WATER FLOW SYSTEM WITHIN THE CERNA VALLEY GRABEN STRUCTURE (SW OF THE SOUTHERN CARPATHIANS, ROMANIA)

Ioan POVARĂ[1], **Mihai CONOVICI**[2], **Constantin MARIN**[1] **& Cristian-Mihai MUNTEANU**[1]

[1]*"Emil Racoviţă" Institute of Speleology, Bucharest, Romania, ipov.iser@gmail.com*
[2]*Geological Society of Romania, Bucharest, Romania*

The Precambrian metamorphic basement of the Southern Carpathians, intruded by granite bodies, is overlain by Mesozoic sedimentary formations, consisting of diverse Upper Jurassic-Lower Cretaceous limestone facies, covered by Upper Cretaceous detrital and volcano-sedimentary deposits (Fig. 1). The main tectonic feature of the region is the Getic Nappe, represented by large outliers (Godeanu and Mehedinţi). Ophiolite suites largely outcrop within the para-autochthonous nappe of Severin. The Danubian Autochthonous comprises various limestone facies and features a duplex structure, resulting from multiple overthrusts, which also affected the granite basement. Transpressive/transtensive regional movements, initiated after the Upper Cretaceous tectogenesis and very active during the Miocene, led to the formation of the Cerna Graben, a complex structure, which locally presents aspects of half-graben, paired graben or pull-apart basins. Along the eastern fault (the border fault), the Mehedinţi Mountains were isostatically uplifted with more than 1000 m; the resulting, positive and negative, "flower" structures drive the karst cold water flow on the Cerna Valley eastern slope.

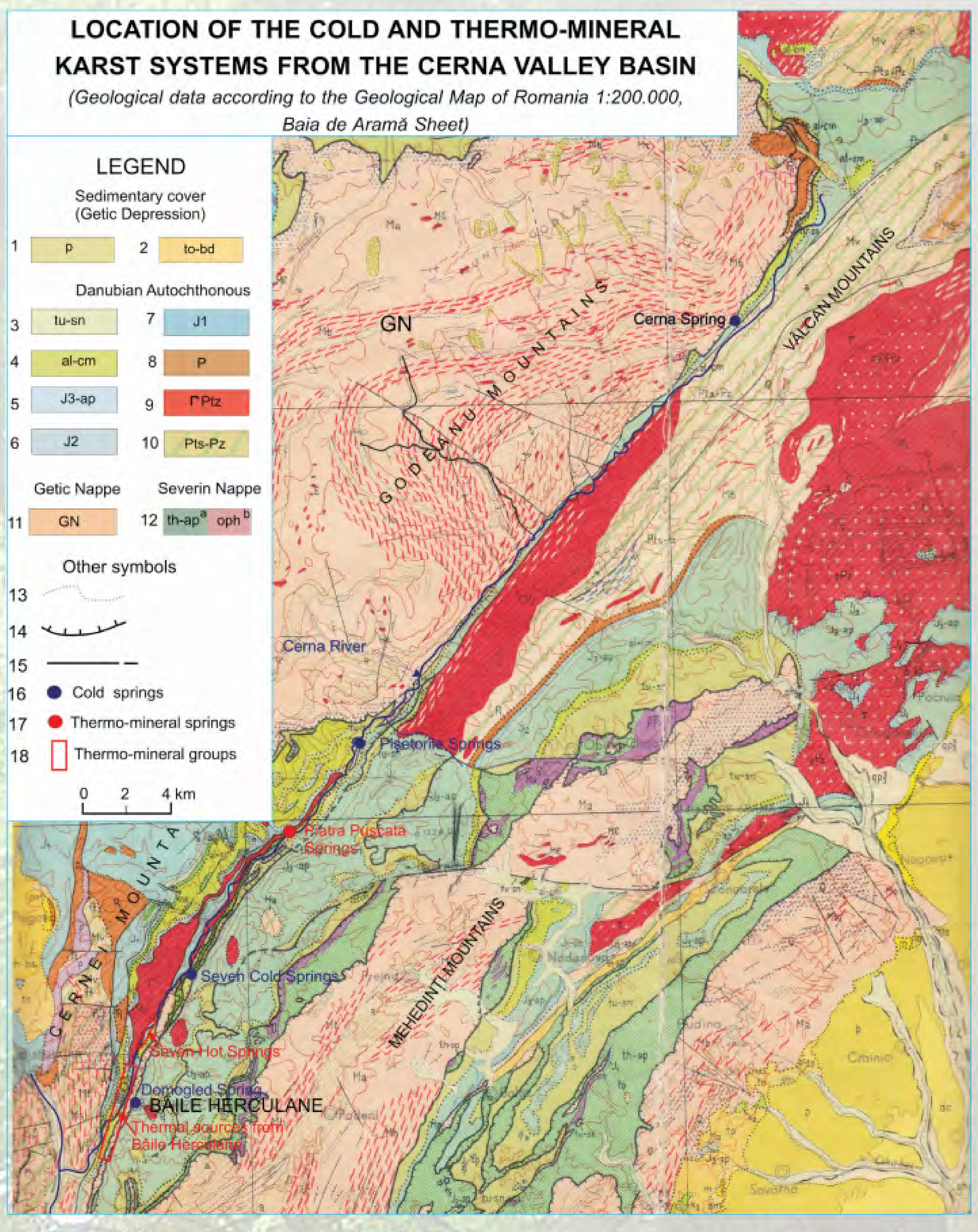

Figure 1. Location of the cold and thermo-mineral karst systems from the Cerna Valley Basin: 1. Marly sands; 2. gravels and sands; 3. Wildflysch Formation (blocks in black slaty matrix); 4. Nadanova Beds (turbiditic limestones); 5. micritic and sublithographic limestones; 6. sandy limestones; 7. quartz sandstones; 8. red conglomerates and sandstones; 9. granites; 10. gneiss-amphibolite schists; 11. micaceous gneiss schists; 12. a) red and black shales, b) basalts and tuffs (ophiolites); 13. geological boundary; 14. overthrust plane; 15. fault.*

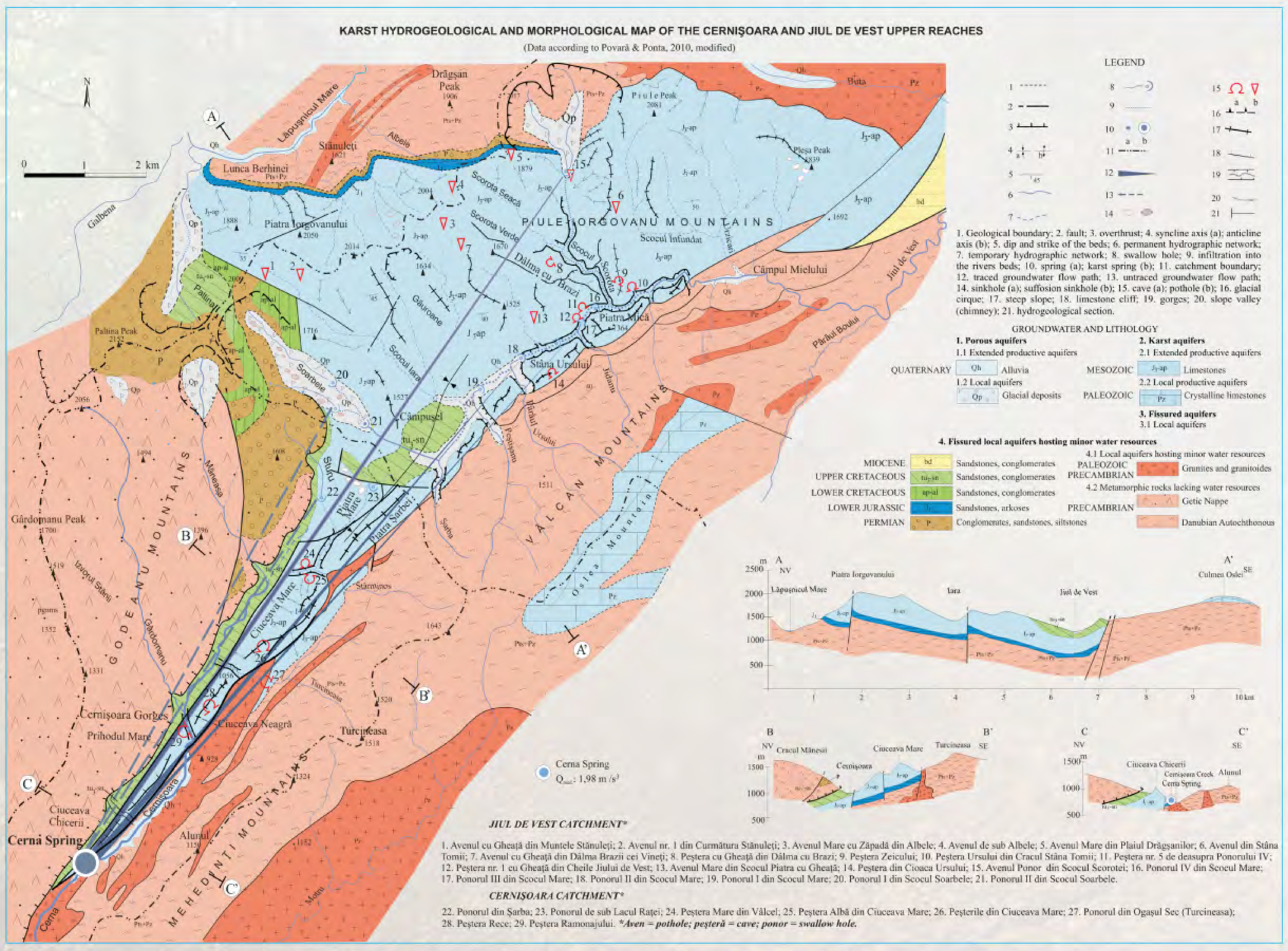

Figure 2. Karst hydrogeological and morphological map of the Cernişoara and Jiul de Vest upper reaches.

Figure 3. Geological and hydrological map of the Pişetori Springs-Arşasca sector of the Cerna Valley. 1. Holocene alluvia; I. Getic Nappe: 1. Godeanu Nappe (mesometamorphic micaceous rocks); 2. Borăscu Nappe (retromorphic Alpine gneisses and micaceous rocks); II. Upper Danubian Unit: 1. Mélange Formation of Presacina/Arjana type, a. black shales (deformed matrix), b. conglomerates and contourites within fragmented piggy-back basins; 2. Iuta/Nadanova Beds (pre-flysch formation); 3. lithographic limestones and limestones with nodules; 4. limestones and sandstones; 5. Liassic sandstones; 6. red granites of Cracu Roşu type; III. Lower Danubian Unit (eastern slope of the Cerna Valley): 1a. black shales (deformed matrix) with limestone olistoliths; 1b. tectonosome over Urgonian limestones; 2. massive Urgonian limestones; 3. Arşasca granites intruded into the Drăgşani metamorphic group; IV. Geological symbols: 1. geological boundary; 2. normal anticline; 3. normal syncline; 4. secondary reversed anticline; 5. strike-slip master fault with the area of ductile deformation and shear direction; 6. uplifted hanging wall with the area of brittle deformation; 7. Riedel-type faults; 8. nappe boundary; 9. olistolithic blocks; 10. hydrogeological cross-section; V. Hydrological and morphological symbols: 1. permanent surface stream; 2. temporary surface stream; 3. sinking stream; 4. temporary stream; 5. non-karst spring (a); karst spring (b); 6. traced groundwater flow path; 7. untraced groundwater flow path; 8. gorges; 9. sinkhole; 10. cave (a); pothole (b); 11. limestone ridge; 12. steep valley; B. Hydrogeological cross-section.

Four binary karst systems (non-karst/Jurassic-Cretaceous limestones) discharge important water resources, at flow rates of up to 0.4-10.5 m^3/s: Cerna Spring (Fig. 2), Pişetori Springs (Fig. 3), Seven Cold Springs and Domogled Spring. The groundwater (calcium-bicarbonate, with a mineralization of less than 300 mg/l) flows with average theoretical velocities of 8-69 m/h. The recession curves show a low development degree of the drowned karst (low *k* coefficient), a quick discharge (high *α* coefficient) and an important contribution of the surface runoff to the systems recharge (high *i* coefficient). On the western, crustal, strike-slip fault, along a distance of 25 km, there are 19 thermo-mineral springs, with an average total flow rate of 69 l/s, joined in 6 groups, depending on their physical and chemical properties. On the same area, 10 wells were drilled, the deepest reaching a depth of 1200 m. Within the Cerna Graben aquifer, the ascending thermo-mineral water is mixed with descending, karst cold water (Fig. 4).

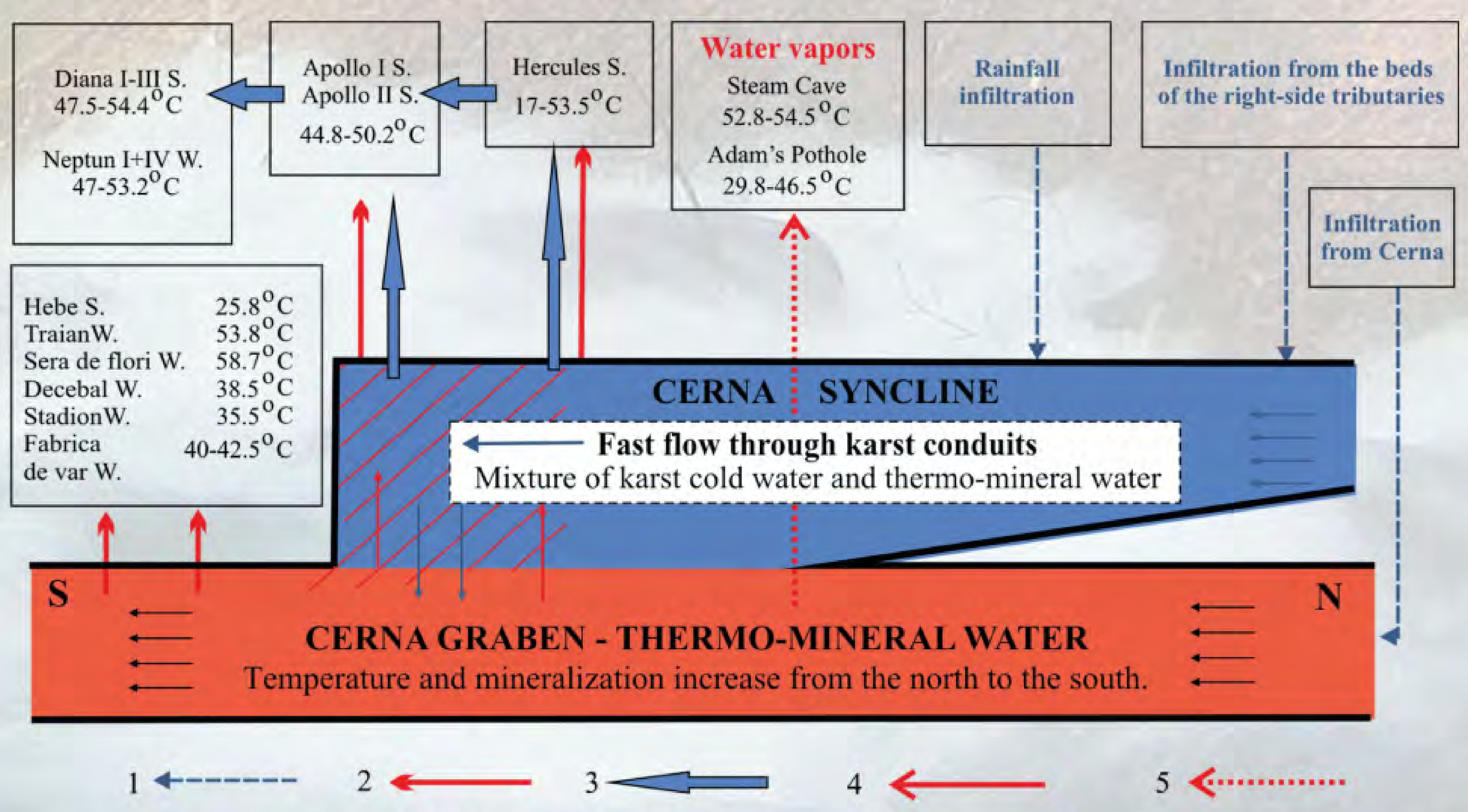

Figure 4. A conceptual model of the functioning of the thermo-mineral aquifer complex from the Băile Herculane Spa.

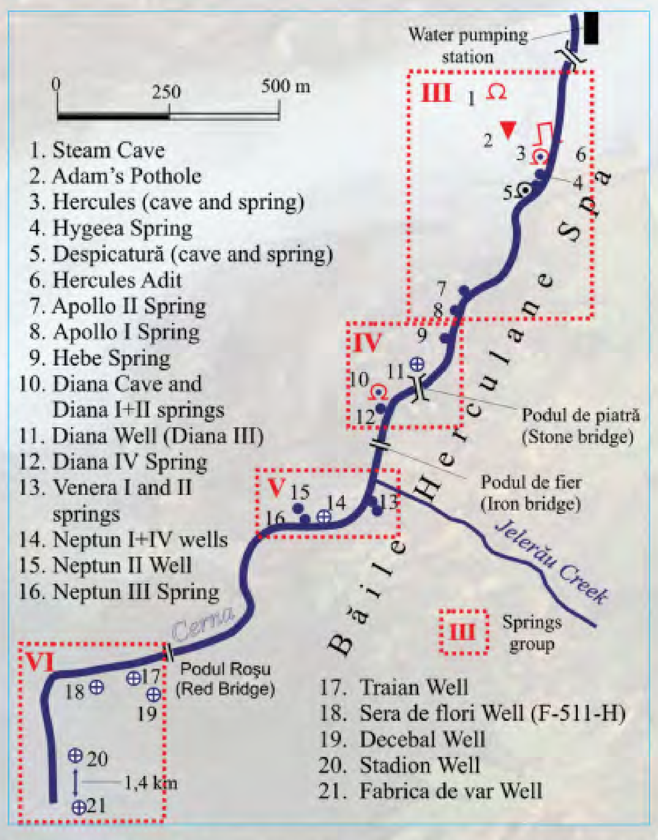

Figure 5. Sketch map showing the location of the thermo-mineral sources from the Băile Herculane Spa.

The chemical composition of the thermo-mineral water varies across the region. The sources located in the north (Crucea Ghizelei Well, Seven Warm Springs, Scorilo Well, the springs groups I and II) are less mineralized than the sources located in the center of the Băile Herculane Spa (Apollo, Hebe) and in the south (Fig. 5). Thus, the total dissolved solids (TDS) rise from the north (*ca.* 300 mg/l) to the south (up to over 8000 mg/l), along with the dissolved H_2S content (0-60 mg/l). Except for the Crucea Ghizelei Well, the water can be assigned to the chloro-sodium hydrochemical facies (Fig. 6). The *TotalQuant* assessment of the thermal water sources from the Băile Herculane Spa points to the presence of many metals and metalloids, including rare earth elements (REE) and actinides in detectable levels (Fig. 7).

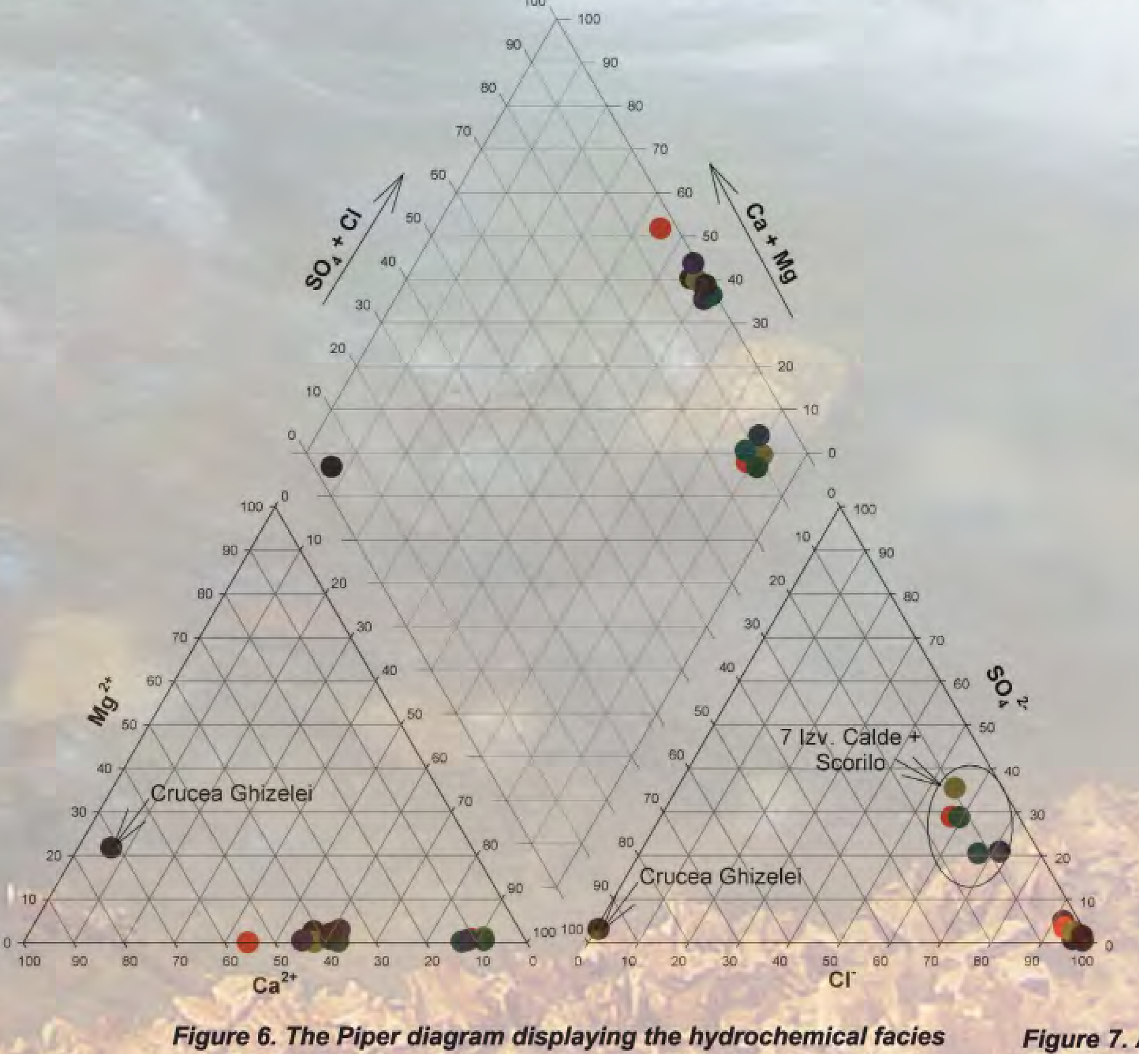

Figure 6. The Piper diagram displaying the hydrochemical facies of the hydrothermal sources from the Băile Herculane Spa.

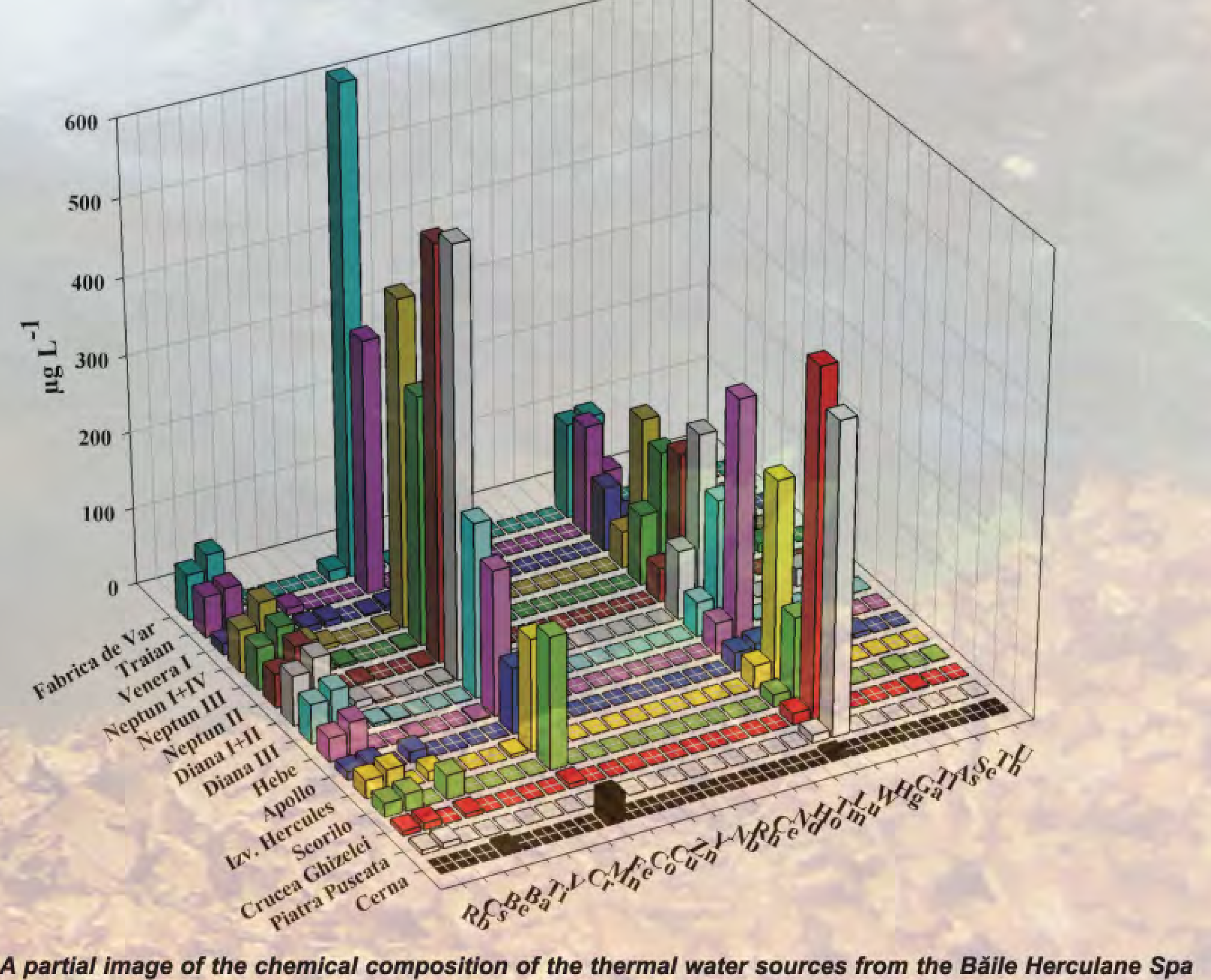

Figure 7. A partial image of the chemical composition of the thermal water sources from the Băile Herculane Spa (TotalQuant method, semiquantitative analysis performed with a PerkinElmer NexION 300S ICP-MS spectrometer).

REFERENCES

POVARĂ, I. & PONTA, G. (2010): Geology and hydrogeology of the Jiul de Vest-Cernişoara Basins, Romania. *Carbonates & Evaporites*, 25(2):117-126.

The project **"Resilience of hydrothermal systems against natural and anthropogenic disturbances. Case study: the hydrothermal reservoir from the Băile Herculane Spa (RESILTHERM)"**, PN-II-PT-PCCA-2011-3.1-1619, has been financially supported by the National Research Council (CNCS), Romania.