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THE DYNAMICS OF UNDERGROUND WATERS FROM BAILE HERCULANE, CERNA VALLEY (ROMANIA)

by

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(1 figure)

RESUME. - Dynamique des eaux souterraines de Băile Herculane, vallée du Cerna (Roumanie).
Les eaux thermo-minérales de Băile Herculane ont trois origines :

- des eaux froides situées en amont, dans des structures hydrogéologiques à l'intérieur même du bassin du Cerna (c'est l'origine principale);
- des eaux très chaudes qui remontent de la zone profonde et qui thermalisent les froides;
- des eaux minéralisées qui proviennent d'une structure située peut-être en dehors de bassin du Cerna, et qui minéralisent des eaux déjà chaudes.

ABSTRACT. - Thermomineral water resources of the Cerna Valley come from three different hydrogeological origins :

- cold waters coming from hydrogeological structures located in the upstream part of the Cerna system;
- hot waters, coming from the depth and thermalizing cold waters;
- mineralized waters coming from a structure probably located outside the Cerna basin, which mineralize warm waters.

INTRODUCTION

The hypothesis that thermomineral waters from Băile Herculane are supplied by perrenial and precipitation waters was checked by 34 tracer experiments.

STUDY AREA

The Cerna Valley is located in the Western part of the Southern Carpathians and is the geographical boundary between the calcareous plateau of the Mehedinţi Mountains in the East and the Cerna Mountains in the West.

The geological structure of the area is composed of Danubian units (the Cerna and Presacina sedimentary zones) and of crystalline formations of the Getic Nappe.

A cover of mainly carbonatic sediments from the Jurassic and the Cretaceous has transgressively developed on the Danubian basement paleorelief.

The high permeability of the Jurassic and the Cretaceous limestones, as well as of intensely fissured granite, closely connected to a structural arrangement which permits both infiltration, accumulation and flow of the underground waters, has influenced the creation of a complex hydrogeological system on the Cerna. This system is composed of three structures : the Cerna syncline, the Cerna graben and the Mehedinti Mountains limestone plateau.

The Cerna syncline is situated on the right side of the Cerna valley and is 25 km in length.

This hydrostructure is supplied by precipitations and by right side tributaries of the Cerna which cross both the syncline flanks and the waters from the endokarstic condense.

In 1970, M. Pascu carried out two tracing experiments with radioactive isotopes on the first two valleys upstream the Hercules I spring.

The swallets are situated at 1.5 km on the Cascada Valley and the second at 3.5 km on the Slatina Valley.

Samples have been collected for both tracers in the Hercules I thermal spring.

In the first case, the isotope was intercepted after 20 h and in the second after 42 h. This experiment has

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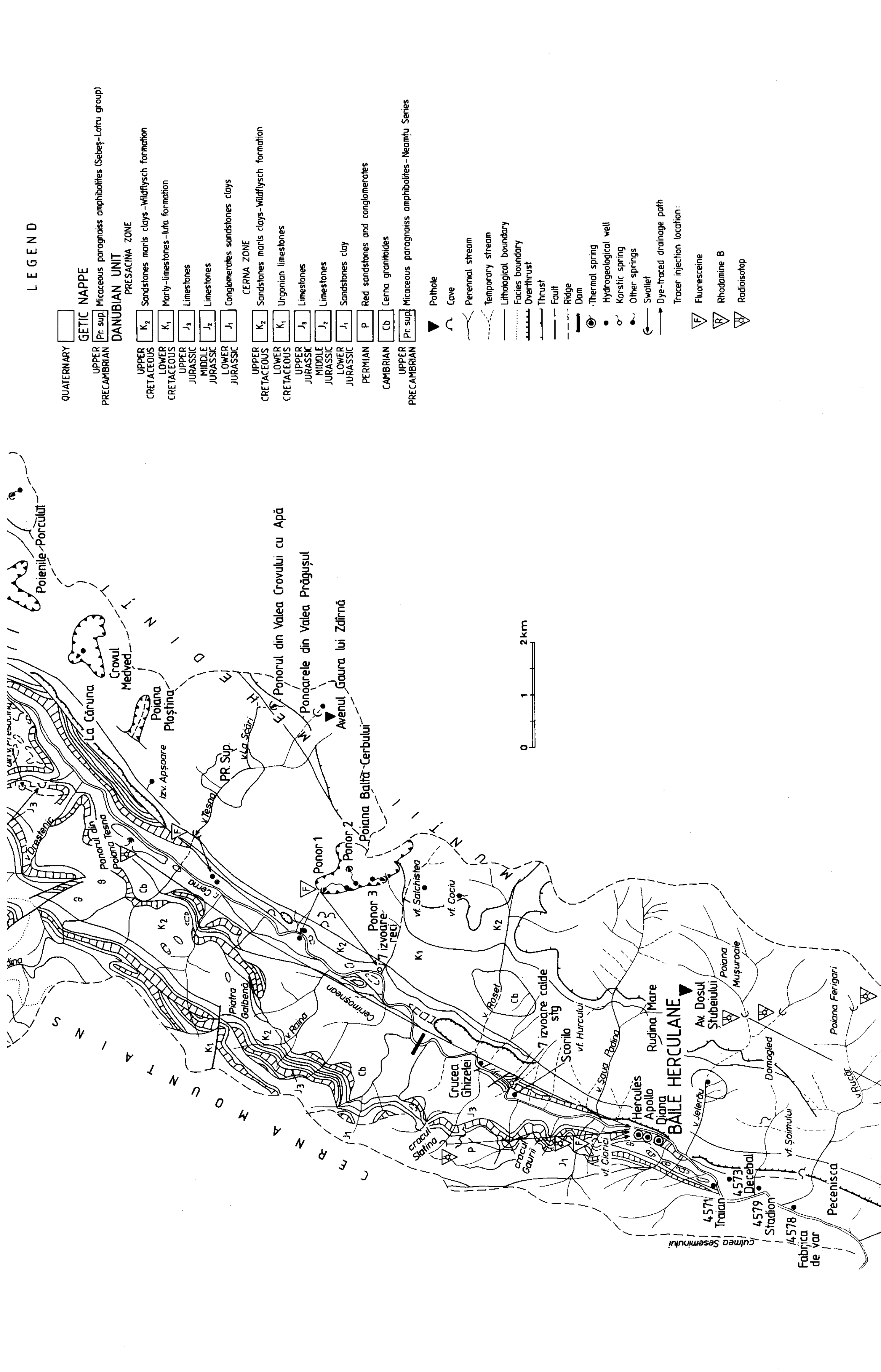

Figure 1. - Central part of a hydrogeological map of the Cerna valley (geology after S. Năstăseanu and I. Bercia).

demonstrated both the alimentation from perrenial waters and the flow from North to South, along the Cerna syncline.

In 1976 and 1977, I. Povara *et al.* have repeated the tracer experiment with dye-tracers (fluoresceine) and obtained similar results regarding the infiltration and the drainage, but the transit speed was lower (2-7 days). At the same time, the dye-tracer was intercepted in the Apollo II thermal spring, which is situated 200 m downstream the Hercules I spring.

I. Povara has done two other dye-tracers, using fluoresceine : the first one in the Grota Cu Abur, and the second directly on intensely fissured limestones (100 m from the cave).

The dye-tracer of the first injection has been intercepted in the Hercules I spring, after 85 h and the second one has not been intercepted, probably because the fissure is closed at depth.

Taking into account the results of these experiments, we can suppose that the right side tributaries of the Cerna situated in the north of the Slatina Valley which transversally cross the Cerna syncline, take part in the alimentation of the structure.

In accordance with the above results, in 1978, G. Simion, E. Gaşpar and I. Povara have tried an experiment with radioactive tracers and dyes in the swallet from the Iuta Valley. This valley is situated at 20 km north from the Băile Herculane spa. The water of the Iuta river (Q = 20 l/s) is going underground in a swallet situated at 300 m upstream the confluence with the Cerna. They have used I-131 and Au-91 isotopes as radioactive tracers and fluoresceine and ammonium bichromate as dye-tracers.

All the injected tracers have been intercepted after 50 minutes in the Piatra-Puscata karstic spring, which is situated at 200 m upstream the Iuta's junction with the Cerna.

The results of this experiment have not ruled out the above hypothesis regarding the contribution of right tributaries of the Cerna to the alimentation of the Cerna syncline aquifer, because the downstream tributaries, in comparison with the Iuta, crossed both the eastern and the western flanks of the Cerna syncline.

Taking into account these reasons, in 1979, G. Simion, G. Ponta and E. Gaşpar have made a tracing with I-131 in the swallet from the Poiana Tesna, at 13 km north from the spa. The swallet appeared at the contact of nonkarstified rocks with the Jurassic limestones.

After 20 days, the tracer has been intercepted in Hercules I and Apollo II springs as well as in the 7 Izvoare Calde Dreapta.

The results of this experiment show that there is afluent drainage along the Cerna syncline on a distance of at least 13 km upstream the spa, and at the same time we can confirm that right side tributaries of the Cerna situated downstream the Iuta take directly part in the alimentation of the above structure.

The occurrence of the tracer in the 7 Izvoare Calde Dreapta situated at 2 km upstream Hercules I spring, gives us a second conclusion about the existence of an underground diffluence on transversal faults which determine a hydrodynamical connection of the Cerna syncline aquifer with the Cerna graben aquifer.

Also in 1979, the same investigators repeated the experiments of M. Pascu (1970) and I. Povara (1976) in Valea Cu Cascada swallet. I.131 was used as a tracer and the samples have been collected from all the springs of the spa. In this way, the tracer was found in all the thermal springs, excepting the Neptun, which is the farthest.

In 1970, some experimental pumpings in the Neptun drilling demonstrated the existence of a drainage of the Diana spring group towards the Neptun group. The tracer has not appeared here because of its concentration decreasing under the detection limit of the utilized apparata.

After these experiments, we can say that the Cerna syncline hydrostructure is certainly supplied by the precipitations and perrenial sources and the drainage is done along the axis of the Cerna syncline (NNE-SSW). These waters which reach the Băile Herculane area, undergo the phenomena of thermalization and mineralization.

The Cerna graben is directed NNE-SSW and has an extension of 64 km. The presence of a groundwater reservoir in this structure is proved by the thermal and karstic springs distributed along transversal fractures, very seldom on longitudinal ones.

G. Simion and E. Gaşpar (1976) have checked the dynamics of underground waters of this structure with a tritium experiment which was injected in the Cerna, 25 km upstream the Herculane spa in a place named the Bobot Gorges.

The tracer has been intercepted in the 7 Izvoare Reci (seven cold springs), Ghizela, Diana and Neptun drillings and confirmed the Cerna's contribution to the Cerna graben aquifer supply.

In 1977 and 1978, I. Povara has done a dye-trace experiment with fluoresceine in the Cerna, 1 km downstream the Bobot Gorges and confirmed once again the discharge of the Cerna graben aquifer in the 7 Izvoare reci and Ghizela and Scorillo drillings.

At the same time, the connection between the Cerna graben aquifer and the limestone plateau of the Mehedinti Mountains is proved by a trace experiment with I-131, injected in the Balta Cerbului swallet by E. Gaşpar in 1975. The travel time of the tracer was 10 h, the radioactive cloud disappearing after another 10 h.

The discharge of the inlet Balta Cerbului (Q =

2 l/s) has a symbolic volume in the supply of the 7 Izvoare Reci (Q = 300 l/s), the main volume of the water coming from another source.

The Cerna graben is transversally divided by fractures and it is possible to admit that the flow of the underground water is stopped, resulting ascending springs along such faults (see the 7 Izvoare Reci, where at least three transversal faults constitute a real fault ridge on the direction of the underground water flow. They divide the Cerna graben in two : a Northern aquifer and a Southern one.

The Northern aquifer is mainly supplied by the Cerna and discharges mostly in the 7 Izvoare Reci and the Southern part is supplied by the waters from neighbouring structures (the Cerna syncline and the western flank of the Mehedinţi Plateau as well as from the Northern aquifer waters, which succeed to surpass the above fault ridge). The last source of discharge supply is little in discharge, but it was demonstrated with tracers intercepted in thermal sources (I-131, Tritium, fluoresceine).

Thus, the Southern Aquifer discharge is done on transversal faults in Băile Herculane, through thermal springs and another one in the Toplet area (1 km south the Herculane spa) with mixed thermal waters from the Cerna graben and karstic water from the Mehedinţi plateau.

The Mehedinti Mountains limestone plateau is situated on the left side of the Cerna, between Arsasca and Pecinisca tributaries, being a large anticline structure. Precipitations and short rivers waters are able to infiltrate in the limestone massif. The discharge of the plateau is made through the existed springs, especially on the western side of the plateau and less on the eastern one. At the same time, an underground discharge is possible in the Cerna graben aquifer, where the Urgonian limestones come into tectonic contact with the Jurassic limestone of the Graben.

Along the axis of the anticline, granites and crystalline rocks of the Danubian basement outcrop in several points.

This basement ascent constitutes a hydrogeological watershed; the Mehedinţi plateau karstic aquifer is divided in a western one, between its axis and the Cerna graben and another one, east of the axis.

These two flanks of the limestone plateau are working as one single system in the upper part of the anticline, where the strata are horizontal and the impermeable basement is lower, as well as along some transversal fractures, which cross the anticline. The connection between these two flanks become active especially during the rainy periods, when the level of the underground water in the limestones is rising.

The western flank aquifer of the anticline is directly supplied by rainfall waters and by the Cerna, upstream the 7 Izvoare Reci.

The discharge of the western flank is done along the anticline axis or is made either laterally towards the Cerna through the springs of the left side of the Cerna.

The eastern flank of the anticline has a maximum of 3 km in extension and represents the most unknown zone.

This area is supplied by rainy waters and probably by the swallets from the Balta Cerbului (no. 2-3) and from the upper part of the Tesna valley, which are situated in the middle of the area. The outlet of this swallet is probably the Cosustea springs.

Other important emergences are situated in the Vîrful lui Stan eastern flank area – the Isverna and the Izvorul Alb (White Spring). The Isverna is supplied by a swallet situated at 2 km north from the spring and the Izvorul Alb has an unknown origin.

Regarding the waters dynamics from the plateau eastern flank, we can suppose a general drainage direction NNE-SSW, parallel to the above anticline axis, having the ending point, the Bîrza and the Toplet emergences. This conclusion is based on extrapolating towards NE the tracer's results'experiments with I-131 in the Poiana Ferigari and the Poiana Musuroaie insurgences, situated on the axis of the anticline, wherefrom the tracer has been intercepted in the Bîrza outlet spring.

During rainy periods, or snowmelting, the level of water in the limestones raises over the impermeable basement altitude in the anticline axis and a lateral drainage appears in the west. This phenomenon goes on till the waters'level in the limestones comes down, under basement minimum altitude in the axis.

THERMOMINERAL WATERS DEPOSIT

The deposit is located in the Cerna graben, between the Crucea Ghizelei (Ghizela's Cross) in the north and the place named Pecinisca in the south, as well as in the Cerna syncline, in the zone of its southern end between the Grota cu Abur in the north and the Coronini Plateau in the south.

The deposits of thermomineral waters are situated in different types of rocks : for the Cerna graben, intensively fissured jurassic limestones and with frequent karstic holes and the Cerna granites strongly tectonized – for the Cerna syncline only jurassic limestones.

General water flow in the deposit is NE-SW depending on the slope and the direction of the structures.

Deposit supply is done mainly by cold waters situated in the upper part of the two structures as well as from the western flank of the Vîrful lui Stan-Domogled anticline and downstream to the 7 Izvoare Reci is added a quantity of very warm waters which deeply flow and penetrate ascending on open fractures (longitudinal and transversal ones) of the Cerna graben and syncline, in the two hydrostructures, and another quantity of strongly mineralized (deposit type) waters from a structure situated maybe outside the Cerna basin.

CONCLUSIONS

Taking into account the alimentation process, it can be concluded that thermomineral watery accumulation represents the product of the component units of three hydrogeological systems :

- cold component - cold waters located upstream in hydrogeological structures within the Cerna system (the largest part);
- thermalized component - very warm waters that ascend from the depth zone and thermalize cold ones;
- mineralized waters - deposit type waters from a structure perhaps situated outside the Cerna basin that mineralize already warm waters.

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