Petrology and mineralogy of ALH-77005 shergottite

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Introduction:

The ALH-77005 Martian meteorite (lherzolitic type) was found at Allan Hills area in South Victoria Land on Antarctica in 1977-1978 [1]. Nyquist et al. [2] described the lherzolitic texture in ALH-77005 meteorite. Moreover, Ikeda [3] suggested the shergottite formation in the plutonic subsurface environment on Mars. We give an overview here about our new microscopical observations that could explain some details of its formation by shock-metamorphism overlapped with magmatic processes.

Methodology:

Petrographical studies were carried out using a Nikon Eclipse LV100POL optical microscope. The phase transitions and lattice defects in constituent minerals were examined by a Renishaw RM-2000 Raman spectrometer attached to a Leica DM/LM microscope. A 785 nm diode laser with 8 mW power as an excitation source was focused onto the surface with a spot size of 1 μm.

Petrography:

The ALH-77005 consists of dominant pyroxene and olivine associated with minor feldspar and chromite. It has coarse-granular texture with locally-arranged microgranular and poikilitic textures (Fig. 1.) as well as melt pockets including recrystallized needle-like crystallites in glassy matrix. The length of the needles is between 10-75 μm and their width between 1-5 μm. In the vicinity of the melt pockets resorption rim can be observed in olivine and the intrusion of dark melt. The textural characteristics above mentioned imply its formation during crystal differentiation in plutonic processes.

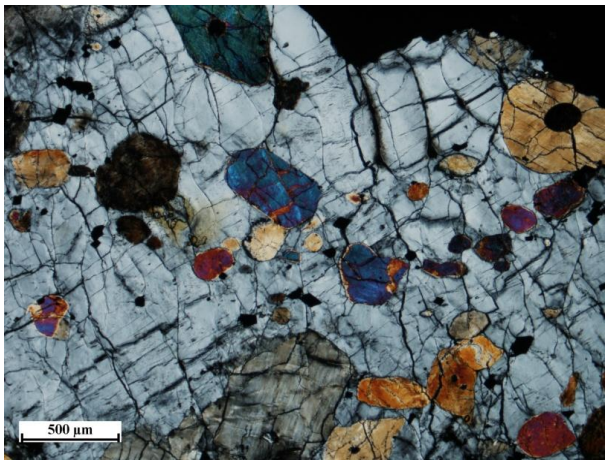

Figure 1: Poicilitic texture in our ALH-77005 sample

Shock metamorphic effects:

The isotropic lath-shaped plagioclase and maskelynite occur close to the melt pockets. Multiple parallel kink-band system is discernible in olivine. Poelchau and Kenkmann [4] described a new shock-metamorphic feature (feather features, FF) in quartz, which might be produced in low shock-pressure regime (7-10 GPa). Their appearances are in a good agreement with our observations in olivine from ALH-77005. Commonly, the FF lamellae tilt to the fractures in a low angle. The ALH-77005 shergottite contains patchy olivine grains with reduced interference color resulted from the thermal annealing followed by postshock melting, which formed melt pockts. Such patchy olivine also occurs in the ringwoodite-bearing shocked chondrite (e.g. NWA 5011) [5].

Raman spectroscopy:

The Raman spectra obtained from the boundary areas and the inside of the melt pocket suggest a recrystallization history related to the annealing in the postshock stage (Fig. 2). The Raman spectra were obtained from four areas characterized by the microtexture related to post-shock annealing as follows: sp1) normal olivine, sp2) olivine with deformation microtextures, sp3) boundary zone between olivine and melt pocket, sp4) recrystallized melt pocket (Fig. 2.). The olivine grain in the vicinity area to the melt pocket shows characteristic Raman peaks at 823, 853 (doublet main vibration) 535, 600, 918 and 957 cm^{-1} (minor peaks).

The main doublet peak seems mostly unchanged among the areas, but second peak of doublet became broader with reduction of its intensity, of which behaivor might be affected by the formation of lattice defects due to post-shock annealing. These facts imply that the duration of postshock pulsation was too short to induce a phase transition to high pressure-temperature minerals, such as wadsleyte and ringwoodite, which have been observed in NWA-5011.

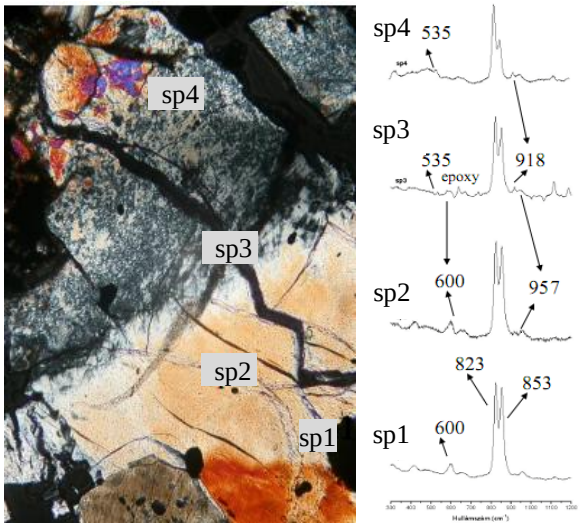

Fig. 2: Raman spectra of differently shocked olivine.

Conclusion:

The ALH-77005 formed by plutonic processes had experienced impact-metamorphic event estimated at 45-55 GPa peak shock pressure (S5 stage). The lack of high-pressure olivine polymorphs suggests that shock pressure pulsation was not enough to reach the activation energy for phase transformation. Therefore, patchy olivine might be corresponding to an intermediate phase on the way to higher-pressure stage during phase transformation.

Acknowledgement

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References:

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