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Consistency of the "MIS 5 Humid Corridor Model" for the Dispersal of Early *Homo sapiens* into the Iranian Plateau

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Introduction

Recent improvements in paleogenetic studies support interbreeding between *Homo sapiens* and other hominins, including Neanderthals and Denisovans over 100 kya (Bergström et al. 2020; Kuhlwilm et al. 2016; Harvati et al. 2019; Scerri et al. 2019). Meanwhile, fossil and archaeological evidence document that *Homo sapiens* were present outside of the African continent at around 194 kya, and are argued to have reached Sahul by about 65 kya (Demeter et al. 2012; Clarkson et al. 2017). This issue raises many questions regarding the time and dispersal route(s) of Eurasian *Homo sapiens* colonisation. In line with these discoveries, besides the Levantine corridor, which was considered as a key area during recent years, the Arabian Peninsula and Southern Asia have been targeted as the other main hominin crossroad areas. Several theories attempt to explain why *Homo sapiens* exited the African continent and spread across the globe. Some scholars suggest that climatic changes which resulted in wet conditions from 120 to 90 kya ago (Tierney et al. 2017) allowed *Homo sapiens* to cross the African Sahara by providing access to fresh water (Scerri et al. 2014). Regardless of what instigated the migration out of Africa, the actual pathway of migrating early *Homo sapiens* is a hot topic among anthropologists. These days, the huge dry deserts of the Middle East and Arabian Peninsula, with minimal fresh water sources, could be considered to act as impenetrable natural barriers to human mobility. Recent palaeohydrological research of the hominin settlements during the Marin Isotope Stage (MIS) 7 to 5, most specifically 5e in the Middle East, suggests that there were enough humid environmental conditions to allow *Homo sapiens* to cross the Arabian Peninsula inland, towards broader dispersal regions (Breeze et al. 2015, Groucutt et al. 2015a; 2018). These include areas such as the Persian Gulf and the Hurmuz Straight areas, or the northern edge of the Persian Gulf entering into the south of Iran. More specifically, recent Palaeolithic research in the Arabian Peninsula has resulted in the discovery of significant Middle Palaeolithic occupations at sites located along the Persian Gulf basin (in the United Arab Emirates to be precise) dated to 125 kya (Scott-Jackson et al. 2009; Armitage et al. 2011; Rose 2010) and multiple MP sites in northern Arabia (Petraglia et al. 2012), as well as in Yemen at the well-dated Middle Palaeolithic sites in the Wadi Surdud (Delagnes et al. 2012). The strong link between MP occupation and fresh water sources such as paleo-rivers and lakes (Breeze et al. 2015; 2016; Groucutt et al. 2015b; 2015c) all support the idea of early *Homo sapiens* dispersals during the humid phases of the Middle and Late Pleistocene periods. When examining a map of MP sites distributed

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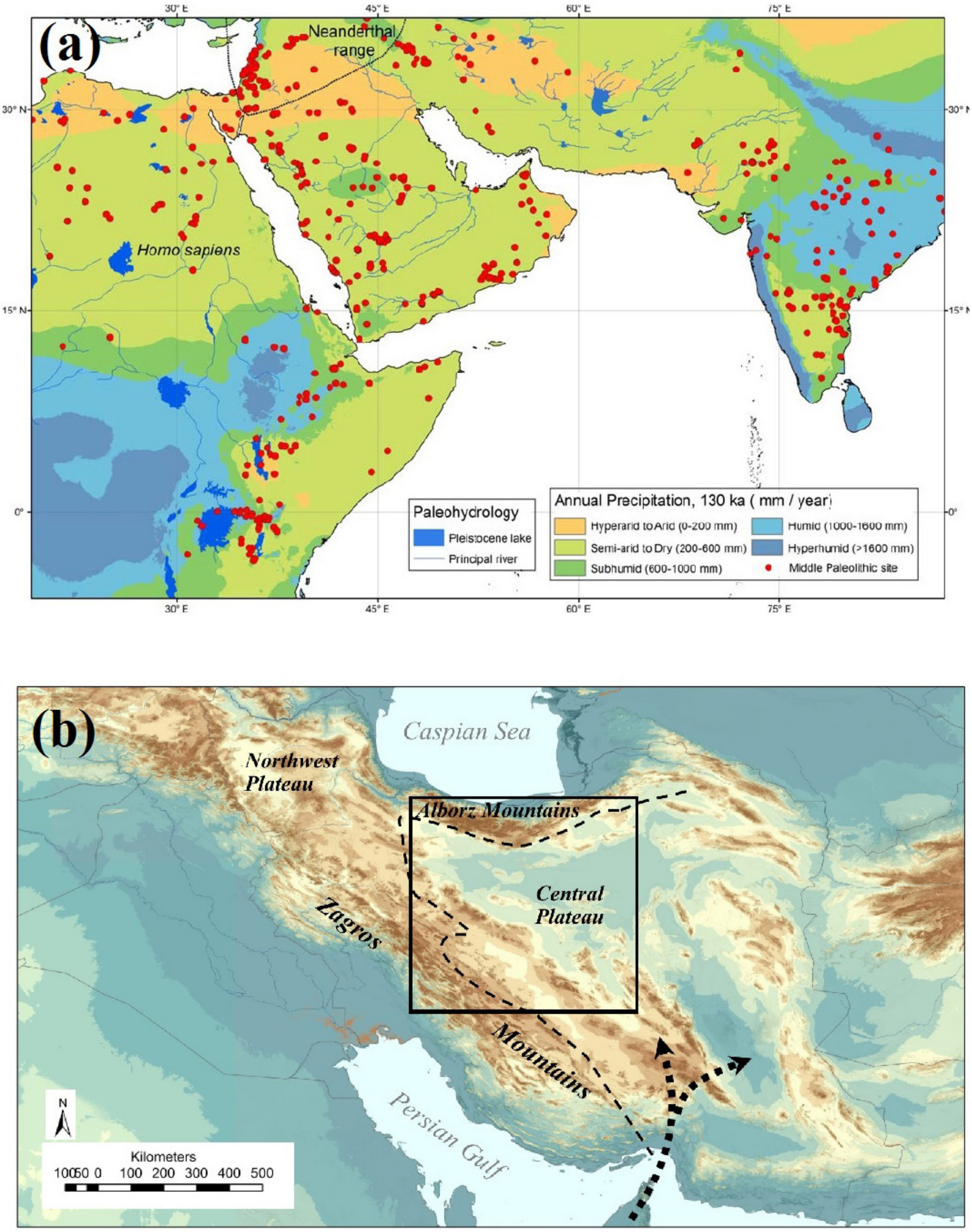

Fig. 1. (a): The distribution of Middle Palaeolithic sites across East Africa, the Saharo-Arabian belt, and India, plotted on a modelled precipitation map for the last interglacial (MIS 5) with positions of major paleolakes (dark blue areas) and paleorivers, which form extensive riparian corridors (blue lines). The Neanderthal range line shows the estimated extent of Neanderthal dispersal from the north. The map shows that Middle Palaeolithic sites are commonly located in interior regions and that their presence in typically arid areas can be explained by the humid climate conditions of periods such as MIS 5, which activated paleohydrological networks and potentially transformed major deserts into savannah grasslands and shrublands (green areas) containing numerous fresh water lakes and rivers. The paucity of sites in Pakistan and eastern Iran almost certainly reflects research history rather than a real pattern (Groucutt et al. 2015a). (b) and (c): Topo-hydrographic map of central Iran with known MP sites and the sites mentioned in this article; maps by the authors.

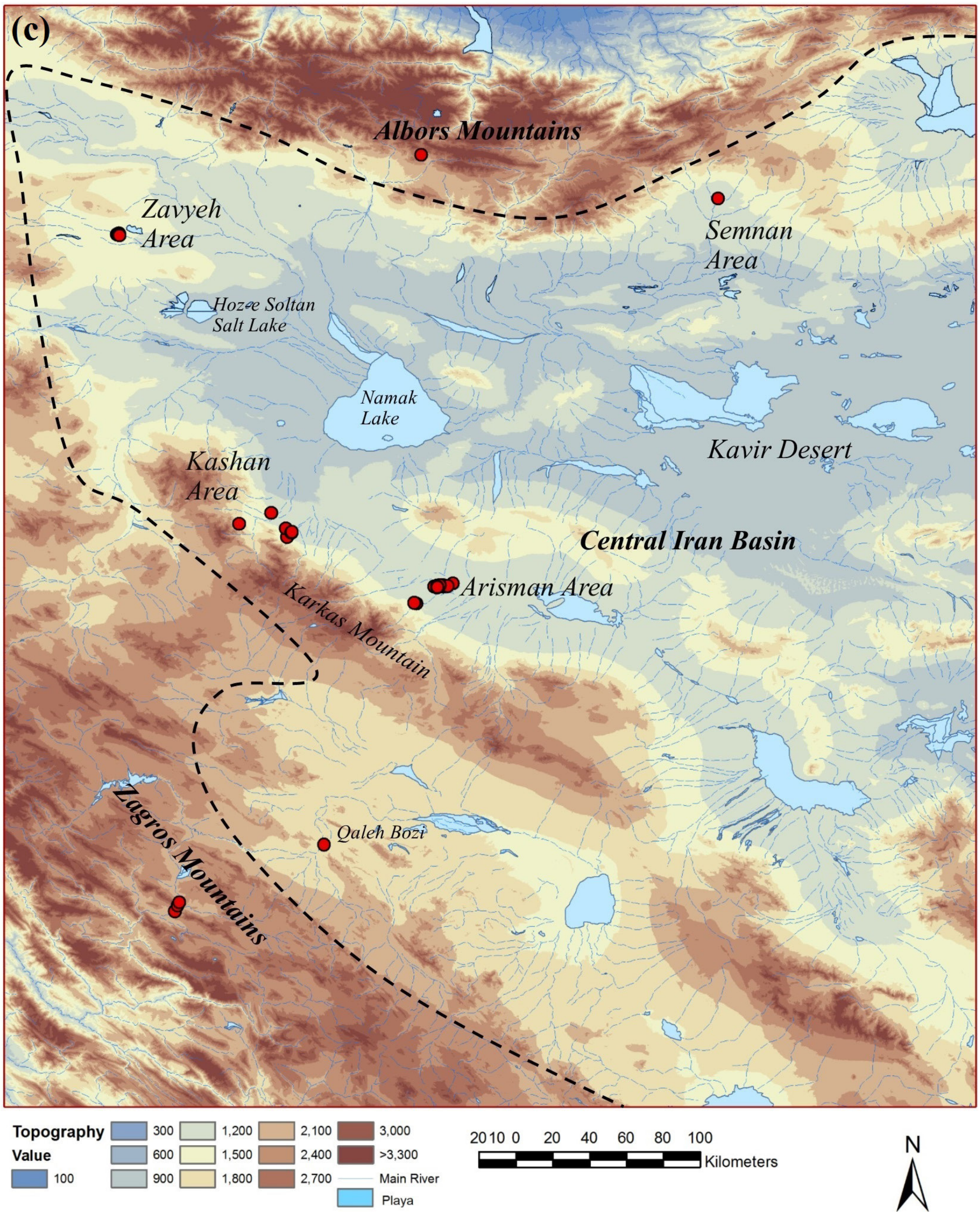

Fig. 1 (continued).

across the southwest and south Asian regions, it is noticeable that there is a meaningful and continuous pattern, whilst the Iranian Plateau at the centre of this map is still blank (**Fig. 1a**).

Biogeographically, the Iranian Plateau as an Afro-Arabian realm (Dennell 2020) has been under-researched for various reasons, and it represents a missing link with regards to the map of early hominin migrations. This large plateau is situated between two bodies of water, the Caspian Sea to the north and the Persian Gulf and Oman Sea to the south (**Fig. 1.b**), and lies along the easiest overland route from the Levant/Arabian Peninsula to the Indian sub-continent and south-eastern Asia (Heydari-Guran 2014, 1). So far, some studies conducted at different sites have yielded important results such as strong evidence for Neanderthal occupation at Shanidar (Solecki 1963), Bisetun (Coon 1957; Trinkaus and Biglari 2006), and Wezmeh (Zanolli et al. 2019) caves. However, based on the identified cultural remains and absolute dating, we suspect that during MIS 4 and early MIS 3, at least, with the appearance of laminar technology, *Homo sapiens* probably colonised the Zagros Mountains at the western rim of the Iranian Plateau (Solecki 1963; Becerra-Valdivia et al. 2017; Ghasidian et al. 2019).

The Iranian Plateau is divided into three different physiographic zones, with the Zagros Mountains covering the southwestern and western parts of it. The Alborz Mountains cover the northern part and the rest consists of the semi-arid environments of the Central Plateau, which comprises two thirds of the entire Iranian Plateau (**Fig. 1b**, **c**). Recently a few Palaeolithic surveys have been conducted in these previously unknown interior regions of the Plateau and have resulted in the discovery of several Palaeolithic occupations (Biglari et al. 2009; Vahdati Nasab et al. 2013; and Heydari-Guran et al. 2015). These discoveries confirm the high potential for the Central Iranian Plateau during the Palaeolithic, and refute the notion that MP settlement was limited to the karstic landscape of the Zagros Mountains. However, the research conducted so-far raises numerous questions regarding settlement patterns and the diversity of culture during the Palaeolithic. Technologically speaking (in terms of typology), the lithic artefacts from the Iranian Central Plateau are reminiscent of areas outside the plateau itself, such as the Arabian Peninsula and even the Levantine Region. These artefacts are different to those of the MP of the Zagros, namely the Zagros Mousterian, which is geographically closer to the Central Plateau of Iran (Heydari-Guran et al. 2015). The Zagros Mousterian is traditionally associated with Neanderthals, since Mousterian artefacts were found in association with physical remains of this species at Shanidar (Solecki 1963; Jaubert et al. 2006). One of the main reasons for these cultural similarities and differences, asides from different elevations and stone raw material resources, is the fact that most of the Palaeolithic sites in the Zagros Mountains (with its Mediterranean climate) are found in shelter sites, while in the Central Plateau (like in the Arabian Peninsula) they are mostly open-air settlements.

Apart from these possible environmental conditions, this study seeks to evaluate the link between MP material cultures and the early *Homo sapiens* who may have entered the Iranian Plateau from the Arabian Peninsula through the Persian Gulf oasis (Rose 2010).[1] Furthermore, we seek to examine if these early *Homo sapiens* were responsible for the MP lithic assemblages, rather than the Neanderthals as previously thought. Recent research in the Arabian Peninsula raises the question of a possible relationship between these two regions (Armitage et al. 2011; Rose 2010). For instance, the bifacial foliates from the Qaleh Bozi cave (Biglari et al. 2009) share stronger similarities with the bifacial tool types of the sites around the Persian Gulf basin (Rose 2010). This hypothesis is in accordance with the MIS 5 humid corridor model (Breeze et al. 2015; 2016; Crassard et al. 2013). Based on this model and our new findings in the Central Plateau of Iran, we aim to answer two important research questions:

a. Can we consider the Central Iranian Plateau as part of the humid corridor during MIS 5 for hominin expansion towards east and northeast?

b. Is there any cultural relationship between the Central Plateau sites and other parts of the Plateau and Arabian Peninsula?

1 Another possible route could be via the Wadi al Batin which drains from the Hijaz into Kuwait (Crassard et al. 2013).

Geomorphic and depositional features as signatures of the humid phases in the northwest of the central Iranian Plateau

The proposed timing for late Pleistocene human expansion into the Iranian Plateau via the southern corridor is during the wet episodes of MIS 5, especially 5e, which is often referred to as a moisture window. In general, MIS 5e is a temperate phase during the interglacial period between ca. 130 to 74 kya. Based on fieldwork and simulation models for North Africa, the Arabian Peninsula, and the Levant, climatic reconstructions suggest that these regions experienced alternating wet/dry phases during MIS 5e (Kutzbach et al. 2020). Geomorphic features in the region from the African Sahara to the Western Arabian Peninsula and the Levant including playas, dry streams, as well as travertine and tufa formations are robust signatures of hydrological activities (Breeze et al. 2015; Groucutt et al. 2015b; 2015c).

The northwest part of the Central Plateau of Iran consists of a large arid/semi-arid area ranging from 800 to 1000 m asl at the southern slopes of the Alborz Mountains and ca. 1500 to 3000 m asl at the northern and eastern edges of the Karkas Mountains to the southwest. This region is part of the Urumieh-Dokhtar Magmatic and consists of various Palaeogene igneous rocks such as granite, andesite, basalt, and tuff (Heydari-Guran et al. 2009; 2015). Previous Palaeolithic studies in this region revealed several geological features with MP and Upper Palaeolithic (UP) occupations all dated to the late Pleistocene including fluvial-lacustrine deposits (playas), sand dunes, and spring-fed travertines (Heydari-Guran 2014; Heydari-Guran et al. 2015; Vahdati Nasab et al. 2013). These features are all related to the presence of water in the landscape.

Playa

Also known as an alkali flat or *Sabkha*, a playa is a desert basin with no outlet, which periodically fills with water to form a temporary lake. In most cases in the Iranian Central Plateau, playas are formed by tectonic movements in the Urumieh–Dokhtar magmatic arch (Stocklin 1968; Ghasemi and Talbot 2006). Based on previous studies (Krinsley 1972), the fluvial-lacustrine deposits in central Iran reflect playa environmental systems, which were formed during periods of higher precipitation/evaporation ratios than those of today. Some playas within the Iranian Central Plateau have flooded on occasion during the wettest years of recent times. All areas in the study region that could have potentially been flooded, or filled with water, during wet period are identified in the environmental reconstruction map (**Fig. 1c**). Moreno and her colleagues argue that these playas indicate former lacustrine periods, synchronous to the glacial stages (Moreno et al. 2012).

There are now linear aeolian deposits, oriented in NW-SE directions and approximately 200 km long within the sandy region south of Daryache Namak in Qom, east of Ardestan City, and about 70 km south of Tehran. It was suggested that the source of the sand is the local playas (Krinsley 1972); however, some scholars believe that the sediment-source lies in the alluvial fans of the Karkas Mountains to the south and southeast (Thomas et al. 1997; Heydari-Guran and Ghasidian 2011, 486).

Travertine and tufa formations

Travertine and tufa deposits are also indicators of the presence, and actions, of fresh water. The detailed geology, geomorphology, and nature of these formations are described elsewhere (Heydari-Guran et al. 2009;

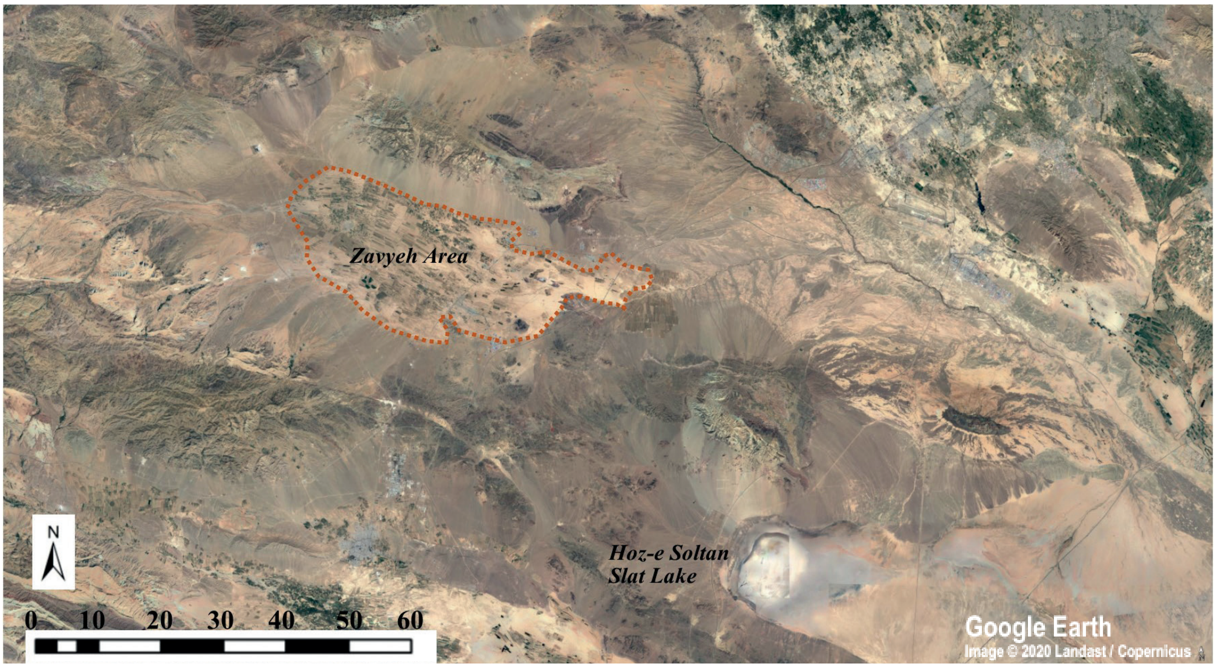

Fig. 2. Satellite map showing the position of the palaeo-lake area in the Zavyeh inter-mountain basin. Image: Google Earth/Landsat – Copernicus; last accessed 27 April 2019.

Heydari-Guran and Ghasidian 2011; Heydari-Guran 2014: Heydari-Guran et al. 2015). Based on field observations and geological maps of central Iran, all travertine and tufa formations are close to the fault systems. For example, the travertine formation associated with early human settlements in the study region are shaped on the Qom-Zefreh Fault, developed along the eastern rim of the Karkas Mountains, and around hot springs along the volcanic mountains system.

MP Sites on the landscapes

Zavyeh

Zavyeh is a fresh water paleo-lake area about 80 km of southwest Tehran and in the northeast end of the interior parts of the Iranian Central Plateau (**Fig. 1c**; **Fig. 2**). The Zavyeh area has attracted the attention of geologists during recent years (Djamali et al. 2006). Due to the extraordinary geological conditions, the inter-mountain basin of Zavyeh (around 500 km²) consists of an ancient shallow lake system lifted up to 20 m higher than the surrounded area by two major Quaternary fault systems (Djamali et al. 2006). Later dendritic drainage systems have cut through the fine-grained lake deposits and exposed deep stratigraphic profiles (**Fig. 3, Fig. 4**). Sedimentological studies by Djamali and colleagues (2006) suggest a late Pleistocene to early Holocene age for the upper deposits of this lake system. In satellite images the range of this lake system can be seen to cover a large area of around 550 km² (**Fig. 2**; **Fig. 3**).

A systematic field-survey of the Zavyeh region identified 27 concentrations of lithic artefacts on the surface of the lake deposits and inside the profiles dating to different periods from the Late Pleistocene through to the Holocene (Heydari-Guran et al. 2015). It was observed that the concentrations associated with MP artefacts consist of reddish-brown silty marl tufa deposits, which probably originate from shallow fresh-water lacustrine environments (Djamali et al. 2006). However, younger materials, including UP and Epipalaeolithic artefacts, were recovered from the surfaces of the shallower gullies and are partly covered

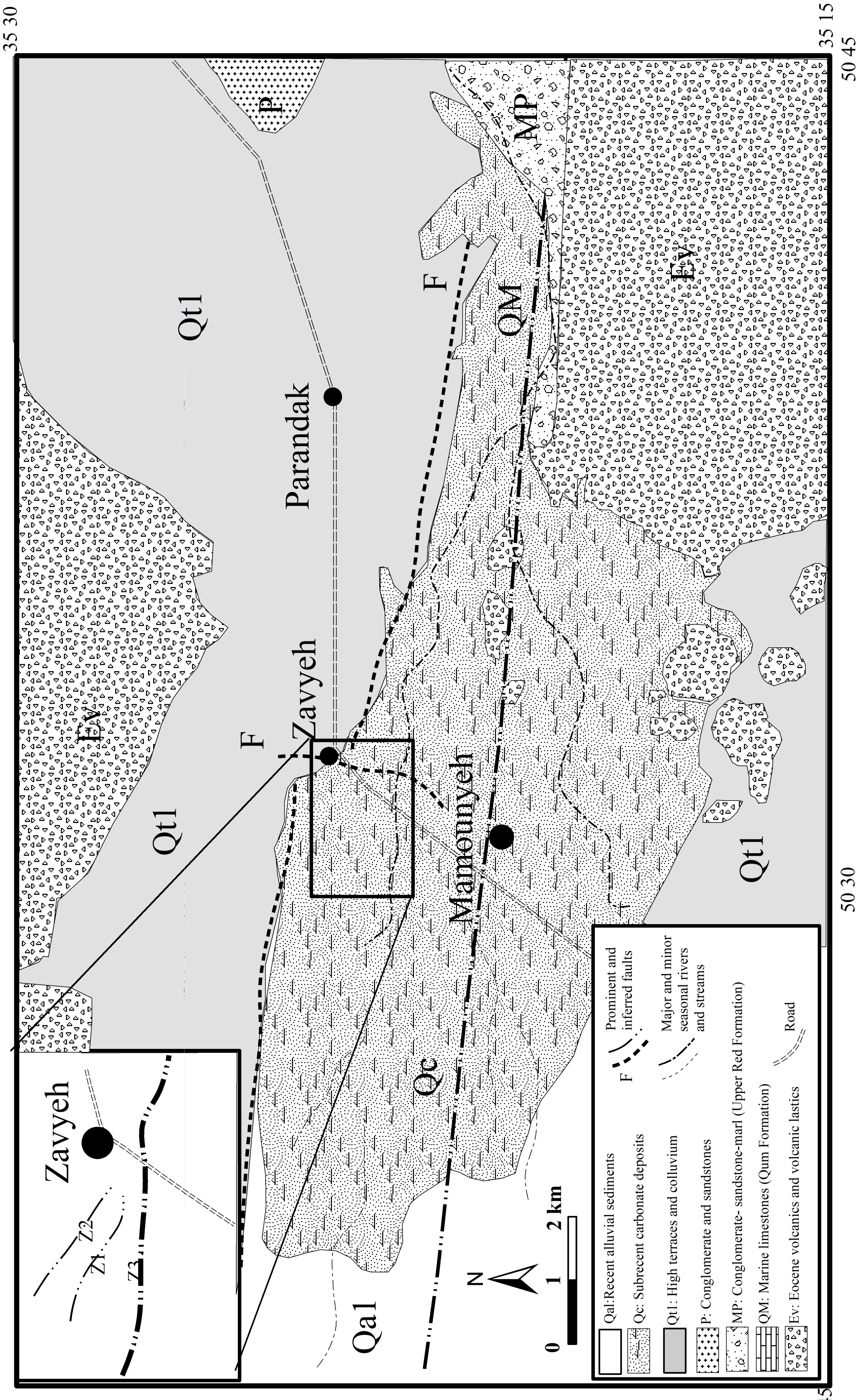

Fig. 3. The geological setting in the Zavyeh region. From: Djamali et al. 2006*, Fig. 1:317.*

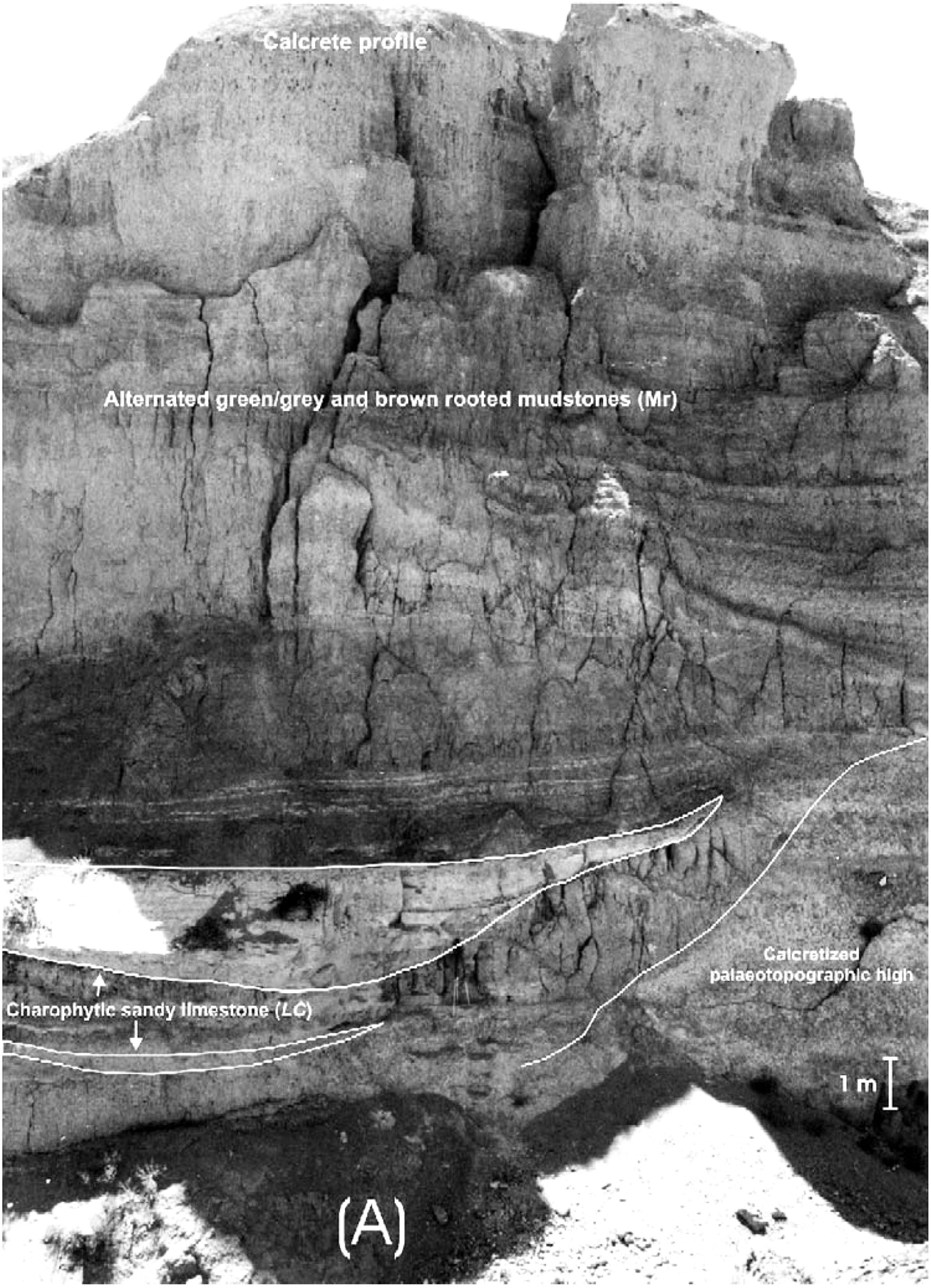

Fig. 4. The studied geological section. From Djamali et al. 2006, Fig. 5.

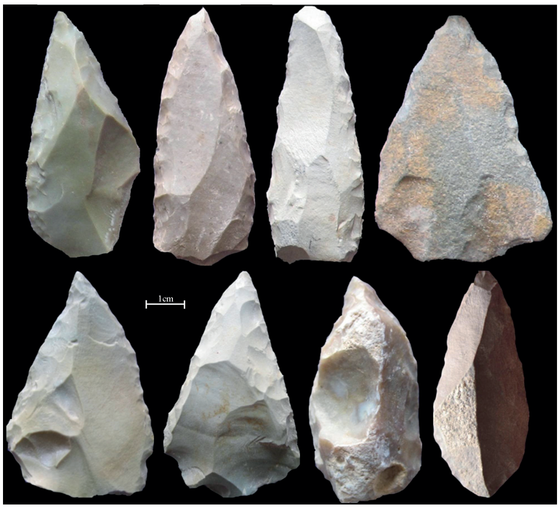

Fig. 5. Zavyeh: selection of different raw materials among the MP artefacts from Zavyeh. After Heydari-Guran 2014, Fig. 5.4.

by alluvial sediments. These younger concentrations were found at higher elevated surfaces than the horizons containing MP finds (Heydari-Guran et al. 2015). The MP assemblages contain a large number of Levallois elements. The size of the Levallois flakes varies from 20 mm to 90 mm, and they tend to be elongated and triangular in shape with sharp points (**Fig. 5**). In addition to retouched points, the number of retouched pieces, including scrapers, is high (Heydari-Guran et al. 2015). In general, the dimensions of the MP tools from Zavyeh are larger than those from the Zagros Mousterian. In contrast to the Mousterian artefacts of Khorramabad and Kermanshah (Dibble and Holdaway 1993), Levallois technology (Boëda 1995) has been employed more frequently in Zavyeh, reminiscent of the pattern employed in the MP of south western Asia especially the Levant (Bar-Yosef 2000; Boëda and Muhesen 1993; Le Tensorer et al. 2011; Shea 2003). A regular use of the Levallois technique has also been observed among the lithic artefacts in the recently studied MP localities of Mirak, located at the northern edge of the Central Iranian Plateau (Vahdati Nasab et al. 2013).

Semnan

Compare to the other regions in the Iranian Central Plateau, Semnan was more targeted for the Palaeolithic investigation (Rezvani and Vahdati Nasab 2010; Vahdati Nasab et al. 2013; Vahdati Nasab and Clark 2014; Vahdati Nasab and Hashemi 2016; Heydari et al. 2020). The sites of Semnan area include Chah-e Jam, Mirak, and Delazian, and they converged around the playa formations (**Fig. 1c**).

Chah-e Jam is located 300 km east of Tehran. It covers an area of 2391 km² and is located ca. 1050 to 1100 m asl (Vahdati Nasab and Hashemi 2016) on the southernmost slope of the Alborz Mountains. Chah-e Jam is a large open-air site, consisting of sandy clay, salty desert, and swamp areas with the Palaeolithic finds mostly distributed in the sandy clay part. The lithic artefacts from this locality are considered to be typical MP artefacts and include a high number of Levallois recurrent flake cores and retouched tools. Among them are various types of scrapers including mostly side and convergent scrapers.

Mirak is situated 220 km east of Tehran on the northern edge of the Iranian Central Plateau. This locality consists of seven mounds. It is a large site of ca. 4 ha and yielded numerous lithic artefacts (Rezvani and Vahdati Nasab 2010). The lithic assemblage from Mirak is considered to be a diagnostic Levallois-Mousterian techno-complex. It includes Mousterian points, convergent scrapers, single and double scrapers, and discoidal and Levallois cores (Rezvani and Vahdati Nasab 2010; Vahdati Nasab et al. 2013). Techno-typologically speaking, Mirak and Chah-e Jam share similarities in the frequent use of the Levallois technique and different types of scrapers. However, Mirak is the only Palaeolithic locality in the Iranian Central Plateau yielded chronology for its Palaeolithic layers. A number of Bayesian-modelled OSL (optically stimulated luminescence) dating for the Pleistocene occupations situates the UP occupation at 21–28 kya and 26–33 kya and the MP layer at 43–55 kya (Vahdati Nasab et al. 2019; Heydari et al. 2020).

Three kilometres north of Mirak lies Delazian, a site with a typical UP assemblage. Delazian is also a large locality consisting of an area around 30 ha and located 1050 m asl. Due to the considerable size of the site, systematic survey was employed for collecting artefacts; in particular, in two trenches of 40 x 4 m large concentrations of artefacts were uncovered. In general, the lithic assemblages from Delazian contain blade and bladelet oriented artefacts, but lack any MP elements. Typical tools include end scrapers, notch and denticulates, as well as a large number of used and retouched pieces (Vahdati Nasab and Clark 2014). Based on the techno-typological characteristics of the lithics, the site was occupied during UP.

Arisman

The Palaeolithic sites of Arisman were first reported during the excavations and survey in the Arisman region during a 2003 Iranian-German joint Project (Heydari-Guran and Ghasidian 2011). Later the authors of this article were invited to conduct an intensive survey in the region which resulted in the discovery of numerous Palaeolithic sites that are spread on the travertine and sand dunes or playas of the region (**Fig. 1c**). Holabad is a thick travertine dome-shape formation over 30 m high and ca. 150 m in diameter at roughly 1100 m asl (**Fig. 6**). It was formed in front of a permanent spring on the southern slope of the Karkas Mountains and at the north eastern margin of the Holabad travertine formation, a 30 m high cliff

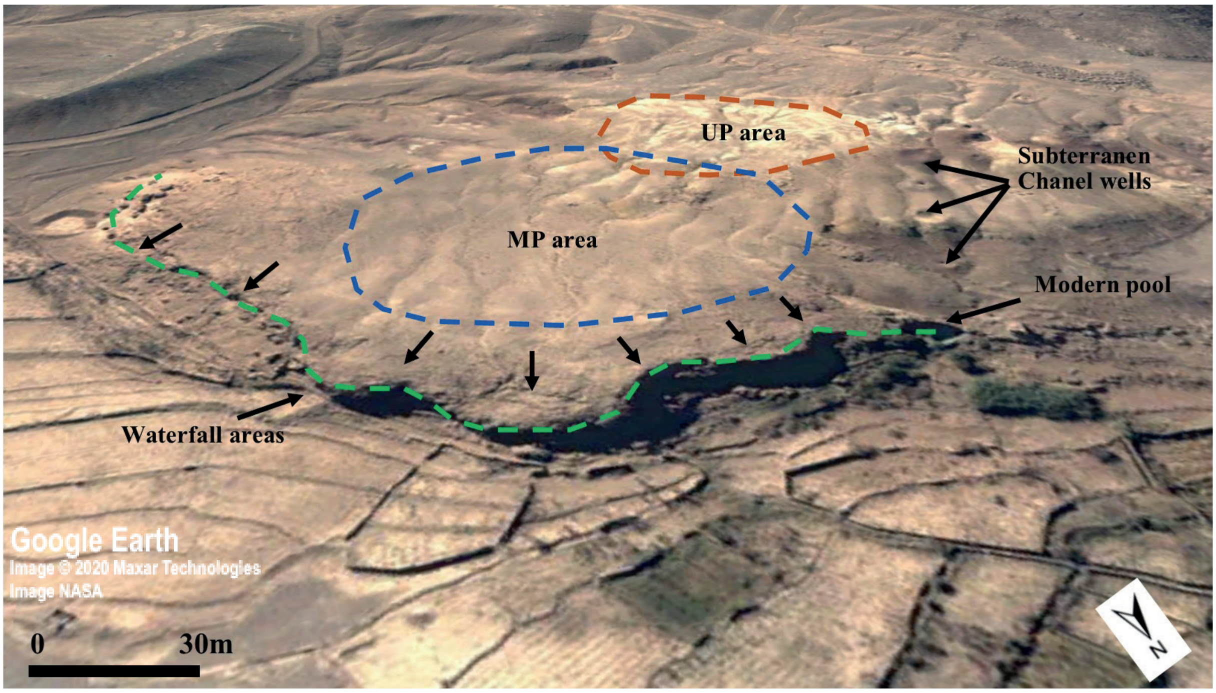

Fig. 6. Satellite picture of Holabad travertine formation. The green line shows the probable waterfall, the blue circle presents the MP occupation area and the red line indicates the UP-occupation area. The configuration of MP and UP occupation and the morphological changes of the Holabad travertine formation indicate the dynamics of hominin occupation on the site. By moving the position of shallow lake within the travertine formation through time, the position of occupied areas changes from the central part (MP) to the adjacent area (UP). Image: Google Earth / Maxar Technologies / NASA; last accessed 27 April 2019; modified by the authors.

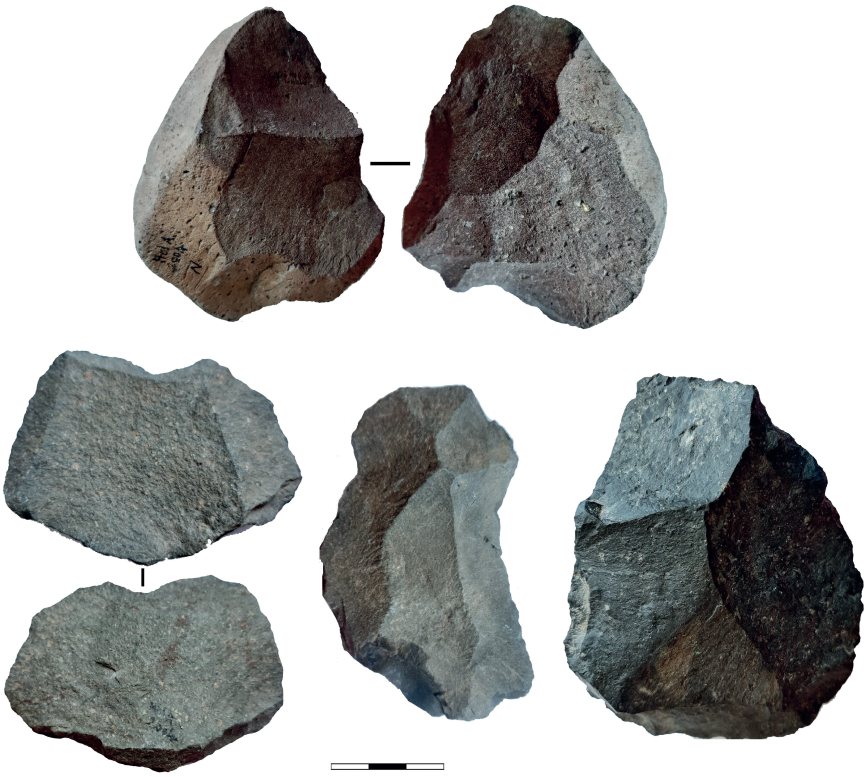

Fig. 7. Holabad and Qaeh Gusheh: a selection of different raw materials among the MP artefacts. Photo by the authors.

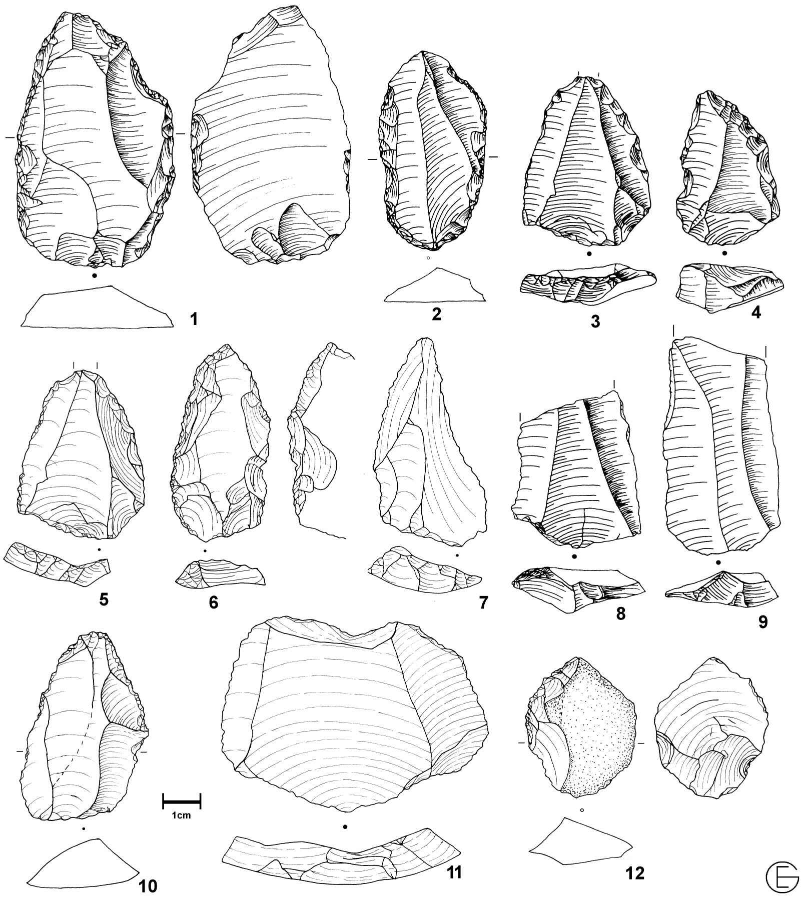

Fig. 8. Holabad: a selection of MP artefacts. Drawings by the authors.

formed by extensive and prolonged waterfall activity (**Fig. 6**). Holabad yielded a total of 956 lithic artefacts from the flat top surface of the formation (Heydari-Guran et al. 2009; 2015; Heydari-Guran and Ghasidian 2011). The site topography, artefact density, and their techno-typological features demonstrate two periods of occupation occurred in two different parts, at the north and at the southeast edges of the formation, respectively. The southeast part yielded mostly younger materials from the UP. It is about two meters higher than the northern area, which on the contrary, contains mainly MP artefacts (Heydari-Guran and Ghasidian 2011). The northern part of the site is defined by wavy-shaped travertine deposits and is heavily eroded in some areas. There, most of the artefacts occurred inside several shallow gullies (maximum 80 cm deep), and are particularly concentrated in an area of red-brown to brown silt and fine sand extending 14 m in length and 6 m in width.

The MP assemblage of Holabad is significant in terms of Levallois flakes, blades, tools, and cores (**Fig. 7**, **Fig. 8**). The cores are mostly Levallois recurrent for flake production. Despite the presence of Levallois blades and points, the related cores are either missing or are reduced to beyond the point where the early products can be recognised. There are several inclined cores characterised by centripetal flake negatives. The knappers struck flakes from both reduction surfaces of the cores alternately without preferring one surface to another (Heydari-Guran et al. 2015; Heydari-Guran and Ghasidian 2011). This type is also one of the main core types of the Levantine Mousterian (Goren-Inbar 1990). The Holabad MP assemblage yielded a relatively wide range of tool types. Points are the dominant tool type including retouched, un-retouched, pseudo- and stemmed points. Most of them are retouched Levallois points with the retouch varying from fine to stepped. Truncated-facetted pieces are also present at Holabad, although they are not as abundant as at Bisetun Cave (Dibble 1984) and Warwasi Rockshelter (Dibble and Holdaway 1993) along the West-Central Zagros Mountains. Unlike at Bisetun, truncated-facetted pieces from Holabad do not have denticulate edges, and the retouches occur in different parts of the blank on either the dorsal or ventral surfaces. It is unlikely that these truncated-facetted pieces were cores for obtaining flakes, as was suggested for Bisetun Cave, since the small flakes resulting from these retouches are rare in the MP assemblage of Holabad. During two seasons of survey in the Qaleh Gusheh region in 2004 and 2005, out of a total of 16 investigated sites, eight localities with MP artefacts were recognised (Conard et al. 2009; Heydari-Guran 2014; Heydari-Guran and Ghasidian 2011). In contrast to the low densities of MP artefacts, there are several UP localities including Qaleh Gusheh localities which produced rich concentrations of lithic artefacts indicating intensive occupations (Heydari-Guran and Ghasidian 2011; Conard et al. 2009). The MP artefacts are made from local volcanic and chert raw materials. The surfaces of these artefacts are heavily patinated and display desert varnish (Heydari-Guran and Ghasidian 2011). They are characterised by the frequent use of the Levallois technique. The cores are mostly recurrent centripetal Levallois flake cores. No blade cores have been observed among the MP artefacts despite the presence of Levallois blades. The tool assemblage mainly includes two groups of scrapers and points. The convergent scrapers are made from Levallois flakes with *chapeau de gendarme* platforms. The heavily retouched edges are reminiscent of the "re-sharpened" scrapers of the Zagros Mousterian (Dibble 1984). The dejeté scrapers, such as those from the Zagros Mousterian, have pointy tips with simple platforms. The other scrapers of the assemblage display fine, non-invasive retouch and are made from thick non-Levallois flakes. Another group of tools are points made from Levallois blanks. Only one retouched point and one pseudo-Levallois point have sharpened tips formed by convergent retouched edges.

Since the MP assemblages of the Qaleh Gusheh sites come from different localities, the study of reduction sequences is hindered by the relatively small numbers of artefacts. Some of the artefacts are found as single MP finds along with the localities with younger material (Heydari-Guran et al. 2015).

Discussion

From a topographical point of view, the Central Iranian Plateau is bound to the north, west, and east by high mountains, while the southern part of the plateau extends over a relatively flat region up to the coast of the Persian Gulf and the Oman Sea. Therefore, this region can be considered as a natural corridor for hominin dispersal into the Iranian Plateau (Heydari-Guran and Ghasidian 2011). Although the Central Iranian Plateau today has experienced hot and dry climatic conditions, the evidence at both a local and regional scale points to several phases of moist climate during MIS 5, which might have resulted in the suggested human intrusion into the inner regions of the Iranian Plateau. This hypothesis is supported by cultural data and human behavioural reconstruction based on the geographical distribution of MP sites and artefacts in the Central Plateau. However, given the lack of absolute dating, only lithic techno-typological analyses can currently provide insights into the chronology of the sites; therefore, current ideas about the cultural chronology of the MP of the Central Plateau need to be evaluated with caution.

Based on what is currently known, the low number of Levallois elements, heavily retouched scrapers, and Mousterian points of the Zagros Mousterian, which are not necessarily made of Levallois blanks, likely belong to the later phases of the MP (Dibble 1984; Dibble and Holdaway 1993). Hole and Flannery (1967) reported on elongated and heavily retouched Mousterian points and argued that these points represent an early form of the Arjeneh points that will appear later during the UP Baradostian period (ca. 42–36 kya; Becerra-Valdivia et al. 2017). These elongated, strongly retouched points are relatively abundant in the Zagros Mousterian (e.g. in Warwasi: Dibble and Holdaway 1993), while the points within the assemblages from the open-air sites of the Central Plateau are mostly made from Levallois blanks. The Hole and Flannery's view hinting at a continuity between the MP and UP was likely shaped by the assumption that a gradual shift took place between these two periods. This assumption was widespread at the time of their research, which predates of two decades the rise of the Out-of-Africa model for modern human origins and the geographical expansion of modern humans and replacement of other hominins.

The techno-typological data on the lithics from the Central Plateau demonstrate that the lack of a strong relationship between the MP habitat areas in the western Zagros Mountains and the Central Plateau is due to the natural barrier of the Zagros Mountains, which extends for at least 300 km in the form of a jagged topographical wall between these two areas. Compared to the Zagros Mountains, the Central Plateau of Iran offered few natural shelters, and the important Palaeolithic sites mentioned here are in fact all open-air sites. Therefore, we suggest that the Central Plateau MP occupations could presumably belong to the wet phases of the Late Pleistocene (MIS 5) period when the climatic condition was not as harsh as in later phases of the Late Pleistocene, especially during the MIS 4 (Djamali et al. 2008).

Characterised by the presence of recurrent Levallois cores and a high number of Levallois flakes with triangular and semi-triangular dorsal scar patterns as well as by low numbers of retouched tools, the MP sites of the central Plateau might be reminiscent of the Levantine Mousterian. However, it should be noted that the Levantine Mousterian industry has been recovered from both open-air and shelter sites (Shea 2003). Yet, the Levallois dominant techno-complexes from the Central Iranian Plateau are extensively derived from open-air sites.

The MP occupations on the Central Plateau of Iran indicate that almost all sites are close to permanent water sources. The travertine site of Holabad and the ancient lacustrine settlement in the Zavyeh are possible examples of human behaviour in arid regions that were strongly tethered to the water sources. Thus, the hominin campsites were probably formed near ponds or marshes of fresh water on the foothills of mountains and lowland areas. The permanent water sources attracted both hominins and game, and consequently allowed relatively continuous settlement systems in these areas. Consequently, we expect future research in Central Iran might document hominin behaviours similar to those that have been recognised in other arid areas, like the El Kowm Basin in the Syrian Desert (Le Tensorer et al. 2007; Hauck 2011), where springs served as magnets for human activities that concentrated on artefacts of otherwise highly mobile hunters and gatherers of the MP. In el Kowm Basin, researchers observe a widespread use of the landscape during the moist phases of the MP, which reflects weak tethering to permanent sources; the more arid climatic phases are in contrast characterised by artefact distributions strongly clustered around reliable water sources (Le Tensorer et al. 2007; Hauck 2011).

With the lack of any hominin physical remains, it is unknown which hominins were responsible for the MP assemblages from the Central Iranian Plateau. Association of the Zagros Mousterian with the Neanderthal remains in Shanidar Cave of the northern Zagros may suggest that the techno-complex could be made by this species throughout the Zagros. However, considering the Zagros as a barrier for penetrating the inner parts of the Iranian Plateau, it is also conceivable that other species were responsible for the MP assemblages of the Central Plateau such as early *Homo sapiens* and that Neanderthals were not present in this area. According to this second hypothesis, we can imagine the presence of a migration route into the Central Plateau from other directions, including the south via Arabia, the Persian Gulf, and the Oman Sea; this rout might have followed the coastal lines towards the north, and eventually into the inner parts of the Iranian Plateau. Recent evidence of hominin occupations scattered on the surface in the areas located on the southernmost part of the Iranian Plateau supports this hypothesis.

Conclusion

The Central Plateau of Iran is one of the largest geographical units in south western Asia and it is currently one of the warmest and driest areas in the world. To the south, it is connected to the Arabian Peninsula. The geomorphological and archaeological evidence from the Pleistocene suggest that this region, as the Arabian Peninsula, experienced humid periods associated with the presence of fresh water sources. The potential for human occupation of the Central Iranian Plateau is strongly related to these favourable climatic conditions (Heydari-Guran and Ghasidian 2011). In particular, occupation of the hyper-arid interior of the Central Iranian Plateau must have been limited to periods of increased precipitation that would have transformed the desert into a highly attractive landscape with sufficient available water and biomass (Heydari-Guran 2014). Due to the fact that the Central Plateau consists of territories located at high altitudes of ca. 2000 to 3000 m asl, which are still today the sources of rainwater absorption, the Central Plateau could be considered as a potential refugium for human populations occupying the interior parts of the Iranian Plateau. The major role of the Central Plateau in the process of human dispersals out of Africa towards the east has been confirmed by the archaeological evidence presented here. This emphasises the diachronic changes between harsh and favourable environments that largely influenced the timing for the successful presence of stable populations on the Central Plateau. By combining the various evidence, including hydrological records, the ecological and even more the cultural connections and similarities between this region and the Arabian Peninsula, it is likely that the Central Plateau of Iran was an attractive region for hominin groups who used the Strait of Hormuz and the Persian Gulf as migration routes and immigrated into the Iranian Plateau. We now know that the MP assemblages in Arabia were manufactured by *Homo sapiens* (Groucutt et al. 2018). The same likely occurred in the Indian sub-continent (Clarkson et al. 2017). Therefore, on the basis of the lithic techno-typological similarities between the assemblages from the Central Plateau area and Arabia and the connection of these two areas, we hypothesise that the makers of Iranian Plateau MP assemblages were more probably *Homo sapiens* rather than Neanderthals. This issue puts the Central Plateau of Iran in contrast to the Zagros region sites where it is widely accepted that Neanderthals were responsible for the MP assemblages (Solecki 1963; Coon 1957).

Nevertheless, proving the MIS 5 humid corridor hypotheses for the dispersal of *Homo sapiens* on the Iranian Plateau requires further multidisciplinary approaches, including absolute dating, micromorphology, isotope studies, and the conducting of additional comprehensive surveys and excavations at key sites such as Holabad and Zavyeh.

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