An Illustrated Prehistory of the Jubbah Oasis: Reconstructing Holocene Occupation Patterns in Northwestern Saudi Arabia from Rock Art and Inscriptions

Maria Guagnin^{a,f}, Ceri Shipton^{b,g}, Moudhy al-Rashid^c, Fares Moussa^d, Sarah El-Dossary^e, Mona Bin Sleimah^e, Abdullah Alsharekh^e, Michael Petraglia^a

^a Department of Archaeology, Max Planck Institute for the Science of Human History, Germany

^b McDonald Institute for Archaeological Research, University of Cambridge, UK

^c Wolfson College, University of Oxford, UK

^d Archaeology, University of Edinburgh, UK

^e Department of Archaeology, King Saud University, Saudi Arabia

^f Research Laboratory for Archaeology and the History of Art, University of Oxford, UK

^g British Institute in Eastern Africa, Nairobi, Kenya

Corresponding author:

Maria Guagnin, Max Planck Institute for the Science of Human History, Kahlaische Strasse 10, 07745 Jena, Germany

Email: guagnin@shh.mpg.de

Abstract

A systematic survey of rock art and associated archaeological features in the Jubbah oasis provides evidence of Holocene occupation from the early Holocene to the present. In total, 1249 panels with rock art and inscriptions, and 159 archaeological sites were recorded on 12 different jebels. Analyses of rock art content and engraving stratigraphy indicate that the iconic Jubbah style had a long tradition amongst pre-pastoral hunters and continued to be used by early herders. We also identify a distinct body of rock art that pre-dates the Jubbah style and may be associated with a nearby Epipalaeolithic site. Our systematic dataset identifies a body of Bronze Age rock art that is further supported by the material culture and radiocarbon dates obtained from the remains of disturbed cairns. The rock art in Jubbah appears to have been created throughout the Holocene occupation of the oasis and similarities in the representation of animals, the choice of location, and the content of rock art scenes are evident from the Bronze Age to the early modern period, and perhaps into the 20th century. Moreover, rock art and epigraphy suggest that occupation phases in Jubbah were sustained long enough for the repeated development of unique local characteristics throughout the Holocene.

Introduction

The oasis of Jubbah in northwestern Saudi Arabia is home to a rich body of rock art, which provides direct evidence of the human populations that occupied this landscape at various points throughout the Holocene. Together with the site of Shuwaymis, the rock art of this region was included on the UNESCO World Heritage list in 2015 (UNESCO 2016). Depictions of cattle herders have led to an attribution of some of the imagery to the Neolithic period, while inscriptions and representations of horses with riders can be placed into the Iron Age and historic periods (Garrard et al. 1981; Khan 2011; 2007; 1993; MacDonald 2012; 2010; Nayeem 2000; Olsen & Bryant 2013). Although some of the rock art has been described and published, systematic data has so far been lacking, and has prevented the establishment of a more comprehensive chronology for the rock art of Jubbah. Moreover, the prehistoric archaeological record of northwestern Saudi Arabia remains poorly known (e.g. Crassard & Drechsler 2013; Guagnin et al. 2016; Groucutt & Petraglia 2012), making it difficult to link the production of rock art to phases of human occupation.

The Jubbah palaeolake, deposits of which are still visible on satellite imagery (Petraglia et al. 2012: Figure 1), is surrounded by a large jebel to the west (Jebel Umm Sanman), and clusters of smaller jebels in the southeast, northwest and southwest (Figure 1). The highest concentration of rock art is found on boulders and bedrock along the base of Jebel Umm Sanman, which forms the core area of the UNESCO site (UNESCO 2016). Since 2011 the slopes of 12 jebels in the Jubbah basin have been systematically surveyed by our team (Figure 1; see also Jennings et al.

2013). All engraved and painted rock surfaces were recorded, and so far amount to a total of 1131 rock art panels, containing 4714 individual animal engravings and 513 human representations. In addition, we also recorded 118 rock surfaces that only contained inscriptions. Archaeological sites located within the surveyed area were also recorded and include lithic scatters, burial cairns, possible habitation sites, and unidentified stone structures. Previous chronological attribution of the rock art has often relied on the interpretation of a small number of outstanding and visually striking rock art panels. The collection of a comprehensive dataset by our team now facilitates the first analysis of the content and stratigraphic relationships across all periods of rock art production and allows first links with identified archaeological features.

The primary aim of the current study was to establish how the location and environment of Jubbah, an oasis surrounded by the sand dunes of the Nefud desert, influenced population dynamics and settlement history throughout the Holocene. We seek to address the following questions: Can the rock art be used to identify the population dynamics of the Jubbah oasis across multiple phases of climatic change? Were human occupation and rock art production continuous or intermittent? Is it possible to identify cultural links to other areas from the imagery the occupants of Jubbah left behind?

Figure 1 Satellite image showing the Jubbah oasis and surrounding jebels; palaeolake deposits are visible in white. Areas surveyed by our team are indicated with white rectangles. Neolithic sites mapped by Garrard and colleagues (1981) are indicated with triangles. Star: location of Al-Rabyah (Hilbert et al. 2014); Cross: location of Jebel Qattar 101 (Crassard et al. 2013).

Background

Environment

In the Jubbah basin, the formation of Holocene lakes has become a focus of research in recent years. The presence of a large palaeolake is attested at around 10,000 BC at the site of Al-Rabyah at the western end of the basin, where an occupation site coincides with a period of lake reduction around 8000 BC (Figure 1). A subsequent return to humid conditions in the mid-Holocene was dated to 4600 BC, and

palaeoecological reconstructions indicate a shallow freshwater lake in a moist and well-vegetated environment (Hilbert et al. 2014). A further, smaller palaeolake was identified at the eastern end of the basin and dated to between 7000 and 6000 BC (Crassard et al. 2013). In the oasis of Tayma, on the western fringe of the Nefud desert, the formation of a lake is reported somewhat later, between 8000 and 6500 BC (Engel et al. 2012). Here, pollen records from lake sediments indicate an expansion of grasslands after 7000 BC, which reached a maximum between 6600 and 6000 BC and subsequently reverted to the drought-resistant shrublands that characterise the area today (Dinies et al. 2015). Sedimentary evidence suggests that due to its location within a dunefield, the Jubbah basin probably continued to receive groundwater recharge during periods of increased aridity, supporting a freshwater oasis even when neighbouring areas were becoming arid (Crassard et al. 2013; Hilbert et al. 2014). The Jubbah basin may therefore have supported human and animal populations across climatic fluctuations of the Early Holocene.

Archaeology

On the Arabian Peninsula domestication arrived in the form of mobile pastoralism (Magee 2014; McCorriston & Martin 2009). Faunal remains recovered from sites along the eastern coast of the peninsula suggest that domestic cattle, sheep and goat were introduced as a package between 6800 and 6200 BC (Drechsler 2007; 2009). Levantine herder populations are thought to have entered the region during the peak of the Holocene humid period when grassland and vegetation expanded across the Arabian Peninsula and provided new pastures (Drechsler 2007). However, although cultural connections with the Levant are apparent in the lithic evidence,

there are no unambiguous traces of incoming populations (Charpentier & Crassard 2013; Crassard et al. 2013; Crassard & Drechsler 2013). The rock art of Shuwaymis indicates the presence of local hunter populations and a possible indigenous adoption of cattle herding, which may have had links to the south of the peninsula (Guagnin et al. 2015; 2016). Nonetheless, in the absence of excavated Neolithic sites with faunal remains in the west and centre of Saudi Arabia, the population dynamics and timing of this transition remain unclear.

Surveys in the 1970s identified 12 possible Neolithic or Chalcolithic sites in Jubbah (Garrard et al. 1981; see also Parr et al. 1978). Eight of these sites were found near the base of sand dunes north and south of the palaeolake, where palaeosols suggest marshy conditions. Four further sites were found on top of palaeolake despoits, suggesting occupation during periods of increased aridity (Figure 1). Recent surveys have identified two further early Holocene sites. At Al-Rabyah, a lithic assemblage with bladelets and geometric microliths was attributed to a drier climatic phase around 8000 BC (Hilbert et al. 2014). At Jebel Qattar 101 El-Khiam and Helwan points similar to those recorded during the Pre Pottery Neolithic (PPN) in the Levant (where they occur between 10,200 and 6900 BC) were associated with a palaeolake that was dated to 7000 - 6000 BC. The site was probably re-visited by groups at numerous times during the Holocene (Crassard et al. 2013). While the archaeological and environmental record of Jubbah remains fragmentary, palaeoecological reconstructions and sedimentary evidence (Crassard et al. 2013; Hilbert et al. 2014) suggest that the palaeolakes of the Jubbah basin were surrounded by a fringe of vegetation and provided an attractive environment for humans and animals across numerous cycles of environmental change.

At the beginning of the fourth millennium BC, Arabia became increasingly arid.

Archaeological contexts in southeastern Arabia indicate a widespread abandonment of sites, and for about 600 years, mobile herders retreated to coastal areas. Areas in the interior of the Arabian Peninsula were re-settled during the Bronze Age, after 3100 BC, although occupation was now concentrated in oases, where subsistence was based on irrigation and agriculture (Preston et al. 2012; see also Magee 2014).

This period was also characterised by the appearance of burial cairns and megalithic monuments attributed to the establishment of Bronze Age pastoral elites (Newton & Zarins 2000). How this period of climatic deterioration affected human populations in the central and northwestern areas of the Arabian Peninsula during the fourth millennium BC remains unknown. In the oasis of Tayma a substantial settlement was established during the Bronze Age and an extensive city wall system was maintained throughout the second millennium BC. This suggests the existence of a large sedentary community, which would have been reliant on irrigation and agriculture (Eichmann et al. 2006; Hausleiter 2010; Magee 2014).

During the Iron Age, inter-regional contact and trade intensified, probably partly as a result of camel domestication, and the settlements in the oases of northern Arabia grew substantially (Magee 2014). From the early first millennium BC, writing was established in western Arabia. Remarkably, literacy was also widespread among nomadic peoples and countless inscriptions engraved onto rock surfaces have survived until today. In the north, these scripts fell out of use around the third century AD and were replaced by Nabatean Aramaic and later Arabic script (Macdonald 2010).

Although settlement and burial sites post-dating the Neolithic have yet to be identified at Jubbah, there is indirect evidence of human occupation. Numerous stone cairns are located along the slopes of the Jebels in the oasis, at least some of which may relate to the pastoral elites identified by Newton and Zarins (2000). Moreover, the rock art clearly attests to the presence of human groups during the Iron Age (Garrard et al. 1981; Jennings et al. 2013; Khan 2011). Remains of the historic oasis settlement are still visible on the northwestern side of the palaeolake today. Travellers in the nineteenth century reported that Jubbah was an important oasis on the caravan route between the Levant and Nejd and the village consisted of approximately 90 houses and 500 inhabitants (Euting 1896). However, due to the scarcity of identified settlement sites, the timing, character and intensity of human occupation in the Jubbah oasis remains unknown. Was Jubbah a place that was revisited for short periods or did the oasis support longer-term human settlement? In the absence of excavated archaeological sites, rock art is our only source of information on the Holocene occupation patterns of the Jubbah oasis.

Methods

A series of systematic rock art surveys was carried out in Jubbah and the surrounding area over three seasons in 2011, 2013 and 2015. The slopes of rocky outcrops and jebels were surveyed in teams of two to four people. Every engraved rock surface was recorded with photographs and a detailed description of the content and landscape context of each panel. The location of each panel was recorded with a GPS, with an accuracy of ca. 3m.

A database was designed to record information on rock art panels as well as individual engravings. Each engraved human and animal figure was identified and recorded separately, and characteristics of the depiction such as animal species and cultural attributes of human depictions (headdress, penis sheath, bow and arrow) were recorded. The level of weathering (i.e. a slow breaking down of the rock surface due to exposure to the atmosphere) and erosion was assessed for each depiction in order to assess the impact on the visibility of the image. This was done to gain an understanding of preservation issues. Moreover, the formation of patina/rock varnish can be locally affected by the presence of moisture, and can also be lost due to weathering and erosion. An assessment of the condition of the rock surface can therefore also provide information on the uniformity of rock varnish formation across the area and its suitability as an indicator of relative age.

A total of 38% of the engravings were well preserved or moderately weathered, where the crispness of the individual peck marks had begun to fade but the image was still clearly visible. A further 62% of the engravings were heavily weathered, eroded or partly exfoliated, where a breaking down of the rock surface was more advanced or loss of grains from the surface had begun to reduce the visibility of the image.

In order to classify the rock art into age groups, the stratigraphy of the engravings was analysed. False colour imagery was created using DStretch (see for example Le Quellec et al. 2015) and used in combination with drawings of each panel to determine the stratigraphic relationship of individual images.

All imagery stratigraphically associated with 'late markers' such as writing, or depictions of domestic camels, domestic horses, or guns, were grouped together. The great majority of camels (1237 images) are either associated with domestication features (such as riders, reins, or hobbling), with writing, or are visibly freshly pecked. While some engravings appear older than they are due to extreme local weathering conditions, there are no known examples of engravings being protected from weathering and thus appearing younger than they are. We are therefore confident of the young age of these engravings. On the Arabian Peninsula wild camels are assumed to have been dramatically reduced in numbers during the Bronze Age and to have only survived in small numbers into the Iron Age (Almathen et al. 2016, supplementary information; Uerpmann & Uerpmann 2012; von der Driesch et al. 2008). We identified 20 camels that had stylistic similarities with 'late camels', but showed advanced weathering and lacked 'late markers'. It is possible that some of these engravings represent wild camels from the Bronze or Iron Age. However, no camel hunting scenes were recorded in the surveyed areas, and the presence of wild camels in the 'late period' cannot be confirmed. In the case of horse depictions, all domestic horses were depicted with riders.

There are probably a number of images that also date to this 'late' period, but are not associated with 'late markers'. Nonetheless, the distinction identifies a body of imagery that can be placed into the last three millennia with a degree of certainty. A comparison with the weathering patterns shows that 30% of these 'late' engravings and paintings are either heavily weathered or eroded (Figure 2). This is probably partly caused by exposure to sand blown wind. There also appears to be considerable variability in the degree to which the local sandstone has been exposed

to weathering and erosion; some rock surfaces show excellent preservation, while others have lost up to 3cm of their original surface (Figure 3). It is unclear whether this is a result of boulders having broken off further up the slope, or due to variable weathering regimes along the topography of the jebel. As a consequence, the condition of the rock surface, and the presence/absence of patina are unsuitable as general predictors of age for the rock art in Jubbah, but can be used to distinguish relative age on individual rock surfaces.

Figure 2 Comparison of 'late' engravings with and without weathering on panel JSM 245b. Engraving of a man with a gun and horses and camels with riders on the right are relatively freshly pecked. On the left a camel and writing are heavily weathered and can barely be distinguished from the rock surface. Modern graffiti is visible along the top of the image.

Figure 3 Eroded rock surface. The original rock surface with dark patina is visible in the centre of the photograph; the rock surface of the surrounding area has been eroded to a depth of up to 2-3 cm.

The distinction of 'late' and 'not late' (i.e. 'early') imagery also allowed spatial analyses of the rock art using a geographic information system (GIS). The density distribution of the panels was calculated using the Kernel density function, in which raster cells at or near the location of the image are weighted stronger. This results in a more accurate representation of distribution patterns and is less dependent on the search radius than a simple density calculation. The Natural Breaks (Jenks) function was used to classify the data for display on the satellite imagery. This function identifies bands based on groups inherent in the data and enhances the visibility of high- and low-density areas, while minimizing the loss of data in the display.

To gain a better understanding of the archaeological context, archaeological sites in the vicinity of the rock art were also recorded. A total of 159 archaeological sites

(including 160 cairns, 21 stone structures, 10 lithic scatters and 9 sites with cupmarks) were identified. Because the survey focussed on the slopes of jebels, recorded archaeological sites predominantly consist of burial cairns. Numerous burials have been disturbed, many in antiquity, and some in recent years. Where possible the survey team tried to recover bone fragments visible on the surface of the disturbed cairns and any other datable materials that were clearly associated with the original content of the cairn. In some cases the team was able to recover small artefacts from the disturbed deposits of the cairns. While this record is inevitable fragmentary, radiocarbon dates obtained from disturbed cairns provide direct evidence of human presence and help to secure the timing of human occupation patterns in the Jubbah basin in a way that is impossible to achieve with rock art alone.

Results

Early Holocene

Stratigraphic analyses of the 1131 rock art panels that have so far been recorded reveal a distinct body of engravings that appears to pre-date engravings of Neolithic hunters and herders in the so-called 'Jubbah style' (see description below). A total of 10 human figures, on six different rock art panels were recorded on the southern tip of Jebel Umm Sanman. The figures consist of large engravings of women with simple, round heads, which are occasionally depicted with what looks like braided hair. The breasts of these women are very large, and the narrow waist is emphasized by large buttocks; on well-preserved examples belts and tassels can be made out (Figure 4).

Four of the depictions show body markings in groups of short dashes across the upper body; other figures have decorated breasts, often with a necklace or collar. Where engravings are well preserved, figures have naturalistic arms, held out on each side, showing the palms of the hands and all five fingers. In three of the figures the head appears to be bird-like, with a small round eye, and in one of them the beak remains clearly visible. In this latter case, an original bird headed figure with a necklace was subsequently re-engraved into a round-headed figure with body markings (Figure 4a, left figure). This indicates that the engravings may have been created over a longer period and may extend across symbolic or artistic conventions. Moreover, in five of the panels the human figures are superimposed by large depictions of equids.

Engravings of this type were only recorded in a confined location within the surveyed area, on the eastern side of the southern tip of Jebel Umm Sanman. While a complete inventory of the engravings of Jebel Umm Sanman has yet to be achieved, preliminary surveys of the main clusters of rock art production indicate that engravings of curvaceous women are not found outside the locations identified here (El Dossary, personal comment). Intriguingly, the engravings are located in proximity to the Epipalaeolithic site of Al-Rabyah (Hilbert et al. 2014), the only known site of this period in the Jubbah Basin. Two isolated lithics found near to the engravings of curvaceous women at sites JSM47 and JSM177 may provide a further link, as they are typologically Epipalaeolithic (Figure 5). Moreover, faunal studies in the Azraq Basin of eastern Jordan have shown that wild equids were a very common species during the Epipalaeolithic, but sharply declined in Neolithic contexts (Martin et al. 2016). While rock engravings cannot be used as proxies for species frequency

(Guagnin 2015), the regular association and superimposition of equids on large engravings of curvaceous women may provide a further indication of their age. A similar pattern was also observed in Shuwaymis, where depictions of wild equids were largely confined to pre-pastoral contexts (Guagnin et al. 2016). While the timing and character of the Neolithic transition in Jubbah remains unclear, and the relationship between local and Levantine lithic types is uncertain (Crassard et al. 2013; Hilbert et al. 2014), it is evident that engravings of curvaceous women were created during the early Holocene and considerably pre-date the local adoption of herding.

Figure 4 Photographs of the 10 'pre-Neolithic' human figures. Curvaceous women are traced in black; equids are traced in white. The original bird headed figure in photograph a is traced in grey; the figure to the right also appears to have a bird-like eye and a possible beak, but the lines were engraved over the original arm and hand. On figure d two engravings in the so-called Jubbah style can be seen superimposed on the right hand side. Photographs were chosen based on the clearest visibility of the engraving. The outlines on some of the figures are therefore slightly distorted by rock shape and photography angle. a, b, c: JSM42B; d: JSM42E; e: JSM53A; f: JSM53B; g: JSM53D; h: JSM65A.

Figure 5 Isolated lithics from sites JSM47 (above) and JSM177 (below). The upper artefact is a backed quartz piece and the lower artefact is a rhyolite end-scraper on a broad blade with some additional lateral retouch. Backed artefacts and end-scrapers on broad blades with additional lateral retouch are both characteristic of the assemblage from the nearby Epiplaeolithic site of Al-Rabyah (Hilbert et al. 2014).

Neolithic transition

In descriptions of the rock art of Jubbah, the so-called 'Jubbah style' features heavily (Khan 2007; 2011). It is used to describe elongated human figures, with long legs that are usually bent at the knee, slim upper bodies, and very thin arms, which are always held out to one side, in a twist of perspective from the frontal view of the shoulders to a profile view of the arms. These figures are usually male and are depicted wearing a penis sheath. In addition, headdresses similar to those observed in Shuwaymis (Guagnin et al. 2015) are also a common feature. Due to their

advanced patina and their occasional association with depictions of domesticated cattle, they have generally been attributed to the Neolithic (see for example Khan 2007). However, systematic analyses of the characteristics and superimpositions of these images suggest that there is a considerable degree of variation, and that these figures, and associated scenes, may have been carved over a longer period.

Although the identification of rock art 'styles' is subjective and not without controversy in rock art research (Khan 1993; see also Jelínek 2004), the iconic Jubbah style clearly forms a distinct artistic tradition. Of 513 human depictions, 49 engravings of human figures could be attributed to the so-called Jubbah style. However, a further 44 engravings of elongated human figures had similar characteristics to the Jubbah style but were more stylised. The similarity of the context of both types of human depictions suggests that they form part of the same engraving tradition, and that this form of human depiction includes a wider range of characteristics.

Of 93 'Jubbah style' or 'elongated' figures, 40 were depicted in hunting contexts.

Only seven human figures were associated with herding scenes and six were depicted on a hunting panel that was later reworked into a herding scene (Figure 6).

In addition, 20 figures were depicted in hunting scenes, often with mixed herds of wild animals in which a single domestic cattle was integrated. In all cases the depictions of cattle appear to be contemporary with the rest of the scene. The context in which these human figures are depicted therefore suggests that the figures were engraved over a longer period across the transition from hunting to herding, and that this transition may have been complex, with some form of overlap

between the presence of domesticates and a continued emphasis on hunting in the iconography.

Figure 6 Panel at Jebel Qattar showing a hunting/herding scene (JQ34D). Two figures are shown with bow and arrow (left and centre). The large figure in the centre left and all depicted domesticates are superimposed on earlier engravings of wild animals.

The longevity of the Jubbah style is particularly evident in panel 34D at Jebel Qattar (JQ34D). The panel contains an earlier scene with wild animals, including ibex, and at least two human figures with bows and arrows, which was later reworked into a herding scene. The human figures on this panel were re-engraved at the same time as a large cattle was added to the panel. However, bows were not re-engraved and hands were added instead (Figure 6). The panel also contains representations of domestic goats, which appear to form part of the herding scene. The stratigraphy and content of panel JQ34D shows strong parallels to the engraving record at

Shuwaymis, where herding scenes were frequently placed over, and integrated into earlier hunting scenes (Guagnin et al. 2015), placing the engravings around the time of the transition from hunting to herding. Moreover, JQ34D is located on a boulder above the site of JQ101, a site containing numerous stone arrowheads linked to the Levantine early Neolithic (PPN) and which has been interpreted as a seasonal hunting camp that may have been repeatedly occupied throughout the early Holocene (Crassard et al. 2013; Jennings et al. 2013). The picture that emerges is therefore one of repeated occupation by groups of hunters, and later herders or hunter-herders.

Evidence for the Neolithic transition in Jubbah is more ambiguous than at Shuwaymis. On nine rock art panels, individual cattle were depicted as part of a hunting scene or integrated into a larger group of wild animals, and on four of these panels the human figures carry bows and arrows. The preservation of these panels is not sufficient to determine the precise timing of individual engraving events, and the possibility remains that some of them are domestic cattle superimposed on earlier scenes. However, the quality of the engraved lines and a similarity in the peck marks suggest that some are contemporary. In general, the adoption of herding in Jubbah is expressed very differently in the rock art. While at Shuwaymis cattle were often depicted in larger numbers, with 15 or more cattle placed over original hunting scenes (Guagnin et al. 2015; Olsen & Bryant 2013) cattle are depicted in much smaller numbers at Jubbah. Within our dataset, a total of 121 domestic cattle were identified on 82 rock art panels. Depictions predominantly show individual cattle. On 56 of 82 panels, engravings show single cattle, with a further 18 panels containing two representations. Only eight panels show three, five or six cattle. While the low

occurrence of cattle herds in the rock art may be the result of artistic convention, or of local herding practices, the depiction of cattle and herding scenes shows that herding was eventually practiced in Jubbah. However, the integration of individual domestic animals within herds of wild animals may indicate a more complex process, where herding was known, but was either not yet practised locally, or had not yet become an established part of the iconography.

Bronze Age

The Bronze Age of Western Arabia was first identified by Anati through detailed analyses of the rock art recorded during the Philby-Lippens-Ryckmans expedition (Anati 1968a; 1968b; 1968c; 1972; 1974). Although excavations at Tayma have since shed light on the Bronze Age occupation and fortification of this extraordinary settlement (Hausleiter 2010), our understanding of this period in the rest of the area remains patchy (Magee 2014; see also Newton & Zarins 2000). In the rock art of Jubbah, identification of Bronze Age imagery proved difficult. The clearest chronological markers identify Neolithic and late Prehistoric/Iron Age rock art. Cattle herding was only viable during the Holocene humid phase, dated to before 4000 BC. Depictions of cattle can therefore be used to identify Neolithic imagery (see above). The domestication of the camel and the horse at the end of the second and the beginning of the first millennium BC (Drechsler 2007, 2009; Magee 2014; Uerpmann & Uerpmann 2012; von der Driesch et al. 2008), and the introduction of writing were used to identify later depictions. However, in the absence of (detailed) depictions of weaponry, the Bronze Age lacks clear visual markers in the rock art. Nevertheless,

stratigraphic analyses indicated a group of engravings with shared characteristics in content and form that is consistently later than the Neolithic imagery, both in superimposition and in weathering. This body of rock art is mostly characterised by the depiction of small scenes, in which one or seldom two oryx or ibex are hunted with dogs. Ostrich, lion, and cattle are also occasionally depicted (Figure 7).

Figure 7 Scenes attributed to the Bronze Age, recorded at Jebel Umm Sanman (left and top right) and Jebel Sataihah (bottom right).

Figure 8 Engraving of a 'double convex bow' (left) and a 'lunate pommel sword' (right), which are characteristic for the Bronze Age of Arabia (Anati 1968c; Newton & Zarins 2000).

Although human and animal depictions are distinctly different from the 'realistic dynamic style' described by Anati, the bows used in the hunt are characteristic of the 'double convex bow' (Anati 1968c). In addition, an engraving in the southwest of the Jubbah basin shows a male figure is holding a 'lunate pommel sword' (Figure 8). This weapon is characteristic for the Bronze Age of Arabia, and is thought to have been a symbol of status amongst the pastoral elite (Newton & Zarins 2000).

While the identification of Bronze Age rock art in Jubbah remains difficult, and limited to specific case studies, sampling of the remains of disturbed cairns during the rock art survey also provided evidence for Bronze Age occupation. At HJ103A the original burial cairn had been completely destroyed, leaving only a ring of discarded stones around the original footprint of the cairn. In the soil inside the original cairn fragments of human bone and a single, small, bronze earring were collected (Figure

9). However, collagen levels in the bone fragments were not sufficient for radiocarbon dating.

A further disturbed cairn (FJ1A) on the base of an adjacent jebel, approximately 1km east, revealed a perforated shell, three small shell beads as well as fragments of human bone (Figure 10 and Figure 11). The larger shell provided a radiocarbon age of 2930-2770 cal BC (Wk43223, calibrated using the marine calibration curve), firmly placing the shell bead into the Early Bronze Age, although there it is possible that the shell was in use for some for some time before its deposition in cairn FJ1A.

A tabular scraper was found on the surface near to the cairn JSM303 and higher on Jebel Umm Sanman than any rock art in this area (Figure 12). These artefacts, commonly found in ritual contexts and perhaps associated with the cairn itself, are characteristic of the Chalcolithic and Early Bronze Age in the Levant (Rosen 1997) and further suggest that many cairns belong to this period.

Figure 9 Disturbed cairn at HJ103A. Detail photograph of the bronze earring found in the remains of the cairn.

Figure 10 Perforated shell recovered at cairn FJ1A.

Figure 11 Side view of the three shell beads recovered from FJ1A.

Figure 12 A tabular scraper from the vicinity of cairn JSM303.

The identification of a distinct body of Bronze Age rock art, the discovery of a bronze earring, Bronze Age stone tools, and the radiocarbon date from the shell bead all provide conclusive evidence that humans occupied the Jubbah basin during this period. However, representations of humans in the Bronze Age are simple and lack the cultural markers observed in the 'Jubbah style' depictions, namely penis sheaths and headdresses. This indicates a change in the rock art tradition, which may have coincided with a break or a change in human occupation. Two pieces of charcoal recovered from a disturbed burial cairn at Jebel Ghawtar (JGW12) provided radiocarbon dates of 5181 ± 120 cal BC and 5105 ± 106 cal BC respectively (

Table 1). The tradition of burial in cairns therefore is found in both the Neolithic and the Bronze Age. It should be noted that this particular cairn (Figure 13) is on the side of a jebel unlike the open-air structures of the numerous other cairns recorded during our survey. In absence of more information relating to the content or internal structure of cairns, continuity and change cannot be adequately assessed from the burial record.

Figure 13 Disturbed cairn at Jebel Ghawtar (JGW12).

Table 1 Radiocarbon dates. Calibrated using OxCal calibration programme.*calibrated using the marine calibration curve.

Lab code	Sample Code	Material	Radiocarbon date	Calibrated date
OxA-30204	JGW12-ENV1	Charcoal	6222 ± 34 BP	5181 ± 120 calBC
OXA-30205	JGW12-ENV1	Charcoal	6143 ± 34 BP	5105 ± 106 calBC
Wk43223	FJ1A	Marine shell	4596 ± 21 BP	2850 ± 80 calBC*

Iron Age

Over half of individual depictions (2455 of 4714 animal representations and 235 of 513 human figures) are associated with 'late markers', i.e. they have a stratigraphic association with writing, domestic horses or camels, or are obviously freshly pecked. While earlier engravings contain a substantial proportion of large and detailed depictions, the imagery of this later period is predominantly small, and simplistic. The rock art of this period is dominated by depictions of domestic camels (57% of animal depictions) and domestic horses (23%), as well as ibex (7%), oryx (5%), while humans are depicted as stick figures (56%) or figures with large bottoms (17%), with handprints making up a further 6%.

Although the content of the late engravings is dominated by domestic horse and camels, there are also striking similarities to the Bronze Age. Hunting scenes of oryx, ibex and ostrich remain common, but animal depictions often have more naturalistic features and scenes are associated with writing. The similarity in content is probably primarily a reflection of the environment, and of the species available for hunting; however, some cultural traits can also be identified. While early depictions of oryx have standardized bodies that cannot be distinguished from other bovid species, the engravers of the Bronze Age began to emphasize the back in a double convex line, with slight humps for the hind and shoulders (Figure 7). This stylistic trait is also visible in the engravings of the Iron Age (Figure 14). However, there are differences in the depiction of humans. During the 'late period' human figures are often shown interacting with each other, i.e. they are facing each other or touching another figure, usually in groups of two or sometimes three. Neolithic and Bronze Age figures generally face in the same direction or face the animal they are hunting or herding.

Figure 14 Two panels from Jebel Ghawtar (JGW70A, above and JGW76, below). There are some differences in the depiction of oryx and dogs, but all oryx depictions are shown with a slight hump over the shoulder, which is characteristic for the late engravings. JGW70A also shows human figures facing and interacting with each other.

There is a considerable degree of uncertainty in the age of engravings that are not associated with late markers but have been exposed to unusual weathering and it is not possible to attribute all engravings to a chronological period. Nevertheless, the distribution of identifiable 'early' and 'late' rock art shows a distinct change in the choice of location. In particular 'early' rock art in the main basin of the Jubbah oasis

shows high density on the slopes facing the palaeolake. Engravings of the 'late period' show considerably higher densities on slopes facing the sand dunes (Figure 15). This is likely because Neolithic and earlier images were created during a humid phase when the lakes were recharged, while the 'late' rock art relates to a period of absolute desertification.

Figure 15 Composite satellite image showing the density distribution of the early rock art (above) compared with the distribution of late rock art (below). The images show the main basin on the oasis, where rock art surveys have covered sufficient ground on all sides of the Jebels to allow spatial comparison. Palaeolake deposits are visible in blue.

Epigraphy

The rock inscriptions of the Jubbah region reflect the known scripts from the Arabian Peninsula attested from the 8th century BC to the 4th century AD (MacDonald 2004).

The Ancient North Arabian scripts attested at Jebel Umm Sanman and the surrounding sites include Thamudic B, Thamudic C, Thamudic D, and a few possible attestations of Hismaic and Safaitic that require closer review. The presence of Ancient North Arabian scripts suggests that the site continued to be used or frequented during the first millennium BC and into the first millennium AD.

Comparatively few early Arabic inscriptions are attested in the areas surveyed. Those that were observed contained known excerpts from the Qur'an and therefore may be confidently dated to the Islamic era.

With respect to the Ancient North Arabian inscriptions, some preliminary remarks and observations may be made to characterise the usage of scripts in this region.

General features of each of the scripts are preserved at the site, such as the direction and the use of cartouches. A general survey of the content of these inscriptions also suggests a similar usage of the scripts for these sites as attested elsewhere in the Arabian Peninsula. Prayers and dedicatory inscriptions, including ones to well-attested gods, such as *rdw* (e.g. JSM46, Figure 16) and *nhy* (e.g. JSM200, Figure 16b), appear in several inscriptions. Both *rdw* and *nhy* are the names of gods that the Neo-Assyrian king Sennacherib (r. 705-681 BCE) claimed to have taken from the Arabs (Retsö 2003). Some of these dedicatory inscriptions and prayers include the personal name of, presumably, the author of the inscription.

Dedications can also appear with drawings of camels. It is possible that some may

refer to, or belong with, the drawing itself. A dedication, such as *l-zgr h-bkrt* “For Zgr, the baby she-camel”, appears alongside a camel drawn with its tail pointing upward (JSM30). The content of the observed inscriptions is consistent with that known from Ancient North Arabian inscriptions from other sites in the region, such as Tayma and its hinterland.

Figure 16 Examples of inscriptions recorded in the Jubbah basin; a: JSM46; b: JSM200; c: JSM30.

In terms of the scripts themselves, some marked variations in letter distributions were observed. Namely, a single inscription may contain a letter form known only for one script, or a “diagnostic” letter, alongside a letter form known only for another script. This would initially suggest multiple scripts being used to write a single word or phrase. Three possible explanations can be explored to explain these inconsistencies and variations in script usage. First, these may call into question current classifications of scripts (see MacDonald 2004). They may alternatively support current understandings of the nature of literacy at the time (see MacDonald 2015) as widespread but informal. Finally, it is possible that these inscriptions show

new letter forms for already attested scripts whose formal repertoires would need revision in light of these observations. Further investigation of the inscriptions is needed to better assess the nature of these observed patterns in script and letter usage.

Overall, the attested Ancient North Arabian scripts and the content of inscriptions fits with those attested at other sites in the Arabian Peninsula and shows the presence of literate or semi-literate nomads in the first millennium BCE. The appearance of early Arabic inscriptions with content from Islamic sacred texts suggests the presence of literate populations in at least the 7th century AD onward.

Historic rock art

The rock art survey also identified 43 human figures with guns, on 21 rock art panels, which were mostly recorded at the back, i.e. the western side of Jebel Umm Sanman. Figures with guns are mostly associated with larger battle scenes in which the majority of fighters are depicted on horseback, with lances (Figure 17). The riders themselves are never shown with guns. Gunmen are always depicted as stick figures and two different postures can be differentiated: more freshly pecked engravings show figures crouching on one knee; more weathered figures are shown standing up, with one arm bent across the head (Figure 2). This was presumably done to show a person standing sideways, and reaching over with one arm to hold the gun with both hands.

Guns were introduced to the Arabian Peninsula at the beginning of the sixteenth century. Accounts from early travellers suggest that matchlocks were preferred over

the more advanced flintlocks and remained in use until the beginning of the twentieth century. The local tribesmen were extremely skilled in the use of these weapons, although they are reported to have backfired considerably. Modern cartridge rifles were introduced to the area from 1883 and were commonly used after 1907 (Elgood 1995). The depiction of guns used by infantry rather than cavalry may relate to a period before technological advances allowed the handling of guns while riding. However, it is also possible that both sides represent different tribes. The Ikhwan militia and the tribe of the Northern Shammar of Syria are reported to have used traditional weapons such as swords and spears until the early twentieth century (Elgood 1995).

Figure 17 Typical battle scene – the rider on the horse is fighting with a lance and being attacked by two crouching human figures with guns (Panel JSM245B).

Discussion

The combined evidence from the rock art survey and the sampling of archaeological sites highlights the longevity of the rock art tradition and human occupation of the Jubbah oasis. Surprisingly, the more favourable climate of the Early Holocene appears to be contemporary with changes in the artistic tradition. Early engravings of curvaceous female figures appear to have no commonalities with the 'Jubbah style'. Instead, the rock art appears to show a sequence where bird headed figures are re-engraved into large female figures, which are subsequently superimposed by engravings of equids (Figure 4). Engravings associated with the 'Jubbah style' make no reference to this earlier body of rock art and appear to have been created after a break in the rock art tradition.

The data collected during the rock art survey also suggests that only few figures in the 'Jubbah style' relate to depictions of herding scenes. The majority are shown in hunting contexts. The Jubbah style therefore appears to have been predominantly used by local hunting groups and much of it may be broadly contemporary with the arrowheads from JQ101, estimated to date between 7000 and 6000 BC. Although the timing for the local transition to a herding economy remains unknown, the rock art does seem to show that the beginning of the Jubbah style pre-dates this economic watershed by some time, pushing the curvaceous female figures and bird headed figures into even earlier periods. The next oldest lithic culture is the Epipalaeolithic from the site of Al-Rabyah, which occurs near to the cluster of large curvaceous female figures and dates to ca. 8000 BC. Interestingly, bird wing remains have been interpreted as having symbolic purposes, such as for headdresses, at the Epipalaeolithic site of Wadi Jilat, Jordan, on the other side of the Nefud Desert (Martin et al 2013).

The integration of domestic cattle into herds of wild animals and the small overall number of cattle depictions highlights important differences in the rock art, and perhaps the Neolithisation process of Jubbah in comparison to Shuwaymis. While a dynamic process with a mixture of introduced and indigenous elements can be assumed for the Neolithisation processes in general, local groups probably also changed their subsistence patterns at different times and at different rates. These processes usually remain largely invisible in the archaeological record. However, the rock art in Jubbah allows us a unique insight into this transition and captures the experience of individuals and small communities. Based on the engravings created by these early Holocene communities, the occupants of Jubbah may have continued to hunt even after their neighbours had adopted herding, leading to the integration of individual domesticates in hunting scenes and herds of wild animals. Perhaps the vegetation of the palaeolake sustained enough wild animals and therefore a predictable food source, leading to a different outcome in the decision-making? Or perhaps the sand dunes around Jubbah provided an extra barrier to the transport of cattle into the oasis? Cattle are only depicted in small numbers. It is not possible to tell whether this is a result of cultural convention – an emphasis on the depiction of an individual animal rather than the herd – or if cattle were actually kept in smaller numbers. However, both the rock art and the palaeoenvironmental record suggest that Jubbah was governed by very different environmental parameters than Shuwaymis. This would have naturally led to different adaptive strategies in the local population.

There are clear local characteristics in the rock art of Jubbah. The artistic tradition of the 'Jubbah style', and the depiction of cultural attributes such as penis sheaths and

headaddresses indicate clear cultural links with the hunters and herders that created the rock art of Shuwaymis and Hanakiyah. However, depictions of domestic goat and sheep have so far not been identified at these latter two related rock art sites further south. Their depiction in Jubbah may therefore be an indication of links to the caprine herders attested in the steppe of eastern Jordan (see for example Betts 1993; Henry et al. 2003; Rollefson et al. 2014).

Our data show marked differences between the rock art of the Neolithic and the Bronze Age. However, the rock art tradition that begins in the Bronze Age shares similarities in the depiction of animals and rock art scenes with the rock art of the early modern period and possibly even the 20th century. Engravings of these later periods are predominantly small, and more stylised, and suggest a shift to the faster creation of images and a focus on larger numbers of engravings in scenes and on panels. Moreover, engravings of the 'late period' show a clear change in location. While this can partly be explained by the drying of the palaeolake, the oasis continues to sustain vegetation today. The proximity to pasture and groundwater should therefore attract human occupation on the inward facing side of the jebels. However, with the domestication of camels, routes in and out of the oasis changed as access via steep sand dunes was no longer an obstacle. Both high-density locations of late engravings in Figure 15 can be easily accessed with camels and provide shelter from wind. While the rock art of earlier periods may relate to occupation sites, the later rock art may relate to routes in and out of the remaining oasis.

The inscriptions recorded at Jubbah attest human occupation across the first millennium BC and the first millennium AD. Moreover, they characterise the occupants of the oasis as part of wider ranging cultural and population dynamics, although with a unique local identity. This observation applies to the occupation of the Jubbah oasis throughout the Holocene, which must have been localised and sustained enough for the repeated development of local variants of broader cultural and economic patterns. In our dataset, distinct local adaptations were visible in the transition to herding, in the use of domesticate animals during the Neolithic, and in the epigraphy. Further local expression may yet be discovered in the lesser-known period of the Bronze Age. The only marked differences in the rock art tradition are visible between early Holocene engravings of curvaceous women and Neolithic imagery, and between Neolithic and Bronze Age imagery. Our dataset shows that burial in cairns was practised in the Neolithic and in the Bronze Age, however, because radiocarbon dates were obtained from disturbed cairns it is not possible to identify further patterns of continuity or change.

While the rock art of Jubbah allows tantalizing glimpses into the iconography and occupation history of Jubbah, many questions remain. These can only be addressed through archaeological excavations – in the identification and dating of actual settlement and burial sites, and through analyses of associated faunal remains. However, our research showed that rock art plays an important role in the reconstruction of prehistoric occupation patterns and cultural dynamics. Moreover, the identification of a similarities in the rock art tradition from the Bronze Age to the 20th century highlights the importance of historic rock art and the need to protect it for the future.

Acknowledgements

We thank His Royal Highness Prince Sultan bin Salman, President of the Saudi Commission for Tourism and National Heritage, and Prof. Ali Ghabban, Vice President, for permission to carry out the fieldwork in Jubbah. The fieldwork at Jubbah could not have been done without the support of our Saudi colleagues, especially Jamal Omar, Abdulaziz al Omari, and Habeeb Turki. We also thank Ian Cartwright, University of Oxford, for fine photography. The rock art research was funded by the European Research Council (no. 295719, to MDP).

References

- Almathen, F., Charruau, P., Mohandesan, E., Mwacharo, J.M., Orozco-terWengel, P., Pitt, D., Abdussamad, A.M., Uerpmann, M., Uerpmann, H.-P., De Cupere, B., Magee, P., Alnaqeeb, M.A., Salim, B., Raziq, A., Dessie, T., Abdelhadi, O.M., Banabazi, M.H., Al-Ekna, M., Walzer, C., Faye, B., Hofreiter, M., Peters, J., Hanotte, O. & Burger, P.A. 2016. Ancient and modern DNA reveal dynamics of domestication and cross-continental dispersal of the dromedary. *PNAS* 113 (24): 6707–6712, Doi: 10.1073/pnas.1519508113
- Anati, E. 1968a. *Rock Art in Central Arabia, Vol 1. The 'Oval-Headed' People of Arabia*. Louvain: Bibliothèque du Muséon.
- Anati, E. 1968b. *Rock art in Central Arabia, Vol 2/1. Fat-Tailed Sheep in Arabia*. Louvain: Bibliothèque du Muséon.

Anati, E. 1968c. *Rock Art in Central Arabia, Vol. 2/2. The 'Realistic-Dynamic' Style of Rock Art in the Jebel Qara*. Louvain: Bibliothèque du Muséon.

Anati, E. 1972. *Rock Art in Central Arabia, Vol.3. Corpus of Rock Engravings, Pts. I-II. Sectors A-H, From Taif to Mahash Wells*. Lovain: Institut Orientaliste de Louvain.

Anati, E. 1974. *Rock art in Central Arabia. Vol.4. Corpus of Rock Engravings, Pt. III. Sectors J-Q, Qahra Range to Najran*. Louvain: Institut Orientaliste de Louvain.

Betts, A. 1993. The Neolithic sequence in the Eastern Jordan Badia. A preliminary overview. *Paléorient* 19 (1): 43-53.

Charpentier, V. & Crassard, R. 2013. Back to Fassad ... and the PPNB controversy. Questioning a Levantine origin for Arabian Early Holocene projectile points technology. *Arabian Archaeology and Epigraphy* 24: 28-36.

Crassard, R. & Drechsler, P. 2013. Towards new paradigms: Multiple pathways for the Arabian Neolithic. *Arabian Archaeology and Epigraphy* 24: 3-8.

Crassard, R., Petraglia, M.D., Parker, A.G., Parton, A., Roberts, R.G., Jacobs, Z., Alsharekh, A. Al-Omari, A., Breeze, P., Drake, N.A., Groucutt, H.S., Jennings, R., Régagnon, E. & Shipton, C. 2013. Beyond the Levant: First Evidence of a Pre-Pottery Neolithic Incursion into the Nefud Desert, Saudi Arabia. *PLoS ONE* 8(7): e68061. Doi: 10.1371/journal.pone.0068061

Dinies, M., Plessen, B., Neef, R. & Kürschner, H. 2015. When the desert was green: Grassland expansion during the early Holocene in northwestern Arabia. *Quaternary International* 381: 293-302.

- Drechsler, P. 2007. The Neolithic dispersal into Arabia. *Proceedings of the Seminar for Arabian Studies* 37: 93-109.
- Drechsler, P. 2009. *The Dispersal of the Neolithic Over the Arabian Peninsula*. Oxford: BAR International Series 1969.
- Eichmann, R., Schaudig, H. & Hausleiter, A. 2006. Archaeology and epigraphy at Tayma (Saudi Arabia). *Arabian Archaeology and Epigraphy* 17 (2): 163-176.
- Elgood, R. 1995. *Firearms of the Islamic World: In the Tareq Rajab Museum, Kuwait*. London: Tauris.
- Engel, M., Brückner, H., Pint, A., Wellbrock, K., Ginau, A., Voss, P., Grottker, M., Klasen, N. & Frenzel, P. 2012. The early Holocene humid period in NW Saudi Arabia – Sediments, microfossils and palaeo-hydrological modelling. *Quaternary International* 266: 131-141.
- Euting, J. 1896. *Tagebuch einer Reise in Inner Arabien*. Leiden: Brill.
- Garrard, A., Harvey, C.P.D. & Switsur, V.R. 1981. Environment and Settlement during the Upper Pleistocene and Holocene at Jubba in the Great Nefud, Northern Arabia. *Atlat* 5: 137-148.
- Groucutt, H.S. & Petraglia, M.D. 2012. The prehistory of the Arabian Peninsula: Deserts, dispersals and demography. *Evolutionary Anthropology* 21: 113-125.
- Guagnin, M., Jennings, R., Eager, H., Parton, A., Stimpson, C., Stepanek, C., Pfeiffer, M., Groucutt, H.S., Drake, N.A., Alsharekh, A. & Petraglia, M.D. 2016. Rock art imagery as a proxy for Holocene environmental change: A view from Shuwaymis, NW Saudi Arabia. *The Holocene* 26(11): 1822-1834.

- Guagnin, M., Jennings, R., Clark-Balzan, L., Groucutt, H.S., Parton, A. & Petraglia, M.D. 2015. Hunters and herders: Exploring the Neolithic transition in the rock art of Shuywaymis, Saudi Arabia. *Archaeological Research in Asia* 4: 3-16. Doi: 10.1016/j.ara.2015.08.001
- Guagnin, M. 2015. Animal engravings in the central Sahara: A proxy of a proxy. *Environmental Archaeology* 20(1): 52-65.
- Hausleiter, A. 2010. The oasis of Tayma. Pages 218-261 in: Al-Ghabban, A.I., André-Salvini, B. & Demenage, F. (eds) *Roads of Arabia: Archaeology and History of the Kingdom of Saudi Arabia*. Paris: Musée du Louvre.
- Henry, D.O., Cordova, C., White, J.J., Dean, R.M., Beaver, J.E., Ekstrom, H., Kadowaki, S., McCorriston, J., Nowell, A. & Scott-Cummings, L. 2003. The Early Neolithic site of Ayn Abū Nukhayla, Southern Jordan. *Bulletin of the American Schools of Oriental Research* 330: 1-30.
- Hilbert, Y.H., White, T.S., Parton, A., Clark-Balzan, L., Crassard, R., Groucutt, H.S., Jennings, R.P., Breeze, P., Parker, A., Shipton, C., Al-Omari, A., Alsharekh, A. & Petraglia, M.D. 2014. Epipalaeolithic occupation and palaeoenvironments of the southern Negev desert, Saudi Arabia, during the Terminal Pleistocene and Early Holocene. *Journal of Archaeological Science* 50: 460-474.
- Jelínek, J. 2004. *Sahara - Histoire de l'art rupestre libyen*. Grenoble: Jérôme Millon.
- Jennings, R., Shipton, C., Al-Omari, A., Alsharekh, A., Crassard, R., Groucutt, H. & Petraglia, M.D. 2013. Rock art landscapes beside the Jubbah palaeolake, Saudi Arabia. *Antiquity* 87: 666-683.

- Khan, M. 1993. *The Prehistoric Rock Art of Northern Saudi Arabia. A synthetic approach to the study of the rock art from Wadi Damm, northwest of Tabuk*. Riyadh: Ministry of Education, Department of Antiquities and Museums.
- Khan, M. 2007. *Rock Art of Saudi Arabia across Twelve Thousand Years*. Riyadh: Deputy Ministry of Antiquities and Museums.
- Khan, M. 2011. *Jubbah - The Land of Golden Sands and the Lost Civilization of Arabia*. Riyadh. Saudi Commission for Tourism and Development.
- Le Quellec, J.-L., Duquesnoy, F. & Defrasne, C. 2015. Digital image enhancement with *DStretch*: Is complexity always necessary for efficiency? *Digital Applications in Archaeology and Cultural Heritage* 2: 55-67.
- MacDonald, M. C. A. 2004. Ancient North Arabian. Pages 488-533 in Woodard, R.G. (ed.), *The Cambridge Encyclopedia of the World's Ancient Languages*. Cambridge: Cambridge University Press.
- MacDonald 2010. Ancient Arabia and the written word. Pages 5-28 in Macdonald, M.C.A. (ed.), *The development of Arabic as a written language*. (Supplement to the Proceedings of the Seminar for Arabian Studies 40). Oxford: Archaeopress.
- Macdonald 2012. Wheeled Vehicles in the rock art of Arabia. Pages 357-396 in: Khan, M. (ed.) *The Arabian Horse – Origin, Development and History*. Riyadh: King Fahd National Library.
- MacDonald, M. C. A. 2015. On the uses of writing in ancient Arabia and the role of palaeography in studying them. *Arabian Epigraphic Notes* 1: 1-50.

Magee, P. 2014. *The Archaeology of Prehistoric Arabia. Adaptation and Social Formation from the Neolithic to the Iron Age*. New York: Cambridge University Press.

Martin, L., Edwards, Y., & Garrard, A. (2013). Broad spectrum or specialised activity? Birds and tortoises at the Epipalaeolithic site of Wadi Jilat 22 in the eastern Jordan steppe. *Antiquity*, 87(337), 649-665.

Martin, L., Edwards, Y.H., Roe, J. & Garrard, A. 2016. Faunal turnover in the Azraq Basin, eastern Jordan 28,000 to 9,000 cal BP, signalling climate change and human impact. *Quaternary Research* 86(2): 200-219.

<http://dx.doi.org/10.1016/j.yqres.2016.07.001>

McCorriston, J. & Martin, L. 2009. Southern Arabia's Early Pastoral Population History: Some Recent Evidence. Pages 237-250 in: Petraglia, M. & Rose, J. (eds) *The Evolution of Human Populations in Arabia – Paleoenvironments, Prehistory and Genetics*. Dodrecht: Springer.

Nayeem, M.A. 2000 *The Rock Art of Arabia. Saudi Arabia, Oman, Qatar, The Emirates and Yemen*. Hyderabad: Hyderabad Publishers.

Newton, L.S. & Zarins, J. 2000. Aspects of Bronze Age art of southern Arabia: The pictorial landscape and its relation to economic and socio-political status. *Arabian archaeology and epigraphy* 11: 154-179.

Olsen, S.L. & Bryant, R.T. 2013. *Stories in the Rocks: Exploring Saudi Arabian Rock Art*. Pittsburgh, PA: Carnegie Museum of Natural History.

- Parr, P.J., Zahrins, J., Ibrahim, M., Waechter, J., Garrard, A., Clarke, C., Bidmead, M. & Al Badr, H. 1978. Preliminary report on the second phase of the Northern Province Survey 1397/1977. *Atlat* 2: 29-50.
- Petraglia, M., Alsharekh, A., Breeze, P., Clarkson, C., Crassard, R., Drake, N.A., Groucutt, H.S., Jennings, R., Parker, A.G., Parton, A., Roberts, R.G., Shipton, C., Matheson, C., al-Omari, A. & Veall, M.-A. 2012. Hominin Dispersal into the Nefud Desert and Middle Palaeolithic Settlement along the Jubbah Palaeolake, Northern Arabia. *PLoS ONE* 7(11): e49840. Doi: 10.1371/journal.pone.0049840
- Preston, G.W., Parker, A.G., Walkington, H., Leng, M.J. & Hodson, M.J. 2012. From nomadic herder-hunters to sedentary farmers: The relationship between climate change and ancient subsistence strategies in south-eastern Arabia. *Journal of Arid Environments* 86: 122-130.
- Retsö, J. 2003. *The Arabs in Antiquity: Their History from the Assyrians to the Umayyads*. New York: Routledge.
- Rollefson, G., Rowan, Y. & Wasse, A. 2014. The Late Neolithic colonization of the Eastern Badia of Jordan. *Levant* 46 (2): 1-17.
- Rosen, S.A. 1997. *Lithics after the Stone Age: a handbook of stone tools from the Levant*. Rowman Altamira.
- Uerpmann, M. & Uerpmann, H.P. 2012. Archaeozoology of camels in South-Eastern Arabia. Camels in Asia and North Africa. Pages 109-122 in: Knoll, E. & Burger, P. (eds.) *Interdisciplinary perspectives on Their Significance in Past and Present*. Vienna: Academy of Sciences Press.

UNESCO 2016. World Heritage list. Rock Art in the Hail Region of Saudi Arabia.

Available at: <http://whc.unesco.org/en/list/1472> (Accessed 14 July 2016).

Von der Driesch, A., Brückner, A., Obermaier, H. & Zander, A. 2008. The hunt for wild dromedaries at the United Arab Emirates coast during the 3rd and 2nd millennia BC> Camel bones from the excavations at Al Sufouh 2, Dubai, UAE. *Archaeozoology of the Near East VIII*. Lyon: Maison de l'Orient et de la Méditerranée, 487-497.