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Late Pleistocene and Holocene Climatic Variability in the Carpathian-Balkan Region

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Research on morphological caracteristics of endokarst in Rarau Massif. Premises for local palaeoclimatic records

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The occurrence of karst in Romania is associated to a variety of carbonate rocks; however, limestone and dolomite are the most relevant in terms of spatial distribution and morphological diversity, as shown by the karst landforms present in Apuseni Mts, Banat Mts, Cerna Mts, the southern area of Retezat Mts, Capatanii Mts, Valcan Mts, Mehedinti and Southern Dobrogea plateaus etc.

Our study area is located in Rarau Massif, in the northern sector of the crystalline axe of the Eastern Carpathians (fig. 1), which comprises, in terms of morphology, of a diversity of genetic categories of landforms among which petrographic landforms on limestone and dolomites stand out.

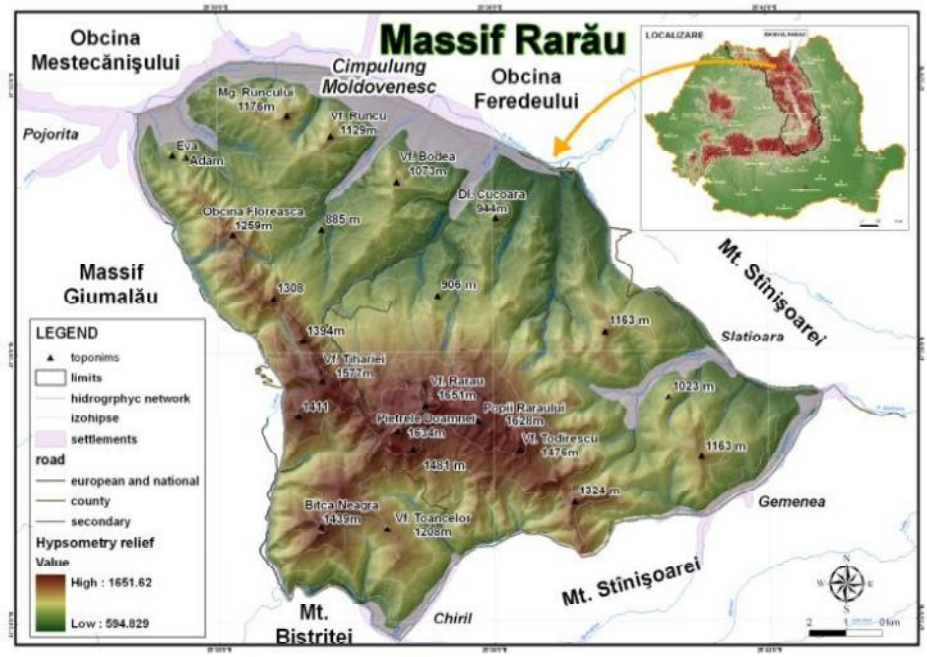

Fig. 1 Localization of study area.

This type of geology is instrumental in the formation of karst by providing favorable conditions for manifestation of carbonate-related processes. However, the endokarst forms identified and mapped thus far in this relatively little studied area are fewer and smaller-sized compared with

those encountered in the areas where classic karst occurs. Surface karst forms are better known, particularly the outlier formation Pietrele Doamnei (Lady's Stones).

Whereas the geomorphological traits of this massif were thoroughly studied by Sircu et al. (1971), Popescu Argesel (1972), Iosep (1972), Rusu (1997, 2002), the karst has only been mentioned in general studies by Bleahu (1972), Valenciuc (1964), Bojoi et al. (1975), Rusu (1997, 2002), and Done et al. (2011). Attempts have been made to map the endokarst from Rarau Massif during several field campaigns led by E. Cristea (1954), M. Bleahu, The Speleology Club Bucovina (1980, 1991, 1992, 1994 with GEISS Club Iasi) and most recently by V. Bouaru (2005, 2012) and our team (2013-2014).

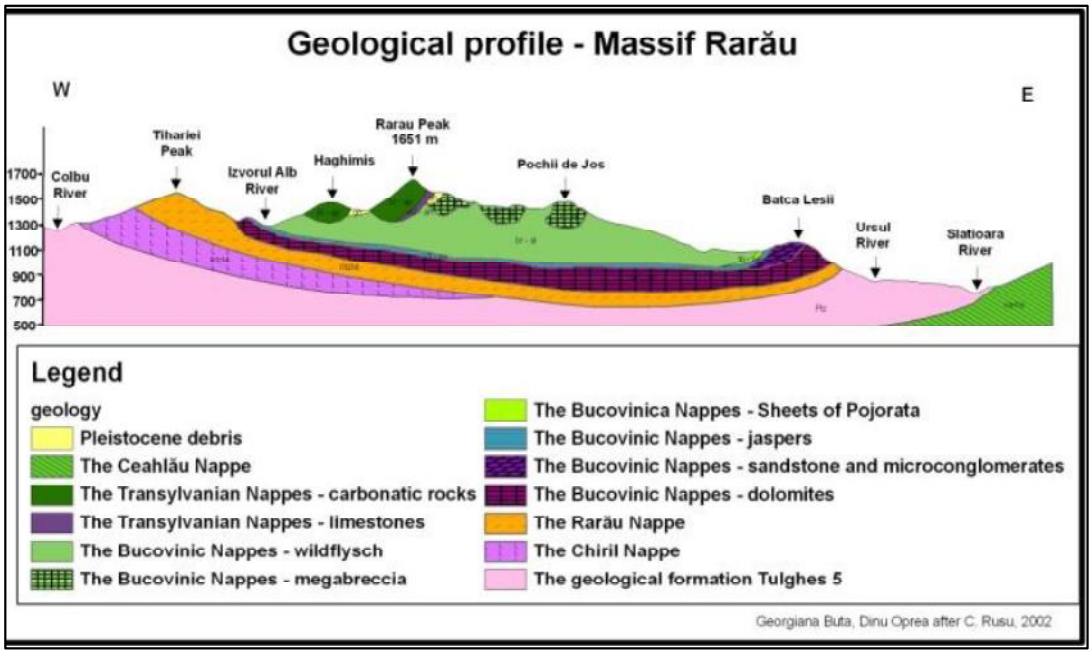

Fig. 2 Geological profile of Rarau Massif.

The traits and layout of carbonate rocks from Rarau Massif are somewhat atypical compared to established karst areas from Romania, whereby they occur as compact and thick strata, (e.g., in Apuseni Mts the thickness of limestone horizons ranges up to 600 m). Instead, in our study area, two types of geological structures were identified as relevant to karst formation:

- the Triassic deposits (Campilian - Anisian) composed of a thick nappe (50 – 150 m) of dolomites and calcareous – dolomites overlying crystalline schists, occurring on the flanks of Rarau syncline
- the Triassic and Cretaceous klippes of the Transylvanian Nappes, included in the Cretaceous deposits of Wildflysch.

The fossilization of the Campilian - Anisian calcareous-dolomitic horizon renders the formation of exokarst morphology nearly impossible. However, the position of these layers within the syncline (fig. 2) suggests that the underground drainage may favor the formation of endokarst. As yet, underground karst forms associated with this horizon have not been brought to light, but hypothetically they may exist.

Albeit klippes occupy a relatively small share of the total karstifiable area, in most instances they form outcrops which are subjected to the corrosive action exerted by rainwater or melt water (fig. 3). Moreover, periglacial conditions have also left a clear mark on the current geomorphology of the klippes.

Aside from the physical and chemical characteristics of limestone and dolomites, the intensely tectonized oliostoliths generated a network of cracks which may have fossil origins resulting either from the rock consolidation process or during their collapse and inclusion in the wildflysch. The deepening of the river network and the creation of slope drainage systems, in relation with the unresisting wildflysch geology, may have resulted in gravitational sliding of blocks, which is reflected in the formation of recent fracture lines. This cracking is dependent on the general lines of stratification, in the case of Rarău-Hăghimiş blocks, or on the klippe position in relation to the slope, as is the case with Pietrele Doamnei (Lady's Stones). The emergence and evolution of gravitational cracks and the formation of underground holes (e.g., (Pestera Liliecilor – the Bats Cave), was explained by Bleahu (1974) according to the theories introduced by Gajac (1963) and Renault (1967, 1969).

Exokarst is relatively scarce in Rarău Massif (mostly consisting of polished surfaces, clints, sinkholes, karst gorges) and has been overlooked by studies devoted to the study of karst. In terms of the typology and distribution of its carbonate rock deposits, Rarău Massif is hardly renowned for its endokarst, aside from the aforementioned Pestera Liliecilor, which is mostly known for hosting a large colony of bats rather than for the specific karst landscape.

Photo 1 Fisurii Cave (photo Dinu Oprea)

Photo 2 Cot Cave (photo Ciprian Sarban)

The structural and lithological differences between the sedimentary limestone overlying crystalline formations pertaining to the syncline and the klippes embedded in the wildflysch prompted us to differentiate between the forms of karst evolving in the two types of environments, both in terms of genesis and morphology. Albeit no caves have been reported to date in the Campanian-Anisian dolomites, we believe some caves have likely formed in these deposits, considering the thickness of the dolomite horizon, its position at the bottom of the syncline and the direction of groundwater drainage.

Calcareous klippes provide greater diversity of underground cavities. Often they correspond to cracks inside the rock mass or resulted from the chaotic arrangement of scree deposits collapsed/removed from the central rock mass. The only morphological element resulting from

karst-specific processes is montmilch, present on the cave walls, as well as small forms of corrosion. Avens occur especially on crack lines, which are rather common within klippes.

Corrosion is very limited in the caves mapped in Pietrele Doamnei area.

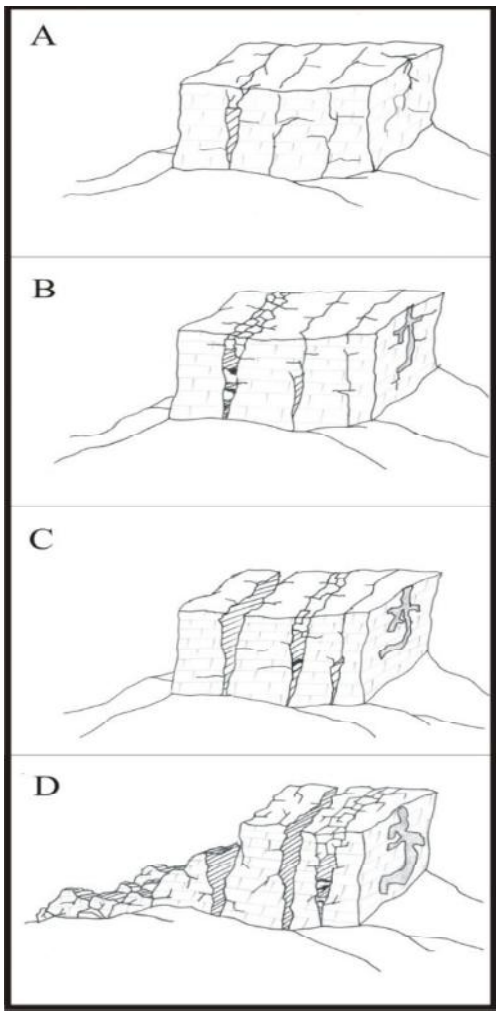

Fig. 3 The geomorphological evolution and the typology of cavities in klippes from Rarau Massif

In terms of morphology, we distinguished three types of underground cavities within the study area:

1 cavities within the chaotic masses of clusters of blocks, as is the case with most cavities mapped in the area of Pietrele Doamnei;

2 cavities / caves corresponding to lithological-tectonic-morphological fissures;

3 mixed caves formed due to tectonics and corrosion.

Whereas Rarău Plateau offers little karst diversity, in the northern slope of Rarău Peak two new caves were dicovered: Fisurii Cave (photo 1), with the longest indoor gallery of the known caves in Rarau, and Cot Cave (photo 2), the first local endokarst form that preserves clear traces of corrosion.

Photo 3 Long Glacier Cave - sediments and glace cave (photo Dinu Oprea, august 2013)

Fisurii Cave (fig. 4a) is located on the northern rock slope of Rarau Massif and was discovered recently by V. Bouaru, albeit we have reason to believe it may be the same cavity mentioned by Tudose (1974) in the northen slope of Haghimis. The cavity is linear and corresponds to a tectonic-lithologicl crack. The length of this cave is about 100 m, and has a somewhat asymmetrical V-shape. The width of the gallery ranges from 50 to 200 cm, increasing towards the upper section. There are no significant elements of endokarst morphology in this cave (with the exception of corrosion microforms on the cave walls), or karst activity, except for water leaking on the cave walls.

Cot Cave (fig. 4b) located within the same area eastward of Fisurii Cave, also discovered by V. Bouaru, formed along a system of cracks within the rock, some of which were independent from the klippe stratigraphy. Its length amounts to approx. 83 cm. This cavity is remarkable among caves occurring in Rarau Massif due to the variety of corrosion forms. The trajectory and slope of

the gallery make this cave rather unusual among caves reported in this area. Albeit water is currently present only on the walls, the morphologyof the cave indicates it was active in the past.

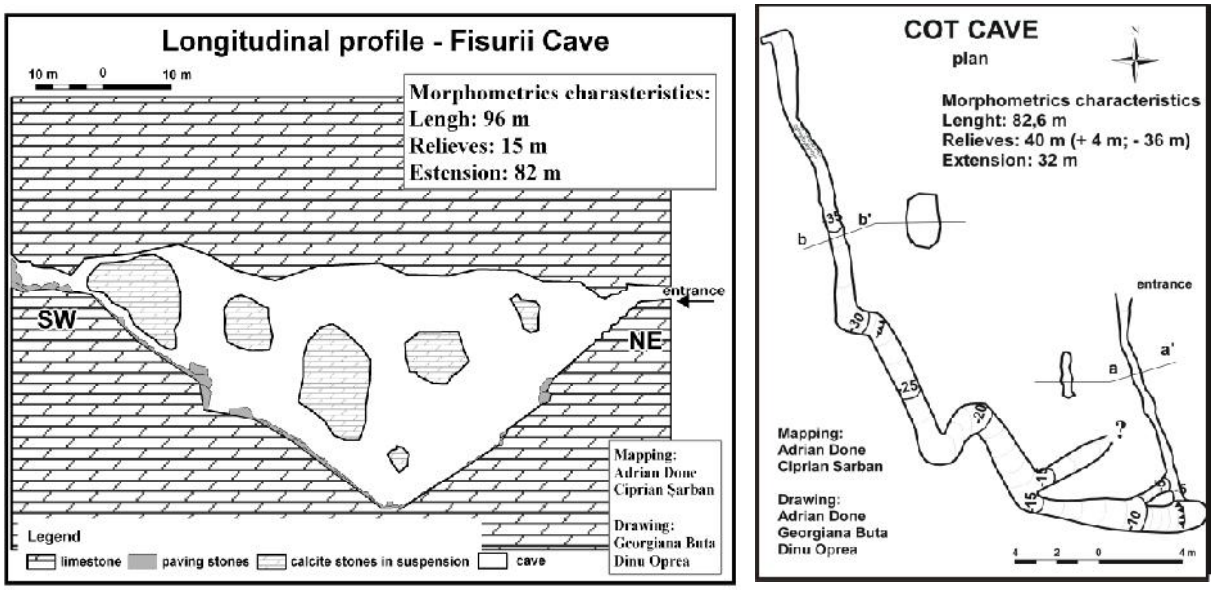

Fig. 4 a. Fisurii cave map; **b.** Cot cave map.

The formation and evolution of endokarst in Rarău Massif indicates there are likely other cavities in this area which have not been discovered to date, thereby we will continue to explore for new caves, as well as investigate the newly discovered ones.

To this purpose, we have begun monitoring climate elements - temperature and humidity - both inside the karst cavities and outside for the duration of one year, in order to establish the current cave climate conditions. The temperature is monitored with iButtons sensors, i.e. data loggers with a 4096 data entry memory for records made with a 0.0625 degrees Celsius precision. The sampling period of the sensors was set to one hour.The sensors were installed in the respective sites so as to remain dry for the entire.

Further on, the endokarstic morphology from Rarau Massif (photo 3) could provide a good opportunity for sedimentological analyses and studies on invertebrate fossils and microorganisms preserved in the cave deposits. These results could provide valuable information on the past local or regional climate pattern.

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