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The Saharan lakes of Ounianga Serir – a unique hydrological system

Ounianga Serir in remote northeast Chad ranks among the most picturesque and interesting areas of the Sahara and includes its largest bodies of water (Fig. 1). They lie in a depression below a sandstone escarpment on its northern flank. The mere existence of these lakes is amazing in a practically rainless region with annual evaporation rates exceeding six metres. The Ounianga lakes are almost exclusively fed by permanent groundwater outflow from a regional aquifer that was recharged for the last time during the early Holocene humid phase and that continuously replaces the immense evaporation losses.

Together with Lake Yoa of Ounianga Kebir, they represent the very last relics of the early Holocene Mega-Chad System – once the Earth's major interior lake. Even if all Saharan lakes are ephemeral phenomena in the geological timescale because of the general trend of climatic desiccation, the dropping groundwater table and the encroaching dunes, the large lakes of Ounianga will persist for the next centuries and even millennia if groundwater support continues at the present rate.

During the last millennia, the steadily blowing northeast trade winds have driven extended dunes into the basin. These dunes have subdivided the once continuous freshwater lake into separate compartments which presently host some 15 lakes with a total surface of about 20 km^2. With the exception of the central salt lake, Lake Teli, they are largely or even completely covered by a thick mat of floating reed that significantly reduces losses by evaporation.

The uncovered central lake therefore undergoes the most evaporation and thus functions as a gigantic evaporation pump which affects the lowest lake level (Fig. 2). As a consequence of the resulting gradient, freshwater is drawn from the more elevated peripheral lakes through the permeable dune barriers before they become saline. This very special mechanism results in persisting freshwater lakes – a paradox under hyperarid conditions at which freshwater becomes saline within short periods because of the increasing concentration of soluble salts due to vaporative enrichment. Only the combined geological, hydrological, climatic and biological factors, i.e. (a) a vast fossil groundwater reserve; (b) the specific position, morphology and orientation of the lake basin; (c) continuous winds from a perpendicular direction; (d) a source of aeolian sand; (e) extreme evaporation driving the central evaporative pump; and (f) the floating reed covers that receive their nutrients from aeolian dust; have created the unique ecological system of Ounianga Serir. There is no comparable freshwater ecosystem in the Sahara nor in any other of the Earth's extreme deserts.

As a result of the extreme aeolian erosion and deflation during the past millennia, only very limited remains of the deposits of earlier lake stages are preserved at positions up to 80 m above the present lake bottom (Fig. 6). They have been radiocarbon-dated to the early Holocene and mainly consist of thinly laminated diatomites and mollusc-bearing carbonates (Fig. 3). The high-resolution sedimentary archives are expected to correlate with the sub-bottom varve records of Lake Yoa at Ounianga Kebir.

Differential precision measurement of the elevation of the uppermost lacustrine deposits by means of the Global Position System (DGPS) allows outlining the maximum early Holocene lake level (Fig. 4). 'Virtual flooding' of digital elevation models (DEMs) using these data indicates the extent of the Ounianga Serir palaeolake during the early and mid-Holocene (Fig. 5). Such models are also helpful in searching for prehistoric sites which usually abound along the former lakeside. Otherwise, ancient shore lines are difficult to locate in rather flat terrain where slight changes in lake levels have resulted in major horizontal shifts.

The relic freshwater lakes of Ounianga Serir have conserved the genetic heritage of the Sahara's humid past over more than 3,000 years of hyperaridity (Fig. 6). Because their ecology has remained widely intact, various aquatic plants and organisms including several species of fish and gastropods have survived to the present day. ACACIA's field studies at Ounianga have only broken the ground for more detailed geological, limnological, hydrological, biological, archaeological, and other research which can rely on the well-established collaboration with the Chadian Centre National d'Appui à la Recherche (CNAR).

Fig. 6 Panorama of Lake Boku. Two thirds of the surface of the 13 m deep freshwater lake are covered by a metre-thick floating reed mat. Fish and gastropods presumably descend from their 9,000 year old ancestors in the deposits exposed 80 m above (arrow). Encroaching dunes have already filled up the adjoining lakes.

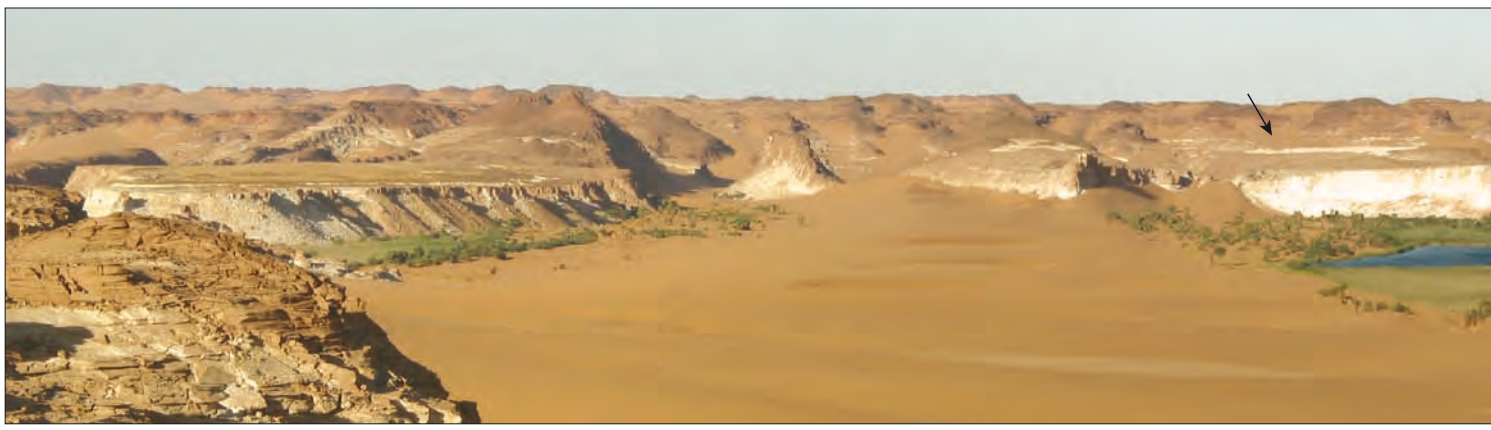

Fig. 1 Lake Teli.
The highly saline central lake of Ounianga Serir. The largest of its three islands has been used as a refuge during the more recent past, as suggested by archaeological remains at its top.

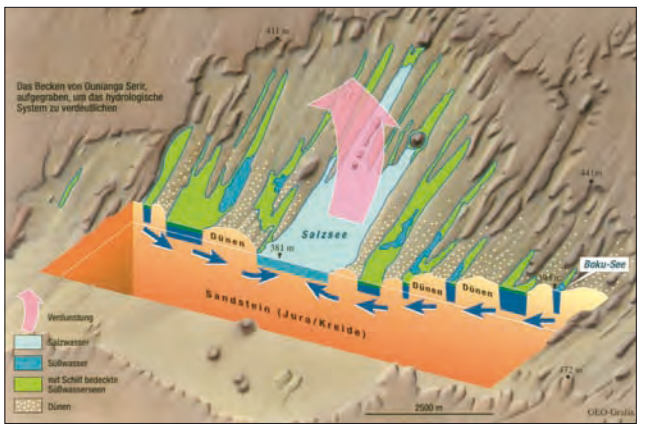

Fig. 2 Schematic block diagram of the Ounianga Serir lake basin. It shows the function of central Lake Teli as an evaporation pump that prevents the salinisation of the adjacent freshwater lakes. See text for further explanations.

Fig. 3 Remnants of the early Holocene deposits typically consist of thinly laminated diatomites and mollusc-bearing carbonates providing a high-resolution environmental archive.

Fig. 4 Lake Teli. The dashed line at about 100 m above the lake marks the approx. maximum lake level during the early Holocene humid phase.

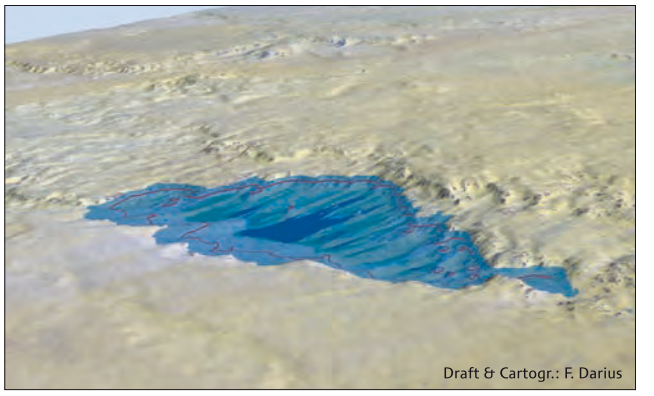

Fig. 5 'Virtual flooding' of a digital elevation model (DEM) of Ounianga Serir shows the calculated extent of the middle Holocene palaeolake.