METALLOGRAPHIC COOLING RATES OF L-GROUP ORDINARY CHONDRITES.
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Shock metamorphism appears to be a ubiquitous feature in L-group ordinary chondrites. Brecciation and heterogeneous melting obscure much of the early history of this meteorite group and have caused confusion as to whether L chondrites have undergone thermal metamorphism within onion-shell [1] or rubble-pile [2] parent bodies. Employing the most recent shock criteria [3], we have examined 55 Antarctic and 24 non-Antarctic L chondrites in order to identify those which have been least affected by post-accretional shock. Six low-shock samples (those with shock grade less than S4) of petrographic types L3-L5 were selected from both populations and metallographic cooling rates were obtained following the technique of Willis and Goldstein [4]. All non-Antarctic L6 chondrites inspected were too heavily shocked to be included in this group. However, 4 shocked L6 chondrites were analyzed in order to determine what effects shock may impose onmetallographic cooling rates.

Metallographic cooling rates were derived by analyzing the cores of taenite grains and then measuring the distance to the nearest grain edge. Taenites were identified using backscatter imaging on a Cameca SX-50 electron microprobe. Using backscatter we were able to locate homogeneous, rust-free, nearly spherical grains. M-shaped profiles taken from grain traverses were also used to help locate the central portions of selected grains. All points which contained phosphorus above detection limits were discarded. Plots of cooling-rate data are summarized in Fig. 1. Data from the high-shock samples are presented in Fig. 1a. The lack of coherency of cooling rates for individual samples is indicative of heterogeneous cooling following shock. This diagram confirms the statement expressed by numerous workers that extreme care must be taken when selecting samples of L chondrites for cooling-rate studies.

Data for the 6 non-Antarctic low-shock samples are presented in Fig 1a. Incoherence of individual samples in this plot is due in part to the analytical technique (the difficulty in finding the exact center of asymmetrical grains) and the slight level of shock (most L chondrites observed were shocked to S3) in these 'least-shocked' samples. The samples do, however, display a general trend in cooling rates. The lowest metamorphic grade yielded the slowest cooling rates and an increase in grade follows an increase in cooling rate. This is the opposite relationship to that predicted by the onion-shell model. Fission track studies of several L chondrites have suggested an origin in an onion-shell parent body [1], but the database used in that study was very limited when compared to both fission track and metallographic cooling rate data for H and LL chondrites [1,2,5]. This study should greatly increase the current database for L chondrite metallographic cooling rates.

Cooling rates for 4 analyzed Antarctic L chondrites are presented in Fig 1c. These samples have experience cooling in a much narrower range than the 4 non-Antarctic L chondrites (0.2 to 100 as opposed to 0.1 to 600 K/Myr in the non-Antarctic L chondrites). They do not show the apparent correlation between metamorphic grade and cooling rate seen in non-Antarctic L chondrites, casting doubt on the validity of any such correlation in this group.

Taylor et al. [2] used results similar to those obtained in this study to suggest that H and LL ordinary chondrite parent bodies were broken up and gravitationally reassembled as rubble-piles. If this disruption took place before the asteroid reached the blocking temperature of Fe-Ni metal, then cooling rate patterns similar to those shown by our non-Antarctic samples could prevail. Antarctic L chondrites yield no correlation between cooling rate and metamorphic grade. If both Antarctic and non-Antarctic L chondrites were derived from the same parent body, then the trend suggested by the non-Antarctic samples is an artifact of the small sample size. If they were derived from different parent bodies, there is still no evidence in either population to support onion-shell bodies. All metallographic cooling rates may have been controlled by a rubble-pile structure, as has been quantitatively shown to be possible if reassembly times for the disrupted parent body were relatively short [6].

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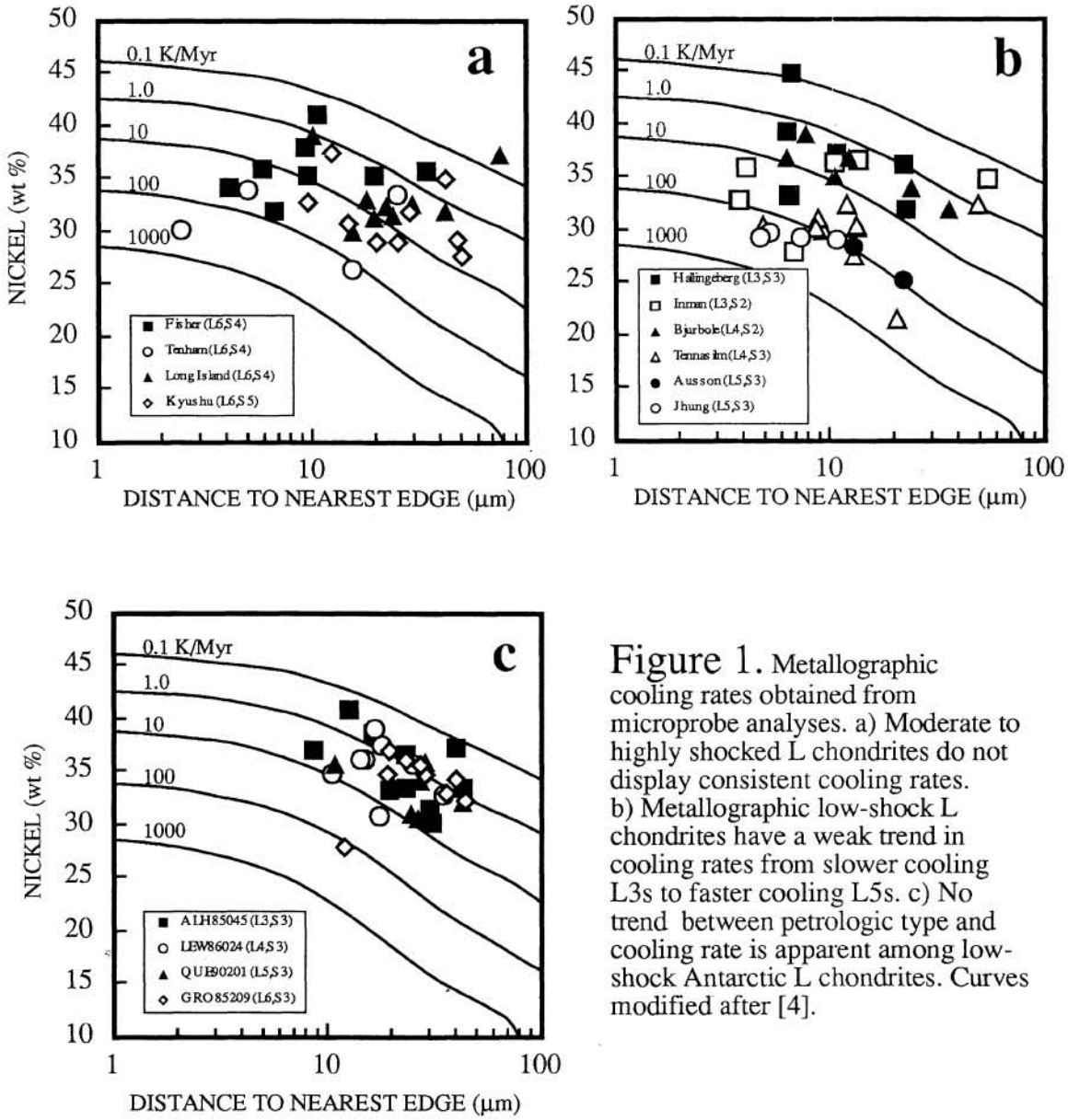

Figure 1. Metallographic cooling rates obtained from microprobe analyses. a) Moderate to highly shocked L chondrites do not display consistent cooling rates. b) Metallographic low-shock L chondrites have a weak trend in cooling rates from slower cooling L3s to faster cooling L5s. c) No trend between petrologic type and cooling rate is apparent among low-shock Antarctic L chondrites. Curves modified after [4].