

Anthropogenic overprints on natural coastal aeolian sediments: A study from the periphery of ancient Caesarea, Israel



Gilad Shtienberg^{a,*}, Justin K. Dix^b, Ruth Shahack-Gross^{a,c}, Assaf Yasur-Landau^{a,c}, Joel Roskin^{c,d,e}, Revital Bookman^e, Nicolas Waldmann^e, Sarel Shalev^{a,f}, Dorit Sivan^{a,c}

^a Department of Maritime Civilizations, L.H. Charney School of Marine Sciences, University of Haifa, Haifa 3498838, Israel

^b The School of Ocean and Earth, University of Southampton, Southampton SO14 3ZH, UK

^c The Recanati Institute for Maritime Studies (RIMS), University of Haifa, Haifa 3498838, Israel

^d The School of Sciences, Achva Academic College, Israel

^e Dr. Moses Strauss Department of Marine Geosciences, L.H. Charney School of Marine Sciences University of Haifa, Haifa 3498838, Israel

^f Department of Archaeology, University of Haifa, Haifa 3498838, Israel

ARTICLE INFO

Keywords:

Eastern Mediterranean
Pedo-sediment
Anthropogenic traces
Islamic period
Caesarea hinterlands
Aeolian coastal sand

ABSTRACT

Near surface sediment stratigraphy associated with ancient human settlements can potentially reveal the complex history of human impact. This study explores such impacts in the area around ancient Caesarea, a well-known Roman to Early Islam period metropolis in the central coastal plain of Israel, with analysis of human-induced macro-features and microscopic remains found in buried sediments. We retrieved these anthropogenic markers through boreholes and analysed them with sedimentological and radiometric dating techniques, integrated with archaeological and historical records. The analysis identified a refuse deposit comprising two grey loamy sand artefact-bearing facies bedded between late Holocene aeolian sand. One anthropogenic facies represents an urban garbage mound and the other may be an agricultural pedo-sediment, both dated to the Roman to Early Islamic periods. The grey pedo-sediment, contained in three boreholes in the lowlands south of Caesarea, covers an area of at least 1.4 km². Apparently improved in terms of soil fertility, we postulate that the pedo-sediment is the outcome of composting enrichment of the soil for agriculture. Taking advantage of the high coastal freshwater aquifer in the study area, we propose that the pedo-sediment represents buried agricultural plots. The comprehensive, multi-disciplinary approach demonstrated in this study of cored sediments outside ancient human settlements is among the few in the coastal area of the southern Levant. It could be relevant to other archaeological sites in the Mediterranean and elsewhere around the world.

1. Introduction

For millennia, humans have manipulated soils for habitation purposes, leading to changes in the physical and chemical properties (Bouma and Hole, 1971; Hole, 1974; Nicosia and Devos, 2014). Therefore, a complex history of human impact on the environment is accruing in sediments and soils. Extensive archaeological and paleoenvironmental research has increased the understanding that significant human perturbations to the landscape occurred throughout hominin evolution, most significantly with the advent of agriculture (Sandor et al., 1990; Certini and Scalenghe, 2011; Zeder, 2011).

In the southeast Mediterranean coastal region, the Holocene period is characterized by ongoing interaction between natural processes and human activities (Bar-Yosef, 1975; Galili and Nir, 1993; Galili et al., 1993; Godfrey-Smith et al., 2003). Anthropogenic activities that have

impacted the environment include site construction, animal domestication, wood/charcoal burning and cultivation of crops. Human activity has left distinct traces in soils such as macroscopic artefacts: pottery, stone tools, architecture and bone remains. Microscopic evidence of human activity includes livestock dung spherulites, ash and micro-charcoal, phytoliths (plant-made minerals which may be preserved in soils and sediments) and enrichment of certain elements (i.e., phosphorous and sulphur) (Weiner, 2010). Techniques used to identify anthropogenic impacts in soils are usually applied to settlement sites and rarely to cultivated hinterlands (Smejda et al., 2017).

This study focuses on the area to the south of ancient Caesarea, Israel (32°30'0"N, 34°53'30"E), a well-known Roman to Crusader period (31 BCE to 1265 CE) urban centre. The continuous efforts of the local population to adapt their activities to both their varying needs and changing natural environments has resulted in human-induced

* Corresponding author.

E-mail address: gshtienb@campus.haifa.ac.il (G. Shtienberg).

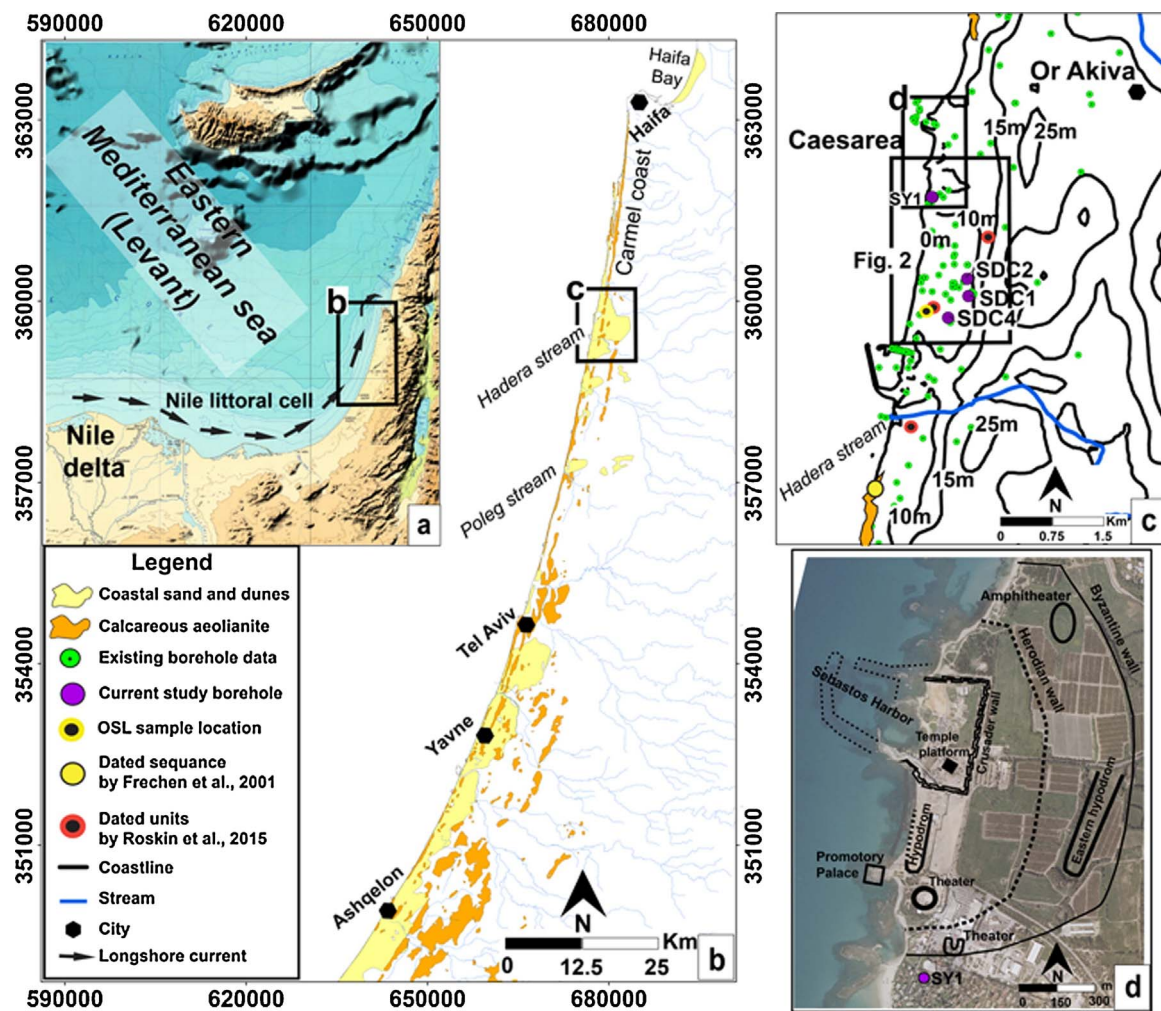


Fig. 1. Regional and sedimentological context of the study area. (a) Map of the southeast Mediterranean illustrating the Nile littoral cell and longshore transport responsible for accumulation of sand along the eastern Mediterranean Israeli coast. (b) Detailed map showing sand sheets and Late Pleistocene aeolianite ridges typical to Israel's coastal plain and the river systems flowing toward the coastal area. (c) Map of the Caesarea area (study site) marking previously published and current boreholes along with dated unit locations. (d) Map of Caesarea (32°30'0" N, 34°53'30" E) annotating the previously excavated site and harbour ruins (modified after Reinhardt and Raban, 2008) in relation to borehole SY1 on a rectified aerial photograph from 2016.

landscape changes, giving rise to a complex cause-effect phenomena (Ackermann et al., 2014, 2015). This study investigates the effect of human settlement on the proximate environment, outside the settlement itself, through analysis of anthropogenic markers present within the local sediment stratigraphy. We identified markers through a combination of sedimentological, petrophysical, geochemical, chronological and microarchaeological analyses conducted on four boreholes. Integration of these new data with extant topographical data, borehole records, established chronology, archaeological finds and historical documentation, resulted in a spatially extensive interpretation of changing settlement and subsistence patterns in the area.

2. The study area

The study area is located in the Caesarea lowlands (Shtienberg et al., 2017), situated in the centre of the 190 km-long coastal plain of Israel (Fig. 1a, b). The study area extends up to 1.5 km east from the Mediterranean Sea between Hadera Stream to the south and Caesarea to the north. South of Haifa Bay, the coastal plain of Israel is dominated by Nile-derived quartz sand deposits attaining thicknesses of 1 to 9 m (Neev et al., 1978; Almador et al., 2000; Zviely et al., 2006; Schattner et al., 2010; Roskin et al., 2015, 2017; Shtienberg et al., 2016). Longshore currents transported this allogenic material to the region

throughout the Quaternary period (Fig. 1a; Picard, 1943; Emery and Neev, 1960; Pomerancblum, 1966; Zviely et al., 2009; Davis et al., 2012). Wave- and wind-induced currents transported the sediments to the beach, and wind carried them inland to form sand sheets and dunes (Fig. 1b). The quartz sand eventually formed the Late Pleistocene sequence consisting of alternating aeolianites (cemented dune sand locally known as 'kurkar') and red-brown silty clayey sandy loams (Palaeosols) overlain by loose sand sheets and dunes (Fig. 1b; Yaalon, 1967; Yaalon and Dan, 1967; Gvirtzman et al., 1998; Frechen et al., 2002; Sivan and Porat, 2004; Mauz et al., 2013). Aeolianites in the vicinity of Caesarea are chronologically constrained between approximately 115 and 50 thousand years ago (ka; Engelmann et al., 2001; Frechen et al., 2004; Sivan and Porat, 2004; Sivan et al., 2004; Mauz et al., 2013; Shtienberg et al., 2017). The overlying palaeosol units, reaching a maximum thickness of 8 m, date from roughly 100 to 8 ka (Gvirtzman and Wieder, 2001; Frechen et al., 2001; Roskin et al., 2015; Shtienberg et al., 2017), indicating they are sometimes synchronous with aeolianite formation (Sivan and Porat, 2004) and sometimes younger. As sea level rose during the Late Pleistocene-Holocene transition, the shoreline migrated eastwards, flooding the shallow shelf (depth shallower than -20 m) c. 8 ka (Sivan et al., 2001, 2004). The Nilotic sands accumulated on the coast, initially covering the palaeosol surface c. 7 ka (Frechen et al., 2002; Porat et al., 2004; Mauz et al.,

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