Géosciences pour une Terre durable

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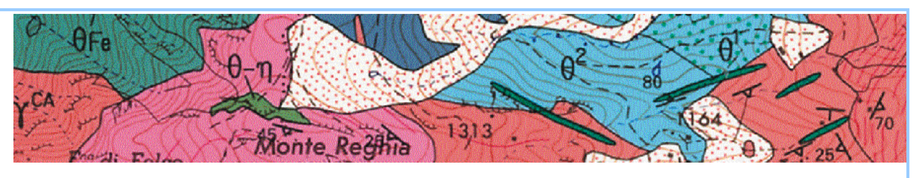

Groundwater resources in Mediterranean karst

From karstification setting to current functioning illustrated with examples

Facing the scarcity due to an arid or semi-arid climate predominating over 43 % of the Mediterranean Basin, and the overexploitation of the surface water, it is necessary, in order to satisfy the increasing water demands, to proceed to a sustainable groundwater management. Mediterranean karstic aquifers are widely presents in the surrounding of Mediterranean Sea (Figure 1); they are either coastal or continental. They are reservoirs of groundwater that are largely under exploited and constitute then future groundwater resource. For water management of this karstic aquifer an hydrogeological study of each system is necessary.

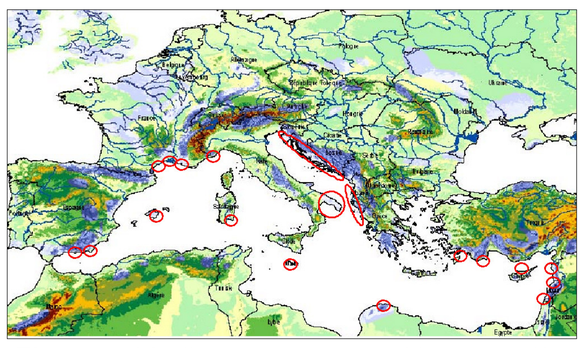

Figure 1. Mediterranean coastal karst aquifer

Methodology

The water management of karstic aquifers request to have good knowledge about the structure and the functioning.

➢Structure :

Structure is linked directly to the geological framework, but also to the karstification development. The karstic system genesis along the Mediterranean basin has been strongly influenced by the basis level variations, due to the sea level fluctuations and regional geodynamic events (Figure 2). This is one reason for having coastal karst aquifers with submarine springs as outlets (Figure 3). Sea level variations have two origins : either due to climate or to Messinian salinity crisis. In first case sea level felt down 120 m deep in quaternary, in second case the fall recorded was 1500 m deep.

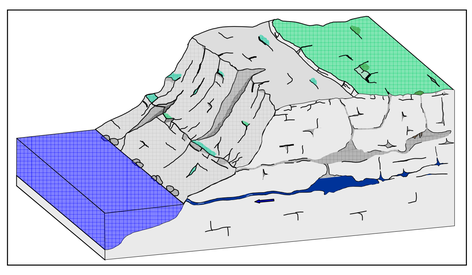

Figure 2. Network development with sea level relation

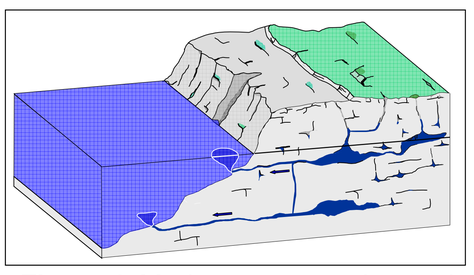

Figure 3. Marine transgression and submarine spring

Studying karst aquifers within their geological and geodynamic sedimentary basin framework allows getting information about the karstification potential development. This is one key of the characterisation of karst aquifers. Several deep conduit has been observed : Chekka deep submarine spring (Lebanon) : – 165 m, Port-Miou conduit (France) explored until – 148 m NGF, Fontaine de Vaucluse (France) conduit surveyed until - 223 m NGF, Fontestramar conduit (France) explored until – 164 m NGF (Figure 4).

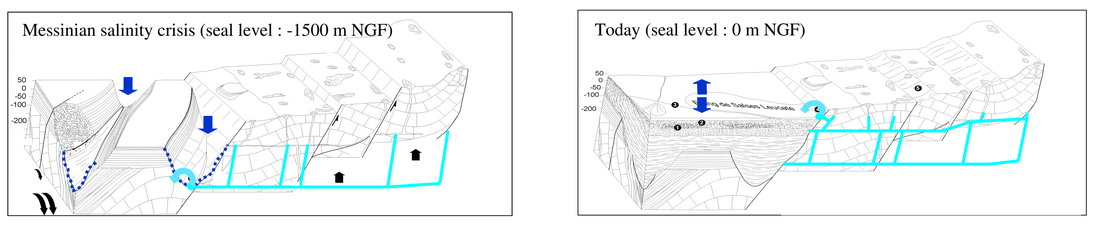

Figure 4. Evolution of Fontestramar karst system structure and functioning (Aunay, 2004)

➢Functionning :

The aquifer study is based on data treatment of rainfall, spring hydrograph (Figure 5) and chemiogram (Figure 6), natural or artificial tracing (Figure 7), with a set of analytical tools (time series analysis, autocorrelation method, cross correlation, recession curve analysis, sorted spring discharge) to get knowledge about the functioning and to assess the water resources of karst systems. Data must be obtained at least on two hydrological year either on land spring or on submarine spring for coastal aquifer. These methods allow getting information about :

→ the presence or not of groundwater resources in the saturated zone
→ the inertia of the system
→ swallow holes / water losses
→ the volume stored water the saturated zone that can be released from storage

These information permit to develop a conceptual model of functioning.

Figure 5. Cent Font hydrograph

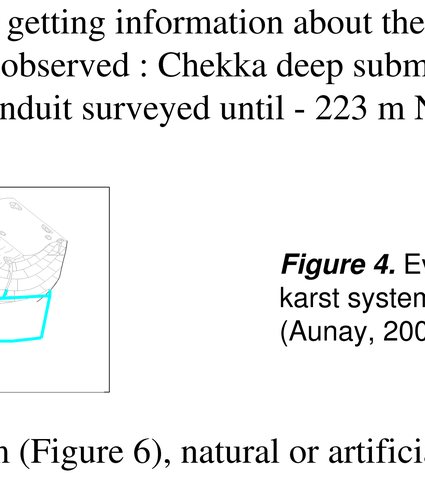

Figure 6. *Cent Fonts chemiogram*

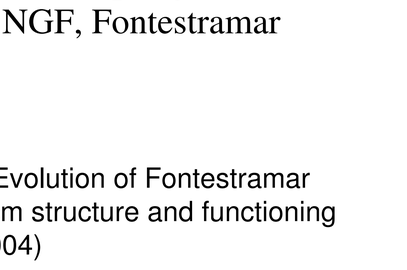

Figure 7. Tracing test

Numerical model validation

The conceptual model can be used for numerical simulating using for exemple reservoir model (Figure 7). It permits discharge prediction

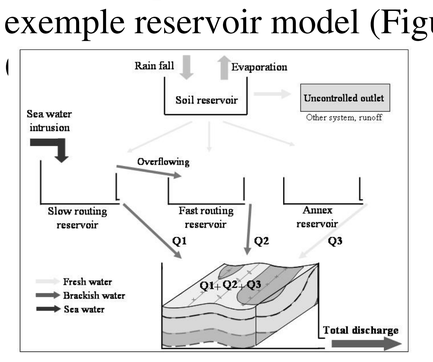

Figure 7. Reservoir model define on Moraig brackish submarine spring (Spain) (Fleury, 2006)

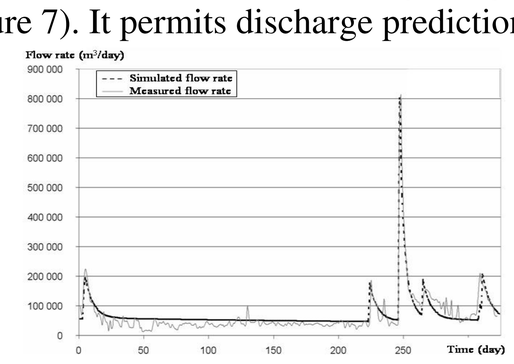

Figure 8. Discharge measured and simulated at Moraig spring (Fleury, 2006)

Also inverse modelling can be carried out taking into consideration recharge such as rainfall and water losses of a river, but also pre-event and event water characterized by natural tracers (Figure 9 and 10).

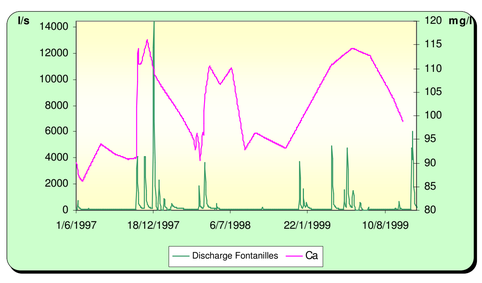

Figure 9. Ca concentration simulating by inverse modelling of Cent Fonts

In this case Ca is the event water and Mg the preevent water. It represents the contribution of two parts of the aquifer (20 % from epikarst and 80 % from saturated zone).

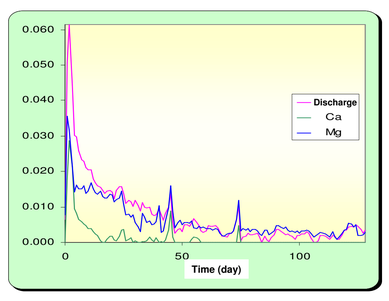

Figure 10. Impulse functions of discharge, Ca and Mg of a Cent Fonts karst system

Conclusions and perspectives

Study of karst aquifer implies multidisciplinary approach with geology and hydrology, that means a good knowledge of the structure and functioning.
Karstic aquifers represent an important groundwater resource for Mediterranean countries. The coastal karstic aquifers are strongly linked with sea. Due to this relation, aquifer resources are very sensitive. For example an overexploitation could modify equilibrium between freshwater and seawater and then cause an inflow of sea water in aquifer. It would damage dramatically groundwater resource.
Also the actual equilibrium between freshwater and seawater could be broken with a rise of seawater level (climatic scenario). So the link with sea represent also a possible source of pollution for karst aquifer, one more reason to emphasize the hydrogeological study.
Karst aquifers can also be used for water supply by an active water management and also for mitigation of flooding risk (temporary overexploitation by pumping).

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This work was undertaken as part of the BRGM-funded research project **COMPLEX'AQUI** and with the financial support of the european project **MEDITATE** (project INCO MPC-1 PL509112).

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