THERMOMAGNETIC STUDY OF CHONDRULES

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Abstract. Thermomagnetic and saturation magnetization curves were obtained for separate chondrules and fine matrix grains from one H- (Allegan) and four L-type (Bjurböle, Elenovka, Saratov, Nikolskoe) chondrites. Mineralogical and petrological data were recovered from chondrule thin sections. The differences observed in the obtained curves seem to suggest episodes in the story of chondrules predating their incorporation into matrices.

Insight into the origin of chondrules would possibly provide valuable information concerning the growth of small solid particles in the solar system to larger planetary bodies. To resolve the controversy about this origin all facts and data revealing the differences between chondrules and matrices, in which they are embedded, seem to be of importance.

With such a purpose we started a thermomagnetic study supported by mineralogical-petrological examination of chondrules as extracted from ordinary chondrites - one H- (Allegan) and four L-type (Bjurböle, Elenovka, Saratov, Nikolskoe). The chondrules were hand-picked, cleaned by a simple mechanical tool and packed into small air-evacuated sealed quartz ampoules. The same procedure was applied to fine matrix grains. The sizes and masses of both chondrules and matrix grains are specified in Table 1.

I. Halliday and B. A. McIntosh (eds.), Solid Particles in the Solar System, 371–374.

Table 1.
Material data

Meteorite	Chondrules size (mm)	Chondrules mass (mg)	Matrix size (mm)	Matrix mass (mg)
Allegan	mixed	61	mixed	50
Bjurböle	d<0.37	23	0.1<d<0.25	50
Elenovka	mixed	25	d<0.1	50
Saratov	0.1<d<0.37	19	d<0.1	50
Nikolskoe	0.16<d<0.5	18	d<0.1	50

For each sample, thermomagnetic and saturation magnetization curves were obtained by the Faraday method. Thin sections were prepared from selected representative chondrules to be optically examined. Mono- and polysomatic chondrule textures were observed under the microscope, olivine or orthopyroxene (bronzite) crystals being spaced by dark glassy and/or opaque intergranular material or inclusions (cf. Figure 1a - c). The thermomagnetic and saturation magnetization curves are shown in Figure 2a - e, where solid lines refer to chondrules and dashed ones to matrices respectively. Heating and cooling are indicated with arrows.

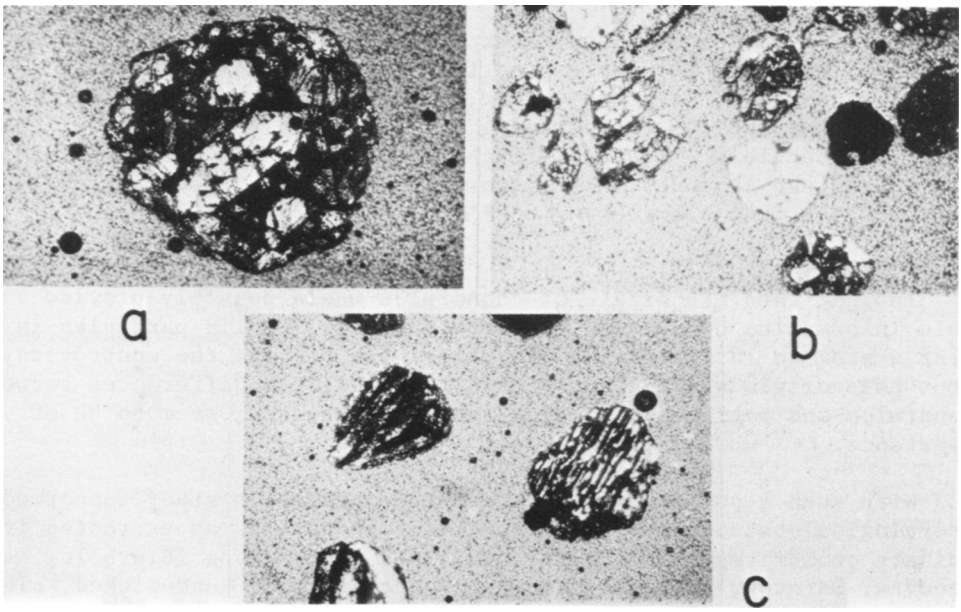

Fig. 1. Photomicrographs of chondrule thin sections: a) Allegan b) Bjurböle c) Saratov.

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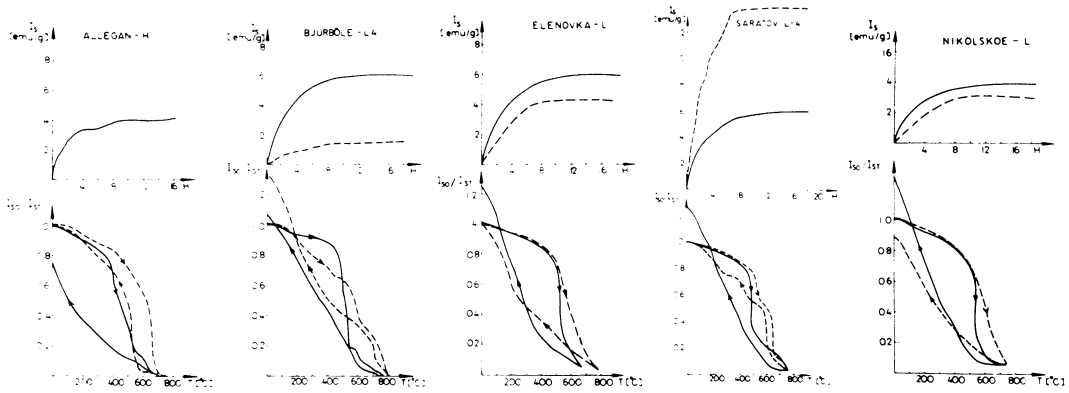

Fig. 2. Thermomagnetic (lower) and saturation magnetization (upper) curves for chondrules from: a) Allegan b) Bjurböle c) Elenovka d) Saratov e) Nikolskoe.

The features of thermomagnetic curves due to blocking, phase transitions or Curie temperatures of various magnetic mineral components are given in Table 2.

Table 2.
Features of thermomagnetic curves (°C)

Meteorite	Chondrules		Matrix	
	heating	cooling	heating	cooling
Allegan	410		480	580
	580		680	
	630			
Bjurböle	480	410	150	580
	610	600	330	730
	780	690	470	
			530	
			600	
Elenovka	530	180	530	330
	700	270	580	580
	stopped at 800	330		
Saratov	500	280	490	650
	540	380	630	
	660	500	730	
	stopped at 740	580		
		630		
Nikolskoe	410	170	410	300
	630	230	580	520
			630	

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Although the features of the thermomagnetic curves require further examination to be unambiguously assigned - except kamacite in Allegan, Bjurböle, Elenovka and Saratov - the versatility of the method as applied was demonstrated. The features of the thermomagnetic curves for the separated chondrules, apparently distinct and rather more numerous than those for matrices, appear to suggest episodes possibly predating their incorporation into matrices. However, the reliability of such a conclusion depends upon better understanding the thermomagnetic curves (and various magnetization remanences) - correlated with mineralogical and petrological data.

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DISCUSSION

Brownlee: What shock pressures are required to alter the magnetic properties of chondrules and matrix?
Lang: The relevant data in terms of remanent magnetizations as affected by shock events and measured for separate chondrules and matrix are not available. It seems unlikely, however, that valuable information on after-shock effects in chondritic material containing previously incorporated chondrules (except for shock-sensitive phase transitions) will be found in features of the thermomagnetic curves.