

## GEOCHEMISTRY OF APOLLO 17 IMPACT GLASSES: REGOLITH COMPOSITIONS.

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Impact glasses are an abundant component in mature lunar regoliths. This investigation of impact glasses extracted from Apollo 17 regoliths (78461,56; 79511,15; 74241,143; 79221,86) attempts to answer the following question:

WHAT CAN LUNAR IMPACT GLASSES TELL US  
ABOUT THE GEOCHEMISTRY OF THE LUNAR CRUST?

Our analyses of impact glasses from Apollo 11 [1], Apollo 14, and Apollo 17 are intended to provide a 'ground truth' for understanding and interpreting the complex geochemistries of these glasses. The investigation has analyzed individual glasses with masses in some instances as small as 1 microgram by electron microprobe and instrumental neutron activation (INAA) for the following elements: Si, Ti, Al, Cr, Fe, Mn, Mg, Ca, Na, K, Sc, V, Co, Ni, Rb, Sr, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Dy, Yb, Lu, Hf, Ta, Th, U, Ir, and Au. The results of these analyses show that the majority of the Apollo 17 impact glasses were produced by fusion of local regoliths. The compositional range of regoliths at the Apollo 17 landing site is large and systematic [e.g. 2]. The Apollo 17 impact glasses compositionally record this characteristic.

With the important realization that impact glasses can be open systems with respect to volatile elements (e.g. Si, Na, K, Rb, Cs) during the impact fusion event [e.g. 3-5], the geochemistries of lunar impact glasses must be plotted as ratios of refractory lithophile elements in order to extract information about the geochemistry of the original fused target. Figures 1 and 2 are demonstrations of this strategy.

Figure 1 is a ternary diagram involving three refractory lithophile elements (Ti, Al, Sc) that have been assigned coefficients (e.g. Sc\*2000) in order to compensate for the large differences in abundances of these elements. For example, Al is a major-element with abundances in the vicinity of 10 wt.% (i.e. 10<sup>5</sup> ppm), whereas Sc is a trace element occurring with abundances of only 10-60 ppm. These large differences among the elements need to be compensated so that the elements can be comparably weighted in the figures, rather than having the data piling up along one side of the ternary. Figure 1 shows that a majority of the 30 Apollo 17 impact glasses analyzed in this study plot near the compositional range of local regoliths (dashed line) at the Apollo 17 site. This trend is caused by mixing between mare volcanics (x) and highlands components. The fact that the impact glasses also mimic this trend demonstrates that impact glasses are chemically recording these mixtures of mare and highlands components, as proposed by Wood [6], Delano et al. [4,7], Meyer [8], and Vaniman [5]. The samples in Figure 1 that are substantially displaced from the local regolith trend (dashed line) are interpreted as exotic to the Apollo 17 site. These exotic glasses have KREEP, Apollo 16-type highlands, and low-Ti mare affinities suggesting that those regolith compositions occur somewhere in the region of Taurus-Littrow.

Figure 2 also involves parameters using refractory lithophile elements. As in the previous figure, the majority of the Apollo 17 impact glasses have chemical compositions consistent with their having been produced by impact fusion of local regoliths. Those glasses plotting away from the local trend are presumed to be exotic to the Apollo 17 site and thereby possess chemical information about unvisited areas of the Moon.

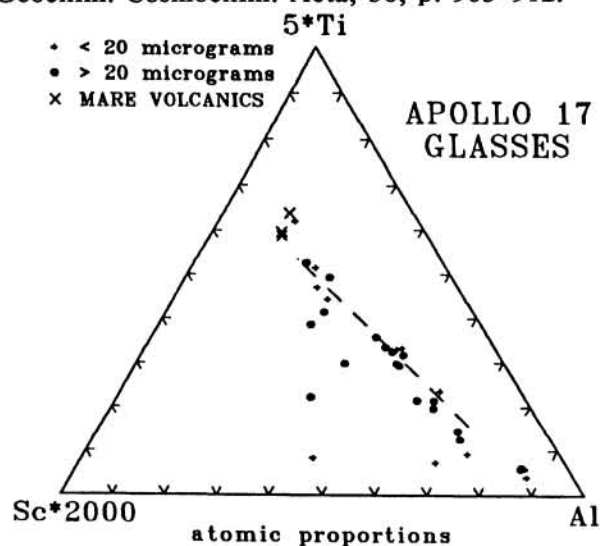
### Conclusions

Our major- and trace-element analyses of impact glasses from Apollo 11 [1], Apollo 14, and Apollo 17 establish a 'ground truth' for understanding the geochemistries of lunar impact glasses. The following conclusions follow from these data:

- (A) Impact glasses contain compositional information about their fused target-materials, which in most instances are regoliths.
- (B) Most impact glasses appear to be locally produced.
- (C) Compositionally unusual impact glasses have been ballistically transported from other regions of the Moon.
- (D) The compositional diversity of the Moon's crust can be explored using impact glasses that are exotic to an Apollo or Luna site. Our data support the concepts of earlier pioneering studies [e.g. 9].

REFERENCES: [1] Delano et al. (1990) LPS-XXI, p. 280-281. [2] Rhodes et al. (1974) PLSC 5, p. 1097-1117. [3] Naney et al. (1976) PLSC 7, p. 155-184. [4] Delano et al. (1981) PLPSC 12, p. 339-370. [5] Vaniman (1990) PLPSC 20, p. 209-217. [6] Wood (1975) Origins of Mare Basalts, p. 194-198. LSI Contrib. #234. [7] Delano (1975) PLSC 6, p. 15-47. [8] Meyer (1978) PLPSC 9, p. 1551-1570. [9] Reid et al. (1972) Geochim. Cosmochim. Acta, 36, p. 903-912.

Figure 1



Dashed line is not a fit to the glass data, but rather is the compositional trend among Apollo 17 regoliths [2].

Figure 2

