CLASTS FROM THE CALCALONG CREEK LUNAR METEORITE;

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The Calcalong Creek lunar meteorite was recovered as a single, 19 gram stone [1]. It is a microbreccia containing submillimeter clasts in a glassy matrix. In thin section, Calcalong Creek resembles "lunar clast-laden impact-melt breccias" of the Stöffler et al. [2] classification. The bulk chips reveal vesicular agglutinates which weld the clasts together. This suggests that Calcalong Creek is a regolith microbreccia with few spherules. Our earlier work [1] showed that Calcalong Creek contains the highest abundance of the KREEP chemical component among the known lunar meteorites. However, a specific REE carrier had not been identified [3]. We report on our petrologic and trace element survey of representative clasts as well as preliminary INAA analyses of the largest bulk chip analyzed to date.

INAA analyses of incompatible elements in 5 chips, totalling 68 mg all exhibit ~100 x CI abundances with a typical KREEP pattern [1] [this work]. One chip contained *more* clasts than representative for Calcalong Creek and another was a tiny, 0.3 mg clast-free matrix sample. This suggests that the KREEPy chemical component is actually carried by the melted matrix rather than in discreet phosphate-rich clasts. Or it may be disseminated throughout the meteorite as very tiny grains.

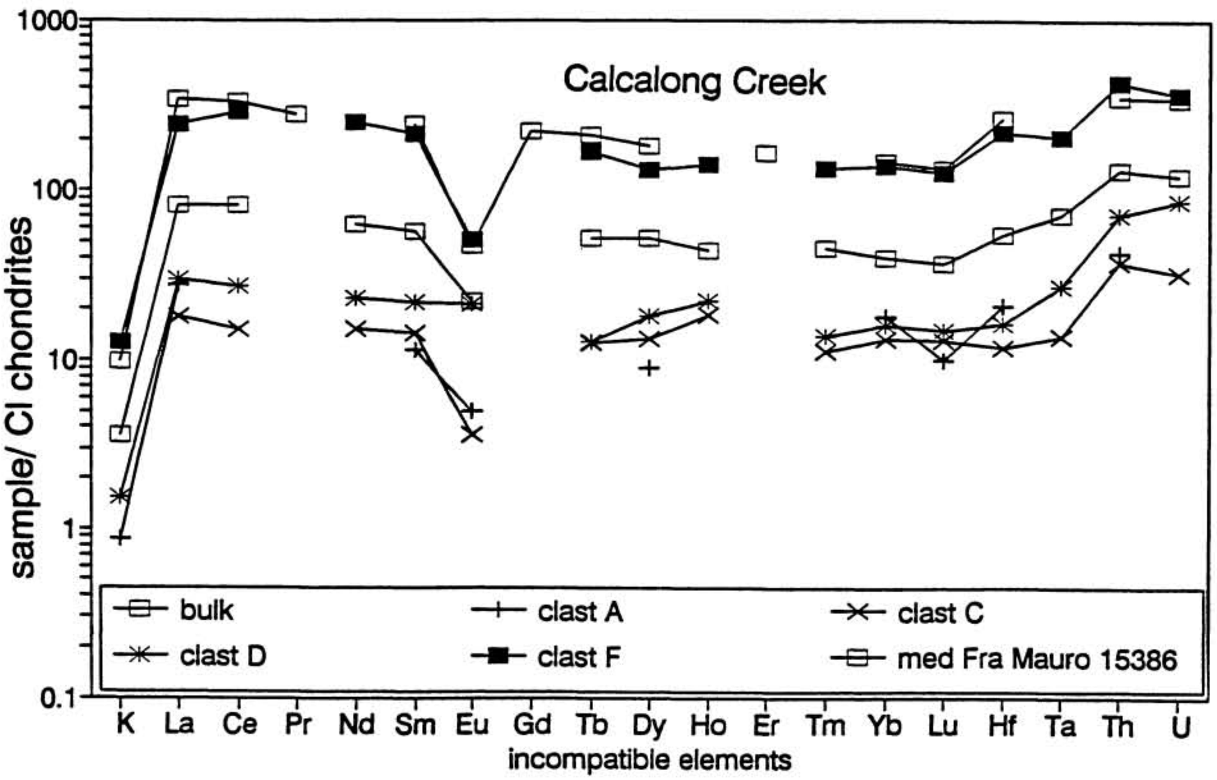
Four clasts representing the most abundant clast lithologies were extracted from chips of Calcalong Creek. The INAA samples were clean splits without matrix or fusion crust. Splits of each clast, with some adhering matrix (except "clast A"), were removed for electron microprobe analyses. Trace element data and major elements (Al, Ti, V, Mg, Ca, Fe) where possible analyzed by INAA are reported as well as petrologic results for clast F.

The largest clast analyzed, Clast F, is a particularly interesting KREEPy basalt with "salt & pepper appearance". It is clearly of KREEP basalt composition and its incompatible lithophiles are quite similar to the medium-K Fra Mauro basalt 15386 [4] [fig. 1]. Notable exceptions are Ni, Ir and Au probably due to meteoritic contamination. KREEPy clasts and KREEPy "contamination" by assimilation of the matrix could certainly dominate the REE abundance pattern of the bulk meteorite [fig. 1]. According to the limits adopted by Warren & Kallemeyn [5], Clast F falls on the boundary between Low-Ti and Very Low-Ti basalts and is a hi-Al mare basalt and hi-K basalt.

A polished mount prepared for electron microprobe analyses contains a roughly triangular remnant, 1.7 mm across, of Clast F attached to a large fragment of matrix. The modal composition of the clast is about 52% pyroxene (pigeonites and ferropigeonites), 43% plagioclase (An_{91-97}; $Or_{0.1-3.0}$), 5% olivine (Fa_{45-78}). Also present are one grain of ilmenite and two of chromian pleonaste. The texture is xenomorphic granular with pyroxenes ranging up to 750 μm; olivines to 210 μm, and plagioclases to 480 μm. There is no sign of shock damage. One large pyroxene grain is zoned, with a core of $En_{58}Fs_{30}Wo_{12}$ and a margin of $En_{40}Fs_{45}Wo_{15}$. Some olivines are zoned but most vary widely in composition from grain to grain (although they may be zoned in the 3rd dimension). Attached to one pyroxene grain is a single small, wedge-shaped mass, 45 μm long, of silica and K-feldspar containing a 20-μm lath of whitlockite. The clast visible in this probe mount contains no other phases likely to contain REE. This perpetuates the mystery of where the incompatible elements are sited.

The remaining three clasts were about 100-200 um in size and contain much lower abundances of incompatible elements (10-30 x CI), but all exhibit a typical KREEP pattern. Clast A is a white, crystalline clast which plots with VLT mare basalts when comparing Al_2O_3 and Sm. Clast C was also crystalline but greenish-yellow in color. It appears to have about 3x the bulk Calcalong Creek abundances of Sc, Cr, and V. It also seems to extend VLT mare basalt trends. Clast D is a white clast which broke into 4 tiny grains. It, too, plots with mare basalts. None of these clasts is considered to be pristine with respect to REE or siderophile abundances.

Our sampling of clasts in the Calcalong Creek lunar meteorite illustrates that it is a mixture of both mare and highland components. Clast F is a KREEP (nonmare) basalt and all clasts exhibit high Ca/Al ratios and plot near Wood's [6] line of demarcation between mare and highland components. The Th and K abundances indicate that it could have come from a region consistent with a lunar nearside highlands composition. The evidence of metamorphism, most likely due to impact(s), suggests that it is unlikely we will find truly pristine clasts. However, the effects of the same metamorphism may reveal the nature of the Calcalong Creek's past.



[1] Hill D. H. et al. (1991) Nature, 352, 614-617. [2] Stöffler D. et al. (1980) Proc. Conf. Lunar Highlands Crust, 51-70. [3] Marvin U. B. & Holmberg B. B. (1992) PLPSC XXIII, 849-850. [4] BVSP (1981) Basaltic Volcanism on the Terrestrial Planets, 271-272. [5] Warren P. H. & Kallemeyn G. W. (1991) Proc. NIPR Symp. Antarct. Meteorites, 4, 91-117. [6] Wood J. A. (1975), Proc. 6th Lunar Sci. Conf., 1087-1102.