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Eocene oil shales from Jordan – Paleoenvironmental implications from reworked microfossils

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ABSTRACT

Reworked microfossils, common in Paleogene sediments in Jordan, are here used to reconstruct the depositional environment. The reworked taxa, which include both calcareous nannofossils and foraminifera of Cretaceous and Paleocene age, were found in Eocene oil shales. The potential provenance of the reworked material and the underlying processes of the reworking are discussed. We differentiate between a subaerial erosion of exposed hinterland strata and a submarine abrasion of sediments.

A total of 73 smear slides have been prepared to identify calcareous nannofossils, another fifteen samples were analyzed for foraminifera. The allochthonous calcareous nannofossil and foraminifera taxa can be linked to a lithified source, which was eroded and transported with both calcitic lithic fragments and organic matter. Multiple factors controlling the transport of the reworked taxa during the time of deposition have been investigated for the Jordanian oil shales. Climate changes are thought to be the cause for changes in the abundance patterns and in the composition of the reworked taxa. The input of common autochthonous components during arid phases and more allochthonous sediment particles during humid periods filled the Eocene sink. A fall in relative sea level, perhaps in combination with increased storm activity, caused a transport of reworked material to deeper parts of the Azraq Hamza Sub-basin. The relative sea level changes in turn were related to syndepositional movements, redefining the shape of the Azraq Hamza Sub-basin and its internal fault-block architecture.

1. Introduction

Micropaleontological studies of source rocks and reservoir deposits are an important tool in understanding the depositional environment of sediments, including oil shales. Reworked microfossils in this context are a disturbance factor for paleoenvironmental interpretations (Rogerson et al., 2012). Highly allochthonous microfossil assemblages indicate noisy sources, thereby making the interpretation of the original paleoenvironment difficult. On the other hand, reworked microfossils provide useful information on transport processes allowing to understand the source of reworking (provenance studies), to track ocean circulations and tectonic events (Ferreira et al., 2008; Pirkenseer et al., 2011). The reworking can occur via rivers as well as by marine waves or storms. Studies based on reworking can be accomplished with a high degree of confidence if allochthonous assemblages can be differentiated from autochthonous ones (Perch-Nielsen, 1985).

Extensive reworking of calcareous nannofossils is reported for areas in which older strata than the studied ones were exposed to submarine or subaerial erosion (e.g. Alqudah et al., 2014; Narvaez, 2005; Perch-Nielsen, 1985; Watkins and Weber, 2005). A variety of reworking mechanisms concerning the contribution of microfossils to shell-bed formation as well as microfossil distribution within a debris flow has been proposed (e.g. Chen et al., 2012; Dattilo et al., 2012; Self-Trail et al., 2002). Mud accumulates directly from suspension in the water column, a process that requires quiet bottom-water conditions. Other observations indicate that deposition of mud is as dynamic as that of sandstone or limestone (e.g. Macquaker and Bohacs, 2007; Schieber et al., 2007).

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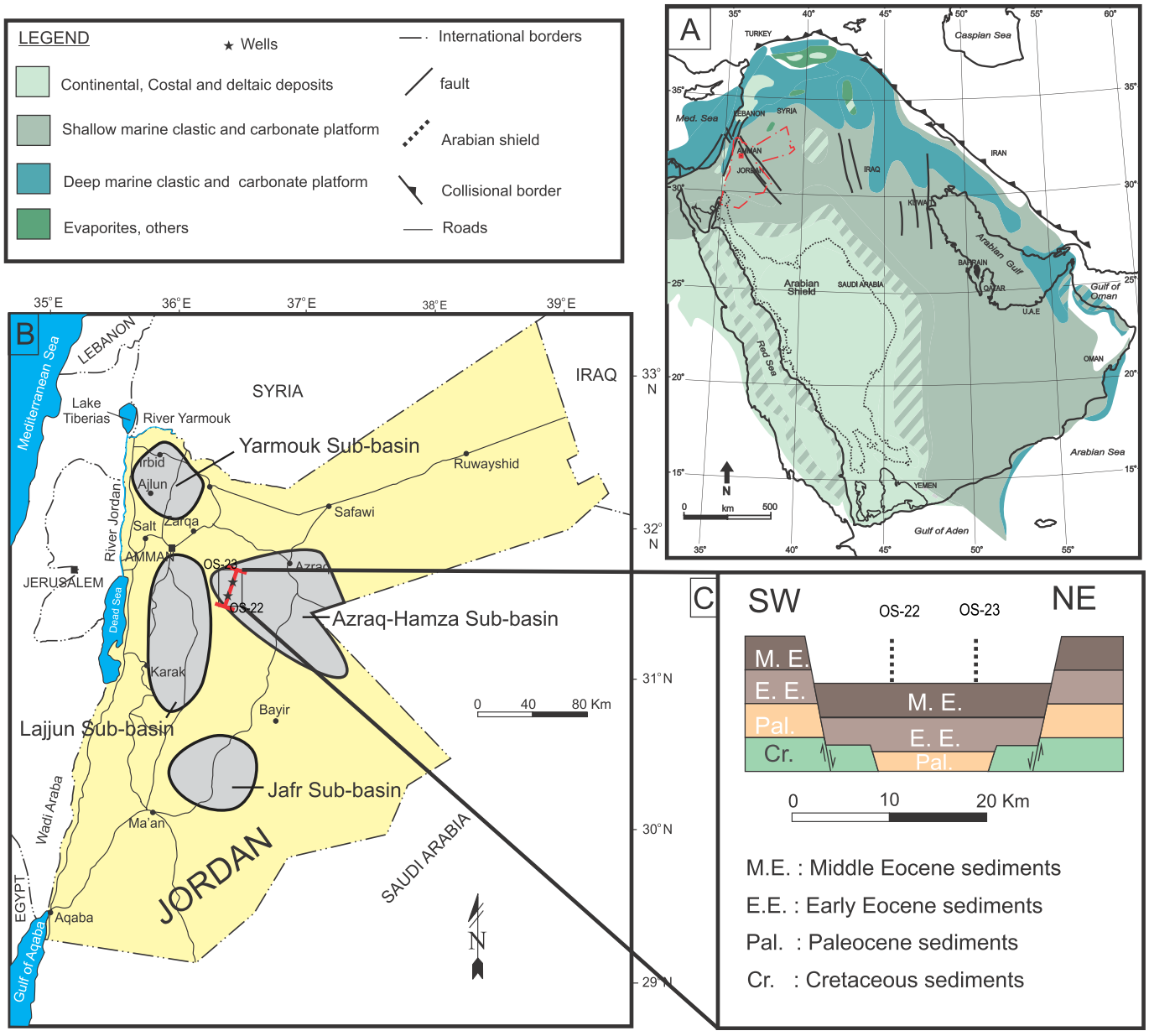

Figure 1. Map of Jordan showing the location of wells OS-22 and OS-23. The cross section illustrates the faults system in the study area. Paleofacies map of the Eocene after Ziegler (2001).

The hydraulic properties of the clay-sized particles must be similar to those of coarser grains in order to be moved along the seafloor. This hydraulic equivalence of clay size particles to coarser grain sizes can be achieved through clumping of electrostatically charged clay particles (Slatt, 2011).

Ferreira et al. (2008) focused on the use of reworked calcareous nannofossils as a dynamic tracer of seawater circulation by proposing a mechanism for sediment transport from Late Cretaceous sources into recent sedimentary sinks. Alqudah et al. (2014) suggested that reworked calcareous nannofossils could be used as dynamic tracers for the tectonic and morphologic evolution of Eocene environments in Jordan.

This study investigates the reworking sources of calcareous nannofossils and foraminifera in laminated oil shales of Eocene age in Jordan. It includes an interpretation of the transport mechanism of the calcium carbonate particles, as reflected by the bio-component assemblages in the sediments studied. Both the allochthonous and autochthonous components of sediment lamination, commonly occurring in the oil shales, will be discussed to provide insights into the dynamics of the oil shale deposition in central Jordan.

2. Geological setting

During the Paleogene Jordan was part of a shallow epicontinental sea, which covered most of central and northeast Jordan. Deposition took place on a carbonate platform that covered north and eastern Arabia (Fig. 1). Differential subsidence gave way to the development of a patchwork of synsedimentary graben and horst structures documented by locally rapidly varying sediment thicknesses. The grabens, with an infill of up to 1600 m of Cretaceous and Paleogene sediments, include the Jafr Sub-basin, the Azraq Hamza Sub-basin, the Lajjun Sub-basin and the Yarmouk Sub-basin (e.g. Abed et al., 2005; Abu-Jaber et al., 1989; Powell, 1989). These sub-basins formed as a result of the genesis of the Syrian Arc during