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Spectroscopic studies of terrestrial impact materials: Preparation for Popigai expedition

N.A. Evdokimova (1), A.V.Rodin(1,2), V.L. Masaitis(3), G.G. Dolnikov(1), O.Z. Roste(1), O.I. Korablev(1), I.S. Timofeev(2), M.N. Popova(4)
(1) Space Research Institute(IKI), Moscow, Russia, (2) Moscow Institute of Physics and Technology (MIPT), Moscow, Russia, (3), Karpinsky Russian Geological Research Institute, St.-Peterspurg, Russia, (4) Spectroscopy Institute, Troitsk, Russia (evdokimova@iki.rssi.ru)

1. Introduction

Terrestrial craters give us an excellent opportunity of direct analisys as opposed to craters out of the Earth. However, on the Earth there are only few sites where traces of strong impacts event could be studied in the field. The traces of ancient impacts are better preserved in the frozen subsoil at subpolar latitudes. One of such sites is Popigai crater, located in sub-polar Siberia, Russia, presumably caused by a giant impactor 35 Ma ago. This astrobleme gives a good chance to observe *in situ* the asteroid crater, impact materials and other consequenses of great energy deposition. The crater was thoroughly studied during last few decades due to impact diamond inventories associated with it [1]. However a number of problems remain unresolved and wait for further studies: the physics and chemistry of impactites and impact breccias; mineral components with metamorphic rocks affected by great shock and impactites; material ejecta; structural forms invoked by crater formation; problems of remote sensing studies and problems related to comparative planetology. In the framework of Europlanet program, we plan the expedition to Popigai site scheduled to 2012.

1. Studies related to Popigai expedition

Preparation to the expedition implies laboratory studies and numerical simulations in several related areas. In particular this includes validation of remote sensing data with respect to impact rocks and structures. Multiple step research are necessary to impliment: spectroscopic laboratory studies of Popigai impact rocks samples; laboratory simulations of impact-induced material; numerical calculation of synthetic spectra. During the forthcoming expedition the 3-level studies are planned: field spectroscopic studies of impact materials outcrops, aerosurveying. satellite data analysis.

1.1 Laboratory studies of Popigai samples

To determine the optical characteristics of impact materials characterized by complex structure at scales compared to optical wavelength in the VNIR range. Samples (tagamites, suevites) from Popigai site were studied using mid-resolution VNIR and FTS spectrometers. An attempt to identify extraterrestrial rare earth elements in the samples was made using high resolution Brucker FTS. In turn REM images of samples allowed for the analysis of microstructure and morphology. Based on X-ray spectroscopy, the analysis of elemental composition was carried out.

1.2 Numerical simulations of impact material scattering properties

Interpretation of remote sensing data related to impact structures requires the development of theoretical techniques, including simulation of synthetic spectra and phase functions. To calculate optical properties of densely packed structured media, various approximations of scattering theory may be implemented, depending on relationships between wavelength λ and characteristic microstructure scale l. If both scale length l and photon free path length L are of the order or less than wavelength, it is necessary to take into accound near field effects.

Calculation of average optical parameters of the continuous medium is then implemented using one of numerous radiation transfer algorithms. Using the knowledge of the microstructure of impact materials from sample analysis and laboratory simulations, one can evaluate optical properties of macroscopic areas covered by such material and identify those areas from remote sensing data.

1.3 Laboratory simulation of impact-induced material

A series of model experiments has been carried out on the high-power Nd:phosphate glass laser facility "Saturn", built by joint efforts of MIPT, IKI, TRINITI research center (Troitsk, Russia) and the Federal Nuclear Center VNIIEF (Sarov, Russia). A beam of first harmonics laser radiation (λ=1.06 μm) with energy from 5 to 50 J and length of 30 ns is focused onto the spot with the diameter of ~0.3 mm, with caustic depth ~0.5mm. The material ejected by laser pulse and collected on the foil was then studied by REM-microphotography and X-ray emission spectroscopy. In the first experiments, normal alkalinity (andesite) and ultramafic (olivine, pyroxene) was used as targets. A typical morphology of condensate are mixed aggregates including spherical monomers and melt drops, reshaped after aggregation and producing a peculiar "branching" structure. These experiments show that laser modeling and subsequent analysis of products may be employed for studying of planetary material transformation during impact of different scales.

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2. Summary and Conclusions

Elaboration of the problems related to impact structures remote sensing, particularly in the infrared spectral range, and the development of validation techniques for such observations is one of the first priorities of the upcoming expedition to the Poipigai site at 2012. The expedition program is open for further discussion and will include other tasks proposed by individual participants.

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References

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