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Attachment 8

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THE COOLING HISTORY AND STRUCTURE OF THE ORDINARY CHONDRITE PARENT BODIES.

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Most major meteorite classes exhibit significant ranges of metamorphism. The effects of metamorphism have been extensively characterized [e.g., 1], but the heat source(s) and the metamorphic environment are unknown. Proposed heat sources include ^{26}Al, ^{60}Fe, electromagnetic induction, and impact [e.g., 2]. It is typically assumed that metamorphism occurred in parent bodies of some sort, but it uncertain whether these bodies were highly structured ("onion skins" [3]) or were chaotic mixes of material ("rubble piles" [4]). The lack of simple trends of metallographic cooling rates with petrologic type has been considered supportive of both concepts [e.g., 4,5].

In this study, we use induced thermoluminescence (TL) as an indicator of thermal history. The TL of ordinary chondrites is produced by sodic feldspar, and the induced TL peak temperature is related to its crystallographic order/disorder [6]. Ordered feldspar has TL peak temperatures of ~120°C, and disordered feldspar has TL peak temperatures of ~220°C. While ordered feldspar can be easily disordered in the laboratory by heating above 650°C and is easily quenched in the disordered form, producing ordered feldspar requires cooling at geologic cooling rates.

We have measured the induced TL properties of 101 equilibrated ordinary chondrites, including 49 H, 29 L, and 23 LL chondrites using the methods of [6]. For the H chondrites (Fig. 1) there is an apparent trend of decreasing induced TL peak temperature with increasing petrologic type. H4 chondrites exhibit a tight range of TL peak temperatures, 190°–200°C, while H6 chondrites exhibit TL peak temperatures between 180° and 190°C. H5 chondrites cover the range between H4 and H6, and also extend up to 210°C. Similar results are obtained for LL chondrites and most L6 chondrites have lower induced TL peak temperatures than L5 chondrites.

The apparent trend of decreasing induced TL peak temperature can be interpreted as reflecting decreasing cooling rate as a function of petrologic type. We attribute some of the scatter in these data to shock metamorphism. Highly shocked meteorites (d, e, and f in the classification scheme of [7]) often exhibit induced TL peak temperatures >200°C. The H5 chondrites that plot above the apparent trend (Fig. 1) tend to have higher degrees of shock.

We suggest that these data are consistent with simple "onion skin" structure for the ordinary chondrite parent bodies. "Rubble piles" are not supported by these data, because, to be consistent, all ordinary chondrite bodies would have to be disrupted in the narrow temperature interval between 650°C (where TL is set) and 500°C or so, the closure temperatures for metallographic profiles, fission tracks, and Ar-Ar.

References: [1] Zhang et al. (1996) *Meteoritics & Planet. Sci., 31,* 87; Guimon et al. (1995) *Meteoritics, 30,* 704. [2] Grimm and McSween (1993) *Science, 259,* 653; Shukolyukov and Lugmair (1993) *EPSL, 119,* 159; Rubin (1995) *Icarus, 113,* 156. [3] Miyamoto et al. (1982) *Proc. LPSC 12B,* 1145. [4] Scott and Rajan (1981) *GCA, 45,* 53; Taylor et al. (1987) *Icarus, 69,* 1. [5] Pellas and Fieni (1988) *LPS XIX,* 915. [6] Sears et al. (1991) *Proc. LPS, Vol. 21,* 493; Hartmetz and Sears (1987) *LPS XVIII,* 395. [7] Dodd and Jarosewich (1979) *EPSL, 44,* 335.

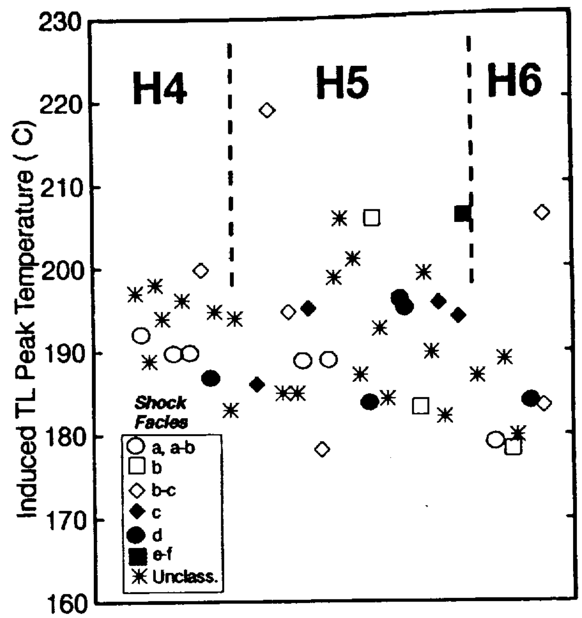

Fig. 1. Induced TL peak temperatures of equilibrated H chondrites. Samples are shown in random order within petrologic types.