HUMAN POPULATIONS AND FORMER SUB-AERIAL LANDSCAPES OF THE ARABIAN GULF: RESEARCH AND CONSERVATION

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Synopsis (178 words)

Between 30 and 14ka the Arabian Gulf was a river valley possibly comprising large freshwater lakes, marshland and estuaries. As a possible environmental refugia this landscape is important, particularly as prehistoric research in Arabia has yet to find any "*evidence for human presence between 38 and 11ka*" (Bretzke *et al*. 2013), poignantly at the same time as the Gulf became free of marine influence. This might suggest that attempting to piece together the jigsaw of regional prehistory without reference to the former sub-aerial Arabian Gulf landscape is to ignore a significant part of the puzzle.

This research combines the results of excavations on Neolithic Littoral Gulf Ubaid sites with marine fieldwork in order to investigate late Palaeolithic/early Neolithic dispersals. This is contextualised through geomorphology, hydrology, geophysics and environmental analysis. This research has highlighted thousands of new sites in Qatar of all periods, and put in place effective methodologies for conservation and management of both the terrestrial environment and the Arabian Gulf submerged landscape. Importantly, terrestrial research has identified landscape signatures that informs research into the submerged Gulf landscape.

HUMAN POPULATIONS AND FORMER SUB-AERIAL LANDSCAPES OF THE ARABIAN GULF: RESEARCH AND CONSERVATION
PhD submission critical review

BACKGROUND AND IMPORTANCE

Since the concept of lake basins in the former sub-aerial Arabian Gulf landscape was first raised by Kurt Lambeck in 1996, the subject has inspired little in the way of fieldwork and less than a handful of papers. On the other hand terrestrial archaeology in Arabia has witnessed major advances in areas such as climate change, geomorphology, regional chronologies and lithics analysis. The absence of research into the former sub-aerial Arabian Gulf landscape may in part be due to the fact that marine projects require additional resources and logistics in a region that has in former times been considered remote. As the region has become more accessible, and the technology for remote sensing and marine geophysics improved, it has become possible to map and interrogate this landscape to better understand regional prehistoric populations.

Lower global eustatic sea levels during the late Pleistocene exposed vast areas of land that could be accessed by prehistoric groups. In the Gulf the areas exposed provided groups with a very different environment to the rest of the Arabian Peninsula. Within the wider context of Pleistocene sea level changes and environmental fluctuation, this landscape may hold clues to understanding issues from early hominid dispersal (Appendix A) and MIS 2 refugia (Rose 2010, Cuttler *et al*. 2012a, Cuttler 2013a), to the origins of ᶜUbaid central Gulf littoral settlement.

Central research themes

Marine research

This research is focused on understanding the populations that inhabited the former sub-aerial Gulf landscape, and on a pro-active management strategy for conservation in the terrestrial and marine areas. This has involved significant amounts of marine geophysical data acquisition, which in turn has led to the refining of data acquisition methodologies. Data captured for the purposes of oil exploration and major infrastructure projects (Al Naimi & Cuttler *et al*. 2012, Cuttler 2012b, Appendix A) have also been subject to analysis. Such data collection provides information about submerged landscapes that is far beyond the extent of any single archaeological research budget.

Terrestrial research

The present-day coastline is simply a reflection of the relationship between regional topography, hydrostatic pressure and changes in eustatic sea level. The current distinction between marine and terrestrial environments did not exist during the terminal Pleistocene and early Holocene as both regions were part of one terrestrial landscape. A holistic approach to prehistoric landscape research should, therefore, consider both as part of the same prehistoric landscape. This summary, therefore, also includes data about the geomorphology, sediments, occupation patterns and monument types within intertidal and terrestrial areas and considers how this information can be applied in marine areas. While no prehistoric archaeological sites have to date been found in the Gulf marine environment, early Holocene Littoral Gulf ^{c}Ubaid (LGU) sites show scant evidence for antecedent occupation. On a macro scale this coastal distribution may be an indication of earlier migration patterns. On a micro scale these sites have the potential to provide important information about topographical preferences (such as peninsulas, wadis etc.) that provide a guide to landscape use in previous millennia.

Landscape conservation and the Qatar National Historic Environment Record

Existing regional inventories were not suitable for the generation, storing, retrieval and interrogation of data and lacked appropriate data standards. This research provided not only a project database, but a comprehensive and effective tool for heritage management at a national level, the Qatar National Historic Environment Record (QNHER). The associated specialist web application, *Athar***GIS** (Appendix B), now provides the Qatar Department of Antiquities with powerful tools for the recording and protection of archaeological sites and monuments. As an Open Source, web based application *Athar***GIS** has the potential to become a future international standard for Cultural Resource Management.

INTERPRETING THE FORMER ARABIAN GULF SUB-AERIAL LANDSCAPE

From the last interglacial at ~130ka to the start of MIS 2 sea levels fluctuated and fell gradually, however, the sub-aerial Gulf landscape was never entirely available to late Middle/early Upper Palaeolithic groups (Appendix A). As sea levels dropped below ~100m at the start of MIS 2 (~30ka) the Gulf was free of marine influence, with an environment likely favourable to early human occupation (Rose 2010, Cuttler *et al*. 2012a, Cuttler 2013a). The confluence of the Tigris, Euphrates and Karun Rivers (the River *Ur-Shatt*) would have flowed through this landscape before finally discharging into the Gulf of Oman (Cuttler *et al*. 2012a). Bathymetric and ETOPO2 data imply the presence of three lake basins supplied with freshwater by the River *Ur-Shatt* (a confluence of the Tigris and Euphrates). The largest of these lakes, the central basin, approached 20,000km^2 (Lambeck 1996, Cuttler *et al*. 2012a, Cuttler & Al Naimi 2013c). Bathymetric and ETOPO2 data also suggests that the topography of the *Ur-Shatt* River valley was relatively wide, with a shallow gradient indicative of a low-energy channel flow (Cuttler 2009, Cuttler 2013a, Cuttler & Al Naimi 2013c, Appendix A). A shallow gradient is defined as a channel with less than a 2% flow-gradient (i.e. a drop of less than 2m over a distance of 100m). The *Ur Shatt* Valley had a flow-gradient of less than 0.0001%, or the equivalent of ~80m over a distance of 800km (Cuttler 2013a). Low energy channels encourage the deposition of fine-grained alluvium, rich in dissolved minerals and the detritus of plants and animals. Rather than being considered a river, this valley was probably more similar to the *Shatt al-Arab* estuary, comprising a contiguous corridor of low-energy marshlands, lakes, anastomosing channels, tidal flats and sandbars (*Ibid*.).

3D seismic data results

Pioneering work in the North Sea successfully analysed 3D seismic data to map the former sub-aerial landscape (Gaffney *et al*. 2007, 2009). This formed part of the methodology for this research (Cuttler 2009, Cuttler *et al*. 2012a, Appendix A), which aimed to map and interpret the submerged landscape around Qatar. Access to 4,000km^2 of high-resolution 3D seismic dataset in the *Al Shaheen* oil field was provided by Qatar Petroleum. The data is from a particularly important location as it covers the eastern extent of the western lake basin and an area of the former *Ur Shatt* River Valley between the western and central basins described by Lambeck (1996).

Lacustrine features and marshland

A timeslice from the 3D seismic (Cuttler 2009, Appendix B) indicates a relatively flat river valley, greater than 20km in width and hosting multiple, abraded river channels. These anastomosing channels indicate low-energy environments capable of supporting marshland flora and fauna. A main river channel is not evident within the timeslice and since the timeslice does not span the full width of the valley a main channel is either absent or lies to the northeast of the dataset. At the northern extent of the dataset is a large depression filled with fine sediment indicative of lacustrine deposition. At ~-60m present mean sea level (PMSL), the height and location of the sediment corresponds to the eastern extent of the western lake basin described by Lambeck. As the lake was part of an exorheic pathway it is reasonable to consider this contained freshwater rather than saline.

The lacustrine and fluvial features evident in the 3D seismic underpin our understanding of the former sub-aerial Gulf landscape. This was not, for example, a narrow fast-flowing erosional river, but more a series of lakes, swamps, anastomosing channels and marshland within a reasonably wide valley (Cuttler 2013a). As an exorheic pathway this valley would have been capable of supporting extensive freshwater flora and fauna during periods when much of the remainder of the Arabian Peninsula could not. The extent to which these features were freshwater is inconclusive; however, since the location of sediments can be pinpointed by the 3D seismic, targeted coring and analysis of environmental proxies can resolve this research question in the future.

Islands, coastlines and wadis

Features evident along the southwestern side of the *Ur-Shatt* Valley include numerous geological rises, which overlooked the valley. Recent research has indicated a preference for Palaeolithic sites on high ground with a view across adjacent plains, providing vantage points for the studying of game or the movements of other hunters (Scott-Jackson & Scott-Jackson 2013a, Scott-Jackson *et al*. 2013b). As sea levels rose above -30 PMSL between 9.5 and 9ka these geological rises would have formed islands, or promontories. Some of the features appear to be marine/coastal relic sand bars, indicative of eustatic sea level still-stands. The identification of these features is important as they have significant potential for the preservation of archaeological deposits in a coastal zone known to be preferential for prehistoric occupation.

The earliest LGU settlements post-dating marine inundation are found almost entirely on islands or within the coastal margins and it would not be unreasonable to consider that occupation from ~12.5ka onwards followed similar patterns. Importantly these former coastal features are accretionary rather than erosional, and provide a context for targeted high-resolution geophysical surveys and a programme of coring. Research within the two main wadis in northern Qatar, *Wādī Debayān* in the northwest and *Wadi Al Jalta* in the northeast has demonstrated that LGU occupation is focused on wadi channels (Cuttler 2009, 2010, 2011a, 2012b, Cuttler *et al*. 2011b, Tetlow & Cuttler *et al*. 2013), and mapping of now submerged wadi channels can potentially provide important data regarding earlier occupation sites.

Geophysical survey, northwest Qatar

Geophysical survey has focused on researching the submerged Gulf landscape. In 2008 GEMS acquired 365 square kilometres of side-scan sonar data for the Qatar Bahrain Friendship Causeway. A total of 83 anomalies of possible archaeological potential were identified within the dataset (Appendix A, Al Naimi & Cuttler *et al*. 2012). These ranged from large-scale seabed topographic features, features indicating a change in the natural sedimentary regime, and debris clusters indicative of wrecks (Figure 1).

Results

Visual inspection showed that all sharp acoustic expressions were of modern origin, while nothing was noted for any potential landscape anomalies. To recognise landscape features a diver has to be able to see both the feature and the landscape. As most anomalies were more than 5m in size, and visibility reduced to less than 5m it was impossible to gain an appropriate landscape perspective of anomalies. The identification of individual features through visual inspection is unlikely due to extensive marine flora and fauna. Any burial cairns (Cuttler et al. 2013d) or stone-built features (Beech & Cuttler et al. 2006, 2008) would be impossible to distinguish from natural reefs. Where submerged landscape features do survive they are likely to be buried or expressed only as ephemeral features that would be difficult to detect using diver visual inspection.

Figure 1: Extent of side-scan sonar coverage taken in advance of the Qatar-Bahrain Friendship causeway, and the distribution of geophysical anomalies

The search for pre-transgression features requires a much wider understanding of the landscape. This should ideally include bathymetric data to reveal the locations of wadi channels and former coastlines, which work at *Wādī Debayān* has shown to be favourable areas for prehistoric settlement (Cuttler 2013a). Sidescan sonar data can also be used for the mapping of sea bed sediments (areas of rock, silt, high and low potential etc.) and for the identification of sea bed anomalies at low resolution (Dingwall forthcoming). Accretionary marine landscape features such as long shore drift are significant as the results from *Wādī Debayān* have demonstrated they can preserve archaeological deposits. However, it is impossible to identify such features through visual inspection as divers normally suggest there is nothing to record. Future research requires multiple platforms, such as a sub-bottom profiler, multibeam (MBES), camera ROV and/or a programme of targeted marine coring. In addition, where the nature of such anomalies cannot be verified evaluation trenching should be considered. Sharp acoustic expressions were found to be modern features with distinctive signatures. In future these can either be dismissed or inspected using an ROV.

Further sidescan sonar to the north of this study area during the 2012-2013 revealed the presence of 7 further steel-hulled wrecks. These dated to within the last 60-80 years, but were previously unrecorded. There is a higher concentration of wrecks in the north along the principle trade routes between the southern Gulf and southern Iraq.

Further consideration of anomaly Bham0028

Anomaly Bham0028 (Figure 1 & Figure 2) ~11km from the Qatar coastline, comprised two parallel, north-south linear anomalies ~27m apart, measuring ~150m in length, with a maximum bathymetric expression of ~0.4m. The two linear anomalies had internal sub-divisions aligned at right angles on an east-west orientation. At the northern extent of the two linear anomalies was what appears to be a triangular-shaped anomaly ~30m along each side. Such right angles are unusual in nature and would suggest an anthroprogenic origin. The feature was evident in two overlapping scans, and was clearly

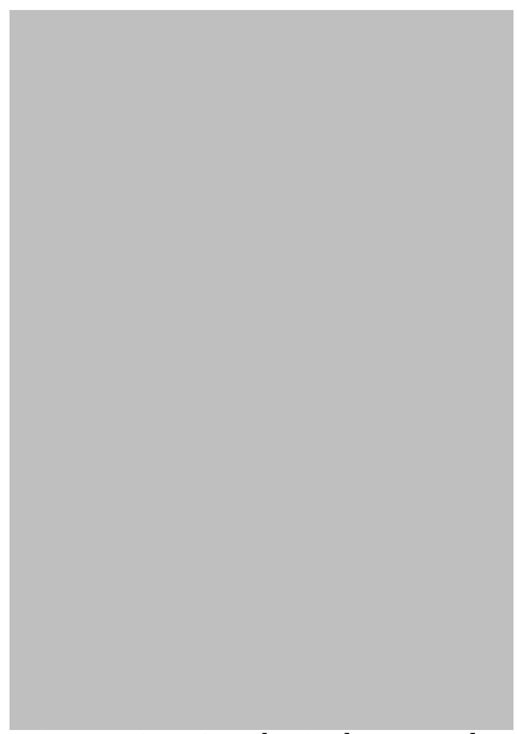

Figure 2: Geophysical anomaly Bham0028 (GEMS 2008)

a true sea bed expression. However, both visual inspection and sidescan sonar survey in 2011 failed to locate the feature, which was considered indicative of changes in the marine environment, such as moving sand.

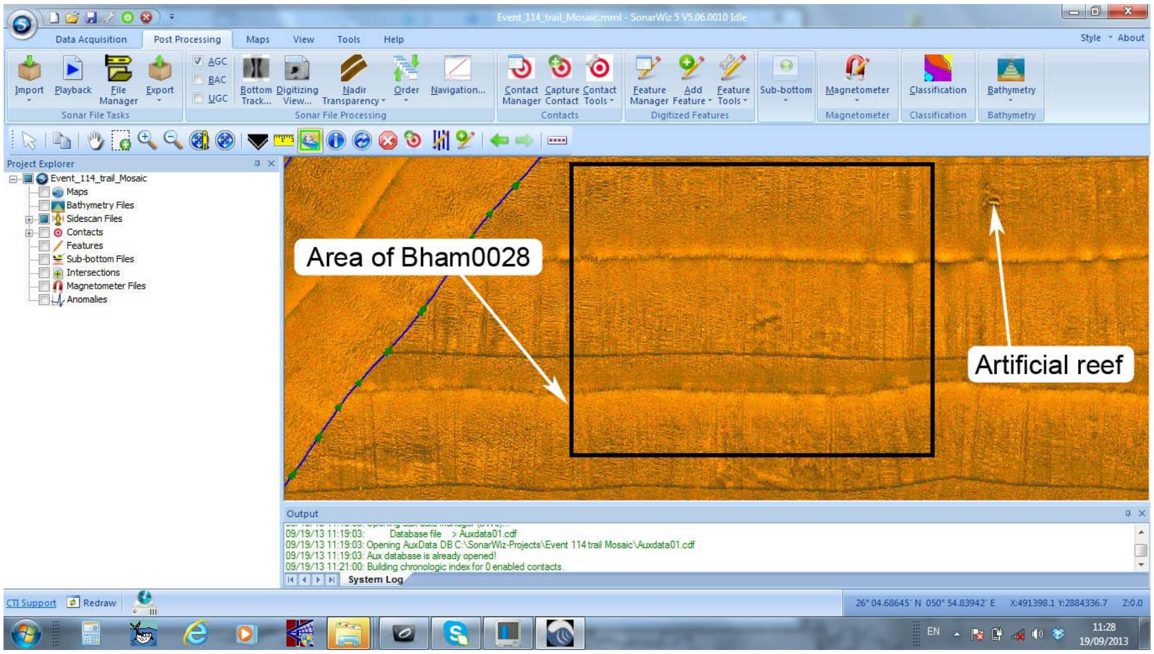

Figure 3: Mosaic showing the results of east-west traverses taken in January 2013.

Given the anthropogenic potential of Bham0028 it was decided to try to locate the anomaly once more using sidescan sonar survey. In January 2013 a survey was designed with east-west transects with a 1km^2 search area around the contact. While the survey showed the presence of some sea bed anomalies, and an artificial reef (Bham0019), there was no evidence for contact Bham0028 within the data (Figure 3). The presence of the reef, evident in the 2008 dataset verified this absence was not due to projection errors.

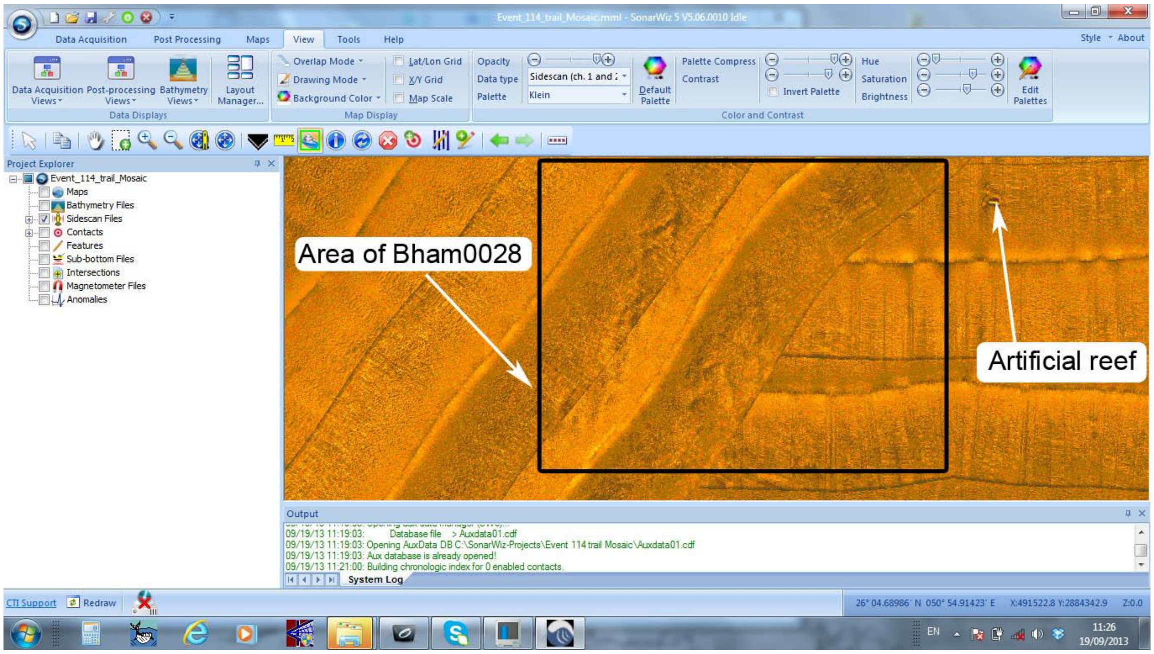

Figure 4: Mosaic showing the anomaly evident in northeast-southwest traverses taken in March 2013

During one final attempt to resolve Bham0028 a survey was designed using the same northeast-southwest orientation and transect lines used by GEMS in 2008. Figure 4 shows a mosaic of the northeast-southwest transects overlying a mosaic of the east-west transects, with contact Bham0028 once more clearly visible within the northeast-southwest transects. The interval between datasets is only three weeks, so the results probably reflect how the data was collected rather than sea bed conditions. Contacts between datasets vary considerably when the transect lines are on different orientations. This research would suggest that certain types of contacts are not visible when surveys are undertaken in one orientation, even despite a good bathymetric expression.

Revised methodologies for sidescan sonar

The survey results suggest that sidescan sonar in one orientation is insufficient to detect all feature types, and a minimum of two orientations should be considered. Much of the data collection to date has involved high-resolution, single orientation transects with a 200% overlap. Future approaches should consider wide swath (low-resolution) multi-directional surveys with a smaller overlap between lines. This represents a similar outlay in terms of time and resources but should encompass a wider range of anomalies, and should form the basis for higher-resolution survey targeted within discrete areas of high archaeological potential. Where possible such surveys should be supplemented by other datasets, such as sea bed characterisation, bathymetric mapping and geomorphological signature analysis.

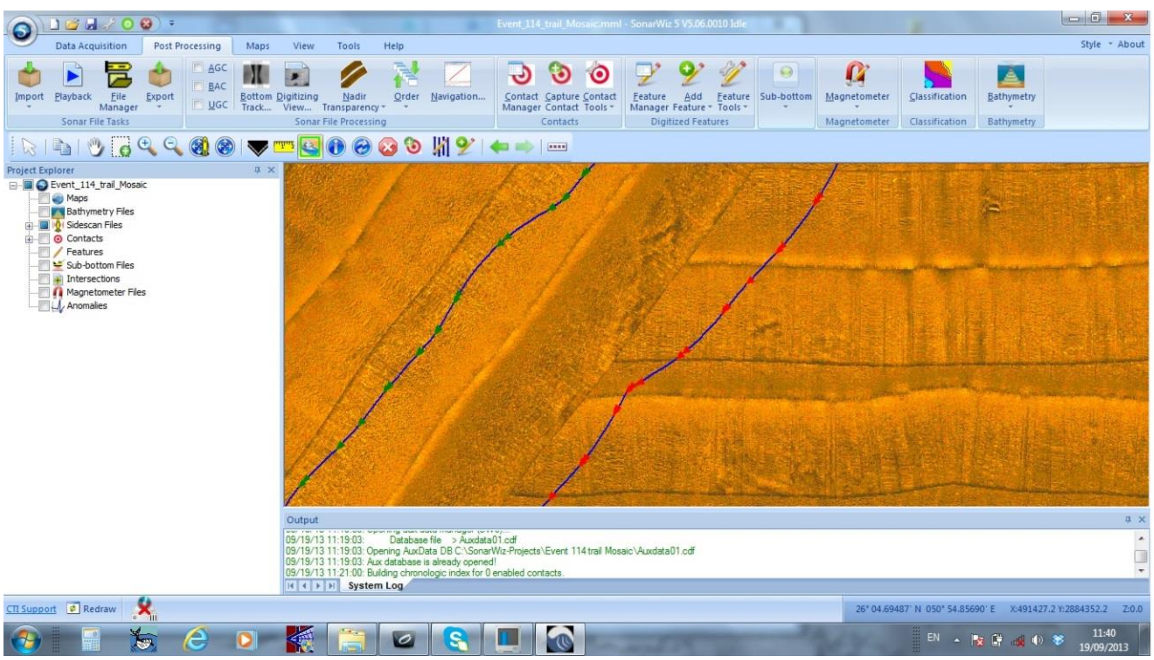

Figure 5: Area of contact Bham0028 with the northeast-southwest sidescan sonar line partially 'peeled back' to reveal the absence of the contact in the east-west lines

Terrestrial research

The Gulf refugia from late MIS 3 to early MIS 1

At ~130ka the Arabian Gulf would have been subject to marine transgression, with sea levels ~4-6m higher than present day for significant periods (Rohling *et al*. 2007, Appendix A). By ~30ka the Ur Shatt Valley would have become fully exposed at a time when the Arabian Peninsula experienced regional hyper-aridity. This potential for occupation within the former sub-aerial Gulf landscape has formed the basis of arguments for an 'environmental refugia' in the Gulf during MIS 2 (Rose 2010, Cuttler 2013). The expansion and contraction of populations due to environmental forcing has also been proposed as the catalyst responsible for the diversity between lithics assemblages across the Arabian Peninsula, a concept termed 'refugia effect theory' (Crassard 2009). Theories of refugia and the effects of refugia in the Near East are not entirely new. V.G. Childe (1928) proposed that as the climate deteriorated, humans, animals, and plants were forced into environmental refugia. This was the catalyst behind a 'Neolithic Revolution', or transition from hunting and gathering to a reliance on domestic species of plants and animals, something Childe termed 'Propinquity Theory' or 'Oasis Theory'.

The enigma of the Littoral Gulf ^{c}Ubaid (LGU)

The surprising discovery of ^{c}Ubaid pottery in the Gulf by Burkholder in 1968 (Burkholder 1972) established a link between late 6th millennium BC groups along the western central Gulf littoral and settlements some 1,000 km to the north in southern Mesopotamia. Masry (1997) describes the enigma of "parallel, identical cultural manifestations in two diverse environmental areas" as "spheres of interregional interaction" and argued that these spheres of interaction had their origins in raw material exchange. He proposed that "cyclic migrations associated with herders or generalised hunter gatherers" were the formative engine behind the development of trade networks between the two regions.

Oates considered "economic or climatic factors, or both" to be key reasons for this interregional interaction (Oates 1978). She further argued that the presence of ^{c}Ubaid pottery at sites in the Gulf was the result of infrequent visits by Mesopotamian traders, since "pots travelled with their owners". This is of course true, but there is no evidence to suggest that the pot owners were not LGU traders travelling to Mesopotamia (Drechsler forthcoming). While these pots may have served as transportation vessels, a significant percentage of pottery assemblages from LGU sites comprise open bowls, cups and decorated wares. Consequently, it may be that the pottery was a trade item in its own right, used for communal feasting events public gatherings and social transactions (Carter *et al.* 2010).

Rose (2010) proposed that the LGU may have been a relic group from a former 'Gulf refugia', the original inhabitants of the *Ur Shatt* landscape. It is therefore, possible that these "parallel, identical cultural manifestations" predate marine transgressions in the Gulf, reflecting shared cultural origins between societies in southern Mesopotamia and the LGU (Cuttler 2013a). However, given the hyper-arid climate, the establishment of settlements in the central Gulf littoral by groups used to a riverine environment, requires further consideration, (Cuttler *et al*. 2011b, Cuttler & Al Naimi 2013c, Cuttler 2013a).

Figure 6: Distribution of Littoral Gulf ^{c}Ubaid sites, showing the distribution extents of ACW and plaster vessels

LGU sites of the late 6th and early 5th millennium BC are concentrated around the central Gulf littoral (Figure 6). Sites such as *ad-Dossriyah* on the east coast of Saudi Arabia have produced ~14,000 sherds of ^{c}Ubaid pottery (Philipp Drechsler pers. comm.), while *Wādī Debayān* has to date produced ~200 sherds. To the south and east of *Al Khor* on the eastern coast of Qatar, Neolithic sites produce relatively few ^{c}Ubaid sherds, often from only from one pot (Beech & Cuttler *et al*. 2005, 2007). Alternatively plaster vessels decorated with a black paint and geometric patterns, thought to be imitations of ^{c}Ubaid vessels, have been found to the south and east of *Al Khor*, such as at *Simaisma* (Cuttler 2011a), *Marawah* Island (Beech & Cuttler *et al*. 2005) and *Dalma* Island (Beech *et al*. 2000). This might imply that the supply of plaster vessels to areas to the south and east of *Al Khor* was limited, or that these groups were part of a different trade network.

Hydrology and aquifers

As sea levels fell during the Last Glacial Maximum (LGM) groundwater hydrostatic pressure across the continental shelf would have also fallen. In hyper arid regions this would have resulted in oasis development in coastal areas and desiccation in the interior (Faure *et al*. 2002). Eustatic sea level rise between 14ka and 7.5ka years ago would have

Figure 7: Periodic extents of the ITCZ (ISM) ~9.5 – 6.3kya after Fleitmann et al. 2004:639, and extent of the Dammam Aquifer catchment area across eastern Arabia

had the opposite effect of equalising hydrostatic pressure at lower levels and encouraging new or increased flow at higher levels (Cuttler 2013a). This would suggest that freshwater may have been available, not only within the *Ur-Shatt* Valley, but also from small oases that developed due to a rise in groundwater hydrostatic pressure. The development of oasis as sea levels rose might to some extent explain why LGU groups migrated westwards, rather than into areas already occupied in the north (*Ibid*.).

Figure 8: Schematic hydrogeological cross section of the Eastern Arabian Peninsula, with exaggerated vertical scale. After Al-Sharhan et al. 2001: 81

Three of the largest Arabian aquifers are located across most of eastern and southeastern Arabia; the most important for fresh water resources is the *Dammam* Aquifer (Figure 7), which discharges around western Saudi Arabia, Qatar and Bahrain (Figure 8). Around Bahrain this is located at depths of between ~15-49m (Zubari & Lori 2006). Much of the fossil groundwater is derived from earlier Quaternary intervals of much greater rainfall and so fresh ground water flow from aquifers would have remained stable, even during hyper-arid periods.

The environment

The Arabian Holocene sub-pluvial is well documented (Cuttler *et al*. 2007, Parker & Goudie 2008, Cuttler *et al*. 2012a) and is probably the result of a northwards movement of the Indian Ocean Summer Monsoon belt (ISM) into the interior of Arabia. Following the analysis of lake bed sediments in the *Rub' al-Khâlî* (McClure 1976, 1984) it was generally assumed to be a phenomenon that affected the entire Arabian Peninsula. As the corpus of environmental proxies has grown, there has been little evidence for this phenomenon to the north of 24 degrees latitude (Cuttler 2013a). Importantly, all LGU sites are located between ~24 and 28 degrees latitude (Figure 7), a hyper-arid region that remained unaffected by the southern ISM or precipitation from Mediterranean westerlies (*Ibid*.). This runs contrary to arguments that LGU settlement reflects early Holocene climatic amelioration (Oates 1978, Masry 1997). The dispersal of ^{c}Ubaid sites within the Arabian Peninsula remained almost exclusively along the coastal margins (with only a few up to ~40km inland, such as at *Ain Qannas*). There are no Gulf ^{c}Ubaid sites deep within the interior of Arabia as would be expected if the ISM moved northwards across the entire Peninsula (Cuttler 2013a).

Isochronous ISM advance

The northwards movement of the ISM across the *Rub' al-Khâlî* not only appears to have varied in the range, duration and intensity at different latitudes, but was also probably isochronous/time-transgressive. Prior to ~10.5ka the ISM belt lay at the southern extent of the Arabian Peninsula (Sirocko 1993) and began to affect parts of the UAE after ~8.5ka (Parker *et al*. 2004). This indicates that the ISM probably took between ~500 and 1500 years to advance from southern Oman to the northern UAE (Cuttler 2013a). This isochronous advance would have been favourable for the expansion of southern Arabian groups into the formerly uninhabitable, *Rub' al-Khâlî* between ~10.5 and 8.5ka (*Ibid*.). Occupation was punctuated by periods of hyper-aridity that can be correlated with the Greenland ice cores (Cuttler *et al*. 2012a). One in particular at ~8.2ka probably lasted for a period of over 160 years (Thomas *et al.* 2007, Cuttler *et al*. 2013c). Such hyper-arid events would have caused the temporary remobilisation of dunes and desiccation of the *Rub' al-Khâlî* interior (Cuttler *et al*. 2007), periods that would be difficult for populations to survive (Cuttler 2013a).

Arguments for micro-refugia

A rise in sea levels and an increase in groundwater hydrostatic pressure would have encouraged the development of coastal springs, particularly in areas that remained below sea level due to the presence of anticlines or bars. The majority of anticlines in the region are aligned ~north-south (for example the Qatar anticline). At the northern extent of the Gulf of Salwa an anticline is aligned ~east-west between Saudi Arabia, through Bahrain to Qatar. Parts of this anticline are now slightly submerged, forming two channels either side of Bahrain. These channels average between -1 and -4m PMSL in depth (Figure 9). The Gulf of Salwa is significantly deeper with over 1,000km^2 lying at a topographic sea bed low of between -50 and -20 PMSL. A second topographic sea bed low of >-20m PMSL and ~130km^2, is located immediately to the south of the anticline within the channel shared between Qatar and Bahrain.

Figure 9: The Bahrain Anticline and the bathymetry of the Gulf of Salwa

As sea levels rose above -50m from ~10.8ka onwards, parts of the Gulf of Salwa would have remained below sea level, but free from marine influence. Between 9.2 to 8.8ka sea levels rose above 23m, leaving large areas of the Gulf of Salwa more than 30m below sea level. Since the highest member of the *Dammam* Aquifer (the *Alat*) discharges around Bahrain at ~-15 to -25m PMSL, it is reasonable to consider that from ~9.2ka onwards hydrostatic pressure of groundwater caused the development of flowing surface water or an endorheic lake in the Gulf of Salwa. Such terminal lakes are often saline due to the accumulation of minerals, but this phenomenon may have been restricted to topographic lows, with freshwater flow at slightly higher elevations (Appendix A). Such a hypothesis can be tested through targeted coring and the analysis of environmental proxies, and provides a framework for future research.

Since the Bahrain Anticline acted as a bar to marine transgression, the flooding of the Gulf of Salwa would have been relatively late, probably between 8 and 7.5ka as sea levels rose above -5m PMSL. However, hydrostatic load on the eastern side of the Arabian plate would have resulted in isostatic readjustment (subsidence) that continued after sea level high stands had been reached (Lambeck 1996). This suggests that the transgressive lag was later than can be inferred from global models of eustatic sea level change.

The earliest LGU sites date to ~7.5ka and are mostly clustered along the eastern coast of Saudi Arabia (Figure 6). Several are located around the coast of Qatar as far as *Al Khor* (including *Wādī Debayān*), and one site is known on the west coast of Bahrain. None of these sites (excluding *Ain Qannas*) show evidence for antecedent occupation and clearly the LGU migrated from elsewhere. If they are relic ‘Gulf refugia’ populations (Rose

2010) we cannot discount the possibility of an early dispersal from the Ur Shatt Valley into micro-refugia rather than a northwards migration. Further sea level rise may also have subsequently flooded any micro-refugia, causing further dispersals at around 7.5ka. The hypothesis that the Gulf of Salwa was a refugia can be tested through geophysics, coring and the analysis of environmental proxy data.

The monuments of the Littoral Gulf ^{c}Ubaid

Settlement

A curious phenomenon that coincides with LGU settlement in the southern and western Gulf littoral is building technology. Gypsum surfaces and related features indicated the presence of structures ('barasti-like houses') at *Dalma* Island, UAE. AMS dating on a datestone (*Phoenix dactylifera*) ~0.25m above a floor surface produced a date of 5120± 170 cal. BC (Flavin & Shepherd 1994). At *Ain as-Sayh*, eastern coast of Saudi Arabia, a total of five 'hut-bearing sites' (A, B, C, D and F) were thought to have been temporarily submerged during a sea level high stand (McClure & Al-Shaikh 1993). Each site produced evidence for a hard, grey lime plaster impressed with reeds on one side and barnacle encrusted on the other. These were interpreted as building remains that "can be assumed to have been standing at the time of encrustation". The walls of the huts were constructed using brackish water reed (*Phagmites communis*), which had then been plastered on the interior face. One building (Site B) was constructed from "substantial *faroosh* blocks" that had been plastered on the inside and survived to a height of more than a metre. Radiocarbon dating on marine shells associated with the huts (Site F) provided dates of 5,475-4,965 cal BC, 5,520-5065 cal BC and 5,590-5070 cal BC (*Ibid*.).

Barnacle-encrusted plaster is also reported at *ad-Dossriyah* to the north (Masry 1997), however, since no large open-area excavations have been undertaken, the presence of dwellings is unclear. At the northern extent of the Gulf the ^{c}Ubaid site of H3, *As-Sabiya*, revealed a complex of structures constructed from *faroosh* (Period 2), with associated radiocarbon dates of 5220-4940 Cal BC at 94% probability (Carter & Crawford 2010). Area 27 at *Wādī Debayān*, also displays evidence for numerous post-built structures. Radiocarbon dating of a hearth within an area of postholes places the earliest occupation at the site to 5550-5470 cal BC (Tetlow & Cuttler *et al*. 2013, Cuttler *et al*. Forthcoming).

Figure 10: Mid-6th millennium BC LGU structure at MR11, Abu Dhabi, (Beech & Cuttler et al. 2005, 2007). Photo courtesy of the Abu Dhabi Tourism and Culture Authority

Perhaps the most substantial LGU-related structure was found at MR11 on the island of *Marawah*, Abu Dhabi Emirate. Excavation of one of a group of 7 mounds revealed a stone-built structure (*faroosh*) approximately 2m wide and 4m long that survived to 0.7m in height (Figure 10). The position of large, flat, *faroosh* slabs suggest that the roof may have been corbelled before collapsing into the interior of the structure. A fragment of charcoal recovered from one of the earliest layers (58) provided a date of 5724-5563 cal. BC (Beech & Cuttler *et al*. 2005, 2007).

As the earliest regional evidence for buildings, such structures are a widespread phenomenon from the southern to the northern Gulf in the early 6th millennium BC. What varies between sites is the construction material. Some buildings are reeds and plaster, others mangrove and *burasti*, and others stone. The construction of dwellings by the LGU, irrespective of locally available materials, suggests the concept of building was important. By the early 5th millennium BC this practice ceases, with communities using more ephemeral construction methods.

House building is normally associated with a fairly sedentary lifestyle. Given that the climate was hyper-arid, these communities might have been expected to use ephemeral structures more suited to a nomadic lifestyle and a wider exploitation of resources. This might suggest that these people were used to a more sedentary lifestyle and permanent houses, and a cultural tradition that was suited to a slightly different environment.

Burials

A significant number of the monuments added to the QNHER between 2008 and 2013 are prehistoric burial mounds, usually deflated, but some surviving >2m in height (Breeze & Cuttler *et al*. 2011, Cuttler *et al*. 2013d). This is a tradition that extends from the 5th millennium BC to the late pre-Islamic period (although the chronology of burial monuments is not as yet complete). The earliest burials in Qatar with absolute dates are two large circular mounds (C1 and C2) on the northeast coast at *Simaisma* (Figure 11). These have provided dates of 4690 to 4460 Cal BC and 4780 to 4560 Cal BC (Tetlow 2010, Cuttler *et al*. 2013d). These dates have implications not just for terrestrial archaeology but also for marine geophysical survey as these are examples of early construction techniques. A stone-built mound is less likely to suffer marine erosion than ephemeral settlement features, and mounds subject to an anaerobic, waterlogged environment shortly after construction offer the best opportunity for finding well-preserved organic deposits. This is particularly important given the relatively poor state of organic preservation across the Peninsula (Cuttler *et al*. 2013d).

Arabian Coarse Ware

Assemblages of ᶜUbaid pottery from LGU sites in the central and northern Gulf as far south as northern Qatar (*Wādī Debayān*) are found in association with a coarse red fabric that has been termed Arabian Coarse Ware (ACW). The origins of this fabric are unknown, and to date no kiln sites have been discovered. Since this has never been found among southern Mesopotamia ᶜUbaid assemblages, Oates (1978) proposed that it was locally produced. Later researchers also took this view, commenting that "*there is little* *doubt that it was the product of the Neolithic inhabitants of the Central Gulf littoral*" (Carter *et al*. 2010:65). ACW is found as far north as Kuwait, where an ACW model boat was discovered at H3 (*Ibid*.). A handful of sherds have also been recorded at *Ga Ga* Island and *Dalma* Island, Abu Dhabi Emirate (Beech *et al*. 2000). The largest assemblages are found in eastern Saudi Arabia, particularly *ad-Dossriyah* (Masry 1997) and *Ain as-Sayh* (McClure & Al-Shaikh 1993) where round-bottomed vessels and vase-shaped pots with narrow bases appear to have been used for utilitarian purposes. Bitumen occurs as a thick coating in the order of 0.5cm on the interior sides and bottom of the vessels. "*Bitumen was evidently the bulk product contained and processed in the pottery and not a simple coating to render it impervious*" (*Ibid*.). This may suggest that (among other functions) ACW was used for the processing and transport of bitumen.

The concept that ACW is a local fabric is intriguing. The prerequisites for pottery manufacture include access to suitable clay sources, fresh water and extensive amounts of wood. Since the LGU sites lay within a hyper-arid region (between 24 and 28 degrees latitude), there is little evidence that they had access to the quantities of wood needed for pottery manufacture. Chemical analysis on ACW fabrics from *Wādī Debayān* and local clays, show that ACW does not carry the signatures of known clay sources within the terrestrial areas of Qatar (Sølling *et al*. forthcoming).

The absence of manufacturing sites may be due to the use of 'bonfire kilns' which are notoriously ephemeral, however, such sites usually leave evidence in the form of 'waster sherds'. To date there is no such evidence that might indicate a local production site anywhere within the Arabian Peninsula. Given the local distribution of the pottery and the absence of production sites, the now-submerged areas of the Gulf cannot be entirely ruled out as former areas of manufacture. The hydrological evidence suggests that prior to marine transgression the Gulf of Salwa was a likely area with fresh water sources.

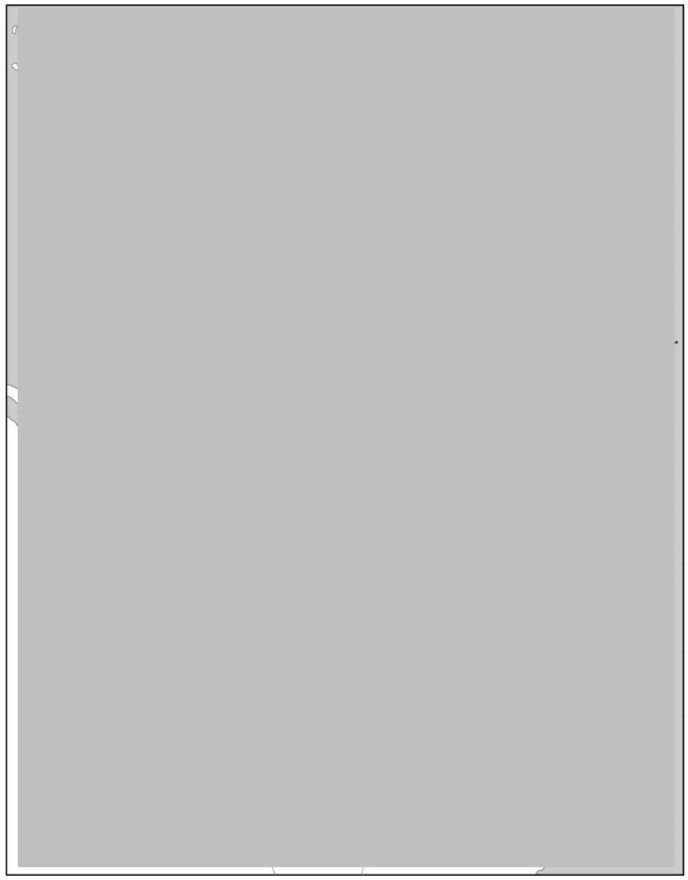

Figure 11: The location of Wādī Debayān and other areas mentioned in the text

The hypothesis that ACW was originally manufactured in now submerged areas of the Gulf of Salwa can in the future be tested should clays suitable for chemical testing be recovered from marine cores from the Gulf of Salwa.

Researching Neolithic landscapes: Wādī Debayān

Survey in advance of the Qatar-Bahrain Friendship Causeway recorded the presence of a lithic scatter and ^{C}Ubaid pottery (QNHER141) at *Wādī Debayān*, northwest Qatar (Figure 11 & Figure 12). The site was subject to excavation between 2009 and 2013 and has demonstrated early to mid-Holocene exploitation of resources across an extensive area. Occupation deposits have mostly been recorded along the northern edge of the wadi, both in the base, sides and on the higher ground (Cuttler 2009, 2010, 2011, 2012b, Cuttler *et al*. 2011b, Tetlow & Cuttler *et al*. 2013, Cuttler *et al*. forthcoming).

Figure 12 Wādī Debayān: Areas of investigation 2009 to 2013

Investigation began with the analysis of the distribution of flint artefacts and targeted test pits. These results were used as the basis for further archaeological work including magnetometry, topographic survey, open area excavation, environmental coring, environmental test pitting and geomorphological studies. The following includes an outline of these results and the implications for research into the LGU and the Gulf landscape.

Areas 10 and 27

The area of the flint scatter QNHER141, (shown in blue on Figure 12) was subject to a magnetometer survey. This did not reveal any discernible anomalies (Figure 13); however, following excavation it became clear that these results probably reflect extensive areas of burning and hearths.

Figure 13: Results of magnetometer survey across the area of flint scatter QNHER141

Test pitting revealed burnt areas and two areas of more deeply stratified deposits. These two areas (10 and 27) were subsequently subject to open area excavation. The archaeological features mostly comprised structural remains (stone-packed post holes and gullies), burnt areas and hearths (Figure 14 &Figure 15) indicative of extensive activity. Radiocarbon dating suggests that occupation commenced the mid 6th millennium BC and continued until the late 5th millennium BC. To date ~200 sherds of pottery originating from southern Mesopotamia have been discovered, most within Area 27. The assemblage also includes >30 sherds of ACW.

Date	**Beta Code**	**@ 2 sigma BC (Intercal 09, Marine 09)**	**@ 2 sigma BC (Intercal 09, Marine 09)**
5480±30 BP	351443	4360-4270 Cal BC	6310-6220 Cal BP
5600±30 BP	351448	4500-4350 Cal BC	6450-6300 Cal BP
5610±30 BP	351444	4500-4360 Cal BC	6440-6310 Cal BP
5650±30 BP	351453	4540-4400 Cal BC	6490-6350 Cal BP
5680±30 BP	351450	4550-4460 Cal BC	6500-6400 Cal BP
5690±30 BP	351447	4590-4460 Cal BC	6540-6410 Cal BP
5770±30 BP	351445	4710-4540 Cal BC	6660-6490 Cal BP
5780±30 BP	351451	4710-4540 Cal BC	6660-6490 Cal BP
5790±30 BP	351452	4720-4550 Cal BC	6670-6500 Cal BP
5810±40 BP	325387	4840-4690 Cal BC	6790-6640 Cal BP
5840±60 BP	325385	4890-4590 Cal BC	6840-6540 Cal BC
5850±40 BP	325388	5000-4790 Cal BC	6950-6740 Cal BP
5870±30 BP	325382	4890-4590 Cal BC	6840-6660 Cal BP
5890±30 BP	351449	4830-4710 Cal BC	6780-6660 Cal BP
5900±40 BP	325384	5190-4850 Cal BC	7140-6800 Cal BP
5930±40 BP	325386	4980-4710 Cal BC	6930-6730 Cal BP
5950±40 BP	325383	4980-4780 Cal BC	6930-6730 Cal BP
6200±30 BP	351446	5280-5050 Cal BC	7230-7000 Cal BP
6050±40 BP	325381	5190-4850 Cal BC	7140-6800 Cal BP
6050±40 BP	325390	5190-4850 Cal BC	7140-6800 Cal BP
6530±40 BP	302411	5550-5470 Cal BC	7500-7420 Cal BP

Table 1: Wādī Debayān, Area 27. Radiocarbon dates provided by charcoal/organic rich sediment from hearths

Figure 14: Excavation of LGU occupation at Wādī Debayān (Area 27). This area shows evidence of post-built structures, hearths and burnt areas dated to the late 6th/early 5th millennium BC

Flint tools include barbed and tanged arrowheads, tabular knives and a polished stone axe on a black flat pebble (one of only a handful of such items found across the region). However, the assemblage comprised predominantly of side scrapers and more rarely semi-peripheral end-scrapers and is a fairly typical Neolithic to Bronze Age assemblage (Crassard forthcoming). In addition to flint tools, four fragments of obsidian were recovered from the area of the flint scatter. Analysis shows the obsidian originates from eastern Turkey (Gratuze *et al*. in prep).

Environmental coring and test pitting

A programme of environmental test pitting and coring was initiated in the base of the wadi, since low-lying areas had a greater likelihood of more deeply stratified deposits. The intention was to investigate the possibility for the survival of stratified environmental deposits relating to the period of LGU occupation within Areas 10 and 27.

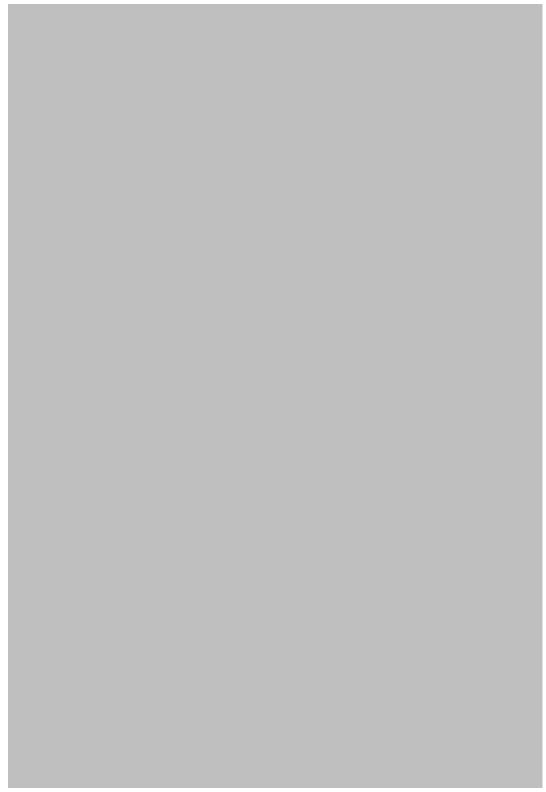

Figure 15: Structural evidence at Wādī Debayān (Area 27)

Figure 16: Environmental test pitting at Wādī Debayān

The environmental test pitting identified marine transgression within *Wādī Debayān* dating to the late 6th and early 5th millennium BC (Figure 16 &Figure 17). This suggests that during the period of LGU occupation sea levels were higher than present day. Areas 10 and 27 were on a peninsula while the remainder of the wadi was subject to marine inundation with the development of mangrove swamps within intertidal areas (Tetlow &

Cuttler *et al*. 2013). By the mid-5th millennium BC more than 1.5m of marine sedimentation had accumulated, with sea-levels stabilising. The appearance of humified organic material and the presence of plants (semi-terrestrial, emergent or aquatic), is indicative of increasingly tranquil conditions that continued until 6200-5950 cal BP (*Ibid*., Cuttler *et al*. 2011b).

Figure 17: Environmental test pit from the base of Wādī Debayān (Cuttler et al. *2011b)*

Archaeologically important natural features

High-resolution topographic survey was undertaken across the area of the flint scatter (QNHER141) and down slope into the base of *Wādī Debayān* (Figure 18). When the vertical scale was exaggerated an irregular linear topographic high, on an approximate north-south alignment, was identified within the base of the wadi (shown as a blue line on Figure 18). This linear feature was evident for a distance of >900m in length and measured 15 to 20m across. Initially it was considered that this may relate to ancient, stone-built fish traps (such as *hadra* and *maskar,* Breeze *et al*. forthcoming). A total of 12 trenches, each 2m in width were aligned perpendicular to the feature. These exploratory trenches revealed the presence of extensive archaeological deposits and demonstrated that this feature was the result of longshore drift from period of higher sea levels.

Figure 18: Wādī Debayān topographic survey results. Higher ground is represented in lighter grey, while the darker areas are topographic lows

Trench 7 (Figure 19 &Figure 20) revealed the presence of a midden, almost 1m in depth with a significant amount of fragmented, burnt fish bone. The assemblage comprised mostly local fish species (*Carangidae*, *Serranidae* and *Sparidae*), normally caught in

Figure 19: North facing section of Trench 7 showing a midden and a possible high-energy event [3045]

near-shore environments. The degree of fragmentation is indicative of inter-tidal reworking of the deposits (Amundsen forthcoming). AMS samples from the basal layers of the midden indicate a mid to late 4th millennium BC date, while the top of the midden provides a mid-3rd millennium BC date. This suggests that the longshore drift developed as a beach-ridge due to during a period of slightly higher sea level, between ~5460 and 4340 Cal BP.

Figure 20: North-facing section of the midden from Trench 7. Note the layer of well-sorted stone sealing the midden

The midden was sealed by a layer of well-sorted, rounded stone <0.20m in size within a matrix of sand, that measured 0.35m in depth (Figure 19 &Figure 20). This layer had the effect of an ‘armour coating’ over the midden deposits preventing deflation. Since the stone was rounded it would appear to have originated from either a fluvial or marine environment. Given that there was no major slope in the locality of the longshore drift, this does not relate to colluvial deposition. The most likely explanation is that this deposit is the result of a high-energy or tsunami event that radiocarbon dates from the top of the midden would place sometime in the second half of the 3rd millennium BC.

Figure 21: Unmarked burials at Wādī Debayān (Photograph Auri Zamora)

Burials

In Qatar charcoal and fishbone middens are unusual. Hearths are normally fairly simple and deposits often subject to rapid deflation. The midden may be associated with some form of industrial process, or may be waste from nearby structures. In order to search for structural evidence, test pits spaced at intervals of 20m were excavated to the east of the longshore drift (Figure 12). While no structural features were found, the test pits revealed the presence of unmarked prehistoric burials, one of which was subject to excavation (Figure 21).

While AMS dating on the burial was unsuccessful, the burial clearly predates the late 3^{rd} to early 2^{nd} millennia BC. Radiocarbon dates of 3000 to 2870 Cal BP and 3930 to 3830 Cal BP from two fire pits cut into deposits overlying the fill of the burial, provide a *terminus ante quem*. The burial also contained fragments of ^{c}Ubaid pottery, that provide a *terminus post quem* for the feature. A 5x5m area around this burial was subject to open area excavation. This revealed the presence of five more burials, which remain unexcavated. These are the first prehistoric burials that do not have a cairn superstructure or some form of marker stones to be discovered in Qatar. This has issues about the visibility of archaeological remains and future research methods for the location of archaeological features in Qatar (Cuttler *et al*. 2013d).

Sea level change

The use of global data for regional sea level curves unfortunately suffers from the absence of absolutes. The transfer of mass between continents as ice sheets expand and contract causes substantial vertical movements in the Earth's crust over extensive periods, results in differences in the timing and the magnitude of relative sea level change around the globe. For this reason extensive radiocarbon dating has been used around *Wādī Debayān* in the attempt to refine the local mid-Holocene sea level curve. In total 47 radiocarbon dates have proved successful in different areas that realate to a wide chronology of shifting occupation within *Wādī Debayān*. This has shown occupation movements in relation to changes in sea levels.

The evidence from Areas 10 and 27 suggests that LGU groups of the late 6th and early 5th millennium BC had a preference for settlement on the leeward side of a peninsula within *Wādī Debayān*. This would have provided shelter from the prevailing wind and from storms. These groups were clearly coastally adapted, and closely followed the coastline. Hence radiocarbon dating of archaeological features close to the coast provides good markers for maximum-highs during each period. The results of this work also show that the mid-Holocene sea level high stand never rose above 2m PMSL (Cuttler *et al.* in prep). Further work will enable a refining of the local sea level curve during the middle to late Holocene.

Discussion

The past 50 years have seen significant advances in our understanding of the LGU. However, since the excavation seasons of foreign missions were often short, and undertaken with limited resources, teams invariably focused on archaeology evident on the surface. This has meant that there has been little opportunity for studies of the wider landscape. Landscape-scale investigations are invaluable for providing LGU sites with important contextual data. *Wādī Debayān* not only adds to the existing corpus of information about LGU settlement, but also provides data about preferable topographic occupation through time, and accretionary features that prevented deflation of archaeological deposits. The connection between relic areas of longshore drift and occupation within the wadi has changed archaeological methodologies and how intertidal features are investigated in Qatar. This research has also highlighted the clear preference by LGU communities for occupation within the two main wadi systems in northern Qatar, *Wādī Debayān* in the northwest and *Wādī Al Jalta* in the northeast (Figure 11).

The challenge now is to apply our understanding of the geomorphology of *Wādī Debayān* to the Gulf landscape, in order to identify similar intertidal features that can be subject to targeted coring. This understanding of taphonomic processes and the application of remote sensing currently offers the best opportunity for successful archaeological research in the marine and inter-tidal environments. Landscape research at *Wādī Debayān* also provides an important baseline for the exploration of submerged wadis in the Arabian Gulf.

Approaches to archaeological research have often assumed that since the landscape is deflated, archaeological deposits only remain where some form of surface expression is evident. Excavations at *Wādī Debayān* have shown not only areas of preferential occupation, but how taphonomic processes can be beneficial to the preservation of archaeological deposits. Furthermore, what is evident on the surface is often only a small representation of the true extent of archaeological deposits. In the future new methodologies, including geophysical survey, topographic mapping and test pitting will need to be employed for the discovery of archaeological remains in such areas. For example, the discovery of unmarked prehistoric burials at *Wādī Debayān* suggest there is an entire class of monument that is being completely missed, and may account for chronological gaps in the archaeological record (Cuttler *et al*. 2013d). Test pitting has proved the most successful in locating these feature types and should now be considered as an important methodology for the investigation of wadi regions; however, the development of geophysical surveys, such as Ground Penetrating Radar are techniques that should be further explored for the location of deposits that do not have a surface expression.

The regional extent of LGU associated construction may be linked to cultural concepts that predate the establishment of coastal settlements around 7.5ka. Such concepts, shared with groups in southern Mesopotamia, may suggest that the '*interregional interaction*' described by Masry (1997) reflects cultural origins that currently can only be hypothesised within the framework of forcing mechanisms such as sea level rise, geomorphology, environmental fluctuation and changes in hydrostatic groundwater pressure. It is therefore, unlikely that the origins of LGU settlement can be satisfactorily resolved without extensive marine archaeological research in the Gulf. The fact that LGU groups built houses and potentially burial cairns from stone (Beech & Cuttler *et al*. 2005, 2007, Carter & Crawford 2010, Cuttler *et al*. 2013d) offers some idea of what might best survive and what the search priorities within the marine areas might be.

The evidence for a high-energy event during the second half of the 3rd millennium BC is intriguing. This is not the first time deposits relating to a possible high-energy event have been recorded within the Arabian Gulf. Along the northern shore of Abu Dhabi Emirate circular pits in the top of the futaisi member were found filled with comgolmerate of an unknown deposition date that "*represent either a high-energy transgressive lag, formed through a reworking of the nearshore sea bed, or possibly a tsunami deposit*" (Williams

& Walkden 2002). While the pits were dated to MIS 5e the date of deposition of the conglomerate was unclear. If there was a high-energy event during the second half of the 3rd millennium BC, future investigation should consider fieldwork around the northwest coast of Qatar to confirm this.

CONSERVATION AND MANAGEMENT OF THE PREHISTORIC LANDSCAPE

Prehistoric landscape research in Qatar provided an opportunity to develop national data standards and a database for the conservation and management of the resource (Appendix B, Cuttler *et al*. 2009, Beardmore *et al*. 2010). Between September 2008 and 2010 a system known as the Qatar National Historic Environment Record (QNHER1) was developed using Microsoft Access and ArcGIS. This involved three main development stages; data standards (including survey recording forms and methodologies); an access database; and a programme of nation-wide cultural mapping. The data base design is detailed in Cuttler *et al*. 2009: 25-51. This was designed to provide conservation and support for the decision making process, and enable heritage managers to respond to the challenges presented by the pace of modern development.

Bespoke software development (AtharGIS)

While QNHER1 was successful, there were a number of issues with the system (Appendix B, Cuttler *et al*. 2009, Beardmore *et al*. 2010), and by early 2010 outline proposals for a new system (*Athar***GIS**) based on open source code were prepared. The underlying concept was for a system that in the near future, could be easily customised by other heritage agencies within the Arabian Peninsula, and in the longer terms at a more global level (Appendix B). In June 2013 the QNHER1 dataset was migrated into *Athar***GIS**, and formally replaced QNHER1 at the Department of Antiquities, Qatar Museums Authority. *Athar***GIS** is a fully-relational HER package detailing sites, events organisations, people, documents, photographs and bibliographic references (Cuttler *et al*. 2013).

Future modules will include a survey module, projects module, consultation and DC module, translation module, public access module, witness module and a buildings module. While it cannot be claimed that the *Athar***GIS** core module is the first bespoke HER software or the first open-source based heritage software, it does represent not only the first HER bespoke application to be developed using open-source software, but also the first national HER to be developed and applied within the Arabian Peninsula.

THE ATHARGIS GEOSPATIAL DATABASE: A BRIEF OVERVIEW OF RESEARCH OUTPUTS

The Wādī Debayān Neolithic landscape

Indications of prehistoric settlement at *Wādī Debayān* were first discovered towards the end of the 2008-2009 season, when a surface scatter of flint and ᶜUbaid pottery (QNHER141, Figure 11 & Figure 12) were recorded approximately 4km to the south of Al Zubara. This prompted a four year programme of targeted research into the landscape around *Wādī Debayān*. The distribution of prehistoric settlement during the early Holocene is clearly distributed around the major wadi channels (Cuttler & Al Naimi 2013). In the north of Qatar there are two important wadi channels, the *Wādī Al Jalta* in the northeast of Qatar and *Wādī Debayān* in the northwest. While the *Wādī Al Jalta* has been the subject of significant development *Wādī Debayān* remains largely undeveloped.

Of the ~300 new features recorded in advance of the Qatar-Bahrain Friendship Causeway, 158 proved to be burial cairns or burial cairn clusters (Taylor & Cuttler 2009), with an average of ~>5 cairns per $1km^2$ (Cuttler *et al*. 2011). Extrapolating this figure across northern Qatar (some $5,500km^2$) would suggest the number of burial cairns in Qatar is in the region of ~25,000, significantly greater than previously thought. Prehistoric cairns had generally been mostly dated between ~300BC and 300AD (Schreiber & Muhle 2008, Schreiber *et al*. 2009). Since two thirds of the cairns had been robbed in antiquity, it was assumed from the remaining one third of cairns, that all of these monuments were of a similar date. The number of cairns highlighted by this research, therefore posed a problem. If the cairns dated between ~300BC and 300AD then it might reflect a sudden and rapid increase in population, which required an explanation. It was postulated that this could be linked to short term climatic changes or changes in technology. An alternative explanation was that the assumed dates were incorrect (Cuttler *et al*. 2011). To resolve this issue the research agenda for the following season (2010 to 2011) focused on the excavation and radiocarbon dating of mounds at *Wādī Debayān* and *Simaisma*. This revealed that the use of burial cairns was a mortuary practice that had been used (with variation) since the Neolithic. However, there still remain significant gaps in the chronology and our knowledge of mortuary practice in prehistoric Qatar (Cuttler *et al*. 2013).

Spatial distribution of archaeological sites

During five years of survey, the QNHER project has recorded thousands of sites in the north of Qatar. To date none of these have proved to be Palaeolithic in origin (Cuttler & Al Naimi 2013). The recording of Palaeolithic surface-scatters/sites in the south of the country (Kapel 1967, Scott Jackson *et al*. 2013), suggests evidence for preferential use of the landscape, with a predominance of sites on high ground overlooking major depressions (possibly palaeolakes) and wadis (*Ibid*.). The absence of evidence for the Palaeolithic in the north of Qatar, may result from environmental or climatic conditions in the north (such as extensive sand coverage), or preferential localised preservation of evidence through subsequent geomorphological processes. However, the presence of early mid-Holocene occupation the north, may explain the absence of Palaeolithic surface-scatters. It is entirely possible that early mid-Holocene groups based reused easily accessible flint from Palaeolithic surface-scatters in the north. The absence of evidence for extensive early mid-Holocene occupation in southern Qatar might suggest earlier surface-scatters in this area remained relatively undisturbed (*Ibid*.).

Research, public outreach and education

While a national heritage register informs and prioritises future fieldwork it is also an important tool for the development of national research frameworks (Cuttler et al. 2013, Cuttler & Al-Naimi 2013). Research frameworks enable resources to be focused on areas where there are gaps in our understanding of the past and avoid the repetition of research by independent groups. The future potential for public access into *Athar***GIS** via the world wide web and the opportunities for both local and regional researchers to access large relational data sets will provide major research possibilities in the future. In the short-term *Athar***GIS** has provided a research context for much of the work of the Qatar Remote Sensing Project. Understanding both the spatial distribution and character of the archaeological record is essential for long-term cultural management, conservation and education. The results of the remotely sensed data will also be used to enhance the Historic Environment Record (currently known archaeological sites) as part of an integrated geographic information system (GIS). As well as providing a proxy dataset for modelling the impact of coastal change and past populations.

FUTURE RESEARCH FRAMEWORKS AND PUBLICATIONS

Submerged landscapes of the Arabian Gulf

Extensive mapping of the marine environment has begun to determine areas of high potential for both settlement and occupation. The mapping of the marine landscape is an essential first step towards conservation, preservation and the development of future research frameworks. Future research should focus on extensive multiplatform remote sensing to enable the targeting of future research areas, this may be done through the development of an Institute for Marine Archaeology and Remote Sensing based in Qatar.

Issues such as the possibility that the Gulf of Salwa was a refugia with fresh water sources and subject to marine transgression very late, can be verified through a programme of coring, radiocarbon dating and analysis of environmental proxies to determine the nature of the landscape and the extent of salinity. Cores from the Gulf of Salwa should also in the future be subject to analysis in an attempt to determine the origins of Arabian Coarse Ware. SedaDNA analysis of environmental cores currently offers the best opportunity to resolve the extent of flora and fauna and the nature of groups that inhabited the former sub-aerial landscapes of the Arabian Gulf. This project is currently underway as part of a collaboration between the University of Birmingham, the Qatar Museums Authority, Maersk Oil Qatar and the University of Copenhagen.

Terrestrial landscapes of Qatar

Excavation at *Wādī Debayān* has shown very clearly a bias towards natural landscape features by prehistoric societies, and how taphonomic processes are important for the preservation of archaeological remains. This understanding can be applied to future methodologies as part of the search for prehistoric remains in both the terrestrial and marine areas of Qatar. In particular this should include further research into areas of longshore drift, and an examination of coastal areas for the presence of high-energy events. Future research might also be focued on karst within northern Qatar. Such features offer significant potential to reveal important information about some of the earliest periods of our prehistory (Cuttler & Al-Naimi 2013). This research should not simply be confined to terrestrial areas, but should consider the presence of karst within the marine submerged landscape, initially through seabed characterisation and topographic mapping.

Conservation and heritage management

The need for heritage management tools within the heritage sectors is universal. *Athar***GIS** is unique in that it provides access to customised, license free software for antiquities departments. This is important given that the costs of such heritage management tools are beyond the budgets of many antiquities departments around the globe. Since the core module accesses internet resources such as Bing Mapping and Google Earth, no further expense is required for georeferenced satellite images or digital maps. Customisation of the user interface to for language and local thesauri would require local knowledge from regional heritage managers. Importantly, it is now be possible with relatively low outlay and minimal training, to use the infrastructure established in Qatar as an example for the development of HERs in antiquities departments elsewhere. As such, *Athar***GIS** is currently well placed define future International standards for global heritage management.

Future publications

Besides publications already prepared for the Journal of Archaeological Science, future publications currently in preparation are themed research volumes covering the prehistoric landscape at *Wādī Debayān*, the development of *Athar***GIS** and global cultural resource management, burial archaeology in Qatar and research into submerged landscapes. The submerged landscapes volume is supported by grants from the Qatar Museums Authority and the National Oceanic Administration America and will detail the results of research in the North Sea, the Arabian Gulf, the Mediterranean and Sundaland in Southeast Asia.

Numbered summary of submitted publications

1. **Cuttler, R.** & Al-Naimi, F. A. 2013. From Land-Locked Desert to Maritime Nation: Understanding Taphonomic Processes and Landscape Evolution in Qatar and the Arabian Peninsula from 14,000BP. *Adumatu*, 22, Riyadh

2. **Cuttler, R.T.**, Tonner, T.W.W., Al-Naimi, F. A., L. Dingwall, L. & Al-Hemaidi, N. K. 2013. The Qatar National Historic Environment Record: A Platform for the Development of a Fully-Integrated Cultural Heritage Management Application. XXIV International CIPA Symposium. Strasbourg, September 2013

3. **Cuttler, R**., Tetlow, E., and Al-Naimi, F. 2013. Typological and chronological variation of burial in Qatar: cUbaid to late pre-Islamic. *Proceedings of the Seminar for Arabian Studies* 43: 1-12

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