

## 4.5.P22

**Hydro(radio)chemical relationships in Guarani aquifer, South America**

D.M. BONOTTO

Instituto de Geociências e Ciências Exatas, UNESP, Rio Claro, Brasil (dbonotto@rc.unesp.br)

This investigation, carried out within the Paraná sedimentary basin, involved the sampling of 77 pumped tubular wells and was realized with the purpose of evaluating the hydrochemistry and radioactivity due to the nuclides  $^{238}\text{U}$ ,  $^{234}\text{U}$ ,  $^{222}\text{Rn}$ ,  $^{226}\text{Ra}$ , and  $^{228}\text{Ra}$  in the Brazilian part of Guarani aquifer. Such aquifer has an average thickness of 300-400 m, being composed of silty and shaly sandstones of fluvial-lacustrine origin, and variegated quartzitic sandstones accumulated by eolian processes under desertic conditions. A thick basaltic package (up to 1,500 m) of the Serra Geral formation overlies this aquifer; it overlies previous formations ranging from the igneous basement to the Paleozoic sediments of the Passa-Dois and Tubarão Groups, being covered by Cretaceous sediments of the Bauru-Caiuá formations [1].

The data evaluation was performed considering that wells intercepting the basaltic package of the Serra Geral formation provided samples representing confined portions of the aquifer, whereas wells not cutting it supplied samples from unconfined portions of the aquifer. Several significant correlations were found involving the geostatic pressure in the confined aquifer, among them: specific flow rate, temperature, dissolved  $\text{O}_2$ , free  $\text{CO}_2$ , pH, redox potential Eh, conductivity, sodium, bicarbonate, carbonate,  $\text{SI}_{\text{calcite}}$ , chloride, fluoride, sulfate, and boron. Carbonates precipitation in the confined aquifer was evidenced by inverse correlation between  $\text{CO}_3^{2-}$  and Ca, Mg, Sr, and Ba. Uranium related directly with the specific flow rate and inversely with the  $^{234}\text{U}/^{238}\text{U}$  activity ratio in the confined aquifer. In the unconfined aquifer, the specific flow rate related inversely with  $^{222}\text{Rn}$  and directly with free  $\text{CO}_2$  and  $^{234}\text{U}/^{238}\text{U}$  activity ratio. Several significant correlations were found involving bicarbonate in the unconfined aquifer, i.e.  $\text{SI}_{\text{calcite}}$ , sodium, calcium, magnesium, strontium, and uranium.

The observed data pattern indicated influence of the underlying Paleozoic sediments in the chemical composition of the waters from Guarani aquifer. The available data allowed estimate the groundwater residence time by the U-isotopes disequilibrium method. Values ranging from 29 up to 61 ka were calculated, depending on the adopted porosity (10-20%). Such time range corresponds to an estimate for infiltrating waters to reach the deeper parts of the aquifer and agrees with the  $^{14}\text{C}$  ages previously evaluated [2].

**References**

- [1] Gilboa Y. et al. (1976) *J.Hydrol.* **29**, 165-179.  
 [2] Kimmelman e Silva A.A. et al. (1989) *Radiocarbon* **31**, 926-933.

## 4.5.P23

**The reactive surface area of fractured rocks and implications on the estimation of weathering rates**

F.A.L. PACHECO AND A.M.P. ALENCOÃO

Department. of Geology, Trás-os-Montes and Alto Douro University, Ap. 1013, 5000 Vila Real, Portugal  
 (fpacheco@utad.pt; alencoao@utad.pt)

**Reactive surface area of a network of fractures**

The reactive surface area of a network of fractures can be estimated from:

$$A_r^f = 2R \times \sqrt{\frac{\rho gn}{12 \mu K}} \quad (1)$$

where  $R$  is the recharge to a spring,  $g$  is the acceleration of gravity,  $\rho$  and  $\mu$  are the specific weight and dynamic viscosity of water, and  $n$  and  $K$  are the effective porosity and hydraulic conductivity of the fractured medium. This area is about three orders of magnitude smaller than the surface area of the mineral grains in a certain volume of rock:

$$A_r^b = M \times S = \frac{R}{n} \times S \quad (2)$$

where  $M$  is the mass of grains involved in weathering and  $S$  is the specific (e.g. BET) surface area. The important consequence of this is that, when flow takes place preferably through the network of fractures (e.g. perennial springs), a normalization of the weathering rates by Equation 2 (usual approach) will be in error by a factor of ~1000.

**Weathering rates**

Using a mole-balance model [1], we related the chemical composition of springs with the weathering of plagioclase and biotite in the granites and schists of the Sordo river basin (North of Portugal). Using a standard hydrograph separation method, a regular finite differences method and data from the literature, we estimated  $R$ ,  $n$ ,  $K$ , and  $S$  for the same area. For plagioclase, the average log rates normalized by Equation 2 (given by  $-15.6 \pm 0.3$ ) are in agreement with average field log rates obtained by other authors, whereas those normalized by Equation 1 (given by  $-12.9 \pm 0.3$ ) are one order of magnitude smaller than average laboratory log rates. If, as we believe, the latter values are the ones to consider, then the huge differences commonly reported in the literature between laboratory dissolution and field weathering rates may sometimes be artefacts of normalization, not a reality. Similar conclusions could be taken from biotite weathering rates.

**Reference**

- [1] Pacheco F.A.L, and Van der Weijden C.H. (1996) *Water Resour. Res.*, **32**, 3553-3570.