

# XXXVIII IAH Congress

**Groundwater Quality Sustainability  
Krakow, 12–17 September 2010**

## **Extended Abstracts**

**Editors:  
Andrzej Zuber  
Jarosław Kania  
Ewa Kmiecik**



**University  
of Silesia  
Press 2010**

abstract id: **204**

topic: **1**  
**Groundwater quality sustainability**

**1.1**  
**Evaluation and management of groundwater — sustainable exploitation**

title: **Geochemical, multi-isotopic and hydrogeological characterization of the mineralized groundwater body of the Entre-deux-Mers area, Gironde (South-West of France)**

author(s): **Eline Malcuit**  
(1) BRGM,  
(2) Institut EGID — Université Bordeaux 3, France, e.malcuit@brgm.fr

**Philippe Négrel**  
BRGM, France, p.negrel@brgm.fr

**Emmanuelle Petelet-Giraud**  
BRGM, France, e.petelet@brgm.fr

**Olivier Atteia**  
Institut EGID — Université Bordeaux 3, France,  
Olivier.Atteia@egid.u-bordeaux3.fr

**Michel Franceschi**  
Institut EGID — Université Bordeaux 3, France,  
Michel.Franceschi@egid.u-bordeaux3.fr

**Alain Dupuy**  
Institut EGID — Université Bordeaux 3, France,  
alain.dupuy@egid.u-bordeaux3.fr

**François Larroque**  
Institut EGID — Université Bordeaux 3, France,  
Francois.Larroque@egid.u-bordeaux3.fr

**Sabine Schmidt**  
EPOC — CNRS — Université Bordeaux 1, France,  
s.schmidt@epoc.u-bordeaux1.fr

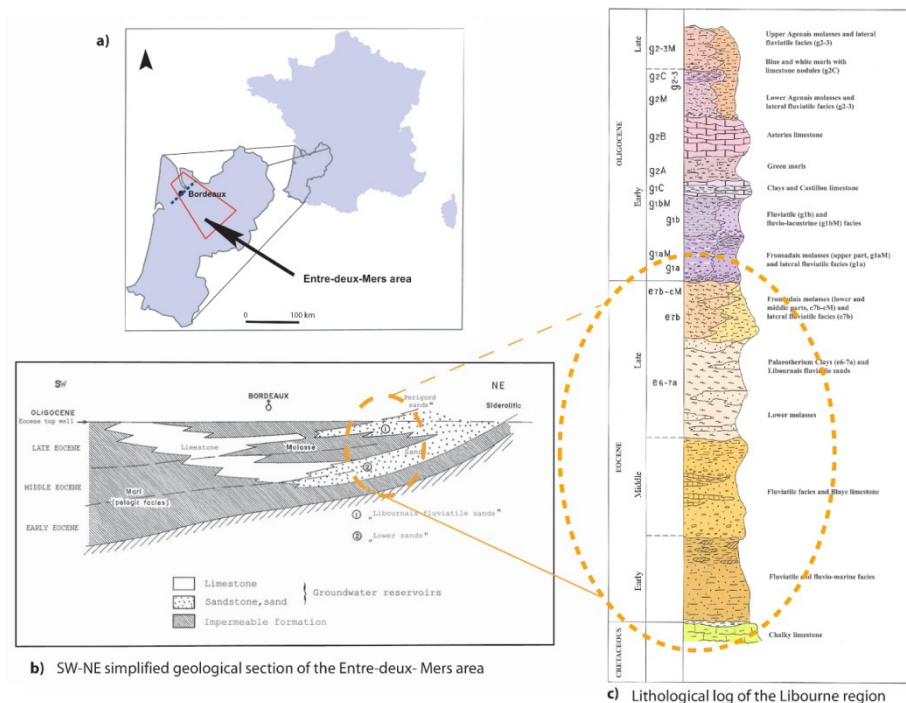
**Pierre Marchet**  
Agence de l'Eau Adour-Garonne, France,  
pierre.marchet@eau-adour-garonne.fr

keywords: geochemistry, multi-isotopes, hydrogeology, salinity

## INTRODUCTION AND OBJECTIVES

In the south-west of France, the Eocene aquifer is one of the main resources for irrigation, thermo-mineral water, and mainly for drinking water in the Bordeaux region.

This aquifer is characterized by the presence of a large saline area (Fig. 1a), centered on the Entre-deux-Mers area, between the Garonne and the Dordogne rivers, where the ground waters show strong mineralization and anomalous levels of critical elements (Chery, 1993; Chery et al., 1994 and Corbier et al., 2005), such as sulfates and fluoride, leading to difficulties of resource exploitation for drinking water supply.



**Figure 1.** a) Location of the Entre-deux-Mers area, b) SW-NE simplified geological section, c) Lithological log of the Libourne region.

Initiated in 2009, the CARISMEAU 2 project, funded by the Bureau de Recherches Géologiques et Minières (BRGM), the Institut EGID — University Bordeaux 3 and the French Water Agency Adour-Garonne (AEAG), focuses on the geochemical, multi-isotopic and hydrogeological characterization of this mineralized groundwater sector of the Entre-deux-Mers area. Its main objectives are to improve the understanding of the origin of the salinity in this mineralized area and to investigate how these waters circulate in the Eocene aquifer and more largely in the multi-layer aquifer system.

## GEOLOGICAL AND HYDROGEOLOGICAL SETTINGS

The deposit sequences characterizing the Eocene aquifer system are progradational westward (Fig. 1b), from detrital deposits (Fig. 1c) to carbonates. The Eocene sands and the Eocene limes-

tones are hydraulically connected, the limit of their extension is located under the city of Bordeaux (Dubreuilh, 1987 and Moussié, 1972). The groundwater recharge may occur through the Eocene outcrops located in the north and north-east of this mineralized area of the Entre-deux-Mers, and also by vertical leakage from the Oligocene aquifer.

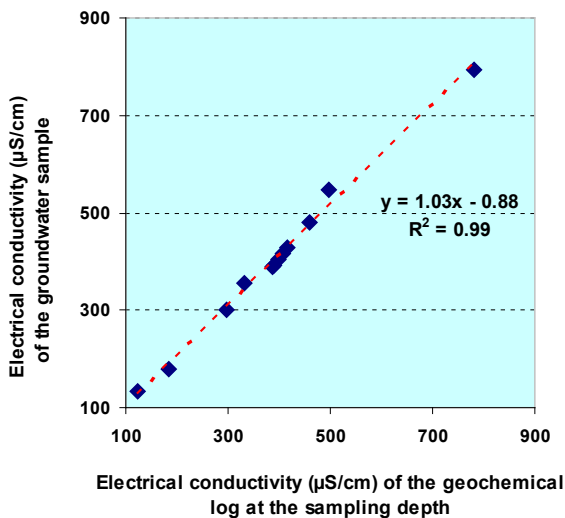
Furthermore, the second aspect to consider in this saline area concerns the piezometric evolution of the Eocene aquifer years after years. In fact, a trough in the potentiometric surface is noticeable for the Eocene Aquifer, centred under the city of Bordeaux (Corbier et al., 2005). For years, the decline of the piezometric surface is roughly one meter per year in the center. The cone of pressure relief in this confined aquifer stretches to the east year after year in the same direction, toward the Garonne and the Dordogne rivers. Moreover, two groundwater ridges separate the trough in the Early and Middle Eocene potentiometric surface from the Atlantic Ocean in the South-West and from the Gironde estuary in the North-West.

### GROUNDWATER SAMPLING AND ANALYTICAL METHODS

In order to improve the understanding of the origin of the salinity and to investigate how these waters circulate, combined geochemical analyses (major and trace elements) and classical isotopic methods using  $\delta^{18}\text{O}_{\text{H}_2\text{O}}$  and  $\delta^2\text{H}_{\text{H}_2\text{O}}$ ,  $\delta^{34}\text{S}_{\text{SO}_4}$  and  $\delta^{18}\text{O}_{\text{SO}_4}$  are carried out. In addition, an innovative isotopic method using strontium isotopes ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) and more exploratory isotopic methods using boron ( $\delta^{11}\text{B}$ ), lithium ( $\delta^7\text{Li}$ ), uranium ( $^{234}\text{U}/^{238}\text{U}$ ) and radium ( $^{228}\text{Ra}/^{226}\text{Ra}$ ) isotopes will be applied on the mineralized area (Négreil et al., 2006, 2007, 2008 and Malcuit et al., 2008).

The first investigation, carried out from September to December 2009, allowed the characterization of about 50 groundwater sampling points in the mineralized area.

The water samples were collected after measurement of their physical-chemical parameters *in situ*. Furthermore, for the wells without any pump completion, a geochemical logging has been done. These geochemical logging have validated the representativeness of abstracted water (Fig. 2).



**Figure 2.** Correlation between the electrical conductivity measured in the wells and conductivity of the sampled groundwaters.

In addition the *in situ* parameters (pH, temperature, electrical conductivity, dissolved oxygen, redox potential, and fluoride concentration) have helped to better characterize the actual hydrogeological and geochemical status of the drillings.

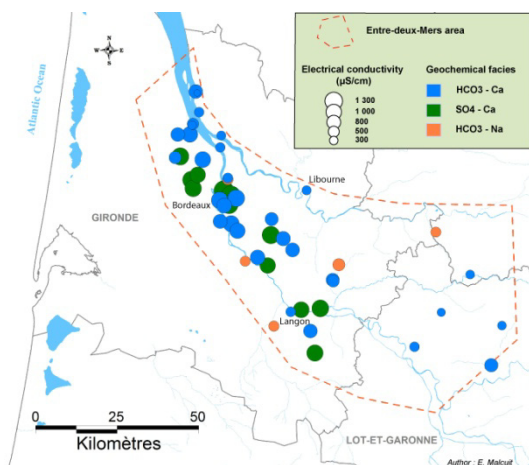
## RESULTS

### Spatial distribution of the mineralized ground waters

The *in situ* electrical conductivity ranges from 130-1630  $\mu\text{S}/\text{cm}$  (Fig. 3). It allows to characterize three highly mineralized areas: the first, centered in Bordeaux and the north-west vicinity of the city; the second in the Entre-deux-Mers area and the last one, in the south-east of the studied area, near the town of Langon.

### The geochemical facies

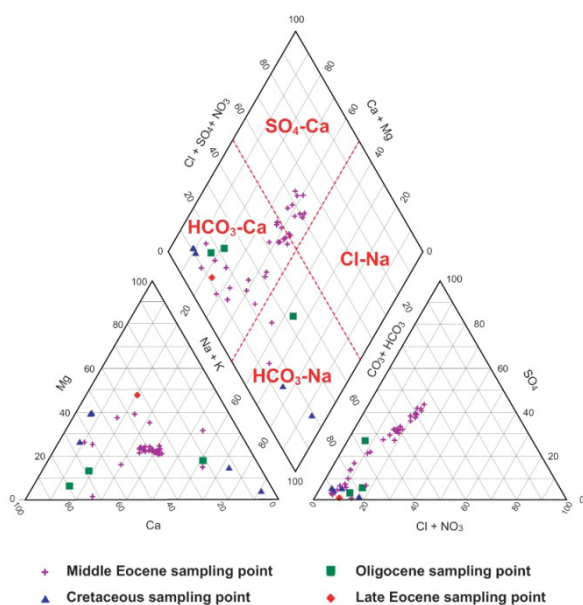
Most of the abstracted groundwaters show a  $\text{HCO}_3\text{-Ca}$  water type (Fig. 4), in agreement with the interaction between the waters and the carbonates rocks of the Aquitaine Basin. However, 12 of the analysed groundwaters have a sulphated-calcic type: these samples are all from the Middle Eocene aquifer. The Piper diagram (Fig. 4.) shows how the Middle Eocene groundwaters are influenced by the sulphates concentration, at the difference of the aquifers over or under the Middle Eocene. We hypothesize these results of the influence of gypsum deposits.



**Figure 3.** Groundwater sampling sites of the first investigation, their electrical conductivity and their geochemical water type.

The spatial distribution of geochemical water types (Fig. 3) indicates that the sulphated-calcic type coincides with the three most mineralized areas, although the bicarbonated-calcic type is the main one in the studied area.

In addition, groundwaters in the saline area with a sulphate concentration exceeding the potability standard also display a fluoride content above the standard. Among the 50 sampling points, 3 exceed drinking water standard for sulphate concentration (e.g. 250 mg/l) and 12 for fluoride (e.g. 1.5 mg/l). All these points correspond to boreholes used for drinking water.



**Figure 4.** Piper diagram of the sampling points.

### Spatial and temporal evolutions/variations of the water quality

Over the past 20 years, the boreholes used for drinking water in the Entre-deux-Mers have presented variations of the water quality and contrasting trends can be highlighted.

A first characterization has been done by comparing the electrical conductivity of the water and chlorides, sulphates and fluorides contents. These four parameters do not always present identical trends. For example some groundwaters show an increase, others a significant decline. But most do not indicate any specific trends.

So far the observed trends do not seem to depend on geographical location or on the excessive mineralization of waters. Further investigations are needed to better understand these results.

### CONCLUSION

Ongoing analyses of major elements confirm the salinity variation in the groundwater system in the Entre-deux-Mers (S-W France). The first results of geochemical analysis and multi-isotope combination will be presented at the conference so as to improve our understanding of the origin of these elements, their behaviour and migration in aquifers.

### REFERENCES

Chery L., 1993: *Interprétation des résultats des analyses isotopiques. Etude de la salinité verticale de l'Eocène moyen dans la zone bordelaise (Gironde)*. BRGM/RR-37732-FR, 36 pages, 1 annexe. (Interpretation of the isotopic analyses results. Study of the vertical salinity of the Middle Eocene in the Bordeaux region).

Chery L., Dusseau P., Sourisseau B., 1994: *Diagnostic de l'accroissement de la salinité des nappes profondes de l'Eocène moyen en Gironde. Programmes de la Communauté Urbaine de Bordeaux (CUB) et du Fond National de développement de l'Assainissement et de l'Eau (FNDAE)*. BRGM/RR-37998-FR, 56 p., 38 fig., 8 tabl., 28 annexes. (Diagnosis of the salinity increasing in the deep aquifers in Gironde. CUB and FNDAE programmes).

Corbier P., Winckel A., Mazurier C., Mauroux B., Platel J.P., Benhammouda S., Dufour P., 2005: *Contrôle qualité et gestion des nappes d'eaux souterraines en Gironde. Année 2004. Investigations préalables à la mise en place d'un réseau qualité sur la nappe de l'Eocène inférieur à moyen du domaine minéralisé. Rapport final*. BRGM/RP-53973-FR. (Quality control and management of the Gironde groundwaters bodies. 2004. Preliminary investigations before setting up the quality network of the Early and Middle Aquifer in the mineralized area. Final report).

Dubreuilh J., 1987: *Synthèse paléogéographique et structurale des dépôts fluviatiles tertiaires du nord du bassin d'Aquitaine. Passage aux formations palustres, lacustres et marines*. Thèse de Doctorat d'Etat. BRGM n°172. 393 pages. (Paleogeographic and structural synthesis of Tertiary fluviatile deposits in the north of the Aquitaine Basin. PhD).

Malcuit E., Négrel Ph., Petelet-Giraud E., Gandolfi J.M., Pédrón N., Brenot A., 2008: *Caractérisation isotopique et géochimique des masses d'eau dans le Bassin Adour-Garonne : interconnexions et hétérogénéités - CARISMEAU. Rapport final. Tome 2: Approche couplée hydrogéologique et géochimique isotopique des Sables Infra-Molassiques du Bassin Adour-Garonne. Rapport BRGM/RP-56737-FR, 136 pages, 74 illustrations, 3 annexes*. (Characterising of water bodies in the Adour-Garonne district by multi-isotopic and geochemical approaches: interconnections and heterogeneities - The CARISMEAU research project. Final report. Part 2. Hydrogeological, geochemical and multi-isotopic approaches of the Infra-Molassic Sands of the Adour-Garonne Basin).

Moussié B., 1972: *Le système aquifère de l'Eocène moyen et supérieur du Bassin Nord-Aquitain. Influence du cadre géologique sur les modalités de circulation*. Thèse, Université de Bordeaux, 100 pages. (The Middle and Late Eocene aquifer system in the north of the Aquitaine Basin. Influence of the geological framework on the water circulation conditions. PhD. Bordeaux University).

Négrel Ph., Colin A., Petelet-Giraud E., Brenot A., Millot R., Roy S., 2006: *CARISMEAU : Caractérisation isotopique et géochimique des masses d'eau dans le bassin Adour Garonne : interconnexions et hétérogénéités - CARISMEAU. Rapport de phase 1*. Rapport BGRM/RP-55069-FR, 128 pages, 62 illustrations. (Characterising of water bodies in the Adour-Garonne district by multi-isotopic and geochemical approaches: interconnections and heterogeneities - The CARISMEAU research project. First report).

Négrel Ph., Petelet-Giraud E., Brenot A., Millot R., Innocent C., 2008: *Caractérisation isotopique et géochimique des masses d'eau dans le bassin Adour-Garonne : interconnexions et hétérogénéités - CARISMEAU. Rapport final. Tome 1: Les outils isotopiques appliqués à la gestion des ressources en eau. Exemple de la masse d'eau des Sables Infra-Molassiques*. Rapport BRGM/RP-56291-FR, 194 pages, 44 illustrations. (Characterising of water bodies in the Adour-Garonne district by multi-isotopic and geochemical approaches: interconnections and heterogeneities - The CARISMEAU research project. Final report. Part 1. Isotopic tools used to the management of water resources. Example of the Infra-Molassic Sands water body).

Négrel Ph., Petelet-Giraud E., Brenot A., Millot R., Roy S., Dutartre Ph., Fournier I., 2007: *Multi isotopic and geochemical constraints of interconnection and heterogeneities of water bodies in the Adour-Garonne district (SW France) - The CARISMEAU research project*. International Symposium on Advances in Isotope Hydrology and its Role in Sustainable Water Resources Management (IHS-2007); 21 – 25 May 2007 Vienna, Austria. IAEA-CN-151.

Négrel Ph., Roy S., Petelet-Giraud E., Brenot A., Millot R., Dutartre Ph., Fournier I., 2008: *Application des outils de diagraphie chimique à la caractérisation des masses d'eau. Techniques - Sciences -Méthodes*. 20 pages. (Geochemical loggings tools applied to water bodies characterisation).





**International Association of Hydrogeologists**



**AGH University of Science and Technology**

**2-vol. set + CD**  
**ISSN 0208-6336**  
**ISBN 978-83-226-1979-0**