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## EVOLUTION OF THE UPPER CRUST MAGMATIC CHAMBERS IN CALDERACOMPLEXES OF EASTERN KAMCHATKA

A number of uppe Quaternary calderas is located in Central part of the East Volcanic belt. Their age decreases from southwest to northeast. These calderas belong to the Karymsky long lasting volcanic centre, caldera of Large Semyachik, Uzon-Geisernaya depression and caldera Krasheninnikov. They are generated above the low depth magmatic reservoirs during the catastrophic large volume explosive pyroclastic eruptions of acid and average composition. Collapse of the roof of magmatic chamber has taken place during these eruptions. Closed depressions - calderas were formed on the surface and filled later by lake sediments. High-temperature hydrotherma! systems and deposits of minerals are connected with these calderas.

We have studied in detail the upper Pleistocene calderas of Large Semyachiksky and Uzon-Geiser areas, which differ by various evolution of crust reservoirs. The basic structural elements and magmatic complexes have been described in detail on the basis of large-scale geological mapping. We have determined their age, composition of paragenesis of mineral phases, evaluated the physico-chemical conditions of crystallization of melts and estimated the evolution of magmatic substance within time. We investigated the role of deep basalts in formation of acid magmas and processes of mixing of melts, as one of the leading factors, explaining the variety of rocks together with crystallizational differentiation.

The essential information as per structure of magmatic reservoirs is given by the large-scale catastrophic eruptions, to which the formation of ignimbrites is related. While studying the sections of ignimbrites, compositions of mineral phases, correlating these sections, we can show the initial structure of a chamber before the eruption and to restore its dynamics in time. It is considered, that the variation of composition of pyroclastic sediments related to formation of volcano-tectonic depressions and composition of mineral phases along the section, both in separate pyroclastic flows, and during total stage of caldera-formation, testifies to the existence of zoning of melt within the magmatic reservoir : a «cap» of high-siliceous (rhyolite, rhyodacite) melts is formed in the apical part of the chamber. These melts are replaced below by dacite and andesit-dacite ones. Zoning is formed within the periods of long "settlement" of melt in situation of a rather closed system and it is fixed only during evacuation of large volumes of pyroclastic material.

Most expressively this zoning is manifested in pyroclastic flows of the Large Semyachik caldera, where we can distinguish the three caldera-forming stages. The intermediate magmatic chamberm, delivering melts of mainly andesite-basalt and andesite composition to the surface, existed inside this structure in precaldera time. The first caldera-forming stage started at the eruption of high siliceous rhyolite ingnimbrites, enriched by alkali and water, and it was finished by ingnimbrites of andesite-dacite composition. High degree of crystallinity and rather homogeneous composition of the insets in these ingnimbrites testify to the quiet conditions of melt crystallization. Absence of intermediate variations between these ingnimbrites allows to assume the presence of a sharp boundary between melt layers within the magmatic chamber. There was a significant time interval between the first and second stages, during which the broken zoning within the chamber was restored.

During the second caldera-forming stage there was an eruption of at least three pyroclastic flows of rhyodacite structure. Reduction of acidity of each subsequent portion, reflects the drain process of more and more deep zones within the chamber. At the end of the second stage there was. an eruption of ignimbrite-like rocks of andesite-basalt structure, that testifies to existence of another magmatic reservoir at deeper levels. The wide range of structures of insets in the ignimbrites of the second stage reflects processes of mixing within the crust chamber.

Relative exhaustion of the upper rhyolite layer within the first two stages and significant convection in the center after introduction of the basalt magma, have resulted in ( levelling ) alignment of the melt structure and in eruption at the beginning of the third stage of ignimbrites of dacite structure. Acidity is reduced in the last pyroclastic flow and slag inclusions of andesite-basalt structure in ignimbrites take place. Bimodality of mineral composition of ignimbrites within the third stage, widely manifested zoning of the insets, simultaneous presence of dacite glasses and slags of andesite-basalt composition, reflect both - earlier processes, and processes of melts mixing occured directly during the eruption.

Increase of basicity of each subsequent pyroclastic flow with the increase of heterogeneity, testifies that the basic volume of acid magma within the crust chamber was exhausted and the stage of caldera formation of Large Semyachik was finished. Total volume of the preserved ground facies makes about 40 $km^3$ fact this volume was, obviously, 3-4 times more, since the thin fractions removed by the ash separation and washed down by water flows, were not taken into account.

The new post-caldera stage of volcanic activity in the caldera of Large Semyachik has again started from the inner outflow of andesite-basalt magma, which had filled up the emptied magmatic chamber after the eruption of ignimbrites. It progressed in time, having generated the cone-shaped andesite-dacite volcanos, extrusive domes and lava flows of rhyodacite composition on the surface.

Evolution of the crust chamber went on differently in Uzon-Geiser area. The acid crust chamber existed here from the pre-caldera time and was manifested in insignificant volumes of extrusive-effusive volcanics. The Uzon-Geiser volcano-tectonic depression consists of two calderas, extended lengthways along the sublatitudinal fault. The western one - caldera Uzon has the overlapped character and cuts the eastern part of depression, which speaks of its younger age. Increase of diameter of the ring structures to the west and existence of fault ledges, testifies to the roof deepening of the crust chamber beneath the Uzon caldera.

There are no ledge faults in the eastern part of this structure. One of the authors considers that the depression was formed alongside with the expansion of a series of explosive funnels. Nevertheless, there are arc faults here, which limit the caldera structure. Introduction of the so-called onboard complex extrusions along these faults. Absence of ring faults confirms the assumption of the smaller depth of the roof in the upper crust chamber in the depression's eastern part. Pyroclastic flows, connected with the Uzon-Geiser volcano-tectonic structure, form two fields - northern and southern. They differ in chemical and mineral composition. It allows to assume, that pyroclastic flows, connected with the eastern part of depression, distributed to the north, and the ones, connected with the western (caldera of Uzon) - to the south.

There was revealed no precise melt stratification in pyroclastics connected with the Uzon-Geiser volcano-tectonic depression, as compared to the pyroclastic sediments of the Large Semyachik caldera. Composition of basic volume of pumice-like welded tuff, reflecting composition of the ignimbrite-forming melt, varies insignificantly from rhyodacites up to dacites, testifying to weak zoning of the magmatic melt in the zone of chamber drainage. Capacity of the acid zone was rather significant since the volume of Uzon ignimbrites (about 30 $km^3$) is comparable with the total volume of the Semyachik ignimbrites.

Pyroclastic of more basic andesite-dacite and andesite composition occurs at the later stages of development of this structure as agglutinates, overlapping extrusions of the onboard complex. Absence of water-bearing minerals in pyroclastic sediments of the Uzon-Geiser depression and low content of alkalis reflect relative dryness of ignimbrite - forming melt.

In its turn, it can point to the fact that the crust chamber within the Uzon-Geiser structure "has not ripened" by the moment of eruption, the cap of highly fluidized flooded melt was not generated within it, as it had occured in the caldera of Large Semyachik. Stripping of the chamber has taken place, probably, during its decompression with the introduction of significant volumes of high-temperature deep melts into the basement of magmatic chamber or as a result of seismotectonic phenomena.

The enclosed section of two pyroclastic flows, connected with the Uzon caldera, divided by

some temporal interval, is stripped in the southeastern board of plateau Shirokoye. Ignimbrite-like rocks composed by basic andesite and andesite-basalt, similar to those, met earlier among the Semyachik ignimbrites, are associated with the first and with the second flows. They form the low-capacity layers among the pumice agglomeration tuffs and are represented in different degree by the caked slag tuffs, up to lava-like facies. They possess many structural features of acid pyroclastic flows: presence of welded tuff-like isolations of melt, its ash fragments, faltering fluidal textures, indicating the current of pyroclastic flow, presence of thin-fractional xenogenic material.

The ignimbrite-like rocks of andesite-basalt composition can represent the deep parts of zonal magmatic reservoir or an independent intermediate chamber, located below. Stratified crust magmatic chamber is usually a barrier of density for the basalts rising from depths. These magmas of raised density can reach the surface only on periphery of the crust magmatic reservoirs, along the ring faults, which limit the zone of distribution of deep acid melts on the surface. Reaching the basis of uppercrust magmatic chambers, they cause convection in its upper levels and, according to many researchers, can provoke explosive eruptions.

Different is also the post-caldera volcanism of the Uzon-Geiser volcano-tectonic depression The underwater eruptions of acid pyroclastic proceeded after the caldera has been formed and filled by the lake. Futher a largely degased acid melt poured on the drained and levelled surface of the lake sediments. It had formed the intercaldera extrusive-effusive complex. Acid lavas carry the attributes of hybridism as nonequilibrum crystal phases and inclusions of basalt composition.

Thus, the history of geological development of the Large Semyachik and Uzon-Geiserny ring caldera complexes confirms the idea of different authors, both domestic, and foreign, on the convective crust-mantle magmatic systems consisting of chains of magmatic chambers, located at different levels in the earth crust. The role of active heat-carrier is played by the basalt melts, periodically intruded into the upper levels of earth crust and interfering consolidation of melt inside the upper-crust reservoirs. In its turn, it provides the thermal feed for the high-temperature hydrothermal systems, for a long time associated with caldera complexes and active transfer of weight, contributing to ore formation.

The January 1996 eruption in Karymsky volcanic center is a vivid example of interaction of melts of different generation levels within the earth crust. This centre lies among a number of volcano-tectonic structures of the East volcanic belt of Kamchatka and represents a complex formation of Plyocene-Quaternary age consisting of a number of volcanic constructions of different composition and a series of ring structures, eccentrically enclosed into each other., the explosive phreato-magmatic eruption of tephra of basalt composition occured on January 2-3 in caldera of the Academy of Sciences, which age is about 30 000 years. The eruption was a reaction to previous seismic events.

Basalts from the deep zones of intermediate magmatic chamber existing within the structure from the beginning of Pleistocene, arrived to its upper cooled down part, and then got to the surface along the formed crack. The thermal pulse was introduced into the upper-crust magmatic chamber beneath the Academy of Sciences caldera and into the connected with it high-temperature hydrothermal system. Acid pumice bombs were thrown out at the final stage of eruption. Plastic, deformations between basalts and rhyodacites testify to the hardening of magmatic emulsion, consisting of components with various viscosity.

The fact, that the basalts could break to surface through the less dense acid material, testifies that the melt in the upper-crust chamber was in subsolidus condition by the moment of the eruption. Influence of the high-temperature basalt melt, even short-term, within one day, led to partial mobilization of the acid melt up to a state of " crystal porridge ". It was obviously carried out in a narrow zone along the transit of basalts: a sort of «testing» of separate zones of crust chamber in vertical section took place.

Analysis of evolution of the uppr-crust magmatic chambers in a series of ring volcano-tectonic structures of East Kamchatka, especially in connection with the last eruption in caldera of the Academy of Sciences, allows to make a forecast of their further activity. The low-power eruptions

mainly of the hybrid melts are possible within the more ancient caldera complexes, such as the Karymsky volcanic center and caldera of the Large Semyachik, where the acid melt within the chamber was either completely exhausted during the process of caldera-forming, or is being in the subsolidus state.

The upper-crust chamber is still being a buffer for the high-temperature deep basalt melts withiln the comparatively young Uzon-Geiser volcano-tectonic depression. It is confirmed by the fact, that all Holocene eruptions of andesite-basalts occured at the border of depression or behind its boundaries This structure is obviously being at the uncompleted stage of its development compared to the previous ones. Therefore it is possible to assume, that the large volume injection of basalts into the foundation of the upper-crust magmatic chamber can result in reanimation of acid with in the chamber and cause an explosive eruption. It can equally be related to the volcano Krasheninnikov, which closes a series of volcano-tectonic structures in the north and can be considered as a young caldera complex being in the stage of its formation.