MINERALOGY OF METEORITE CHELYABINSK AS KEY TO APOLLO ASTEROIDS ORIGINATION. S. Voropaev[1] , A. Eliseev[2] and D. Petukhov[2], [1]GEOKHI RAS. Kosygina 19, Moscow, 119991, Russia. E-Mail: voropaev@geokhi.ru. [2]MSU, Faculty of Chemistry, 1-3 Leninskiye Gory, Moscow, Russia,119991. E-Mail: eliseev@inorg.chem.msu.ru

Introduction: Using the Raman spectroscopy that we anticipate will be used in future planetary surface exploration, we have identified and characterized the major, minor and trace mineral phases in rock chips and dust of the meteorite Chelyabinsk, fall 15 February 2013, over Chelyabinsk, Russia. Raman spectra are shown for olivine, pyroxene, feldspar, magnetite, pyrrhotite (an Fe sulfide group), calcite and, possibly, parisite [1]. The variations in composition of the silicate minerals represent different stages of crystallization at dust/gas clouds of solar nebula heating by shock events.

Samples: On 19 February 2013, GEOKHI RAS sent an expedition from staff of the laboratory of meteoritic for the collection of the substance of the meteorite in the region of settlements the Deputy, Pervomaisky and Emangelinka, about 40 km to the South West from Chelyabinsk. It was first found about 3.5 kg fragments of the meteorite, and mineralogical, chemical and isotopes compositions were analyzed. Main result is that meteorite Chelyabinsk is ordinary chondrite, type LL5-S4 W0 according international classification. Preliminary analysis of trajectory and orbit established that the Chelyabinsk superbolide was fragment of an Apollo asteroid, specific group of near-Earth objects. Special issue of “Geochemistry International” journal under edition of academician Galimov E.M., MAIK “Nauka/Interperiodica” (Russia), July 2013, will be devoted to the detailed review of the investigations conducted.

Procedure: Renishaw InVia Reflex Spectrometer System was used for all of the Raman measurements reported here. High power near infrared diode laser, 300 mW at 785 nm, was used as the excitation source for most measurements; DPSS laser radiation, 100 mW at 532 nm, was used for a few. The Raman spectrometer has a spectral resolution of 1–2 cm^{-1}. Also, Scanning Electron Microscopy (SEM) and energy dispersive X-Ray microanalyses (EDX) were performed on a Leo Supra 50VP microscope equipped with Oxford-Instruments X-Max detector. Measurement parameters of the microscope system during analysis were: low vacuum (N_2, 40 Pa), 15 kV electron beam, working distance 7 nm.

Results: Mineralogy of meteorite Chelyabinsk provides additional data to better understand the gas – and hydro-dynamical behavior of the Sun protoplanetary nebulae resulting in planetesimals formation [2]. It comprises the olivine (forsterite) with average composition Mg_2SiO_4, mainly. Also, Chelyabinsk contains orthopyroxene (enstatite), with minor feldspar, albite. Their paragenesis and textural relationships are consistent with formation at the hot edge of accretion disk situated close to the Sun where the subsequent transport and slow cooling gives the pyroxene crystals time to sink and accumulate to high concentrations of the SiO_2 [3]. Although the main rock composition was found to be fairly homogeneous, some zoning was observed as the grains with pyrrhotite and ferric oxides (magnetite and titanomagnetite) enrichment, see Fig. 1. Moreover, Raman spectroscopy has permitted mineralogical information to be obtained through the identification of new spectral features in the meteorites. Carbonates like calcite polymorphs were analyzed in the Chelyabinsk meteorite. Calcite appears as most stable polymorph whereas no evidence for aragonite (high temperature polymorph) was found. Possibly, parisite have been found in Chelyabinsk as well. These spectra seem not to have been reported previously in LL chondrites, to our knowledge.

It is known that Apollo asteroids have been perturbed into region of Earth's orbit (crossing 1 AU) from origin locations in other parts of the solar system, presumably from the inner asteroid belt (< 2.5 AU) [4]. The combination of the all above mentioned mineral phases at the parent Apollo asteroid body was possible only in case of significant turbulence in its formation area.

References:

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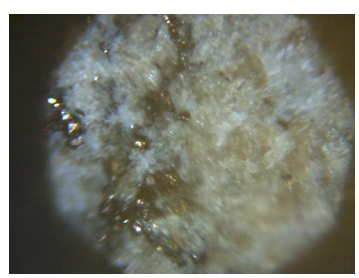

Fig.1 Rock composition of meteorite Chelyabinsk.