Shock structures in the Morasko meteorite - preliminary SEM data

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Abstract

This paper is a preliminary review of main shock deformations in the Morasko meteorite. Three main types of metamorphism structures occur in the investigated material: (i) brittle, (ii) plastic and (iii) thermal. Their interpretation may indicate, that Morasko meteorite reveals several stages of shock, eg.: extraterrestrial collisions and fall on the Earth.

Key words: shock, metamorphism, the Morasko meteorite

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Introduction

Huge pressure and high temperature generated during meteor impact on the Earth may cause so-called "shock" changes in the meteorite structure.. Iron meteorites are the only type of meteorites, for which the association with terrestrial impact craters has been found (Lipschutz 1968). Metallographic investigations of shock changes in iron meteorites were started by Nininger (1956), Lipschutz and Anders (1961) as well as Maringer and Manning (1962). Jaeger and Lipschutz (1968) noticed that single crystals of kamacite, cohenite and schreibersite deformation may be caused by shock, which can be shown on the X-ray diffraction investigation. Shocked kamacite shows unusual features during the X-ray diffraction, like asterism or diffuse Laue spots (Leonhardt 1928). According to Jaeger and Lipschutz (1967a), it may indicate that kamacite had been severely shocked. Shock pressure higher than 190 kbar can cause crystallographic deformations in three meteoritic minerals: 1) kamacite, 2) cohenite and 3) schreibersite (Lipschutz and Jaeger 1969). Sharp and DeCarli (2006) emphasize the use of static high-pressure data on phase equilibria together with shock wave and thermal physics calculations, which allow interpretation of observed microstructures in shocked meteorites. The main effects of shock structures in meteorites, which are possible for microscopic observation are deformations: brittle, plastic and thermal. The mentioned types are present in the meteorite Morasko.

Samples and methods

To observe the shock structures, five fragments of the Morasko meteorite were selected. Their description is shown in the table 1. Their surface has been sanded, polished and etched (Fig. 1 a, b). SEM investigations were conducted using a Philips XL 30 ESEM/TMP scanning electron microscope (SEM) equipped with an EDS (EDAX) detector. The analyses

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were carried out at the Faculty of Earth Sciences, University of Silesia, Sosnowiec.

Results and discussion

The optical observations show, that the investigated material was strongly shocked (Fig. 1 c). The characteristic feature is the presence of crushed crystals of cohenite and schreibersite grains. Cohenite and schreibersite occur as large crystals and veins. During the SEM observations a three types of shock deformation were noted: brittle, plastic and thermal. Nevertheless, it seems that the plastic deformation prevails over brittle structures. This is probably caused by plastic properties of the metal (Jastrzębska 2009). Brittle deformations are slots on the phases contact and sometimes have a brecciated form. They mainly occur in the kamacite (Fig. 1 d). Their formation were done at extremely low temperatures (in the case of iron temperature is about -190 °C), so it may prove that a collision in the space occured. Meteorites, which have these deformation easily may be disintegrated during impact (Semenenko and Tertichnaya 1996).

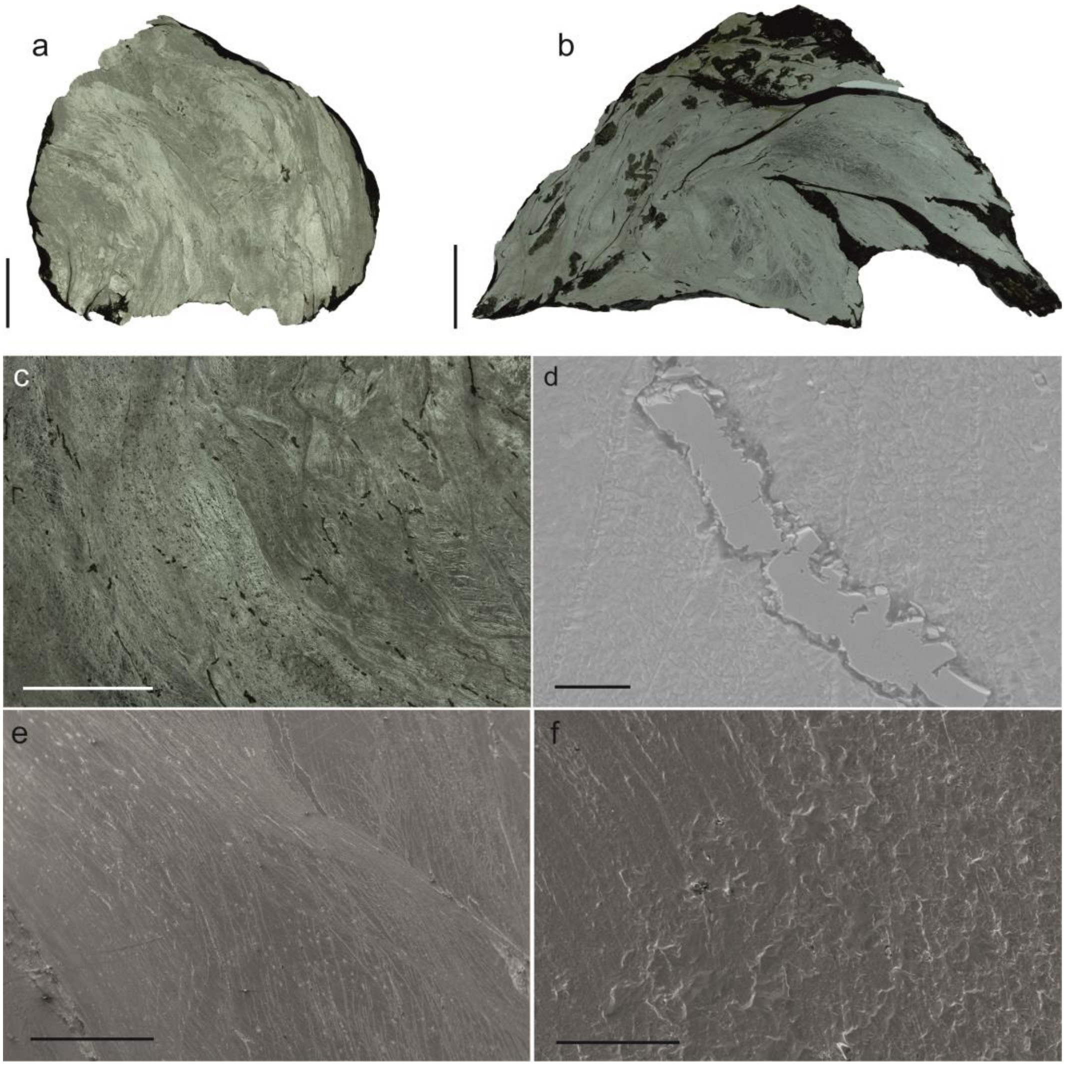

Fig.1. a, b) Two of the investigated Morasko meteorite fragments M1 and M2, scale bar is 1 cm; **c)** strongly shocked surface of meteorite sample M2, scale bar is 0.5 cm; **d)** crushed schreibersite grain in sample M2, scale bar is 20 μm, BSE image; **e)** abnormal course of Neumann lines in sample M4, scale bar is 100 μm, BSE image; **f)** recrystallized kamacite in sample M4, scale bar is 50 μm, BSE image.

Tab.1. Investigated fragments of Morasko meteorite.

Meteorite	Sample number	Type of sample	Mass
Morasko	M1	End-piece	37.61 g
	M2	End-piece	127.3 g
	M3	End-piece	78.71 g
	M4	End-piece	37.6 g
	M5	End-piece	47.88 g

Plastic deformation is a plain structure and Neumann lines (Fig. 1e), which arise into kamacite, as a result of rapidly short-term pressure. In the studied meteorites, one of the characteristic features are deep Neumann lines, which in some areas form a complex of many systems. These lines break down at the grain boundaries.

Thermal changes usually blur or completely remove pressure evidences, causing partial or complete recrystallization of kamacite (Fig. 2 f). This phenomenon can affect the whole body of the meteorite or only its outer zones, heated during the flight through the atmosphere (Jastrzębska 2009).

Summary

Morasko meteorite has a clear signs of strong shock. Genesis of this extraterrestrial body seems to be related with collisions in space and during fall on the Earth's surface. Jaeger and Lipschutz (1967b) claimed that for most of the shock effects in iron meteorites was responsible individual collisions between asteroids, which was 650 ± 60 million years ago, while occurence of several Morasko craters confirms a huge energy librated during impact. Recreating the exact history of the Morasko meteorite thus requires further detailed studies.

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