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A contribution to late Middle Paleolithic chronology of the Levant: New luminescence ages for the Atlit Railway Bridge site, Coastal Plain, Israel

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ABSTRACT

The Atlit Railway Bridge (ARB) prehistoric site is located on the northern coastal plain of Israel, within natural caves which formed in calcareous aeolianites (kurkar), perhaps during a high sea-stand. Flint artifacts belonging to the Levantine later Mousterian tradition and faunal remains were found embedded in the kurkar infill of two caves. The aeolianites in which the caves had developed were previously constrained by $IRSL_{50}$ dating of feldspars to be older than the last interglacial highest sea-stand (Frechen M. et al., 2004; Chronology of Pleistocene sedimentary cycles in the Carmel Coastal Plain of Israel. Quaternary International 121, 1–52), providing a maximum age for the artifacts.

Samples for luminescence dating were collected from the infill of the two caves (II and III), from the same deposits as the archaeological finds. Both quartz and alkali feldspars (KF) were extracted and measured using four different luminescence signals: optically stimulated luminescence (blue OSL) and violet stimulated luminescence (VSL) on quartz; and the infrared stimulated luminescence (IRSL) post-IR-IR_{290} signal and the IR_{50} signal corrected for anomalous fading on KF.

The ages obtained from analyses of the different minerals and signals mostly agree within errors. The new luminescence ages date the sediment infill in Caves III and II to ~90 ka and ~70 ka, respectively, indicating that hominin occupation of this locality is coeval with the nearby Skhul Cave and Layer B in Tabun Cave.

1. Introduction

The southern Levant is a critical region for examining hominin biological and cultural evolution during the Middle Paleolithic (MP), particularly given the presence of both Neanderthals and early anatomically modern humans in the region (McCown and Keith, 1939; Rak, 1998; Shea, 2010; Weinstein-Evron, 2015; Langdon, 2016). Moreover, lithic typologies attest to extensive inter-site variability during this period, but the factors responsible - different hominin abilities, socio-cultural choice and behaviours, climatic and local ecological factors, or chronology - are unclear (e.g. Jelinek, 1981; Bar-Yosef and Meignen, 1992; Goren-Inbar and Belfer-Cohen, 1998; Hovers, 2009; Belfer-Cohen and Hovers, 2010; Kadowaki, 2013). Finally, the timing and nature of the transition between the late MP and the Upper Paleolithic is of special interest, especially given the debate over cultural continuity and apparent association of this period with the dispersal of anatomically modern humans Out of Africa (Bar-Yosef, 2002; Shea, 2008; Belfer-Cohen and Goring-Morris, 2009; Hershkovitz et al., 2015). Consequently, robust dating MP sites in this region is a critical issue.

Initially, radiocarbon was the principal source of chronometric data for the MP (e.g. Weinstein, 1984; Henry, 1992). Advances in this field of dating – including introduction of accelerator mass spectrometry, improved pretreatment chemistry of samples as well as statistical tools – still renders radiocarbon an essential tool for dating terminal MP sites (e.g. Bronk Ramsey et al., 2004; Bronk Ramsey, 2009; Taylor and Bar-Yosef, 2014). However additional radiometric methods are needed to date deposits and sites from early and middle MP which are beyond the limit of radiocarbon (ca.

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40–60,000 years BP, Taylor and Bar-Yosef, 2014:24). Methods commonly applied to MP occupations include electron spin resonance (ESR) for teeth (see review by Grün, 2006), and luminescence dating methods which include among other techniques thermoluminescence (TL) for burnt flints (e.g. Valladas et al., 2013) and optical stimulated luminesce (OSL) for quartz grains in sediments (see review by Roberts et al., 2015). They have extended the range of dating for the MP considerably and improved precision of dating through cross-checking of ages between different methods to create a more robust chronometric framework for this period in the southern Levant (e.g. Mercier et al., 2013). The luminescence methods have proved especially useful, given that many sites lack organic remains (bones, teeth, charcoal) and contain only burnt flint and sediment.

As new techniques are developed in luminescence dating, there is a need to test them in sites where they can be compared to well-established methods such as radiocarbon or OSL (Wintle, 2008; 2010). Some of the new methods, such as violet stimulated luminescence (VSL; Jain, 2009), aim at dating samples older than 200 ka, a time range usually not covered by OSL. The best test case for a comparative study of luminescence methods is a site which is younger than 200 ka, is rich in both quartz and feldspars, and has some age control. Atlit Railway Bridge (ARB) is such a site; its relative age has been established by previous luminescence dating to be younger than the last interglacial high sea-stand (MIS 5e; Frechen et al., 2004); according to the lithic assemblage it is of late Mousterian age (Ronen et al., 2008); and it is situated in the coastal plain sandy aeolianites and soil sequence rich in quartz and feldspars.

Here we present a comparison of several luminescence methods on samples from ARB, show how the ages compare with each other, and provide a robust age for the site. These ages are then placed within the context of late MP chronology for the southern Levant.

2. Background to the study region

Mount Carmel and the adjacent coastal plain of northern Israel (Fig. 1) are characterized by a Mediterranean climate with a mean annual temperature of 19 °C and annual precipitation of ca. 600–800 mm. Varied habitats are available in this region, ranging from typical Mediterranean forests or maquis on Mount Carmel to dunes, swamps and agricultural land on the coastal plain (Orni and Efrat, 1971). The region is of immense importance for prehistory, with well over 200 documented prehistoric sites spanning a range of periods and cultures in an area of ca. 30,000 ha (Olami, 1984; Ronen, 1977; Tsatskin and Ronen, 1999; Nadel et al., 2012; Weinstein-Evron, 2015). Of particular note are several caves and rock shelters clustered on the western side of Mount Carmel (Tabun, Jamal, Skhul, el Wad, Sefunim, Kebara and Misliya), as well as other sites in northern Israel (Qafzeh, Amud, Manot) that have yielded a rich and lengthy record of archaeological remains dating to the Lower Paleolithic (Late Acheulian and Acheulo-Yabrudian cultural entities, ca. 500–220 ka) and Middle Paleolithic (Mousterian cultural entities, ca. 245 to 45-47 ka) (Garrod and Bate, 1937; Ronen, 1984; Weinstein-Evron et al., 2003; Bar-Yosef and Meignen, 2007; Shea, 2013; Hershkovitz et al., 2015; Weinstein-Evron, 2015). The MP sites are unparalleled in that they contain remains of both early anatomically modern humans (Skhul I-IX, Tabun C2, Manot; Qafzeh) and Neanderthals (Kebara 1–2, Tabun C1, Tabun B, Geula, Amud), making the Carmel in particular, and northern Israel in general, a unique region for the study of human evolution (e.g. McCown and Keith, 1939; papers in Akazawa et al., 1998; papers in Bar-Yosef and Pilbeam, 2000; Shea, 2010; Langdon, 2016).

Mousterian sites on the adjacent Carmel narrow coastal plain are, in contrast, ephemeral and comprise scanty cultural and organic remains embedded in aeolian calcarenite or red soils, locally termed kurkar and hamra, respectively (e.g. Ronen, 1977; Ronen et al., 1999; Boenigk et al., 1985; Galili et al., 2007; Ronen and Chernikov, 2010; Galili et al., 2017). One such occurrence is the Atlit Railway Bridge (ARB) locality, situated ca. 5 km northwest of the caves of Tabun and Skhul (Fig. 1; Ronen et al., 2008).

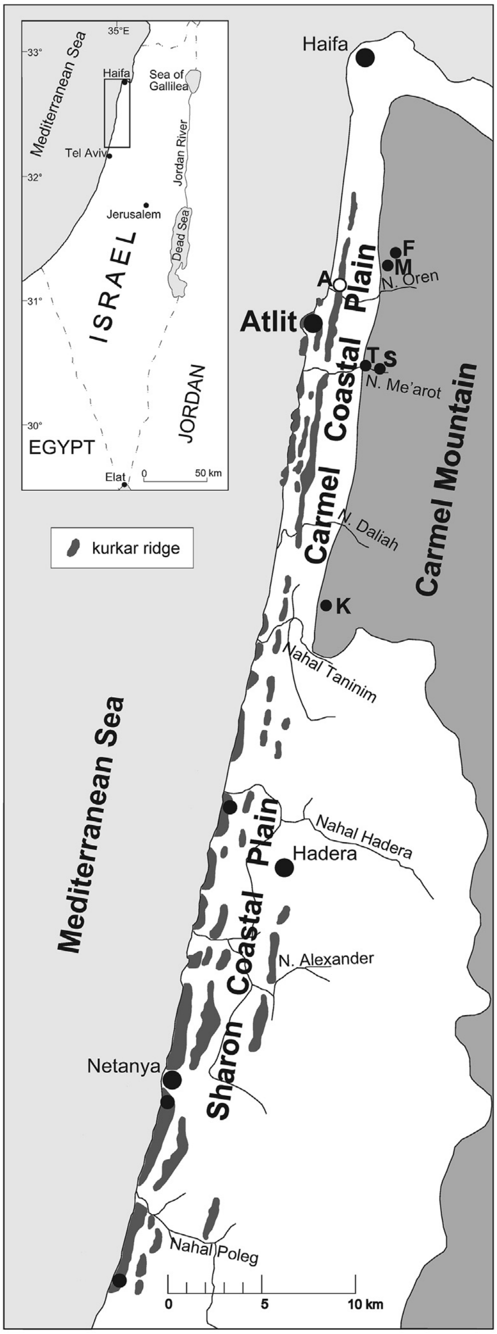

Fig. 1. Location map showing the Atlit Railway Bridge site (small open circle marked with A) and the Sefunim (F), Tabun (T), Skhul (S), Misliya (M) and Kebara (K) caves nearby (modified from Frechen et al., 2002).

The topography of the Israeli coast is made up of four to five longitudinal Pleistocene kurkar ridges that run parallel (north-south) to the coast. These ridges alternate with troughs filled with clays, sands and alluvial sediments (Issar, 1968; Almagor, 2002;