Poster

Unique Cave City Vardzia, Georgia – Geology, Destruction Processes and Protection measures

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Intraducion

A unique cave city Vardzia of 12th century, combines urban, defensive and monastic complex, is hewn into the volcanic tuff flow of the Pliocene andesitic-daciteic composition. In 1283, after a strong earthquake, the cave complex was severely damaged, but it did not cease its operation. The results of the geological investigation showed that the Vardzia area has a complex geological structure. It is situated on the eastern slopes of the Erusheti ridge is hewn into the 900 m long tectonic block, which is detached from the main rocks and is gradually subsiding towards the Mtkvari gorge. In addition, the Vardzia block is split into several microblocks by a joint set and thereby its stability lessens. The matter is made worse by the fact that the active deep fault runs along the Vardzia complex in the Mtkvari gorge and presents a potential earthquake source. For this reason, it is clear that the important monument of the Georgian cultural heritage is in danger of natural gradual destruction and earthquake hazards.

Methodology

The works were carried out with the application classical geological methods as well as high sensitivity modern tools. To determine exact hypsometric location and vertical displacement of the a differential high accuracy DGPS – Leica Viva GS15 was used. At the same time, monitoring of dynamics of the front part of Vardzia is being carried out continuously by stationary IBIS-FM radar.

Geological Characterization of the Vardzia Region

Vazdzia region is constructed by subaerial Pliocene volcanogenic-sedimentary rocks of andesit-dacite composition– the so-called Goderdzi suite. This suite is located discordantly on the mid-Eocene tuff-breccias and sandstones and is also discordantly covered with thick flow series of Quaternary dolerites (Skhirtladze, 1958). Goderdzi suite is strictly divided in two big parts: the lower part with the thickness of 200-250 m is built with pyroclastic formations, in which mainly dark, weakly cemented coarse material of hyperstenic and 2-pyroxene andesitic and andesitic-dacitic composition prevails. Somewhere in this coarse tuff suite one can mark cenotypal thin-layered pyroxene andesitic rare flows, above this part there is a 20-80 m thickness slightly welded fine-grained andesitic-dacitic tuff flow (Vardzia horizon) It was the segment of the volcanogenic rocks where the Vardzia comlex was hewn in the 12th century (Fig.1). Vardzia horizon presents fine-grained andesitic-dacitic slightly welded tuffs (Branney & Kokelaar, 2002). It is well observed in relief because of its whitish color. Its thickness in the Vardzia section is 40-60 m and is different in the northern and southern directions. It should be noted that the horizon outcropping mainly on the left benches of the Mtkvari river, while they are marked fragmentarily on the right ones. Tuffs of the Vardzia flow are rather soft rocks. They make fingers dirty although it is impossible to crash them by hand. Their color changes from lateritious-pink to light grey-white. In the petrographic sense these tuffs can be divided into three parts: lithoclastic, porphiroclastic and cementing materials.

Fig. 1. Panoramic view of the Vardzia region. In white color – volcanic flow of andesitic-dacitic composition. At the top of the flow–an upper part of the Goderdzi suit. In right – the Vardzia cave city.

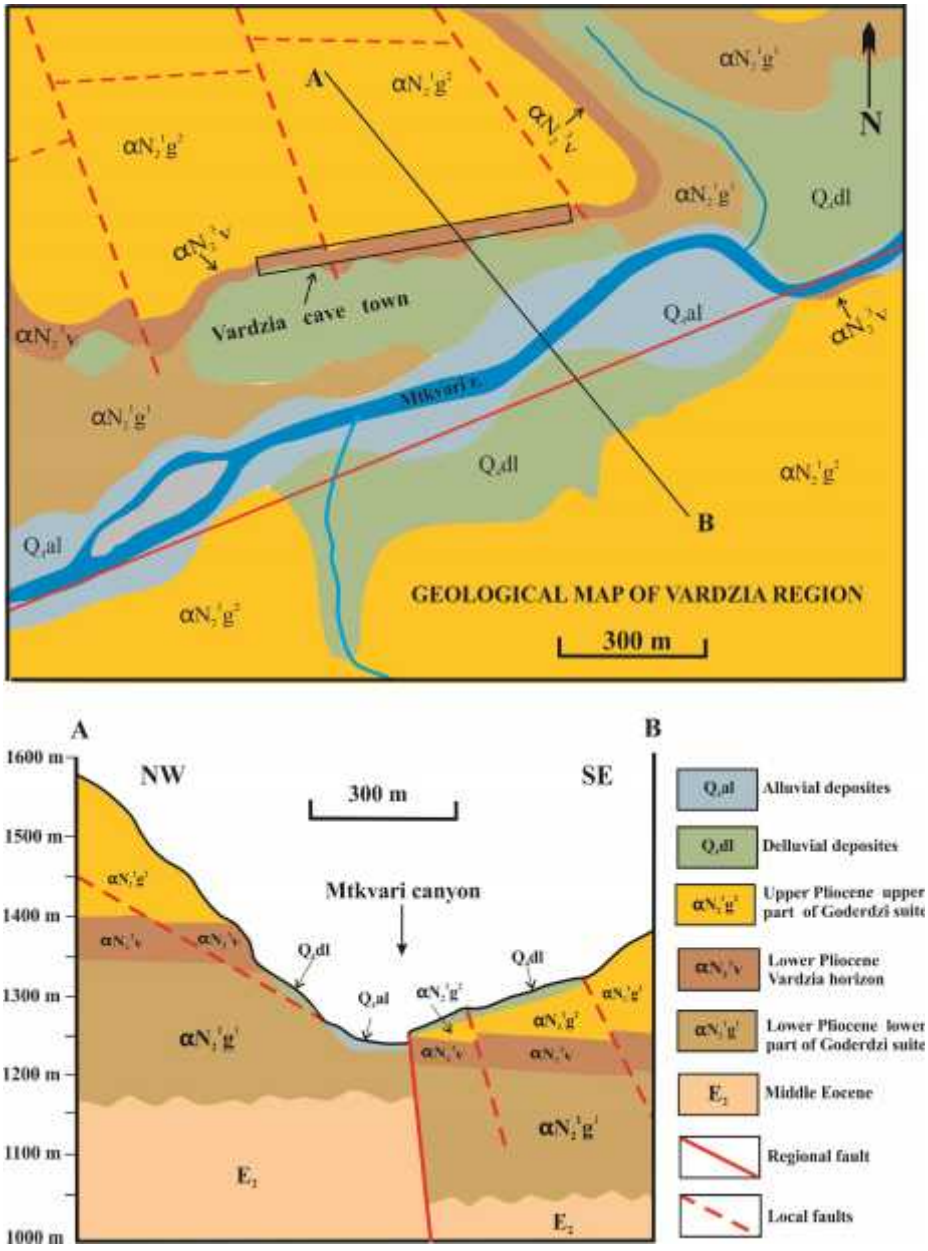

Figure 2. The geological map of Vardzia area, and its cross section.

Tectonic Structure of the Vardzia Region

Tectonic structure of the Vardzia region is rather complex (Gamkrelidze, 2000). There tectonic fault of two types are distinguished (see fig. 2): 1) faults provoked by regional geological processes and 2) those conditioned by local gravitation phenomena. The basic tectonic structure of the area is a deep fault, which traces towards SW-NE and actually goes along the Mtkvari river gorge. Along the fault the Vardzia area is divided in two large geoblocks: a western block – Vardzia (Erusheti) and an eastern – Javakheti. Along it, after the Vardzia horizon was formed (beginning of the Pliocene), a significant vertical displacement was detected.

We detected exact heights asl of the upper border of the Vardzia horizon in the exposures at both sides of the Mtkvari river using a high accuracy differential GPS. As a result the Vardzia horizon in the Vardzia complex is situated upper in comparison with the right riverside by 127 m (Okrostsvaridze et al., 2016). Apparently, the centre of Vardzia destructive earthquake in 1283 was located right along this fault.

Destruction Processes

Destructive processes of cave city Vardzia conditioned the type of rocks in which it is built and complex tectonic structure. It is hewn into the weakly cemented volcanic tuff flow of the andesitic-dacitic composition. Tuffs of the Vardzia flow are rather soft rocks, therefore it suffers constant weathering and destruction. It should be noted that these rocks can be cut even with a simple iron knife and this very factor must have been the reason to build the Vardzia complex into these rocks.

No less important a role plays the destructive processes of Vardzia complex tectonic structure. The 900 m long tectonic block of Vardzia, which is detached from the main rocks and is gradually subsiding towards the Mtkvari gorge, is split into several microblocks (Fig. 3), therefor its stability is reduced even further. Also strong erosion processes taking place along the Mtkvari gorge, cause significant destruction processes.

Figure. 3. Microblocks in SW part of Vardzia Area: light color fine-grained andesitic-dacitic welded tuffs.

Conclusion

Thus, the study showed that Vardzia, is hewn into the weakly cemented volcanic tuff flow of the andesitic-dacitic composition, therefore it suffers constant weathering and destruction. Also, tectonic structure of the Vardzia region is rather complex. Exact measurements carried out with the GPS showed that the 900 m in length Vardzia block is lowered by 30.6 m in comparison with the adjacent block. In addition, the Vardzia
worse by the fact that the active deep fault runs along the Vardzia complex in the Mtkvari gorge and presents a potential earthquake source. If we take into consideration the rather strong erosion processes taking place along the Mtkvari gorge, it makes clear that the important monument of the Georgian cultural heritage is in danger of natural gradual destruction and earthquake hazards. The only factor contributing to relative stability of the Vardzia cave city is somewhat harder basalt-andesitic lava-flow existing under it.

Protection measures

Due to the fact that Vardzia region is characterized by complicated tectonic and geological construction, its protection measures are difficult. We consider that to fortify sliding blocks, traditional concrete reinforcement constructions should be used. Besides, clefts which are present in andesitic-dacitic slightly welded tuffs should be sewn up on high temperature by heating them up over $1000^{0.}$ At the places where these clefts are wide, they should be filled by the same material brought from other exposures and afterward be heated.

References

Branney M.J. & Kokelaar, B.P ., 2002. Pyroclastic Density Currents and the Sedimentation of ignimbrites. Geological Society London Memoir 27, 143 p.

Gamkrelidze I.P.,2000. Once More on the Tectonic Zoning of the Territory of Georgia. Geological Institute proceedings. New series. vol.115, pp. 204-208 (in Russian).

Okrostsvaridze A., Elashvili M., Popkhadze N., Kirkitadze G., 2016. New Data on the Geological Structure of the Vardzia Cave City, Georgia. Bull. Georg. Natl. Acad. Scinces (in print).

Skhirtladze N. I., 1958. Post-Palogene Effusive Volcanism of Georgia. Publishing House of the Geog. Acad. Sci. Tbilisi, 165 p.