

LATE ACCRETED MATERIAL ON THE LUNAR SURFACE: CONSTRAINTS FROM HIGHLY SIDEROPHILE AND CHALCOPHILE ELEMENTS IN ANCIENT LUNAR IMPACTITES. P. Gleißner¹ and H. Becker¹, ¹Freie Universität Berlin, Institut für Geologische Wissenschaften, Malteserstr. 74-100, 12249 Berlin, Germany (gleissner@zedat.fu-berlin.de).

Introduction: Knowledge of the composition and timing of late accretion onto terrestrial planets is crucial for our understanding of the latest stage of planetary accretion in general, but also its influence on some important compositional parameters (e.g., the arrival of volatiles). In principle ancient lunar impactites may provide constraints on the composition and timing of late accreted projectile populations. Yet, no consensus has been reached on the origin of variably fractionated highly siderophile element (HSE) patterns [1-4], their formation age and assignment to specific basin-forming events [e.g. 2-5].

The compositional range of HSE ratios in lunar impactites was either interpreted to reflect signatures of compositionally distinct basin forming impactors [1, 2] or to result from mixing of several ancient impactor compositions [3]. In either case, the nature of the putative impactors and the chemical variability of impacting populations with time remain not well understood [4]. Alternatively the observed range in HSE compositions may have been produced by large-scale metal-sulfide-silicate segregation in large impact melt sheets [6]. The impactite HSE signature would then reflect fractionation shortly after large impacts rather than processes on the parent bodies of the impactors.

Results and Discussion: Impactites from different landing sites display broadly linear correlations of $^{187}\text{Os}/^{188}\text{Os}$ (representing the long-term Re/Os ratio of the samples) and HSE ratios which range from chondritic to suprachondritic [1-4]. All impactites which exceed the chondritic range display peculiar high Ru/Pt ratios, a feature which is observed only in a limited number of differentiated metal-bearing meteorites [7]. Available data for siderophile volatile elements range from CI chondrite-like element ratios to strongly fractionated, exceeding the range of primitive meteorites [8].

If the observed spread in HSE ratios between 0.5-1 g samples of lunar impactites was caused by multiple impactors of distinct composition rather than mixing of chondritic with suprachondritic material, then the composition of most impactors was outside the range of known meteoritic compositions sampled on Earth. On the other hand, HSE ratios of all samples investigated by modern methods [1-4, 7] define correlation trends which can be satisfactorily explained by mixing of impactor compositions, similar to known meteorite compositions.

Many Apollo 16 impact melt rocks display sub-mm-scale Fe-Ni metal-schreibersite-troilite intergrowths. Modeling of solid metal-liquid metal partitioning in the Fe-Ni-P-S system indicates formation of these objects by closed system crystallization of solid metal from already fractionated metal melt compositions. Impactites with the highest proportion of metal usually display the most fractionated HSE pattern. The latter observation is inconsistent with fractionation of the HSE during large-scale fractional crystallization and metal segregation in impact melt sheets. Large-scale fractional crystallization of solid metal from S and P rich metallic melt with high P/S in planetesimal or embryo cores is currently the most likely process that may have produced the non-chondritic HSE compositions (including high Ru/Pt ratios) in lunar impactites [7].

The range of HSE ratios in ancient lunar impactites [7] and available impactite formation ages from internal isochron methods [3, 5] are consistent with accretion of chondrite-like and differentiated impactors at 4.2 Ga and variable mixing of their compositions on the lunar surface [3]. Se/Te and S/Se ratios in the range of CI chondrites were found recently in a Fe-Ni metal rich Apollo 16 impact melt rock displaying fractionated HSE patterns similar to volatile element depleted iron meteorites [8]. Impactites with slightly suprachondritic HSE ratios display S-Se-Te ratios suggestive of a predominance of primitive impactor compositions similar to carbonaceous and non-carbonaceous chondrites [3, 8]. These data are further evidence for large-scale mixing and remelting of impactites of different provenance (containing differentiated and primitive impactor material) on the lunar surface.

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