

HYDROGEOLOGICAL REGIONAL CLASSIFICATION OF THE ROMANIAN KARST

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ABSTRACT

Hydrogeological features of the Romanian karst are specific for each of the main geo-structural units of the country. Such differences, supported by field data, conduct the author to distinguish four hydrogeologic types of karst: Carpathian Orogen karst type, North Dobrogea karst type, platform karst type and post-tectonic Carpathians' cover karst type.

Key words: karst, hydrogeology, classification, Romania.

CLASSIFICATION HYDROGÉOLOGIQUE RÉGIONALE DU KARST ROUMAIN

RÉSUMÉ

Généralement, les ressources en eaux accumulées dans les dépôts carbonatés qui participent à la constitution des unités géo-structurales majeures du territoire de la Roumanie, révèlent des caractéristiques spécifiques différentes en ce qui concerne l'alimentation, la circulation et la décharge de l'eau.

Suivant les observations, auxquelles s'ajoutent les données du terrain on réalise une différenciation des régions karstiques de la Roumanie sur des critères hydrogéologiques, comme suit: Karst de l'Orogène Carpathique, Karst de l'Orogène de la Dobrogea du Nord, Karst de la plate-forme, Karst de la couverture post-tectonique carpathique.

Mots-clés: karst, hydrogéologie, classification, Roumanie.

Dividing the karstic areas into regions with common specific characteristics has been subject of various classification. Based upon this classification there have been established different criteria such as morphological features, tectonic structure, hydrogeological structure, geographical position, karst age and so on. One of the first classifications belongs to Cvijic (1924-1926) which is based on morphological criterion and makes out three types of karst: holokarst (complete karst), merokarst (incomplete karst) and transitional karst.

In 1975 KOMATINA suggested a karst classification based upon regional geotectonic criteria, distinguishing two extreme

types of karst: the platform karst and the geosynclinal karst region, in accordance with the two major structural categories, in which are involved the rocks of the Earth sedimentary crust. The platforms are individualised by the horizontal position of the layers (ledges) little bent and flat relief while the geosynclinal regions are individualised by strong folded structures and outstanding relief. Within the framework of the platform karst the author points out a karstic area with subhorizontal beds and folded zone karst, while, regarding the geosynclinal regions, he separates the mio-geosynclinal karst from the eu-geosynclinal karst.

In 1977 HERAK proposed the tectogenetic approach to karst terrains classification, based on the morphological and hydrogeological differences. According to him it is possible to identify the two main tectogenetic types of karst: epi-orogenic and orogenic karst.

In Romania, till now, the karst regions classifications are based upon lithological, structural and morphological criterions. BLEAHU *et al.* (1976) distinguished five types of karst: lower karst plateaus, high karst plateaus, high calcareous ridges, lower calcareous bars and isolated calcareous massives. GORAN (1993) proposed three genetic classes of karst relief: platforms, calcareous bars and isolated massifs while ORGHIDAN *et al.* (1984) differentiate: crest karst, plateau karst and calcareous bars karst.

The carbonate rocks in Romania are spread on a territory of about 5000 km². and are included in geological structures which belong to the Alpine Orogen (Carpathians and North - Dobrogea Orogens) and to the Moesian Platform (SENCU, 1978; *see also* BLEAHU & RUSU, 1965).

The Carpathians Orogen consists of the deformed units (which outcrops in the Carpathians and the Apuseni Mountains) and post - tectonic elements (foredeep, molassic depressions, post - tectonic covers and alpine subsequent magmatites) which bound the folded units (SĂNDULESCU, 1984).

The various tectonic, structural and morphological conditions in which the carbonate rocks develop are directly reflected in the recharge, circulation and discharge of the underground waters, facts that lead us to the differentiation, hydrogeologically speaking, of four types of karst (Fig. 1):

- Carpathians Orogen karst (folded units karst)
- North - Dobrogea Orogen karst
- Platform karst
- The Carpathians post - tectonic cover karst.

A. CARPATHIANS OROGEN KARST

Within the folded units of the Carpathians Orogen, the carbonate deposits are included in complicated geological structures, strongly folded and faulted, which are often drawn into large systems of overthrusts. The orogenic movements raise the mass of rocks at high elevations, creating high level differences, therefore a strong hydraulic gradient which, together with the fissures, favoured the intense karstification of the carbonate rocks.

The carbonate rocks from the Carpathians Orogen are represented by sedimentary and metamorphosed limestones and dolomites, and by calcareous sandstones and conglomerates. They outcrop over the Carpathians deformed units area, but they generally cover small and very dispersed territories. Larger areas, covered by these rocks are situated especially in the Western half of the Southern Carpathians and in the Apuseni Mountains.

Superficial water courses from the karstic areas of the Carpathians orogen often present temporary character, inflow of water in riverbed and downstream flow are frequently simultaneous, underlining the complex character regarding the relations between the superficial and the underground flow.

The karstic aquifer systems present various stages of development, beginning with an incipient one of the underground organisation flow, up to a unique drain of the system. Mean velocity of the underground waters is relatively high, the labellings with tracers providing values of 45 m/hour in Bihor Mountains (42 labellings), 46 m/hour in Padurea Craiului Mountains (78 labellings) and 53 m/hour in Vascau Plateau (8 labellings). The residence time of the underground waters is relatively short, and the flow sources and the physico-chemical parameters of the waters present a great variation in time, as well as for a high flood as for a hydrogeological cycle.

The various morphological features of the karstic zones from the Carpathians Orogen (mountain relief, of a high or lower

plateau, of ridge of calcareous bar) impact in their turn the karstic aquifers, a certain variability of the hydrodynamic and physico-chemical parameters as those named above.

The biggest karstic springs in Romania have average flows of 1 - 2 m³/sec, and their appearance is tied up to the presence of a homogeneous mass of limestones with a large extension, as well as to the non karstic areas, with a great extensions, within the binary karstic aquifer systems.

The Barsa spring from the Mehedinti plateau and sources from Cheile de Jos of Dâmbovița River belong to the first category, while the Izvarna spring from Vâlcan Mountains and „Izbucul Cernei“ from homonymous mountains belong to the second one. The „Izbucul Cernei“ is the biggest medium flow source, in Romania (2 m³/s), with its ecart of variation between 0.5 and 10 m³/s and a hydrogeological basin surface of 85 km².

In Apuseni Mountains, although the limestones and dolomites are developing over large areas, the intense „tectonisation“ has led to mosaic forming structures, with carbonate and non-carbonate outcrop rocks. This structural frame did not support the development of the wide karstic aquifer systems, so that there are no big sources, in exchange there are numerous sources with discharge between 300 - 600 l/s.

B. THE NORTH DOBROGEA OROGEN KARST

This type of karst is characterized by the same geological structure, very complicated as the previous type, but here it is cut off by a flat relief, with a low table land aspect. The carbonate rocks are represented by the triassic dolomitic limestones and they outcrop in the northeastern part of Northern Dobrogea (Tulcea zone), looking as isolated small size massifs but having a quite important development in depth. The small hydraulic gradient of the aquiferous accumulations, as well as the dry pluviometric regime of the area (400 - 500 mm/year), determine reduced discharges of the springs, under 10 l/sec. The main direction of the underground waters drainage

is towards Razelm Lake (ESE), a zone where the hydrokarstic structures lapse in an axial way (PASCU, 1983).

C. THE PLATFORM KARST

The Moesic Platform, developed in southern and southeastern part of Romania, has in its geological constitution a thick package, up to 1500 m carbonate rocks, Malm - Barremian aged. These rocks outcrop within limited areas in the South of the Romanian Plain, (along the Danube banks, at Giurgiu), but cover extensive areas in the Southern part, in Bulgaria. The carbonate complex is getting slowly deeper and deeper in the Northern part under the recently deposits, approaching depths of 2000 m towards North Bucharest, zone where the aquifer is thermalised. East Malm - Barremian limestones are raising up again for to show up along the Danube banks, at Hârșova and South Dobrogea. Within this region, they are partially covered by a succession of cretaceous-neogene aged deposits, from which the sarmatian limestones thickness outstands. The carbonate deposits in South Dobrogea outcrop only over the main valleys and over Black Sea cliff, being covered almost everywhere, by a thick stratum of loess.

In South Dobrogea, the geological, structural and morphological conditions have favoured the development of karstic aquifer platform type, characterized by a quasi-horizontal position of the limestone layers, by the great thickness of carbonate succession and by the lack of a folded tectonic style and by a strong affecting of the limestone mass with vertical faults, which separate them in numerous blocks. The South Dobrogea flat relief has imposed to the Malm - Barremian and Sarmatian aquifers small hydraulic gradients which provided a slow underground waters flow, with the an average speed of 2.6 - 5.4 m/year for the first aquifer and of 0.8 m/year for the second one (DAVIDESCU *et al.*, 1991).

The superficial flow is limited to a few slow water courses having frequently a temporary character. The low precipitation

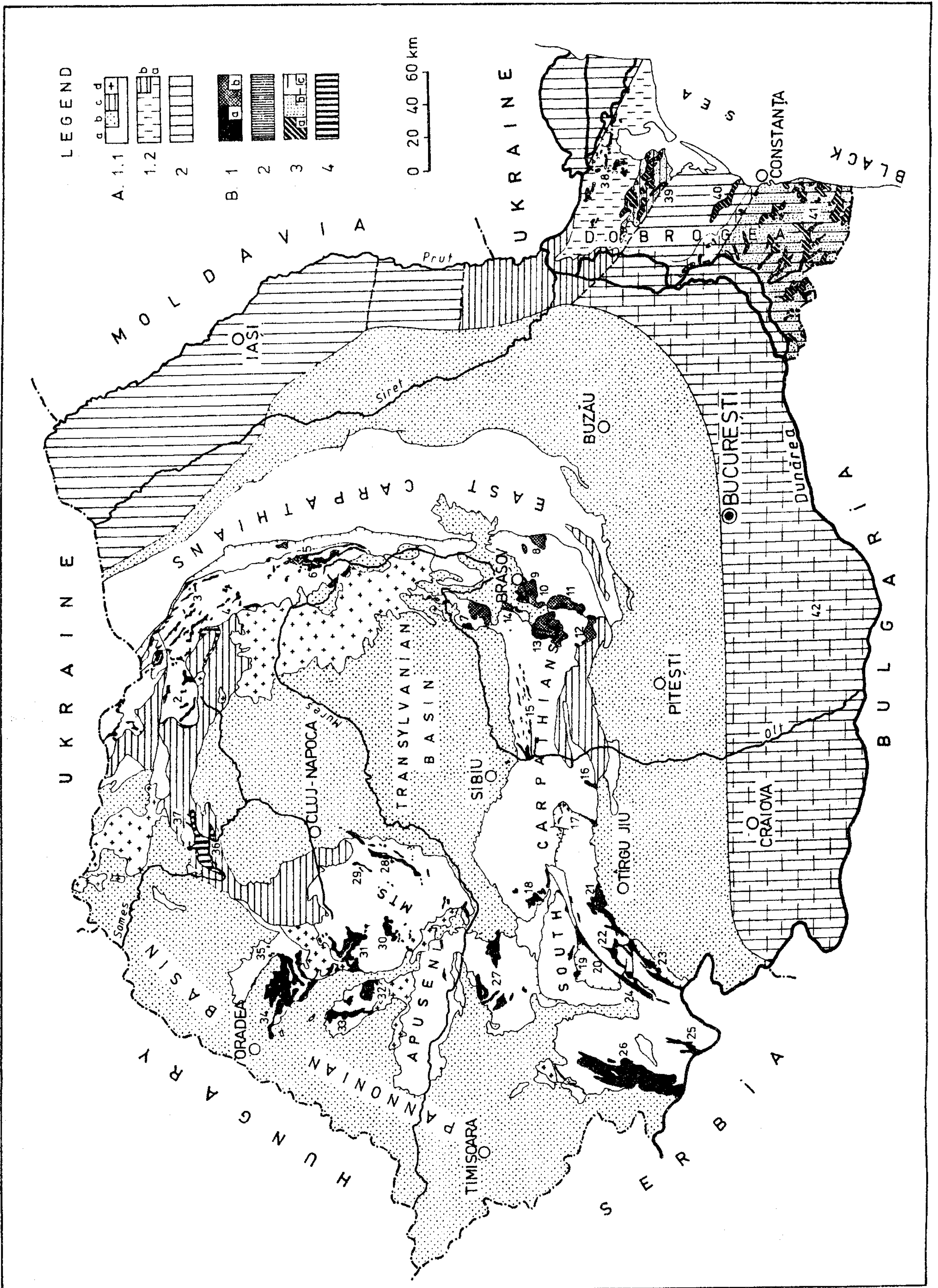




Fig. 1
Distribution of the hydrogeological karst types in Romania (structural map after SÂNDULESCU, 1984).
A. Geotectonic major units: 1.1. Carpathians Orogen: a-Orogenic formations; b-Foredeep and molassic depressions; c-Post-tectonic covers; d-Subsequent alpine magmatites; 1.2. North-Dobrogea Orogen: a-Orogenic formations; b-Post-tectonic covers; 2-Platforms.
B. Hydrogeological karst types: 1-Carpathians Orogen types: a-Limestones and dolomites; b-Calcareous sandstones and conglomerates; 2-North-Dobrogea Orogen type; 3-Platforme type: a-Limestones in outcrops; b-Limestones covered by loesses; c-Limestones covered by Pre-Quaternary deposits; 4-Carpathians post-tectonic covers type.
Distribution des types hydrogéologiques du karst de la Roumanie (carte structurale d'après SÂNDULESCU, 1984).
A. Unités géotectoniques majeures: 1.1. Orogène Carpathique: a-Formations orogéniques; b-Dépressions de molasse et d'avant-fosse; c-Couverture post-tectonique; d-Magmatites subséquentes; 1.2. Orogène de la Dobrogea du Nord: a-Formations orogéniques; b-Couverture post-tectonique; c-Plate-forme.
B. Types hydrogéologiques de karst: 1 - Orogène Carpathique: a-Calcaires et dolomies; b - Grès et conglomérats calcaires; 2 - Orogène de la Dobrogea du Nord; 3 - Plate-forme: a - Calcaires en affleurements; b-Calcaires couverts par loess; c - Calcaires couverts par dépôts pré-quaternaire; 4 - Couverture post-tectonique carpathique.
Denomination of morfologic units numbered on the map:
Noms des unités morphologiques numérotés sur la carte:
 1-Maramureş Mts., 2-Rodna Mts., 3-Rarău Mts., 4-Giurgeu Mts., 5-Ceahlău Mts., 6-Hăghimaş Mts., 7-Perşani Mts., 8-Ciucaş Mts., 9-Piatra Mare Mts., 10-Postăvaru Mts., 11-Bucegi Mts., 12-Leaota Mts., 13-Piatra Craiului Mts., 14-Codlea area., 15-Făgăraş Mts., 16-Buila-Vânturariţa Mts., 17-Lotru and Căpătâni Mts., 18-Sebeş Mts., 19-Retezat Mts., 20-Cerna-Jiu passage, 21-Vâlcan Mts., 22-Mehedinţi Mts., 23-Mehedinţi Plateau, 24-Cernei Mts., 25-Almăj Mts., 26-Banat Mts., 27-Poiana Ruscă Mts., 28-Trascău Mts., 29-Gilău Mts., 30-Poeni Plateau (Metaliferi Mts.), 31-Bihor Mts., 32-Vascău Plateau (Moma Mts.), 33-Codru Mts., 34-Pădurea Craiului Mts., 35-Rez Mts., 36-Someşan Plateau, 37-Preluca Mts., 38-Tulcei Mts., 39-Babadag basin, 40-Casimcea area, 41-South-Dobrogea, 42-Moesian Platform.

(4-500 mm/year) because of the high evapotranspiration participates, in a limited manner to the aquifer feeding.

The Malm - Barremian and Sarmatian aquifers from Moesian Platform are the most extensive carbonate aquifer in Romania. Within the Romanian Plain, these aquifers cover a wide area; it is little inspected and exploited. In South Dobrogea the karstic aquifers cover a territory of about 5000 km². Generally they are of free level, being studied in detail and intensively exploited, representing the unique feeding source with zone drinkable water.

The Babadag basin represents the post-tectonic cover of the North Dobrogea Orogen, which according to its evolution and geological constitution (installed area upon a stabilised basement, with big thicknesses and tabular structure) forms a platform type cover, with the same type of karst. The basin

is represented by a „sinclorium“, with an area of about 700 km², NNW - SSE oriented, with an east axial sinking, under the Razelm Lake and Black Sea. The filling of basin is mainly made up of upper cretaceous limestones and sandy limestones, their thickness reaching 1000 m. The aquifer accumulations localised in these deposits, present a small hydraulic gradient. That's the reason why they induce a slow, movement to the East, where they get probably, unloaded by submersible sources.

D. THE CARPATHIANS POST-TECTONIC COVERS KARST

The post tectonic covers through Carpathians Orogen, have been deposited in sedimentary basins with a labile basement (with intermittent subsidence) and have been formed by deposit alternations with various

lithological constitutions, where the carbonate rocks are frequent. The structure of these deposits is generally speaking, low inclined and the tectonic accidents have limited amplexness, when these accidents appear. The carbonate succession of these alternations often reach thickness of tens meters and contain, in general, aquifer accumulations with local importance, mainly fed on the outcrop zone.

Such a situation can be met in the northwestern side of Transilvanian Basin where within the succession of the eocene deposits, two calcareous horizons outstand, their thickness of 20 and 30 - 50 m being separated by marls and gyps alternation with a thickness of 40 - 70 m. The Someșeni Plateau from this area is individualized by an evolved exo- and endokarst.

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