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Using 36Cl data to quantify the paleorecharge in arid region. Example of the North Western Saharan Aquifer System.

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A comprehensive understanding of large-scale systems such as multi-layer aquifers in sedimentary basins (e.g. North Western Saharan Aquifer System –NWSAS- or the Great Artesian Basin) requires to investigate the recharge history to Quaternary timescale. In fact, for such systems, the residence time of groundwater is often in the order of 100 000 years to 1 million years, the recharge occurring during past, intermittent humid periods paced by the quaternary climatic cycles.

In this study, we propose to reconstruct the history of the recharge over the Continental Intercalaire (CI) aquifer, one of the two main aquifers of the NWSAS. It extends over 1 million km2, shared between Algeria, Tunisia and Libya. We focus on the main recharge area of the CI aquifer located in the Algerian Atlas Mountains. Existing chlorine-36 data (36Cl half-life: 301 ka) indicate that groundwater residence time in this system is around 1 million years. A set of modeling approaches is combined to model the theoretical 36Cl/Cl distribution within the aquifer as a function of different recharge scenarios. Seventeen 36Cl/Cl data from two distinct flowpaths provide temporal constraints on groundwater ages. A simple piston model is used to simulate the distribution of theoretical 36Cl along these flowlines as a function of the distance from the outcrop with respect to a recharge scenario. Simplified climatic scenarios are constructed considering humid periods only during interglacial cycles. This allows to define 9 recharge rates (Rh(i)) associated to last interglacials (from marine isotope stages MIS1 to MIS19). In addition, a constant recharge Rg was considered during glacial periods. For each recharge scenario, the recharge values are constrained by using a Markov Chain Monte Carlo (MCMC) inversion, which yields the best agreement between measured and modeled 36Cl/Cl.

This MCMC probabilistic inversion approach allows identifying plausible sets of the 10 parameters (9 Rh(i) and Rg) involved in the simple piston-flow model. Sensitivity tests were conducted to reevaluate the initial 36Cl/Cl value. The best agreement with the 36Cl/Cl data and with the paleoclimatic records is obtained with an initial 36Cl/Cl value around 175x10^{-1}5 at.at^{-1}, significantly higher that the 133x10^{-1}5 at.at^{-1} in the literature (Guendouz and Michelot, Journal of Hydrology, 2006). The computed Rh varies from few mm.yr^{-1} to more than 60 mm.yr^{-1}. Recharge associated to glacial periods is around 1 mm.yr^{-1} or less. In our best simulations, the computed Rh(2) and Rh(5), corresponding to the MIS5 and MIS11, respectively, appear more humid than to the Holocene (Rh(1)) in good agreement with continental and marine climatic records (Lang and Wolf, Climate of the Past, 2011).