THREE VESTA-LIKE BASALTIC ASTEROIDS AND THE ORIGIN OF EUCRITES

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The 1970 discovery of calcium-rich clinopyroxenes in the near-infrared spectrum of the large asteroid 4 Vesta[1] led to the conclusion that this asteroid has a differentiated basaltic crust, presumably of erupted lavas. Vesta has since been of special interest to asteroid and meteorite researchers. To asteroid researchers, Vesta has presented the puzzle of why one body preserved a differentiated crust, while apparently no other large asteroid has done so. To meteoriticists, Vesta has seemed a possible, and perhaps the unique, parent body for eucrite basaltic achondrites[2].

We have observed five-color photometry and near-infrared spectra (0.8-2.5 μm) of the three Earth-approaching asteroids that strongly resemble Vesta[3 4], and bear on the problems mentioned above. The asteroids are 3551 (1983 RD), 3908 (1980 PA), and 1985 DO2.

The spectra of 3551 and 3908 are indistinguishable, while that of 1985 DO2 has a broader pyroxene band at 0.9 μm. All three asteroids have deeper pyroxene bands (0.9 and 1.9 μm) than Vesta, consistent with larger mineral grain sizes. In turn, this could stem from the expected coarser regoliths on smaller bodies. Apart from the band depths, the spectra of these three small asteroids are nearly identical to that of Vesta.

Although the eucrites appear to have come from a Vesta-like object, they probably are not pieces of Vesta itself. Drake[2] noted the dynamical problems of delivering fragments from Vesta to Earth in the timescale of 10^7 to 10^8 years, indicated by cosmic ray exposure ages. Further, Wasson[5] noted that eucrites appear chemically linked to pallasiates and diogenites from the mantle and the core/mantle boundary of a shattered parent body, not an intact body like Vesta. Davis et al.[6] and Davis[7] emphasize that the survival of Vesta's basaltic crust implies an upper limit on the number of larger primordial asteroids. Only in models with a few such bodies does Vesta have a high probability of avoiding erosion of the basaltic surface layer, or complete disruption. Davis' recent model[7] suggests that Vesta is the only body of its size to form and produce a basalt crust, but that about half a dozen smaller, 300-400 km diameter asteroids formed and fragmented.

The three small, planet crossing asteroids observed by us thus may help resolve some of the problems that have been raised about the survival of Vesta-like objects and the origins of eucrites. These three Earth-approaching asteroids are probably not fragments of Vesta, but rather of one or more Vesta-like (or somewhat smaller) asteroids that were disrupted. While generally consistent with the theoretical asteroid models of Davis et al., they suggest that other Vesta like bodies did form, and they may modify slightly the boundary conditions that should be imposed on the collisional models. For example, from our bolometry, we have measured the diameters of the objects, finding 3.5 km for the

largest. This means it must come from a body that had at least a 3.5 km-deep basaltic crust. This in turn may place limits on the size of the parent body.

These three asteroids may include the immediate parent bodies of eucrites. Their earth-approaching orbits would be consistent with the short cosmic ray exposure ages of the eucrites and remove the problem of delivering them directly from Vesta.

References

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