

15 ROMANIA: MONEASA AREA

15.1 Overview

In-depth studies of the karst hydrogeology in the Codru Moma mountains were carried out by I. Oraseanu. Since these studies best illustrate the study area, we will give extensive quotes from them.

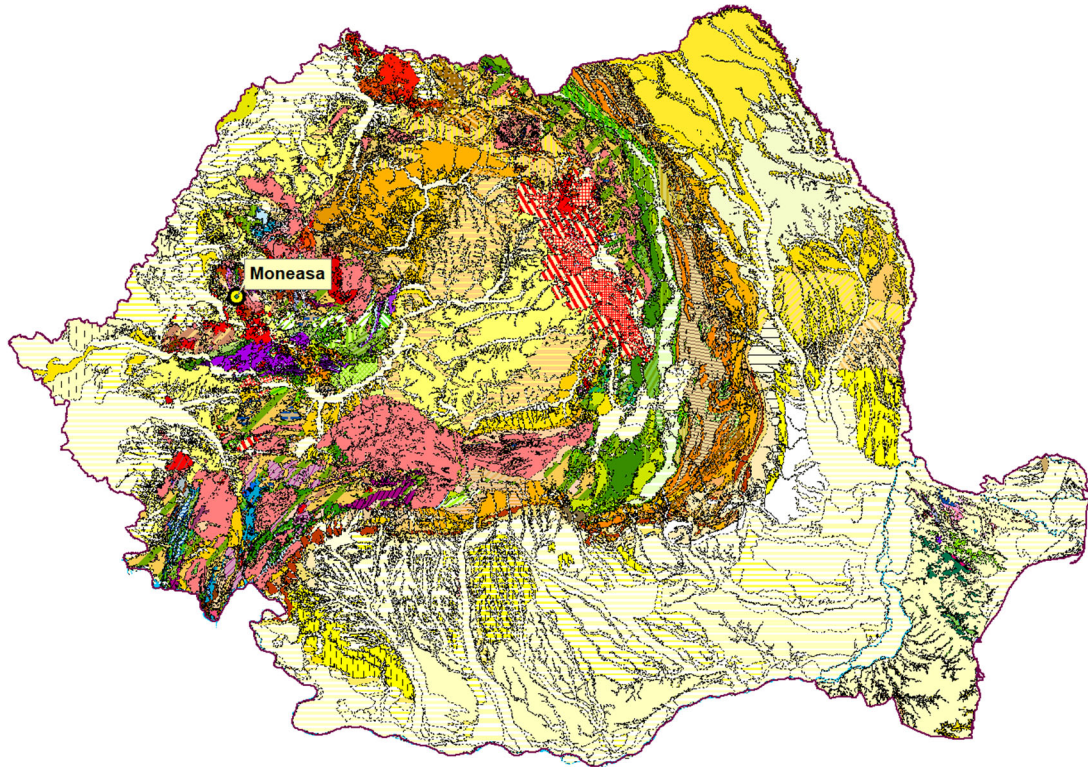


Figure 59: Location of the test - site

The test site is in the Moneasa resort region, situated in the Apuseni Mountains in the western-central part of the Codru-Moma massif, and has morphological variety due to a complex geological structure. Moneasa resort is well known for its thermal waters (24 to 32.8°C), which are exploited through four springs and three wells. Despite the low altitude, Moneasa resort is located in a submontane landscape, with the narrow valley of the Moneasa river surrounded by higher ground reaching over 700 m in elevation. The slope gradients exceed 15 degrees over much of the area (51.5% of the total surface area). Near the resort, these are covered by hardwood forests where *Fagus silvatica* is the predominant species (forests represent 85% of the township territory). The natural therapeutic factors include the moderate temperate continental climate, the sedative-indifferent bioclimate with stimulating-tonic trends, and the mesothermal oligomineral waters.²

The Codru-Moma Mountains extend over an area of about 1200 km², located in the western part of the Apuseni Mountains, and take the form of a NW-SE striking nappe system, bounded laterally by two Neogene basins: that of Crișu Negru (Beiuș) to the NE, and that of Crișu Alb (Zarand) to the SW. They consist of two zones which are quite distinct in terms of topography: the Codru Mountains to the north, and the Moma Mountains to the south. These are separated by the Moneasa valley and by its tributary Boroaia in the western half, and by the Lugii valley and the

Briheni brook further to the east. Carbonate terrains of the Codru-Moma Mountains occupy an area of 169 km², distributed as follows:

- Dumbrăvița de Codru-Moneasa-Dezna area (66 km²);
- Clăptescu area (13 km²);
- Vașcău plateau (90 km²).

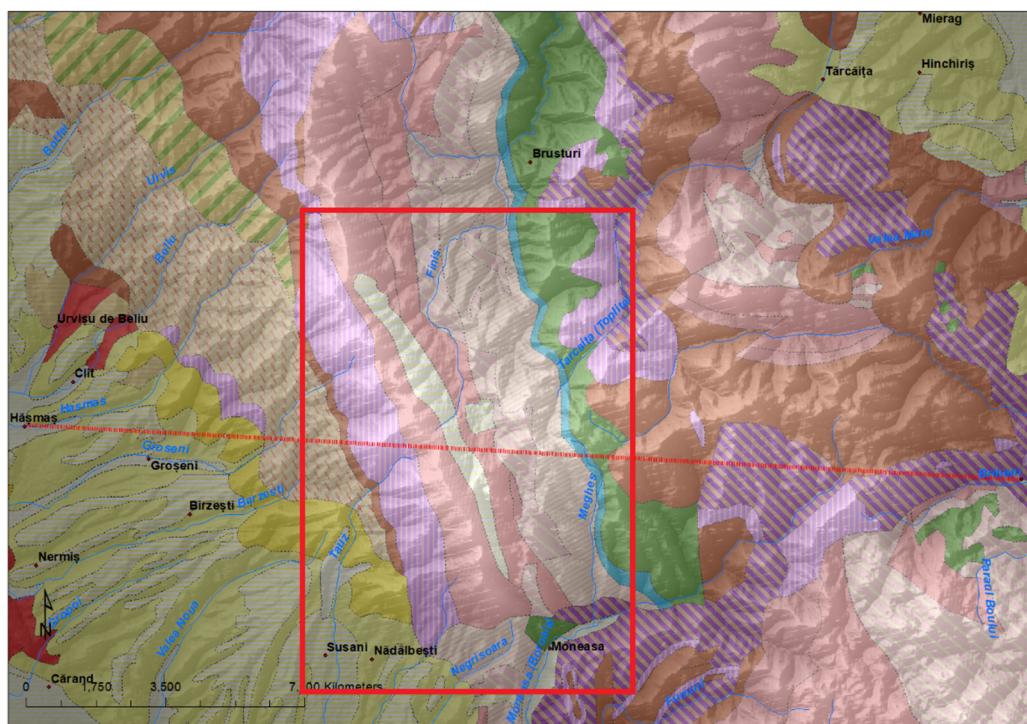
The study area is the Dumbrăvița de Codru-Moneasa-Dezna karst system, the area focusing on the Grota Urșilor - Băilor Brook and the Moneasa Brook.

15.2 Geology

The Codru domain, with formations incorporated in the Codru nappes, include a crystalline basement. This is overlain by sedimentary deposits consisting of thick Permian-Werfenian molasse deposits, overlain by predominantly carbonate facies deposited up to the Early Jurassic period. A subsequent sea retreat episode lasted during the Middle Jurassic, before the Codru domain was again covered by sea during the Tithonic-Neocomian time interval.

Between the Crișu Negru stream to the north and the Moneasa spa to the south, carbonate deposits form a continuous strip, incorporated in the generally homoclinal, eastward dipping geological structure of the central part of the Codru Mountains. This main strip, consists of Triassic limestones and dolomites with average outcrop widths of 2-3 km. To the east there is a second, discontinuous, limestone strip with average outcrop widths of only 50-100 m, which consists of Early Jurassic limestone.² The two carbonate strips are separated from one another by thick deposits consisting mainly of Norian and Rhetian shales and sandstones, which are virtually impermeable and thus isolate the groundwater located in each of the two carbonate strips. The main carbonate strip is underlain by Werfenian quartz sandstones, while the secondary limestone strip is overlain by flysch type deposits of Tithonic-Neocomian age. The lower half of the eastern slope of the ridge and the streambed of Ursului brook are covered by quartz sandstone scree and boulders deposits, which frequently cover the Early Triassic deposits. In the Codru-Moma Mountains, outcrops consist of sedimentary deposits which belong to the Finiș, Moma, Vașcău and Colești nappes.

From a geological point of view, the Moneasa area is situated in the area where the Moma Nappe thrust is over the Finiș Nappe. The Finiș Nappe formations make up a homocline that faces approximately North-South, and contains the Permian Rhyolitic Formation and the Werfenian quartzitic sandstones. They comprise thick predominantly limy facies including black dolomites (Anisian), black limestones with cherts - the Roșia Formation (Ladinian), white dolomites and violet breccious limestones (Carnian), marly, argillaceous shales and silty marls interbedded with rare decimetric black limestones and quartzitic sandstones - Codru Formation (Norian), argillaceous or silty shales with rare decimetric interbeds of dolomites, limestones and quartzitic sandstones - the Carpathian Keuper (Rhaetian), massive nodular and breccious red limestones - "Moneasa marble" (Lower Jurassic) followed by a flysch-like formation consisting of interbeds of marls, shales and sandstones (Tithonic and Neocomian).²



Legend

GEOLOGICAL DEPOSITS

Quaternary

- qh2 Gravels and sands belonging meadow
- qh1 Gravels and sands belonging to the lower terrace
- qp3 Gravels and sands belonging to the lower terrace
- qp3/3 Reddish clay
- qp2/3 Gravel and sands belonging to the lower terrace
- qp1/3 Gavels deluvial - proluvial
- qp1 Gravels
- qp Gravels, sands

Neogene

- pn Marl clays, sands, gravels
- vh+bs1 Sandstones, limestones, marls
- to Marls, cinerite

Paleogene

- Pg1+y Reddish clays
- if Marls, carbonaceous schists, limestones
- rp Clays, sands, sandstones, bituminous marl-limestones
- it Marne, g/psum, clay (layers with Nummulites perforatus)
- pr Sandstone flysch

Cretaceous

- ma Coarse sandstones, micro conglomerates, conglomerate
- al+vr Curbiticortical sandstones, marls, massive sandstones
- st+cp Conglomerates, sandstones, limestones with rudists, marls with inoceramid species (Gosau facies)
- sn Breccias, conglomerates, sandstones, blackish shales
- br+ap Marly, calcareous sandstone, marly shale
- br Massive white limestone
- ne Bauxite, limestone marls, sandstones, marly shales

Jurassic

- J3 White and gray massive limestones
- J2 Limestones, micaceous sandstones, marly shales
- J1 Gray marls

Triassic

- ws Quartz conglomerates and sandstones, purplish shales
- rh Black fossil limestone, motley shales, argillite, sandstones
- T3 no-Massive white and pink limestones; on-White dolomites
- T2 Limestones, dolomites, marly shales
- ld Black limestone, shales, massive white and pink limestones
- wc+an Black dolomites, black limestones, dolomites, dolomites and sandstone slabs
- T1 Black limestones, dolomites, dolomites and sandstone slabs; quartz conglomerates and sandstones, purplish shales

Proterozoic

- P Marly shales, black phyllites; Conglomerates, tuff sandstones; tuff sandstones, conglomerates tuffaceous, tuffs p Rhyolite (quartz porphyry); Micaceous sandstones with hieroglyphs; Laminated conglomerates, laminated sandstones, purplish phyllites

C1

Pz

Pts - Pz

- Arieseni series: green phyllites, sandstones, conglomerate, amphibolous schists
- Paluseni Series: metaconglomerate, phyllites
- 1. Codru Granitoides: granitoides, migmatites, amphibolites; 2. Arada series: quartz, sericite, chlorite-sericite schists, graphitic quartzite, porphyroids; paramphibolites; green tuffogenic rocks; 3. Muncel Series: sericite-chlorite schist with biotite; porphyroids; crystalline limestones, gneiss granites; Biharia Series: chlorite schist with albite + epidote, crystalline limestones; crystalline dolomites; amphibolites with albite and epidote;

Migmatites Ng-Q

q

Ng-vs

arr

η

α, tosm

δ

yPg1

yδPg1

Migmatites Pg

αPg1

yδm(Pg1)

yδm

αPg1

δ

ρ

δPg1

ρPg1

Migmatites Mz-Pg

ρ(sn-Pg1)

Migmatites Mz-Pz

P

γ

ρP

Migmatites Pz

γ

Migmatites Precambrian - Pz

yfg

Metamorphic rocks

Msy

Ma

Mtr

Mv

a

c

lt

Arieseni series: green phyllites, sandstones, conglomerate, amphibolous schists

Paluseni Series: metaconglomerate, phyllites

1. Codru Granitoides: granitoides, migmatites, amphibolites; 2. Arada series: quartz, sericite, chlorite-sericite schists, graphitic quartzite, porphyroids; paramphibolites; green tuffogenic rocks; 3. Muncel Series: sericite-chlorite schist with biotite; porphyroids; crystalline limestones, gneiss granites; Biharia Series: chlorite schist with albite + epidote, crystalline limestones; crystalline dolomites; amphibolites with albite and epidote;

Migmatites Ng-Q

q

Formation volcanogenic-sedimentary, pyroclastic breccias, conglomerates, pyroclastic micro-breccias, tuffs alternating with microconglomerates and conglomerates, microconglomerates, sandstones and andesitic nature sands (pn)

Andesite with piroxene

Dacite

Andesite (pn, to-sm)

Diorite

Granodiorite (Pg1)

Granodiorite (Pg1)

Migmatites Pg

αPg1

Andesite (Pg1)

Porphyry granodiorite (Pg1)

Granodiorite porphyre (Pg1)

Dacite (Pg1)

Granodiorite

Rhyolite

Diorite (Pg1)

Rhyolite (Pg1)

Migmatites Mz-Pg

ρ(sn-Pg1)

Rhyolite

Migmatites Mz-Pz

P

Granite

Rhyolite

Migmatites Pz

γ

Granite

Migmatites Precambrian - Pz

yfg

Gneiss granites (Pz2)

Metamorphic rocks

Msy

Metasomatic granitoides

Ma

Mica schists and paragneiss

Mtr

Porphyroids

Mv

Phyllite, chlorite-sericite schists

a

Amphibolites

c

Meta basalts, meta dolerites, meta gabbros, amphibolous schists

lt

Crystalline limestones

Green tuffogenic rocks

Figure 60: Geological Map; Source: Geological Map of Romania, scale 1:200.000, author Geological Institute of Romania.

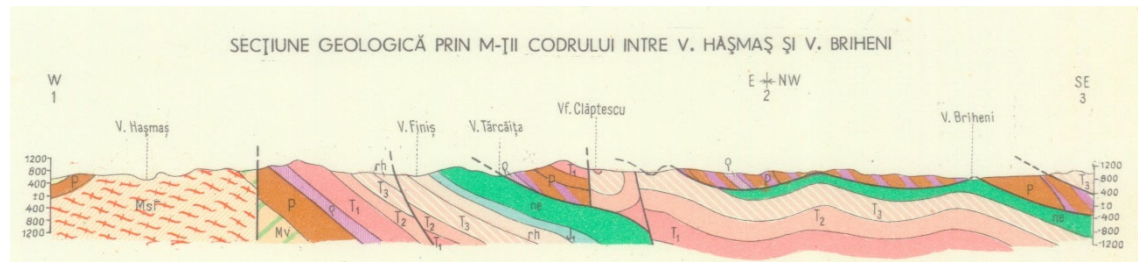


Figure 61: Cross section of Codru Moma Mountains; Source: Geological Map of Romania, scale 1:200.000, Brad, author Geological Institute of Romania.

15.3 Geomorphology

The topography of the Codru Mountains closely mirrors their geological structure and make-up. This includes three main mountain ridges, which strike roughly north-south and incorporate hard rocks of Permian age. Those ridges bound two depressions, which are formed of less competent rock formations and are occupied by the upper reaches of the longest rivers in those mountains, Finiș and Tărcăița. Water in the southern part of the Codru Mountains is collected by the Moneasa brook, a tributary of the Dezna stream, which is in turn a tributary of Crișu Alb river. The valley of Moneasa brook is tectonically controlled, closely following the strike of the overthrust plane of the Moma Nappe over the Finiș Nappe. In the karst area the stream tributaries, that are excavated mainly in carbonate formations (Scărița, Megheș, Băilor, Pietros), only come only from the right side. Băilor brook is mainly supplied by water discharged through Grota Ursului outlet cave. The underground cavities in the Moneasa area consist of several caves and potholes, including: Peștera cu Apă de la Moară cave (2012 m), Grota Ursului cave (250 m), and the pothole in Teia valley (1337.5 m long, and -90 m deep).²

15.4 Climate

The climate of the Moneasa area is continental, with moderate mountains, and some Mediterranean influence. The mean annual air temperature is 7.9°C. There is a moderate air humidity, with a mean value of 77% which varies by ~10% between the cold and warm season. The annual average cloud cover is 6 tenths and the effective sunshine duration is 2035 h/year. The average annual precipitation is 788 mm, with a hydrological deficit in May and July-September. In Moneasa the exposure to the west and the nature of the valleys where the resort is located result in a milder deficit. The snow layer can develop from October until April, with the greatest thickness in February (16.4 cm), and 98 mm water is contributed from melted snow during the whole year. The average wind speed in the area is 4 m/s, with winds predominantly from the ESE. General climate data for the study area were obtained from the CARPATCLIM database, with a spatial resolution of $0.1 \times 0.1^\circ$ grid (WGS 1984 reference system). These are spatially interpolated data from a regional weather station network for the 1961–2010 time interval.

15.5 Hydrogeology

The study area is the Grota Ursului karst system. The description is found in Orăseanu (2010): “Considered in global terms, the karst area which extends between Brătcoia, Tinoasa, Izoi and Moneasa, together with its catchment area that extends further to the west up to Izoi ridge, makes up a single karst system, part of which displays a thermal character in its southernmost end, and

whose underground water flow is directed from north to the south, discharging mainly through Grota Ursului spring and the thermal outlets" (Figure 62).

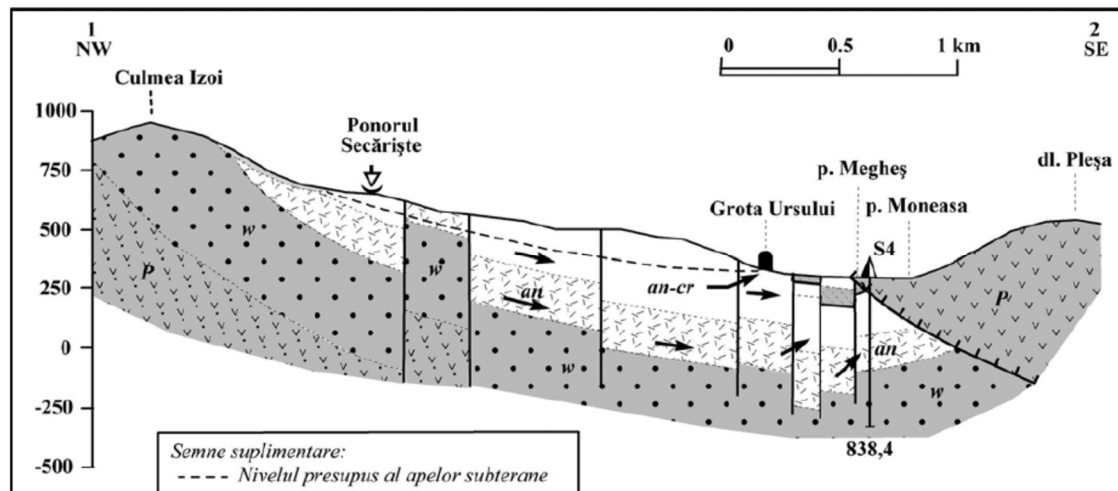


Figure 62: Cross section between Izoi peak and the confluence between Megheș and Moneasa brooks. Source: Orașeanu I., 2010.

The thermal waters from Moneasa, both those from the natural springs as well as those encountered through drilling, are karstic in nature, arising from the carbonate deposits of the Finiș homocline, near the contact with the impermeable deposits of the Moma Thrust. The springs on p. Băilor emanate from the carbonate deposits, on a 180 m long alignment, located upstream of where the brook reaches the Permian deposits. From a geothermal point of view, the whole area of the Băilor brook is an anomalous area with the maximum near spring 4, (A. Apostol et. al., 1975). The water which cannot be carried within this system, as a consequence of the limited transfer capacity of the karst channels and fractures, flows toward the east, through overflow springs in the Megheș brook catchment area (Figure 63). Connections between the water sinking into the swallets in the Brătcoia and Izoi-Tinoasa karst depressions, and the cold and thermal outlets situated along Băilor and Megheș brooks, have been delineated by tracer tests. Băilor brook originates from Grota Ursului cave and it receives a further significant inflow of thermal water, downstream from this outlet.

The chemistry of the cold and thermal karst waters in the Moneasa-Tinoasa area is calcium-magnesium bicarbonate with low mineralization (200-400 mg / l). Cold waters are more mineralized than warm waters. At the springs on the Băilor brook, there is an increase in the water temperature and a decrease in its mineralization as it approaches the overhang plan of the Moma Thrust. Over time, the chemical composition of the spring water undergoes large fluctuations, the most important variations being recorded in the ionic species Na +, K +, Cl- and SO4 -. These variations are natural and emphasize the presence of cold karst waters at the origin of the thermal waters from Moneasa.⁶

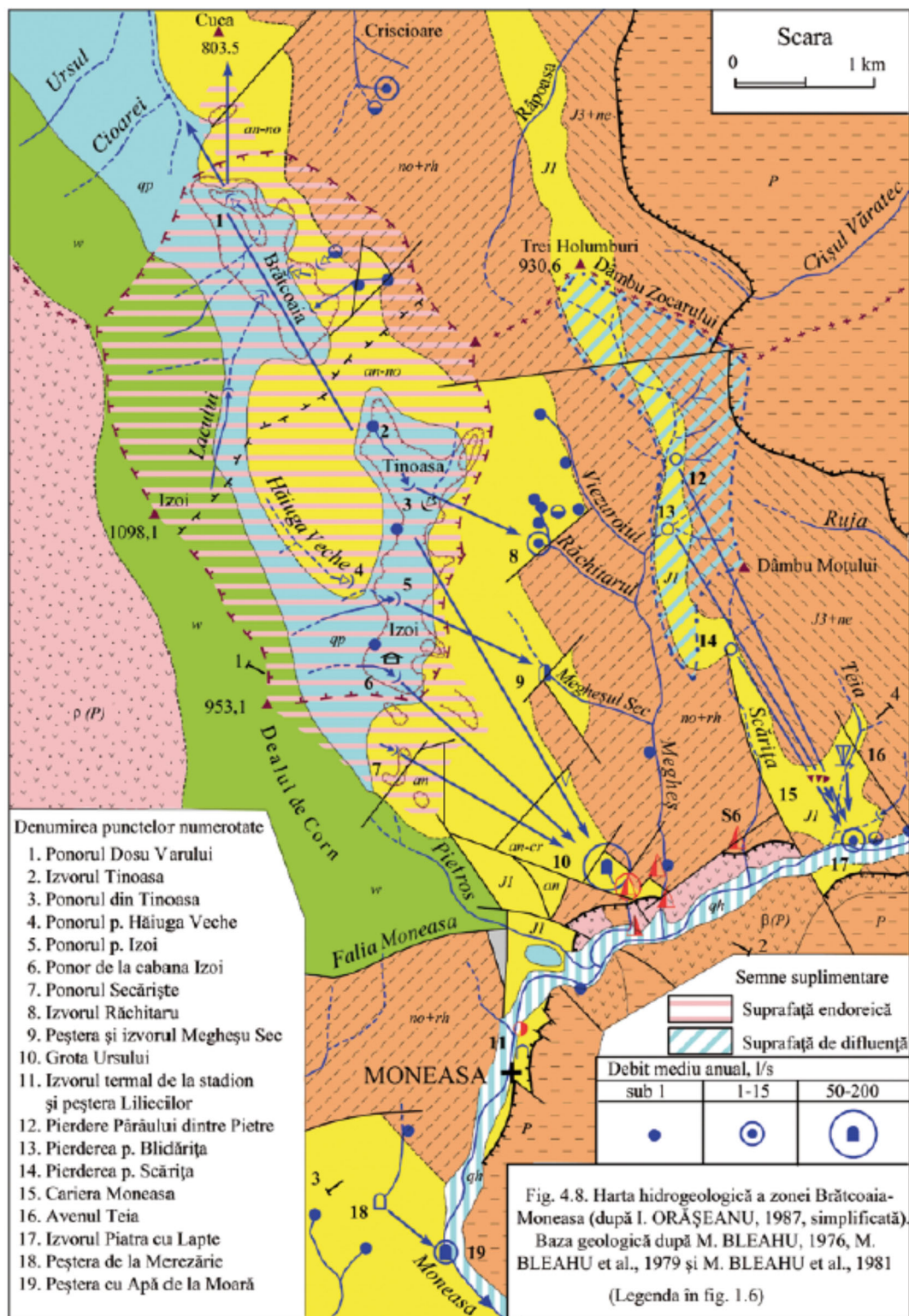


Figure 63: Hydrogeological Map of Bratcoia - Moneasa area; Source: Orăşeanu I., 2010.

15.6 Hydrodynamic characteristics of the springs (and river)

The flow rate is monitored in a systematic way in the gauging station (g. s.) installed by the National Institute for Hydrology and Water Management (NIHWM) on Băilor brook, in the area where the brook reaches the alluvial plain of Moneasa brook (Ciuperca g. s.). The gauging station has been in operation since 1976. The average flow rate for the time interval 1976-1997 is 198 l/s, with a range of 50 to 5,520 l/s. In order to measure the flow rate of the underground stream in Grota Ursului, a gauging station was installed inside the cave in the place where a mine passage intersects the underground stream. Monitoring was conducted from October 1997 to September 1998, and the average recorded flow rate was 58 l/s, while the average water temperature was 8.8°C.

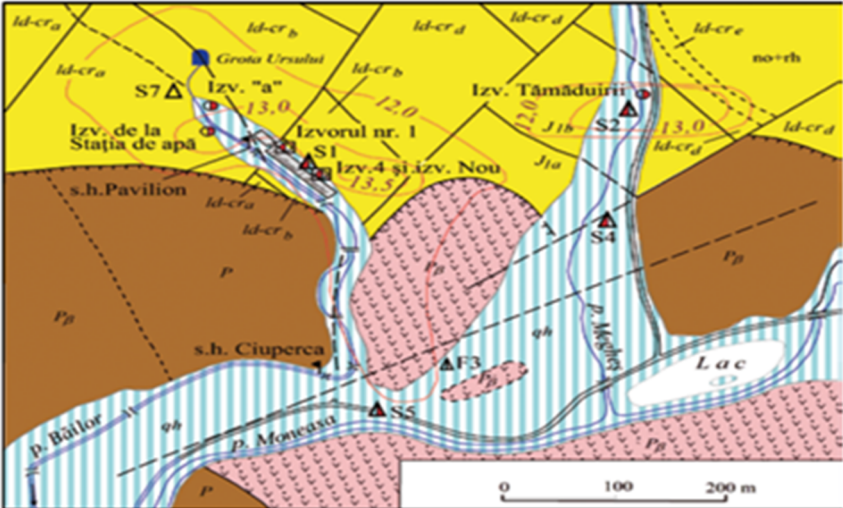
15.7 Data available for the project

1. Grota Ursului spring			
Data type	Time step	Monitoring period	Time period
Discharge	1 day	2.3 year	10/1986 – 12/1987, 10/1997 - 09/1998
Major anions/cations	2 times a year	1.3 year	10/1986 – 12/1987
pH	2 times a year	1.3 year	10/1986 – 12/1987
Electrical conductivity	1 day	1 year	10/1997- 09/1998
Temperature	1 day	1 year	10/1997- 09/1998

2. Bălor spring			
Data type	Time step	Monitoring period	Time period
Discharge	1 day	1 year	10/1997- 09/1998
Electrical conductivity	1 day	1 year	10/1997- 09/1998
Temperature	1 day	1 year	10/1997- 09/1998

15.8 Summary

Pilot name	Moneasa area		
Country	Romania	EU-region	South East Europe
Area (km ²)	66	Lithology	Limestone

At the global scale, the karst area which extends between Brătcoiaia, Tinoasa, Izoï and Moneasa, together with its catchment area makes up a single karst system, part of which displays a thermal character in its southernmost end, and whose ground water flow is directed from the north to the south, discharging mainly through Grota Ursului spring and the thermal outlets.	 Legend: - qh – Quaternary – recent alluvia - P – Permian: Sandstones, clay shales, diabases - Jlb – Jurassic, Liasic: Red breccia limestone - Jla – Jurassic, Liasic: Black limestones and black schists - rh+no – Norian+Rhetian: Black limestone, yellow limestone, red and green schists - ld+cr – Ladinian+Carnian: - a: White limestone - b: Limestone sandstones, yellow schists, black limestones - c: Yellowish pink brecciated limestone - d: Gray white dolomites - e: Black limestone with chert
Monitored objects	Brooks (two), river gauge station (two), wells (two)
Monitored data	Discharge, temperature, EC, chemistry, (isotopes, fluorescence – occasionally)
Contact person	Diana Perșa (persa.diana@yahoo.ro)

15.9 References

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