

ASTEROID DYNAMICAL FAMILIES: MOSTLY MYTHICAL? J. F. Bell, Planetary Geosciences Division, Hawaii Institute of Geophysics, Honolulu, HI 96822.

INTRODUCTION: The orbital elements of many asteroids show a tendency to clump around certain preferred values. These concentrations were first noted around 1918 by K. Hirayama and were interpreted by him as evidence of violent disruptions of larger parent bodies, of which the present asteroids are residual fragments. Current wisdom holds that recent catastrophic impacts were the disrupting events. The existence of these "asteroid families" suggests that the deep interior structure of planetesimals in the 300-1000 km diameter range now lies exposed for our inspection by means of telescopic observations and spacecraft. Many imaginative reconstructions of former planetesimals made by "reassembling" asteroid families have been published. Most such reconstructions have assumed a particular proposed list of family assignments, in recent work usually that of J. Williams. For the three large families first proposed by Hirayama in 1918 this is not a serious problem, as all later dynamical analyses have confirmed their existence. However, Carusi and Valsecchi have shown that there is a surprising lack of agreement between different analysts as to the membership of the smaller families introduced since 1918 (1). Two new data sets provide an increased amount of information on the mineralogical composition of asteroids: the Arizona 8-color asteroid survey of 569 objects (2), and the 52-color infrared spectral survey (3) of over 100 objects. This study uses the results of these telescopic observational programs and the most recent mineralogical interpretations in an attempt to determine which of the innumerable proposed dynamical associations are actually families in the strict sense in which the term was used by Hirayama, i.e. fragments of a common parent.

METHODOLOGY: The literature was searched for all proposed asteroid families. Each author's families were considered separately. Taxonomic types assigned to each asteroid were those of D. Tholen (4). An evaluation of whether a family is "real" was based on the mineralogies inferred for each taxonomic type from visible and IR spectrophotometry (5). Families predominantly of one taxonomic type, or of types which are geochemically related, were considered "true families". Families consisting of mixtures of differentiated and undifferentiated types (e.g. S-types and C-types) or geochemically incompatible types (e.g. E-types and S-types which would imply the existence of iron-free and iron-rich pyroxenes in the same body) were considered "false families".

RESULTS: The classic Flora, Eos, and Coronis families are dominated by S-types and easily qualify as true families. The Themis family consists of C-like and B-like objects, and is probably the remains of a partially metamorphosed carbonaceous-chondrite-like parent body. These families remain real regardless of which author's lists of family assignments are used. The Phocaea family consists of mixed S and C types, supporting the idea that this concentration is produced by resonances rather than a fragmentation event. The Nysa/Hertha family must be at least partly "real" since the smaller members are mostly of the rare F-class. These could be highly metamorphosed chondritic material spalled off the surface of E-type Nysa; however the M-

class Hertha is very difficult to fit into a sensible parent body (6). Among the other small families found in recent studies, many cannot be properly evaluated since they are largely composed of small objects whose spectra and albedos have not been determined. However, almost all of those which are amenable to testing fail to qualify as families in Hirayama's sense. No author seems to have any particular success in identifying physically associated asteroids.

CONCLUSIONS: The transition from real to doubtful families in terms of mineralogy found in this study corresponds closely to the transition noted by Carusi and Valsecchi (1) between families which are identified by many authors using different methods and those which are not. This suggests that the true number of recognisable asteroid families is only 4 or 5, and that most or all of the others in the literature do not represent the remains of a fragmented parent body. Possible reasons for this include the use of excessively sensitive methods for defining families, or the existence of an underlying dynamical structure in the asteroid belt which produces associations by perturbations. The Phocaea group seems to be an example of the latter process. Whatever the reason, it appears that the number of identifiable families has been generally overestimated, and that physical studies of family members aimed at reconstructing parent bodies should be restricted to the few unambiguous families. In particular, the common practice among asteroid spectroscopists of treating the Williams families as the "official" families should be abandoned, since these family assignments do not appear significantly more reliable than many others. It also appears desirable that the terminology proposed by Gradie et al. (6, p. 361) be adopted to clarify discussion. In this system a "group" is any concentration of objects in proper orbital element space; a "family" is a group which is thought on physical or mineralogical grounds to be fragments of a common parent body; an "association" is a group which is thought to be of purely dynamical origin (like the Phocaea group). At present, Eos, Coronis, Themis, Flora, and possibly Nysa can be considered well-established as families; all other "families" should be called groups until better evidence of common origin is discovered.

REFERENCES: (1) A. Carusi and G. B. Valsecchi, Astron. and Astrophys., 115, 327-335. (2) B. Zellner et al., Icarus, 61, 355-416. (3) J. F. Bell et al., BAAS 17, 729. (4) D. J. Tholen, thesis, Univ. of Arizona, 1984. (5) J. F. Bell, this volume, Table 1. (6) J. C. Gradie et al., Asteroids, (Univ. Ariz. Press, 1979) p. 359-390.