Evidence of Late Heavy Bombardment signature in H-chondritic fall of Assam, India

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Introduction: Mahadevpur is a classified H4/5 chondrite, which fell in Mahadevpur, Arunachal Pradesh, India (27°40' N, 95°47' E) on 21 February, 2007, breaking down into several fragments before falling [1]. Amongst those several fragments, one of the largest fragment weighting ~ 60 kg [1] was recovered from Pengeri, Assam [2,3], situated close to Mahadevpur (~ 43 km). The geographic proximity of collection also suggests that the Mahadevpur meteorite and the other fragment collected from Pengeri are paired [4]. However, there has been no attempt to geochemically and isotopically correlate the Mahadevpur meteorite with the fragment of it collected from Pengeri. In this study, we determined the concentrations of 43 major and trace elements including the Nd and Sr isotopic composition of the Mahadevpur H4/5 ordinary chondrite and the large fragment of it collected from Pengeri.

Samples description: Samples of Mahadevpur [1] was obtained from Physical Research Laboratory, Ahmedabad, India (Courtesy of Prof. J. N. Goswami), and samples from the ~ 60 kg Mahadevpur-fragment collected from Pengeri was provided by Jorhat Science Centre & Planetarium (JSCP), Jorhat, India, (Courtesy of Dr. Pranabjyoti Chetia, Curator, JSCP) who previously collected it from a private source [1,2,3] and curated in their museum for public display.

Methods: The meteorite samples were dissolved in ultra-pure HF-HNO_3 and HCl-HNO_3 acid in Teflon^{TM} screw-cap containers in Class-100 working space. The major and trace elements concentrations of the samples were measured using a quadrupole ICP-MS (X-Series II, Thermo Scientific^{TM}), and $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ measured using a TIMS (Triton plus, Thermo Scientic^{TM}) at the Centre for Earth Sciences, Indian Institute of Science, India. The initial $^{87}Sr/^{86}Sr$ was calculated using Rb and Sr concentrations determined using ICP-MS.

Results and Conclusions: Major, trace elements concentrations (patterns) as well as the Nd isotopic compostions of Mahadevpur ($^{143}Nd/^{144}Nd$ = 0.512566) and the Mahadevpur-fragment collected from Pengeri ($^{143}Nd/^{144}Nd$ = 0.512562) are almost identical consistent with the suggestion that they are paired samples derived from the same meteorite parent-body. The two fragments show similar REE concentration, Er/Yb, Y/Ho, and Zr/Hf. However, the Sr isotope compositions of these two samples are distinct from each other ($^{87}Sr/^{86}Sr$ of Mahadevpur = 0.758391, $^{87}Sr/^{86}Sr$ of Mahadevpur-fragment collected from Pengeri = 0.755113). These two samples also show a distinct Rb/Sr (Rb/Sr of Mahadevpur = 0.32, Rb/Sr of Mahadevpur-fragment collected from Pengeri = 0.27) suggestive of an early Rb loss in the Mahadevpur-fragment collected from Pengeri. The modelled initial $^{87}Sr/^{86}Sr$ of this suspected Rb loss fragment coincides with the modelled $^{87}Sr/^{86}Sr$ of Mahadevpur at around 4.137 Ga, and modelled $^{87}Sr/^{86}Sr$ of Mahadevpur through time also interestingly coincides with that of an ordinary chondrite from literature data [5] at 4.09 Ga. These ages range within the period of Late Heavy Bombardment (LHB), which is believed to have occurred between 3.8-4.1 Ga [6]. Our calculated ages also range within the ages of certain impact melt breccia from Apollp 16 landing sites [6], which were possibly affected by LHB impacts. According to Late Heavy Bombardment (LHB) event, around 3.8-4.1 Ga, the inner Solar System was bombarded with rocky bodies, that were resultant of collision between early formed planetesimals [6]. Based on intersection of these ratios and a calculation of time for Rb loss ($\Delta t \rightarrow$ time since formation of CAIs) [7], we conclude finding evidence for resetting of Rb-Sr chronometer in the Mahadevpur-fragement collected from Pengeri, which dates around the time of LHB.

Our interpretation of the lower Rb/Sr and less radiogenic measured $^{87}Sr/^{86}Sr$ of Mahadevpur-fragment collected from Pengeri compared to the Madadevpur meteorite, together with their similarity in elemental concentration patterns and Nd isotopic composition, is that the Mahadevpur-fragment collected from Pengeri with lower Rb/Sr and $^{87}Sr/^{86}Sr$ could have sourced from a region of the parent-body affected by Rb volatilization event during the period of LHB, while the fragment with higher Rb/Sr and $^{87}Sr/^{86}Sr$ could have originated from a region unaffected with Rb volatilization. These fragments together with other fragments could have been ejected from the parent-body in space in later stages, which then could have travelled through space in a group prior to falling on Earth.

References:

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