IMPACT-INITIATED SYNTHESIS AS A SOURCE OF ORGANIC MATTER ON THE EARLY EARTH: AMINO ACIDS FORMATION FROM THE COMPONENTS OF A NITROGEN-METHANE ATMOSPHERE IN THE CASE OF VOLATILE-POOR STONY IMPACTORS.

M. A. Zaitsev, M. V. Gerasimov, and A. S. Vasiljeva, Space Research Institute of the RAS, Profsoyuznaya st. 84/32, Moscow, Russia, 117997, mzaitsev@iki.rssi.ru.

Introduction: It has been assumed in the aspect of the prebiotic synthesis of organics on the early Earth that the impact-initiated synthesis of organic compounds (OC) was highly competitive in performance with other main abiotic sources of OC, such as delivery by accreted bodies, photochemical synthesis, synthesis under the action of lightning discharges, etc. [1].

We observed formation of simple amino acids from components of nitrogen-methane gas mixtures during laboratory high temperature (4000-5000 K) laser vaporization of peridotite. The simulated conditions of high temperature vapor were similar to the conditions that occur during hypervelocity impacts at velocities of 10-15 km/s [2].

Experiment: The laser vaporization of a peridotite target (made of powdered peridotite, compressed in a tablet) was carried out using a Nd-glass pulse laser (λ=1,06 μm), according to the standard technique [2]. Peridotite, consisting of olivine and pyroxene – the main constituents of stony meteorites [3], was a mineral analogue of the matter of stony asteroids or planetesimals. Nitrogen-methane gas mixtures in the chamber for laser vaporization (P = 1 atm, T = 298 K) contained 4 and 50 vol. % of CH_4. The mixtures were possible analogues («methane-rich» and «metane poor») for the early Earth atmosphere. The components of the model gas mixtures were the only sources of carbon, hydrogen, and nitrogen (essential for OC formation) in our experiments. Solid condensates, formed after the laser vaporization of the peridotite target, were subjected to triple water extraction using an ultrasonic bath. The extracts were merged, evaporated, dried and the dry residue was subjected to derivatization with N-(tert-butyldimethylsilyl)-N-methyltrifluoroacetamide (MTBSTFA) under the optimal conditions [4]. Then, volatile and thermally stable derivatives of initial thermally labile OC, extracted from the condensates, were analyzed by GC/MS.

Results and their discussion: In the condensates obtained in the atmosphere of 50 vol. % CH_4 such amino acids as sarcosine – the main product, alanine, glycine, serine, aspartic acid and some others were found at ppm level. Among the other detected OC were: urea – the main product, some hydroxycarboxylic and dicarboxylic acids. In the condensates obtained in the atmosphere of 4 vol. % CH_4 we found such amino acids as alanine – the main product, and glycine. We also identified the following OC: urea – the main product, succinic acid, and some hydroxycarboxylic acids. The yield of amino acids and other OC was much more significant for the «methane-rich» gas mixture.

An impact-generated vapor cloud provides extreme conditions (high temperature and pressure, the presence of free oxygen, etc.), which are incompatible with the presence of any significant abundances of any complex OC [2]. Nevertheless the OC formation can take place even under such conditions due to some factors. Among them: proceeding of heterogeneous catalytic reactions (in particular, Fischer-Tropsch type reactions) on the extremely developed surface of condensing silicate particles, and the formation of the mantle, composed of high-molecular-weight (soot-like) organic matter and molecular carbon, on the surface of these silicate particles. The carbonaceous matter preserves the low-molecular OC, forming simultaneously, against thermal destruction and oxidation.

A nitrogen-methane atmosphere, even with low abundance of CH_4, favors the impact-initiated formation of biologically significant OC despite the absence in stony impactors of C, H, N and other chemical elements, essential for the OC formation. Described combination of carbon- and nitrogen-bearing atmospheric gases as sources of C, H, and N with condensing silicate particles as a catalyst could provide efficient impact-initiated synthesis of biologically significant prebiotic OC.

Conclusion: There are hypotheses, that the early Earth atmosphere could contain significant amounts of methane [5]. In the case this atmosphere also contains nitrogen, or other N-containing gases, as the main constituents, the impact-generated organic matter could contain, in particular, simple (consisted of 2-4 carbon atoms) protein and non-protein amino acids together with hydrocarbons and high-molecular-weight soot-like products – the main components of the synthesized carbonaceous matter [6]. The atmosphere could be a significant source of C, H, N for the impact-initiated formation of amino acids in the case of volatile poor stony impactors.

The biologically significant OC could be synthesized even at early stages of the Earth evolution due to impacting planetesimals. However, the efficiency of the organic matter accumulation on the planetary surface was determined by conditions (mainly temperature conditions), that could favor or impede its preservation in different periods.

Aknowledgements: This work was supported in part by I.17P Program of the RAS.

References: [1] Chyba C. and Sagan C. (1992) *Nature* 355(6356):125–132. [2] Gerasimov M. V. et al. (1998) *Earth, Moon and Planets* 80:205–259. [3] Rubin A. E. (1997) *Meteoritics & Planetary Science* 32:231–247. [4] MacKenzie S. L. et al. (1987) *Journal of Chromatography A* 387:241-253. [5] Galimov E. M. (2017) *Geochemistry International* 55:383–401. [6] Zaitsev M. A. et al. (2016) *Solar System Research* 50:113-129.