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Mass Burial site of the Gryphaeas in Upper Cretaceous sedimentary cover of the Khrami massif, Lesser Caucasus, Georgia

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Abstract. Earth's globally significant geological heritage is recognized by UNESCO as a scientific, educational, environmental protection and economical areas. We believe that we have found one such site in the sedimentary cover of the Khrami massif. This pre-Jurassic crystalline massif (~500 km^2) is located in Georgia, within the Lesser Caucasus orogenic belt. On its eastern periphery, near the village of Kldeisi, a geological phenomenon is preserved in the volcanogenic-sedimentary rocks. A massive colony of well-preserved Gryphaeas is exposed in the Maastrichtian carbonate sediments. The length of this exposed part is ~50 meters, with an average thickness of ~5 meters. This exposure is intersected in the central part by a ~1.5 meter-thick gabbroic subvolcanic body. The Gryphaeas outcrops are covered with a ~2 meter-thick volcanic layer, with SiO_2 content ranging from 30 to 47% and CaO content ranging from 22 to 36%. A similar mass burial of the Gryphaeas has not been described in the scientific literature, and figuratively, we can call it "Pompeii of the Gryphaeas". Gryphaeas are shallow sea mollusks, representing a class of Bivalvia in the Gryphaeidae family. These fossils existed from the Triassic to the middle Paleogene period. We believe that the Kldeisi Gryphaea exposure is unique due to the preservation of this colony in its primitive form, attributed to volcanic activity. Consequently, it offers a best-case scenario of active geological processes and biosphere interaction. Nevertheless, the outcrop reveals several interesting geological patterns, such as the succession of Gryphaea layers and volcanic layers. Additionally, basalt pillow lavas can be found in the surrounding bulk material. As is known, since Maastrichtian times, the Transcaucasus microplate initiated rifting processes and gradually separated the southern provinces: Artvin–Bolnisi and Loki–Karabakhi zones. Most likely, this volcanic activity represents part of this process. We firmly believe that the Kldeisi Gryphaea outcrops represent a significant geoheritage and educational site and, consequently, the foremost geotourist attraction.

Keywords: The Gryphaea, Mass burial, Kldeisi site, Khrami massif, Lesser Caucasus.

1. Introduction

Earth's globally significant geological heritage recognized by UNESCO as a Scientific-educational, envronmental protection and economical areas. Such area are protected and promoted through the UNESCO Global Geoparks Network [1]. Georgia has several sites of outstanding geoheritage with cultural and hystorical connections. We believe that we have found one such site in Georgia, in the sedimentary cover of the Lesser Caucasus pre-Jurassic Khrami crystalline massif [2]. The first data on this geoheritage site are discussed in the publication.

2. Regional Geology

Georgia is located between the Black and Caspian Seas, in the WS Caucasus Mountains. The Caucasus is composed of three large geomorphological units: The Greater and the Lesser Caucasus mobile belts and and the Transcaucasian Microplate. Despite its relatively small territory (69,700 km2), Georgia hosts a wide variety of geological formations, spanning a vast range of geological time, from the Precambrian to the Quaternary [3].

The Khrami pre-Jurassic crystalline massif (~500 km2) is situated in South Georgia, approximately 100 km from Tbilisi, within the Lesser Caucasus orogenic belt. It represents a Horst-like uplift of the Artvin-Bolnisi zone and is mainly composed of the pre-Hercynian gneiss-migmatitic complex and late Variscan granitorides. The complex is intersected by late Cretaceous gabbroic dikes [3]. On its eastern periphery, near the village of Kldeisi, a massive colony of well-preserved Gryphaeas is exposed in the Cenomanian volcanogenic-sedimentary rocks.

3. Brief description of Gryphaeas

Gryphaea one of the marine bivalve mollusks in the family Cypraeidae, a genus of extinct oysters, known as “devil's toenails”. They lived in large colonies in warm, shallow waters and sat on the sea-floor with their shells partially buried in the mud, typically measuring approximately 5-7 cm. These fossils range from the Triassic period to the middle Paleogene period but are primarily found to the Triassic and Jurassic periods. Its distribution is common in various areas of Europe. The complete fossils consist of two articulated valves: a larger gnarly-shaped shell (the "toenail") and a smaller, flattened shell, the "lid". The soft parts of the animal occupied the cavity between the two shells, just like modern oysters [4].

4. Brief description of the Kldeisi Gryphaeas mass burial site

The Kldeisi Gryphaeas mass burial site is situated in the upper part of the Upper Cretaceous carbonatized sediments on the Khram massif (Tetritskaro suite). The Pachydiscus neubergicus (Hauer) and Hauericeras sulcatum (Kner) fauna, dated to the Maastrichtian, is found in this sequence [5]. The exposed part is approximately 50 meters in length, with an average thickness of about 5 meters (Fig. 1). This exposure is intersected in the central part by a roughly 1.5 meter-thick gabbroic subvolcanic body. The Gryphaeas outcrops are covered with a approximately 2 meter-thick volcanic layer of carbonate-basaltic composition (Fig. 2), which is, in turn, covered with a deciduous forest.

This outcrop of the Grypheas consists of homogeneous rocks, which are broken into large blocks (approximately 1.2 x 2.3 x 4.5 meters) (Fig. 1). The sizes of Gryphaea range from 4-7 cm, and they are closely spaced (Fig. 2). The voids between them are filled with products of volcanic activity. It is worth noting that in this outcrop, there is an alternation of volcanic and Grypheas layers, evidence of multiple volcanic eruptions. We believe that the Kldeisi Gryphaeas site is unique due to the preservation of this colony in its primitive form, attributed to volcanic activity. Consequently, it offers the best-case scenario of active geological processes and biosphere interaction. Figuratively, we can call it the "Pompeii of the Gryphaeas". It should be noted that we have not found similar mass burials of Gryphaeas in the scientific literature.

5. Materials and Methods

We studied the Kldeisi Grypheys site in detail. We collected 12 samples of this mollusk and determined their species. We also investigated the genetic type and U-Pb geochronology of the Kldeisi submarine volcano.

Major and trace elements geochemical analyses were conducted using LA-ICPMS at the MSALABS laboratory in Canada.

Fig. 1. Fragments of the Kldeisi Gryphaeas mass burial site: a - blocks of rocks built by Gryphaeas and b - close-up of Gryphaeas exposed.

Fig. 2. Fragment of basaltic volcanic layer of the Kldeisi Gryphaeas mass burial site.

6. Results

Paleontological research has shown that the fossilized mollusks are Gryphaeas and belong to the class of Bivalvia in the Gryphaeidae family (Fig. 3). They are shallow-water, warm-water mollusks, and they existed from the Triassic to the middle Paleogene period, but are mostly restricted to the Triassic and Jurassic. It should be noted that this mollusk is known as 'devil's toenails' [4].

Fig. 3. The Gryphaea fossilized mollusk (7x5 cm) of Kldeisi site.

The Kldeisi site volcanic layer consists of dark-colored, massive, homogeneous rocks interspersed with calcite veins. A geochemical study of these rocks showed that they were the product of a basaltic magma but were enriched with CaO. In this ash layer, the SiO_2 content ranges from 30 to 47%, Al_2O_3 from 4.7 to 8.0%, MgO from 7.5 to 11.5%, FeO from 4.15 to 6.75%, Na_2O from 0.86 to 1.59%, K_2O from 0.54 to 1.8%, and CaO content ranges from 22 to 36%. This combination of chemical elements [Ca > Mg > Fe > (Na + K)] is characteristic of carbonate magmas rather than silicate ones. In terms of trace element geochemistry, this volcanic layer is closely related to the intra-plate mid-ocean ridge basalt (MORB) [6].

7. Discussion

This publication on the Kldeisi Gryphaeas mass burial site is pioneering, and therefore, many issues are unclear and controversial. However, we can confidently state that this colony of Gryphaeas lived in a shallow sea water environment, as evidenced by the analysis of terrigenous material. A 1.5 meter-thick subvolcanic body intruded into this colony, covering and thereby preserving it. It is known that since Maastrichtian times, rifting processes began in the Transcaucasus microplate, gradually separating the southern provinces, specifically the Artvin–Bolnisi and Loki–Karabakhi blocks [3]. Most likely, this volcanic activity is a part of this process. However,

the exact timing of this event remains uncertain. Further research is needed to clarify the type of magmatism and other related aspects.

8. Conclusions

On the eastern periphery of the Khrami massif, near the village of Kldeisi, a massive colony of well-preserved mollusks is exposed in the Maastrichtian carbonate sediments. The fossilized mollusks are Gryphaeas and belong to the class Bivalvia in the Gryphaeidae family. They are shallow-water, warm-water mollusks and existed from the Triassic to the middle Paleogene period.

The length of the Gryphaeas colony outcrop is approximately 50 meters, with an average thickness of about 5 meters. The outcrop is intersected in the central part by a subvolcanic gabbroic body with a thickness of approximately 1.5 meters and is covered with a volcanic layer that is about 2 meters thick. The SiO_2 content of the volcanic formation ranges from 30 to 47%, and the CaO content ranges from 22 to 36%. In terms of trace element geochemistry, this volcanic layer is closely related to the intra-plate mid-ocean ridge basalt (MORB).

We believe that the Kldeisi Gryphaea exposure is unique due to the preservation of this colony in its primitive form, attributed to volcanic activity. Consequently, it offers the best-case scenario of active geological processes and biosphere interaction. We could not find information about a similar mass burial of Gryphaeas in the scientific community. We firmly believe that the Kldeisi mass burial outcrop of the Gryphaeas (often referred to as the 'Pompeii of Gryphaeas') is a significant geoheritage and educational site and, as a result, the foremost geotourist attraction.

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