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New perspectives on coastal landscape reconstruction during the Late Quaternary: A test case from central Israel

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ABSTRACT

The stratigraphic architecture of coastal plains is determined by the interactions between local (e.g. fluvial processes and topography), regional (e.g. climate) and global (e.g. sea level) forcing factors, primarily during the Late Quaternary Period. Detailed stratigraphic and sedimentological analyses of boreholes, cored between coastal ridges in the lowlands, coupled with optically stimulated luminescence (OSL) dating, and integrated with existing onshore and offshore databases, has enabled a 4-D reconstruction of the evolution of the coast of Israel during the last glacial-interglacial cycle. This model revealed that Nilotic-sourced littoral sand, intermittently transported inland by wind, has either been lithified into aeolianite or pedogenized into orange–brown palaeosol from about 100 ka to 8 ka. Dark silty clay wetlands were deposited between the aeolian coastal ridges adjacent to streams which cut the Israeli coastal plain and flow westward, from the Last Glacial Maximum until the onset of the Holocene. These units are topped by beach and aeolian quartz sand dated to 6.6–0.1 ka. Diachronous thicknesses and lithological dissimilarities were identified between the sections studied and previous reports on adjacent coastal aeolianite ridges. Streams were found to be a dominant control on the stratigraphical composition and related facies architecture due to fluvial-induced erosion. Consequently, the relief variations between the lowland and cliff controlled aeolian pedogenesis as well as alluvial processes from about 80 to 5 ka. Climate, mainly influenced by precipitation and dust input, induced pedogenic processes; while sea level lowstand during the Last Glacial Maximum is shown to have hindered sediment deposition in the shallow offshore, which in turn affected aeolian transport, reducing sediment accumulation on the palaeo-coastal plain. The palaeoenvironmental model presented in the current study serves as an example for understanding the evolution of similar low-latitude siliciclastic-rich low-gradient shelf-coastal areas during the last glacial-interglacial cycle. Furthermore, it demonstrates the influence of local to global forcing factors on these environments.

1. Introduction

During the Quaternary, relative sea level (RSL) fluctuations have had a major influence on the sedimentary archives of continental shelves and the adjacent coastal plains. The effect of sea-level on accommodation space is one of the major influences on aggradation and erosion, and hence on the distribution of sediments across the shelves. Additional interconnected factors operating at all scales, such as tides, waves, storms, precipitation, sediment input and vegetation cover, also play important roles in the depositional and erosional phases that shape the litho-stratigraphic architecture. Moreover, local processes, such as stream-courses, modify pre-existing depositional patterns and induce irregular erosion patterns, while local relief variations affect soil formation processes (Dan et al., 1968; Paton et al., 1995; Yaalon, 1997).

Aeolianite-palaeosol-sand sequences, which are characteristic of low latitude, siliciclastic shallow shelf and coastal areas, reflect this dynamic interaction between accommodation space, sediment supply and climate changes (Hearty et al., 2007; Brooke et al., 2003; Bateman et al., 2004; Zazo et al., 2005; Faust et al., 2015). Consequently, detailed chronostratigraphic study can potentially reveal changes in the environmental conditions during the Quaternary (Huntley et al., 1993, 1994; Rose et al., 1999; Huntley and Prescott, 2001; Preusser et al., 2002; Munyikwa, 2005; Tripaldi and Forman, 2007; Amorosi et al., 2009;

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Fitzsimmons et al., 2009; Roskin et al., 2011a; Brooke et al., 2014; Rowe and Bristow, 2015a, 2015b). Coastal stratigraphic studies have been conducted across the Mediterranean basin, in Spain (Fornós et al., 2009; Mauz et al., 2012), Sardinia (Coltorti et al., 2010; Thiel et al., 2010), Tunisia (Mauz et al., 2009, 2012; Elmejdoub et al., 2011), Cyprus (Tsakalos, 2016) and Egypt (El-Asmar, 1994; El-Asmar and Wood, 2000). These are characterized by alternating Late Pleistocene aeolianites, palaeosol units and accompanying alluvial facies. These studies have mainly focused on the correlation between dune formation and late Quaternary sea level oscillation, while less attention has been given to the coastal geomorphic response to climate, aeolian and alluvial processes. Furthermore, the studied units were usually site-specific, and not correlated with the adjacent terrestrial and submerged stratigraphies.

The Late Quaternary coastal palaeogeography of Israel has been studied since the 1940s in an attempt to correlate the coastal outcrop stratigraphy with transgressive and regressive sea level phases (Avnimelech, 1950). Later works concentrated on radiometric (luminescence and radiocarbon) ages for the central coastal aeolianite cliff sequences which yield ages younger than about 75 ka (Engelmann et al., 2001; Frechen et al., 2001, 2002; Porat et al., 2004; Moshier et al., 2010; Mauz et al., 2013). Hardly any attention has been paid to the submerged stratigraphy and to the sequences of lowlands located between coastal ridges. These locations potentially include palaeosols containing valuable climate indicators, and useful evidence for reconstructing past environments (Gvirtzman and Wieder, 2001; Zazo et al., 2005; Fitzsimmons et al., 2009). The relatively short time-frame attributed to the exposed sequences; the paucity of adequate subsurface chronostratigraphic studies; the absence of correlation of the coastal cliffs to the nearby lowland areas (Fig. 1c and d); and the lack of connection of the inner shelf to the coastal stratigraphy, have all hindered detailed reconstruction of the stratigraphic architecture of coastal areas and the investigation of the dominant long-term factors that affect the evolution of the coastal landscape.

The present study investigates the eustatic, climatic and local controls on the morphogenesis of the coastal system during the Late Quaternary of a selected study area located in central Israel (Fig. 1 for location). The findings are correlated in a wider environmental and climatic perspective, enabling the construction of an evolutionary model of the coastal environment over the last glacial-interglacial period. These goals were achieved through high-resolution sedimentological and chronostratigraphic studies of seven cores drilled in the Alexander-Hadera lowland area adjacent to the mouths of Nahal (Stream in Hebrew; N.) Hadera and N. Alexander (Fig. 1 for location). The new data were integrated with an existing detailed onshore and offshore database. The study area was selected based on: (1) the inclusion of

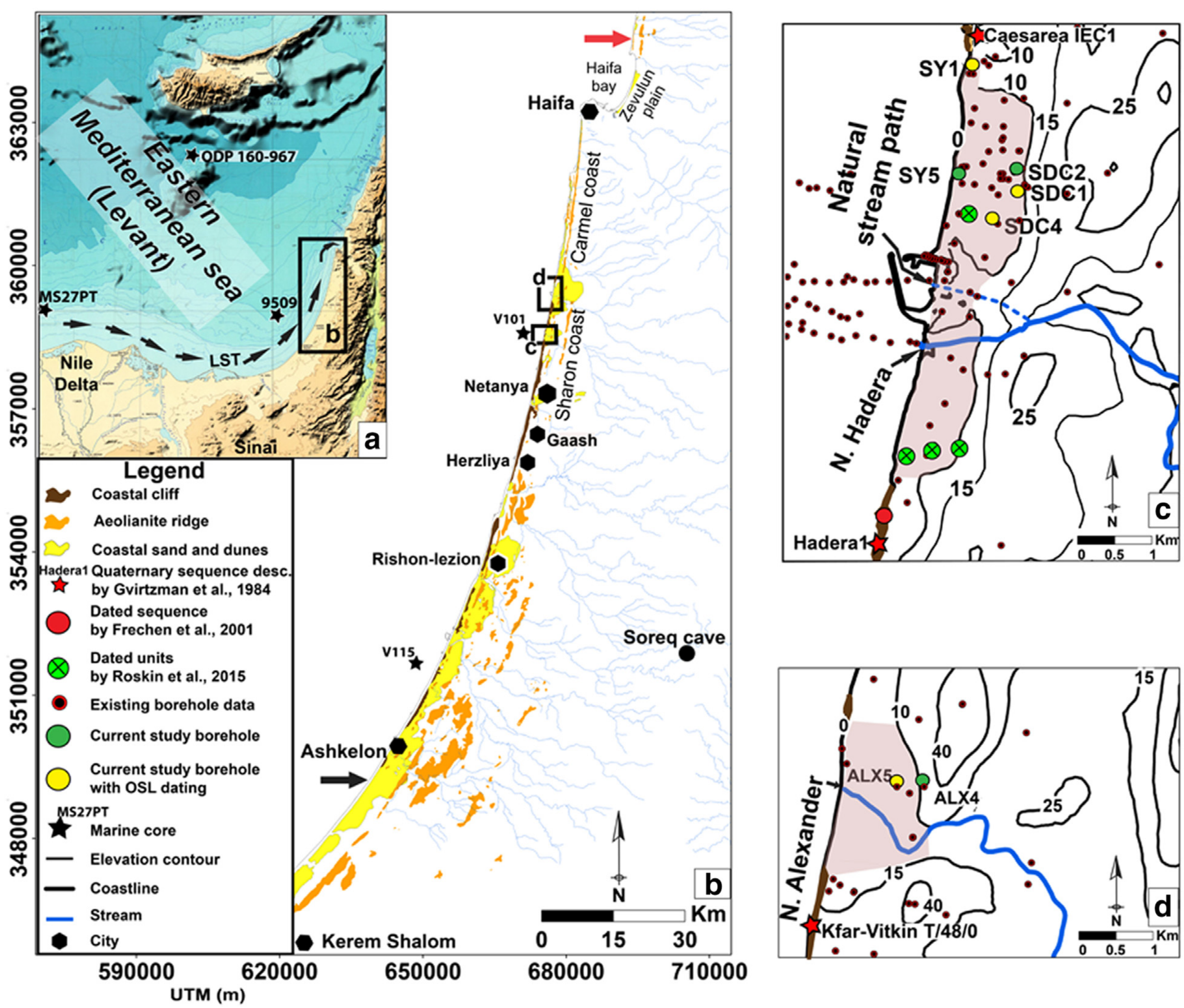

Fig. 1. The regional and sedimentological context of the studied area in the SE Mediterranean. (a) Location map of the study area in the south-eastern Mediterranean, showing the Nile littoral cell, longshore transport (LST) and existing marine drilling locations. (b) The sand sheets and Late Pleistocene aeolianite ridges of Israel's coastal plain. The wider parts of the coastal plain and coastal shelf are at the south (black arrow), while the narrow areas are at the north (red arrow). (c) Zoom into the Hadera area with existing logs, dated units and current study drilling location conducted in the 'lowland' area (grey polygon). (d) Zoom into Alexander area with existing logs and current study drilling location conducted in the 'lowland' area (grey polygon). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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