THE SMERDYACHEE LAKE: A POSSIBLE IMPACT CRATER NEAR MOSCOW, RUSSIA. D.D. Badjukov[1], F. Brandstätter[2], M.A. Ivanova[1], A.V. Korochantsev[1], G. Kurat[2], C.A. Lorents[1], M.A.Nazarov[1], Th. Ntaflos[3], J. Raitala[4], D.A. Sadilenko[1], [1]V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Kosigin str., 19, Moscow, 119991, Russia (badyukov@geokhi.ru), [2]Naturhistorisches Museum, Postfach 417, A-1014, Vienna, Austria, [3]Univ. Wien – Geozentrum, Institute of Petrology, Althanstr. 14, A-1090 Vienna, Austria, [4]University of Oulu, FIN-90401 Oulu, Finland

Introduction: The Smerdyachee Lake has been suggested as a possible meteorite crater in 1987 [1]. The assumption was based on a circular shape of 7the lake and its unusual depth. This year our group carried out field works at this lake. New data support the possible impact origin of this structure.

Geological setting: The Smerdyachee Lake (Fig. 1) is located in the Moscow district (55°44’0’’N, 39°49’15’’E) approximately 140 km east of Moscow. There is a nice pinewood around the lake. Quaternary alluvial and fluvioglacial sandy deposits, about 20 m thick, cover Cretaceous and Jurassic sands and clays with phosphorites. Below the Mesozoic sediments (20 m thick) there are Carboniferous limestones. The sub-circular lake has a well-developed rim wall about 15 – 20 meters high. The rim distinguishes the lake from other numerous rounded lakes of the Moscow district. The rim-to-rim diameter of the structure is 350 m. The depth of the lake is 30- 40 meters

Fig. 1. The Smerdyachee crater. The lake is 250 m in diameter and is surrounded by a rim.

The study of the rim showed that it consists of sand without distinct layering. No brecciation or other deformation features were recognized. There are fragments of Carboniferous limestones and Cretaceous phosphorites in the rim sand. A fragment of a possible impactite was found at a depth of 20 cm.

Mineralogy and petrology: Optical microscopy, ASEM, EMPA and INAA studies of the impactite were carried out. The rock consists of quartz and feldspar grains embedded into a melt matrix of a vesicular structure (Fig. 2). Large grains (>150 – 200 µm) are rounded, smaller grains are either angular or sub-angular and sometimes have corroded margins or new-formed reaction rims. No planar deformation features were found in quartz grains. The matrix consists of brown transparent or rarely colorless glass, which includes tiny or dendrite-like crystals of hercynite-magnetite composition. Low-Ca pyroxene (Fs_{40-65}) crystals are also present (Fig. 3).

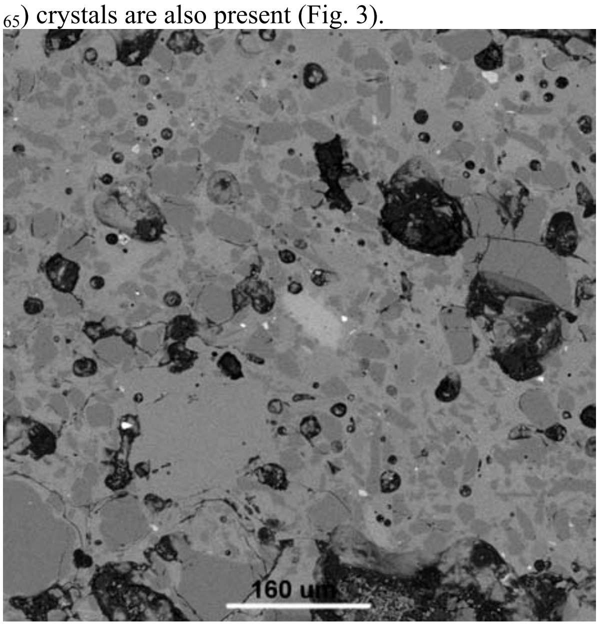

Fig. 2. BSE image of a possible impactite. Rounded and angular quartz and feldspar grains (dark gray) are embedded in glassy matrix (gray).

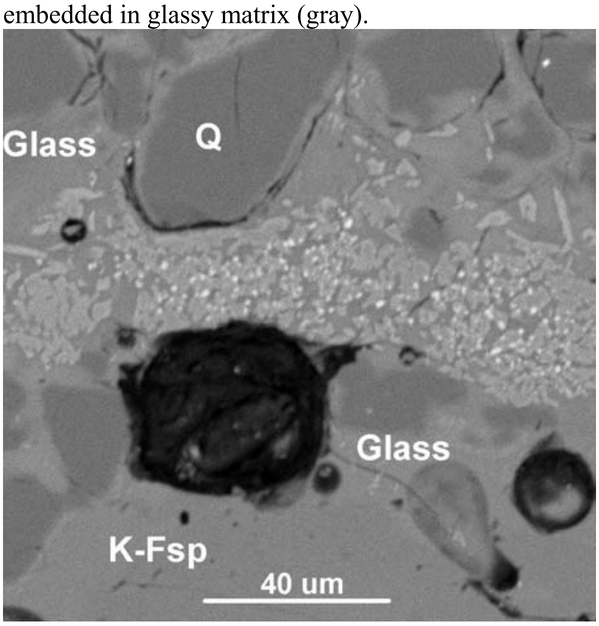

Fig. 3 BSE image of the matrix of possible impactite. Oxide (white) and pyroxene (light gray) crystals are embedded in the matrix glass (center and right).

The matrix contains numerous small (< 20 µm) quartz and feldspar relic grains. Average composition of the glass matrix is (wt%): 62.4 SiO_2, 19.4 Al_2O_3, 6.9 FeO, 1.6 MgO, 1.5 CaO, 1.6 Na_2O, 4.3 K_2O, 97.7 Total. Colorless glasses are richer in SiO2 and alkalis and poorer in FeO than the colored ones. They are generally close to feldspar compositions. Calculated mineral norms are plotted on ternary diagrams (Fig. 4, red dots). The mineral modes of brown glasses (Fig. 4) deviate distinctly from the central point of the diagram (Fig. 4, blue dot)

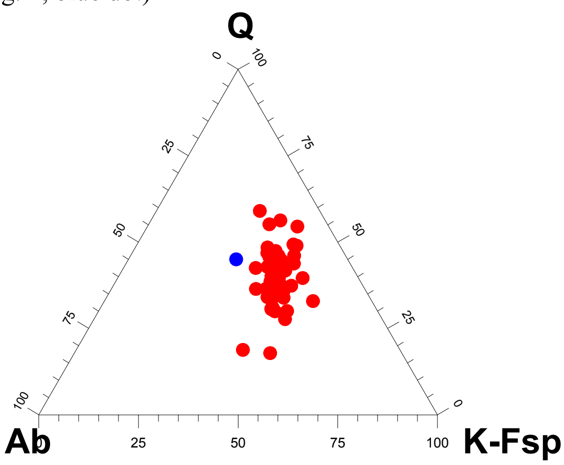

Fig. 4. Q-Ab-K-Fsp (weight) ternary diagram of the brown matrix glasses.

The point corresponds approximately to the triple melt minimum in the Ab-Q-K-Fsp system [2] and, hence, represents a composition of first fractions of liquid. The discrepancy between the triple point and the brown glass compositions may be due to non-equilibrium very fast melting of precursor sediments. The discrepancy could be also related to more complicate composition of the precursor sediments. It is clear however that the heating event, which produced the rock, was very short because the matrix glass is highly heterogeneous (Fig. 4) and contains small relic feldspar grains surrounded by reaction rims. In texture the rock can be classified as pseudobreccia experienced lithifaction due to instant melting of the sediment

INAA analysis shows that the whole rock has a typical crustal REE element abundance pattern. Ni, Co and Cr contents (ppm) are 20, 6.5, and 50, respectively. They correspond to concentrations of these elements in the terrestrial upper crust. Thus no geochemical evidence for contamination with a cosmic material is present.

Discussion: In the morphology, (the circular shape and the well-developed rim) the Smerdyachee Lake is very similar to fresh simple impact craters. The

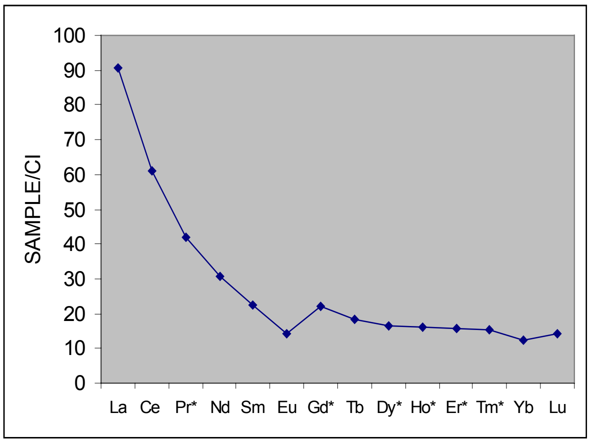

Fig. 5. Normalized REE abundance pattern of the Smerdyachee possible impact rock

find of the possible impactite confirms the explosive formation. The rock has a natural composition and no evidence for an artificial origin of the rock was found. Apparently it was formed in a short heating event, which was most probably caused by shock loading. There are many rocks of similar texture among impactites. The absence of PDFs in relic quartz grains can be explained by the high porosity of the original sediment [3 and references therein]. It is typical for impactites derived from non-consolidate sediments. The structure can be considered as a good example of a well-preserved small impact crater formed in non-consolidated sedimentary rocks. One can calculate the energy of the impact event [4] to be about 10^{15} J. The excavation depth can be estimated to be about 35 m. The estimate conforms with the presence of limestone and phosphorite fragments in the rim. We assume that an iron projectile formed the crater because all explosion craters of such size are known to be produced by iron impactors [e.g. 5]. The Smerdyachee crater must have been formed less than 10,000 years ago, otherwise the glacial erosion must have destroyed it.

References: [1] Y. V. Kestlane and K. H. Melle (1987) XX All-Union Meteoritic Conference, Tallin, abstracts, part I, 47-48. [2] E. G. Ehlers (1975) The interpretation of the geological phase diagrams. W. H. Freeman and Company, San Francisco. [3] R. A. F. Grieve, F. Langenhorst, and D. Stoffler (1996) *Meteoritics & Planet. Sci., 31,* 6-35. [4] H.J. Melosh (1989) Impact Cratering. A Geologic Process. Oxford University Press, New York. [5] R.A.F. Grieve and L.J. Pesonen, (1996) *Earth, Moon, and Planets*, *72*, 357-376