Age and origin of Apollo 16 feldspathic fragmental breccias

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In order to improve our understanding of lunar impact history and development of crustal terranes on the Moon, we measured ^{40}Ar-^{39}Ar ages and major+trace element compositions of anorthositic and melt breccia clasts from Apollo 16 feldspathic fragmental breccias 67016 and 67455. These breccias represent the Descartes terrane, a regional, highly feldspathic unit of the central nearside highlands generally considered to be ejecta from the nearby Nectaris basin. The goal of this work is to place better constraints on the emplacement age and provenance of the Descartes breccias.

Four anorthositic clasts from 67016 yielded well-defined ^{40}Ar-^{39}Ar ages ages ranging from 3842±19 to 3875±20 Ma (relative to MmHb-1=513.9 Ma). Replicate analyses of these clasts all agree within measurement error. The weighted mean age for these clasts is 3862±12 Ma (95% conf., n=7, MSWD=1.3). There is little evidence for older components in the Ar spectra of these clasts. In contrast, fragment-laden melt breccia clasts from 67016 yield apparent ages of 4.1 to 4.2 Ga and evidence of even older material (to 4.5 Ga) in the high-T fractions. The 67455 clasts have more variable spectra with evidence for low-T Ar loss. Plateau ages of 3801±29 to 4012±21 Ma for three anorthositic clasts (weighted mean 3935±86 Ma), and 3987±21 Ma for one melt breccia clast were obtained.

Diagnostic trace element ratios (Sr/Ba, Ti/Sm, Sc/Sm) in these clasts all change systematically to lower values with increasing incompatible element abundance. These trends are consistent with mixing of ferroan anorthositic rocks with KREEP and/or Mg-suite components.

An assembly age of 3862 Ma based on the 67016 anorthositic clasts would be younger than Serenitatis and identical with the accepted age of the Imbrium basin. Trace element compositions of clasts in the Descartes breccias suggest a provenance in the Procellarum-KREEP terrane. The combination of age and provenance constraints implies that the Descartes breccias formed during the Imbrium event or by local craters rather than as Nectaris ejecta. Older ages for coexisting melt breccia clasts probably reflect incomplete degassing rather than the emplacement age of the breccias.

Water chemistry of lake inlets and outlet as a predictor of sediment characteristics and internal cycling of phosphorus

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Chemical characteristics of lake sediment determine if PO_4 is released during anoxia. The reductive dissolution of hypolimnetic sedimented $Fe(OH)_3$ is not accompanied by release of PO_4 if Psenner sequential extractions [1] reveal, (1) the molar ratio of Al_{NaOH25}:$Fe_{bicarbonate/dithionite}$ is >3; or (2) the molar ratio of Al_{NaOH25}:$P_{(H20\ +\ bicarbonate/dithionite)}$ is >25 [2]. The extractable Al and Fe hydroxides strongly adsorb PO_4. We have evaluated chemistry of inlets and outlets for four lakes, and estimated input and output fluxes of Al, Fe, Mn, and P, based on a combination of (1) numerical averages of chemistry of multiple seasonally-distributed samples, (2) chemical characterization of high discharge events, and (3) approximate areas drained by the inlets. Concentrations of total acid-soluble, and total dissolved and organically-bound Al, Fe, Mn, P, and DOC are typically reduced 75 to 90% during water's passage through the lake. Photodegradation of organically-bound metals apparently releases inorganic species which precipitate as hydroxide and scavenge PO_4. Psenner-extractable proportions of total Al, Fe, Mn, and P in the sediment are approximately the same as are lost during lake residence time, based on inlet and outlet chemistry. We estimated the sedimentation rate of $Al(OH)_3$, $Fe(OH)_3$, Mn(hydroxide?), and P to the profundal areas of the lakes with ^{210}Pb-dated cores [3]. These rates are similar to the rates at which Al, Fe, Mn, and P are removed from the lake water column. Thus, comparison of inlet and outlet stream chemistry yields inferences about sediment chemistry, and enables predictions about P retention by lake sediment.

[1] Psenner *et al.* (1988) *Hydrobiologia* **170,** 91-101. [2] Kopáček *et al.* (2005) *Environ. Sci. Technol.* **39,** 8784–8789. [3] Norton *et al.* (in press) *Sci. Tot. Environ.*