COMPARISON OF SHOCK METAMORPHISM IN CARBONACEOUS AND ORDINARY CHONDRITES; E.R.D. Scott[1], K. Keil[1], and D. Stöffler[1,2] (1) Planetary Geosciences Division, Department of Geology and Geophysics, SOEST, University of Hawaii, Honolulu, HI 96822, (2) Institut für Planetologie, Westfälische Wilhelms-Universität, D-4400 Münster, Germany.

We compare the shock metamorphic features of ordinary and carbonaceous chondrites using a new shock metamorphism classification devised for ordinary chondrites by Stöffler et al. [1]. This classification scheme is based on the shock effects in large olivines and plagioclase grains that are visible by optical microscopy. The chief criteria for defining six stages of shock metamorphism are features in olivine [2]: stage S1, sharp optical extinction, <5GPa; stage S2, undulatory extinction (>2°); stage S3, planar fractures, 5-10 to 15-20 GPa; stage S4, mosaic extinction ; stage S5, planar deformation features or "elements" plus complete conversion of plagioclase to maskelynite, 30-35 to 45-55 GPa; stage S6, recrystallization near melt zones.

Carbonaceous chondrites. Table 1 summarizes the shock stages obtained by Scott et al. [this volume] for 42 carbonaceous chondrites using the classification scheme of Stöffler et al. [1]. 28 of the C2-C3 chondrites studied show shock features of stage S1, 5 are stage S2 and 1 is stage S3. For the C4-6 chondrites studied, which are nearly all members of the newly defined CK group [3], 5 are stage S2, 2 are stage S3 and 1 is stage S5. Thus the mean level of shock in carbonaceous chondrites of groups CM2, CO3, CV3, CK4-6 and other C2-C4 chondrites is stage S1-S2.

Ordinary Chondrites. From studies by Stöffler et al. of 100 ordinary chondrites [1, unpubl. data] and literature studies of shock levels in 300 ordinary chondrites, we estimate that shock stage S3 is most abundant. The proportions of H and LL chondrites showing stages S2-S4 are 70±15 and 85±15%; for L chondrites, which have the highest fraction of stage S5 and S6, 70±20% are stage S2-S5. In each group the proportion with stage S1 is 5-20%. Overall, there is a tendency for the abundance of stages S4-S6 to increase with increasing petrologic type. This trend is strong in the L group, but weak in LL and possibly absent in H. Nevertheless, the proportion of stages S4-S6 in type 3 (13% overall) appears to be significantly lower than in types 4-6 (20-50%). The most heavily shocked H-L-LL3 chondrites we have observed to date are Parnallee and Mezö-Madaras (S3), Suwahib (Buwah) and Khohar (S4) and Carraweena (S5), which are all L3.6-3.9 chondrites.

Discussion. The mean level of shock in carbonaceous chondrites, stage S1-S2, is lower than that for ordinary chondrites, stage S3. In both ordinary and carbonaceous classes there is a tendency for shock levels to increase with increasing petrologic type. We cannot tell whether our samples are representative of rocks on the surface of the parent asteroids, but since the C chondrites come from 8 or more bodies and the O chondrites from at least 3 different bodies, it is possible that the sample trends truly reflect asteroid properties.

We do not support the theory that the correlation between metamorphic type and shock metamorphism results from impact heating. The mean shock level of chondritic material and the abundance of impact melt are far too low for post-shock temperatures to have converted type 3 to types 4-6. Equipartition of energy between melting and ejection of fragments will cause impact melt to escape from asteroids [4]. In addition there seems to be a distinct difference between the ages of mildly shocked chondrites of 4.4-4.5 Gyr and the ages of shocked chondrites of 0.1-4 Gyr.

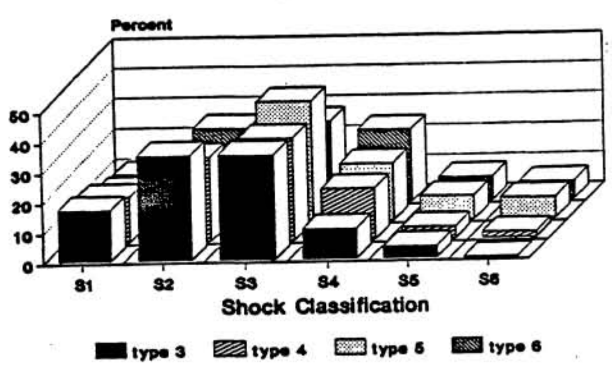
Differences between mean impact velocities on ordinary and carbonaceous chondritic asteroids are unlikely, but preferentially smaller sizes for carbonaceous asteroids could ensure a greater loss of highly shocked and faster moving ejecta [4]. However, it is more likely that the fundamental reason for the differences in shock levels is that well lithified, dry type 5-6 chondritic target materials can survive high shock pressures without dispersal or comminution much better than weakly lithified or unlithified type 2-3 material that is highly porous and loaded with volatile minerals, possibly including ice. Dispersal of volatile-rich C2-C3 materials is aided by shock heating and expansion of volatiles on release from high pressure [5]. Shock heating of type 2-3 material will be more intense than that of type 5-6 material because of the higher porosity of the former. Dispersed or fragented type 2-3 materials that are heavily shocked may be too fine-grained to survive as meteorites if lost from the asteroid, and too rapidly altered if they are retained.

References. [1] Stöffler D., Keil K., Scott E.R.D. and Taylor G.J. (1991) in preparation. [2] Stöffler D. (1972) Fortschr. Mineral. 49, 50-113. [3] Kallemeyn G.W., Rubin A.E. and Wasson J.T. (1992) Geochim. Cosmochim. Acta in press. [4] Scott E.R.D. et al. (1989) In "Asteroids II", R.P. Binzel et al. eds, Univ. Arizona, pp. 701-739. [5] Kieffer S.W. and Simonds C.H. (1980) Rev. Geophys. Space Phys. 18, 143-181.

Table 1. Shock classifications of 42 carbonaceous chondrites

Group	S1	S2	S3	S4	S5	S6
CM2	6	0	0	0	0	0
Other C2	1	2	0	0	0	0
CO3	14	0	0	0	0	0
CV	6	2	1	0	0	0
Other C3	1	1	0	0	0	0
CK4	0	3	0	0	0	0
Other C4	0	1	0	0	0	0
CK5-6	0	1	2	0	1	0

Ordinary Chondrites



Carbonaceous Chondrites