Laminated lake sediments are considered as high-resolution archives of past climatic and environmental conditions (see Renberg, 1983; Saarnisto, 1986, 1991; Sturm and Lotter, 1995; Bradbury et al., 1996; Kemp, 1996; Lamoureux and Bradley, 1996; Wohlfarth et al., 1998; Hughen et al., 2000; Brauer, 2004; Zolitschka, 2007; Wanner et al., 2008; Bauer et al., 2009; Francus et al., 2013; Ojala et al., 2013). Fossil lacustrine deposits enable to obtain an absolute chronology and an almost continuous time scale, in the case of the Holocene based mostly on radiocarbon datings (Brauer et al., 1999, 2000; Lamoureux, 2001; Enters et al., 2006). In some cases, stable sedimentary conditions in the lakes favor formation of undisturbed sediment sequence with annual lamination (varves) (Chu et al., 2005; Tylmann et al., 2012). Another advantage is a relatively high sedimentation rate estimated from 0.3 to a few millimeters per year, which gives a possibility to trace any changes in lake environment within a few months or a year (Petterson et al., 1993; Valpola and Ojala, 2006) (Fig. 1). Finally, full cores of fossil lake sediments offer possibility to perform comprehensive laboratory studies which allow tracing even small environmental and climate changes, especially during the Holocene (Dean et al., 1999, 2001; Elbert et al., 2012; Czymzik, et al., 2009; Last, 2001; Smol et al., 2001; Tiljander et al., 2002; Welc, 2016).

Palaeoclimatic data provided by lake sediments can be also successfully correlated with archaeological and geoarchaeological proxy, what allows to grasp relationships between subsequent phases of development and collapse of ancient cultures and civilizations in context of natural environment transformations, especially a climate change (it should be noted here, that although it seems obvious that ancient cultures were influenced by climate changes, this issue has only recently been initiated in profound multidisciplinary investigations) (see Ralska-Jasiewiczowa et al., 1998; Weiss, 2000; Weiss and Bradley 2001; Zolitschka et al., 2003; Staubwasser, Weiss 2006; Kröpelin, 2008; Welc and Marks, 2014).

Studies of lake and paleolakes sediments are particularly significant in desert and semi-desert areas where there is usually a lack of high resolution paleoclimatic proxies. North-eastern Africa belongs to such regions. At present, Egypt and Sudan are located in a hyper arid desert zone, however past climatic conditions were significantly different from the present one. Palaeoclimatic and geoarchaeological data collected so far suggest clearly that transformations of the natural environment resulted mostly from north-south migration of the monsoon rain belt (Intertropical Convergence Zone = ITCZ) (Welc, 2016).

In effect of migration of ITCZ zone to the north, during early and middle Holocene in southern Egypt and northern Sudan numerous freshwater lakes have developed. They were identified in almost the whole area of the present Western Desert. The geological map of Egypt (1: 500,000) reveals that playa sediments filled extensive depression mostly at the foot of high cliffs, rock walls and the edge of...
desert plateaus. In southern and central Egypt over hundreds sites with playa are still preserved (Embabi, 2004) (Fig. 3). Only in the Farafra Oasis area, geological maps and surface surveys enable to estimate a total number of such sites to be over 100 with a total surface area of approximately 500 km² (El-Rashidi, 2002).

The largest playa are located in the southern part of the Western Desert, among others in Bir Tarfawi, Bir Sahara and Nabta Playa (Figs 2–4). Another large ensemble of fossil lake sediments has been preserved to the south of Kharga (Fig. 2) depression and along Darb Al-Arb’ain (Embabi, 2004). During last decades playa sites were extensively mapped and studied by numerous expeditions, especially in the area of Abu Ballas (Pachur and Röper, 1984), Gilf Kebir (Kröpelin, 1989), Bir Kiseiba and Nabta Playa (Wendorf and Schild, 1998; Wendorf et al., 2001). (Figs 2–5). The compressive studies of archaeological sites in the context of playa sediments in Bir Tarfawi, Nabta Playa and Bir Kiseiba regions allowed a creation of the first detailed environmental change scenario and correlated it with phases of past human settlements in south-western Egypt during Holocene (Schild and Wendorf, 2001, 2013). Numerous dry and wet pulsations dating back to the Early, Middle and late Holocene were detected and placed in a proper chronological order (based on 14C and TL datings). These episodes reflect stabilization of the summer mon-
soon season ca. 10 ka cal BP and the gradual disappearance of the monsoon rains ca. 6 ka cal BP. However, this process was not linear, as evidenced by several short dry episodes. Finally, palaeoclimatological and geoarchaeological research in the Nabta region allowed distinguishing 7 wet main pulsations (summer monsoon advance to the north) (Schild and Wendorf, 2013, see table below).

<table>
<thead>
<tr>
<th>Date</th>
<th>Name of climatic informal unit</th>
<th>Climate</th>
<th>Depositional environment</th>
<th>Past human activity</th>
<th>Archaeology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger Dryas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.2–9.9 cal ka BP</td>
<td>Pre-El Adam interphase</td>
<td>Hypothetical arid</td>
<td>Emergence of photogenic dunes followed by sandy playas. Contracted desert.</td>
<td>Desert abandoned by humans.</td>
<td>Early Neolithic</td>
</tr>
<tr>
<td>9.9–9.5 cal ka BP</td>
<td>Post-El Adam phase</td>
<td>Arid</td>
<td>Interstratified eolian sand bed in playa deposits.</td>
<td>Desert abandoned by humans.</td>
<td></td>
</tr>
<tr>
<td>9.5–9.1 cal ka BP</td>
<td>El Ghorab interphase</td>
<td>Humid</td>
<td>Silty and sandy playa were deposited.</td>
<td>No houses remains or storage pits were found in Nabta Playa region.</td>
<td>Middle Neolithic</td>
</tr>
<tr>
<td>8.9–8.1 cal ka BP</td>
<td>El Nabta / El Jerar interphase</td>
<td>Humid – local climatic optimum in Nabta region.</td>
<td>Maximum of local precipitation, reduced silt deposition due to vegetation cover, small permanent lakes, extensive semi-sedimentary settlements. Dry savanna with desert and semi-desert animals predominated.</td>
<td>Oval huts with storage pits and big settlements appeared in Nabta Playa region with association of dotted wavy line decorated pottery. Human existence on desert throughout the year. Most probably sorgo was cultivated in Nabta region.</td>
<td>Middle Neolithic</td>
</tr>
<tr>
<td>8.1–7.9 cal ka BP</td>
<td>Post El Jerar phase</td>
<td>Arid – 8.2 ka event</td>
<td>Sharp reduction of the vegetation, increased eolian erosion, violent seasonal rains, intensive clastic deposition in playa basins.</td>
<td>No human presence on desert.</td>
<td></td>
</tr>
<tr>
<td>7.9–7.5 cal ka BP</td>
<td>Ru’at El Ghanam interphase</td>
<td>Humid</td>
<td>Development of phytogenic dunes, local rains resulting in surface washes.</td>
<td>Sheep, goat and domestic caprines appeared in Nabta region. Large, bell – shaped storage pits and abundant grinding stones are very frequent kind of findings in Nabta area. Houses are round in outline often with slanted-line walls.</td>
<td>Late Neolithic</td>
</tr>
<tr>
<td>7.4–6.6 cal ka BP</td>
<td>Ru’at El Baqar interphase</td>
<td>Humid</td>
<td>Alluvial deposits in wadis and closed basins.</td>
<td>In the Nabta Playa area cult and ceremonial installations appeared, among them most important is so called “calendar circle”, which may have had astronomical functions. Cult of cattle is also widespread in Nabta region.</td>
<td></td>
</tr>
<tr>
<td>6.6–6.5 cal ka BP</td>
<td>Post-late Neolithic Arid phase</td>
<td>Arid</td>
<td>Deflational basins.</td>
<td>Sparse human occupation on desert.</td>
<td></td>
</tr>
<tr>
<td>6.5–5.5 cal ka BP</td>
<td>Bunat El Asnam interphase</td>
<td>Humid</td>
<td>Seasonal rains and alluvial washes.</td>
<td>Sparse human occupation on desert.</td>
<td></td>
</tr>
<tr>
<td>5.5–4.7 cal ka BP</td>
<td>Post-Neolithic arid phase</td>
<td>Arid</td>
<td>Sparse human occupation on desert.</td>
<td>Sparse human occupation on desert.</td>
<td></td>
</tr>
<tr>
<td>4.7–4.3 cal ka BP</td>
<td>Hyper arid phase</td>
<td>Arid</td>
<td>Hyper arid desert.</td>
<td>Sparse human occupation on desert.</td>
<td></td>
</tr>
<tr>
<td>4.3–3.3 cal Ka BP</td>
<td>Humid interphase</td>
<td>Relatively humid</td>
<td>Rare local rains.</td>
<td>Sparse human occupation on desert.</td>
<td></td>
</tr>
</tbody>
</table>
Project (NCCP) was initiated, founded by the National Science Centre (DEC-2012/05/B/ST10/00558, ID: 185179, OPUS, ST10) (Marks et al., 2016, 2017; Welc, 2016). The main objective of the project was a reconstruction of the Holocene climate fluctuations in Egypt based on research of lacustrine sediments from Nile Delta and especially from the Faiyum Oasis. At present time, the Faiyum occupies a natural depression modeled by deflation during the late Pleistocene. In its northern part there is the shallow and hyper-saline Qarun Lake, a relic of a vast Holocene freshwater reservoir (Figs 6–8). Without any doubt the injection of the Nile water into the depression in the Early Holocene was due to reactivation of a summer monsoon in the Ethiopian Highlands. At that time a vast lake developed in a central part of the Faiyum Oasis. During the annual floods the river water fed the lake, favouring deposition of mineral-organic sediments. These deposits constitute a unique archive of late Quaternary palaeoclimatic data for the northern (lower) part of the Nile Basin. The dynamics of hydrological and climate changes in the Nile Basin are

Fig. 5. Early Holocene silty – sand laminated lake sediments studied in El Berget area, south of Nabta Playa (photo F. Welc).

Fig. 6. Digital map – DEM, based on Landsat 8 data, showing Faiyum depression and Qarun Lake preserved in its northern part (drawing F. Welc).
reflected in the lithological and geochemical characteristics of the sediments deposited in the Faiyum, because freshwater filling of the depression have changed concordantly with fluctuations of the Nile waters, which in turn resulted from varying intensity of the Indian monsoon reaching Ethiopian Highland (Welc, 2016).

Correlation of high-resolution palaeoclimatic data from the Fayum Nile Delta and those from the Western Desert will be one of the most important scientific challenges in the future. It will allow to create a coherent scenario of climate change with the background of past human settlement transformations in North-East Africa, especially for area of Egypt and Sudan. In order to initiate discussions on this topic in Warsaw has been organized in 2016 Fourth Geoarchaeological Conference, entitled Late Pleistocene and Holocene climatostratigraphy of Northeastern Africa reflected in lake sediments and geoarchaeological data. The Conference was devoted among others the issues connected with playa sediments preserved in Egypt and Sudan with background of past human settlement. The meeting was held in Institute of Archaeology Cardinal Stefan Wyszynski University in Warsaw (8–9th April, 2016) under scientific patronage of the International Commission of the Later Prehistory of Northeastern Africa, Committee on Quaternary Research of the Polish Academy of Sciences and National Committee of INQUA. The main goal of the conference was to initiate discussion concerning development of uniform climatostratigraphic subdivision for the area of Northeastern Africa in Late Pleistocene and Holocene, based on wide range of geoarchaeological data. Submitted papers presented results of field and laboratory research of the lacustrine sediments form Egypt and Sudan, carried out with a broad range of methodologies including sedimentological, palaeobotanical and others. Paper were presented by specialists actively involved in interdisciplinary archaeological projects in Northeastern Africa from Poland, Czech Republic, Germany, UK, Egypt and United States. The most interesting presentations are presented in this volume of Studia Quaternaria.

Fabian Welc

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