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Synoptic conditions of fine-particle transport to the last interglacial Red Sea-Dead Sea from Nd-Sr compositions of sediment cores

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A B S T R A C T

The sediments deposited at the depocenter of the Dead Sea comprise high-resolution archive of hydrological changes in the lake's watershed and record the desert dust transport to the region. This paper reconstructs the dust transport to the region during the termination of glacial Marine Isotope Stage 6 (MIS 6; ~135–129 ka) and the last interglacial peak period (MIS5e, ~129–116 ka). We use chemical and Nd and Sr isotope compositions of fine detritus material recovered from sediment core drilled at the deepest floor of the Dead Sea. The data is integrated with data achieved from cores drilled at the floor of the Red Sea, thus, forming a Red Sea-Dead Sea transect extending from the desert belt to the Mediterranean climate zone. The Dead Sea accumulated flood sediments derived from three regional surface cover types: settled desert dust, mountain loess-soils and loess-soils filling valleys in the Dead Sea watershed termed here “Valley Loess”. The Valley Loess shows a distinct $^{87}Sr/^{86}Sr$ ratio of 0.7081 ± 1, inherited from dissolved detrital calcites that originate from dried waterbodies in the Sahara and are transported with the dust to the entire transect.

Our hydro-climate and synoptic conditions reconstruction illustrates the following history: During glacial period MIS6, Mediterranean cyclones governed the transport of Saharan dust and rains to the Dead Sea watershed, driving the development of both mountain soils and Valley Loess. Then, at Heinrich event 11, dry western winds blew Saharan dust over the entire Red Sea - Dead Sea transect marking latitudinal expansion of the desert belt. Later, when global sea-level rose, the Dead Sea watershed went through extreme aridity, the lake retreated, depositing salt and accumulating fine detritus of the Valley Loess. During peak interglacial MIS 5e, enhanced flooding activity flushed the mountain soils and fine detritus from all around the Dead Sea and Red Sea, marking a significant “contraction” of the desert belt. At the end of MIS 5e the effect of the regional precipitation diminished and the Dead Sea and Red Sea areas re-entered sever arid conditions with extensive salt deposition at the Dead Sea.

1. Introduction

The last interglacial peak, Marine Isotope Stage 5e (MIS 5e), was associated with stronger northern hemisphere insolation, higher global sea levels (e.g. Marino et al., 2015; Stirling et al., 1998) and higher average global temperatures (e.g. Lauritzen, 1995; Leduc et al., 2010) compared to the Holocene, and may be an analogue for a future warmer world (Govin et al., 2015). In this perspective the present-day areas of the Sahara-Arabia deserts are of special interest since their margins are densely inhabited and global climate models predict enhanced aridity in these regions with future warming. The Dead Sea, situated at the northern fringe of the desert belt, is a sensitive monitor for past hydroclimate changes in the Levant region as global climate shifted from glacial to interglacial conditions (e.g. Kiro et al., 2016; Stein, 2001; Stein et al., 2010; Torfstein et al., 2015).

During glacial times large amounts of desert dust were blown from the dry Sahara Desert and settled at the Negev Desert, Judea and Galilee Mountains (Frumkin and Stein, 2004; Revel et al., 2010).

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Part of the desert dust that settled on the Judea Mountains was rapidly washed to the Dead Sea or dissolved, providing calcium and bicarbonate ions to the lake that in turn formed there the primary aragonite material that comprises part of the lacustrine formations (Belmaker et al., 2014; Haliva-Cohen et al., 2012; Stein et al., 1997). The remaining fine detritus that accumulated as loess material or mountain soils mainly during glacial intervals (Crouvi et al., 2009; Faershtein et al., 2016) was remobilized and washed by floods to the lake during interglacial intervals. While this description, drafted by Haliva-Cohen et al. (2012), explains how fine detritus was mobilized in the Dead Sea watershed on glacial-interglacial timescales, it does not reconstruct in detail the patterns of dust mobilization during the terminations periods (glacial–interglacial transitions) or during the last interglacial.

Here, we establish the patterns of dust mobilization along a geographical and climate transect extending from the Dead Sea watershed in the north at the sub-tropical Mediterranean climate zone to the Sahara-Sahel boundary in the south. We aim to reconstruct the hydroclimate regime and synoptic conditions that controlled the mobilization of fine detritus particles to the eastern margins of the Sahara Desert, during the transition interval that extends from penultimate glacial MIS 6 through the termination period T2 (135–129 ka) to the last interglacial peak MIS 5e (129–116 ka). While the Dead Sea received its fine particles mainly by floods that washed the surface cover of its watershed, fine detritus recovered from cores drilled in the Red Sea floor (Fig. 1) comprise desert dust that was blown to the sea and settled on its floor (Palchan et al., 2013; Sirocko and Lange, 1991; Stein et al., 2007).

We present mineralogical and chemical data and Nd-Sr isotope ratios of fine detritus samples recovered from the deepest floor of the Dead Sea by drilling. The Dead Sea data are compared and integrated with previous data on fine detritus recovered from the Red Sea cores (KL23 and KL11) (Palchan et al., 2013; Stein et al., 2007).

2. Chronology and lithology of the cores

2.1. The geological setting of the Red Sea and Dead Sea basins

The Red Sea region is subjected to rifting and continental drifting (e.g. Mohriak and Leroy, 2013). The sediments exposed in its watershed are a series of shallow marine – lacustrine and terrestrial sediments were deposited comprising mainly sands, some evaporites and carbonate rocks and minor shales (Bunter and Magid, 1989; Hadad and Abdullah, 2015). In addition, the major exposed lithologies surrounding the Red Sea are the late Proterozoic granitoids and related rocks of the Arabian Nubian Shield (e.g. Bentor, 1985; Milési et al., 2004).

The country rocks in the watershed of the Dead Sea are mainly Mesozoic and Cenozoic marine dolomites, limestones, cherts and chalks and Neogene-Quaternary basalts, carbonates and sandstones. These rocks supply only a minor portion of the fine siliciclastic detritus deposited in the Dead Sea. Fine detritus material that is deposited in the lake is dominantly derived from desert dust that was settled in the watershed and transported to the lake by seasonal floods (Belmaker et al., 2011; Haliva-Cohen et al., 2012). Some of the dust settled in the watershed went through pedogenic processes forming the mountain soils and loess deposits that later were also washed to the lake.

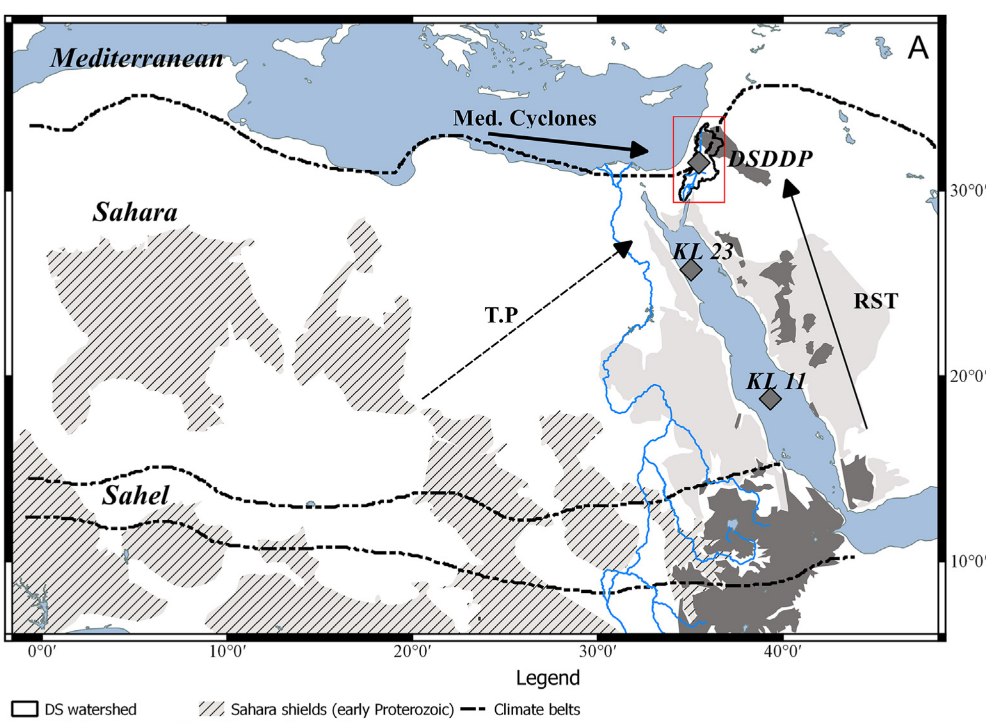

Fig. 1. Location maps. **A.** The Red Sea-Dead Sea transect with the studied cores crossing the desert belt marked as grey diamonds. The regional climatic belts are marked as dashed black lines. Arrows indicate the principal trajectories of the dust transport. Solid arrows mark transport of dust and rain through Mediterranean cyclones or active Red Sea troughs "RST", a dashed arrow marks the rain path of a tropical plume "T.P". A red square marks the inset of Figure 1B. **B.** The Dead Sea watershed, including the studied sites. Also noted by blue lines are the major fluvial paths leading to the Dead Sea drainage system. T.R (Terra Rossa), MTL (Moutain Top Loess), V.L (Valley Loess) and DS (Dead Sea). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)