USING VESTA AND ITS FRAGMENTS TO CONSTRAIN THE HISTORY OF THE MAIN ASTEROID BELT

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(4) Vesta, a 530 km diameter intact differentiated asteroid, is currently unique. There is compelling evidence, however, that Vesta once had "sister" objects (e.g., some V-type asteroids, defined as objects with spectral features similar to Vesta's crust, were not produced by collisions on Vesta itself [1]; a few eucrites have different oxygen isotopes than standard eucrites [2]). Additional Vestas in the main belt would be consistent with dynamical models predicting the asteroid belt lost much of its primordial mass long ago (e.g., sweeping resonances caused by planetary migration, ejection by planetary embryos in the asteroid belt; [3]). If true, *Vesta was not always special*.

Vesta's eucrites, however, may present us with contradictory evidence for a large primordial belt. About 7% of all eucrites are unbrecciated and unshocked, with half of those having Ar-Ar shock degassing ages of 4.48 Ga [4]. The existence of a meteorite-producing population of ancient unbrecciated eucrites is puzzling because these objects should have been battered on Vesta's surface. To explain this, [4] argued the unbrecciated eucrite precursors were ejected from Vesta in a major impact event at 4.48 Ga. This can solve one problem, but it does not explain how a swarm of small asteroids survived 4.48 Gy of collision and dynamical evolution, or why a belt with multiple Vesta-like objects only managed to produce unbrecciated eucrites from (4) Vesta alone [e.g., 5]. *Perhaps Vesta was special after all*.

We investigated these issues using *Boulder*, a new code capable of simulating the dynamical depletion and collisional fragmentation of multiple planetesimal populations using a statistical particle-in-the box approach [6]. We input into *Boulder* an estimate of the primordial main belt size distribution [7] stretched across 10 semimajor axis zones and a number N of Vesta-size objects. We tracked these populations and their fragments for ~600 My until the time of the late heavy bombardment 3.9 Ga. We then assumed the populations dynamically lost sufficient mass that collisional grinding over the next 3.9 Gy could produce the current main belt population [7].

Our preliminary results suggest the history of Vesta strongly constrains main belt history. First, we find that an excited primordial main belt >3 times the current population produces too many V-type fragments among Vesta and her sisters; collisions/dynamics cannot get rid of all of the evidence. Our result is consistent with new dynamical work that indicates the primordial asteroid belt only lost ~50% of its mass during the late heavy bombardment [8]. It also implies that (i) the asteroid belt was never massive enough to form objects *in situ* by standard pairwise accretion models, (ii) it never contained planetary embryos, and (iii) Vesta may have always been unique to the main belt. The observed fragments from Vesta's sisters are most likely debris from the terrestrial planet region that was captured during the earliest times of solar system history [9].

Second, we argue that Vesta's observed family of $D < 10$ km objects has such a steep size distribution that it can only be several hundreds of My old. If true, Vesta's largest basin, the presumed source of much of the Vesta family, is similarly young. This result fits with growing evidence that most of the prominent meteorite classes were produced by young asteroid families [10].

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