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Paleogeographic evolution and paleoenvironmental reconstruction of the Sudd area during the Early-Mid Holocene, Sudan

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ABSTRACT

Sixty-five diatom species were identified from five localities within the top Umm Ruwaba Formation (namely Bara A, Bara B, Binaya, Sayal and Kosti). The recovered diatoms have been used here to confirm the existence of the so-called Lake Sudd, which once covered parts of central and southern Sudan, and lasted from 5.253 to 11.300 Ka B.P. The diatom assemblage indicates deposition in fresh to slightly saline water. The distribution of large-sized diatoms, noted within the study material, is attributed to the presence of spots characterized by high nutrition which correspond to the beach of the ancient lake. Integration of the paleontological results and remote sensing data permits the delineation of the lake boundary.

1. Introduction

The existence of Lake Sudd of the Sudan was first mentioned by Lombardini (1865), an Italian hydraulic engineer, later confirmed by Wilcocks (1904), and Lawson (1927). The aforementioned authors considered the remarkable flatness of the plain lands of the central and southern Sudan and assumed that a minor rise of water of the White Nile would cause a flooding of extensive areas. According to Lawson (1927), the lake comprised the Blue and the White Niles from Khartoum in the north and southward to Juba. Ball (1939) confined the lake to the White Nile valley and the northern part of the present day Sudd region. Radiometric dating using C^{14}, conducted on the lake sediments, suggests that the lake has lasted from 5.253 to 11.300 Ka B.P. (Berry and Whiteman, 1968).

The sediments of the Lake Sudd are reported from the Upper Nile, Bahr el Ghazal, Equatoria, the Blue Nile and Khartoum States (Whiteman, 1971; El Shafie, 1975). However, the exact aerial extension of the lake is, so far, not well defined. The aim of this study is to document the morphological variability of the observed diatom taxa and to test their value as paleogeographical indicators of the lake boundary.

The climate in the study area (Fig. 1) varies from semi desert in the north to tropical in the south. The rainy period is short in the north with mean rainfall of 20 mm^3 and increase southwards to reach more than 1000 mm^3 (Fig. 2). The southern part of the study area is covered by tropical acacia savanna, while the Hashab and Talh acacias grow in the north.

2. Methodology

Nine cutting samples and three cores collected from the five localities were analyzed for their diatom content. ArcGIS software was used to produce a contour map for the study area from the Digital Elevation Model (DEM), which allows, upon integration with paleontological data, the reconstruction of the lake boundary.

3. Results and discussion

Microscopic investigations of 12 slides from the 5 localities (Fig. 1), revealed the existence of 68 forms and varieties of diatoms. Sixty-five of the recovered diatoms have been quantitatively evaluated as in situ mass occurrences, while three other species have been considered as re-deposited forms (Fig. 3).

The recovered forms can be assigned to two families: Centrophyceae which comprises three genera: *Cyclotella*, *Melosira* and *Stephanodiscus* and Pennatophyceae that includes 18 genera: *Achnanthes*, *Asterionella*, *Cocconeis*, *Cymatopheura*, *Cymbella*, *Diatoma*, *Diploneis*, *Epithemia*, *Eunotia*, *Gomphonema*, *Gyrosigma*, *Navicula*, *Neidium*, *Nitzschia*, *Pinnularia*, *Rhopalodia*, *Surirella* and *Synedra*. The diatom species are well-distributed in the study sections; an exception to this is the material from Bara which is characterized by its mass occurrence of diatom valves (Figs. 1 and 3). The investigated diatoms at this point consist exclusively of varieties

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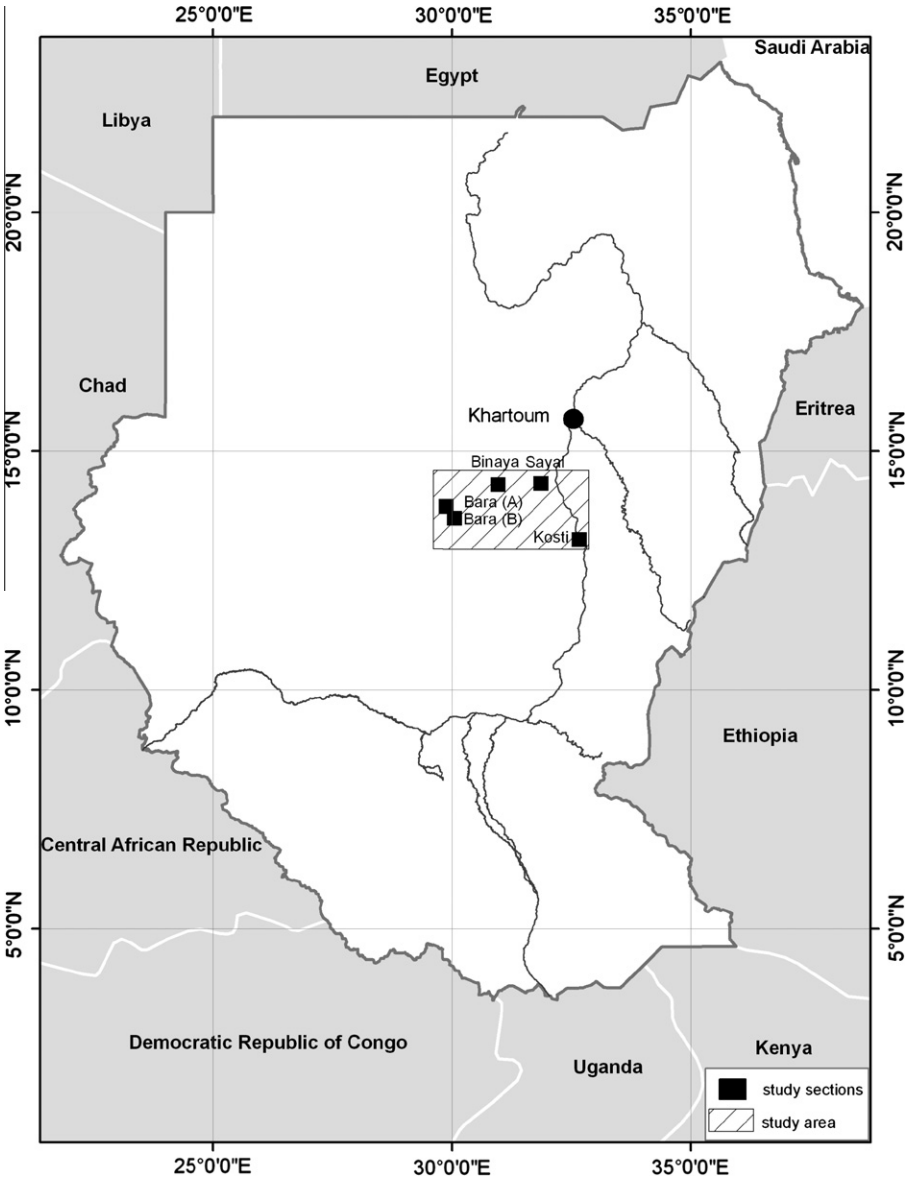

Fig. 1. Location map of the study area.

indicative of freshwater or slightly saline water (0–5%). Among the present material, are forms which can tolerate low salinity conditions e.g. *Cyclotella meneghiniana*, *Navicula hungarica* var. *capitata*, *Rhopalodia gibberula*. Other species which can withstand a certain minimal salinity are encountered herein in much greater numbers but they are less developed e.g. *Achnanthes minutissima* var. *cryptocephala*, *Asterionella formosa*, *Cocconeis placentula*, *Diatoma hiemal*, *Gomphonema olivaceum*, *Navicula rhyncocephata*.

Two samples (A and B) analyzed from Bara area yielded 29 taxa of diatoms. Planktonic forms frequently found in lakes, were noted only in sample (A) e.g. *Asterionella formosa*, *Cyclotella operculata*, *Stephanodiscus astraea* and *Nitzschia acicularis*. The remaining diatoms are benthonic–littoral varieties among which some species are of conspicuous overgrowth and are basically noted in mass quantity, e.g. *Synedra ulna*, *Gomphonema olivaceum*, *Cymbella cymbiformis*, *Epithemia* sp., *Rhopalodia gibberula*. Species living on the bottom of lakes and small water reservoir were also encountered within the assemblage, e.g. *Cycoltella meneghiniana*, *Achnanthes oestrupii*, *Navicula exigua*. The assemblage includes varieties that live in swamps, e.g. *Eunotia arcus*, *E. flexuosa* and *Pinnularia viridis* which were described only from sample B.

We can conclude from above that the diatom taxa in sample B indicate the shore portion of the lake deposit where the nourishing substances were concentrated.

At Binaya section, 36 diatom species (represented mainly by single valve) were described from three samples. Some of the planktonic taxa reported from the Bara section are also found within this assemblage. However, a greater variety of the benthonic–littoral forms is reported in Binaya section (e.g. species of the genera *Navicula* and *Achnanthes*), but the assemblage exhibits, in comparison with sample B, a decrease in the forms characteristic of overgrowth, e.g. *Epithemia* sp., *Cymbella cymbiformis* and *Rhopalodia gibberula* coupled by a quantitative decrease in *Synedra ulna*. Typical lacustrine diatoms include among others *Navicula verecunda* and *Surirella ovata* var. *hantensis*.

The diatom recovery at Sayal section comprises 20 species and varieties described from four samples. Although Sayal assemblage is less diverse, in comparison with the preceding sections, the number and type of genera remained unchanged. Consequently, it can be assumed that the diatom assemblage at Sayal belongs to the same lake.