

## Groundwater geochemistry in the Gârda Seacă–Ghețari–Poiana Călineasa karst area (Bihar Mountains, Romania)

### Natural setting

The area under investigation occupies the watershed bounded to the west by the valley of Gârda Seacă and to the west and to the south by the valley of Ordâncușa. In geological terms, this territory is rather homogeneous, most of its deposits belonging to the Bihar Autochthonous Unit. The Wetterstein white reef limestones are those which occur in overwhelming percentage, with additional occurrences of Anisian gray dolomites existing in the western part. Formations included in the Gârda overthrust occupy small areas stretching mainly along the two main valleys, and they consist of Werfenian conglomerates and quartzite sandstones, and of Late Permian breccia with crystalline schists fragments included.

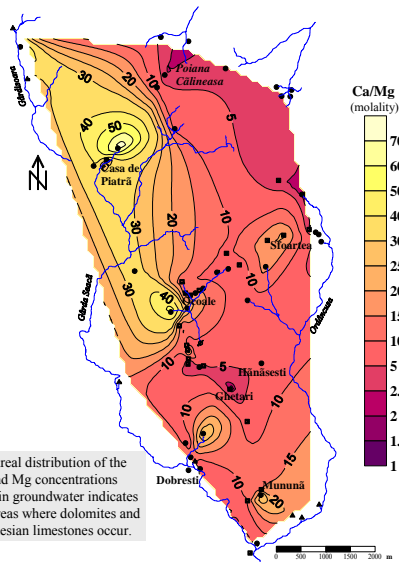
The two main valleys that border the area under investigation are deeply entrenched, with specific land forms and stream flow characters that are controlled by the underlying geological substratum. In terms of land forms, the entire area extending between the two valleys may be described as a karst „plateau”, devoid of a surface stream network and possessing a very well developed underground karst system. Among the surface karst land forms a special mention deserve sinkholes, that in certain places cluster as „sinkhole fields”, or occur in lineaments along the strike of the faults or fractures.

### Types of outlets

The investigated groundwater sources belong to the following three classes: (a) outlet caves, (b) free flow springs, (c) springs supplied by phreatic aquifers, consisting mainly of lithological contact springs, with small (less than 0.5 m<sup>3</sup>) storage pools of natural or anthropic origin, (d) „fountains”, a term by which local people designate excavations where a few (sometimes less than one) cubic meters of water may accumulate, generally supplied by lithological contact springs as well.

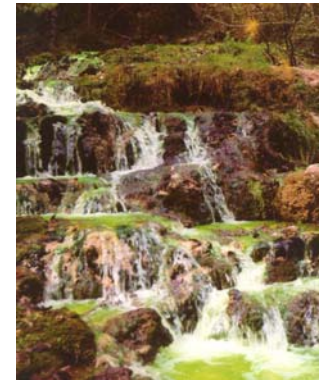


The “Fountain” in Valea Iepeii, a typical karst spring in terms of water chemistry, the main drinking water source that exists in the eastern part of the area.



The areal distribution of the Ca and Mg concentrations ratio in groundwater indicates the areas where dolomites and magnesian limestones occur.

In order to assess the extent to which the karst processes concerned the substratum within which the groundwater sources occur, there has been investigated the behavior of several physical and chemical water parameters, especially of those which describe the chemical process of carbonate rocks dissolution. Outstandingly relevant in this respect proved to be the ionic strength of the solution, the weight of the Ca<sup>2+</sup> + Mg<sup>2+</sup> sum of concentrations and the ratio between the K<sup>+</sup> and the HCO<sub>3</sub><sup>-</sup> ions concentrations. In hydrochemistry, the equivalent of ionic strength is water mineralization, a direct proportionality existing between these two parameters. In the case of groundwater of the considered area, in terms of this parameter worth mentioning are on one hand the clear distinction of outlets whose water flew across carbonate formations as compared to outlets associated to a non-karst substratum, and on the other hand the homogeneity which is recorded in the case of the first three types of sources. The significance of this latter remark is that irrespective of dissolution taking place in an actual karst conduit, or during a more or less prolonged contact with a specific, appropriate host rock (for instance with carbonate rocks conglomerates), the result in terms of water mineralization is similar.



### General chemical characteristics

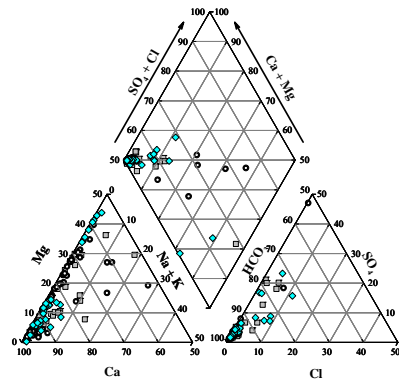
The chemical composition of the groundwater in the investigated area is consistent with the typical pattern recorded in carbonate karst areas, with Ca<sup>2+</sup> and Mg<sup>2+</sup> being the major cations, while HCO<sub>3</sub><sup>-</sup> is the major anion. The TDS content ranges from less than 25 mg L<sup>-1</sup> to more than 400 mg L<sup>-1</sup> and its distribution is a function of the petrography of the substratum through which the water flows. Specifically, in those places where water flows mainly along silicic formations (the southern part of Poiana Călineasa, the area between Clujului Hill and Ocoale Depression, and to the north of Dobrești hamlet) lower mineralization values are recorded. It is worth mentioning that the values of this parameter increase from the central area of Gârda Seacă–Ordâncușa watershed toward its margins.

The weight of the Ca<sup>2+</sup> and Mg<sup>2+</sup> ions in the cations totals amounts to more than 90%. This results in a space distribution of the total hardness of the water that is virtually identical to that of the water mineralization values. Alternatively, the values of the Ca/Mg molal ratio display a different pattern, highlighting dolomites and magnesian limestones, in those places where they exist, namely in the north-east, central-east, and the south-western extremity of the area.



The “Fountain” in Vuiașă, the main drinking water source for the inhabitants of Ghețari village.

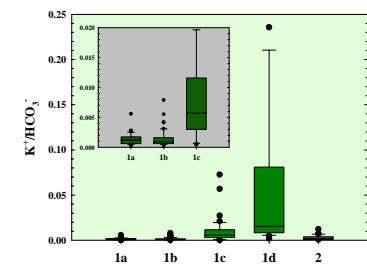
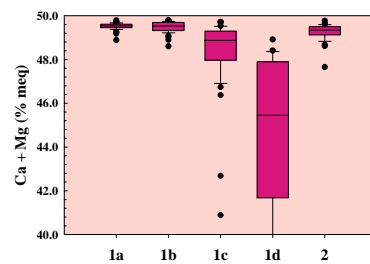
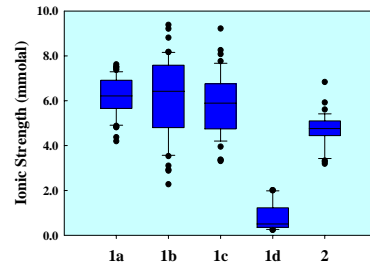
The values of the weight of the Ca<sup>2+</sup> + Mg<sup>2+</sup> sum of concentrations cluster within a narrow range in the case of sources belonging to actual karst, they are distributed on a slightly wider range for the substratum moderately concerned by karst processes, and appear as clearly distinct for the areas that are not significantly concerned by karst processes. The ratio between the K<sup>+</sup> and the HCO<sub>3</sub><sup>-</sup> ions concentrations clearly discern the sources associated to a substratum that is not significantly concerned by karst processes from the other sources.



### Amplitude of karst processes effects

As a function of the amplitude of the karst processes effects on the substratum, groundwater sources rank into the following categories:

- actual karst outlets, that include, obviously, outlet caves and typical karst springs, in both cases the associated underground flow paths extending over up to several kilometers length;
- outlets for which the amplitude of the karst processes effects on the substratum is moderate, and which include springs and fountains associated to karst aquifers of small extent;
- outlets with their water flowing through a substratum that it is not significantly concerned by karst processes, and thus corresponding, as a general rule, to shallow karst aquifers;
- outlets discharging from non-karst formations of from alluvial and slope deposits.



1 – groundwater, where (a) are karst outlets, (b) outlets discharging from a substratum moderately concerned by karst processes, (c) substratum slightly concerned by karst processes, (d) non-karst substratum; 2 – surface water.