [7] observed for the DaG shergottites. LREE enrichments are observed in phases that typically have low LREE concentrations (e.g., Fig. 1). Furthermore, Sr and Ba abundances are strongly enriched in these phases and are also elevated in some grains of other minerals such as high-Ca pyroxene and plagioclase, whose REE abundances do not appear to have been affected. These elements are also enriched in the clasts we analyzed, as well as in whole rock analyses of these meteorites [1, 2].

In the DaG 476/489 shergottites, several areas of altered impact melt material show strong LREE enrichments and highly elevated Sr and Ba concentrations, that were attributed to terrestrial contamination [7]. However, an analysis of impact melt glass from DaG 262 has a flat REE pattern and trace element abundances that appear to be consistent with derivation from the surrounding material. This suggests that there may have been some differences in the weathering experienced by these two groups of meteorites. These could be related to mineralogical and/or textural differences between the meteorite types (e.g., porosity, shock effects), or could be due to differences in the duration and/or type of alteration experienced.

Petrogenesis: Despite the terrestrial alteration experienced by DaG 262 and 400, some phases appear to have retained their original compositions (for at least some elements) and these data may be used to make inferences about the origins of these meteorites. We noted above that six plagioclase grains and one high-Ca pyroxene have REE patterns that fall within the range of compositions of their counterparts in ferroan anorthosites [12], suggesting an affinity to these rocks (Fig. 2). In addition, the HREE abundances of the low-Ca pyroxene and olivine we analyzed are similar to those determined from FAN rocks [12].

Both petrographic and mineral chemistry data [1, 2, 9, 10] indicate that DaG 262 and 400 are dominated by feldspathic components largely derived from ferroan anorthositic precursors. The mineral REE data presented here are also consistent with their derivation from FAN rocks. However, lithologies related to Mg-suite rocks have also been observed in these meteorites [10] and our data show evidence of this as well. The REE patterns for the clasts from DaG 262 and 400 show a range of compositions that overlap the ranges observed for both FAN and Mg-suite highland rocks [14]. Indeed, the data are consistent with a derivation of the clasts from these two source rock types, or mixtures of them. Most of the clast REE compositions can be duplicated by adding 10% or less of an average Mg-suite component to an average FAN composition.

Conclusions: Our study of the DaG lunar meteorites provides yet additional evidence that terrestrial alteration of hot desert meteorites is not limited to a few select groups, but rather is a widespread phenomenon, that must be carefully taken into account in geochemical investigations, particularly those relying on whole rock analyses. Nevertheless, we find, as did Crozaz and Wadhwa [7], that careful \textit{in situ} analyses of pristine phases can provide petrographic information about the origins of these meteorites.