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Palaeoenvironmental inferences from late Quaternary sediments of the Al Jafr Basin, Jordan

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ABSTRACT

Sedimentological, palaeontological and mineralogical analyses of sediments from the endorheic Al Jafr Basin were conducted to better understand the depositional and hydrological conditions on the southern Jordan Plateau in the late Quaternary. Surficially exposed carbonate-rich sediments in the western part of the basin contain ostracod (micro-crustacean) shells of *Ilyocypris* cf. *bradyi*, *Candona neglecta*, *Heterocypris salina*, *Fabaeformiscandona fabaeformis*, *Pseudocandona* sp. and *Herpetocypris brevicaudata*. The shells of these and other more rare species, and charophyte and mollusc remains indicate that the sediments were formed in a wetland setting of shallow freshwater to slightly oligohaline ponds, streams and swamps. The present more northern distribution of some of the recorded taxa implies that climate conditions were probably cooler during the wetland formation. Radiocarbon age data for biogenic carbonate from two locations suggest that the wetland setting existed during the second half of Marine Isotope Stage (MIS) 3 or possibly earlier. A significantly higher water table must have existed in the basin during wetland formation; and wetter climate conditions are inferred for the catchment or at least for its highest and most humid westernmost part. Deflation and local sediment accumulation by wind and occasional sheet-wash events apparently prevailed in the region since MIS 2. Our newly presented data and inferences do not support the reconstruction of a previously reported large and relatively deep Pleistocene lake in the Al Jafr Basin. However, more extensive studies are certainly required for a detailed assessment of the Quaternary hydrological conditions in southern Jordan.

1. Introduction

A good understanding of the natural moisture variability is important for the prediction of future water-availability changes in response to further global warming. Accessible water is a decisive factor in the Levant controlling human occupation since the migration of modern humans out of Africa (Goldberg, 1986; Vaks et al., 2007). Reconstructions of Quaternary environments and hydrological systems in southern Jordan improve our understanding of past environmental consequences of climate change and the availability of local resources for early humans. During the last decades, archaeological, geomorphological, geophysical and geological studies were conducted on the Jordan Plateau to reconstruct landscape change and times of occupation (Quintero et al., 2002; Davies, 2005; Rech et al., 2007; Abu-Jaber et al., 2009; Batayneh, 2011).

Sediments in the presently hyper-arid region of the Al Jafr Basin on the Jordan Plateau represent a valuable sedimentary archive of environmental and hydrological change in southeastern Jordan. Exposed sediments in the basin were partly regarded as fluvial and lacustrine deposits indicating Pleistocene periods of wetter conditions (Huckriede and Wiesemann, 1968; Bender, 1974; Davies, 2005). According to Huckriede and Wiesemann (1968), Bender (1974), Davies (2005) and Bandel and Salameh (2013), a large (1000–1800 km^2) and deep lake occupied the flat basin of Al Jafr in the late Pleistocene. Davies (2005) presented sedimentological and geochemical data for a 31-m long sediment core from the central part of the Al Jafr Basin which apparently represents the last

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>30,000 a BP of lacustrine and aeolian-alluvial deposition. The chronology of the core is based on two radiocarbon ages derived from charcoal samples collected from the uppermost 8 m of the core (Davies, 2005). Additional age data and analysis of sediment sequences in the basin are surely desired for a better understanding of the Quaternary depositional history of the Al Jafr Basin. Davies (2005) suggested that the region experienced several cycles of alluvial deposition, erosion and lacustrine sediment accumulation with the latter representing periods of significantly higher moisture availability compared to present conditions. In addition to the geological studies, archaeological sites including one containing evidence for a Chalcolithic to Bronze Age cortical flake industry in the vicinity of the presumed ancient lake provide indications for the presence of sufficient surface water resources during late Quaternary periods (Quintero and Wilke, 1998; Quintero et al., 2002; Rech et al., 2007).

The occurrence and chronological assignment of an ancient large lake in the presently hyperarid centre of the Al Jafr Basin remains enigmatic. Thus, our study aimed at a re-assessment of the depositional setting in the basin. New findings from five locations in the western part of the basin are presented here to contribute to a better knowledge of its depositional setting and the environmental conditions since the late Pleistocene.

2. Study region

The Al Jafr study area is an internally-drained closed basin, situated on the Jordan Plateau (30°17′N, 36°17′E; ~850 m above sea level) in the southeastern part of Jordan. The basin is the largest drainage system of the region with an east–west extension of 130 km and a north–south extension of 100 km. The centre of the basin is a commonly dry playa (or *Qa'*) covering an area of about 240 km^2 (Rech et al., 2007). The Jordan Plateau is part of the Upper Cretaceous to Paleocene Arabian carbonate platform representing shallow to deep marine carbonates and marls (Moumani, 2005). Multiple horst and graben structures with strong vertical displacements are exposed along the northern boundary of the Al Jafr Basin and are controlled by the Karak-Wadi al-Fiha fault system (Bender, 1974). The Quaternary sediments of the study region are mainly underlain by the Muwaqqar Chalk-Marl Formation of Maastrichtian to Paleocene age (Moumani, 2005; Batayneh, 2011). Exposed rocks of this formation have a maximum thickness of 27 m in the Al Jafr Basin and mainly consist of marl and chalk including chert beds (Moumani, 2005; Batayneh, 2011). Apart from limestone and chalk of the Eocene Umm Rijam Chert Limestone Formation in the north and northwest of the Al Jafr playa, late Pleistocene unconsolidated sediments of the Jafr Formation cover the Muwaqqar Chalk-Marl Formation in the region. The Jafr Formation comprises alluvial to lacustrine conglomerates, silts, marls and carbonates regarded as calcretes with a thickness of 5–8 m (Batayneh, 2011). Sediment marked as Pleistocene carbonate and marl in Fig. 1 represents the Jafr Formation of Moumani (2005), who regarded it of fluvial and lacustrine origin. In addition, unconsolidated aeolian sediments occur in the Al Jafr Basin (Bender, 1974; Batayneh, 2011). Exposures in the adjacent region of the basin are characterized by Mesozoic and Cenozoic chalk, marl, bituminous and silicified limestone, phosphorite and chert (Davies, 2005). Vast expanses of desert pavements are spread in the uplands of the study area. Modern sediment dynamics in the basin are dominated by wind erosion and accumulation of aeolian deposits. Fluvial transport is subordinated and occurs only sporadically during winter months (Davies, 2005).

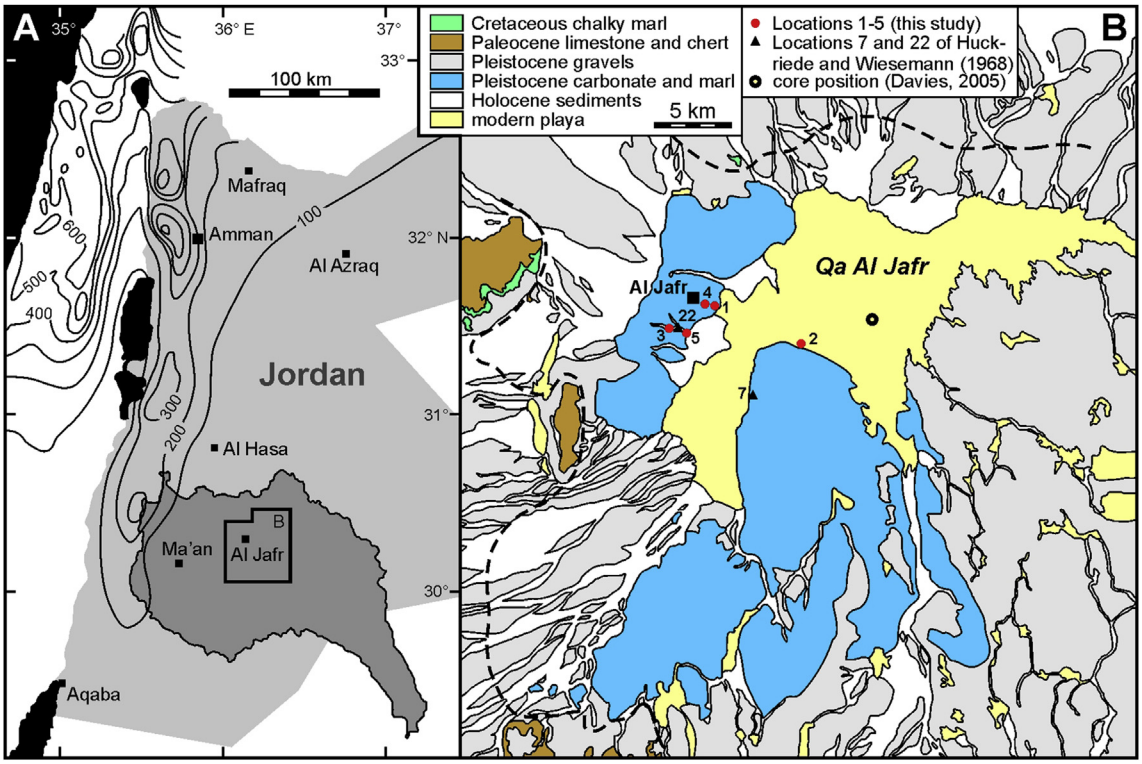

Fig. 1. A: Catchment area of the Al Jafr Basin, modified from Al Kuisi and El-Naqa (2013), and mean annual precipitation contour lines for the southern Levant (USGS, 1998); B: Geological overview of the Al Jafr Basin, modified from Huckriede and Wiesemann (1968), and locations of our study, those of Huckriede and Wiesemann (1968; Locations 7 and 22 are "Punkt 7" and "Punkt 22" of their study) and of the 31-m long core of Davies (2005). Broken line shows extent of large Pleistocene lake proposed by Huckriede and Wiesemann (1968).