COLD VS HOT ACCRETION OF TIESCHITZ AND OTHER CHONDRITES;
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Interpretation of textures in some unequilibated ordinary chondrites (UOCs) is the basis for the viewpoint that these meteorites, or at least some chondrules within them, were accreted while hot enough to be plastic; recent observations of Tieschitz have been central to this development (1-5). I disagree with these interpretations and propose an alternative view that these same textures provide strong evidence for cold accretion.

Textural interpretations that demand high temperatures of accretion are at odds with the cosmochemical evidence. The absence of Fe_3O_4 and the presence of FeS in nebular condensates within ordinary chondrites indicate that accretion occurred between 400 and 600 K; condensation curves of the most volatile elements (Bi, Tl, In) strongly suggest that accretion temperatures of ordinary chondrites (types 3-6) lie mostly within the range 420 to 500 K (6,7). Estimates based on oxygen isotope ratios are in agreement (8). The absence of pronounced recrystallization of ultrafine-grained matrix in UOCs (9) and the characterization of carbon in Tieschitz (10) also argue for low temperatures during accretion of these stones.

Many writers have commented on indentions of chondrules with some suggestions of plastic deformation, and Kurat (1) has compared agglomeration of chondrules to the welding of terrestrial tuffs. However, welded tuffs contain flattened and highly deformed particles; their textures are quite unlike those of chondrites whose chondrules are generally spherical (11). More recently, an influential argument for post-accretional deformation of hot chondrules was made by Hutchison et al. (2), based largely on observations of irregular chondrules in Tieschitz. Several papers elaborating this theme have followed (3,4,5).

The alternative view presented here is that indented chondrules (Fig. 1) and close-fit textures (Fig. 2) in chondrites were produced by removal of material from chondrule contacts by pressure-induced diffusion (PID), a form of diffusive mass transport analogous to pressure solution, during compaction of the chondrite (12). At low temperatures, e.g., 400 to 600 K, PID is dominant over plastic deformation mechanisms; it generally affects the surfaces of particles without deforming their interiors. Analogous textures occur in terrestrial rocks (12).

The interpretation of indented chondrules, irregularly shaped chondrules, and fitted contacts between chondrules as due to adjustment by flow of hot material places strong constraints on accretion intervals and parent body environments that are difficult to reconcile with other observations on chondrite textures and chemistry. Estimates of temperatures required for plastic deformation range from $800^{\circ}C$ (2) to over $1000^{\circ}C$ (4). Accepting these values leads to other suggestions: accretion began immediately after chondrule formation (4); matrix grains and chondrules in UOCs formed in the same thermal event (4); white matrix in Tieschitz was injected between chondrules as a melt (2); dark matrix was liquid when added to chondrules (3); the carbon in this dark matrix was introduced at a cooler, post-accretion stage (3); and there are others (2). These problems and constraints are not encountered for accretion temperatures of 420 to 500 K suggested by the cosmochemical and isotopic estimates (6,7,8) and favored here for development of compaction fabrics produced by PID.

The view presented here accepts that dark rims were acquired by chondrules before accretion (9), that white matrix in Tieschitz (Fig. 2) may be the "sink" for part of the material removed from chondrules at low temperatures (13), and that overburden pressure was too low for brittle crushing of grains.

The interiors of chondrules are thus undeformed, not because they crystallized after indention (2), but because the indented shapes resulted from removal of material at chondrule surfaces after solidification and at temperatures too low for internal plastic deformation to be effective. Tieschitz is only one of many chondrites in which this has occurred (12).

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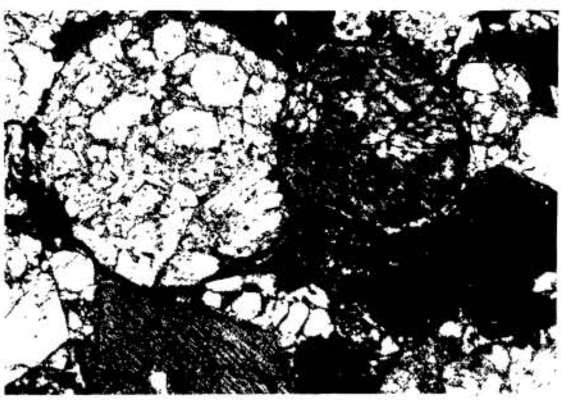

Fig.1. Indented chondrule pair in Tieschitz. Note fitted fabric here and in Fig. 2. (See Ref. 13)

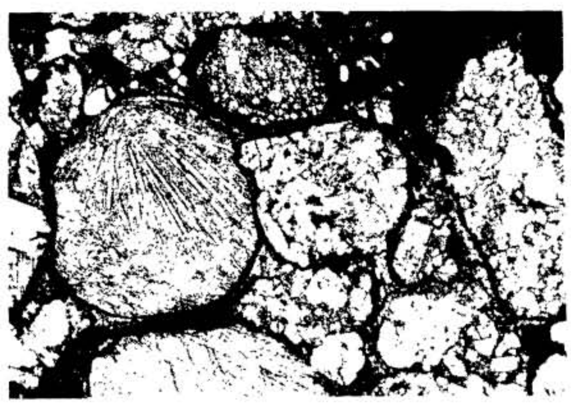

Fig.2. Close-fit chondrules in Tieschitz. Note white matrix between dark rimmed chondrules.