

ORAL

## 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 consist primarily of hornblende, pyroxene, and volcanic glass (Skhirtladze, 1964). The thickness of the layers varies between 5 m to several decimeters, while their distribution area is wide and includes the Kartli and Kakheti regions in Georgia and the western region of Azerbaijan (Fig. 1).

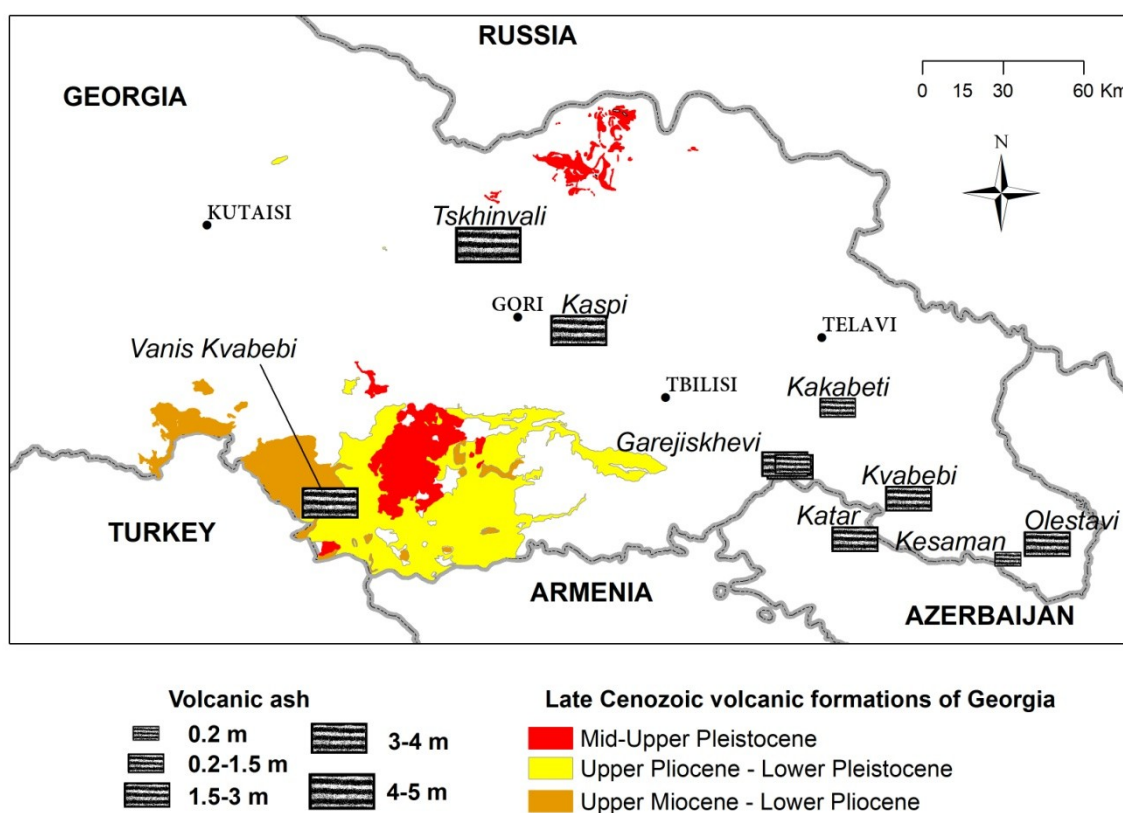


Fig. 1. Schematic map of distribution of the Late Cenozoic volcanic formations and Late Miocene volcanic ash layers in the intermountain depression of the Eastern Caucasus.

### **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 the village Metekhi railway station, in the Nadarbazevi gorge, it amounts to 2.5–3 m. In the east, particularly in Kakheti, the thickness of these layers further diminishes, and in the Gareji ravine, it ranges between 1–1.5 meters, and further to the east at the "Kvabebi area", thickness of the volcanic ash 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).

The source of the above-described volcanic ash isn't clear, 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**

The Samtskhe-Javakheti volcanic highland has an area of more than 5000 km<sup>2</sup> (1500–2000 m asl), however, a large part of it is located in the south within the territories of Turkey and Armenia. Three main magmatic intervals of activity should be marked in the formation of the highland: (1) Upper Miocene to– 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 the Abul-Samsari linear continental volcanic ridge was formed (Okrostsvardze et al., 2016).

The question about the 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 present-day Turkish-Georgian border. One of the megacaldera structures of this volcano is located in the Niala valley within the territory of Georgia (15x22 km, 2800–2200 m asl), which is injected by post-volcanic andesitic extrusives and known as Gumbati mountain (2996 m asl). At present, the Niala valley caldera is covered with Quaternary sediments, bounded by andesitic lava flows, and open to the eastern direction. From Niala's caldera, ignimbrites of andesitic composition flow out, so-called Vardzia ignimbrites (Ustiev and Jigauri, 1971), and extend more than 35 km to Khertvisi castle, with a thickness of 30–80 m (Okrostsvardze and Popkhadze, 2016).

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

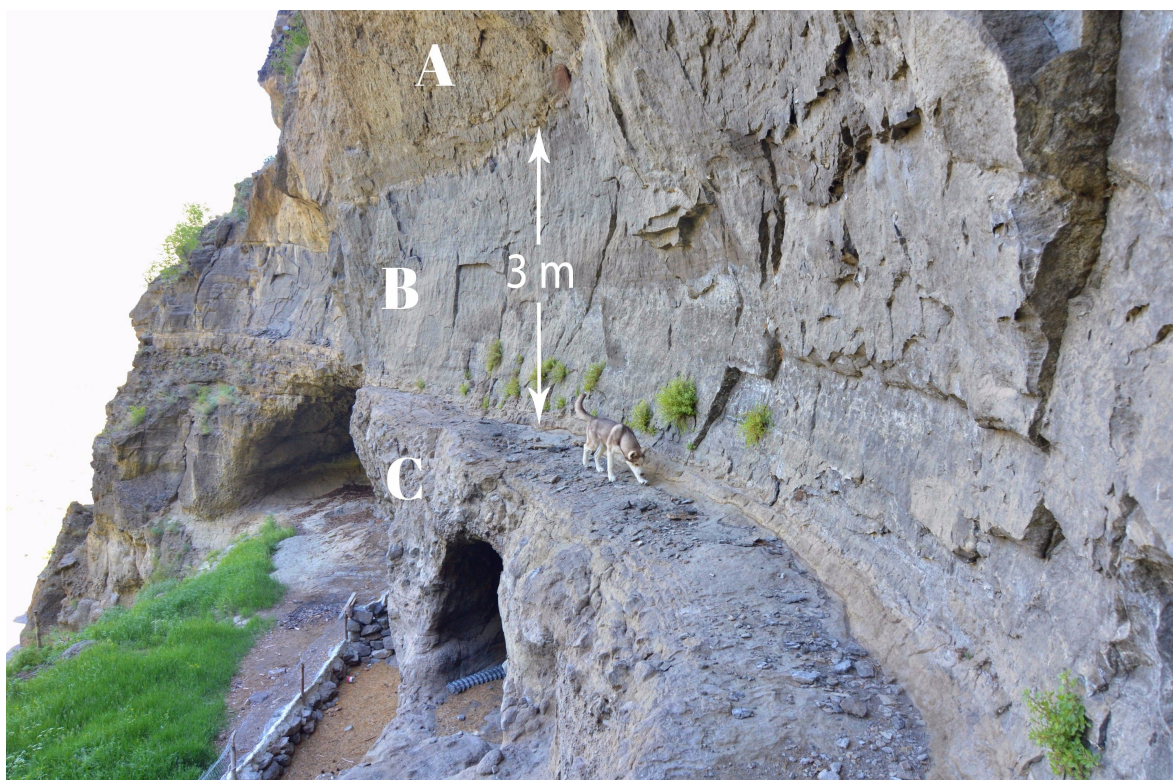


Fig. 2. Exposure of the volcanic ash layer of the Vanis Kvabebi, Vardzia formation. A = medium-grained tuffs, B = andesitic volcanic ash, C = coarse-grained tuffs.

### U-Pb dating results on the zircons

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

### Discussion

Based on analysis of the information available to us, we believe that the Goderdzi formation is the product of megavolcano activity. There is no doubt that 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 the above-discussed volcanic layers was associated with a strong magmatic center, namely, the Niala megacaldera of the Gumbati Megavolcano, which was the source of the Goderdzi volcanic pyroclastic formation (Okrostsvaridze and Popkhadze, 2016).

## **Conclusion**

Thus, if we take into account that the average distance from the Niala megacaldera to the volcanic ash layers located in the Eastern Caucasus intermountain depression (300–400 km), and also the thickness of these layers (from several decimeters up to several meters), then our view on the 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 the result of a caldera explosion that was the source of the Goderdzi formation. Analyzing the volcanic explosivity index—VEI (Newhall and Self, 1982)—of the this formation and considering the largest volcanic eruptions of the Earth (Bryan et al., 2010) prompts us to suggest that the volcanic ash layers in the Eastern Caucasus intermountain depression were formed as a result of the Niala megacaldera explosion.

## **References**

- [Bryan, Scott E.](#), Peate, Ingrid U., Peate, David W., Self, Stephen, Jerram, Dougal A., Mawby, Michael R., Marsh, J.S., and Miller, Jodie A., 2010. The largest volcanic eruptions on Earth. *Earth-Science Reviews* 102(3–4): 207–229.
- Newhall, C.G., and Self, S., 1982. The Volcanic Explosivity Index (VEI): An estimate of explosive magnitude for historical volcanism. *Journal of Geophysical Research, Oceans* 87(C2): 1231–1238.
- Okrostsvaridze, A., and Popkhadze, N., 2016. Megavolcano in the Late Cenozoic Samtskhe-Javakheti Volcanic Province? Lesser Caucasus, Georgia-Turkish Border. *VI International Workshop on Collapse Calderas, Hokkaido, Japan, 4-10 September 2016*. International Association of Volcanology and Chemistry of the Earth's Interior, p. 42.
- Okrostsvaridze, A., Popkhadze, N., Bluashvili, D., Chang, Y.H., and Skhirtladze, I., 2016. Pliocene-Quaternary Samtskhe-Javakheti Volcanic Highland, Lesser Caucasus—as a result of mantle plumes activity. In Gilbert, A.S., and Yanko-Hombach, Valentina, eds., *Proceedings of the Fourth Plenary Conference of IGCP 610 “From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary” (October 2-9, 2016; Tbilisi, Georgia)*, Georgian National Academy of Sciences, Tbilisi, pp. 127–131.
- Skhirtladze, N.I., 1958. *Postpaleogenovyj effuzivnyj vulkanizm Gruzii [Post-Paleogene Effusive Volcanism of Georgia]*. Tbilisi, Akademiâ Nauk Gruzinskoj SSR. (In Russian)
- Skhirtladze, N., 1964. On the use of volcanic ashes for dating volcanic formation. *XXII International Geological Congress, 14–22 December, 1964, New Delhi*, pp. 207–214.
- Ustiev, E.K., and Jigauri, D.I., 1971. The welded tuffs from Vardzia formation (southern Georgia). *Izvestia AN SSSR* 4: 3–16. (In Russian)