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Geochemical features of the geothermal and mineral waters from Apuseni Mountains, Romania

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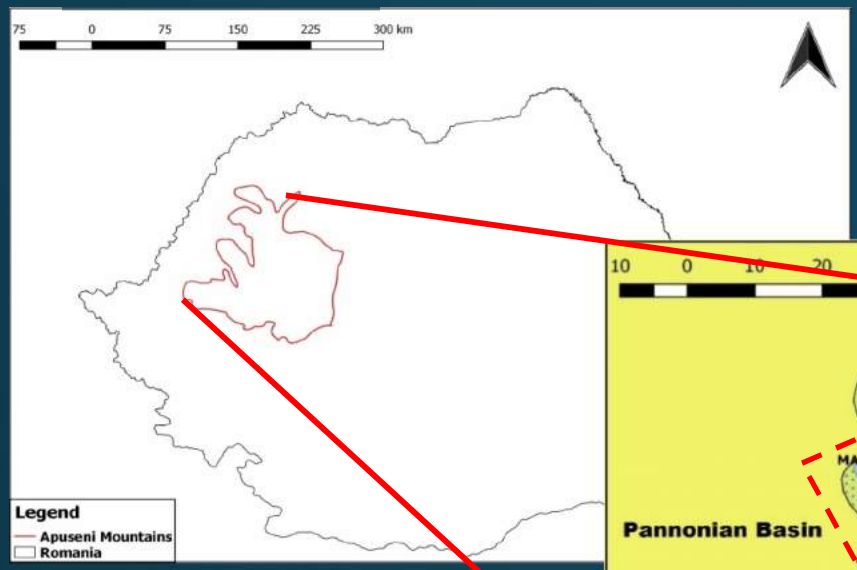
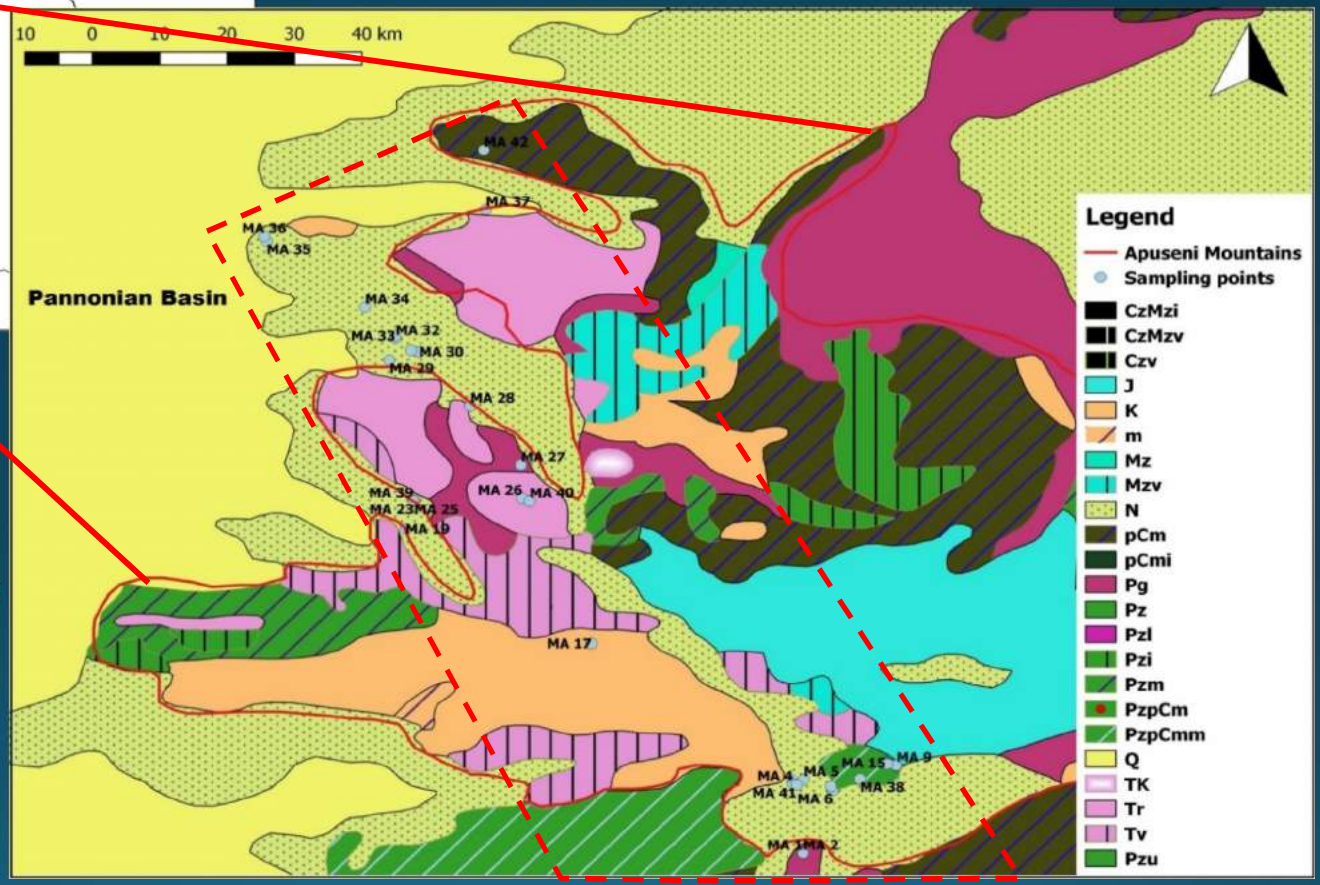
Study area



Total of 42 investigated water sources on a NW-SE transect



Geological background:

- Northern Apuseni Mts.:
  - ✓Early Proterozoic - Variscan basement;
  - ✓Pre-Alpine nappes (Late P – Lower Cr).
- Southern Apuseni Mts.:
  - ✓Middle J ophiolites;
  - ✓Late J calk-alk magmatic rocks;
  - ✓Cretaceous sediments;
  - ✓Neogene magmatic rocks.

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Current status

- The Apuseni Mountains are known for their metalliferous resources;
- The presence of thermal waters was already know by the Romans;
- Several papers/research reports describe the occurrence and chemical features of these waters;
- A detailed and comprehensive work on the hydro-geochemistry and associated gases, and interpretation of the geothermal conditions in the area is still lacking.

Objectives

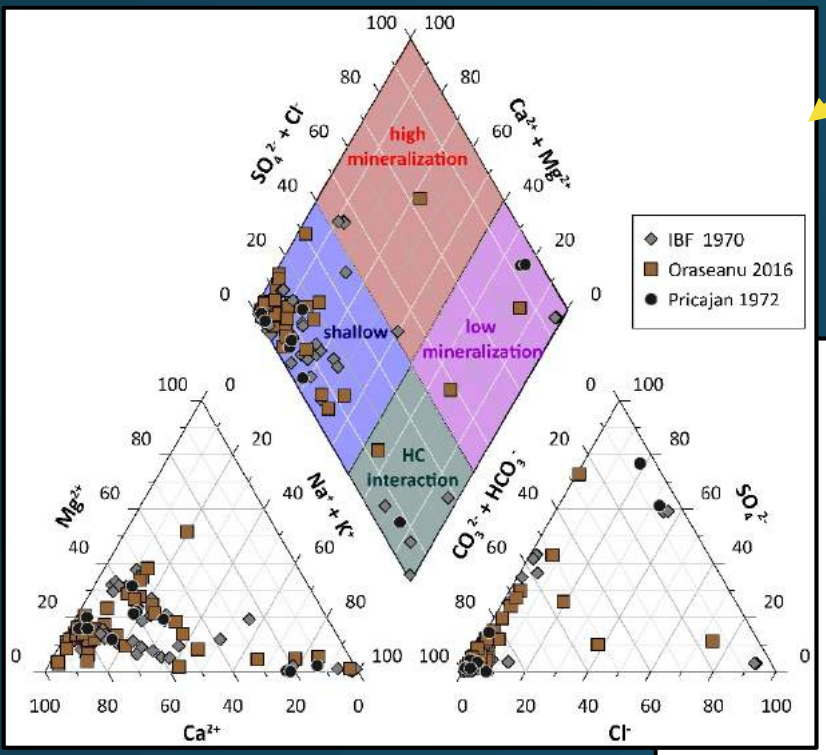
- Investigation on the isotopic composition of the waters, together with their chemistry;
- Determination of the geochemistry of the associated gases together with their origin;
- Constraining the geothermal conditions in the area by using the geochemical interpretations.

Sampling

- 42 sampling points;
- In situ determinations:
  - ✓ *Flow rate;*
  - ✓ *Physico-chemical parameters (temperature, pH, Eh, EC);*
  - ✓ *Alkalinity;*
- Ex situ determinations:
  - ✓ *Major ions;*
  - ✓ *Water isotopes;*
  - ✓ *Dissolved gases;*
  - ✓ *Free gases;*
  - ✓ *Carbon isotopic composition of CO_2;*
  - ✓ *Isotopic composition of noble gases.*

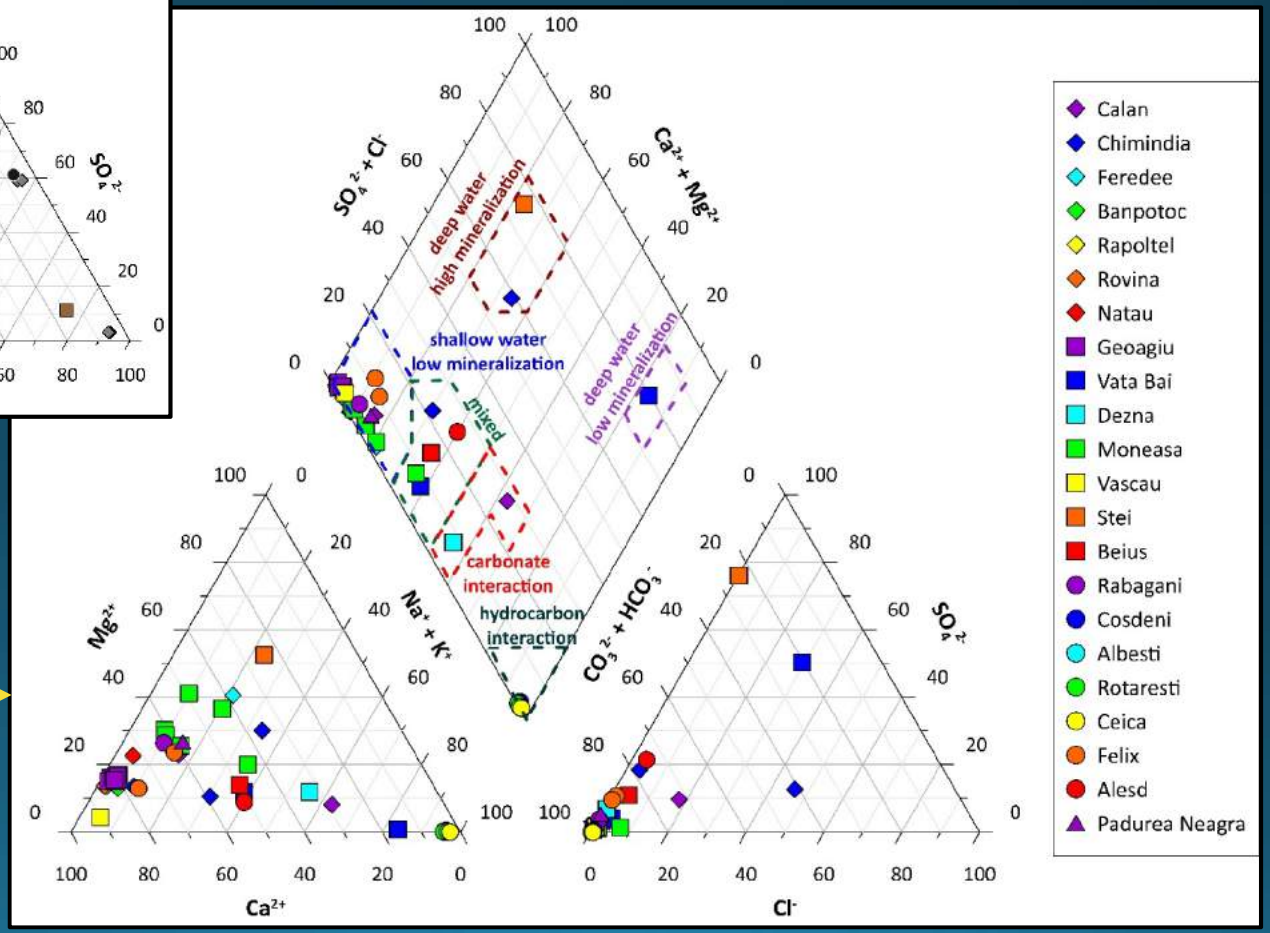
Results

Literature data



- 4 groups have been distinguished;
- Predominant water type calcium bicarbonate (Ca-HCO_3), and sodium bicarbonate (Na-HCO_3) in the NW area.

Present study data



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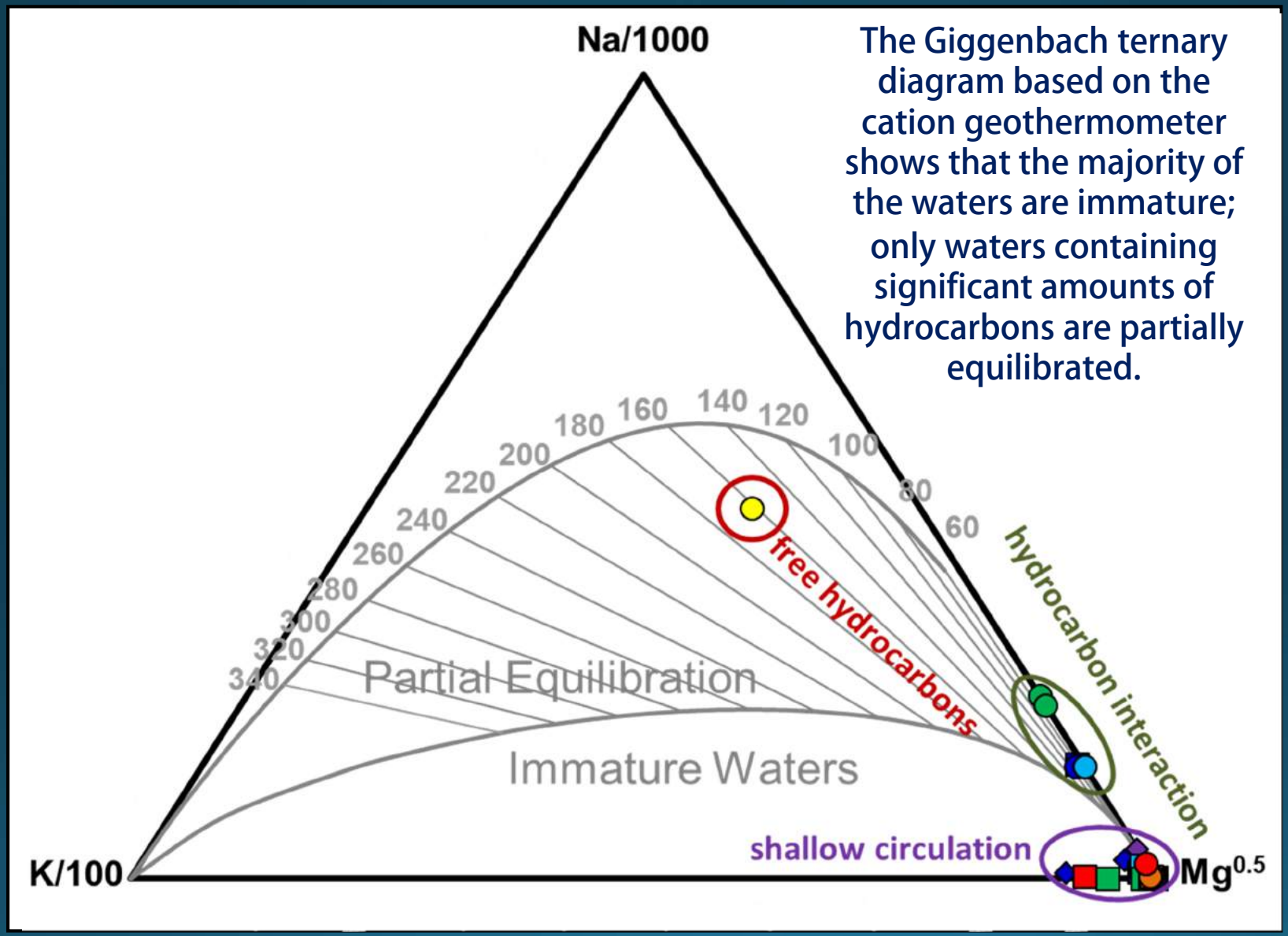
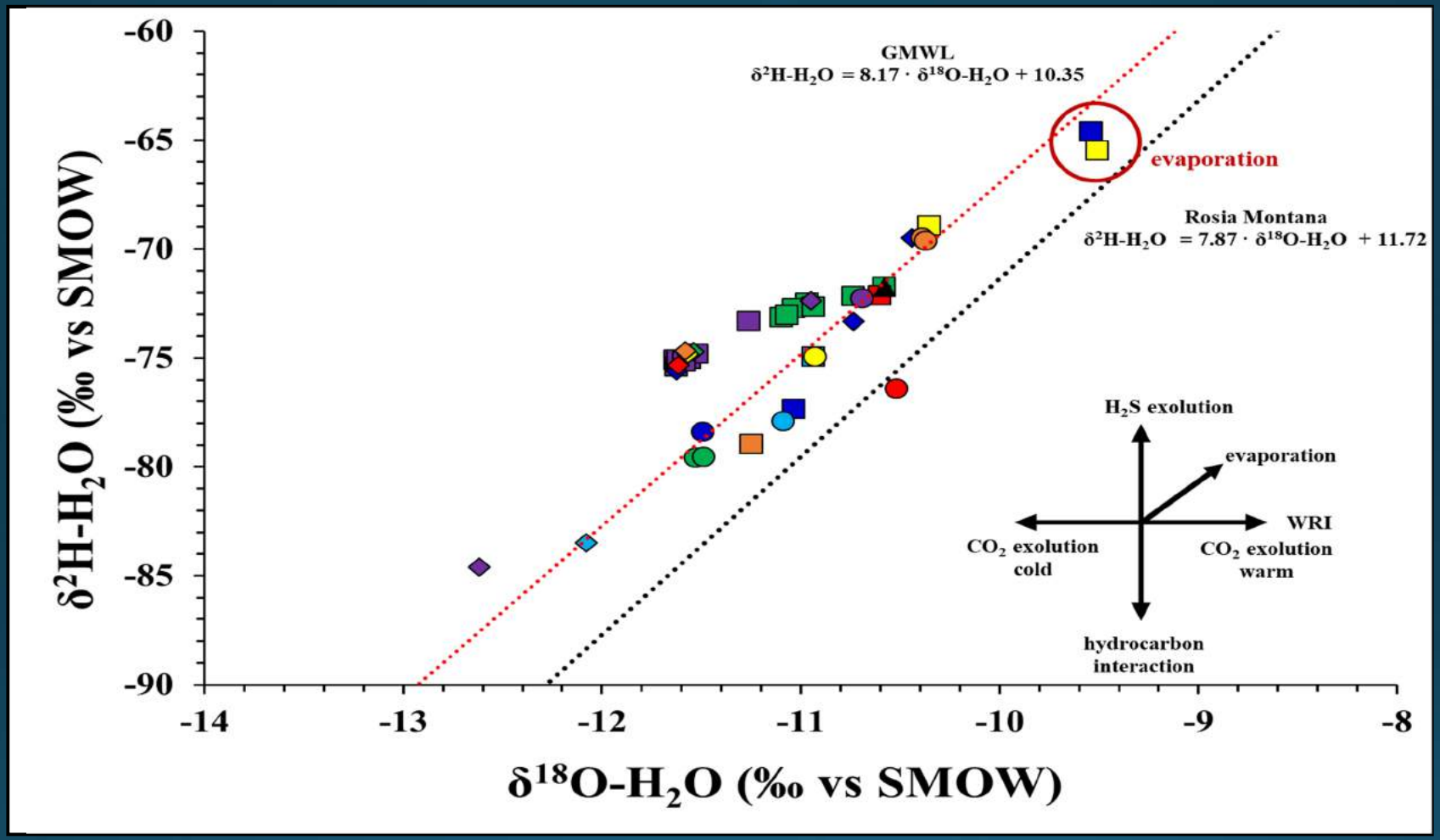
Results



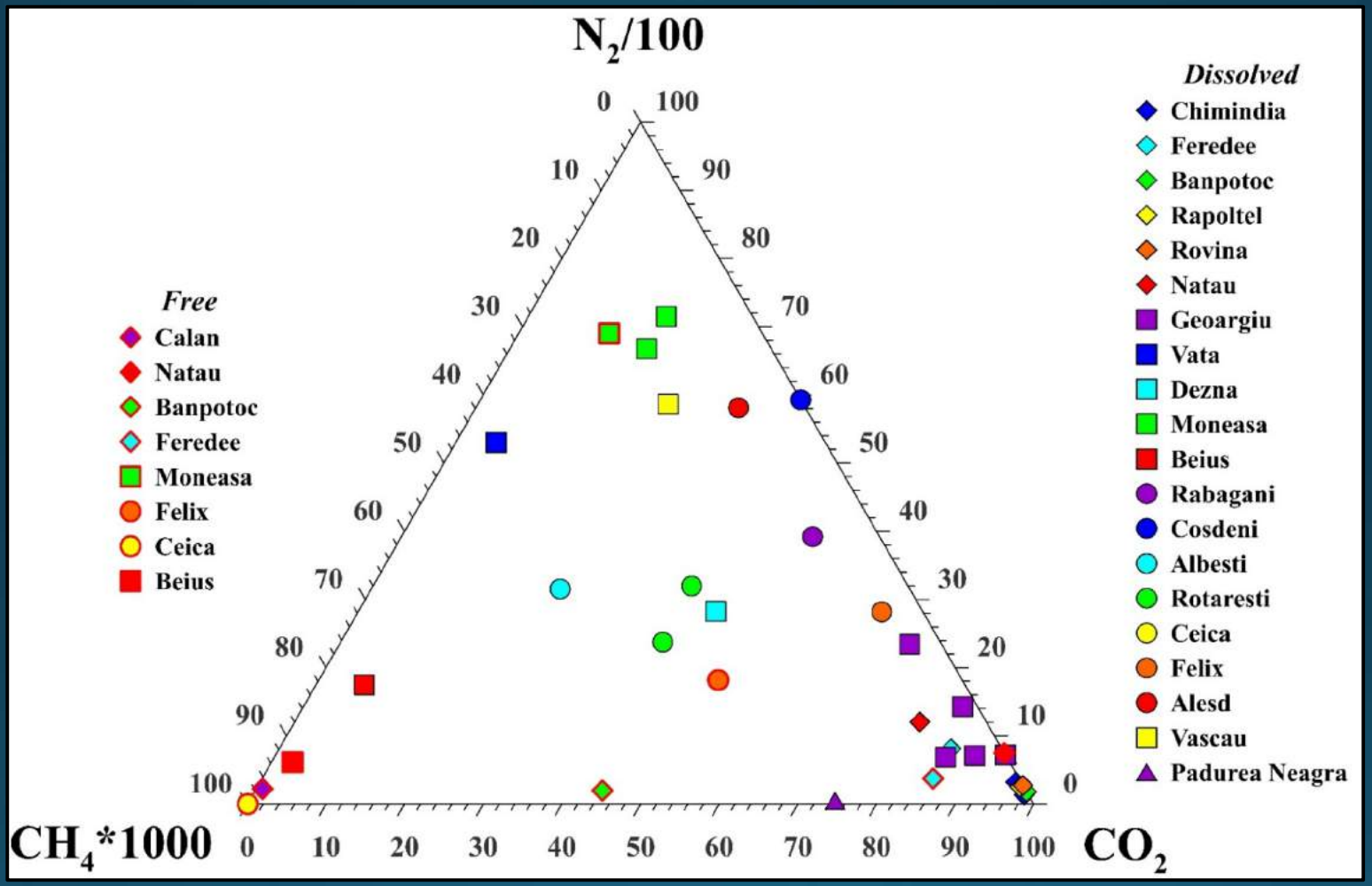
The Giggenbach ternary diagram based on the cation geothermometer shows that the majority of the waters are immature; only waters containing significant amounts of hydrocarbons are partially equilibrated.

Results



- Sampling points are mainly supplied with water of meteoric origin;
- Sampling points from the NW interact with hydrocarbons while the one from the SE are affected by exolution of CO_2;

Results



- Sampled sources in the SE area show high concentration of CO_2 and low concentration of N_2;
- Gases from NW area are rich in methane.

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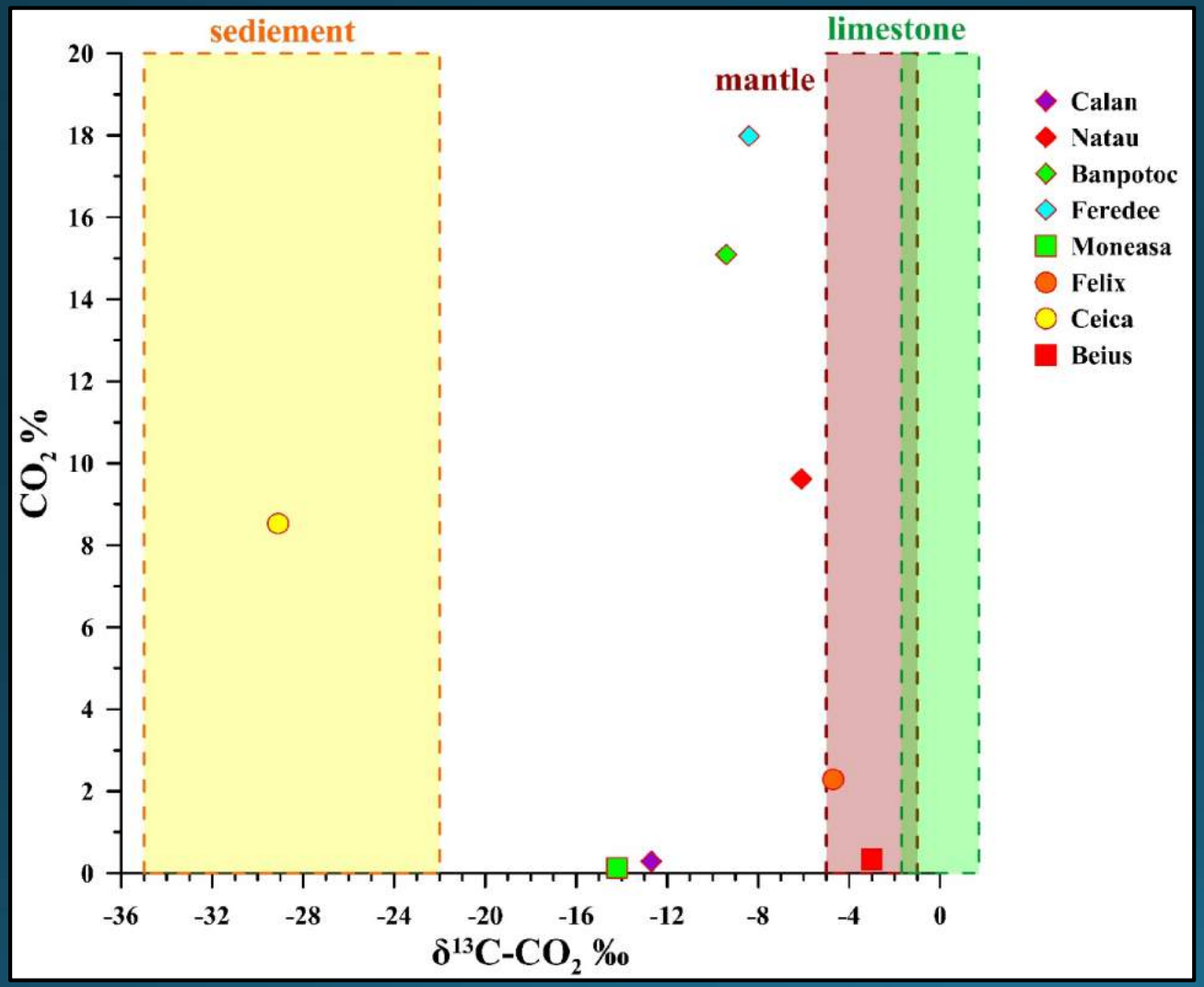
Results



- Sources from the southern part of the Apuseni Mountains contain CO_2, probably from inorganic sources, while moving towards the north the isotopic composition of CO_2 shifts towards organic/sedimentary origin.

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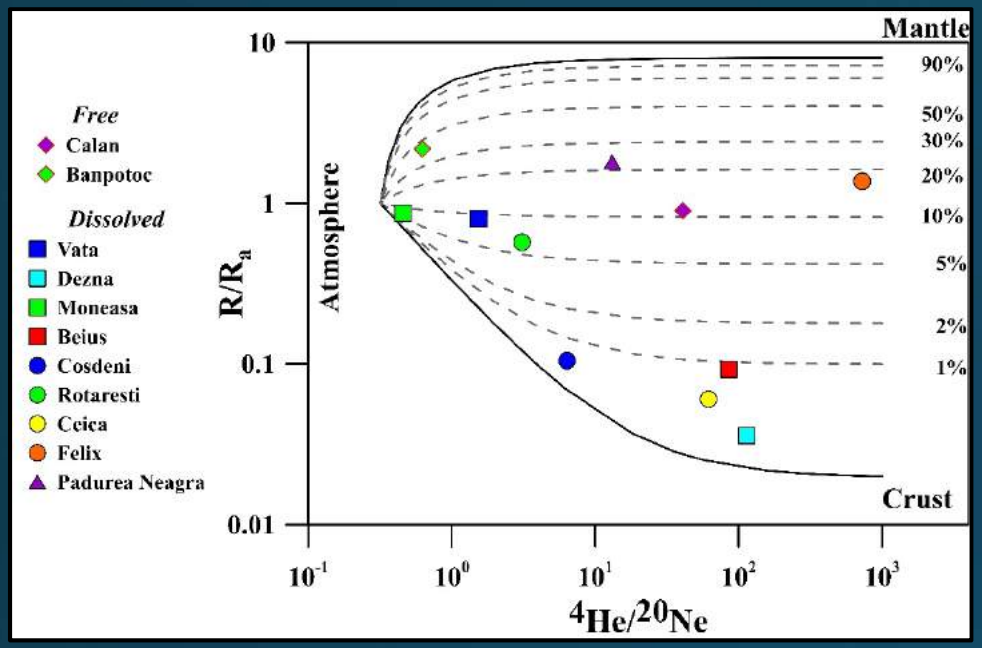
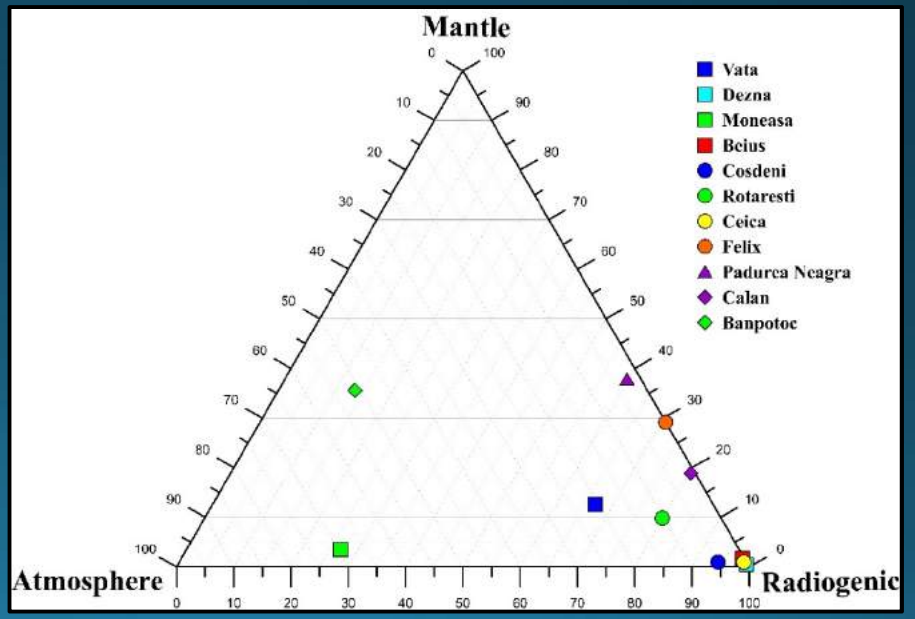
Results



- All the samples are mainly crustal some are purely crustal (those with mantle <1%) and others have a significant mantle contribution (SE part);
- Local end-member in the case of $^{3}He/^{4}He$ could be considered the Banpotoc sample ($R/R_a = 2.18$).

- The helium/neon isotopic ratio suggests that the majority of the samples are of radiogenic (crustal) origin;
- Only two samples are different: Moneasa which is mainly of atmospheric origin, and Banpotoc which has a important contribution of mantle helium.



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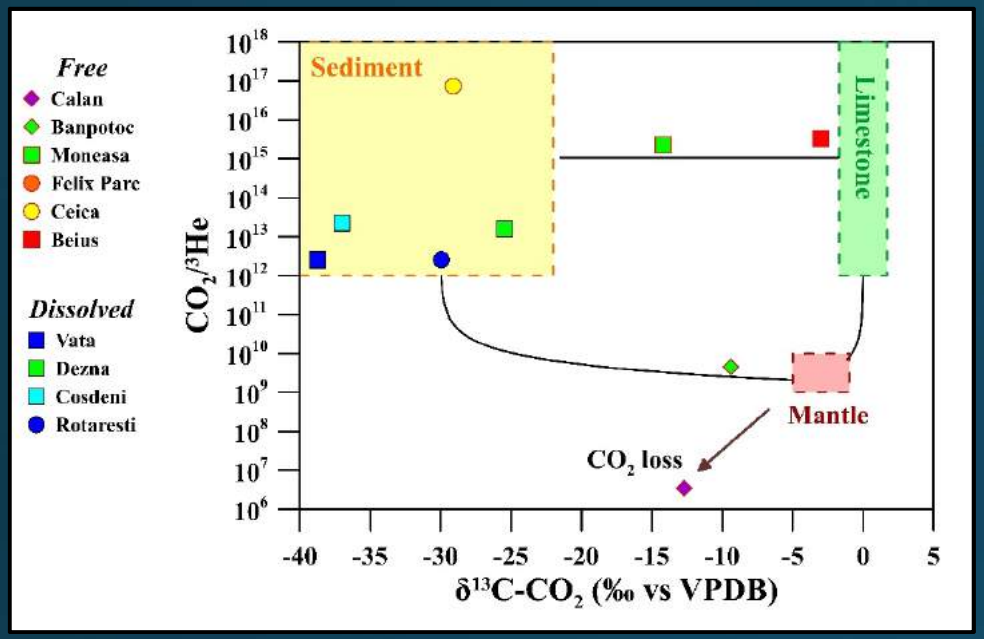
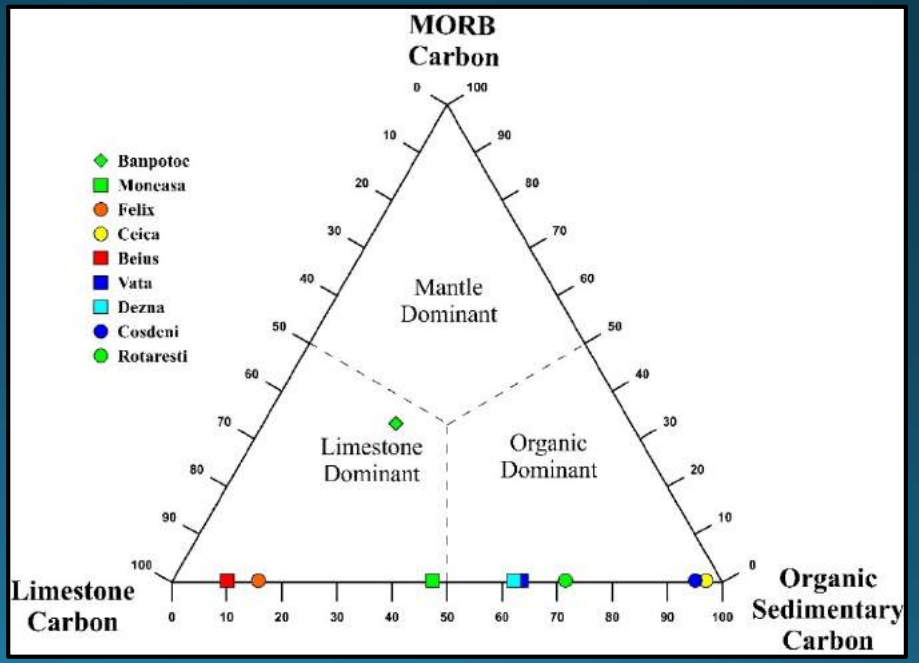
Results



- $\delta^{13}C\text{-}CO_2$ ranges from -38.7 to -3 ‰ vs. V-PDB;
- Similarity to helium, CO_2 has a mainly crustal origin, but the $CO_2/^3He$ ratio for some samples indicate significant mantle contribution;
- The sample of Calan is likely affected by extreme loss of CO_2 due to precipitation of calcite.

- The same calculation done in the case of carbon-13 in CO_2 the sites are spilt between a dominant limestone and organic/sedimentary carbon source;
- Banpotoc sample shows significant input of mantle carbon.



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Conclusions

- Calcium-bicarbonate and sodium-bicarbonate types are the most common waters in the system;
- The whole system is supplied by the infiltration of meteoric water;
- The waters in the southern area of the Apuseni Mountains show high CO_2 content with a significant mantle contribution for both helium and carbon;
- In the NW part of the study area the waters interact with hydrocarbon reservoirs, and show high content of CH_4;
- The geothermal systems from the study area show different features: the southern part seems to be mainly linked to the Neogene volcanism of the Southern Apuseni Mts., while the northern part is influenced by the Pannonian basin.