3.1. RODNA MOUNTAINS

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They are considered one of the most representative units of the Eastern Carpathians range, in the northern group of which they are included. Their outstanding features are the massive shape and the extension (50 km in length, 25 km in width and a surface of about 1300 km^2).

Their geologic structure is dominated by a core of crystalline schists, including few epi- and meso-metamorphic series, overthrusted and extensively faulted, both in their northern (Dragoş-Vodă fault) and in their southern (Rodna fault) parts. The western and southern border areas of the crystalline mass are transgressively covered by Paleogene and Neogene formations, which include mainly sandstones, marls, conclomerates and nummulitic limestones, locally penetrated by Neogene igneous formations (dacites, andesites, rhyolites). A geo-structural frame of the massif compiled from the tectonic sketches of the geologic maps 1:50,000 (Krautner et al. 1978, 1982, 1983 and 1989) is presented as the core of the Figure 1. The surface topography is significantly marked by Quaternary glacial processes, which resulted in specific forms (glacial cirques and lakes) occurring mainly in the northern face. Three distinct morphological compartments were separated: *Ineu* (2279 m maximum elevation), *Pietrosu* (2203 m maximum elevation) and *Bătrâna* (1710 m maximum elevation), with still many other summits of more than 2000 m included in the first two compartments.

Rainfall, which is abundant in this area, increases constantly from low to high elevation, from 700 mm/year (at 331 m elevation) to 1300 mm/year (at 2000 m elevation). Along a year time span, the number of days including rainfall is almost 200 mm (according to records from 1896 to 1970). This contributed to the installation of a vigorous network of surface streams, among which worth mentioning area *Iza*, *Vişeu* and *Bistriţa* to the north and *Someşul Mare* to the south.

Limestone formations occur under two distinct facies, located both at the margins and toward the inner part of the mass of crystalline rocks. Due to their isolation, each one of the limestone bodies underwent an interdependent hydrogeological evolution (Fig. 1 A, B, and C).

a) In the north-western corner of the mountain range, Eocene sandy marls and nummulitic limestones, followed by Oligocene flysch formations (alternating shales and sandstones), were deposited above the quartz micaschists of the *Rebra* series. One hydrocarstic system was identified in this area (Fig.1 B). It includes a swallet cave (the loss of *Măgura* valley, at 1250 m elevation, with a flowrate of 10-15 l/s, Fig. 1 B, no. 4), with passages developed on a length of over 3000 m and a depth of 161 m, and the resurgence *Izvorul Albastru al Izei* (1040 m elevation, Q=30-40 l/s, Fig.1 B, no. 5), the two being separated by a straight line distance of 2000 m. The passages of the swallet cave rapidly deepen into the limestone stack, eventually following the tectonic contact Eocene/Oligocene (a major fault, only visible within the cave) and the crystalline substratum (Viehman et al., 1979). The resurgence has also been explored through successive diving actions starting with early 80's. Post spring-siphon development of the cave includes some 530 m of galleries and two other siphons to the actual end part (Tămaş 2006, personal communication). Several small caves and potholes were also identified to the zone between the entrance and the exit from the karst system.

A similar setting occurs in *Telcişor* catchment area, where the hydrokarstic system *Tăuşoare-Zalion* (Fig.1 C) includes two caves which intercept stream losses, on the valleys of *Izvorul Tăuşoarelor* (950 m elevation, Q=10-12 l/s, (Fig. 1 C, no. 6) and *Jgheabul lui Zalion* (880 m elevation, Q=3-5 l/s, Fig. 1 C, no.7) respectively. Fluoresceine tracer tests (Table 1) indicate a unique cave system known as *Tăuşoare-Zalion Complex* (Viehman et al. 1964).

The common resurgence is the spring of *Izvorul Rece* (550 m elevation, Q=30-40 l/s, Fig.1 C, no. 8), with part of its flowrate tapped for water supply. The two stream caves are quite extended: *Izvorul Tăuşoarelor* is 16.1 km long and 461 (-356, +105 m) deep, while *Jgheabul Lui Zalion* is 4.5 km long and 303 m (-299, +4) deep. Their passages closely parallel the two main regional tectonic lineaments, which strike respectively E-W (the northern and the southern faults) and N-S (the overthrust of sedimentary formations over the crystalline bed rock).

Tăuşoare cave is somehow emblematic for the speleological activity in Romania due to numerous national and international exploring expeditions organized since its discovery on the year of 1956 till present (Viehman & Şerban 1963, Viehman 1973). The mineralogical researches that were performed throughout the cave galleries since early 60's revealed the presence of rare minerals as myrabilit and epsomit (Motiu et al. 1977), gypsum anthodites (Jule 1972), or limestone balls (Fabian & Viehman, 1979).

In spite of the small volumes they occupy, the sedimentary limestones are highly fractured, especially at the contact with the crystalline schists. Specific flow directions were favoured as a consequence, as for the instance in the cave *Grota Zânelor* (1527 m elevation, Fig. 1 Tectonic sketch, no. 9). The main stream in the cave (Q=3-5 l/s) flows along a NW-SE direction, while its tributaries are striking mainly NE-SW. The resulting maze of passages develops over a deep of 112 (-98, +14) m including 25 water falls on a total length of 4.3 km, which is fifteen fold the straight line distance between the extreme points reached by the cave.

b) The crystalline limestones included in the metamorphic series are the second carbonate facies occurring in Rodna Mountains. In *Borşa-Fântâna* area (Fig. 1 A), where they are associated to the clorite and the sericite-clorate schists within one of the *Repedea* series formations, their maximum thickness reached about 600 m. The specific exokarst morphology and a certain number of potholes and small caves indicate vigorous karstification processes in the area. The most important karst phenomenon in this area is *Avenul din Podul Cailor* (over 200 m long, -106 m deep) located at 1630 m elevation (Fig. 1 A, no. 3). The associated hydrokarstic system includes two swallet areas, out of which the more remote *Ponoarele din Ştiol* (1500 m elevation, Q = 1-1.5 l/s, Fig. 1 A, no. 2) were traced by means of radioactivable tracers to the spring *Fântâna* (950 m elevation, Qmed =150 l/s, Fig. 1 A, no. 1), part of which is tapped for the water supply of *Borşa* city (20,000 inhabitants). The average tracer velocity was 25 m/h, for a straight line distance of 2930 m. Stream losses identified on *Bistriţa Aurie* headwaters can hypothetically be linked to the same hydrokarstic system. The spring of *Fântâna* is only the upper level on the aquifer hosted in the limestone body, which display a north-western dip of 20-25°.

Water wells drilled downstream to the spring also identified mineralized water and increased concentrations of CO_2 indicating the presence of an important fault cutting the limestone body.

The middle complex of the metamorphic *Rebra* series also includes relatively thick strips of crystalline limestones (20-40 m), alternating with terrigenous rocks (micaschists, quartzites) with gneiss and amphibolites interlayers which may host aquifers of greater or lesser importance. Mining works in *Pârâul Băilor - Cobăşel* area, at 700 m elevation, have been flooded when they reached such crystalline limestone strips. The yielding capacity of the aquifer indicated by pumping test is about 50 l/s of water with a relatively significant content of CO_2. Fluoresceine tracer tests indicated that for the same flow path, apparent velocities can vary between 20-30 m/h and 135 m/h, as a function of the momentary flowrate of the underground streams. Water inflows were also associated, which resulted in abandoning the mining

	Date	Quantity (gr)	Swallet	Source	Δt (hours)
1	28.08.1956	300	Tăuşoare C.	Izvorul Rece	No result
2	01.12.1957	1400	Tăuşoare C. (entrance?)	Izvorul Rece	180
3	18.07.1958	600	Jgheabul lui Zalion C. (entrance)	Izvorul Rece	85
4	13.06.1961	2000	Tăuşoare C. (end part)	Izvorul Rece	42.3

Table 1. Characteristics of fluorescein tracer tests

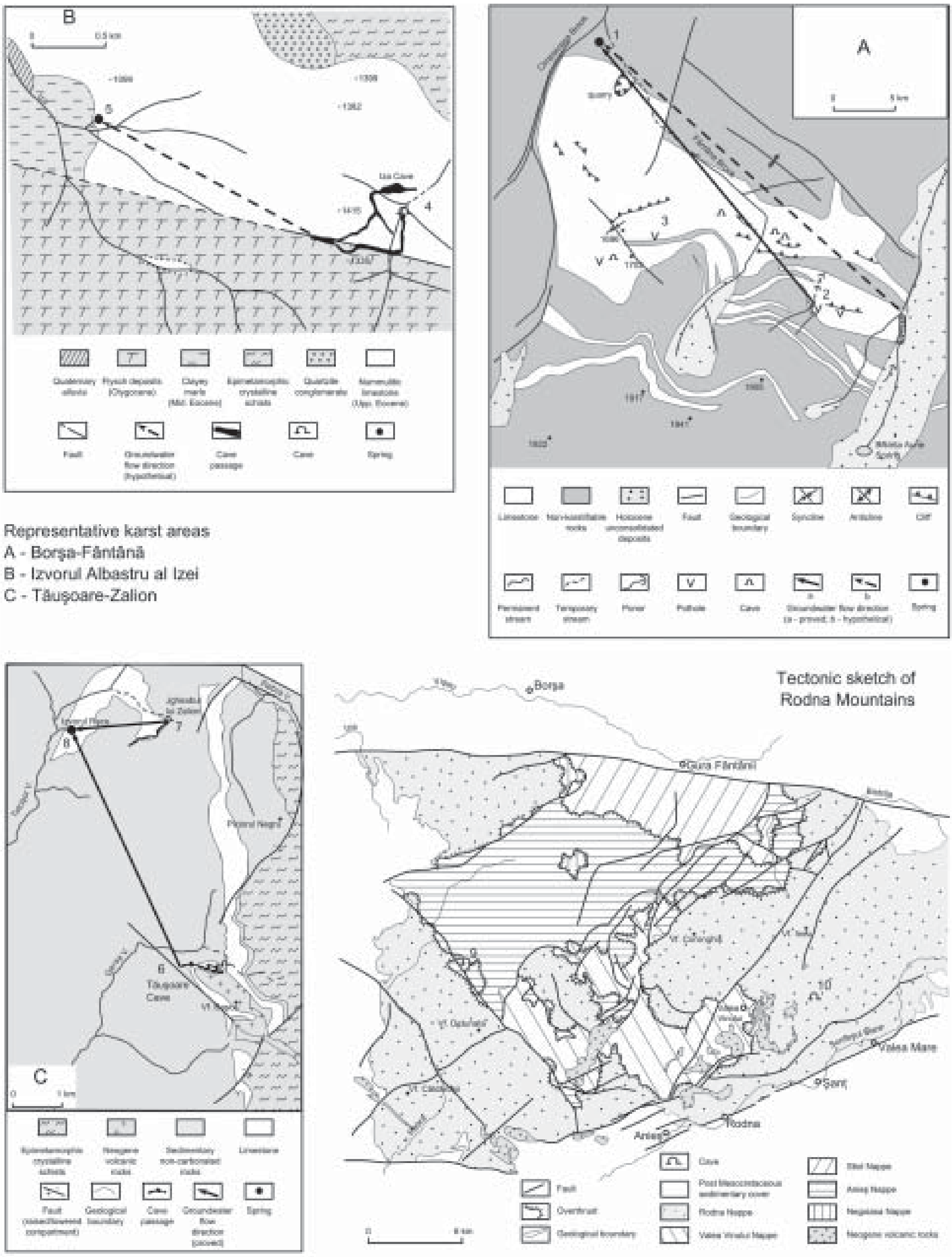

Figure 1. Tectonic sketch and representative karst areas of Rodna Mountains
A - Borșa Fântână;
B - Izvorul Albastru al Izei (redrawn from Viehman et al. 1979, with modification);
C - Tăușoare - Zalion karst system (compiled from Viehman et al. 1964 and Krautner et al. 1989).

works. The cave networks occurring to elevation of 800 m (*Cobăşel* cave, 570 m long, Fig. 1 Tectonic sketch, no. 10), 850, 940, 1040 and 1100 m (several caves 50-300 m long) include in their profound sections small streams (1-3 l/s), which also supply the aquifer intercepted at lower elevation.

The morphology of the large passages in *Cobăşel* Cave displays lithologic control (plane ceiling and gently dipping floor that follows the dip of the insoluble mineral interlayers while some other galleries and the general shape of the cave obey the tectonics of the area e.g. mainly NW-SE but also rectangular E-W and N-S fissure systems (Istvan & Miclea 1994).

A comparative study performed on fissures (microtectonique) and cave gallery orientation of the three important cave of Rodna Mountains (Silvestru & Viehman 1982) revealed high similarities of gallery orientation despite their different lithological context. Eventually the authors concluded that the tectonics of the styrique phase generated the most important fissure systems exploited by groundwater.

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