SHOCK AND ANNEALING RECORD IN ZAKŁODZIE ENSTATITE METEORITE

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Introduction: The Zakłodzie is an ungrouped enstatite meteorite [1,2,3] with achondritic-like texture. Various processes were considered to explain the texture: 1) strong static thermal metamorphism and formation of EL7 typ chondrite [1], 2) impact melting [2], 3) igneous crystallization of cumulate during slow cooling (formation of primitive achondrite) [3]. The above processes operate in extremely different conditions, and acceptation of each of them put strong constrains on origin of Zakłodzie as either chondrite or achondrite.

The goal of the study is to define role of the above processes in evolution of meteorite based on nanostructure of twinned enstatite crystals. The approach is that all the above mechanisms might have led to twinning of pyroxene [4,5,6], but resulting nanostructure would differ. Several striated crystals were studied in FIB-TEM at Tecnai F20x-twin transmission electron microscope in GFZ, with a field emission gun electron source operating at 200 kV.

Results: Twinned and striated enstatite in Zakłodzie consists of disordered mixture of both orthorhombic and monoclinic polymorphs, domains of which are heterogeneously distributed. Clinopyroxene dominates, with its domains reaching up to 40 nm in thickness. In some parts, very thin lamella of cpx overgrown with opx are also abundant. Orthorhombic polymorph forms usually very thin lamella, and only limited number of lamella up to 20 nm in width was observed. Electron diffraction patterns show strong streaking, which results from stacking disorder produced by coherent interleaving of blocks of ortho- and clinoenstatite.

In regions of strong striation, pyroxene reveals additional diffraction contrast in TEM, manifested by distinct change in orientation of parts of lamella (up to 200 nm long). Presence of such heterogeneously distributed domains is interpreted here as a result of kinking of crystals. In spite of being sheared and kinked, lamella are also cracked, and in many cracks traces of recrystallization and annealing are observed.

Disscussion: Intergrowths of ortho- and clino- polymorphs of enstaite can develop by a number of different mechanisms. On meteoritic parent bodies the mechanisms are linked either to slow cooling during igneous processes [4,5], annealing [4] or sustained shearing and shock [6]. Heterogeneous distribution of orthorombic and monoclinic polymorhps, domination of cpx and relatively large thickness of its domains in Zakłodzie are suggestive of pyroxene inversion due to shearing and shock [6], which is also in good agreement with kinking. However, shock event itself is not sufficient to cause annealing observed in pyroxene of Zakłodzie. To account for this, it is reasonable that after severe shock event, the meteorite was buried in deep parts of warm ejecta and thermally annealed. The cooperation of both processes on chondritic parent body may explain texture of Zakłodzie.

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