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The post-impact metamorphism textures of various type meteorites

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Abstract

In this paper, a review of the features of shock metamorphism in stony and iron meteorites is given on the examples of Chinga and Sikhote-Alin iron meteorites before and after high-intensity shock loading; and Chelyabinsk LL5, Tsarev L5 chondrites.

1. Introduction

The study of extraterrestrial substance in recent years has been given a special attention. This is due to both the activation of planetary missions for the small bodies exploration in the Solar system, and increasing amount of newly discovered meteoritic samples. Shock waves are an integral part of the extraterrestrial matter evolution processes. Kinetics and mechanism of phase and structural transformations in this material influenced by the shock waves. It is possible to obtain a wide range of these transformations in a one sample during the converging waves loading experiment [1].

2. Samples and methods

A series of experiments on shock wave loading were performed on the fragments of Chinga IVB, Sikhote-Alin IIAB, Chelyabinsk LL5 and Tsarev L5 meteorites [2-5]. Samples and conditions for their low- and high-intensity explosive loading in the laboratory experiments are presented in [2, 3]. Microstructure studies were carried out using the Zeiss Axiovert 40 MAT optical microscope and scanning electron microscopy Carl Zeiss Σigma VP with energy dispersive spectroscopy (EDS) and electron backscattering diffraction (EBSD) units.

3. Results and discussion

A spherical central cavity of the ball from the Chinga meteorite was formed after the explosive loading. It is explained by realized conditions of the high-speed high-intensity loading and the fact that Chinga ataxite have a quasi-isotropic macrostructure. The formation of adiabatic shear bands and regions of localized material flow. It should be noted that the Schlieren bands on the surface of Chinga sample both in the initial substance and after shock experiments were observed (fig.1).

Figure 1: Sector of the ball from the Chinga meteorite after shock wave loading (diameter 56.01 mm).

Because of it heterogeneous texture of the Sikhote-Alin sample in the central part the distribution of cracks and discontinuities is not spherical (fig.2). The features of shock metamorphism were observed in the Sikhote-Alin iron meteorites, such as traces of $\alpha \rightarrow \varepsilon \rightarrow \alpha$ transformations in kamacite, $\alpha \rightarrow \gamma \rightarrow \alpha_m$ massive transformation in kamacite, contact melting zones at the rhabdite ‒ kamacite boundary, and complete remelted phosphide regions. It was shown that the polycrystalline texture of the contact melting zone was formed by the bcc phase that was supersaturated solid solution of phosphorus in the α-Fe(Ni) [6]. It was determined that the nature and distribution of deformation defects and areas with traces of $\alpha \rightarrow \varepsilon \rightarrow \alpha$ transformation along the radius of the spherical sample are under the influence of the geometry of the shock-wave action and the original macro- and microstructure of the meteorite. EBSD and the local X-ray analysis clearly show that Fe-Ni alloy of meteoritic origin after action of an explosive spherical compression contain areas undergoing polymorphic $\alpha \to \varepsilon$ and $\varepsilon \to \alpha$ transitions [1,6].

Figure 2: Cross-section of a ball from the Sikhote-Alin meteorite after shock wave loading (diameter 50.00 mm).

Previously, the studies of Saratov L4 meteorite by spherical shock waves loading demonstrated immiscible silicate and sulfide melts, redox reactions and effect of anomalous mass transfer [2-4]. In contrast to porous material of Saratov L4, which were partly destroyed after the shock experiment, Tsarev L5 material were saved. Shock loading of the Tsarev L5 provide a wide range of temperature and pressure effects. Radial disposing of textural shock effects within the material refers to increment of the shock intensity from the sample surface to the center. As the result, zones of deformation, melting and partial melting of the material were developed after shock experiments with chondritic material. Estimation of the internal structure transformation was done. Shock features in the Tsarev L5 meteorite material of the different shock level was obtained as the result of the experimental shock. As initial material in the outer part of the sample as completely melted material in the central part can be observed. Furthermore, it is possible to compare experimentally created textural shock features with original material and melted parts of the Tsarev meteorite breccia material.

4. Summary and Conclusions

Possible structural changes in the meteorite matter formed with significant peak pressures and temperatures were demonstrated as the result of simulation experiments. Experimental conditions allow one to obtain the range of effects in the testing substance from the plastic deformation to the complete melting.

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References

[1] Muftakhetdinova R.F. et al. An effect of contact melting in the Sikhote-Alin iron meteorite after isentropic spherical shock waves loading, Letters on materials Vol. 5(1), pp. 110-114, 2015.

[2] Kozlov E.A., Zhugin Y.N., Litvinov B.V. et al. Features of physicochemical transformations of chondrites "Saratov" in spherical shock waves, DAN, Vol. 353 (2): pp. 183-186, 1997.

[3] Kozlov E.A., Zhugin Yu.N., Litvinov B.V. et al. In: Abstracts of Int. Conf. Shock Waves in Condensed Matter, July 12-17,1998, St.−Petersburg., Russia, pp. 182—183, 1998.

[4] Rusakov V.S., Kupin Y.G., Badyukov D. D. et al. State of Fe atoms in minerals of the Saratov chondrite affected by spherical impact waves, Geochemistry International, pp. 300—303, 1998.

[5] Gizzatullina R. F., Grokhovsky V.I., Yakovlev G.A.. The structural changes in the kamacite-rhabdite boundary regions of shock loaded Sikhote-Alin iron meteorite, Meteoritics & Planetary Science. Vol. 49 (SI) pp. A137

[6] Muftakhetdinova R.F., Grokhovsky V. I., Kozlov E. A., Khomskaya I. V., Yakovlev G. A., Phase transformation $\alpha \to \varepsilon$ in meteoritic Fe − Ni alloy under shock-wave loading, Technical Physics. Vol. 61 (12), pp. 1830–1834, 2016.