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GEOLOGICAL REPORT

"NORTHERN WALL SECTION OF THE LEZHA CASTLE"

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1. GENERAL

1.1 INTRODUCTION

The relevant data on the geological-engineering conditions is displayed in this report in the framework of the project "Provision of consultancy for design services for the EU4CULTURE Project Support for the revitalization of cultural heritage sites and monuments affected by the earthquake in Albania". The section considered in the framework of this design beolongs to the northern wall of the Lezhë Castle.

Consequently, a detailed field analysis has been carried out by the author of the study and the ordering party. The walls of the castle are generally in a bad condition, due to over time amortization, earthquakes, weather coniditions, as well as lack of long-term maintenance. For this reason, it seems reasonable that within the framework of this project, the revitalization of this historical monumrny can be achieved.

Evaluating the geological, geomorphological, hydrogeological and geological-engineering factors in this section of the wall, the geological reconnaissance method would be put into effect, taking advantage of the natural features in this area. Simultaneously with the geological survey of the area, a special care was devoted to the identification of possible geodynamic phenomena on site.

All the drilling works were laid out in the topographical plan on a scale of 1:500 that was made available to the experts by the ordering party. The provided geological study was backe up by proximity studies as well as other authors.

This study is complete and is valid for the project-implementation phase.

1.2 SITE LOCATION

The area that requires in-depth geological engineering study is located in the territory of the Castle of Lezhë, more precisely in the northern wall section which showcases multiple constructive deteriorations. In the photo below, this part of the wall is circled in red.

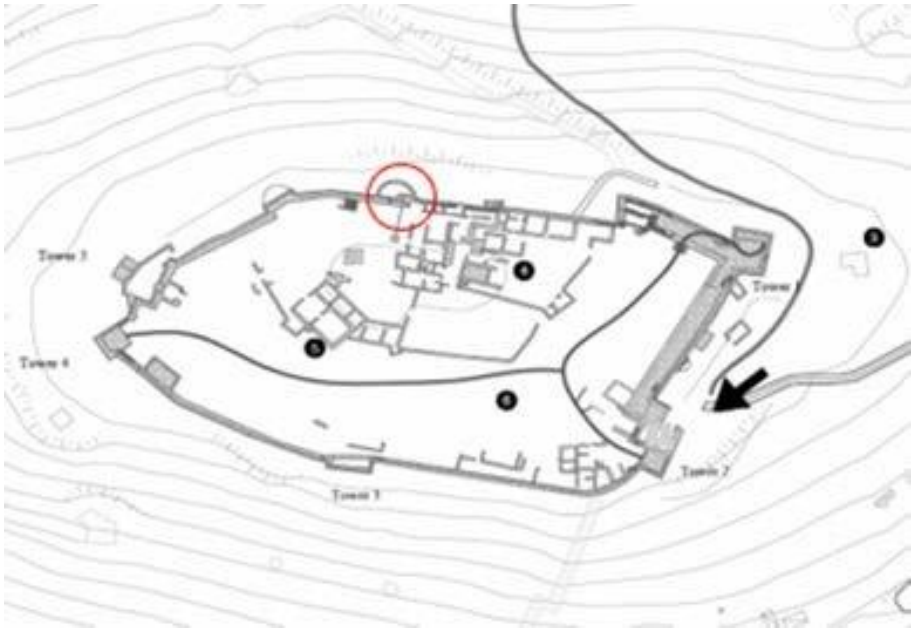

Fig. 1: Geographic Location of the study area

1.3 PURPOSE

The purpose of this study is to fully clarify the geological-engineering, hydro-geological and geo-technical conditions of this part of the Castle wall.
Therefore, in cooperation with the ordering party, the following study operations were agreed and carried out:

- A general geologic engineering reconnaissance of the site and of the northern part of the wall in particular were both carried out.
- Proximity studies of the site and the city of Lezhë in general were also used.
- At the same time, a geological and engineering assessment was carried out in the slope outside the castle walls, to identify any phenomenon that could affect the stability of the walls.
- Based on the completed works, 2 geologic-lithological profiles of the square under study were built.

1.4 GEOLOGICAL COMPONENTS OF THE AREA

In general, the region of the city of Lezha and its surroundings have this geological structure:

- Upper Cretaceous deposits,
- Paleocene-Eocene deposits,
- Eocene deposits, Lower Oligocene deposits,
- Quaternary deposits.

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1.4.1 Upper Cretaceous Deposits

These deposits are spread in all the structures of the Kruja area. They are found in the carbonate structures discovered on the surface of Renc-Kakariq. In this area, the lower part of the section is represented by dolomite with dolomitic limestone interspersed, containing several layers of rudist. Above, the cut is dominated by dolomitic limestone with rare intercalations of massive dolomites. Above are dolomites interbedded with stratified bioclastic limestones. The thickness of the Upper Cretaceous deposits in this area reaches 750 m.

Fig. 2: View from Paleogene limestone (lower Oligocene)

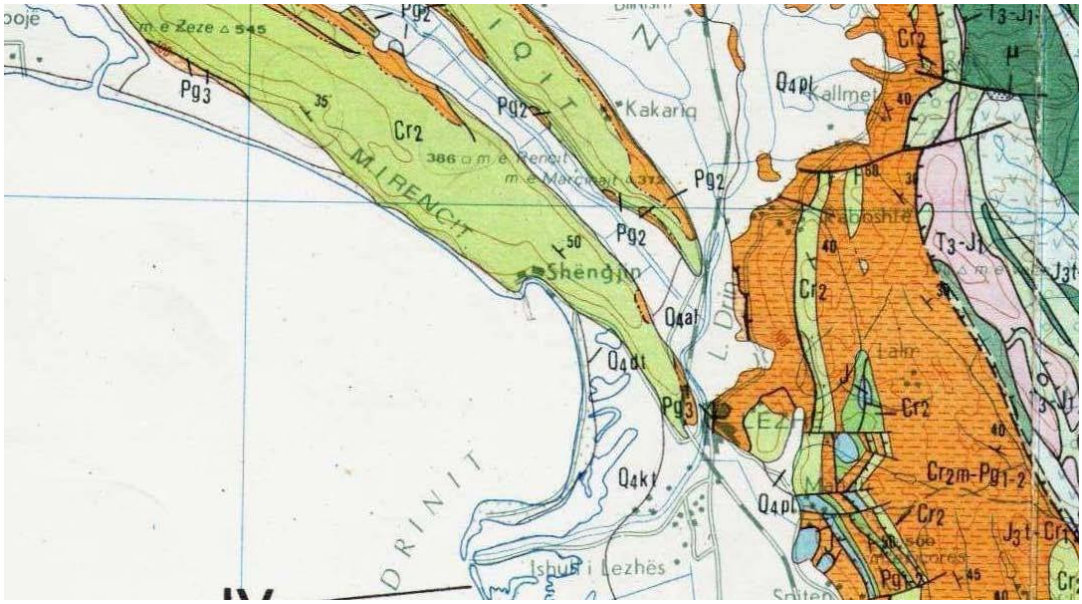

Fig. 3: Geological map of Lezhë

1.4.2 Paleocen-Eocen Deposits

They present the upper part of the "new fleece". Since they are placed successively on the Maastrichtian flysch, they have the same distribution as the Upper Cretaceous deposits. They are represented by flysch and flyschoidal deposits, mainly sandstone-siltstone, interspersed with layered to massive sandstones and conglomerates. Also in the cut, outcrops in the form of elongated lenses of clayey-marly limestones and layers of turbiditic limestones with gray to beige color, in which planktonic foraminifera are collected, can be distinguished. Their thickness reaches 1000-2000m.

1.4.3 Eocen Deposits

These deposits are spread throughout the structures of the Kruja area. They are placed with a stratigraphic disconformity on top of the Upper Cretaceous deposits. In the stratigraphic break, almost everywhere a bauxite bearing level is encountered. Lithologically, these deposits are represented by biomicritic limestones with macroforaminifera, layered and rarely layered. Their thickness reaches 50-120m.

1.4.4 Lower Oligocen Deposits

These deposits are laid out on both sides of the structures of Renc and Kakariq. Their lower part is represented by the transitional marl pack. Above the transitional marl pack, a thin clayey-sandy sheet successively follows, on which successively follows a sandy-clay-conglomeratic sheet, divided into several lithological packages, with a total thickness exceeding 2100m.

1.4.5 Quaternary Deposits

Quaternary deposits are widespread in the Lezhë-Shengjin region. They occupy the Lezhë plain, the beach areas, the ridges of the hills, the Dajc-Blinishti plain, etc. Quaternary deposits are presented differently, depending on the place where they were formed. In the Lezhë-Shengjin region, there are mainly lagoon-marsh deposits as well as colluvial, proluvial and deluvial deposits, as well as marine deposits in the beach areas. Colluvial, deluvial and proluvial deposits consist of clay, siltstone, sand and pieces of rock. Their thickness varies up to 30m.

The lagoon-swamp deposits occupy almost the entire plain of Lezhë and Dajc-Blinishti as well as Shengjin. They consist of clay, siltstone, fine sand, waste and plant roots, etc. Their thickness reaches up to 50m. Quaternary marine deposits occupy the coastal parts of the region. They are represented by sand and gravel.

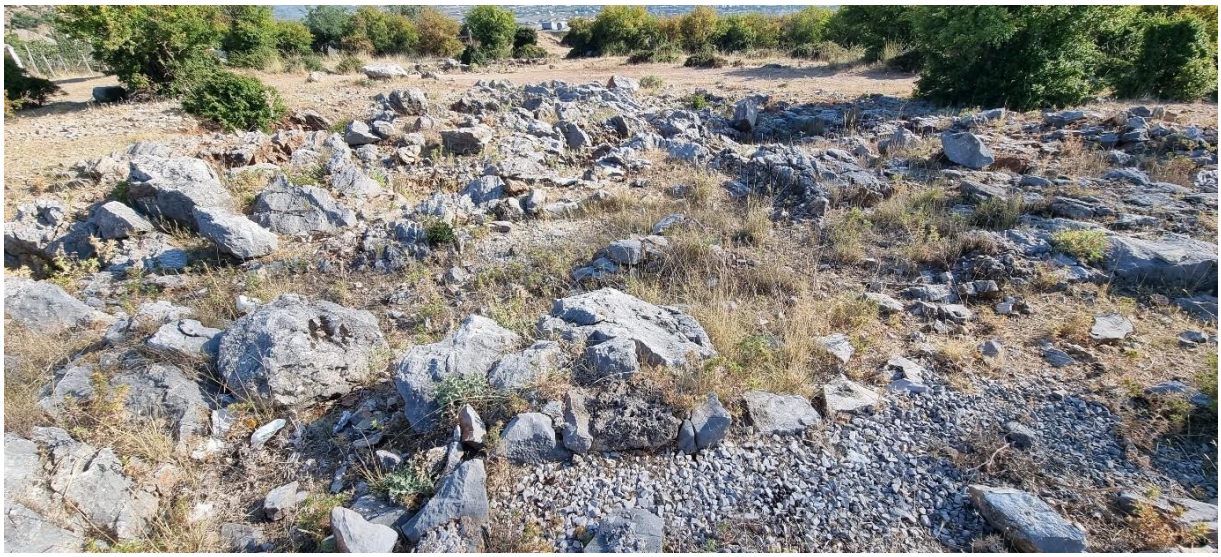

Fig. 4: View of limestone rocks Upper Cretaceous.

1.5 GEODYNAMIC PHENOMENA

In the study of the geological phenomena of this area, we are based on the existing studies and on the new information we received from the current study. Based on these data, we are describing the geological phenomena that are present in the geological formations found in this area.
The most visible geological and geodynamic phenomena observed in this area of Lezhë are:

- The weathering phenomenon
- The phenomenon of the movement of deluvial-eluvial covers, landslides.
- The phenomenon of water flooding
- Seismic phenomena

Such phenomena has been explained in detail in the chapters below:

1.5.1 The weathering phenomena

The phenomenon of weathering in our construction site is noticed, but in a non-alarming form for the stability of the site, since we mainly have limestone rocks, quite compact. This phenomenon is observed only on the surface of the rocks in the form of cracks that do not go deep.

1.5.2 The phenomenon of the movement of deluvial-eluvial covers, landslides

This phenomenon in our study area is not noticed since the formations are rocky and quite stable. Even in the plain area where the deluvial and alluvial cover is very thick, this phenomenon is not dangerous since the terrain is horizontal.

1.5.3 The phenomenon of the water flooding

This phenomenon endangers only the plain area. In the quotas where the castle building is located, this phenomenon is unlikely to happen.

1.5.4 The seismic phenomenon

The seismicity of a place is determined as a function of the size of the earthquakes (magnitude, intensity, seismic moment, etc.) and the frequency of their occurrence. In this context, the seismicity of the Lezhë-Shengjin region is characterized by an intense active seismic microactivity (from frequent small earthquakes, from rare medium earthquakes and very rare large earthquakes). The region studied by us enters the area with intensity maximum seismic VIII front (MSK-1964).

From the general studies carried out by the Institute of Seismology, it was found that earthquakes with M=5.0 have a recurrence period of 3.6 years, earthquakes with M=5.5 have a recurrence period of 10.1 years, earthquakes with M=6.0 have 29.1 years, earthquakes with M=6.5 years repeat every 93.9 years, while earthquakes with M=7.0 have a recurrence period of 505.6 years. If we look at the distribution from the probabilistic point of view, It turns out that every year in Albania we have to expect an earthquake with M up to 4.7 (with a probability of 75%), every 5 years, while every 50 years we have to expect an earthquake with a magnitude of up to 6.1 (with a probability of 75%) and every 100 years we have to expect one terms with magnitude up to 6.4 (with 75% probability.

2. GEOLOGICAL-ENGINEERING CONDITIONS

From the reconnaissance carried out in-situ, the documentation of the natural wearings, as well as the browsing of the archival materials of the studies performed in this area, by the author of the study and other authors, it results that the area where the castle of Lezhë is be located is a mountainous area. The later are generally built from limestone rocks, where Upper Cretaceous limestone dominates, with a generally thin quaternary cover, up to 0.9 meters thick, near the castle wall and more up to 2-4 meters in the slope part.

Due to its position on the ground, built on top of the hill above the city of Lezhë, the geological and engineering conditions of the Castle are simple and generally good. The problems with the structure, the wall of the castle, are due to its extreme damping. From the detailed inspection that was done on the northern wall and generally along the entire perimeter of the castle wall, it turns out that we are dealing with problems that come from the condition and the impact on the foundations.No cracks are present due to the effect of drought or swelling.

From the reconnaissance done, it results that the foundations of the fortress wall are based on limestone rock with very good geotechnical properties. In the grounds of the castle, we have distinguished only these two layers:

Layer No. 1

It makes up the covering part of the square, which in the part we are studying has a thickness of up to one meter. They are brown to reddish sandstones with pebble content reaching 30-40%, with little moisture, moderately compacted plastic. The thickness of this layer is up to one meter.

For this layer, we are giving the following physical-mechanical properties:

- Granulometric composition
- Gravel fraction (>4.75 mm) 16.6%
- Sand fraction (0.75 – 4.75mm) 30.4%
- Dust fraction + clay (<0.75mm) 53.0%
- Natural humidity Wn= 23.8%
- Upper limit of plasticity WL= 32.9%
- Lower limit Wp= 22.1%
- Plasticity number F = 10.8
- Specific weight Δ = 2.69gr/cm3
- Natural volumetric weight γ = 1.95 -2.06 gr/cm3
- Porosity n = 42 %
- Porosity index e = 0.545
- Deformation modulus E1-3 = 150kg/cm2
- Internal friction angle φ = 20°
- Cohesion c = 0.25 kg/cm2
- Allowed load σ = 2.50 kg/cm2

Layer No. 2

They are Limestone rocks of the Upper Cretaceous, compact, thick layers, slightly weathered on the surface. The foundations of the castle wall are supported on this layer.
In the graphic material attached to the study, it is presented in geological and lithological section 1-1, respectively as layer no. 2.

The physical and mechanical parameters of the limestone layer are as follows:

- Specific weight 2.70 g/cm3
- Natural volumetric weight.....2 63-2.65 g/cm3
- Uniaxial compressive strength...650-850 kg/cm2
- Cohesion.....30-40 kg/cm2
- Coefficient of hardness V -VI
- Excavation category VIII
- Allowed load Φ= 10 kg cm2

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3. CONCLUSIONS AND RECOMMENDATIONS

- The construction site of the Lezha castle is in good geological and engineering conditions.
- From the geomorphological point of view, it is a square on the upper part of a hill, with side slopes of up to 30-40 degrees.
- The level of underground water is very deep.
- No geodynamic phenomena were observed in the square and in its vicinity
- Due to its position on the ground, built on top of the hill above the city of Lezhë, the geological and engineering conditions of the Castle are simple and generally good.
- The problems in the structure, the wall of the castle, are due to its extreme damping.
- From the detailed inspection that was done on the northern wall and generally along the entire perimeter of the castle wall, it turns out that we are dealing with problems that come from the condition and the impact on the foundations.
- No cracks have been detected due to the effect of drought or swelling.
- From the reconnaissance carried out, it results that the foundations of the fortress wall are based on limestone rock with very good geotechnical properties.
- If it will be excavated for a new foundation, before filling, the geologist should be present on site for the corresponding report and record.

Fig. 5: The wall of the castle located in the rock, in the northern part

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Fig. 6: The rock that come to the surface near the wall (northern part).

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