STRUCTURE AND FRAGMENTATION OF THE PARENT ASTEROIDS OF ORDINARY CHONDRITES. G.J. Taylor, E.R.D. Scott, A.E. Rubin, P. Maggiore, and K. Keil, Institute of Meteoritics and Department of Geology, University of New Mexico, Albuquerque, NM 87131.

Structure: Although there is little supporting evidence, it is widely believed (e.g., 1-4) that the H, L and LL chondrite parent bodies, presumably three asteroids, had onion-shell structures with the most metamorphosed type 6 meteorites in their cores surrounded by successive shells of type 5 through 3 material. This model predicts an inverse relation between cooling rate and petrologic type. Alternatively, if accretion of 100 km bodies took $>10^7$ yr and ^{26}Al was the heat source, then maximum metamorphic temperatures would have been reached in planetesimals a few km in radius before parent asteroids formed (5-7). Time scales for accretion are not well known, but Allende, for example, did not accrete into a km-sized planetesimal before ^{26}Al had largely decayed (8). Subsequent accretion of hot planetesimals into parent bodies could ensure that cooling rates at 500°C were controlled by burial depth in the parent bodies and are not inversely correlated with petrologic type. The only data supporting an onion-shell model are fission-track data on six H chondrites (4); similar data on L chondrites fail to show an inverse correlation of type and cooling rate (9). Thermal models for chondrite parent bodies lend some support to onion-shell models as they predict high proportions of type 5-6 material (7,10). In contrast, published metallographic cooling-rate data do not support an onion-shell model (7). To further test whether a correlation exists between petrologic type and cooling rate, we determined the metallographic cooling rates of 19 ordinary chondrites Results appear in Table 1 and are plotted in Fig. 1 along with published data (4, 11, 13-16).

The data support the previous conclusion (7) that no correlation between cooling rate and petrologic type exists for ordinary chondrites. This is not due to errors in the metallographic method: metallographic cooling rates have been determined on four of the six H chondrites on which track measurements were made (4) and agreement is excellent. In fact, agreement is excellent for 10 of the 12 chondrites for which both track and metallographic data exist. We find that cooling-rate data are consistent with the metamorphosed-planetesimal model (7). If they ever existed, which we doubt, onion-shell parent bodies 100-km in size, must have been catastrophically broken up and reassembled prior to slow cooling through 500°C.

Fragmentation: Metal grains in the clastic matrices of the H chondrite regolith breccias Fayetteville and Weston (8), Dimmitt (17), Plainview and Breitscheid (Table 1) indicate cooling rates of between 1 and 10^3 K/Myr. This wide range in cooling rates implies a similarly wide range in burial depths. Using Wood's (11) thermal models, materials composing regolith breccias were derived from depths of a few kilometers to as many as 100 km on asteroids 200 km in radius. Assuming the thermal diffusivities of chondrite parent bodies are not drastically lower than the 0.007 cm^2/sec used by Wood, we conclude that chondrite regoliths contain material derived from a wide range of depths, much of it from many tens of kilometers. Because this material could not be excavated from such great depths without destroying 100-km radius bodies, it appears that the H chondrite parent asteroid was disrupted and subsequently reassembled after slow cooling through 400°C. Theoretical studies of the collisional evolution of asteroids indicate such disruption and reassembly is possible for a large range of impact energies (18-20). Under these conditions, gravity causes the fragments to reassemble, forming a brecciated rubble pile. Subsequent collisions produce a regolith containing material which cooled through 500°C at the whole range of burial depths. (Crabb and Schultz (21) reached a similar conclusion from a study of exposure ages of chondrites, but they made the probably erroneous assumption of an initial onion-shell structure for the three parent bodies.)

Table 1. Metallographic cooling rates (K/Myr).

Meteorite	Type	Cooling Rate
Allegan	H5	15
Ausson	L5	(3)*
Beaver Creek	H4	5000
Breitscheid matrix	H	10-5000
clast	H5	300
Bjurböle	H4	2
Conquista	H4	20
Dhajala	H3	50
Estacado	H6	10
Ipiranga	H6	30
Kernouvé	H6	10
Kesen	H4	20
Krymka	L3	1
Nuevo Mercurio	H5	15
Plainview matrix	H	2-1000
clast	H5	20
Queen's Mercy	H6	(10)
Quenggouk	H4	(10)
Richardton	H5	20
Sete Lagôas	H4	20
Sutton	H5	(10)

* Data in parentheses have large errors and are excluded from Fig. 1.

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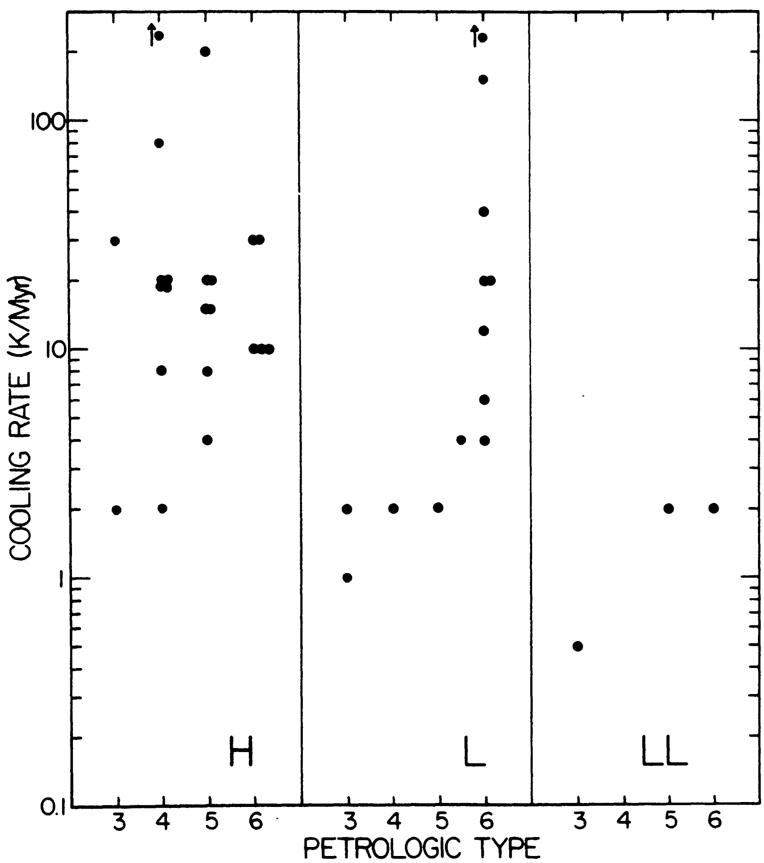

Fig. 1. Contrary to onion-shell models, metallographic cooling rates are not inversely correlated with petrologic type.