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The thermal history of enstatite chondrites. Y. Zhang, P. H. Benoit and D. W. G. Sears. Cosmochemistry Group, Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, Arkansas 72701, USA.

In an attempt to decipher the complicated thermal history of the enstatite chondrites, the CaS-enstatite (Larimer and Buseck, 1974; Fogel *et al.,* 1989), cubic sulfide (Skinner and Luce, 1971) and sphalerite (Kissin, 1989; El Goresy and Ehlers, 1989) systems have been applied, but the results have not been straightforward. The CaS-En thermometer gives metamorphic temperatures which appear reasonable, but which do not correlate well with petrologic type. The cubic sulfides yield reasonable temperatures for the EH chondrites, but the values for EL chondrites are very low. To some extent, the problem has been the lack of low petrologic type EL chondrites. Here we discuss data for the recently discovered EL3 chondrites (Chang *et al.,* 1992) and we examine the applicability of the Fe-Ni-P system for thermometry.

The CaS-En thermometer uses three reactions including equilibria between metal, CaS, SiO_2, enstatite and FeS. The method is crucially dependent on the activity coefficients for Si and $CaSiO_3$ which are in solid solutions with metal and enstatite, respectively. The cubic sulfide thermometer uses the solubility of FeS in MgS and MnS, while the ZnS thermometer (which is pressure-dependent) uses the solubility of FeS in ZnS. Current equilibration temperature estimates for enstatite chondrites including the EL3 chrondrites are listed in Table 1.

TABLE 1. Estimates of equilibration temperatures (°C) for enstatite chondrites.*

	Petrologic type							
	EH				EL			
System	3	4	5	6	3	4	5	6
En-CaS	1030	950	830	—	**830**	—	—	1025
Cubic sulf	400	680	600	—	**≤400**	—	—	<400
ZnS	410	(1859)†	—	—	**500**	—	—	550
Fe-Ni-P	**<450**	**500**	**550**	—	**≤450**	—	—	**<450**

* Literature data (see text), present data (bold type).
† Heavily shocked.

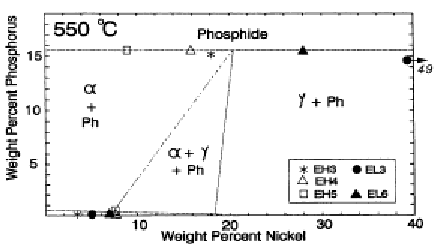

FIG. 1. Isotherm from the Fe-Ni-P phase diagram with data for enstatite chondrites superimposed.

In an attempt to use the Fe-Ni-P system as a thermometer for enstatite chondrites, we used the phase diagram of Doan and Goldstein (1970). Like the other systems, this required extrapolation to lower temperatures (Fig. 1). The temperatures calculated from this system mirror those of the sulfides, suggesting major differences in the thermal history of the EL and EH chondrites.

Two points may be made from the data in Table 1. The EH3 and EL3 chondrites have similar En-CaS equilibration temperatures to those of the higher petrologic types which we suspect reflect pre-metamorphic equilibria. Second, both the cubic sulfides and the phosphides yield metamorphic temperatures for the EH chondrites which are similar to those for ordinary chondrites, while EL chondrites yield very low temperatures. The EL chondrite parent body must have cooled at especially slow rates, perhaps because it was much larger than the EH parent body, or maybe the cooling rate on EL body was governed by the attenuation of the heat source rather than burial depth.

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