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MOSSBAUER STUDY OF SHOCK INDUCED EFFECTS IN THE FE-NI 50/50 ORDERED ALLOY IN METEORITES*

by

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ABSTRACT

Using the flying plate technique we have investigated by Mossbauer Spectroscopy, the shock induced effects in the ordered iron-nickel alloy of meteorites. The degree of long-range order in the ordered alloy is reduced by shock event.

Key-words: Order-disorder; Fe-Ni Alloys; Shock Effects; Meteorites.

INTRODUCTION

Using the flying plate technique (Meyers 1974), we have investigated the effects of shock on the ordered Fe-Ni phase with superstructure Llo, in the nickel-rich iron meteorite Santa Catharina, and in the LL-chondrite Saint-Severin.

The ordered Fe-Ni 50/50 phase can be identified by Mossbauer Spectroscopy, due to the characteristic asymmetrical spectrum of the Llo superstructure arising from the non cubic environment of the Fe atoms in this Fe-Ni alloy (Danon et al 1978).

The structure of iron-nickel alloys submitted to shock pressures have been studied by X-ray diffraction and electron microscopic analyses (Donukis et al 1971). The results obtained with Fe-30% Ni and Fe-32%Ni showed almost complete alpha-gamma transformation. The new gamma-phase exhibit particular mechanical and structural properties.

Changes introduced by shock effects in the ordered state of the Fe-Ni ordered alloy, have not yet been studied. Interesting results have been reported with Cu_3Au showing that the degree of long-range order in the ordered Cu_3Au alloy, as evidenced by resistivity and stored energy, is reduced only moderately at shock pressures up to 290 Kbars (Beardmore et al 1964). High shock pressures cause appreciable destruction of long-range order.

EXPERIMENTAL

To submit meteorite samples to shock waves, we construct a special stainless steel system on which a flying plate submitted to an explosive charge permits to exposure the sample to shock waves of hundreds of Kbars. In this technique the sample is cooled in water immediately after the shock, in order to minimize simultaneous thermal effects.

The Mossbauer absorbers have been made with: a) thin slices of the Santa Catharina meteorite, measured before and after exposure to shock pressures of 100 and 200 Kbars. b) A sample of the LL-chondrite Saint-Severin submitted to shock pressures up to 530 Kbars. The iron-nickel phases of the sample pulverized by shock have been studied using the magnetically separated fraction which has been purified from troilite (FeS) and the silicates with concentrated HF.

RESULTS AND DISCUSSION

The iron-nickel 50/50 ordered phase (superstructure Llo)is present as a major constituent of the nickel-rich ataxite Santa Catharina. We have investigated the effect of shock pressures up to 200 Kbars on the order-disorder state of this meteorite.

The hyperfine parameters of the different Fe-Ni alloy phases obtained by Mossbauer Spectroscopy are listed in Table I. The Mossbauer spectrum of the unshocked meteorite can be fitted with: a single paramagnetic gamma-phase, the typical spectrum of the ordered phase Fe-Ni, and a magnetic phase which can be attributed to the disordered Fe-Ni alloy (Danon et al 1979a).

As one goes from 100 to 200 Kbars the proportion of the ordered-phase markedly decreases from 50.23% to 23.72% and consequently the amount of disordered phase increases(from 12% to 42%).

The linewidths of the disordered phase are broadened as expected from the increase of the alloy's disordered state. The gamma-paramagnetic phase (taenite < 32%Ni) remains unalterable after shock, and no gamma to alpha transformation is observed.

Shock waves effects are visible by metallographic analyses as slip planes. Scanning Electron Microscopy observation confirm the presence of the two different Fe-Ni phases (a Ni-rich and a poorer-Ni) and disclose morphological changes in the poorer-Ni phase. This can be a consequence of mechanical deformation, then, a similar morphology is produced by rolling effects.

The results of shock induced pressures on the Santa Catharina ordered alloy, can be explained by a reduction of the degree of long-range order of the Fe-Ni 50/50 ordered phase by shock waves. This result is similar to that observed with the Cu_3Au ordered alloy in which, in the pressure range from 290 to 370 Kbars the degree of long-range order decreases sharply (Beardmore et al 1964).

The metal faction extracted from the Saint-Severin meteorite exhibit a complex Mossbauer spectrum which arises from the superposition of: a magnetic spectrum due to the alpha-phase (kamacite) with low Ni content, the typical pattern of the Fe-Ni ordered-phase and a smaller proportion of a paramagnetic-phase corresponding to the disordered gamma-phase with less than 32%Ni (Danon et al 1977b).

After shock we observe a decrease of about 10% of the ordered phase, and modifications in the values of the hyperfine parameters. The quadrupole splitting decreases slightly and the hyperfine field increases from 289 kOe to 292 kOe showing a tendency to a decrease in the degree of long-range order of the Fe-Ni ordered alloy (Larsen et al 1982). An increase of 16% in the proportion of the gamma-paramagnetic phase is also observed.

The alterations in the ordered state of the Fe-Ni alloy in Saint-Severin by shock is less remarkable than that observed in the Santa Catharina meteorite. This is probably due to the fact that the degree of ordering in Saint-severin is higher than that in Santa Catharina. A much higher shock would be required in order to verify an important effect.

TABLE I

		IS (mm/s)	QS (mm/s)	W(mm/s)	H (mm/s)	A%
unshocked	ordered-phase	-0.06	0.18	0.43	290	50.23
	disord-phase	-0.03	-	0.71	305	12.03
	paramag-phase	-0.19	-	0.52	-	37.73
shocked 100Kbar	ordered-phase	-0.08	0.19	0.38	289	42.36
	disord-phase	-0.07	-	0.91	310	19.70
	paramag-phase	-0.19	-	0.42	-	37.93
shocked 200Kbar	ordered-phase	-0.07	0.20	0.33	289	23.72
	disord-phase	-0.05	-	1.00	301	42.32
	paramag-phase	-0.19	-	0.40	-	34.00

TABLE CAPTION

TABLE I - Hyperfine parameters of the Santa Catharina meteorite submitted to shock pressures. IS=isomer shift (ref. ^{57}Co/Rh); QS=quadrupole splitting; W= line width; H= hyperfine field; A= relative area.

REFERENCES

Beardmore P, Holtzman A H and Bever M B 1964 Trans. Met. Soc. AIME 230 735.

Danon J. Scorzelli R B, Azevedo I S, Galvão da Silva E and Guimarães J R 1981 Proc. Int. Conf. on the Application of the Mossbauer Effect, Srinagar, India, p 333.

Danon J, Scorzelli R B, Souza Azevedo I, Christophe-Michel-Levy M 1979a Nature 281 469.

Danon J, Scorzelli R B, Souza Azevedo I, Curvello W. Albertsen J F and Knudsen J M 1978 C.R. Acad. Sci., Paris 287 199.

_________________1979b Nature 277 283.

Donukis T L, Lobodyuk V A, Savvakin G I, Titov P V, Fedas N P and Khandos L G 1971 Fiz. Metal. Metalloved 31 182.

Larsen L, Roy-poulsen H, Roy-poulsen N O and Vistisen L 1982 Phys. Rev. Lett. 48 15.

Meyers M A 1974 Ph.D.Thesis, University of Denver, Colorado, USA