Oral

Pliocene-Quaternary Samtskhe-Javakheti Volcanic Highland, Lesser Caucasus – as a Result of Mantle Plumes Activity

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Introduction

In the SW part of the Lesser Caucasus, at the Pliocene-Quaternary, the Samtskhe-Javakheti subaerial volcanic highland (asl 1500-2500 m) was formed, which is located discordantly on the mid-Eocene sediments. In Georgia area the highland occupies more than 4500 km^2, however its large part is located in the South in Turkey and Armenia territories.

The study of the Samtskhe-Javakheti volcanic highland lasts for some decades. Among the researchers N. Skhirtladze (1958) has made a valuable contribution. In the formation of the highland three big magmatic activity should be marked: 1. Early Pliocene – when dacite-andesitic volcanic tuffs of 700-1100 m thickness and flows (s.c. Goderdzi suite) were formed; 2. Late Pliocene-Early Pleistocene – when dolerite flows of 100-250 m thickness were formed and 3. Mid Pleistocene-Holocene volcanic activity, when Abul-Samsari linear volcanic ridge was formed to the south of dolerite flows.

Based on field, petrologic, petrochemical and isotopic studies, we consider that all three stages of the Samtskhe-Javakheti volcanic highland formation were connected with the activity of the mantle plume flows (Morgan, 1972) and not with melting processes of the residual subduction of oceanic crust in the mantle as it is considered at present (Neill e al., 2013). Our consideration is confirmed by the results of a new experimental modeling (CNRS/IRD/Blaise Pascal University): the melting of the subducted oceanic crust into the mantle. According to the experiment an oceanic crust submerged into the mantle at the beginning is melting, although in the Mg-rich environment a perovskite ($MgSiO_3$) mineral envelope is permanently formed. A melting point of which is significantly higher than that of the mantle. It melts fully already at the boarder of the lower mantle and outer core, in the area of layer D, where the temperature increases at 1000^0 C.

Field, petrological and geochemical investigations

A large part of the highland is built up by the Goderzi suite, witch is represented by volcanic lava-breccias, pyroclastic rocks, andesite-basalt lava flow and ash fall huge deposits of andesite-dacitic composition. Formation of the series was conditioned by several cycles of volcanic eruptions in the range of 5.2 – 2.6 Ma (zircons U-Pb dating), with a mantle source of magma chamber (Chang et al., 2013). The question about magmatic center of the Goderzi suite is still debated, but it is clear, that it was a huge formation. Based on physical volcanology, the analogy of such structure is considered as super/mega volcanoes. The evidences of such structure are the following: a large volume of volcanic material (> 1500 km^2); big thickness (700-1100 m in average), big size of volcanic breccias (diameter >1 m), large scales of lava flows (length 35 km, thickness 30-80 m) and big thickness of volcanic ash horizons, 300 cm at some places (Fig. 1).

According to above-mentioned descriptions, a volcano, giving the Goderdzi suite, was not an ordinary formation but it was a mega volcano (Okrostsvaridze et al., 2016). In addition, taking into consideration all petro- and geochemical parameters, these rocks do not belong to the island arc formations.

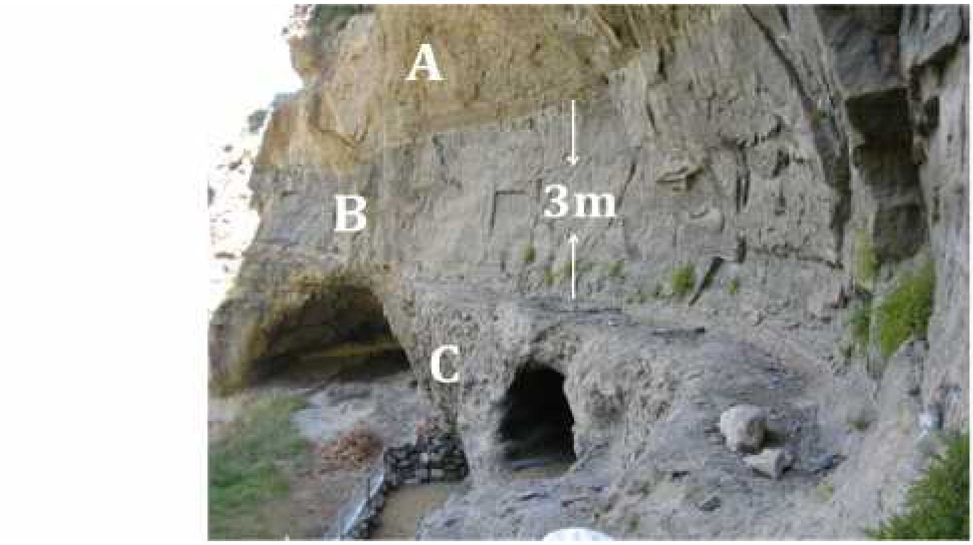

Fig. 1. The exposure of thick layer of volcanic ash at the northern benches of Vani kettles.
A- medium-grained tuffs, B – grey volcanic ash, C – coarse-grained volcanic tuffs.

Basaltic flows of the Javakheti volcanic plateau of 100-250 m thickness were formed as a result of the second magmatic Late Pliocene-Early Pleistocene activity of this volcanic highland (2.4-1.6 Ma; Chang et al., 2013). The strata are dark grey, fully-crystalline, coarse-grained, weakly differentiated massive rocks, mainly consisting of olivine, mafic labrador, monoclinic pyroxene and titanaugite. According to petrochemical data, they are more related to mid- oceanic ridge basalts than to island arcs. Content of SiO_2 in these flows varies in the range of 49-51% and that of MgO varies within 6-8%. There $^{143}Nd/^{144}Nd$ parameter varies in the range of +0.51703 - +0.52304, and $^{87}Sr/^{88}Sr$ parameter – from 0.7036 to 0.7042. By all these characteristics these are typical continental basalt strata, genetic relation of which to mantle plumes is doubtless.

The third - last magmatic activity of the Samtskhe-Javakheti volcanic highland, which took place at Mid-Pleistocene-Holocene (0.35-0.025 Ma; Chang et al., 2013) is a classic example of „hot spot"(Okrostsvaridze, 2011). As a results of this magmatic activity the Abul-Samsari linear volcanic ridge was formed, which stretches to the S-N direction for 40 km with the 8-12 km width and contains more than 20 volcanic edifices. According to the Sr and Nd isotopic parameters ($^{143}Nd/^{144}Nd$=+0.52504; $^{87}Sr/^{88}Sr$=0.0421) the magmatic source of this ridge was mantle reservoir; formation of its volcanic edifices in time occurred from the southern to the northern direction. At the same time volcanic activity decreases. To the south of the Abul-Samsari ridge the highest (elevation 3305 m) and oldest (0.35-0.30 Ma) volcano Didi Abuli (Big Abuli) is located. To the North the heights and ages of volcano edifices gradually increase. Further North the youngest volcano Tavkvetili is located (elevation 2583 m, age 0.025-0.30 Ma). Unlike other volcanoes it still has a crater. One can see from this brief description that the Abul-Samsari ridge has all signs characterizing intraplate volcanic ridge.

Conclusion

Based on the results of the petrologic, petrochemical and isotopic studies we believe that all three stages of the formation of the Javakheti volcanic highland were related to an activity of mantle plume, therefore it is possible the highland be viewed as a relatively small-scale magmatic province. This consideration is confirmed by the following important factors of the mantle plume manifestations within the highland: super/mega volcanoes – magmatic activity forming the Goderdzi suite; continental flood basalts – dolerite flows of Javakheti volcanic plateau; intraplate linear volcanic ridge - Abul-Samsari volcanic ridge.

Discussion

If we assume the results obtained then the history of geological development of the region becomes more interesting because of a close genetic relation between a Paleozoic granite-gneiss crust (Artvini-Bolnisi platform), Paleogene volcanic arc formations (Akhaltsikhe depression) and the products of Pliocene-Quaternary mantle activity (Samtskhe-Javakheti volcanic highland). Such a circumstance makes it possible to reconstruct an important geological process in future, such as thermochemical interaction of mantle plumes and a subduction zone.

In addition, as the modern studies show, as a result of thermochemical interaction of mantle plumes and a lithosphere, important metallic ores are formed. Newly-formed powerful hydrothermal system accumulates associations of Cu-Ni-Pt, Fe-Pt, Au-As, Ag-Sb, Sb-Hg and other metals at the barriers of basaltic flow. It should be noted that such an accumulation of metals is observed at the upper horizons of the Goderdzi suite, which forms the basis for their study in detail.

As for the question of the Javakheti mantle plume generation, maybe it is a marginal manifestation of the Northern flow of the Eastern Africa mantle plume.

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