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GEOLOGY AND TECTONICS OF POLOVRAGI CAVE - ROMANIA

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Polovragi Cave, with its 10,350 m of passages developed on three levels is located in the Southern section of the Paring and Capatinii Mountains, part of the Southern Carpathian Mountain Range. A limestone ridge/belt was formed in the Jurassic, and is crossed by several rivers. Oltet River penetrated the limestone ridge/belt, generating steep gorges 10 - 20 m wide at the base and three to four hundred meters high. A few hundreds of meters into the limestone, part of the waters of the Oltet River sink underground through an impenetrable swallet, generating the Polovragi cave. The cave is developed in the Eastern/left side of the river.

1. Introduction

Polovragi Cave is located in the Southern section of the Capatinii Mountains, which are part of the Southern Carpathian Mountain Range, Romania (Fig. 1). A limestone ridge was formed in the Jurassic, and is crossed by Oltet River, generating steep gorges 5 to 10 meters wide at the base and 300 m high (Fig. 2). Twenty five meters above the bottom, the gorges enlarged up to 40 m, where several cave

entrances, including of Polovragi Cave may be found. A second erosional level at 75 m above the bottom of the gorge with several cave entrances is present. A few hundreds of meters into the limestone, part of the waters of the Oltet River sinks underground through an impenetrable swallow hole, generating the Polovragi Cave. The cave is developed on the left side of the river, by successive captures of the Oltet River along east-west fractures. The cave and gorge were formed in the same time.

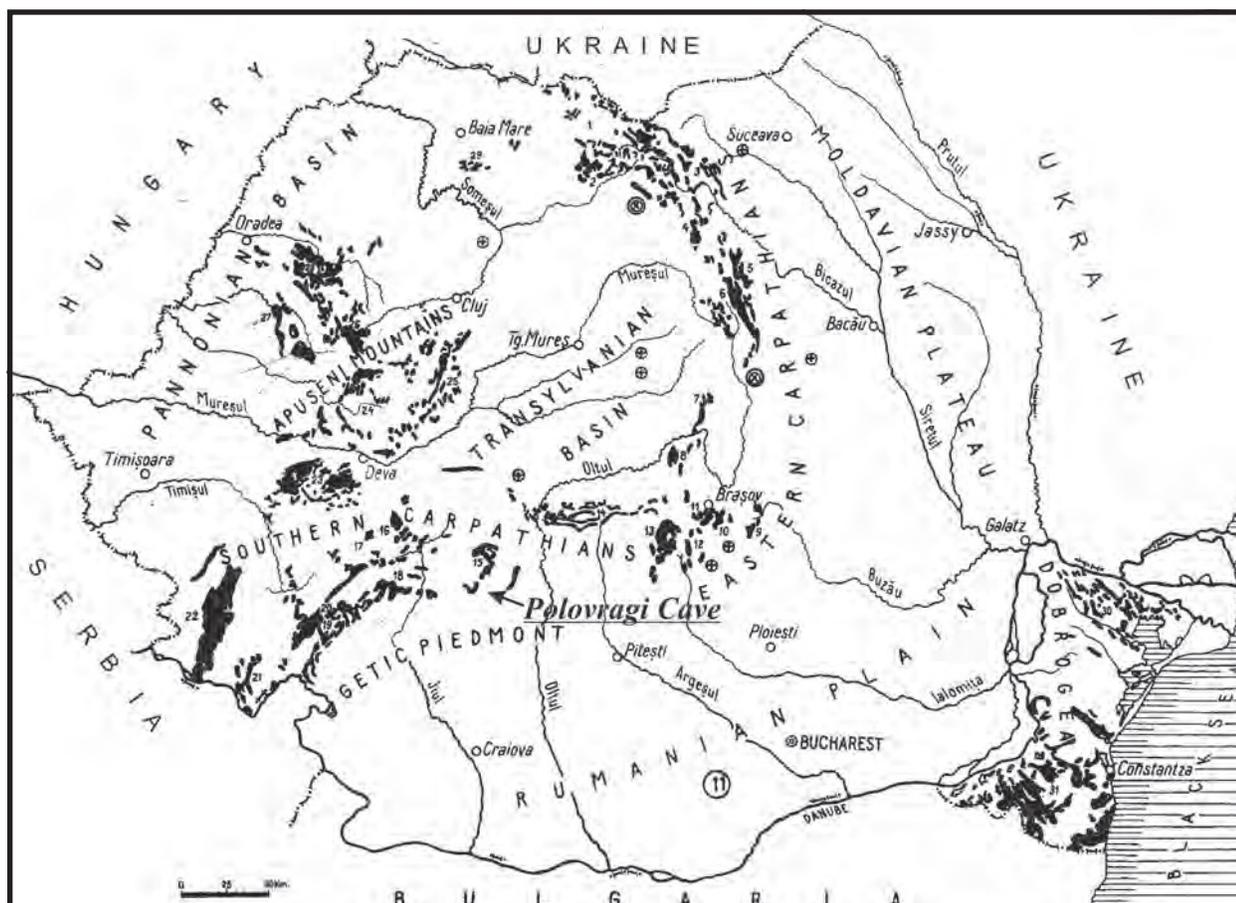


Figure 1: Karst of Romania Map (after Bleahu, 1972) with location of Polovragi Cave.



Figure 2: Oltet Gorges.

The main entrance of the cave was known for a long time, as Cave of Pahomie from Polovragi. A brief description of the cave was made by Joanes in 1868, followed by another by Alexandru Vlahuta in "Romania Pitoreasca" (1901). The first data regarding the location of the cave were published in 1929 by P. Jeannel and E. G. Racovita. In 1951, Chappuis and Winkler published the first description of the cave itself (Bleahu et al., 1976). The first paper related to the cave, which includes a map of 961 m of passages was published in 1961 by Silvia Iancu. In 1974, "Focul Viu" Grotto, from Bucharest, Romania began an extensive study of the area, surveying the cave, and conducting geologic, geomorphologic, and tectonic observations. In 1976, a description of the cave was included in the book *Pesteri din Romania (Caves of Romania)* (Bleahu et al., 1976). In 2006, in the *Field Trips in the Karst of Romania*, edited by Silviu Constantin, a brief description of the Oltet River/Polovragi Cave is presented by Cristian Goran and others.

2. Regional Physiography and Geology

The hydrographic network in the area is dominated by the Oltet River, with a yield of 300 to 400 liters/second, forms a natural boundary between the Parang (West) and Capatinii Mountains (East), collecting the surface and underground waters in the area, including the spring of Polovragi Cave. During geologic times, the changes in the base level of the Oltet River controlled the development of the four known levels in the cave.

The geology of the area is complex; a relatively small area of sedimentary rocks, including limestone, overlies a granitic and crystalline basement. The crystalline rocks are part of the Oltet Thrust and have been penetrated by Susita granitoides and are overlain by Mesozoic deposits. The Mesozoic deposits are 100 to 500 m thick, depending on their position in the Oltet micrograben. Jurassic sandstones (Dogger - Middle Jurassic) outcrop at the entrance in the Oltet Gorges, on both sides of the river. These are calcareous in the upper part (10 – 120 m thick) and Dogger (Middle Jurassic) in age based on *Belemnites* findings (Nedelcu, 1978). These deposits are overlain by up to 400 m of Tithonian (Upper Jurassic) limestones. Measurements in the area indicate bedrock is dipping to the southeast between 17° and 23° (on Figure 3, bedrock is dipping about 410, due to 2x vertical exaggeration.). Microscopic analysis determined that this 400 m thick unit is formed from several limestone layers 50 to 80 m thick, separated by calcarenites. The limestones are strongly fissured and fractured, with breccia fragments 0.5 – 2 mm size identified along the fracture planes. The joints and fractures are part of two distinct systems: one north-south and the second one northwest-southeast (dips 800 to 900). The Jurassic limestones are overlain by Cretaceous Flysch represented by black calcareous marls and green clays with coal beds. A Neogene deposit south of the Oltet Gorges is represented by sedimentary rocks of the Getique Nappe and is characterized by an east-west fault system.

3. The Cave

The Polovragi Cave is located on the left side of the Oltet River and has six entrances, three are fossil and three active. The upstream entrance (dry - 2 x 3.5 m size) is at the northern end of the gorges, at about 15 m relative elevation (645 m elevation), and initially functioned as a sinking stream (Fig. 4). At the bottom of the gorge, in the same area the Oltet River is sinking partially underground through

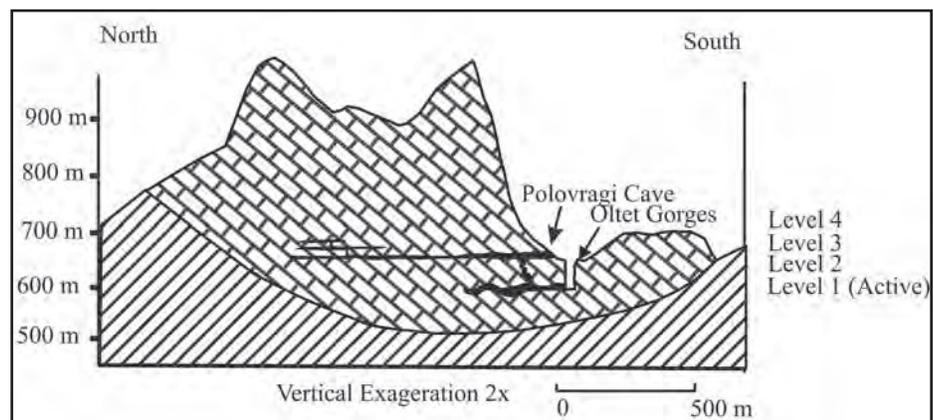


Figure 3: Stages of passages development in the Polovragi Cave.

a swallow hole (630 m elevation), generating Polovragi Cave's stream. In the upper section of the gorges a diffuse infiltration occurs through the bedrock fissures recharging the cave's stream. The next three entrances are 1.4 km downstream at the Oltet River elevation, (6 x 1 m, 4 x 1 m, 4 x 1 m, size – 605 m elevation). Through these entrances a karst spring is fed by the cave stream (one permanently and two temporally, during heavy rains or melting snow). About 25 m above, the main entrance of the cave is located (7 x 11 m size – 630 m elevation). Next to it is a smaller one, 1 x 0.4 m, both being fossil.

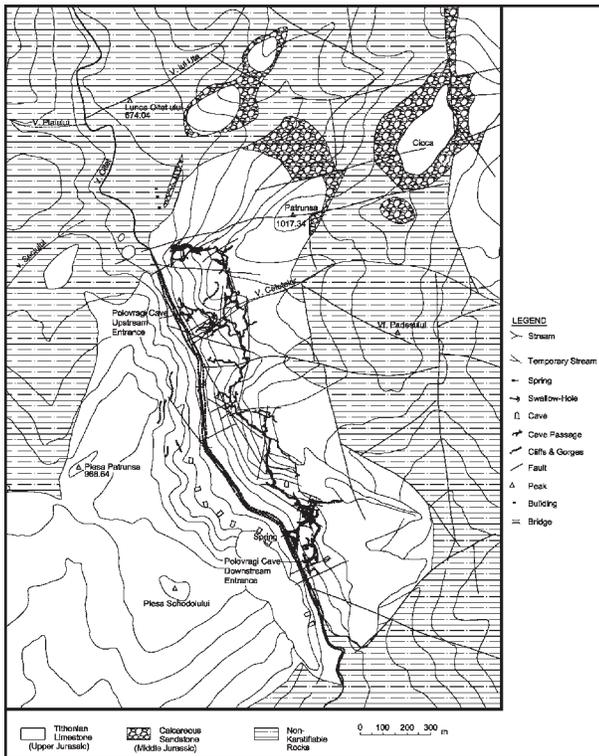


Figure 4: Geologic and Tectonic Map of Oltetului Gorges/Polovragi Cave Karst Area.

Polovragi Cave with 10,350 m of passages and 87 meters vertical development (-62 m, +25 m) has a ramification coefficient of 6.81 and an extension of 1,520 m. It is a cave with a stream water table. For description purposes, the cave was divided in three sections: The Access Section, the Upstream Section and the Downstream Section (Fig. 5).

The Access Section, with 1,224 m of passages, is between the upstream entrance and The Wonder Chamber. Generally, the passages are small, formed along east-west, northeast-southwest oriented fractures, and developed on three different levels, most of them being formed by sinking streams. The passages in the Access Section have frequent changes in direction and an average height of 1 m. This area functioned for long period of time completely submerged (under phreatic level). This hypothesis is sustained by the cave morphology (horizontal ceiling, narrow passages), negative corrosion forms (ceiling pendants), and large argillaceous deposits. In two areas were the passages narrow, a strong air flow exists, and a group of eccentric stalactites were formed. In most of this section, those three cave levels are distinct, but in some areas they come together forming one large borehole, well decorated with stalagmites up to 4 m high and 2 m in diameter (The Dome). Large deposits of argillaceous materials and the existence of numerous ceiling collapses (breakdown), complete the description of this section. Upstream of The Dome, Passages 23 and 25 make the connection with the Upstream Section of the cave. The Access Section has a meander segment, well decorated with columns and rimstones, and at the end of an ascendant passage is an underground lake.

The Upstream Section is formed mainly by Passages 27, 23, and the Wonder Passage, with a total length of 2,880 m. The fractures in this area are oriented north-south and east-west. As in the Access Section, several passages formed by sinking streams generated a main borehole, Passage

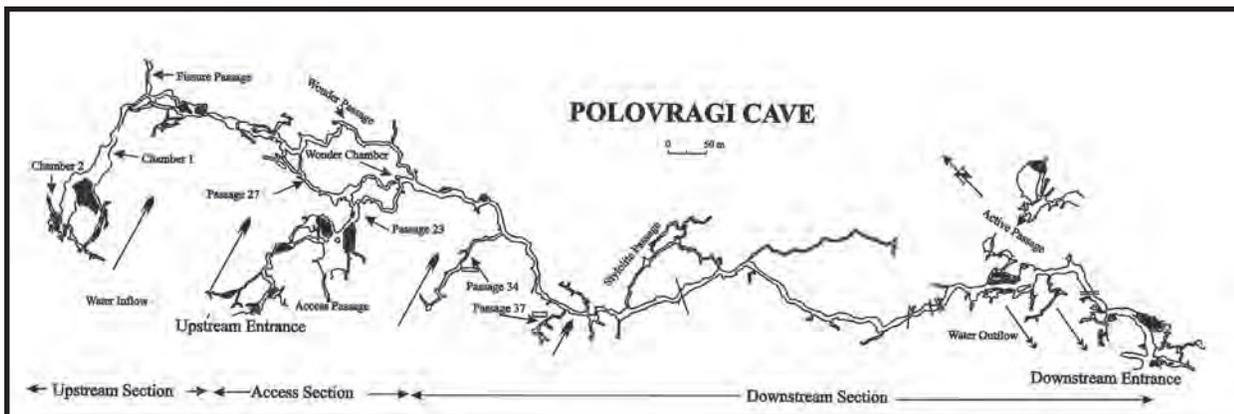


Figure 5: Polovragi Cave.

27, which has two upper level passages with chimneys recharged by sinking streams located on the side of the mountain. The passages which form the main borehole in this section originated near the limestone/noncalcareous rock interface and are developed on three levels, 13 m apart. Their morphology varies from conduit flow to well decorated sections, with calcite deposits occupying most of the passage. The place where the three levels join forms large rooms, Chamber I and Chamber II. These large rooms were developed at the intersection of the fractures systems mentioned earlier. A 15 m deep Fissure Passage was surveyed in this area. Downstream from Chamber I, Passage 27 is formed by combination of high and medium level passages. The difference in elevation between the two levels decreases downstream from 4 m to 1.5 to 2 m. The medium level continues downstream 110 m, ending in argillaceous deposits 5–10 m thick, which separate this segment from the Wonder Passage. The medium/main level passages are about 3 m height with some lower areas, and is connecting with Access Section through Passages 23, 25, and 27. The Downstream Section of the cave with 5,067 m is the longest one. The Main Passage is a result of the intersection of passages of the Access Section and Upstream Section. The main fault system which controlled the development of this area is oriented north–south, east-west, and northwest-southeast. Except the Active Passage, the entire section corresponds to the medium level of the previous two sections.

The passages mapped on the right/west side of the Main Passage were formed by partially sinking streams recharged by Oltet River, and those close to the main/downstream entrance represent hydrogeologic conduits to the main spring. Downstream of the Wonder Chamber, the main passage is oriented north - south, 3 to 4 m high, partially decorated, with sand and clay on the floor. The footprint of an old flow channel recharged by a temporary surface stream through a chimney was mapped. Beyond Passage 37, the main passage narrows to 1 x 1 m, with thick argillaceous deposits, gravel and boulders on the floor to the intersection of Stylolites Passages, which is a side meander of the main passage. Past the junction with the Stylolites Passages, the main passage becomes wider and higher (borehole type) up to the downstream entrance of the cave. In this area a narrow passage was identified which descends to the lower level of the cave (Active Passage). The waters are coming in through a sump, 12 m deep and 54 m long, followed by a second 30 m long sump, the end of it not being found yet. Between this sump and the sinking point on the Oltet River, the path of the stream is unknown. It is possible to be formed by inundated conduit, penetrable or not for the divers.

The subterranean stream cross the Active Passage, sinking in a series of five downstream sumps, the water coming out in the Oltet Gorges through three entrances (one permanently active and two temporally, during heavy rains or melting snow), with a 50–100 l/s yield, and a temperature of 7.10 C. This temperature is constant year around. The fractures oriented northeast–southwest are controlling the development of the cave in this section. As in Figure 2, the caves passages generally follows the fractures, faults and joints identified at surface by geologic mapping. The cave map identified some of those features during the survey and illustrates the important roll of the tectonics in the genesis of the cave.

4. Conclusions

Polovragi Cave is a cave with a stream water table, developed on four levels (three fossils and one active). . In a multi-level cave, the largest passages are typically those that have been active for the longest period of time (Palmer, 2007), in our case being the Medium Level.

The rock in which the Polovragi Cave is developed has a CaCO₃ content close to 90%. Based on A Bulk compositional classification of carbonate rocks (Leighton and Pendexter, 1962), the rock is included in the limestone category. As a result, the passages developed in this limestones are well decorated, the water with CO₂ being capable to dissolve the limestone and to generate flowstones.

Numerous fractures, faults, and joints, identified during geologic mapping, proved afterwards to have a significant impact in the cave development. At the intersection of tectonic planes, the main chambers were formed. The majorities of the passages were developed along or parallel to these tectonic features. The changes in direction of the passages are also controlled by tectonics.

The noncalcareous rocks/limestone boundary combined with the tectonic structure, control the location of the sinking points along the Oltet River, or on the side of the mountains. Here, temporary streams develop occasionally, sinking underground through swallow holes and generating narrow passages, which are part of the Polovragi Cave System.

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