LADOGA ASTROBLEME
(Summary of previous articles)

V.Yurkovets
valery.yurkovets@gmail.com

The article deals with the geological, geomorphological, landscape, petrographic and other evidence that the trough of Lake Ladoga is a young astrobleme. It's estimated age is about 40 thousand years. Structural and geological data indicate that the fall of the cosmic body has broken the integrity of the Baltic Shield. This led to the appearance of local volcanism in the area. More than 1,500 cubic kilometers of ash were emitted into the atmosphere by the eruption. This had resulted to the so-called paleolithic "nuclear winter", which destroyed a paleolithic sites of Kostenki-Borshchevo area.

The article offers an explanation of some anomalies in the deep part of Lake Ladoga - the so-called "Barantidas" and gas emissions. They may be associated with the work of the Ladoga volcano in its fumaroles stage (subaqueous analog of Kamchatka's "Valley of Geysers" or "Yellowstone park" in America).

Pressure on the rocks can reach several gigapascals, temperature - tens of thousands of degrees when massive cosmic body falls on the Earth. This leads to the formation of the crater of the explosion, which is composed of impact breccias several types, and other impact rocks - impact melt glass, pumice and scoria, and impact melt rocks, that macroscopically similar to volcanic (effusive) rocks. Breccia which contains more than 10% of impact glass and resembling volcanic tuffs are called suevite. In addition, the impact event is accompanied by shock metamorphism of minerals in the rocks of the target. Those are fractures, planar elements, isotropization and shock-thermal decomposition.

Shatter cones are specific shock formations. The finding of the cones reliably indicates the impact events.

So, the impact events took place, if there are structural features of the crater of the explosion, shatter cone, impactites, elements of shock metamorphism in rocks.

As shown in previous publications (Yurkovets, 2011b, 2011c), the structural elements of the crater of the explosion, shatter cones, impactites, impact metamorphism of the target rocks – all these occur in the deep-water part of Lake Ladoga.

1. Crater

Structural-tectonic scheme of the Ladoga astrobleme is presented in Figure 1. It contains three structural elements - the crater of the explosion, subsidence caldera and Lake Ladoga, that is the result of superposition of the two structures.

As to caldera subsidence, it is the result of a grand-scale volcanic event. This will be described below.

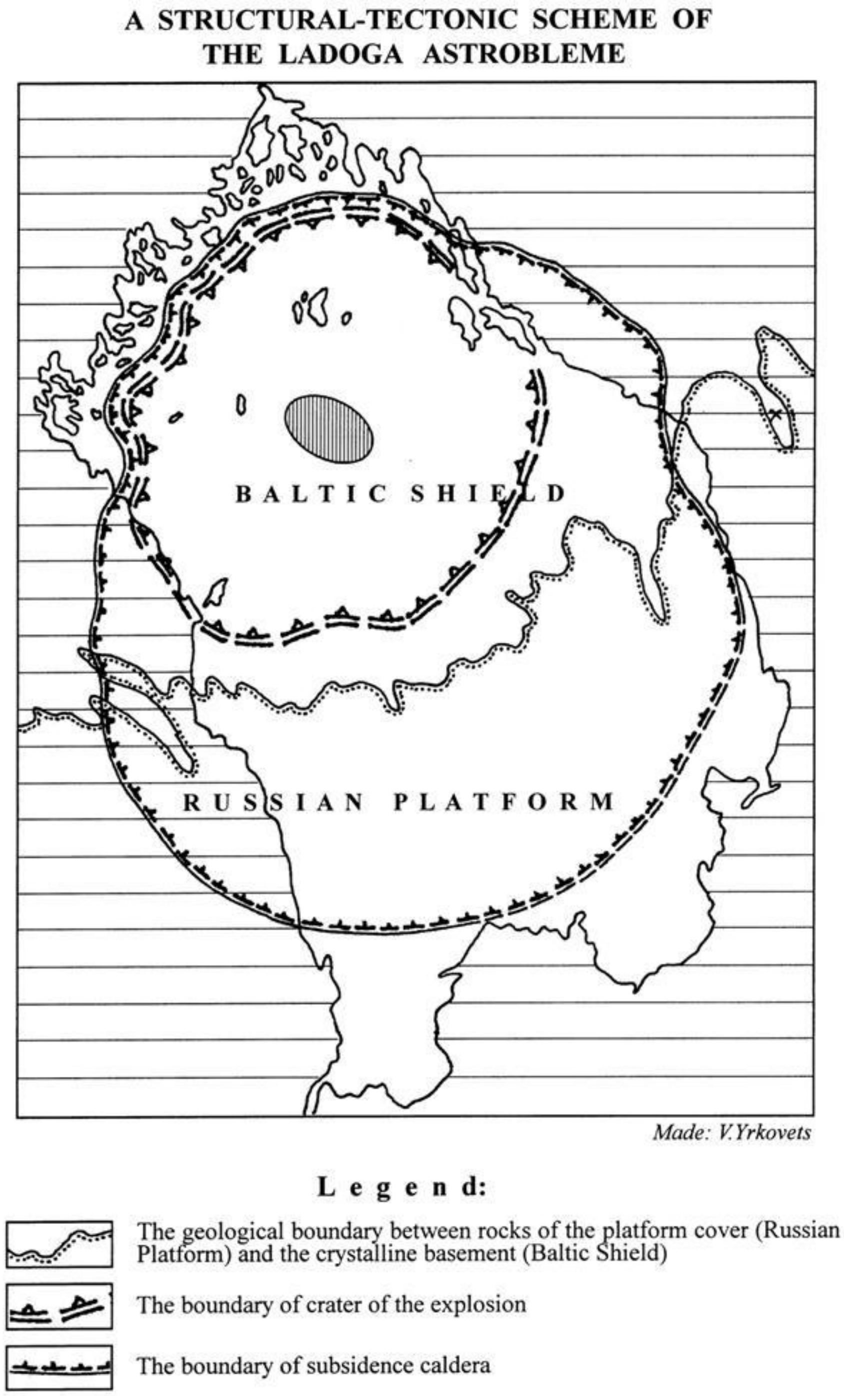

Fig.1 A structural-tectonic scheme of the Ladoga astrobleme

The crater of the explosion is deep part of Lake Ladoga. It is interpreted by geologists of the Institute of Limnology RAS as a tectonic structure - "Riphean graben-syncline" (Atlas of Lake Ladoga, 2002). However, the proportions and details of the structure ideal coincide for astrobleme. While the suppositious tectonic nature of this depression is in contradiction with the fundamental geological and structural characteristics of this area - this is tectonically stable area (Russian platform). In addition, the Riphean age of Ladoga trough is refuted as the theory (such local long-lived structures are impossible), and the absence in the bottom of Lake Ladoga sediments older Pleistocene age.

Again, the observed depression parameters - width and depth of the crater, the thickness of impact rock complex, perfectly coincide with the calculated model of impact events (Yurkovets, 2011b). Fragments of the outer wall of the crater are well preserved on the surface - Fig. 2 and 3.

Fig. 2 The inner side of the outer wall of the crater

Fig. 3 External side of the outer wall of the crater

Fragments of the outer ring of the crater are a chain of bluffs (on the inside) and steep slopes (from outside), stretching along the western shore of Lake Ladoga at a distance of about 35 kilometers from the start of the first bluff, located between the villages Cheremukhin and Vladimirovka until the end of the last, did not reach about 3 miles to the mouth of Vuoksi in Priozersk (Yurkovets, 2011c).

2. Explosive allochthon breccia.

Explosive breccias present in the vicinity of Lake Ladoga in large quantities. Its main difference from the glacial deposits is that they are not rounded, therefore, have not been moved. Below are expressive examples that show two large blocks. They was raised by the explosion and laid on the glacial deposits - Figure 4 and 5.

Fig.4 Lump weighing several tons (natural formation) Vottovaara. Karelia

Fig.5 Varashev stone. Ladoga, Pograngkondushi. Height of about 2 meters

3. Shatter Cones.

The shatter cones are found on Cape Vladimirovka in the western part of Lake Ladoga. The most representative sample is shown in Figure 6. Despite the fact that the cones were formed in the very solid rocks - slates, they have a classic look: flat "bottom" (left) and coming from it a "horse tail" (right).

Fig.6 Shatter cones. Ladoga, Cape Vladimirovka

Shatter cones slightly rounded, as found in surf zone.

4. High-temperature transformation of the target rocks.

They are impact melt rock - partially crystallized (Fig. 8) rock that looks similar to the basalts (Fig. 7). But it contains, however, minerals of target rocks with features of shock metamorphism: fractures, planar elements in quartz, shock glass - Fig.9-10.

Fig.7 Impact melt rock from Cape Vladimirovka.
The size of the long axis of 11 cm

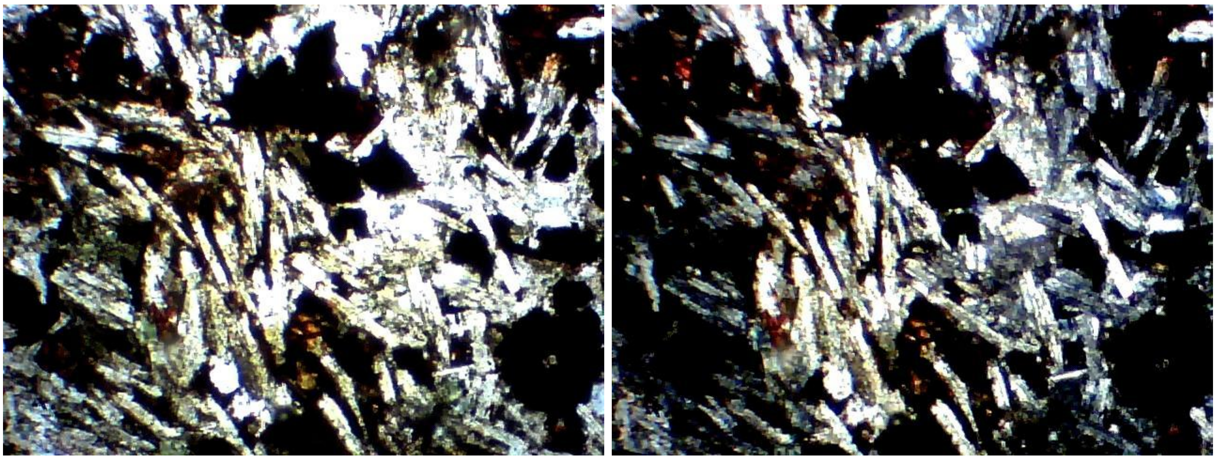

Fig.8 The basic matrix of the impact melt rock
Horizontal size is 1.3 mm. Right - with the analyzer. Left - no analyzer.

There is only one specimen of such impact melt rock. It is also found in the coastal zone of Cape Vladimirovka. Cape Vladimirovka located in the western side of deep part of Lake Ladoga. Since the entire coastal area in the region of Lake Ladoga is covered a layer of glacial deposits, the outcrops of impact melt rock (and shatter cones) are not identified, strictly speaking.

However, impact melt rock is more dense formation, located in friable mass of authigenic breccias. That's why they are decoded (taking into account place of finding) in the chain of coastal anomalies. These anomalies trace its spread to the northwest and southeast from the place of finding - along the lake shore. These anomalies include a series of small capes jutting out into the water surface of Lake Ladoga, stretching parallel with the external wall of the crater.

5. Shock metamorphism of target rocks.

The metamorphism is represented by the necessary and sufficient (for the classification of impact events) varieties - fractured rock components of the target minerals, the planar elements and diaplectic changes in quartz, shock-thermal decomposition.

Inclusions in impact melt rock. As mentioned above, the inclusions carry all of these features - fractures, the planar elements and diaplectic changes in quartz, shock-thermal decomposition (conversion of minerals to the glass), Fig.9-10.

Fig.9 Inclusion in impact melt rock. The band of fractured quartz is in impact glass. Horizontal size is 1.3 mm. Right picture is taken with the analyzer, left picture - without the analyzer.

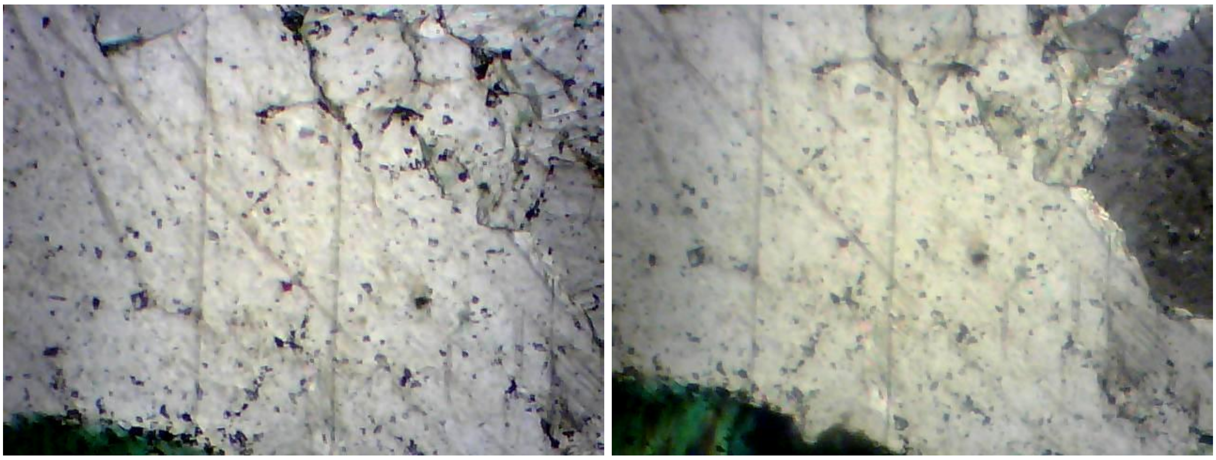

Fig.10 Inclusions in impact melt rock. Planar elements are in quartz. Horizontal size is 1.3 mm. Right picture is taken with the analyzer, left picture - without the analyzer.

Allochthon breccias. The impact complex must be mainly presented by breccias of Middle Riphean sedimentary rocks - sandstones, siltstones, grits and conglomerates. This follows from the Geological Map of the trough of Lake Ladoga, compiled by A.Amantov (Atlas of Lake Ladoga, 2002). These rocks are shown on the map in the deep part of Lake Ladoga. They are marked on the map as the "middle Riphean, undivided." Two specimens of these breccias (of a few one founded inside the crater) were selected for mineralogical analysis of thin sections. The first specimen was found at Cape Vladimirovka, the second one - at the mouth of r.Vuoksy in Priozersk (Yurkovets, 2011c). Both specimens are the quartz sandstones with interbedded gritstown.

In addition, the ***first specimen*** (Cape Vladimirovka - Fig. 11) also has macroscopically distinguishable inclusions of impact glass - Fig. 12.

Fig.11 Riphean sandstone (first specimen)
The size of the fragment is 10 cm

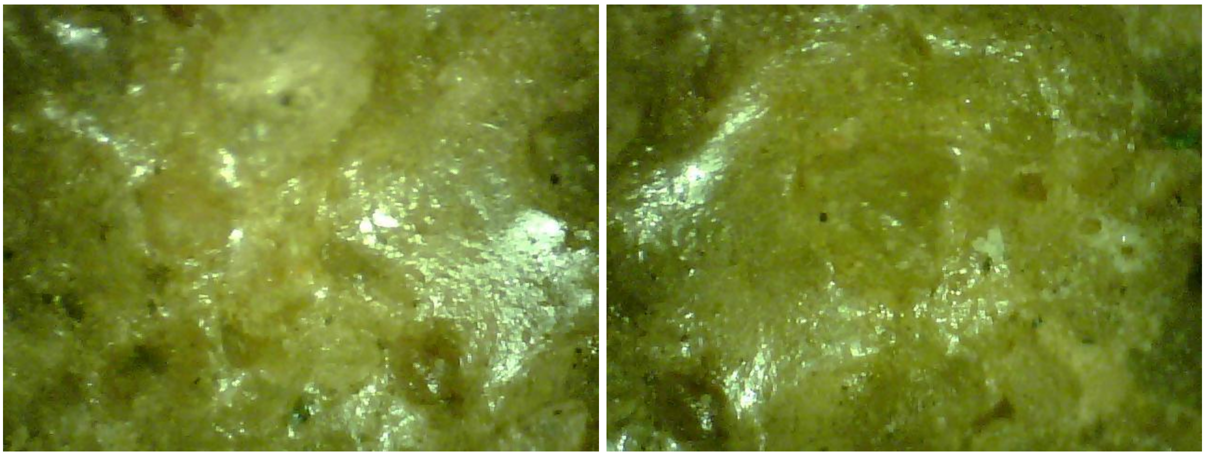

Fig.12 Inclusions of impact glass in the Riphean sandstone.
Horizontal size of 3 mm

Fracturing of quartz grains in this sample is very large. On the periphery of the grains and along cracks are diaplectic changes - Figure 13 (dark).

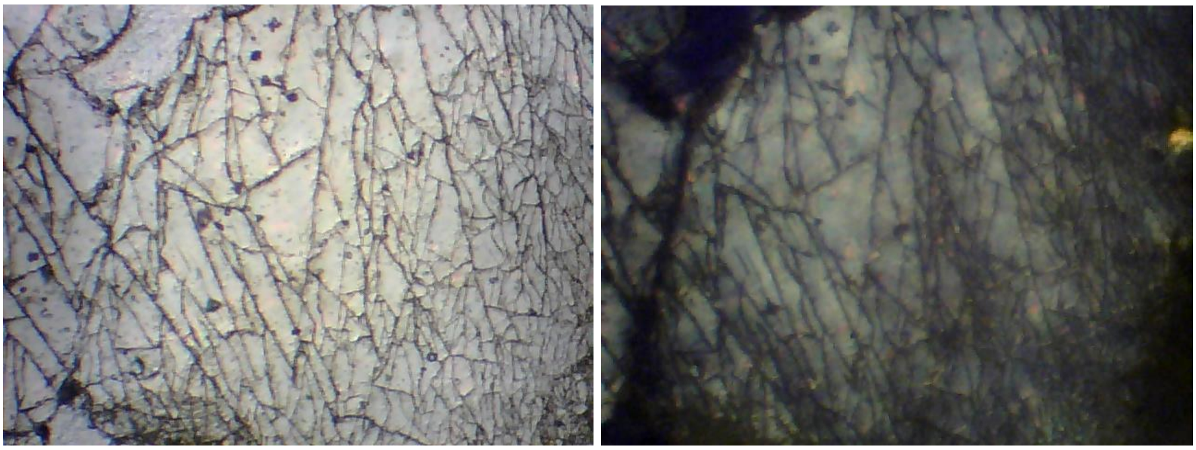

Fig.13 Fractured quartz grain with diaplectic changes.
Horizontal size is 1.3 mm. Right picture is taken with the analyzer, left picture - without the analyzer.

Below is another piece of the thin section with a grain of quartz, in which besides fracturing and diaplectic changes you can see at least two sets of planar elements (parallel lines) - Fig. 14.

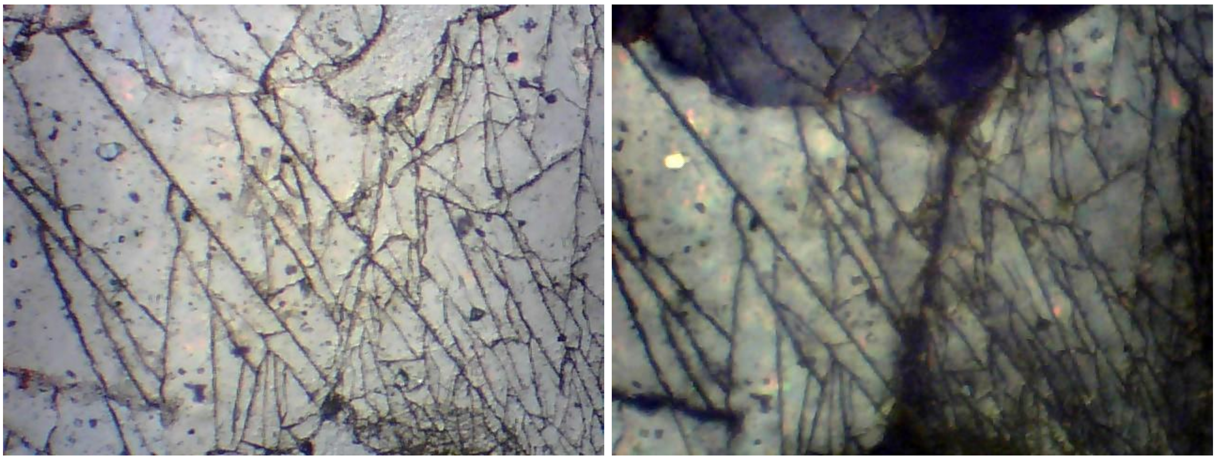

Fig.14 Fractured quartz grain with diaplectic changes and planar elements.
Horizontal size is 1.3 mm. Right picture is taken with the analyzer, left picture - without the analyzer.

Some quartz grains almost completely converted to the diaplectic mass - Fig. 15.

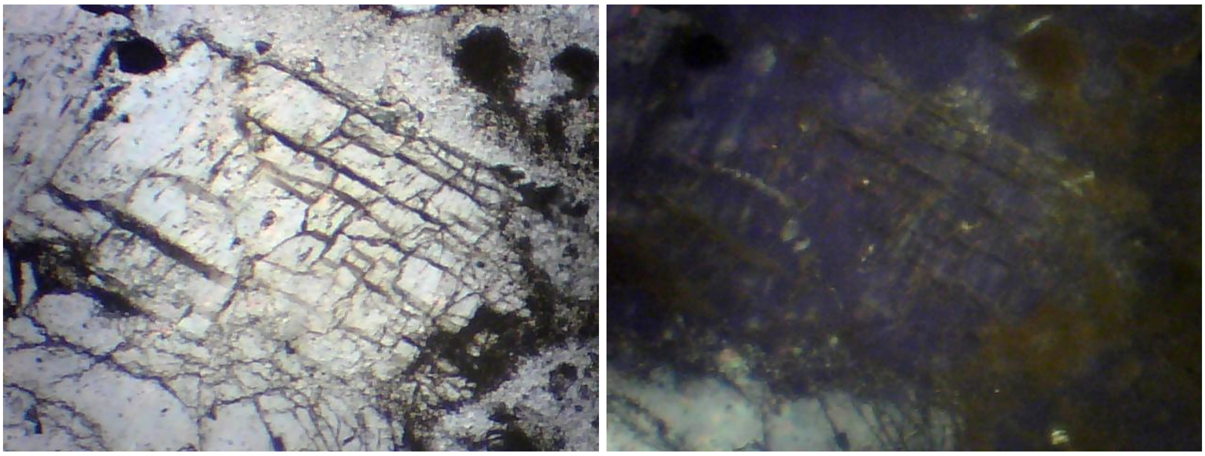

Fig.15 Fractured diaplectic quartz grain
Horizontal size is 1.3 mm. Right picture is taken with the analyzer, left picture - without the analyzer.

The second specimen (mouth r.Vuoksy) macro- and microscopically indistinguishable from the first specimen - the same shock fractures, planar elements and diaplectic changes in quartz grains, from which (quartz grain) the selected specimens of sandstone consists mainly - Fig.16-17.

It should be noted that under the microscope in crossed nicols diaplectic changes in quartz are visually have shades of dark gray to black, but the image sensor of camera shows shades of purple. Whatever its causes, they do not interfere in the diagnosis of impact changes.

Fig.16 Chip of Riphean sandstone (second specimen)
The size of the fragment is 10 cm

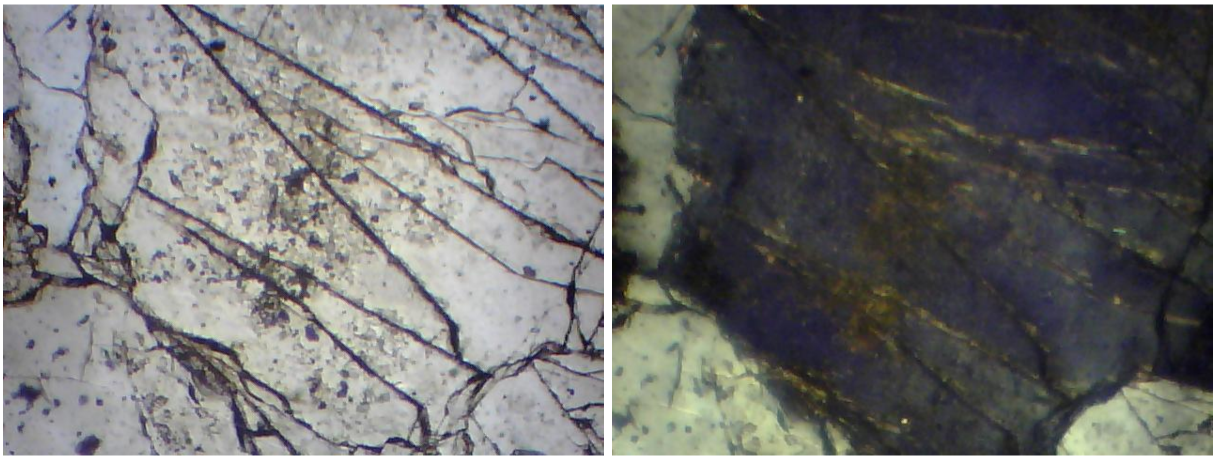

Fig.17 Fractured quartz grain with planar elements and diaplectic changes.
Horizontal size is 1.3 mm. Right picture is taken with the analyzer, left picture - without the analyzer.

6. Other signs of astrobleme.

Other sign of astrobleme is the so-called «Impact spallation». It is related with rarefaction waves during impact cratering. Specimens with evidence of impact spallation often found in the vicinity of Lake Ladoga (as well as of impact breccias). The mechanism of this cleavage is described in «Impact spallation in nature and experiment» (Ernstson Claudin Impact Structures, 2011). This phenomenon usually occurs in rounded boulders, which often have a spherical shape - Figure 17.

Fig.17 Example of impact spallation. The size of a boulder is about 40 cm

7. Subsidence caldera

As described in previous articles, the fall of the meteorite broke integrity of Baltic Shield. This led to the grand eruption at place of fall (Yurkovets, 2011b). As a result of the eruption, more than 1,500 cubic kilometers of ash has been thrown out into the atmosphere. The ash fell on the vast territory. According to volcanologists I.V.Melekestsev and others (Institute of Volcanology FESC, Russian Academy of Sciences) which have studied this ash, this area is 2.5 - 3 million square kilometers (Melekestsev et al, 1984).

These ashes are widespread on the Russian plain, especially in the southern part - in the Voronezh and Rostov regions. They are also found in the Ukraine, Bulgaria, Romania, Greece, Cyprus, and in marine sediments of the Eastern Mediterranean (Melekestsev et al, 2002). First these ashes were discovered and described in the sections of Kostenki and Duvanki (v. Aleksandrovka, Voronezh region). Their common name is «CI-tephra" (Campanian Ignimbrites), since the origin of the tephra was forcedly associated with the probable catastrophic ejection of Campanian ignimbrites by the Campi Flegrei volcanoes in Italy. Because other volcanic centers that are suitable for the time of the eruption and ash composition was not known then.

An alternative view, associated with the impact event proposed in article "Ladoga astrobleme". It resolves all the contradictions and explains, in particular, the unprecedented scale of the eruption, for which Campi Flegrei volcanoes are too small. This eruption was so powerful that it caused a climate catastrophe on the Earth, known as the "nuclear winter" of the Paleolithic. This event destroyed the Palaeolithic settlements of Kostenki-Borshchevo area (Yurkovets, 2011b).

The article offers an explanation of some anomalies in the deep part of Lake Ladoga - the so-called “Barantidas” and gas emissions (Assinovskaia, Nikonov, 1998). They may be associated with the work of the Ladoga volcano in its fumarole stage. There is every reason to believe that at the bottom of the deep part of Lake Ladoga is working subaqueous analog of Kamchatka's "Valley of Geysers" or "Yellowstone park" in America (Yurkovets, 2011a).

DNA genealogical aspect. Catastrophic climate-forming events are the "bottleneck" for haplogroups. They were also the cause of migration and, consequently, cause of the formation new branches on the Phylogenetic tree of Y-chromosome.

An illustration of this statement is the articles of A. Klyosov and I.Rozhanskiy devoted to the calculation of the chronology of the emergence of male haplogroup of modern humanity. This calculation was based on the analysis of the base haplotypes of the slowest 22-marker Y-chromosome panel (Klyosov, 2011a,b; Klyosov, Rozhanskiy, 2011). Comparison the phylogenetic tree of Y-chromosome, constructed from these data, with the climate curve (Yurkovets, 2011a) suggests that the formation of haplogroup C, I2 and R (or their parents' haplogroups, as P, or NOP, IJK) was a consequence of this event. This, in turn, reveals not only time of generation these branches but also - georeferencing, that is, place of formation of these haplogroups. Such a place in this case is the south of Russian plain. With high probability these are Paleolithic sites of Kostenki-Borshchevo area. They are only known, suitable for age and geography.

Another consequence was a seismic wave from the explosion of enormous power that swept through the Earth's surface and its depths, reflected and refracted many times at the boundaries of media and geological structures of different order. This has caused tectonic shifts in the lithosphere and increased volcanic activity, at least in the Caucasus and the Mediterranean, for which is proof of the same age eruption (Gazeev, et al, 2011; Melekestsev, et al, 2002).

Thus contribution to the bottleneck of haplogroups could make volcanoes of Campi Flegrei of Italy and the Caucasus. Perhaps this event (and this date - 40 thousand years ago) is also a key event in the tragic fate of the Neanderthals.

Supplementation. As mentioned above, the destruction of a Baltic Shield solidity has led to the appearance of local volcanism in the area of impact. Effusive basalts, mapped in the northeastern part of the crater, suggest that. A ridge of extrusive domes of gabbro-granosyenites, breaking through the Middle Riphean sediments at the bottom of the Lake Ladoga deepest part, suggests it too.

This wide range of petrographic composition within a single eruption is difficult to explain with the uniqueness of the Ladoga astrobleme, but this is matter for future research. Nevertheless, the obvious solution to this problem lies in the fact that the basalts of the structure, if it really is a astroblemes, these basalts are not. Perhaps they are "impact melt rocks", which form their own geological bodies such as Lake Ladoga basalts. Impact melt rocks mainly formed in dense igneous and metamorphic rocks and rarely found in craters formed in sedimentary strata. The fact speaks in favor of the assumption. This is observed in our case - cover and subvolcanic basalts are prevalent in the northeastern part of the crater within the metamorphic rocks of the Baltic Shield.

Since impact melt rocks inherit traits common chemical composition of rocks from which they are formed, our basalt, if they really are impact melt rocks, could be formed only from basic rocks. What exactly takes place in this area - the metamorphic rocks of the Baltic Shield are mainly metabasites and amphibolites, ie metamorphosed and metamorphic rocks of basic composition.

Else real evidence that the basin of Lake Ladoga is the astrobleme (which broke the integrity of the Baltic Shield) exists. It is a volcanic ash, which, according to the Caldera subsidence and the absence of effusive thickness was a main product of the eruption. Except, of course, basalt (about which, however, there is doubt) and subvolcanic gabbro-granosyenites (for which there is no doubt.)

The gabbro-granosyenites are shown as subalkaline leucocratic granite series in the legend to the Geological Map of the A.Amantov (Atlas of Lake Ladoga, 2002). Trachytic ash correspond to these rocks. However, for the ashes were related to the Ladoga astrobleme, additional conditions are needed. Firstly, they (because of the extraordinary magnitude of the event) must be widespread. And secondly, they have to be the Upper Pleistocene age.

These ashes are on the Russian plain, and they really are widely distributed. Their composition, age and spread size ideally suited to the conditions. This is the so-called “CI tephra” of Kostenki and Duvanki (Aleksandrovka), Voronezh region, where it was first found and described. In addition, the CI tephra was found in the Rostov region, Ukraine, Bulgaria, Romania, Greece, Cyprus, in marine sediments of the Eastern Mediterranean (Melekestsev et al, 1984; Melekestsev et al, 2002).

The composition of these ashes is trachyte, which corresponds to the composition of the subvolcanic structures in the crater of Lake Ladoga. Age is 40 thousand years, ie Upper Pleistocene, which fits well into the chronological framework of bottom sediments of Lake Ladoga. As to the area of distribution, it is huge. According to volcanologists Institute of Volcanology, FISC RAS IVMelekestsev and others involved in the study of the ash, it is 2.5 - 3 million square kilometers.

The origin of the tephra associated now with the catastrophic eruption of the Campi Flegrei in Italy. What, however, absolutely impossible to accept. The fact that the volume of ejected by Campi Flegrei volcanos ash estimated at 75 - 150 cubic kilometers. It cannot exceed the upper ceiling of 150 cubic kilometers, which is already somewhat overstated, as empirically established that the amount of ash ejected into the atmosphere and lava eruptions in pyroclastic flows of this type are approximately equal to, or are in the ratio 2:3. The volume of pyroclastic flow material in the Campi Flegrei is approximately equal to 140 cubic kilometers (Melekestsev et al, 2002). In order to not exceed this amount, the authors had to " smudge" this tephra on such a vast territory is very thin - 3 - 5 cm, however, even at a distance of 1200 km from the alleged source of these authors - Crete - a layer of the tephra is 6 sm. And in the Voronezh region of Russia, ie at a distance of 2000 km, layers of ash are found up to 50 cm thick (Kostenko), and more. For example, the average thickness of the Aleksandrovka’s ash (the same area) is 62 cm.

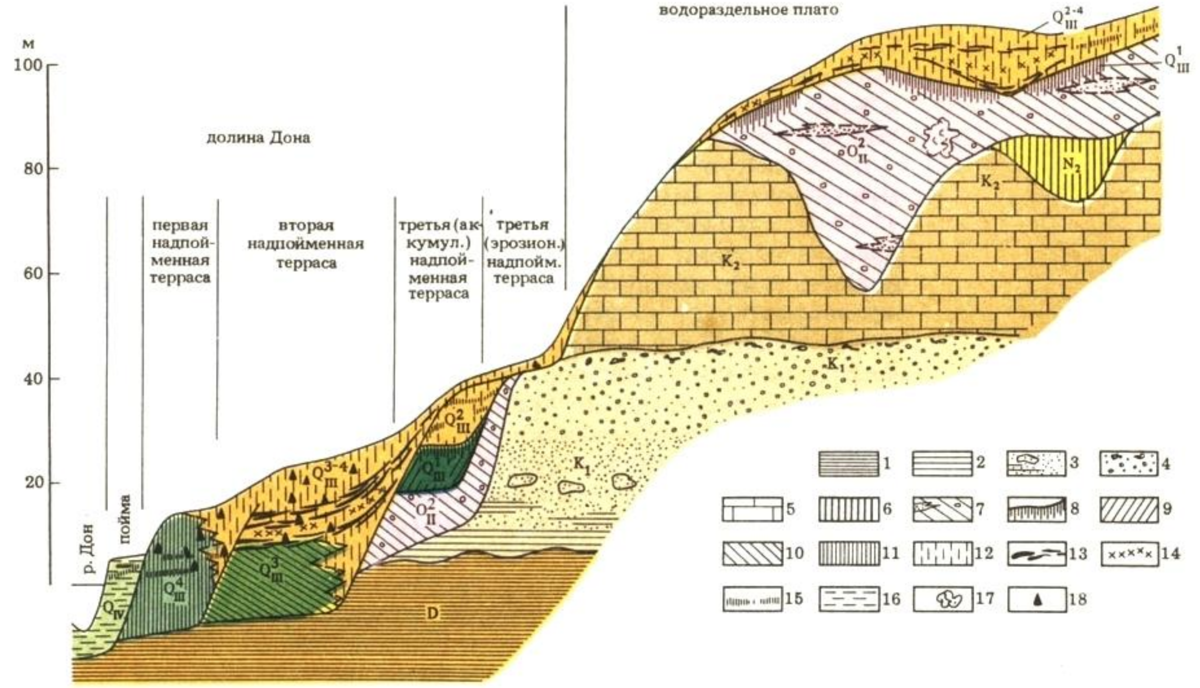

Fig. 10 Diagram of geological and geomorphological structure of the right bank of the Don Valley in Kostenki-Borshevo area (for *G.I. Lazukov) 1 - Devonian clay, 2 - Lower Cretaceous clay, 3 - Lower Cretaceous sands with interbedded clay and sandstone, 4 - Cenomanian sands, 5 - writing chalk, 6 - Scythian sediments horizon, 7 - deposits of the Dnieper horizon, 8 - Mikulino buried soil, 9 - sediments of third terrace (accumulative), 10 - alluvium of second terrace, 11 – alluvium of first terrace, 12 - loess loam and sandy loam, 1 3 - humus thickness on the second terrace and the watershed plateau, 14 - volcanic ash, 15 - postmikulino buried soils, 16 - floodplain alluvium, 17 - glacial outliers, 18 - cultural strata of the Upper Paleolithic sites.*

The authors have tried to avoid this contradiction by means of "lows of relief " - ravines, hollows, which could accumulate (in theory) the redeposited ash. But this is contradicted by the reality of the observed pattern of distribution of ash in the section. So, a layer of ash on the "classical" scheme of geological and geomorphological structure of the right bank of the Don Valley in Kostenki-Borshevsky area is present not only in section of low terraces, but also on the watersheds too (Lazukov et al, 1981) . The decrease in thickness is observed only on steep slopes - Fig. 10. In general, it beds concordant to the underlying and overlying humus layers (ancient soils). Thus, redeposition perhaps there was, but even at relatively undisturbed watersheds the ash relics of several tens of centimeters thickness are preserved.

The latter circumstance greatly (on several times) increases the amount of eruptive material ejected into the atmosphere. Its volume based available data can be estimated only roughly. For this purpose we take into account that the thickness of the tephra decreases to the south. At a distance of 1,200 km from Lake Ladoga, its thickness is 50 cm (the minimum for the area). At a distance of 2900 km (Crete), its thickness is still large and is equal to 6 cm. If we take an average thickness of 50 cm of tephra, which is also the minimal assumption, the volume of eruptive material ranges from 1,250 to 1,500 cubic kilometers (actually it will be more).

These values are in agreement with the volume of the Ladoga trough, which in the first approximation can be taken as the volume of the water mass of Lake Ladoga - 838 cubic kilometers, because the specific gravity of ash more than two times less, then the volcanic material from which it is formed.

Here, however, the natural question arises - where the thick tephra layers that were formed in the direct vicinity of the eruptive center? There is a very simple answer on this question - they have not survived because the area after the fall of the cosmic body was twice plowed by glaciers of Wurm II and III glaciations (Yurkovets, 2011). The ice sheet here at that time reached the thickness of 1500 meters or more, and marginal part of the glacier during the peak of glaciation had reached at a distance of 500 kilometers south of Lake Ladoga (Grosswald, 1989; Grosswald, 2002).

Another argument, which led volcanologists in favor of an Italian source, is the identity of the chemical composition of ashes of Kostenki and Campi Flegrei ignimbrites. However, this fact cannot be decisive in order to give preference to one or another eruptive center, characterized by eruptions of alkaline composition of the material, since the chemical composition of trachyte volcanism is not determined by geography, but by processes of differentiation of magma. And if we take the chemical composition of the trachytes is not of our two locations, and trachytes in general - trachytes from any point of the planet, then we will see that their variations are not much different from those variations that we observe in our two cases. As an illustration, here we can recommend, for example, classic work on the petrography A.N.Zavaritskii or E.A. Kuznetsov, where are the data.

So, if you assume as a working hypothesis that the trough of Lake Ladoga was formed by the fall of the cosmic body, all the anomalies of the Ladoga get their consistent explanation. The reason (and the actual size) for such dramatic climate-event, what has been called "nuclear winter" Paleolithic become clear. This is a fallout of a huge masses of ash on the Russian Plain and southern Europe around 40,000 years ago, that interrupted the pre-Aurignacian of Kostenki (Anikovich, et al , 2007). According to the considerations presented above, the eruption, which had so disastrous, was at least ten times more powerful than it could have been anticipated earlier - on the basis of known volcanic centers adjacent to the region.

The same number - 40 thousand years ago - in addition, is clarified date of formation of the Ladoga astrobleme. And, therefore, it's most ancient bottom sediments and volcanic rocks of the crater.

References

Assinovskaia, B.A., Nikonov, A.A., 1998. Zagadochnye iavleniia na Ladozhskom ozere. "Priroda", Moskva [Mysterious events on Lake Ladoga. "Nature", Moscow] 5:49-53.

Gazeev, V.M., Gubanov, A.G., Leksin, A.B., Dokuchaev, A.Y., Isakov, S.I. 2011. Pliocen-chetvertichnye peply na territorii Yuzhnogo Federal'nogo okruga (problemy, paradoksy, idei). Vestnik Vladikavkazskogo nauchnogo centra [Pliocene-Quaternary ash in the South Federal District (the problems, paradoxes and ideas). Journal of Vladikavkaz Scientific Centre] 2,(3):39-47. (In Russian)

Institute of Limnology RAS, editor Rumyantsev, V.A. 2002. "Ladozhskoe ozero" Atlas ["Lake Ladoga" Atlas] St. Ptereburg. (In Russian)

Klyosov, A.A. 2011a. DNK-genealogiia osnovnyh gaplogrupp muzhskoi poloviny chelovechestva (Chast' 1). Vestnik Rossiiskoi Akademii DNK-Genealogii [DNA genealogy of major haplogroups of male half of humanity (Part 1). Proceedings of the Russian Academy of DNA Genealogy] 4(5):988-1014. (In Russian)

Klyosov A.A. 2011b. DNK-genealogiia osnovnyh gaplogrupp muzhskoi poloviny chelovechestva (Chast' 2). Vestnik Rossiiskoi Akademii DNK-Genealogii [DNA genealogy of major haplogroups of male half of humanity (Part 2). Proceedings of the Russian Academy of DNA Genealogy] 4(7):1367-1494. (In Russian)

Klyosov A.A. Rozhanskiy I.L. 2011. Arhaichnaia (arhantropnaia v terminah antropologii) liniia gaplogruppy A. Vestnik Rossiiskoi Akademii DNK-Genealogii [Archaic (archanthropines in terms of anthropology), the line of haplogroup A. Proceedings of the Russian Academy of DNA Genealogy] 4(7):1495-1502. (In Russian)

Melekestsev, I.V., Kiryanov, V.Y., Praslov, I.D. 1984. Katastroficheskoe izverzhenie v raione Flegreiskih polei v Italii – vozmozhnyi istochnik vulkanicheskogo pepla v pozdnepleistotsenovyh otlozheniiah Evropeiskoi chaste SSSR [The catastrophic eruption in the Campi Flegrei (Italy) - a possible source of volcanic ash in late Pleistocene sediments of the USSR]. Volcanology and Seismology. Ed. USSR Academy of Sciences. Moscow. 3:35-44. (In Russian)

Melekestsev, I.V., Gurbanov, A.G., Kiryanov, V.Y., Chernykh, V.I., Sulerzhitsky, L.D., Zaretsky, N.E. 2002. Vulkanicheskie peply eksplozivnyh izverzhenii pozdnego pleistotsena na territorii Vostochnoi I Yuzhnoi Evropy. Katastroficheskie protsesy I ich vliianie na prirodnuiu sredu [Volcanic ash explosive eruptions in the late Pleistocene in Eastern and Southern Europe. Catastrophic processes and their influence on the environment]. Ed. "Regional public organization of scientists on problems of applied geophysics." Moscow. 65-86. (In Russian)

Yurkovets, V.P. 2011a. Climatic Correlations. Proceedings of the Russian Academy of DNA Genealogy] 4(8):1633-1659.

Yurkovets, V.P. 2011b. Ladozhskaia astroblema. Vestnik Rossiiskoi Akademii DNK-Genealogii [Ladoga Astrobleme. Proceedings of the Russian Academy of DNA Genealogy] 4(10):1997-2018. (In Russian)

Yurkovets, V.P. 2011c. Ladozhskaia astroblema. Prodolzhenie. Vestnik Rossiiskoi Akademii DNK-Genealogii [Ladoga Astrobleme. Continued. Proceedings of the Russian Academy of DNA Genealogy] 4(12):1997-2018. (In Russian)

Ernstson Claudin Impact Structures, 2011. Impact spallation in nature and experiment, http://www.impact-structures.com/category/impact-highlights/

Link to Journal "Proceedings of the Russian Academy of DNA Genealogy" - http://aklyosov.home.comcast.net/~aklyosov/index.html#vestnik