

ON THE SIZE DISTRIBUTION OF THE S-TYPE ASTEROIDS; D.R. Davis and C.R. Chapman, Planetary Science Institute, Tucson AZ 85719

One clue to unraveling the history of the asteroids and the processes that acted to form them is their observed size-frequency distribution. Asteroids generally show increasing body numbers with decreasing size. Previous work has established that collisions have been the dominant process acting on the asteroids since they accreted and were thermally modified early in solar system history. Interpretations of the observed asteroid size distribution have ranged from there being relatively little collisional modification so that the present size distribution preserves the primordial signature of the accretional process (1, 2, and 3) to extensive collisional evolution such that the present distribution is the product of collisions at all sizes except the very largest asteroids.

Recognition of different taxonomic classes of asteroids led to the realization that there are significant differences between the size distributions of different classes (4), although increasing numbers of asteroids with decreasing size remains a feature of the distribution of all classes. The most recent analysis of the size distribution of different taxonomic types is by Chapman in Gradie, *et al.* (5); Figure 1 shows the size distribution for all asteroids together with that of the C-type and S-type asteroids separately. Although all asteroids together show the trend of increasing numbers with decreasing size, the S-type asteroids seem to show an unusual distribution that flattens at sizes below ~40 km diameter. While a decrease in the number of asteroids over a limited size range is seen in the distribution of other taxonomic types (e.g., C-type near 70 km in Fig. 1), the trend toward increasing numbers resumes at still smaller sizes. The apparent flattening of the S types occurs at a much smaller size and is more pronounced than the "dip" in the C-type distribution.

The size distribution for the different asteroid taxonomic types has been investigated by Davis (6) in terms of different material strengths for the various types of asteroids. In particular, S-type asteroids were argued to be quite strong collisionally, which should lead to a near power-law size distribution in the collisional environment of the asteroid belt. Such a model, indeed, predicts that the power law should continue down to very small--a confirmed flattening in the size distribution would contradict at least part of the model. The indicated flattening is based on the two smallest diameter bins in the size distribution where a significant bias correction factor has been applied to the observed number of asteroids in order to determine the bias-corrected number, so caution is in order, especially for the point shown in parentheses.

Let us inquire about what such a flattening in the S-type distribution might mean for these asteroids and their collisional history. Any depletion of small S asteroids must imply that they are not being produced in the expected number---we cannot think of any mechanism that would preferentially destroy only S-type asteroids smaller than 40 km in diameter. One possible way to limit the production of small S-type fragments would be if the larger S-type precursors were especially strong, or contained strong chunks no smaller than 40 km diameter. Relatively few fragments smaller than 40 km would be produced, except by rare, unusually energetic collisions. A variation on this idea is that originally proposed by Chapman (4) when it was incorrectly believed that there was similar structure in the S-type size distribution at larger sizes. He suggested that S types are the collisionally exposed cores of differentiated parent bodies, which resist further collisional fragmentation.

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In that case the size distribution would reflect the original sizes of the cores, and the small-size flattening would indicate that a decreasing fraction of the original asteroids were melted at small sizes. The induction heating model of Herbert (7) does predict a size dependence, among others, to the efficacy of the heating process.

The canonical view of S-type asteroids (cf. 8) is that they are stony-iron core bodies of differentiated asteroids, generally consistent with the interpretation we have just discussed. Several alternative interpretations, however, cannot readily be reconciled with a "strong chunk" explanation for the flattening. If the S types are ordinary chondrites (9), then there is little likelihood that parts of them would be particularly strong because the strengths of ordinary chondrites are similar to those of other rocks. Taylor (10) has recently argued that core formation even in differentiated parent bodies is difficult and that the maximum size chunks of metal in a 200 km S-type body might be no larger than 10 meters.

Clearly, further data on the S-type asteroid size distribution is needed to confirm and extend that shown in Fig. 1. If the indicated flattening is real, then this presents a major puzzle in understanding the nature and history of the S asteroids.

References: (1) Kuiper, G.P., Y. Fujita, T. Gehrels, I. Groeneveld (1958), *Astrophys. J. Suppl.* **3**, 289-428; (2) Anders, E. (1965), *Icarus* **4**, 399-409; (3) Hartmann, W.K. and Hartmann, A.C. (1968), *Icarus* **8**, 361-381; (4) Chapman, C.R. (1974), *Geophys. Res. Lett.*, **1**, 341-344; (5) Gradie, J.C., Chapman, C.R., and Tedesco, E.F. (1989), in *Asteroids II*, (eds. R.P. Binzel, T. Gehrels, and M.S. Matthews), Univ. of Arizona Press; (6) Davis, D.R. (1989), in *Asteroids Comets Meteors III*, 39-44; (7) Herbert, f. (1989), *Icarus*, **78**, 402-410; (8) Bell, J.F., Davis, D.R., Hartmann, W.K., and Gaffey, M.J. (1989), in *Asteroids II* (eds. R.P. Binzel, T. Gehrels, and M.S. Matthews), Univ. of Arizona Press; (9) Wetherill, G. and Chapman, C.R. (1988), in *Meteorites and the Early Solar System* (eds. J. Kerridge and M.S. Matthews), Univ. of Arizona Press; (10) Taylor, G.J. (1990), *EOS*, **71**, 1433.

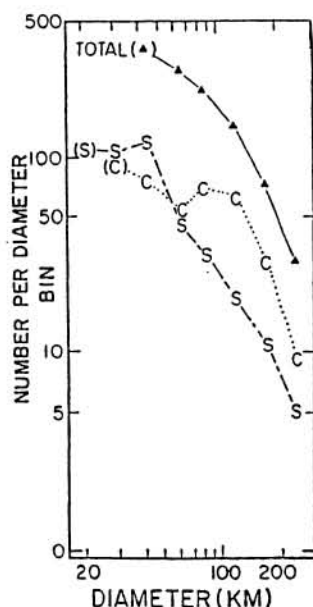


Figure 1. Bias-correct size-frequency distribution for the total asteroid population, together that for the C- and S-type asteroids separately. Modified from Gradie *et al.* (1989).