CHRONOLOGY OF VOLATILE LOSS FROM BASALTIC ACHONDRITE PARENT BODIES

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Introduction: Many planetary objects are depleted in moderately volatile elements but the exact mechanisms involved remain unclear. ^{87}Rb-^{87}Sr chronometry provides a powerful tool for determining the timing of volatile depletion, which is key for understanding its causes. To better constrain the timing of volatile depletion in early protoplanets we obtained high-precision Sr isotopic data for angrites and eucrites.

Results: Sr isotopic measurements were performed in dynamic mode using the Thermo TRITON at ETH Zurich. The external reproducibility for the ^{87}Sr/^{86}Sr ratio ±5 ppm (2s). Basaltic and cumulates eucrites plot on a single isochron, whose initial ^{87}Sr/^{86}Sr is 0.698980 ± 0.000027 (2 SD), consistent with previously reported data but a factor of 4-5 more precise than values obtained in previous studies [1]. In contrast, mineral separates from angrites D'Orbigny and Angra dos Reis have indistinguishable ^{87}Sr/^{86}Sr but variable ^{87}Rb/^{86}Sr ratios, possibly reflecting recent Rb addition. Thus, using the measured ^{87}Rb/^{86}Sr to correct for ^{87}Rb-decay could results in spuriously low initial ^{87}Sr/^{86}Sr for angrites. However, the measured ^{87}Sr/^{86}Sr associated with a negligible ^{87}Rb/^{86}Sr for D'Orbigny accurately reflect the true initial ^{87}Sr/^{86}Sr of this angrite, which is indistinguishable from the eucrite initial.

Discussion: The higher initial ^{87}Sr/^{86}Sr of angrites and eucrites compared to Ca-Al rich inclusions (CAIs) may be used to determine a timescale of volatile loss. This requires assumptions regarding the Rb/Sr ratio of the reservoir from which the parent bodies of basaltic achondrites accreted. If we assume 2-stage model for Rb loss starting from a solar nebula reservoir (^{87}Rb/^{86}Sr=1.5), Rb-depletion occurred at 3±1 (relative to CAI 3529-Z [2]) or 5±2 Myr (relative to CAI D7 [3]) at the earliest. The 2-stage model ages would provide the earliest possible time of Rb-loss. Such a late Rb-loss is difficult to reconcile with other evidence for rapid accretion and differentiation of the parent bodies of differentiated meteorites, [e.g., 4] and the Rb-Sr data may indicate that the angrite parent body followed a evolutionary path different from that of other early protoplanetary bodies. Collisions during a more protracted accretion of the angrite parent body might be responsible for the relatively late Rb-loss, possibly related to removal of volatiles by multiple impacts. Yet another interpretation of the elevated initial ^{87}Sr/^{86}Sr ratios of angrites/eucrites compared to CAIs is that the Sr isotopic composition of CAIs is not representative of the initial ^{87}Sr/^{86}Sr in the angrite-forming region. This may be the case if CAIs carry nucleosynthetic Sr isotope anomalies or if their Sr isotopic composition was modified by stable Sr isotope fractionation [5].

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