Characterization and Origin of karstic thermal waters of the North Eastern part of Algeria

Touhami FERAGA , Séverin PISTRE , Jean-Luc SEIDEL, Christelle BATIOT , Véronique DE MONTETY .
UMR 5569 Laboratory HydroSciences, HSM - University of Montpellier - CNRS - IRD, 163 street Auguste Broussonnet, 34090 MONTPELLIER, France

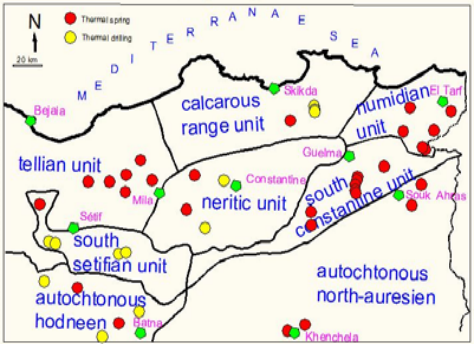
Objectives:

- Thermal spring survey of NE Algeria
- Internal and external geotectonic factors of the thermal water uprising
- Hydrodymic functionning of the aquifersystems supplying the thermal springs
- Hydrochemical characteristics of the thermal waters.

Study Area:

- North-east of Algeria: NW of Bejaia to the Tunisian border
- Surface area 56 000 km² area..
- Climate : humid in the coastal zone and semi-arid in the Tellian Atlas.
- Algerian alpine range is constituted by superposed heterogeneous series from Trias to Eocene, partially masked by a Mio-Pliocene sedimentation.
- Two sampling campaigns and hydrochemical analyses of 51 water sites

Principal geological units



Triassic deposits Gypso-saliferous diapirs are characterized by clayey-gypso-saliferous diapirs in all the geological units.

Calcareous range unit
Paleozoic to Lutetian limestone.
Neritic unit
Jurassic to Cretaceous limestone.
South Constantinois unit
Jurassic-Cretaceous-Eocene marly limestone
Setifian unit
Jurassic-Cretaceous-Eocene limestone.
Tellian unit
Jurassic to Eocene marly limestone and limestone
Autochtonous unit
Jurassic to Eocene limestone
Numidian unit
Aquitano-Burdigalian clays and numidian sandstones.

Geophysics:

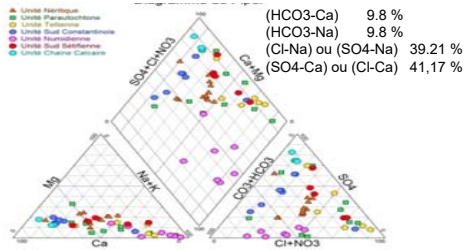
Electrical and seismic prospections ⟶ thermal springs emerge along major faults or unconformable contacts

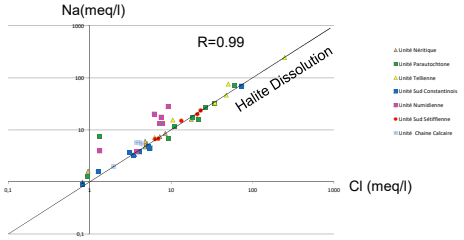
Temperature:

Facies	Temperature	Conductivity
(HCO3-Ca)	30,4 - 36,3 °C	714 - 1231 µS/cm
(HCO3-Na)	35,2 -66,4°C	665 - 2880 µS/cm
(SO4-Ca) ou (Cl-Ca)	30 - 93,3°C	874 - 4210 µS/cm
(Cl-Na) ou (SO4-Na)	29,8 - 63°C	1361 - 26600 µS/cm

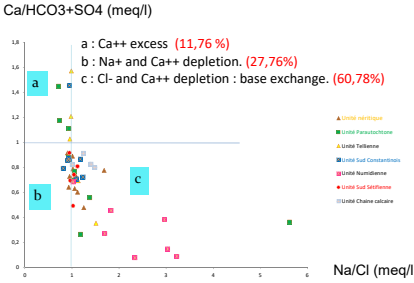
Results:

Facies of the thermal waters

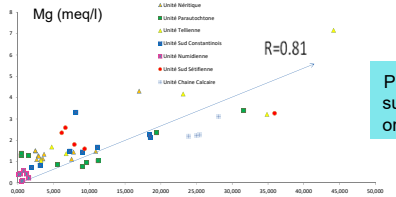




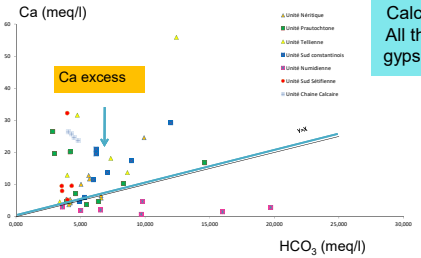
Fit of Major part of thermal waters with the halite dissolution line. Na enrichment for the Numidian unit water is probably the result of a cationic exchange with clay levels.



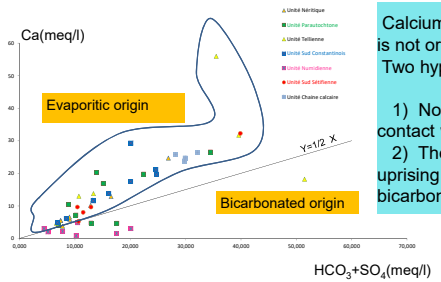
60.76 % of water points are subjected to base exchange
27.76 % of water points exhibit a Ca and Na depletion
11.76 % of water points exhibit a Ca excess with respect to bicarbonate and sulphate ions
Water-rock interactions confirm the presence of evaporitic series and base exchange processes



Proportional evolution of sulphate and magnesium suggests a magnesium sulphate dissolution of saliferous origin (Trias evaporites).



Calcium depletion for the Numidian unit waters
All the other water points exhibit a Ca excess inferred to gypsum dissolution.



Calcium originates essentially from sulphate dissolution and is not or poorly related to bicarbonate dissolution.
Two hypotheses can explain this differenciation :

1) North Eastern Algeria waters do not stay enough time in contact with carbonated rocks.
2) Thermal waters can precipitate calcite during their uprising to the surface becoming impoverished in bicarbonate.

Conclusion:

Four water groups have been characterized:

1) Hypothermal waters with a (HCO_3-Ca) facies, weakly mineralised = rapid circulation inside carbonated reservoirs
2) Mesothermal waters with a (HCO_3-Na) facies, weakly or moderately mineralised = base exchange between water and clayey levels
3) Hyperthermal waters with a (Cl-Na) facies, highly mineralised = deep circulation and chemical exchange with an evaporitic and sedimentary bedrock
4) Hyperthermal waters with a (SO_4-Ca) facies, highly mineralised = deep circulation in contact with Triassic formations