ON THE GEOLOGIC REALITY OF ASTEROID FAMILIES. James C. Granahan and Jeffrey F. Bell (Planetary Geosciences Division, Dept. of Geology and Geophysics, SOEST, University of Hawaii, 2525 Correa Rd., Honolulu, HI 96822)

The principal orbital elements (a, i, and e) of the main-belt asteroids show a tendency to clump around certain preferred values. These concentrations were first noted by K. Hirayama in 1918. He designated these concentrations "asteroid families" to emphasize his belief that they were produced by the disruption of a large proto-asteroid, leaving behind many fragments in orbits approximating those of the parent body.

There are two major methods of defining asteroid dynamical families. The first one is to plot asteroids according to their proper orbital elements and visually determine an asteroid family by the apparent clusters seen on the plots. This method was first used by Hirayama[1], and most recently by Williams[2]. The second method is to apply cluster statistical analysis to asteroid proper element data to determine what groups of asteroids are families. This was done by Carusi & Massaro[3] and most recently by Zappala et al[4]. Visual workers generally obtain a larger number of asteroid families than the cluster statistical workers.

Our geologic analysis was applied to two of the most recent asteroid family classifications. Williams[2] used 2065 numbered asteroids and the Palomar-Leiden Survey asteroids as his sample population, finding 117 families. Zappala and co-workers[4] utilized 4100 numbered asteroids in their hierarchical clustering analysis of asteroid families, finding only 21 families. The mineralogical composition of some of these family asteroids can be determined by means of telescopic spectra. The spectra database used in this analysis was mainly the asteroid survey and classification by Tholen[5] with some comparisons with the Barucci[6] and Tedesco[7] asteroid taxonomies. The mineralogical interpretations of Bell[8] was used to turn the asteroid types into geologic material types.

An asteroid family is thought to result from a catastrophic collision of the parent body. In most cases the impactor is disintegrated in the collision and is therefore not detected by telescopic observation. The parent body breaks up after impact and its littered debris becomes an asteroid family. Therefore, an asteroid family should be able to be reconstructed into a geologically sensible parent body.

Families predominantly of one taxonomic type present little problem of interpretation; they are almost certainly fragmented parent bodies which were originally of homogeneous composition. Families of mixed types could also be produced by fragmentation, if the parent bodies were differentiated. For example, if the present V asteroid 4 Vesta were disrupted by catastrophic impact, the resulting asteroid family could contain objects representing Type M (metal core), A (olivine lower mantle), R (peridotite upper mantle), and V (basalt crust). Some other combinations of types could also be produced by fragmentation of parent bodies which were differentiated, but which did not form a simple layered structure with a discrete iron core. However, even with the most liberal assumptions, many other combinations of types in a family are nearly impossible. One example is a mixture of igneous and primitive types (e.g. S types and C types). It appears unlikely that many asteroid parent bodies could contain significant amounts of thermally unaltered chondritic material in combination with extensive magmatic differentiation.

To evaluate the Zappala[4] and Williams[2] asteroid families with the aforementioned geological model was straightforward. First the Zappala4 and the Williams[2] asteroid databases were sorted according to their family identifier. Then this compilation was compared with the taxonomic systems of Tholen[5], Barucci[6], and Tedesco[7]. It was found that the Tholen classification scheme provided the best spectral database for this study since it contains the most identified asteroids and the most reliable albedo measurements. The Barucci[6] and Tedesco[7] classification schemes

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provided some verification of geologic tends of the asteroid families as seen through the Tholen asteroid classes. Assuming that all family members are derived from a single parent body, our database was then checked for geologic contradiction and matches. This was compared to asteroid family "robustness"statistics as presented in Zappala et al[4]. Both Zappala and Williams families were compared for correspondence or lack thereof.

The following are key results of the above analysis:

(1) Themis, Eos, Koronis, Maria, and Vesta families are nearly identical in both family classifications. They also are geologically consistent with the common parent body model.
(2) The Williams Nysa family, which is geologically consistent (provided that Nysa is omitted), virtually disappears in the Zappala classification.
(3) Most of the geologically questionable Williams families do not directly correspond to Zappala families. 80 of the Williams families have no correspondence to any of the Zappala families.
(4) Many of the Williams Families can not be derived from a common parent body. Most Zappala families can be.
(5) Some interloping asteroids may be present in the Zappala Eos and Themis families.

The general conclusion of this study is that the Zappala et al[4] analysis appears to be closer to "reality" than that of Williams in terms of number of families and fraction of asteroids belonging to families, but the assignment of a particular asteroid to a given parent body is somewhat uncertain.

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