Karymshina Caldera – the first Kamchatka supervolcano. New data on the geological structure of the area, the stages of volcanism and pyroclastic volumes (based on field work in 2012-2015)

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The work presents new data on the giant caldera discovered in 2006 in southern part of the Kamchatka peninsula. The caldera was formed during Eopleistocene (1.2 to 1.5 Ma). The caldera boundaries were reconstructed and its dimensions appeared to be approximately 15-25 km. The area of study covers several groups of thermal springs: the Bol'she-Bannaya, Mal. Bannaya, Karymchina, Karymshina, and Verkhne-Paratunka ones. The largest group is the Bol'she-Bannaya springs; which were investigated extensively by many different methods during the 1970s. The reconstruction of the large caldera boundary in this area [1] yields a different location of the present-day hydrothermal systems, in particular, of the Bol'she-Bannaya system. The caldera boundary has been found to pass through the Bol'she-Bannaya springs area. It was also found that numerous outcrops of acid lavas (domes, dikes, short lava flows) occur along the caldera boundary, these formations are relatively young, being formed less than 0.5–0.8 Ma. This data leads to the suggestion that the present-day hydrothermal activity in this area is related, on the one hand, to high crustal permeability at the caldera boundary (due to existing faults), while on the other hand, to the large magma chamber probably existing in the area which retains its heat and continues to supply fluids and water that are circulating around it to overlying hydrothermal system. This chamber cased the caldera generation in the Eopleistocene followed by a resurgent dome growth in the Lower/Middle Pleistocene.

We have reconstructed the boundaries of a large lacustrine basin that was formed in the caldera after the resurgent uplift appearance as well as the boundaries of thick pyroclastic flow protruding out of the caldera. Three complexes are distinguished according to consecutive stages of the caldera development: pre-calderian, caldera-forming (calderian) and post-calderian.

The pre-calderian stage (complex I) is assumed to have mid-Pleiocene age (3.4 – 2.6 myr). During the field work done in 2012, the volcanic edifices which existed just before the caldera formation were revealed and described for the first time. The data on the geochemistry and oxigen isotopism for rocks which build up pre-calderic volcanoes, were obtained in the laboratory of stable isotopes or the Oregon State University, USA. This data allowed to make a preliminary conclusion that the supercaldera was formed at the region where for long time (during whole Pleiocene) the high-siliceous volcanism took place [2].

The caldera-forming stage (complex II) has Eopleistocene age (1.78 – 1.2 myr). It is mainly represented by ignimbrites and crystalloclastic tuffs related to the caldera-formation, which side with volcanic relics shaped the border of the structure at the pre-calderic stage. At the central part of the depression the total observed thickness of ingimbrite deposits reaches 1000 m. During fieldwork in 2012-2014 a vast field of ignimbrites, traces of a large pyroclastic flow associated with caldera Karymshina, was mapped for the first time. Ignimbrites were found at a distance up to 35-40 km from the edge of the caldera [3]. The maximum thickness of the flow exceeds 500 m, the area of the pyroclastic flow deposits is about 298 km^2, and their total volume is about 84 km^3.

The post-calderic stage (complex III) is dated to Lower and Middle Pleistocene (0.5 - 0.8 myr). The extrusions and high-siliceous lavas were studied. The size and thickness of some extrusions and lava flows were specified. It was found during the field works that there are thick lava flows slightly sloped from the central part of the depression towards the rim, which are related to some of extrusion domes. The total volume of high-siliceous extrusions was estimated. The comparison study of volumes of high-siliceous extrusions and lava flows was done for three regions of Kamchatka: the Karymshina caldera (the post-calderic stage, Southerm Kamchatka), the Geiser Valley (Eastern Kamchatka) and the Chashakonja volcano (the Sredinny ridge). The Karymshina caldera is found to have the largest scale in high-siliceous volcanism. Total volume and area of extrusions and related lava flows reaches 2.68 km^3 and 26.44 km^2, correspondingly [4].

It is shown that the caldera-forming eruption was a major one in Kamchatka in regard to its volume of ejected material (approximately 825 km^3 or $2x10^{15}$ kg by its mass), and ranks as a major eruption worldwide [5].

Conclusions

(1) A new large caldera (15×25 km), the Karymshina caldera, has been discovered in southern Kamchatka.

(2) An approximate **volume of material erupted** during the caldera generation was estimated to be **about 825 km^3**, which makes **a weight of 2×10^{15} kg**. This eruption should therefore be considered as the largest so far known to have occurred in Kamchatka and to be among the great eruptions worldwide.

(3) A tectonic uplift (4 × 12 km × 200 m) interpreted as a resurgent dome has been reconstructed in the northwestern part of this caldera, bounded by straight northeast and northwest trending faults. Also **the boundary of a lake**, which had existed in the caldera to the South from the resurgent uplift, has been reconstructed.

(4) During fieldwork in 2012-2014 **a vast field of ignimbrites**, **traces of a large pyroclastic flow** associated with caldera Karymshina, **was mapped for the first time**. Ignimbrites were found at a distance up to 35-40 km from the edge of the caldera. The maximum thickness of the flow exceeds **500 m**, the area of the pyroclastic flow deposits is **about 298 km^2**, and their total volume is **84 km^3**.

(5) It has been unambiguously established that the volcanoes of mounts Goryachaya, Yagodnaya, Levaya Karymchina, etc., located out of the caldera, but close to the boundaries of the caldera, are older and must be considered as **evidence of a major volcanic phase that proceeded the caldera generation**. It proved by the fact that the Karymshina rocks (mostly acid tuffs and ignimbrites) that fill the caldera in some cases lay on the lavas that compose the above volcanoes.

(6) New data were obtained on the setting of the rhyolite domes widely abundant in the area of study. It was shown that they are mostly confined to the boundaries of the caldera and to the boundary of the resurgent dome situated in it. Most of the domes were emplaced much later following caldera generation, they have ages of 0.5--0.8 Ma, and they should be regarded as **a consequence of postcaldera volcanism**.

(7) The structural setting of the **present-day hydrothermal systems** in the area of study has been revised. It was observed that all larger hydrothermal systems (the Bol'she-Bannaya, Karymshina, and Verkhne-Paratunka ones) **are confined to the boundaries of the Karymshina caldera**.

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Parameters of processes in deep geospheres assessed from mineral inclusions in sublithospheric diamonds

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Mantle is a silicate shell situated between the Earth's crust and metallic core, and it comprises about 70% of the mass of the Earth. According to geophysical data mantle is divided into 3 parts: upper mantle (lower boundary at 410 km), transition zone (410 – 670 km) and lower mantle (670 – 2900 km). Upper mantle is sampled by xenoliths in alkaline basalts and kimberlites, as well as by the large blocks uplifted to the surface by tectonic processes. An important information concerning the composition of lower mantle and transition zone is provided by mineral inclusions in a rare variety of diamonds transported from sublithospheric depths.

The most common minerals in such inclusions, demonstrating that they come from the lower mantle, are bridgmanite (metasilicate $(Mg,Fe)SiO_3$ with perovskite crystalline structure), $CaSiO_3$ with perovskite structure and ferropericlase (Mg,Fe)O). Comparison of the composition of these minerals with the results of experiments, conducted at high pressure and temperature, shows that in many cases the bulk composition of their primary source is similar to peridotites from the upper mantle.

An important problem concerns the presence of metallic alloy in the rocks of lower mantle. It stems from experimental data demonstrating, that at pressures above 30 GPa FeO in peridotitic phase assemblage should disproportionate forming Fe_2O_3 entering bridgmanite solid solution and Fe^0 forming metallic phase. A number of geochemists suggested that disproportionation reaction is the main cause of the redox evolution of mantle during the early stages of the formation of the Earth.

To assess the redox conditions and possible presence of Fe-rich alloy in the domains of lower mantle where sublithospheric diamonds originated I estimated position of the stability fields of carbon-bearing crystalline compounds coexisting with rock-forming minerals of the pyrolitic lower mantle. This diagram demonstrates that the field of diamond stability is separated from that of Fe-rich metallic alloy by the field of co-existence of iron carbides with

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ABSTRACTS

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