USING METEORITES TO FIND THE AGE OF THE MOON-FORMING EVENT.

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Introduction: The largest impact ever to occur in the inner Solar System was probably the collision of a Mars- to nearly Earth-sized object with the proto-Earth, leading to the formation of the Earth's Moon [1-4]. Such a large event could have produced a huge number of fragments that would been ejected from cis-lunar space. Many of these would have become Main-Belt-crossing, either by direct injection onto high eccentricity orbits or via planetary encounters/resonances. In some ways, this represents the reverse of the modern meteorite-delivery process. When these objects moved into the Main Belt, they would have had high relative velocities with the objects there (> 10 km/s), much higher than the velocities of background asteroidal objects (~5 km/s). By combining their large numbers with their high speeds, we find these objects would have dominated impact heating in the Main Belt close to the time of the giant impact. This putative pulse that simulations show would then decay over ~100 Ma [5], and might be identifiable in the meteoritic record.

The largest databases of thermal resetting ages of Main Belt asteroids comes from the Ar-Ar ages of ordinary chondrites and eucrites. Although it is frequently not possible to determine whether a given age from the early Solar System comes from impact or parent body metamorphism, there are meteorites with copious impact melt, impact melts with chondritic compositions, and other meteorites that have clearly been significantly heated by impact. Limiting our consideration to these meteorites, there are still 26 OC samples >4.3 Ga in age [6, 7]. Within that data, it appears that there may have been a pulse of impact heating 100±30 Ma after the formation of CAIs. We suggest that the ordinary chondrites are recording the age of the Moon-forming impact, although the possibility that these events come from terrestrial planet leftovers cannot be ruled out..

Interestingly, this same Ar-Ar age, ~4.48 Ga, is found among numerous unbrecciated eucrites that lack obvious shock features. Our model indicates these may be "quench" ages made by giant impact ejecta excavating warm material from depth on their parent body (Vesta). Other meteorite groups, such as the iron silicates (e.g., from IAB, IIE irons), also show similar age patterns to shocked stones, with strong features shown near 4.48 Ga. The interpretation of the origin of these ages warrants further analysis.

References:

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