Noble gases in groundwater from the Albian aquifer (Paris Basin): fluid dynamics and palaeoclimatic record

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The Albian sands of the Paris Basin represent one of the shallowest (-600 m) confined aquifer in this thick sedimentary basin. Hydrogeologic informations lead to identify and select an interesting stream line, between the recharge area (Gien-Auxerre, SE) and the middle of the Basin (Paris). This flow line is characterized by a strong depression of hydraulic pressure beneath Paris, induced by the massive pumping out performed since last century. A recent hydrological and geochemical study (Raoult *et al.*, 1997) demonstrates that localy the albian groundwater is variously mixed with water raising up from the underlying neocomian aquifer. According to this study, the mixing area corresponds to the maximum of depression of the piezometric surface in the middle of the basin. On the other hand, water from the periphery of the basin seems to be free of mixing with neocomian water. Noble gas measurements were performed on the same samples (12 analyses) used for the geochemical study (Raoult *et al.*, 1997). The aim of this work was to perform very precise noble gas analyses along this well known flow line in order to better constrain the horizontal and vertical transports accross the albian aquifer highligted by the geochemical study. Helium isotope fluxes from the Dogger aquifer were estimated by Marty *et al.* (1993), and were used to date the residence time of water in this aquifer. The second aim of our study was to test this estimation of the vertical helium flux in the Paris Basin by determining precisely the flux that come in into the Albian aquifer.

Results

The noble gas isotopic analyses presented in this study have been carried out in the isotope geochemistry laboratory of the ETH in Zurich (Switzerland).

The ^{4}He content of the albian groundwater vary strongly along the studied stream line. Water samples from the periphery of the basin display small amounts of ^{4}He that increase regularly with the ^{14}C age of the water (Fig. 1). The ^{4}He content of these samples corresponds to the amount of ^{4}He released *in situ* by the aquifer and which has been computed on Fig. 1 with the U and Th contents of the albian sands. The ^{3}He/^{4}He ratio, normalized to the atmopsheric value (Ra), decreases rapidly from 0.97 Ra for the youngest water near the recharge area to 0.17 Ra for the oldest one. This is characteristic of a radiogenic ^{4}He *in situ* production. On the other hand samples from the middle of the basin show a huge increase of the ^{4}He water content (Fig. 1) compared to the samples from the periphery of the basin. On the contrary the ^{3}He/^{4}He ratios of these samples are uniform around 0.1–0.07 Ra.

Such a strong increase of ^{4}He content compared to the theoretical *in situ* production must be related to an external flux of Helium. In Fig. 1 the estimated vertical flux from the dogger aquifer (Marty *et al.*, 1993) was added to the albian *in situ* production. The excess ^{4}He in the albian waters may be explained by such a vertical flux through the Paris basin. Moreover the ^{4}He content of waters correlates perfectly with the augmentation of Na content (Fig. 2) attributed by Raoult *et al.* (1997) to the mixing with water from the neocomian aquifer.

The ages obtained with the ^{4}He production for the samples free of excess helium (periphery of the Albian aquifer) are very similar to the ^{14}C ages of the waters. The ^{4}He method of dating groundwater is less precise when it exists a disturbing external flux of

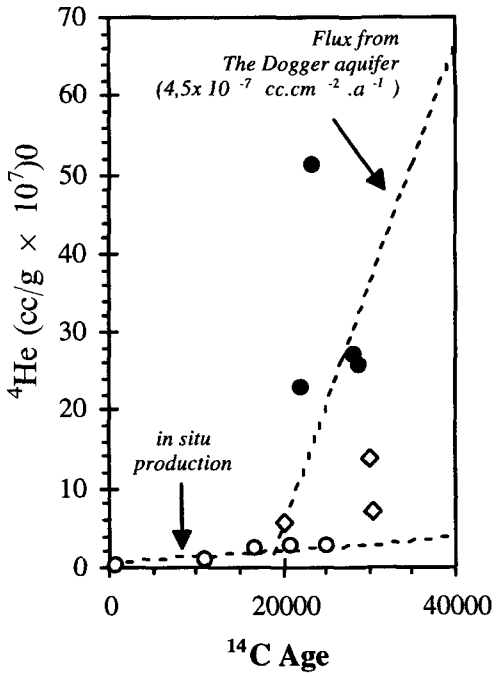

FIG. 1. ^4He *vs* ^{14}C age. Samples from the periphery of the basin (open circles) fall along the ^4He *in situ* production line. Samples from the midle of the basin (full circles) and intermediate samples (open diamonds) display excess ^4He that can be explained by adding the dogger flux proposed by Marty *et al.* (1993).

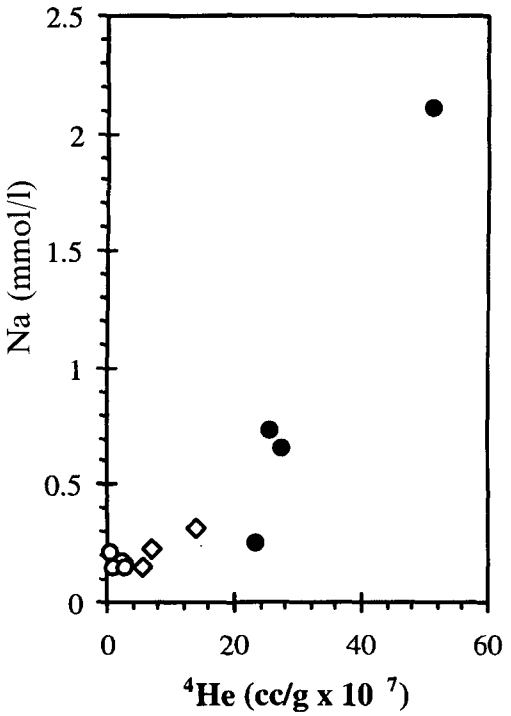

FIG. 2. Na *vs* ^4He. Same symbols as Fig. 1.

helium. However, this study demonstrates that the estimation of vertical helium fluxes through the sedimentary basins could be clearly defined, allowing to determine water ages in deep aquifers.

Noble gas palaeotemperature record

Recharge palaeotemperatures can be determined by the noble gas (Ne, Ar, Kr, Xe) concentrations in groundwater systems, because solubility of noble gases in water is temperature dependent. The noble gas content of the water samples from the Albian aquifer have recorded the palaeotemperature of the Paris Basin since 40 ka and especially during the last glacial episode, which one is about 2°C around 20 ka.

References

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