Late Miocene Volcanic Ash Layers of the Intermountain Depression of the Eastern Caucasus: the Products of the Megacaldera Explosion?

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Introduction

The Caucasus is a central segment of the Mediterranean Alpine-Himalayan collisional orogenic system and consists of the Greater and Lesser Caucasus orogens and intermountain depression. There are numerous layers of volcanic ashes in the late Miocene marine sediments (dated paleontologically) of the Eastern Caucasus intermountain depression. The ashes consists primarily of hornblende, pyroxene and volcanic glass (Skhirtladze, 1964). The thickness of the layers varies between 5 m - several decimeters, while their distribution area is wide and includes Kartli and Kakheti regions in Georgia and Western region of Azerbaijan (Fig. 1).

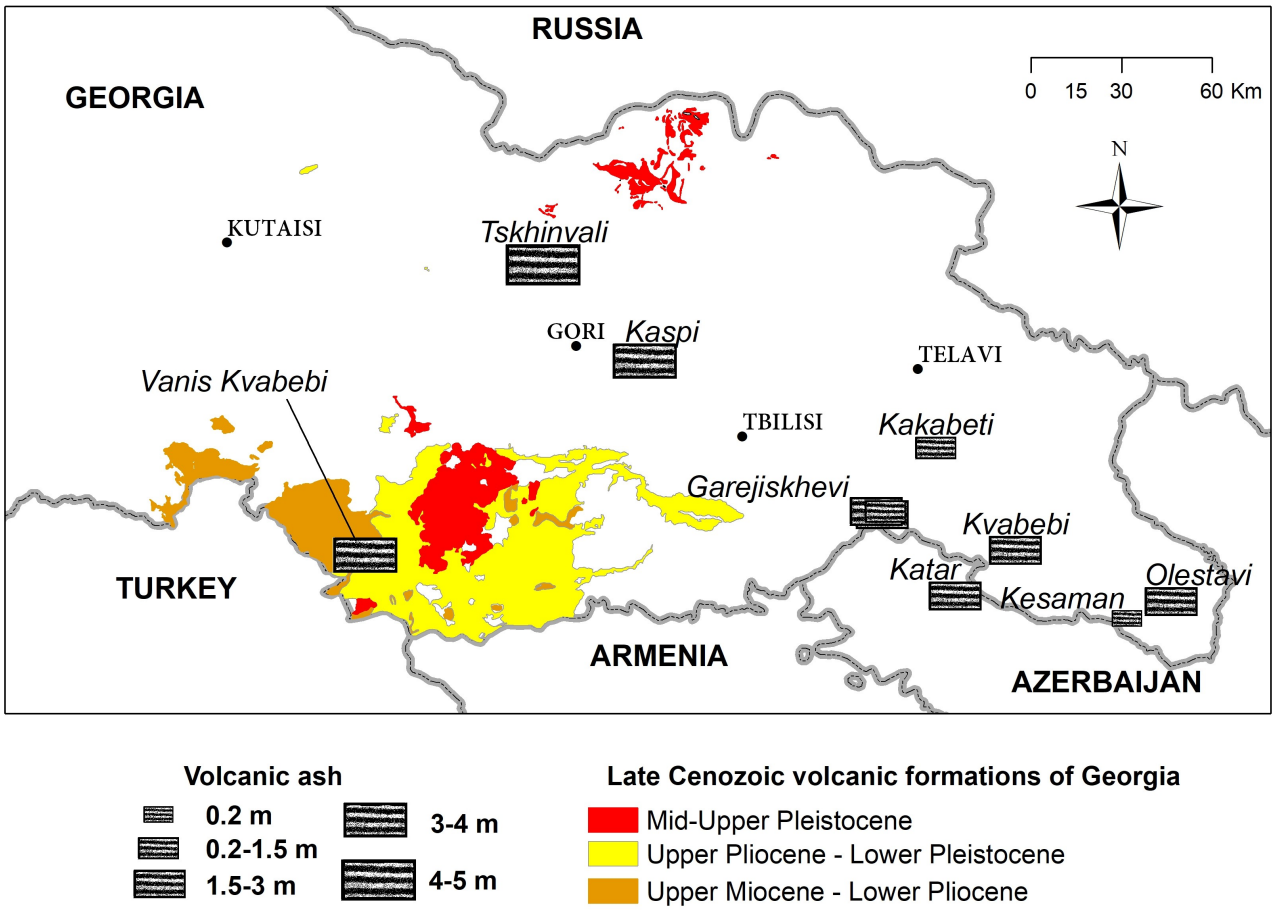

Fig. 1. Schematic map of distribution of the Late Cenozoic volcanic formations and Late Miocene volcanic ash layers in the intermountain depression of the Eastern Caucasus.

Description of Volcanic Ash Layers

The volcanic ash layers are dark grey, quite dense and at the same time light rocks that chemically correspond to andesite. The mineral composition is quite simple and is mainly represented by isometric 0.5-1.7 mm diameter grains of volcanic glass, andesine and hornblende.

The thickest layer is marked at the village Sarabuki near the town Tskhinvali, where it exceeds 5 m and is andesitic according to its composition. The thickness of volcanic ash layers reduces to the east, and at vil. Metekhi railway station, in the Nadarbazevi gorge, it amounts to 2.5-3 m. In the east, particularly in Kakheti, thickness of these layers further diminishes and in the Gareji ravine it ranges between 1-1.5 meters, and further to the east at "Kvabebi area" thickness of volcanic layers is 50-80 cm. In the upper Miocene sediments the volcanic ash of andesitic composition is recorded in Azerbaijan, namely at the village Kasman, where it amounts to 10-20 cm (Skhirtladze, 1964).

It isn't clear what was the source of the above described volcanic ash, however, due to its age and distribution geometry, it is necessary to look for its source in the Lesser Caucasus, particularly at the Samtskhe-Javakheti volcanic highland, and not in the Greater Caucasus. It is known that in the Greater Caucasus subaerial volcanic activity started only in the middle Pleistocene (Skhirtladze, 1958).

Samtskhe-Javakheti volcanic highland

Samtskhe-Javakheti volcanic highland has an area more than 5000 km^2 (1500-2000 m a.s.l.), however a large part of it is located in the South on the territories of Turkey and Armenia. Three main magmatic activity should be marked in the formation of the highland: 1. Upper Miocene – Lower Pliocene, when huge 700-1000 m thick dacite-andesitic volcanic tuffs (so-called Goderdzi formation) were formed; 2. Upper Pliocene-Lower Pleistocene, when 120-270 m thick continental flood basalts were formed and 3. Mid-Upper Pleistocene, when Abul-Samsari linear continental volcanic ridge was formed (Okrostsvaridze et al., 2016).

The question about magmatic center of the Upper Miocene – Lower Pliocene Goderdzi formation is still debated, but our detailed investigations allow us to conclude, that its magmatic center was a megavolcano, which was located at the Turkish-Georgian border. One of the megacaldera structures of this volcano is located on Niala valley (territory of Georgia) (15x 22 km, 2800-2200 m asl.), which is injected by post-volcanic andesitic extrusives and known as Gumbati mountain (2996 m a.s.l.). At present, the Niala valley caldera is covered with quaternary sediments, bounded with andesitic lava flows and open to the eastern direction. From Niala's caldera, ignimbrites of andesitic composition flow out (so-called Vardzia ignimbrites) and extend more than 35 km to Khertvisi castle, with 30-80 m thickness (Okrostsvaridze, Popkhadze, 2016).

It should be noted, that in the Goderdzi formation of the riv. Mtkvari valley, 2-3.5 m thick volcanic ash layers were observed 270 m hypsometrically above Vardzia ignimbrite flow (Fig. 2), which shows similarity to those in the Eastern Caucasus intermountain depression in chemical and mineralogical, as well as by structural-textural features. We used U-Pb method of dating Vardzia ignimbrite flow zircons and received very interesting results.

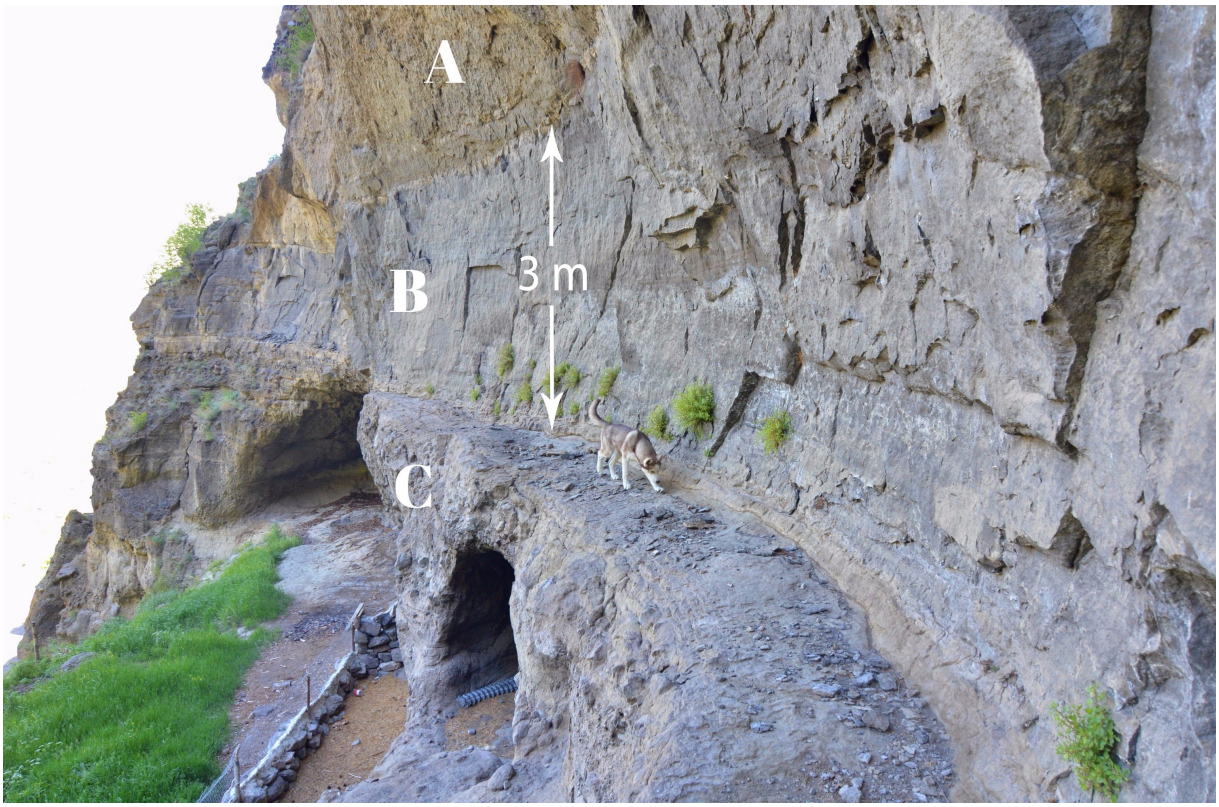

Fig. 2. The exposure of volcanic ash layer of the Vanis Kvabebi, Vardzia formation.
A- medium-grained tuffs, B – andesitic volcanic ash, C – coarse-grained tuffs.

Zircons U- Pb dating result

The dating the zircons of the Vardzia ignimbrites flow was done at National Taiwan University, by U-Pb method, using LA-ICP–MS equipment. The samples were taken from three main parts of the flow and was dated 72 zircon grains: in the end of the flow (at 35 km), near the Khertvisi castle (13GEO-04), in the central part of the flow (at 15 km) near the Vardzia cave city (13GEO-05) and at the beginning of the flow (at 2 km) near the Arzameti castle (13GEO-06). The results are as follows: 13GEO-04 = 7.50±0.42 Ma; 13GEO-05 = 7.54±0.21 Ma; 13GEO-06 = 7.52 ± 0.21 Ma. Thus, according to these data, Vardzia ignimbrite flow represents the Late Miocene formation, which crystallized around 7.5 Ma ago.

Discussion

Based on the analysis of the information available to us, we believe that the Goderdzi formation is the product of the Megavolcano activity. There is no doubt that the volcanic ash would be deposited after the accumulation of the explosive pyroclastic material. According to these arguments, the age of the ash layers, found by our group in the Mtkvari valley, should be the same as the age of the Vardzia ignimbrite flow. If we share this idea, then the Miocene volcanic ash layers in the Eastern Caucasus intermountain depression are in full correlation with the Goderdzi formation volcanic ash layers according to their age, and also chemical and mineralogical composition. This indicates that the formation of above discussed volcanic layers was associated with a strong magmatic center namely to Niala megacaldera of the Gumbati Megavolcano, which was the source of Goderdzi volcanic pyroclastic formation (Okrostsvaridze, Popkhadze, 2016).

Conclusion

Thus, if we take into account that average distance from Niala megacaldera to the volcanic ash layers, located in the Eastern Caucasus intermountain depression, is 300-400 km, and also thickness of these layers (from several decimeters up to severall meters), then our view on megacaldera explosion in Samtskhe-Javakheti volcanic province during Late Miocene becomes more reasonable.

Therefore if we compare the results of the research, we should assume that the volcanic ash layers in the Eastern Caucasus intermountain depression were formed as a result of caldera explosion that was the source of the Goderdzi formation. Analyzing the volcanic explosivity index – (VEI) (Newhal, Seld, 1982) of the this formation and introducing the largest volcanic eruptions of the Earth (Bryan, 2010) made us suggest that the volcanic ash layers in the Eastern Caucasus intermountain depression were formed as a result of Niala megacaldera explosion.

Reference

Bryan, S.E., 2010. The largest volcanic eruptions on Earth. ***Earth-Sc. Reviews, v.102, pp. 207-229.***

Newhall C. G., Self S., 1982. **The Volcanic Explosivity Index (VEI):** An Estimate of Explosive Magnitude for Historical Volcanism. *J. of Geophysical Research, 82, 1231-1238.*

Okrostsvaridze A., Popkhadze N. 2016. Megavolcano in the Late Cenozoic Samtckhe-Javakheti Volcanic Province? Lesser Caucasus, Georgia-Turkish Border. *IAVCEI VI Intern. Workshop on collapse calderas. Hokkaido, Japan, p. 42.*

Okrostsvaridze, A., Popkhadze, N., Bluashvili, D. Chang, Y. H., Skhirtladze, I. 2016. Pliocene-Quaternary Samtskhe-Javakheti Volcanic Highland, Lesser Caucasus – as a Result of Mantle Plumes Activity. *In: IGCP pr. 610 plenary conference proceeding, Tbilisi, Georgia, pp. 127-131.*

Skhirtladze N., 1964. On the use of volcanic ashes for dating volcanic formation. *In book: "for the XXII session of international geological congress", Metcniereba, Tbilisi, pp. 207-214.* Skhirtladze N. I. *Post-Paleogene effusive volcanism of Georgia. Tbilisi, "Metsniereba", 1958, p. 165.*

Ustiev E. K., Jigauri D. I. 1971. The velded tuffs from Vardzia formation (southern Georgia). *Izvestia AN SSSR, vol. 4, pp. 3-16 (in Russian).*