IMPACTS OF LARGE METEORITES AS A POSSIBLE SOURCE OF COMPLEX ORGANIC SPECIES ON TITAN. M. V. Gerasimov[1] and E.N.Safonova[1]. [1]Space Research Institute, RAS, Profsoyuznaya, 84/32, 117997, Moscow, Russia, mgerasim@mx.iki.rssi.ru.

Introduction: Titan is a unique satellite in the Solar system, which have a dense atmosphere composed mainly of nitrogen, argon, and methane [1]. Such a composition of the atmosphere is favorable for production of some simple organic molecules (C_2H_2, C_2H_4, etc.) at high altitudes in the atmosphere due to photochemical processes and an interaction with high-energy particles [2]. Decent and accumulation of these organics in the surface ice is considered as a possible reason for coloring of Titan's surface. An impact of a large meteorite or a comet can produce a liquid water reservoir, which is capable to exist before its freeze out for hundreds and thousands of years [3]. The complication of organic species, which can be trapped from surface ice into such crater ponds, is considered as a possible process for the origin of Titan's life [4]. Existed models do not consider the role of an impact itself in the production or degradation of organics in the vicinity of the crater. There is a large number of works showing the possibility of synthesis of complex organic molecules at reduced conditions under the action of various energy sources. Hypervelocity impact itself is generally considered as destructive process for organics because counteractions of space bodies usually occur at high velocities with release of large energies, which result in destructive for organics high temperatures. But the expansion of the hot impact-generated plume, its rapid cooling, and counteraction with the environment also acts as an energy source capable of production of organic species. Earlier we reported about rather efficient synthesis of volatile organic molecules during simulated impact-induced vaporization of silicates in atmosphere of He and H_2 [5]. The formation of nonvolatile organic components in such processes was indicated by the abundance of carbon in C-C and C-H bonding during investigation of the forming condensates by methods of X-ray-photoelectron-spectroscopy (XPS) [6]. The aim of the present work was to investigate experimentally the possibility of synthesis of complex organic molecules from atmospheric methane in case of an impact of a siliceous body on Titan's surface.

Experimental procedure: Our experiments were performed using standard laser pulse (LP) technique [7]. Special precautions were made to decrease the background level of organic pollution and to avoid contamination during experimental processing. A sample of peridotite from mantle intrusions was mounted in a sealed aluminum 450 cm^3 volume cell. Special glass tube and the optical front window formed internal glass compartment. Six glass plates were mounted inside this glass compartment for collection of condensed products after simulated impact vaporization of the sample. In one set of experiments the cell was filled by a model Titan's atmosphere composed of N_2(90 mol%) and CH_4(10 mol%) at room temperature and pressure. In another set it was filled by pure methane. Estimated temperature of vaporization was in the range 4000-5000 K. Condensed products were removed from glass plates and afterwards organic products were extracted from this condensate by their dissolution in n-hexane. Chromatographic analyses were done using «Pegasus 4D» chromatograph-mass-spectrometer with time-of-flight analyzer (70 eV ionization energy). Separation of species was done using RTX-5MS (30m) capillary silicon column (50^oC (2 min.) -10^oC/min. – 300^oC (12 min.)). Computer processing was done using NIST libraries. Control experimental runs were performed in a pure nitrogen atmosphere.

Preliminary results: Chromatographic analysis shows the presence of rather complex hydrocarbons in the mixture extracted from the experiment. An example of the chromatogram is shown in Fig. 1. Hydrocarbons are mainly presented by alkanes (~50%), alkenes (~40%), cyclic (~5%), and polycyclic (<1%) hydrocarbons with degree of polymerization up to C_{30}. About 5% of organics were presented by oxygen-containing species. The quantity of polycyclic hydrocarbons was sufficiently increased (up to 10%) in experimental runs in pure methane. Fig. 2 shows relative quantities of organic species and Fig. 3 shows numbers of molecule types vs. the number of carbon atoms in a molecule. There is a slow decrease of produced quantities of organic species with an increase of their complication. In general, molecules with even numbers of carbon atoms are more abundant compared to molecules with odd numbers. We could measure only organics soluble in n-hexane but visually all the condensed material was heavily black (control runs produced light gray condensates) and did not loose that color after hexane treatment. This indicates for the presence of sufficient amount of kerogen like material or soot.

Discussion and Conclusions: Experiments show a rather efficient synthesis of complex organic molecules during an impact related vaporization of silicates in methane-containing atmospheres. The output of complex organic molecules is qualitatively sufficiently higher compared to that in experiments in oxidizing environment [8]. The presence of insoluble carbonaceous material makes it difficult to estimate the conversion rate of carbon from methane into complex organics. We claim for heterogeneous catalysis on the surface of glass nano-particles which are condensing in the spreading cloud and fill-in its whole volume (see Fig. 4.). The synthesis of organics in the present experiment was performed by involvement of only carbon and hydrogen from methane. Titan's atmosphere also has sufficient amount of nitrogen. The involvement of nitrogen together with methane into the vapor plume chemistry possibly can provide the synthesis of amino-acids since amino- and carbonyl- groups were also present in correlation with C-H bonds in the condensate in some LP experiments [9]. We did not find any nitrogen-containing organics in our analysis and the problem of their identification is still open.

Performed experiments show the principle possibility of synthesis of rather complex organic compounds from the atmospheric methane on Titan in the place and time of a hypervelocity impact of a meteorite, large enough for a penetration through its atmosphere. In combination with the production of a long life warm oasis in the impact crater [3] impact-produced complex organic species can be a good source for the possible evolutionary complication towards the hypothetical origin of life on Titan.

Acknowledgment: This research was supported by RFBR grant 02-05-64419.

References: [1] R. E. Samuelson, et al. (1981) *Nature* ***292***, 688-693. [2] C. Sagan and W. R. Thompson (1984) *Icarus*, ***59***, 133-161. [3] Artemieva, N. and Lunine, J.I. (2003) *Icarus*, ***164***, p. 471-480. [3] R.D. Lorenz et al. (2001) *Enantiomer,* **6**, 83–96. [5] L. M. Mukhin et al. (1989) *Nature*, ***340***, 46-48. [6] M. V. Gerasimov et al. (2000) *LPS* ***XXXI****,* CD-ROM, #1259. [7] M. V. Gerasimov et al. (1999) Physics and Chemistry of Impacts. In: Laboratory Astrophysics and Space Research, P. Ehrenfreund et al. (eds.) KAP, 279-329. [8] M. V. Gerasimov et al. (2002) In: ***36th*** *Vernadsky-Brown Microsymposium*, GEOKHI RAS, Moscow, CD-ROM, # MS023. [9] M. V. Gerasimov et al. (2002) *LPS* ***XXXIII****,* CD-ROM, #1276. [7]

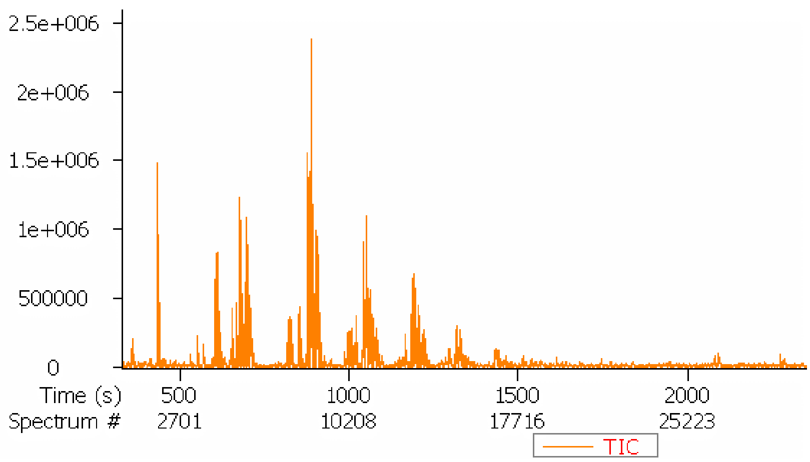

Fig. 1. A part of a chromatogram from an experiment in N_2(90%)+CH_4(10%) atmosphere.

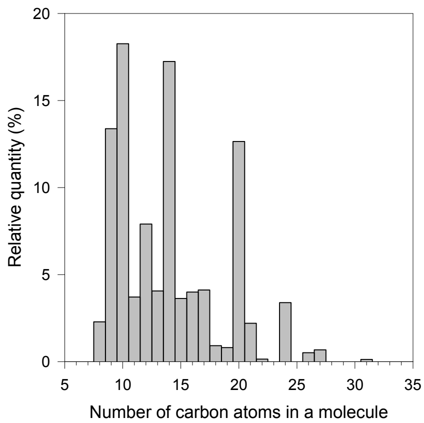

Fig. 2. Relative quantities of hydrocarbons vs. the number of carbon atoms in a molecule.

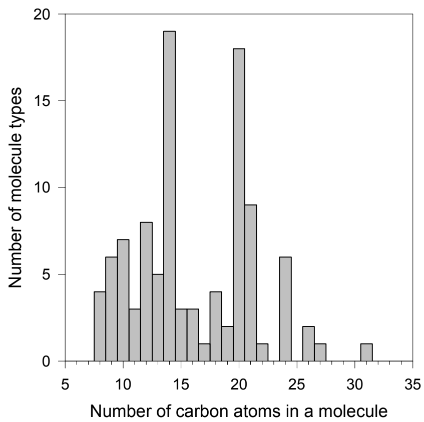

Fig. 3. Diversity of hydrocarbons vs. the number of carbon atoms in a molecule.

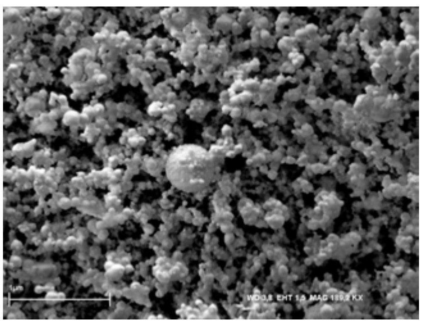

Fig. 4. SEM picture of the condensed material from an LP experiment. The scale bar is 1 μm.