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"Groundwater ages" of the Lake Chad multi-layer aquifers system inferred from 14C and 36Cl data

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Assessment of recharge, paleo-recharge and groundwater residence time of aquifer systems of the Sahel is pivotal for a sustainable management of this vulnerable resource. Due to its stratified aquifer system, the Lake Chad Basin (LCB) offers the opportunity to assess recharge processes over time and to link climate and hydrology in the Sahel.

Located in north-central Africa at the fringe between the Sahel and the Sahara, the lake Chad basin (LCB) is an endorheic basin of 2,5.10^6 km^2. With a monsoon climate, the majority of the rainfall occurs in the southern one third of the basin, the Chari/Logone River system transporting about 90% of the runoff generated within the drainage basin. A complex multi-layer aquifer system is located in the central part of the LCB. The Quaternary unconfined aquifer, covering 500 000 km^2, is characterized by the occurrence of poorly understood piezometric depressions. Artesian groundwaters are found in the Plio-Pleistocene lacustrine and deltaic sedimentary aquifers (early Pliocene and Continental Terminal). The present-day lake is in hydraulic contact with the Quaternary Aquifer, but during past megalake phases, most of the Quaternary aquifer was submerged and may experience major recharge events.

To identify active recharge area and assess groundwater dynamics, one hundred surface and groundwater samples of all layers have been collected over the southern part of the LCB. Major and trace elements have been analyzed. Measurements of ^{36}Cl have been carried out at CEREGE, on the French 5 MV AMS National Facility ASTER and ^{14}C activities have been analyzed for 17 samples on the French AMS ARTEMIS. Additionally, the stable isotopic composition was measured on the artesian aquifer samples.

In the Quaternary aquifer, results show a large scatter with waters having very different isotopic and geochemical signature. In its southern part and in the vicinity of the surface waters, groundwaters are predominantly Ca-Mg-HCO_3 type waters with very high ^{36}Cl/Cl ratio ($>1000.10^{-15}$ at/at) very likely linked to the bomb pulse. These high ^{36}Cl/Cl ratios are in the same order than the ^{36}Cl/Cl signature of surface waters active modern recharge in this area. In the other part of the Quaternary Aquifer, waters are Na-HCO_3-SO_4-Cl type and are characterized by lower ^{36}Cl/Cl ratios (around 200.10^{-15} at/at), suggesting longer residence time of the groundwaters. The ^{14}C contents of the unconfined aquifer waters are all above 50 pmc, suggesting recent or Holocene recharge of this system. In contrast, the confined aquifer has a more homogeneous geochemical signature. The ^{14}C contents are below all 0.5 pmc and mainly below detection level. ^{36}Cl/Cl ratios are $<100.10^{-15}$ at/at. while the stable isotopic composition exhibit a clear trend for more depleted waters.

These data consistently suggest that groundwaters of the confined aquifer are much older than previously perceived and that they were recharged during humid period older than 50ky. Although ^{36}Cl data allow to identify active recharge, age distribution and residence time of groundwaters of the Quaternary aquifer appear to be more complex.