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Palaeohydrological corridors for hominin dispersals in the Middle East ~250–70,000 years ago

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ABSTRACT

The timing and extent of palaeoenvironmental connections between northeast Africa, the Levant and the Arabian Peninsula during the Middle and Late Pleistocene are critical to debates surrounding dispersals of hominins, including movements of *Homo sapiens* out of Africa. Although there is evidence that synchronous episodes of climatic amelioration during the late Middle and Late Pleistocene may have allowed connections to form between northern Africa and western Asia, a number of palaeoclimate models indicate the continued existence of an arid barrier between northern Arabia and the Levant. Here we evaluate the palaeoenvironmental setting for hominin dispersals between, and within, northeast Africa and southwest Asia during Marine Isotope Stages (MIS) 7–5 using reconstructions of surface freshwater availability as an environmental proxy. We use remotely sensed data to map palaeohydrological features (lakes, wetlands and rivers) across the presently hyper-arid areas of northern Arabia and surrounding regions, integrating these results with palaeoclimate models, palaeoenvironmental proxy data and absolute dating to determine when these features were active. Our analyses suggest limited potential for dispersals during MIS 7 and 6, but indicate the formation of a palaeohydrological corridor (the 'Tabuk Corridor') between the Levant and the Arabian interior during the MIS 6-5e glacial–interglacial transition and during MIS 5e. A recurrence of this corridor, following a slightly different route, also occurred during MIS 5a. These palaeohydrological and terrestrial data can be used to establish when proposed routes for hominin dispersals became viable. Furthermore, the distribution of Arabian archaeological sites with affinities to Levantine assemblages, some of which are associated with *Homo sapiens* fossils, and the relative density of Middle Palaeolithic assemblages within the Tabuk Corridor, are consistent with it being utilised for dispersals at various times.

1. Introduction

Pleistocene out of Africa hominin dispersals are key events in human evolution. When evaluating the routes such dispersals may have followed, it is clear that the Levant and northern Arabia represent critical regions connecting the Sinai Peninsula, the only terrestrial route out of Africa, to Eurasia during the Middle and Late Pleistocene (Petraglia and Alsharekh, 2003; Derricourt, 2005; Lambeck et al., 2011). The climates and environments that prevailed in these regions during the late Middle and Late Pleistocene would therefore have been a primary control on the timing and extent of hominin dispersals, including those of *Homo sapiens*, via this continental route.

The terrestrial route via the Sinai is of special interest in human evolutionary studies, as the earliest documented fossils of *Homo sapiens* known outside Africa were found in the Levant, and date to ~130–90,000 years ago (ka) (Valladas et al., 1988; Grün et al., 2005), suggesting that an important dispersal event occurred during (or prior to) Marine Isotope Stage (MIS) 5. However, interpretations vary on whether this was a locally limited 'failed dispersal' (Mellars, 2006a, 2006b; Oppenheimer, 2009, 2012; Mellars et al., 2013) or part of a wider expansion that extended into Arabia and southwest Asia (e.g. Petraglia et al., 2010; Armitage et al., 2011; Rose et al., 2011; Boivin et al., 2013; Groucutt et al., 2015a,b). Subsequent relatively unambiguous evidence for the presence of *Homo sapiens* outside Africa is not known until MIS 3 in Southeast Asia and

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Australia. For example, fossils from Tam Pa Ling cave, Laos, have been dated to ~63–43 ka (Demeter et al., 2012, 2015), and those from Lake Mungo, Australia, to ~50–45 ka (Bowler et al., 2003), although emerging East Asian fossil evidence is consistent with a much earlier arrival of *Homo sapiens* (Liu et al., 2015). However, species attributions based on lithic assemblages from intervening locations and time periods remain controversial, and estimated dates based on genetic data for key evolutionary events such as dispersals are currently strikingly variable (compare Scally and Durbin, 2012; Mellars et al., 2013; Groucutt et al., 2015a). There is therefore considerable ambiguity in the potential extent and chronology of hominin dispersal events in the Middle East during the late Middle Pleistocene and Late Pleistocene, and the species involved.

Here we consider the potential for hominin dispersals out of Africa via a northern (*trans*-Sinai) route to the Levant and northern Arabia (Fig. 1) during the late Middle to Late Pleistocene (MIS 7–4), a time period spanning the MIS 5e (Last Interglacial) interval associated with widespread environmental amelioration. These regions occupy a critical geographical position for evaluating the spatial extent of dispersals via the Sinai route, although the archaeological and palaeoenvironmental records from Arabia are currently less well understood than those of the Levant and North Africa. Here, we focus on data from the Nefud Desert, northern Saudi Arabia (Figs. 1 and 2), where dated Middle Palaeolithic stone tool assemblages indicate the presence of hominin populations during MIS 7, 5c and 5a (cf. Petraglia et al., 2011, 2012). Moreover, numerous records of undated typo-technologically Middle Palaeolithic assemblages from across northern Arabia indicate that these were far from isolated occurrences (cf. Groucutt and Petraglia, 2012, Fig. 1). This emerging body of archaeological evidence raises important questions pertaining to regional connections, and the routes by which these hominin populations penetrated the Arabian Peninsula.

Most of the region is hyper-arid at present (Fig. 2), however, as will be discussed here, episodic climatic amelioration occurred during the Pleistocene. During these events the distribution of surface freshwater would be a significant control upon the penetration of this area of the mid-latitude desert belt (*sensu* Finlayson, 2013, 2014; Groucutt and Blinkhorn, 2013), as humans require abundant freshwater on a virtually daily basis, particularly in deserts, where high temperatures compound heat stress and water loss. Furthermore, several lines of evidence are indicative of a persistent arid barrier across northern Arabia, even during amelioration episodes (N. Arabian Desert Barrier, Fig. 2). We therefore combine catchment-level palaeohydrological analyses and distribution data for Middle Palaeolithic archaeological sites, to examine relationships between reconstructed palaeohydrological corridors and evidence for hominin dispersals into northern Arabian Desert. The resulting palaeohydrological mapping provides a basis for testing hypotheses relating to potential migration routes exploited by humans and other animals in terms of freshwater availability.

1.1. Study area

The study area encompasses northeast Egypt, the Sinai Peninsula, the Levant, northern Arabia and the Lower Euphrates (Fig. 1), which constitute the critical region for modelling terrestrial routes out of Africa. The term 'northern Arabia' is here defined as the arid region east of the Sinai Peninsula, including parts of southeast Jordan, southern Iraq, and northern Saudi Arabia (Fig. 2). It has been suggested that dispersals could have occurred across the Jordanian desert plateau during Pleistocene wet phases, for which two routes have been proposed (Fig. 1). The first, the 'Azraq Corridor', connects the Levant to Arabia via northern Jordan and along the Wadi Sirhan depression (Cordova et al., 2013; Ames et al., 2014; Ames and Cordova, 2015). The second, is a southern route from the Negev

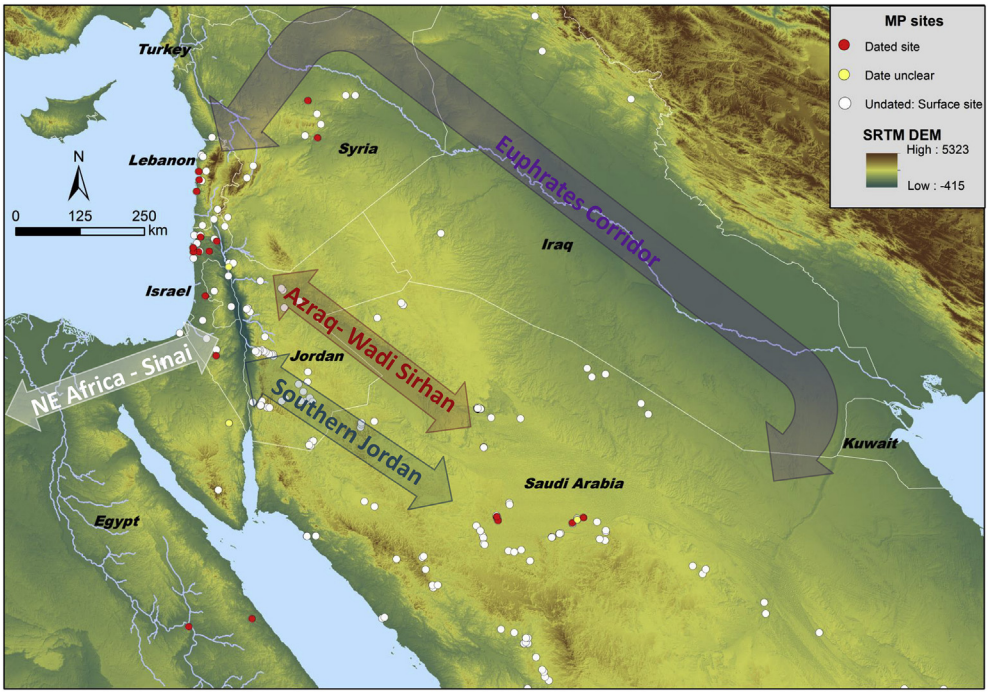

Fig. 1. Spatial distribution of Middle Palaeolithic sites across the study region (which excludes Cyprus and the northern Mediterranean coast). Dated sites are differentiated from surface assemblages. Data is overlain upon SRTM v4 DEM data (Jarvis et al., 2008; Reuter et al., 2007), and borders are marked (white). Previously suggested potential routes for Pleistocene dispersals between Northern Arabia and the Levant are marked as arrows and labelled. Present drainage systems that may have been active for much of the Pleistocene are also displayed.