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: **460**

topic: **6**
General hydrogeological problems

6.1
Hard rocks as specific media — methods and results

title: **Exploring groundwater in weathered crystalline basement areas: a method integrating geomorphologic, geologic and geophysic approach**

author(s): **Robert Wyns**
BRGM, France, r.wyns@brgm.fr

Jean-Marie Gandolfi
BRGM, France, jm.gandolfi@brgm.fr

Pierre-Clément Damy
BRGM, France, pc.damy@brgm.fr

Frédéric Touchard
BRGM, France, f.touchard@brgm.fr

Maritxu Saplairoles
BRGM, France, m.saplairoles@brgm.fr

Bernard Monod
BRGM, France, b.monod@brgm.fr

Isabelle Bouroullec
BRGM, France, i.bouroullec@brgm.fr

Caroline Prognon
BRGM, France, c.prognon@brgm.fr

keywords: hardrocks, weathering, fissured layer, weathering aquifers, Magnetic Resonance Sounding

In most of crystalline basement areas, aquifers are stratiform and linked to old weathering profiles (Wyns et al., 2004; Lachassagne et al., 2001, 2006; Maréchal et al., 2003, 2004; Cho et al., 2003; Dewandel et al., 2006). 80 to 90 % of groundwater reserve is located in a fissured layer (figure 1), the deepest horizon of weathering profiles, where porosity and permeability result from cracks related to inflation of some minerals (biotite, pyroxenes, olivine…) during weathering.

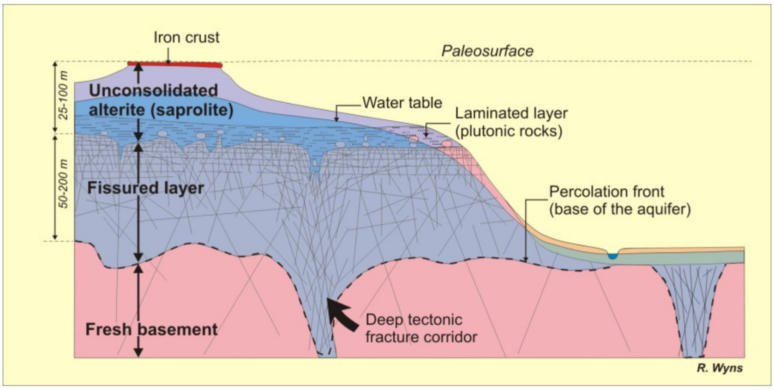

Figure 1. Conceptual cross-section of paleoweathering profile showing stratiform aquifer (after Wyns et al., 2004).

In French Massif Central, a survey is being carried out in order to establish a map of groundwater potentialities. The basement rocks, hercynian in age, are made up of granitoids, gneisses and micaschists.

The first stage of the study is to attribute a note of favourability to each geological formation, according to rock content in inflatable minerals, using 1/250,000 scale geological map. In Limousin area, the geological formations have been classified in 6 classes, according to their ability to develop a thick fissured layer (table 1):

Table1. Classification of the geological formations of Limousin areaaccording to their favourability to develop a weathering aquifer.

code	Legend
0	Formations that are not concerned by weathering aquifers (sedimentary formations, surficial deposits, veins)
1	Unfavourable (acidic volcanics, rocks without micas)
2	Low favourability (amphibolites, muscovite-bearing granites)
3	Favourable (2-micas granites, micaschists, leucocratic gneisses)
4	Very favourable (biotite-bearing granites, biotite gneisses)
5	Extremely favourable (diorites, granodiorites)

The second stage is to identify the age of the weathering through the realisation of a map of palaeosurfaces, in order to predict the evolution of the porosity resulting of geological evolution of the region.

Five weathering profiles, associated with palaeosurfaces, have been identified in the study area: an infra-Stephanian profile, an infra-Permian profile, an infra-Liassic profile, an Early Cretaceous profile, and an Eocene profile. In all profiles anterior to Liassic deposits, the porosity of the aquifers has been sealed by crystallisation of carbonates and sulphates, due to burying below a thick sedimentary cover and to additive weathering (calcrete, dolocrete) prior to Liassic transgression. Only Early Cretaceous and Tertiary weathering profiles are considered as favourable for the preservation of open porosity in the fissured layer.

The final map (figure 2) results from crossing the favourability map (stage 1) with geomorphologic map (stage 2). It gives the location of geologic formations where weathering aquifers, if preserved from recent erosion, have retained an open porosity up to now.

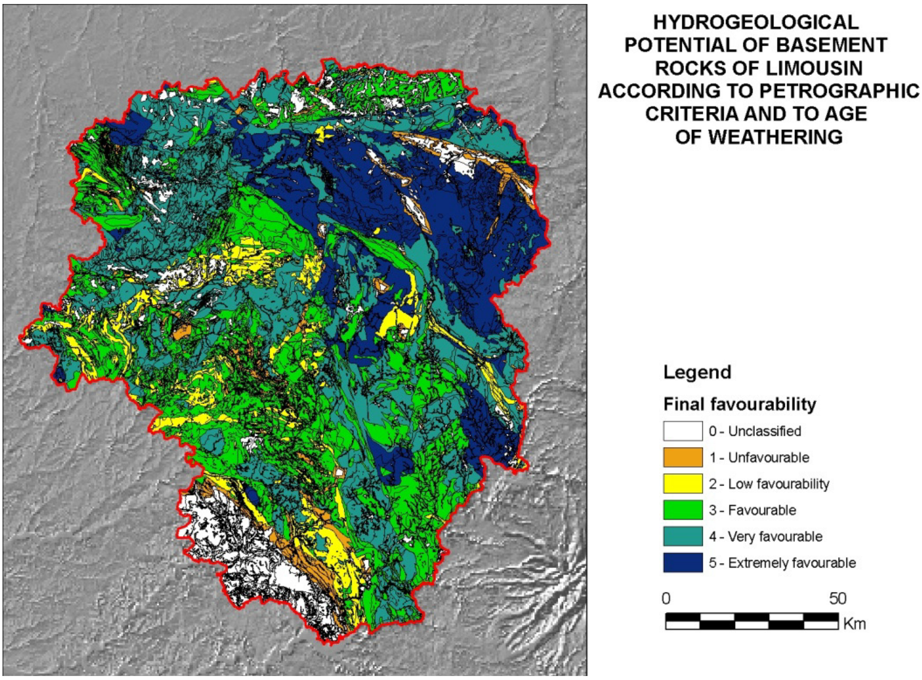

Figure 2. Final map of groundwater potential for Limousin region.

In a further stage, characterization and quantification of aquifers will be carried out in selected favourable zones: geometric modelling of the aquifers and water table, coupled with Proton Magnetic Resonance Sounding (Wyns et al., 2004; Baltassat et al., 2005), will conduct to groundwater reserve mapping (figure 3). These maps will be relevant for localisation of water reserves and for mean characteristics of aquifers (3D modelling of porosity and permeability at the scale of large zones (100 to 1000 km^2 and more), in order to better plan the management of groundwater and surface water.

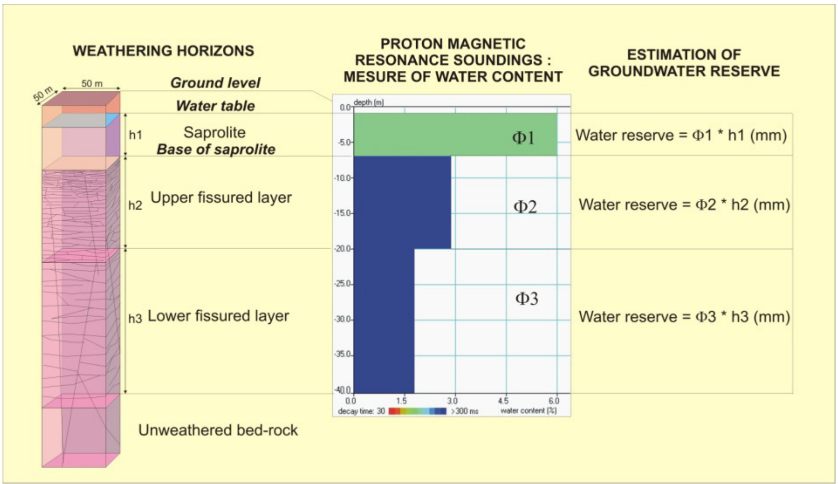

Figure 3. Principle of groundwater reserve mapping using geometric modelling of aquifer coupled with Proton Magnetic Resonance Soundings (From Wyns et al., 2004).

Groundwater reserve mapping has been carried out in numerous areas of western France since 1998. An example is shown in figure 4 (Chemillé 1:50,000 map, Maine et Loire).

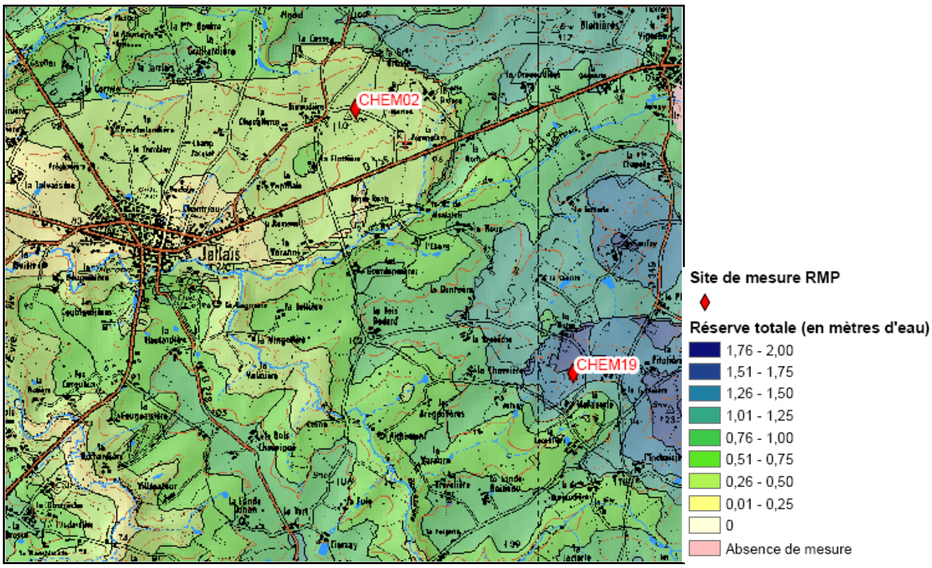

Figure 4. Example of groundwater reserve map in micaschists (East of Nantes, France).

REFERENCES

Baltassat J.M., Legchenko A., Ambroise B., Mathieu F., Lachassagne P., Wyns R., Mercier.J.L., Schott.J.J., 2005: *Magnetic resonance sounding (MRS) and resistivity characterization of a mountain hard rock aquifer: the Ringelbach catchment, Vosges massif, France*. Near Surface Geophysics, 3, n° 4, pp. 267-274.

Cho M., Choi Y.S., Ha K.K.C., Kee W.S., Lachassagne P., Wyns R., 2003: *Paleoweathering covers in korean hard rocks: a methodology for mapping their spatial distribution and the thickness of their constituting horizons. Applications to identify brittle deformation and to hard rock hydrogeology*. Korean institute of geoscience and mining bulletin, 6, n° 2, pp. 12-25.

Dewandel B., Lachassagne P., Wyns R., Maréchal J.C. and Krishnamurthy N.S., 2006: *A generalized hydrogeological conceptual model of granite aquifers controlled by single or multiphase weathering*. Journal of Hydrology, 330, pp. 260-284.

Lachassagne, P., Wyns R., Bérard P., Bruel T., Chéry L., Coutand T., Desprats J.F., and Le Strat P., 2001: *Exploitation of high-yield in hard-rock aquifers: Downscaling methodology combining GIS and multicriteria analysis to delineate field prospecting zones.* Ground Water, 39 (4), pp. 568-581.

Lachassagne P., Wyns R., 2006: *Généralités. 4. Aquifères de socle, (basement aquifers).* In Aquifères et Eaux souterraines en France - Roux J.C. (Ed), AIH, 2 vol., pp. 43-51, BRGM Editions.

Maréchal J.C., Dewandel B., Subrahmanyam K., 2004: *Contribution of hydraulic tests at different scales to characterize fracture network properties in the weathered-fissured layer of a hard rock aquifers.* Water Resources Res., 40, W11508.

Marechal J.C., Wyns R., Lachassagne P., Subrahmanyam K. Touchard F., 2003: *Anisotropie verticale de la perméabilité de l'horizon fissuré des aquifères de socle : concordance avec la structure géologique des profils d'altération (vertical anisotropy of permeability in fissured layer of basement aquifers : agreement with geological structure of weathering profiles).* Comptes rendus Geoscience, Vol. 335, pp. 451-460.

Wyns R., Baltassat J. M., Lachassagne P., Legchenko A., Vairon J., and Mathieu F., 2004: *Application of SNMR soundings for groundwater reserves mapping in weathered basement rocks (Brittany, France)*. Bulletin de la Société Géologique de France, 175 (1), pp. 21-34.

International Association of Hydrogeologists

AGH University of Science and Technology

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