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Asteroid 4 Vesta: Large impact event clusters at 4.5 Ga and 3.8-3.5 Ga

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Eucrites are extraterrestrial basalts and cumulate gabbros formed, and subsequently more or less metamorphosed, at the crustal level of the HED (Howardite-Eucrite-Diogenite) parent body, thought to be the asteroid 4-Vesta. Studying brecciated eucrites using the $^{40}Ar/^{39}Ar$ technique offers the best way to understand the bombardement history of 4-Vesta [1].

Early pioneer $^{40}Ar/^{39}Ar$ studies [1] suggested that brecciated eucrites have impact ages between ~4.1–3.4 Ga. However, Kennedy et al. [2] presented an (>70% ^{39}Ar plateau) age quality filtered database along with new robust $^{40}Ar/^{39}Ar$ plateau ages on brecciated eucrites suggesting instead ages between ~3.8 and 3.5 Ma. Nevertheless, the total number of plateau ages was quite small, possibly creating a sample bias [2]. In this study, plagioclase, matrix and melt rock aliquots from ten brecciated eucrites were examined by the $^{40}Ar/^{39}Ar$ techniques to provide a more robust statistical record for the impact heating history of 4-Vesta. We obtained two distinct population of ages.

We obtained a new concordant (P = 0.16) concentration of six plagioclase and three matrix plateau ages from three polymict breccia with a weighted mean age of 4500 ± 4 Ma (2σ). This is resolvably younger than the series of crustal cooling $^{40}Ar/^{39}Ar$ plateau ages ranging from 4533 ± 12 Ma to 4514 ± 6 Ma recorded by a series of (unshocked) unbrecciated eucrites [3]. We interpret such an age concentration as indicating a single large-scale heating event recorded by several unrelated meteorites. Could this event be related to the Veneneia impact?

When combined with the results from [2], the breciated eucrites analyzed in this study yielded altogether six plagioclase, matrix and melt rock plateau ages ranging from 3850 ± 21 Ma to 3469 ± 35 Ma suggesting that no impact with sufficient energy to *fully* reset the K/Ar has been recorded between 4.5 Ga and 3.85 Ga, or after 3.45 Ga. We propose that these eucrites come from a similar region on Vesta that was initially excavated around 3.85 Ga and then bombarded by background-level (i.e. as normally expected on any exposed surface in the asteroid belt) impacts for the next 350 Ma or so until ejection from Vesta.

[1] Bogard, CdE2011 ; [2] Kennedy et al., GCA2013. [3] Jourdan et al., Goldschmidt 2016.