# From Land-Locked Desert to Maritime Nation: Landscape Evolution and Taphonomic Pathways in Qatar From 14 ka

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***Abstract:*** Throughout prehistory the landscape of Qatar was shaped by climate change, cycles of sea level rise and fluctuations in rainfall. As a result of sea level changes the Arabian Gulf now surrounds the western, northern and eastern sides of the landmass, but for most of prehistory Qatar was part of a land-locked, hyper-arid region. This paper considers the conditions that affected human behaviour in prehistory and the varying taphonomic processes favourable for site preservation. These are fundamental tenets of landscape archaeology, placing sites within the wider context of a landscape that is the product of climatic fluctuation and geomorphological change.

## Introduction

Landscape evolution, taphonomic processes and an understanding of environmental change remain a fundamental key to the future study of prehistoric Arabia. In such a marginal environment minor changes in climate or differing geological conditions most likely forced populations to migrate or, conversely, isolated groups within environmental refugia. In Qatar this can be divided into three main elements:

**Geomorphology:**

- Topography, affecting water runoff and groundwater tables
- Natural resources (such as availability of flint, obsidian quartz, faroosh, limesone etc)
- Karst features including sediment depressions and aquifers
- Sand coverage across the peninsula

**Climate:**

- Regional fluctuations in rainfall
- Global climate changes, affecting wind patterns, sea level rise
- Natural resources (such as changes in flora and fauna affected by climate changes).

**Cultural Interaction including:**

- Migration
- Trade
- Cultural exchange

Each of these has contributed to a greater or lesser extent to the prehistoric archaeological map of Qatar, from enforced migrations due to sea level change (Cuttler 2013), to the availability of groundwater and small-scale agriculture within karstic depressions (Sadiq & Nasir 2002). This paper reviews our current understanding of the Holocene palaeoclimate and geomorphology, and considers some of the taphonomic processes affecting the preferential survival of regional prehistoric sites.

## Karst and archaeological landscapes

The shape of Qatar is the surface expression of an elliptical, anticlinal arch aligned approximately north-south through the centre of the country. This is one of the largest structural features of the Arabian Plate (Fig. 1).


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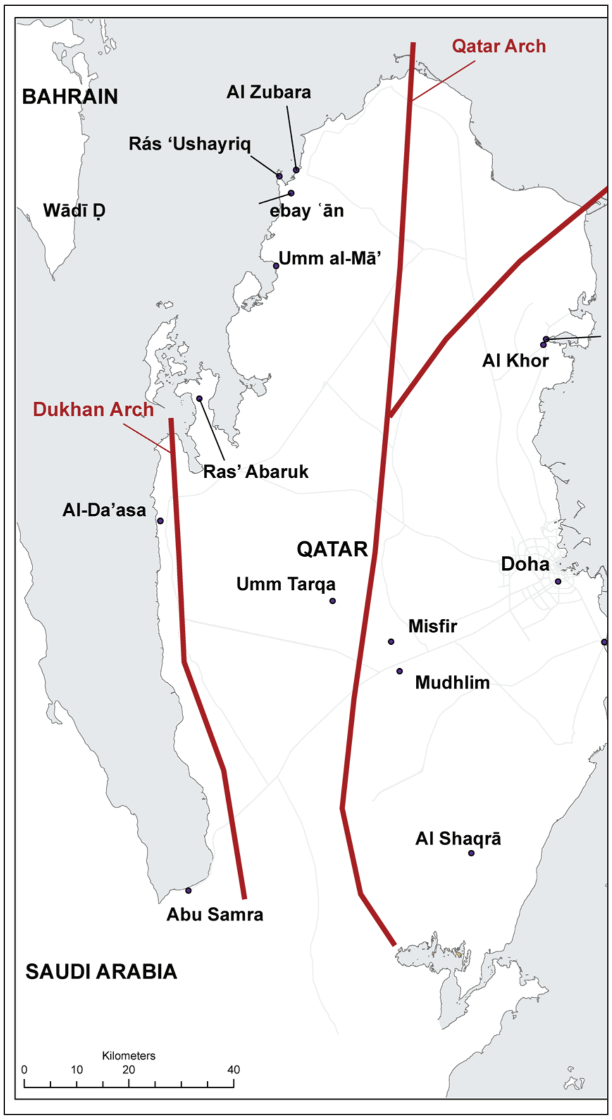


**Fig. 1: Map showing the location of features mentioned in the text.**

Substantial wadi systems, charged on a seasonal basis, can be traced from this anticline towards the coast. The desert is characterised by rock outcrops with a fragmented-stone and lithosol regolith. The rock exposures comprise mainly of Tertiary limestone, shale and dolomite of the Upper Dammam Formation, which formed in shallow marine conditions in the latter half of the Eocene Epoch, prior to 34 million years ago (*Ibid.*).

Karst in Qatar formed during phreatic conditions in the Middle Pleistocene (around 560,000 to 325,000 years ago) due to the dissolution of carbonate-evaporite deposits by circulating groundwater. This left sub-surface cavities in the limestone, dolomite gypsum and anhydrite horizons of the Eocene Rus and Dammam Formations (*Ibid.*, Waltham *et al.* 2005, Ford & Williams 2007). Karst takes the form of caves, which during various phases of structural collapse, produces depressions, sinkholes and sediment hollows. It has been calculated that there are more than 9,700 caves (duhul)/karst-related features in northern Qatar. Most of the sediment filled basins are a surface expression of karst, and range from~50m to ~3 km across. Some reach depths of over 25m while others are only a few centimetres deep (Sadiq & Nasir 2002). The general absence of flowstone, stalagmites, stalactites, crystals and coralloid coatings (Fogget *et al.* 2002) indicative of more recent phreatic conditions, may imply that the caves have been subject to on-going collapse rather than an absence of wet climatic phases since the Middle Pleistocene. Figure 2 shows a five stage, schematic chronology of karstification, collapse, sediment transport, total collapse and surface sediment basin formation.

- *Karstification*: caves form at or near the water table, where slightly acidic rain or groundwater slowly dissolves the limestone. As the water table drops an enclosed cavity remains with no surface expression.
- *Partial cavity collapse*: a drop in the water table reduces internal support, and decreases the mechanical stability of the structural arch, which begins to collapse. Where partial collapse of the overlying arch propagates to the surface, an entrance to the cavity is formed.
- *Sediment transport*: partial cavity collapse resulting in a surface entrance allows for Aeolian or alluvial sediment transport into the cavity.
- *Punctuated cavity collapse*: Where the

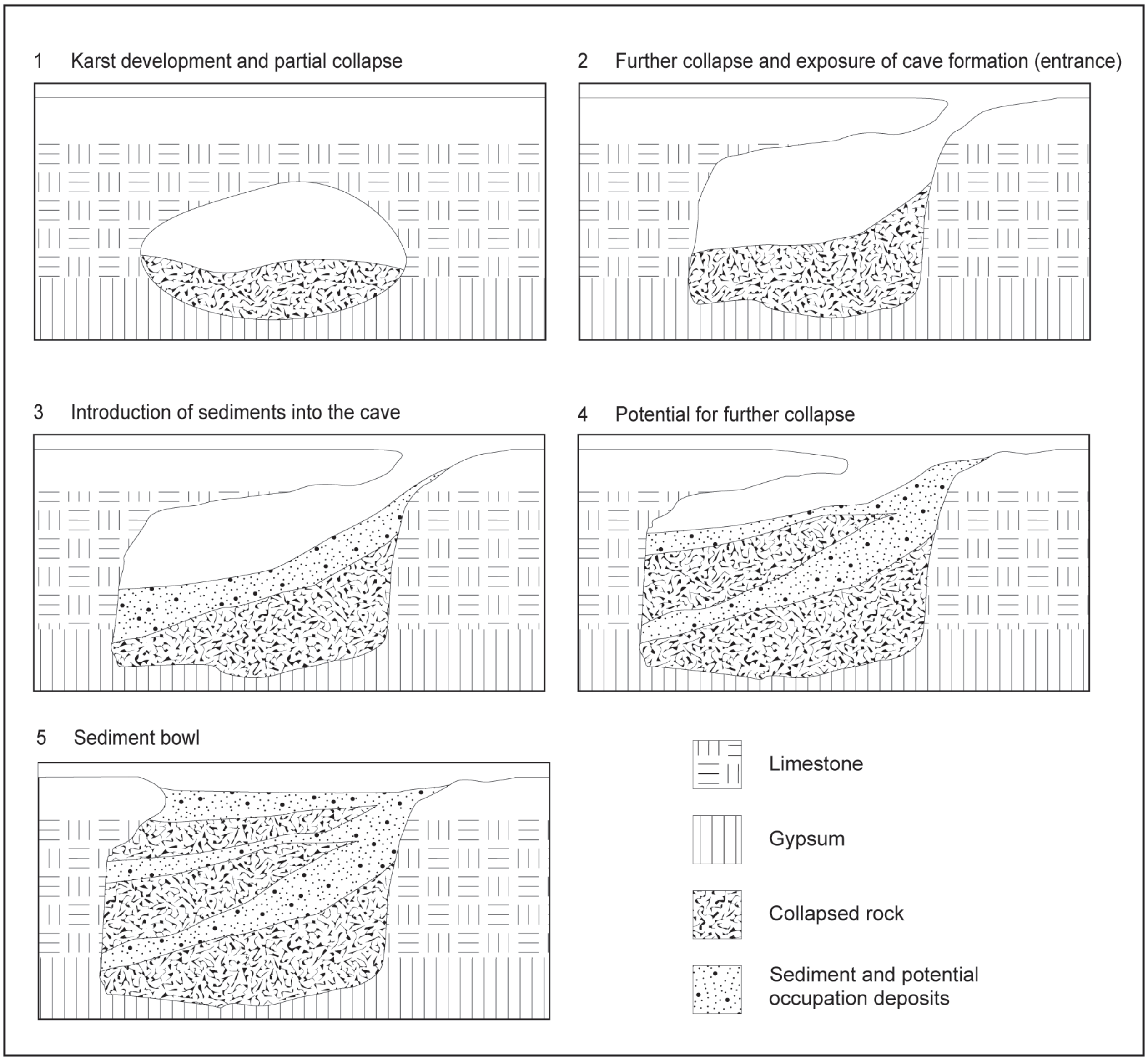


**Fig. 2: Schematic karstification, from closed cavity to sediment basin (derived from Sadiq & Nasir 2002).**

arch is unstable sediment transport into the cavity may be punctuated by phases of further collapse.

- *Sediment basin formation*: The final collapse of the arch into the cavity results in a surface depression or sinkhole, which may partially fill with sediment.

Caves are routinely added to the Qatar National Historic Environment Record (QNHER), a national record held by the Department of Antiquities of all sites of either archaeological or geological interest. Of particular interest are two caves, Misfir (QNHER 352) and *Mudhlim* (QNHER 356), both located ~30 kilometres to the southwest of Doha (Fig. 1). The arch of the cave at *Misfir* (Fig. 3) has partially collapsed leaving an entrance ~12 metres by 4.5 metres into the cavity (Stage 4). The cave measures~70 metres across and extends to a depth of over 100 metres. Most of the deposits inside comprise large limestone rocks that are the result of

**Fig. 3: *Misfer* Cave, showing partial cavity collapse, and sediment transport into the cave through the entrance to the right, as in Karst Stage 3 and 4 (photo R. Cuttler)**

roof collapse; however, at the base of the cave is a fine, Aeolian sand. Unfortunately, these sediments show no evidence of human activity; however, it is possible that partial collapse of the arch seals earlier deposits. Locals report water being present at the very base of the cave as late as the mid-1980s, with the deeper areas of the cave remaining cool during the summer months.

The cave at *Mudhlim* (Figs. 1 & 4) lies 6 kilometres to the south of *Misfir*. In 2002 the cave was reported to have an entrance measuring 15 metres across, extending to a depth of 150 metres (Sadiq & Nasir 2002). When the cave was visited in May 2010 only the remains of the arch at the back of the cave was evident. A large crack or gulley around the southern side of the depression was indicative of recent collapse (as in Stage 5, Fig. 2). The underside of the remaining arch had a surface coating of soot from fires which must have been lit within the cave prior to collapse. As this is a direct indicator of human occupation, samples were taken for radiocarbon dating. These provided uncalibrated radiocarbon dates of 330 ± 40BP and 700 ± 40BP (Beta Analytic 282142/3). Calibrated using IntCalO4 to 1210-1290 CalAD, 1430-1630 CalAD (2 sigma), the radiocarbon dates indicate that the cave was in use between the 13th and 16th centuries, and the final collapse of the arch is a more recent event.

## Groundwater and palaeorecharge

The availability and quality of ground water can be divided into two zones in the north and south of Qatar (Fig. 1). Rainfall recharge is greatest in the north where shallow wells have lower concentrations of dissolved solids. There is significantly less recharge in the southern and southwestern zones where recharge and poor groundwater circulation is reflected in a poor quality of groundwater (Al-Sharhan 2001). Prior to mechanical pumping, most hand-dug wells were capable of recharging at a rate equivalent to extraction, with the water table at a depth of ~37 m below ground in central Qatar and at much shallower depths in northern Qatar (Eccleston *et al.* 1981).

Mountainous relief is a significant mechanism for the capture of water runoff, which at discharge normally has a shallow depth to the water table or even an uninterrupted flow of surface water. The absence of high relief in Qatar restricts water flow to a system of hinterland

**Fig. 4: *Mudhlim* Cave, mostly collapsed, but with soot on the remaining cave arch (photo R. Cuttler)**

recharge and coastal discharge. Sediment filled depressions caused by karst, account for ~335km$^2$ of the surface area of Qatar, and where they contain soils, they are known as *rawdah*. The *rawdah* have a major impact on the pattern of interior drainage by forming catchment areas for surface water runoff. These catchment areas prevent water from discharging into the sea via the wadi systems, and allow for a gradual recharge of aquifers through seepage. Thus ground water is recharged in the interior and discharges around the coast, where it occurs as a shallow fresh water lens above saline water (Lloyd *et al.* 1987).

Groundwater is present in aquifers within the Lower and Upper Dammam formations. Some of these aquifers were reputed to surface as springs beneath the floor of the Arabian Gulf. When travelling through the Gulf in the early part of the last century R. Cheeseman (1923) commented 'One at least (aquifer) discharges under the sea, and so strong is the flow that native boats are able to replenish their drinking-water from it'. Prior to 8ka this process may have caused the upwelling of springs within the exposed *Ur Shatt* Valley (Rose 2010, Cuttler 2013).

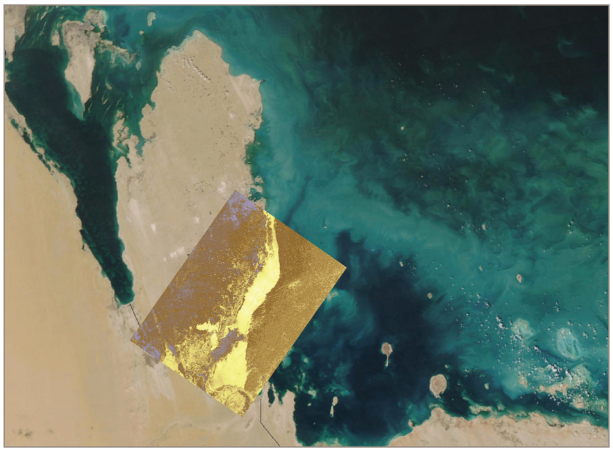

**Fig. 5: SIR-C/X-SAR image (Space Radar Laboratory 02/010/1994, PR52514) overlying a NASA satellite image showing deposits of sand as a light yellow expression around the southeast coast.**

## Aeolian sand transport during the late Pleistocene and early Holocene

The Arabian Gulf currently inhibits Aeolian sediments being carried by the prevailing northwest 'Shimal' wind as far as northern Qatar. Prior to 13ka, significantly lower sea levels probably facilitated the transport of oolitic sands across the exposed floor of the Arabian Gulf. As sea levels rose the Arabian Gulf became a sediment trap, cutting off the supply of Aeolian sand to the northwest of Qatar (Glennie & Singhvi 2002). Fossil ridges and possible relict strand dunes on a northwest trend are known to exist within the Gulf (Sarnthein 1972). Furthermore, fossil sea-floor dunes have been mapped from LANDSAT images in the Gulf of Salwa between Qatar and Bahrain (Al-Hinai *et al.* 1987). Large barchan dunes are now mostly evident in the southeast of Qatar, and form the northernmost extent of the *Rub' al-Khālī*.

Given the potential for increased sediment supply during the late Pleistocene, it seems plausible that sand coverage across Qatar was more extensive than today. A geo-referenced SIR-C/X-SAR image (Space Radar Laboratory 02/010/1994, PR52514, Evans *et al.* 1997) overlying a NASA satellite image shows a distinct expression (shown in light yellow on Fig. 5) in the marine areas off the southeast coast of Qatar. This expression has a similar reflectance to large barchans dunes in terrestrial areas further to the west, and seems likely to represent significant sand deposition within the marine environment. A plausible explanation for this deposit is that it was originally sand from the surface of Qatar that has subsequently been deposited along the southeast coast by the prevailing northwest 'Shimal' wind. More extensive dune formation combined with hyper aridity would most likely have led to periods where conditions were less than favourable for occupation during the late Pleistocene.

## Gulf Palaeo-shoreline reconstruction

### Topography and vegetation of the former sub-aerial Gulf basin

The bulk of the Arabian Plate is formed from pre-Cambrian rocks, with exposures of middle to late Proterozoic rock (800-650 ma) along the western side of Saudi Arabia (Glennie 2005). The Arabian Plate is slowly subducting below the Eurasian Plate, which has resulted in a gentle southwest to northeast tilt in the plate. The Arabian Gulf basin is a direct result of this subduction, and at the extent of the Last Glacial Maximum (LGM ~26 – 19ka) the Gulf was entirely free of marine influence. Instead of flowing into the Gulf, the confluence of the Tigris-Euphrates Rivers (known as the Ur Shatt River) would have flowed through the Gulf basin,discharging into the Gulf of Oman through the Strait of Hormuz.

The topography of the former *Ur Shatt* River valley was relatively flat, with outline bathymetric models indicating that during the LGM, this river fed large freshwater lakes (Lambeck 1996). Refining these models using ETOPO2 data (a combination of satellite altimetry observations, shipboard echo-sounding and data from a Digital Bathymetric Data Base - NOAA) confirms the presence of a western basin (Fig. 6). The basin reaches a depth of ~75m below present mean sea level (PMSL), and rises to ~60m below PMSL at its southeastern extent. Supplied by freshwater from the *Ur Shatt* River from the northwest, this feature would have formed a large freshwater lake around 15 metres in depth (Cuttler *et al.* 2012). ETOPO2 data analysis also confirms the presence of a central basin ~50km further to the east. With a maximum expression of more than 90m below PMSL, and rising to ~69m below PMSL at its eastern extent, this basin probably formed a fresh-water lake approaching an area of 20,000km$^2$, with a water depth of ~20m.

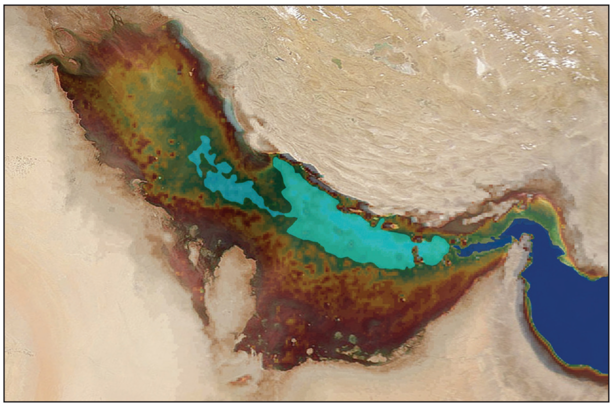

**Fig. 6: Extent of marine transgression at approximately 13ka**

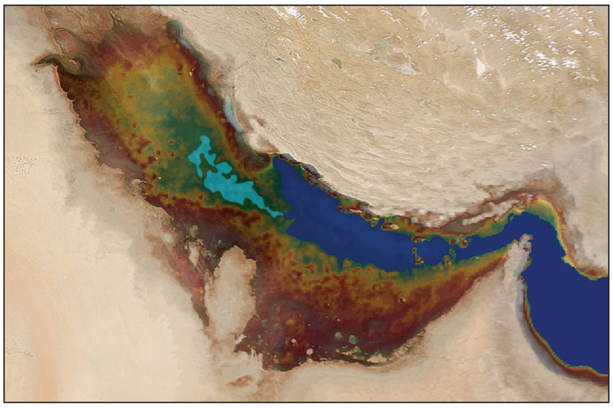

**Fig. 7: Extent of marine transgression at approximately 12ka**

Such bathymetric models do not allow for subsequent tectonic adjustment, hydrostatic pressure or Holocene marine deposition (*Ibid.*, Cuttler 2013).

### The vegetation of the former Ur Shatt River valley

The present-day *Shatt-al-Arab* in southern Iraq is, in essence, the northern extent of the former *Ur Shatt* River valley and most likely provides us with the closest modern parallel to the pre-transgression Gulf flora. The *Shatt-al-Arab* forms a wide, deltaic region that has a relatively flat topographic expression allowing for slow-moving water, anastomosing channels, alluvial deposition and marshland development. Prior to drainage schemes (from the late 1970's onwards) the *Shatt-al-Arab* formed part of a vast flood plain featuring permanent lakes, marshes, and the largest date palm forest in the world (some 17 to 18 million date palms). This marshland supported a wide variety of flora and fauna including papyrus, rushes, reeds and a wide variety of aquatic species.

Given similarities with the topography of the Gulf, it is not unreasonable to consider that the region could have supported a similar environment. Furthermore, rather than considering the former Ur Shatt as simply a river, the flat topography suggests that during the LGM the valley was a series of shallow freshwater lakes conjoined by swamps and marshland. Bordered by mountains to the northwest and an expanse of hyper-arid desert to the southeast, this potentially 'green corridor (الممر الأخضر)', was probably crucial in terms of natural resources for early human groups.Being a wide, low-energy environment, the *Ur Shatt* River valley most likely sustained a wide range of flora and fauna in much the same way as the *Shatt al Arab* does today. Given this, it is interesting to consider that the *Ur Shatt* River valley may once formed the southern extent of the 'Fertile Crescent'.

## Models of marine transgression and shoreline reconstruction

While the absence of multiple sea level index points necessitates the use of global sea level curves, the timing and the magnitude of relative sea level change differs slightly around the globe. During the Last Glacial Maximum (26.5 to 19ka) global eustatic sea level was ~125 ± 5m lower (Fleming *et al.* 1998) than PMSL. As a consequence most of the Gulf, which averages ~35m in depth (Lambeck 1996), remained free from marine incursion until at least 13ka, when the Strait of Hormuz became a narrow waterway at the mouth of the Ur Shatt River. The approximate extent of marine transgression at 13ka is shown on Fig. 6 in dark blue and the locations of the possible former western and central lake basins in light blue. At ~12.5ka, sea levels rose above -69m PMSL, inundating the central basin (Fig. 7). This event must have forced communities living around the central basin to adapt from a freshwater to a saline/coastal regime, or migrate elsewhere within the gulf basin (Cuttler 2013).

Topographically, the northern Gulf is lower than the southern and western Gulf, and by 10ka the effects of sea level rise would have resulted in a long, narrow sea (Fig. 8). As late as 10ka large areas between the Emirates, Qatar and Bahrain remained an open landscape (Lambeck 1996, Kennett & Kennett 2006).

After 10ka periods of still-stands were punctuated by periods of more rapid marine transgression, and while the general rate of sea

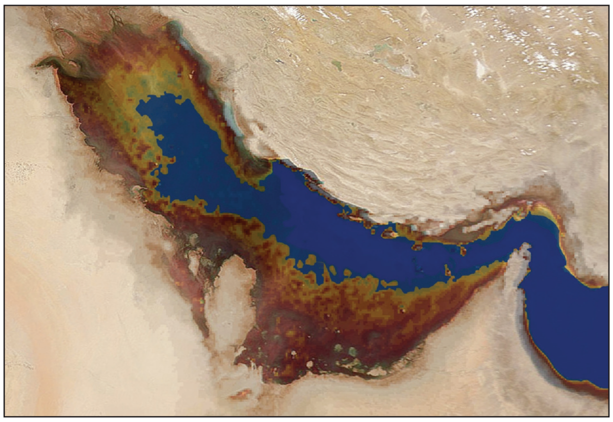

**Fig.8: Extent of marine transgression at approximately 10ka**

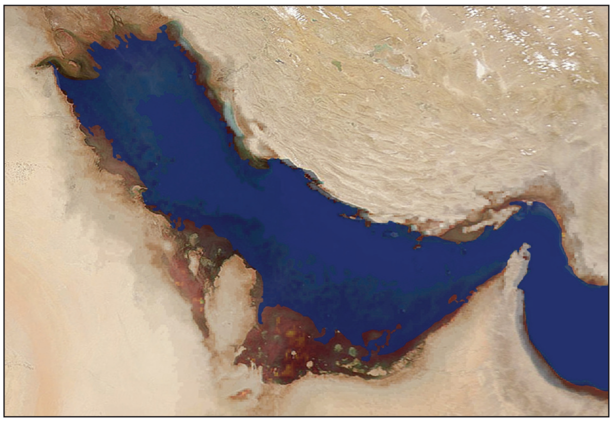

**Fig. 9: Extent of marine transgression at ~ 8.2ka.**

level rise decreased in the early Holocene, the speed of transgression increased in the Gulf due to low topographic gradients (*Ibid.*). Between 8.9 and 8.1ka proxy records indicate rapid sea level rises of~1.8m every 100 years (Bird *et al.* 2010). This was probably due, in part, to late Quaternary meltwater pulses into the Atlantic from glacial lakes in North America, a phenomenon that also influenced short-term global climate change (Lewis & Teller 2007). The largest meltwater pulse relates to a former glacial lake of over 440,000 km$^2$, known as Lake Agassiz. Around 8.2ka the retreating Laurentide ice sheet in North America finally collapsed, allowing the lake to empty into the North Atlantic through the Hudson Bay. Stable Isotope records from the Greenland ice cores suggest this prevented thermohaline circulation in the North Atlantic, affecting global weather patterns for ~160 years (Thomas *et al.* 2007). This in turn was the probable cause of hyper-aridity across the Arabian Peninsula and the temporary remobilization of dunes in the *Rub' al-Khālī*, (Cuttler *et al.* 2007).

As late as 8.2ka extensive areas between Qatar, Bahrain and the Emirates most likely remained free from marine influence (Fig. 9). Combined estimates for global eustatic sea level rise suggest that at ~8ka global sea levels remained more than ~13m below PMSL (Flemming *et al.* 1998). Sea level index points from Singapore suggest a rapid rise of approximately 14.4m between 8.9ka and 8.1ka, with levels stabilising between 7.8ka and 7.4ka (Bird *et al.* 2010).

The present shoreline was probably reached before 6ka (Lambeck 1996, Bird et al. 2010), with radiocarbon dates on relic beaches between 1.5 and 2.0m above high water providing radiocarbon ages between 5.8 and 4.7ka (Vita-Finzi 1978), and 4.4 and 3.8ka (Taylor & Illing 1969). The presence of beach deposits in the southeast of Qatar, more than13 kilometres

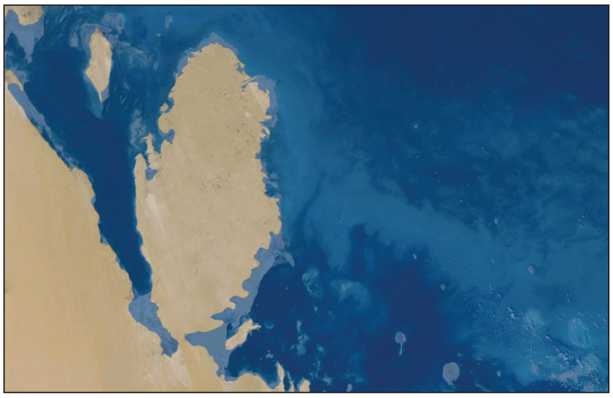

**Figure 10: Extent of marine transgression around Qatar and Bahrain at ~+2m PMSL at ~6 – 4.4ka.**

inland, also indicate a sea level high of ~2m above PMSL between 6 and 4.4ka (Jameson & Strohmenger 2013), while Dalongeville and Sanlaville (1987) argue for a sea-level high stand slightly earlier at 6.3ka. During this period Qatar was almost an island, connected to the remainder of the Arabian Peninsula by a thin strip of land (Fig. 10). Since the dunes in the southeast of Qatar are Aeolian in origin they are likely to post-date a fall in sea level and so are almost certainly less than 4ka old. In addition, this shoreline reconstruction suggests an early Holocene site at *al-Shaqrā* in southwestern Qatar (Kapel 1967, Inizan 1980) and was once a coastal site, with access to both terrestrial and marine resources.

### Tectonic adjustment

The extent of stasis, uplift and subsidence in various parts of the Arabian Plate is debateable (Uchupi *et al.* 1999); however, Qatar would appear to have been subject to uplift at differing rates across the peninsula. Fluvial gravel deposits mapped within the terminal channel of the Hofuf Formation in central and western Qatar, were originally deposited close to sea level during the Miocene (~8 and 3ma). These are now located at elevations of between 20 and 100m above sea level. This is interpreted as the result of long-term tectonic uplift related to the structural tilting of the Arabian Plate (Jameson

& Strohmenger 2013). The differing heights of the gravels suggest greater tectonic uplift in the south (~100m) than in the north (~20m), implying a maximum tectonic uplift of ~0.4 to 2m every 100ka. Assuming a constant rate, this would suggest a maximum uplift of ~0.2m during the Holocene. Given a tidal range >1m, the effects of tectonic uplift in Qatar during the Holocene are probably imperceptible in the archaeological record. One note of caution is the presence of raised beaches radiocarbon dated between 40 and 21ka in southeast Qatar (*Ibid.*). Such a date would imply rapid uplift >50m within the past 40ka. A possible explanation for this is that these radiocarbon dates, which were undertaken on shell, are too recent due to the replacement of shell aragonite by high magnesium calcite (Webb *et al.* 2007).

### The Palaeoenvironmental Evidence

Radiocarbon dates from lacustrine carbonates, travertines and groundwater indicate the occurrence of a major pluvial period within the Arabian Peninsula at ~10 to 6ka (McClure 1976, Stokes 2003). Such pluvial periods may result from fluctuations in global weather patterns associated with the retreat of glaciers in the northern hemisphere. Changes at higher latitudes probably altered the Inter Tropical Convergence Zone (ITCZ), weakening of the Shimal wind and allowing the Indian Summer Monsoon (ISM) to move northwards into the interior of the Arabian Peninsula. As a consequence, between 10 and 6ka parts of the now hyper-arid regions of the Arabian Peninsula received monsoon rainfall (Radies *et al.* 2005, Parker *et al.* 2006, Parker & Goudie 2008). This is commonly known as the Arabian Holocene sub-pluvial period, or the Holocene climatic optimum.

However, there is evidence for significant variation in the magnitude of the sub-pluvial period from different parts of the Arabian Peninsula. Palaeoenvironmental evidence suggests that this period was generally shorter at high latitudes (Fleitmann *et al.* 2004). It is possible that the monsoon rainfall belt associated with the ITCZ never reached farther north than the northern Emirates, ~23-24 °N (Radies *et al.* 2004, Fleitmann *et al.* 2004). While there is evidence for pluvial periods in the Nefud Desert (~28 °N) between ~8.7 and ~8.1ka (Crassard *et al.* 2013), ~9.5 to 7.8ka (Shultz & Whitney 1986), and slightly later at ~5.5ka (Whitney 1983), it is not clear if this is related to the northwards movement of the ITCZ or to cyclonic rainfall from Mediterranean north Westerlies (Shultz & Whitney 1986). The northwards movement of the ITCZ was either time-transgressive or a sudden event, and this remains a subject of debate. Speleothem profiles indicate a rapid increase in ISM precipitation between ~10.6 and 9.7ka in southern Oman (Fleitmann *et al.* 2007), while the onset of pluvial conditions is recorded in the northern Emirates at ~8.5ka (Parker *et al.* 2004), which suggests a time-transgressive northwards movement of the ISM over a period of 500 to 1,500 years.

### The Palaeolithic debate

The first chronology of the 'Stone Age cultures of Qatar' was produced by Holger Kapel (1967), whereby flint assemblages were divided into four groups termed 'Qatar A to D'. On typological grounds 'Qatar A' was considered to be of Palaeolithic origin. Subsequent excavations at Al Khor produced 'Qatar A' flint tools within layers radiocarbon dated to the mid to late 5th millennium BC (Inizan 1980). This led to the general assumption that there were no Palaeolithic remains in Qatar and the subsequent abandonment of this line of research for over twenty years. More recently research in the south of Qatar has successfully focused on the use of digital elevation models and geomorphological studies to locate occupation plateaus formerly in littoral zones during periods of climatic amelioration (Scott-Jackson *et al.* 2013).

## The Early Holocene

Important sites from the early Holocene in Qatar (Fig. 1) include *al-Shaqrā, al-Khor, Ras Abaruk (Al-Burūq) Al-Dasah* (*A-DaKsah*) and *Wādī Debay'ān*, (Kapel 1967, de Cardi 1978, Inizan 1980, Cuttler *et al.* 2011). Early Holocene sites in Qatar recognised as 'ᶜUbaid-related', correlate with the sea level high stands and palaeoshoreline reconstructions around the 2m contour and are almost exclusively coastal. The more extensive of these sites are focused on the two main wadi channels in the north of Qatar, the *Wādī Debay'ān* and the *Wādī al Jalta*. Radiocarbon dated samples from *Wādī Debay'ān* suggest occupation from ~7.5ka onwards, possibly associated with a community from former sub-aerial regions of the Gulf (Cuttler 2013). Besides a significant assemblage of ᶜUbaid pottery, the site has produced flint tools of the 'Arabian Bifacial Tradition' and fragments of obsidian that have been shown to originate from Eastern Turkey (Gratuze *et al.* forthcoming). This suggests that, following the marine transgression, Qatar formed part of an established regional network of prehistoric (possibly maritime) trade and exchange that extended over 3,000 kilometers.

## Discussion

### Karst and archaeological landscapes

Following the emergence of anatomically modern humans in Africa ~160-190ka, two potential routes for hominid dispersals out Africa have been postulated (Oppenheimer 2009, Conroy & Pontzer 2012). These comprised a northern route through the Sinai Desert into the Levant, and southern route across the Bab al Mandeb into Arabia. While a southern route has major geographical obstacles such as the *Rub' al-Khālī* sand sea and the Strait of Hormuz, this route has recently been given more weight as genetic research stressed the importance of connections between southern Arabia and eastern Africa (Kivisild *et al.* 2004, Forster and Matsumura 2005). However, stratified Arabian Palaeolithic sites related to these dispersals are rare (Rose *et al.* 2011, Delagnes *et al.* 2012, Usik *et al.* 2013). Stratified sites such as Jebel Faya, Sharja (Armitage *et al.* 2011, Bretzke *et al.* 2013) and the Jubbah palaeolake in the Nefud (Petraglia *et al.* 2012) are considered of international importance because they link lithic typologies to absolute dates. In Qatar karst offers one of the best opportunities for the preservation of stratified Palaeolithic assemblages. However, to date, the potential of this line of research remains relatively unexplored. Radiocarbon dates indicating mid-Islamic occupation at Mudhlim, only provide a date for the final phase of activity, but do serve to highlight the importance of karst for the preservation of archaeological deposits.

During five years of survey the QNHER project has recorded thousands of archaeological sites in the north of Qatar, none of which have proved to be Palaeolithic in origin. To date most of the potential Palaeolithic sites have been recorded in the south (Kapel 1967, Scott Jackson *et al.* 2013), where there is evidence for preferential use of the landscape, with a predominance of sites on high ground overlooking former lake basins and wadis (*Ibid.*). This is contrary to what might be anticipated given that groundwater in the north is closer to the surface than in the south, and is of significantly better quality. While it is possible there was not a presence in northern Qatar throughout the Palaeolithic, this scenario seems unlikely. Perhaps this anomaly might in part be explained by preferential, localized geomorphological or climatic conditions, or adverse conditions in the north of Qatar, such as extensive sand coverage. Conversely, sites from the early mid-Holocene onwards are mostly located in the north, particularly around the major wadis, and this might provide some clue regarding the absence of Palaeolithic sites. It is possible that early mid-Holocene groups based in northern Qatar reused the flint from Palaeolithic sites, which remained readily accessible on the surface. Similarly, there is very little evidence for extensive early mid-Holocene occupation in southern Qatar, where Palaeolithic sites appear to have remained undisturbed (*Ibid.*).

**Climate change and 'Refugia effect' theory**

The argument that changes in climate and sea levels may have acted as a fundamental mechanism behind population dispersals and cultural transformations during the late Pleistocene/early Holocene has formed the basis for theories of 'environmental refugia' (Rose 2010) and 'refugia effect' theory (Crassard 2009). These theories suggest that for much of prehistory, the isolation of groups encouraged the development of localised, autochthonous lithics traditions, which to some extent may explain the significant diversity between lithics assemblages from various parts of the Arabian Peninsula. Refugia could have been small desert oases such as Ain Qanas (Masry 1997) or larger areas such as the Yemeni highlands and parts of Dhofar, Oman (Crassard 2009). Large-scale 'environmental refugia' may have included former sub-aerial regions that were subject to late Pleistocene/early Holocene marine inundation, such as the Arabian Gulf (Rose 2010, Cuttler 2013). These theories suggest that an ameliorating climate would have enabled groups to move across the Arabian Peninsula, bringing them into contact with other groups. Palaeolithic and early Holocene occupation at Jebel Faya, Sharjah, shows evidence for occupation during wet phases and abandonment during hyper-arid periods (Bretzke *et al.* 2013), supporting the concept of an association between climatic change and landscape use.

However, the concept of 'environmental refugia' being the 'engine room of invention' is not a new idea. In his 1928 book "The Most Ancient Near-East", V. G. Childe proposed 'Propinquity Theory' or 'Oasis theory' as an important catalyst in the origins of agriculture. He argued that as the climate deteriorated the clustering of humans, animals, and plants into environmental oases would have enforced a transition from hunting and gathering to a reliance on domestic species of plants and animals, a transition he described as a 'Neolithic Revolution'. Certainly there is some evidence for a link between changes in climate and the emergence of new technocomplexes. In the southeast of the Arabian Peninsula, for example, a short burst of hyper-aridity around 8.2ka appears to coincide with a change from predominantly blade based cultures, such as 'Qatar B' (Kapel 1967) and Fasad (Charpentier and Crassard 2013) to bifacially worked points generally described as 'Arabian Bifacial Tradition' (Edens 1982).

Climatic amelioration across much of the southern extent of the Arabian Peninsula between 10 and 6ka probably resulted from the mean summer position of ITCZ being located much farther north of its present position. Similarly there is emerging evidence for early Holocene pluvial periods further to the north that may have been associated with Mediterranean Westerlies (Shultz & Whitney 1986, Crassard *et al.* 2013). As Qatar is located in a region between 24 and 26 °N, there currently remains very little evidence to suggest that either of these weather systems had much effect on this region. There is also little evidence for the widespread stabilisation of Aeolian sediments, as was observed further to the south in the *Rub' al-Khālī* (Cuttler *et al.* 2007). The extent of sand coverage across Qatar during this period is largely unknown; however, the absence of the Arabian Gulf as a trap for Aeolian sediments, may suggest that sediment supply for most of the late Pleistocene was significantly more extensive than at present. More recently, much of this Aeolian sediment may have been deposited in the southeast, or in the marine areas off the southeast coast by the predominant north-westerly ‘Shimal’ wind.

### Submerged landscapes

Regional hyper-aridity during MIS 2 coincided with low sea levels during the LGM. While much of the Arabian Peninsula became uninhabitable due to a deteriorating climate, sea level change exposed an area of land ~250,000km$^2$, probably featuring marshland, lakes and a major river valley. This pre-transgression landscape remains a missing fragment in the regional prehistoric jigsaw, and cannot reasonably be ignored when discussing Pleistocene or early Holocene migration. In the absence of the opportunity to directly observe this landscape, and given the major issues associated with marine exploration, shoreline reconstructions from bathymetry, landscape mapping, coring and geophysics provide an important first step towards understanding the dynamics of how human groups interacted within the landscape. Such processes provide both a platform for resource management and afford a genuine basis for future research. The coastal distribution of ᶜUbaid sites, for example, may reflect the effects of marine transgression and the distribution of Gulf pre-marine transgression communities (Cuttler 2013). The rising sea levels that eventually shaped Qatar also facilitated extensive prehistoric trade networks in such items as ᶜUbaid pottery and obsidian with southern Mesopotamia and eastern Turkey. Such changes also facilitated important maritime trade routes, the exploitation of coastal resources and the development of pearling, which probably commenced fairly soon after the early mid-Holocene marine transgression (Carter & Crawford 2010).

### Geomorphology

Fifty years of archaeological research in Qatar has largely focused on the discovery and excavation of sites with a surface expression. This is not unreasonable given the timescales within which research teams worked, and the accessibility of remote areas for survey and excavation. However, it is clear that not all sites are deflated, and those without a surface expression often have a better preserved stratigraphic sequence. The processes by which a site maintains a surface expression are normally due to erosion rather than deposition, resulting in little or no remaining stratigraphy. Certainly the evidence at *Wādī Debay'ān* (Tetlow *et al.* forthcoming) suggests that a range of natural processes affect the preservation and destruction of stratigraphy. Surface sites provide invaluable data, but the best opportunity to significantly progress current research questions is through the discovery of stratified sites within both the terrestrial and marine environments. While the location of such sites may to some extent reflect former 'environmental refugia’ the preservation is more the result of localised geomorphological conditions such as karst, longshore drift and marine sedimentation, each of which have landscape signatures from remote sensing that can form the basis for future research frameworks and exploration.

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**ملخص:** تشكّلَ مشهد قطر الطبيعي على مدى عصور ما قبل التاريخ استجابة للتغير المناخي ودورات ارتفاع سطح البحر وتقلبات نسبة الأمطار. ونتيجة لتغيرات مستوى سطح المياه، فإن الخليج العربي يحيط اليوم بقطر من الغرب والشمال والشرق، مع أنها عبر معظم عصور ما قبل التاريخ كانت جزءا من منطقة أرض مغلقة وجافة جدا. تعرض هذه الورقة الظروف التي أثرت في السلوك البشري إبّان عصور ما قبل التاريخ، والتوجهات المختلفة للمستحثات المناسبة التي تحافظ على سلامة الموقع. وهذه قواعد أساسية لبنية المشهد الطبيعي الآثارية، وتحديد هذه المواقع ضمن المشهد الطبيعي الأشمل الناجم عن تذبذب المناخ والتغير الجيومورفولوجي.

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