

Preliminary Report of Reconnaissance Fieldwork in Southwest Saudi Arabia, May–June, 2012

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1. The DISPERSE Project in Southwestern Saudi Arabia

Landscapes evolve dynamically due to an interplay of processes occurring over different time-scales. Tectonic deformation, volcanism, sea level changes, by acting on the topography, the lithology and on the patterns of erosion-deposition in a given area, can moderate or amplify the influence of climate at the regional and local scale, impose or alleviate physical barriers to movement, and modify the distribution and accessibility of plant and animal resources in ways critical to human ecological and evolutionary success (Bailey and King 2011; King and Bailey 2006). The DISPERSE project, an ERC-funded collaboration between the University of York and the Institut de Physique du Globe, Paris, aims to develop systematic methods for reconstructing landscapes associated with active tectonics, volcanism and sea level change at a variety of scales in order to study their potential impact on patterns of human evolution and dispersal. These approaches utilise remote sensing techniques combined with archaeological and tectonic field surveys on land and underwater.

The archaeology of the Arabian Peninsula is pivotal to the understanding of the timing and mode of the earliest dispersals of modern human and earlier populations from Africa into Eurasia. Traditional emphasis on the Nile-Levant dispersal route has been challenged by growing evidence supporting a Southern Route, through the Bab al Mandab Straits (e.g. Beyin 2006; Petraglia and Alsharekh 2003). Yet, despite recent key developments in our knowledge of hominin occupation in Arabia (e.g. Armitage *et al.* 2011; Rose *et al.* 2011), the Palaeolithic archaeology of the peninsula remains patchy. This situation is particularly marked in the coastal region of Southwestern Saudi Arabia, where little work has been carried out since the Comprehensive Archaeological Survey Program (CASP) in the 1980s (Zarins *et al.* 1980, 1981). This region is particularly key in dispersal debates given its proximity to the Bab al Mandab Straits and a now-submerged landscape in the southern Red Sea potentially utilised by populations to move between Africa and Arabia.

Identification of possible routes and conditions of hominin dispersals from Africa throughout the last 2mya has focussed on reconstructing broad-scale climatic and vegetation zones. Dispersals into, and across, Arabia were probably controlled by global climatic and sea level fluctuations, with low sea stands allowing dispersals across water bodies (Rose 2004; Bailey *et al.* 2007; Lambeck *et al.* 2011), and periods of humidity allowing expansion of occupation ranges into present-day deserts (Petraglia *et al.* 2011). Yet within broad-scale reconstructions, understanding the physical morphology of the landscape and its evolution through time is also critical to palaeoenvironmental reconstruction at the scale experienced by hominin populations. The major tectonic event that is the opening of the Red Sea over the last 30my has been associated with several episodes of tectonic deformation and magmatism. Along with palaeoenvironmental changes, these processes have shaped the present landscape over the last 2my, a time-scale relevant to human evolution. The region is hence a key one to study the influence of tectonic, magmatic and eustatic processes on landscapes and the potential of the latter in creating attractive conditions for hominins settlement and dispersal.

2. Reconnaissance Fieldwork, May-June 2012

2.1 Aims and Objectives

The fieldwork took place between 22nd May and 15th June, and its principal aim was to assess the potential of the study region for examining the interrelationship between hominin settlement and dynamic landscape evolution with specific reference to tectonic and volcanic processes.

Objectives:

Objective One: To characterise the broad scale-landscape zones within the study area, from the coastal plain to the western part of the Arabian escarpment, as a function of the geology and geomorphology, and to relate this to possible underlying tectonic and volcanic processes.

Objective Two: To record the archaeology observed during the course of this reconnaissance and to assess the potential of landscape zones for archaeological preservation and future investigation.

Objective Three: To locate stratified sedimentary sequences with or without archaeology within them, for palaeoenvironmental reconstruction.

Objective Four: To install scientific equipment on the Farasan Islands for monitoring burial temperatures in shell mounds as an aid to improved dating of the many shell mounds of the area.

The results from the reconnaissance will form the basis for the development over the coming months of a targeted program of archaeological and landscape characterisation work to be carried out from 2012–2014.

2.2 Methods

The multi-disciplinary nature of the DISPERSE project means that methods from both earth science and archaeology are employed during fieldwork and research. Landscape and tectonic studies require the use of geological maps, satellite imagery and topographical data together with field observations in order to identify and characterise the processes acting at various scales, from that of a single outcrop to that of the volcanic edifice or that of the mountain belt.

Archaeological survey, in contrast, operates between the meso-landscape scale and that of the individual site. Areas for investigation were targeted for their archaeological potential based on factors such as favourable sedimentary conditions for the preservation of *in situ* archaeology, the presence of known archaeological sites in a given area, (e.g. the locations of sites recorded by the Comprehensive Archaeological Survey Program), and proximity to landscape features potentially attractive to hominin populations e.g. sources of water or raw material, such as lava flows.

Moving between these different scales of study and disciplines requires flexibility in the fieldwork itinerary. As the understanding of the landscape features, their history of development and their associated archaeological potential evolves through observations made in the field, so must the strategy and areas targeted for more detailed study evolve. The routes taken and areas visited during the fieldwork are outlined in Figure 1.

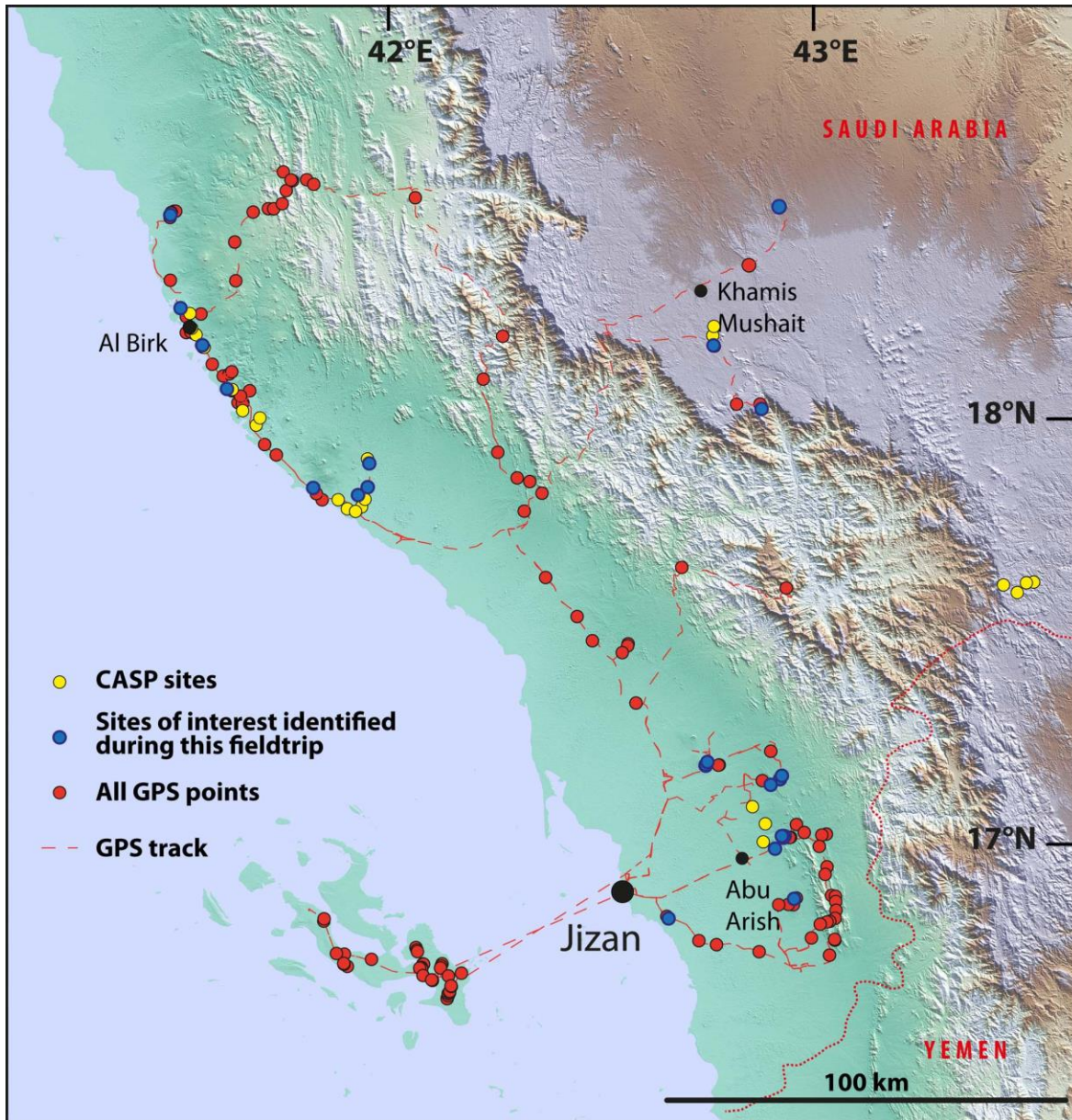


Figure 1. Map showing the itinerary followed by the DISPERSE team during the May-June 2012 reconnaissance field trip and key cities and towns. 'Sites of interest' refer to sites described further in Appendix 1. Map prepared by Maud Devès.

2.3 Summary Results and Discussion

Objective 1. Landscape Zone Characterisation

On the basis of geomorphological, geological and tectonic observations, one can distinguish between three large-scale landscape units: the coastal area that extends between the Red Sea coast and the escarpment, the escarpment itself and the Arabian platform (Figure 2).

Coastal Area

The overall morphology of the coastal 'plain' of western Saudi Arabia is that of a gentle slope rising from sea level to the foot of the escarpment. The landscape of the coastal area varies considerably, however, as a function of the underlying tectonic and volcanic processes and their impact on the topography, lithology and processes of erosion and deposition. One such distinction is visible between the characteristics displayed in the area extending north and east of the town of Jizan and those apparent in the area of Al Birk.

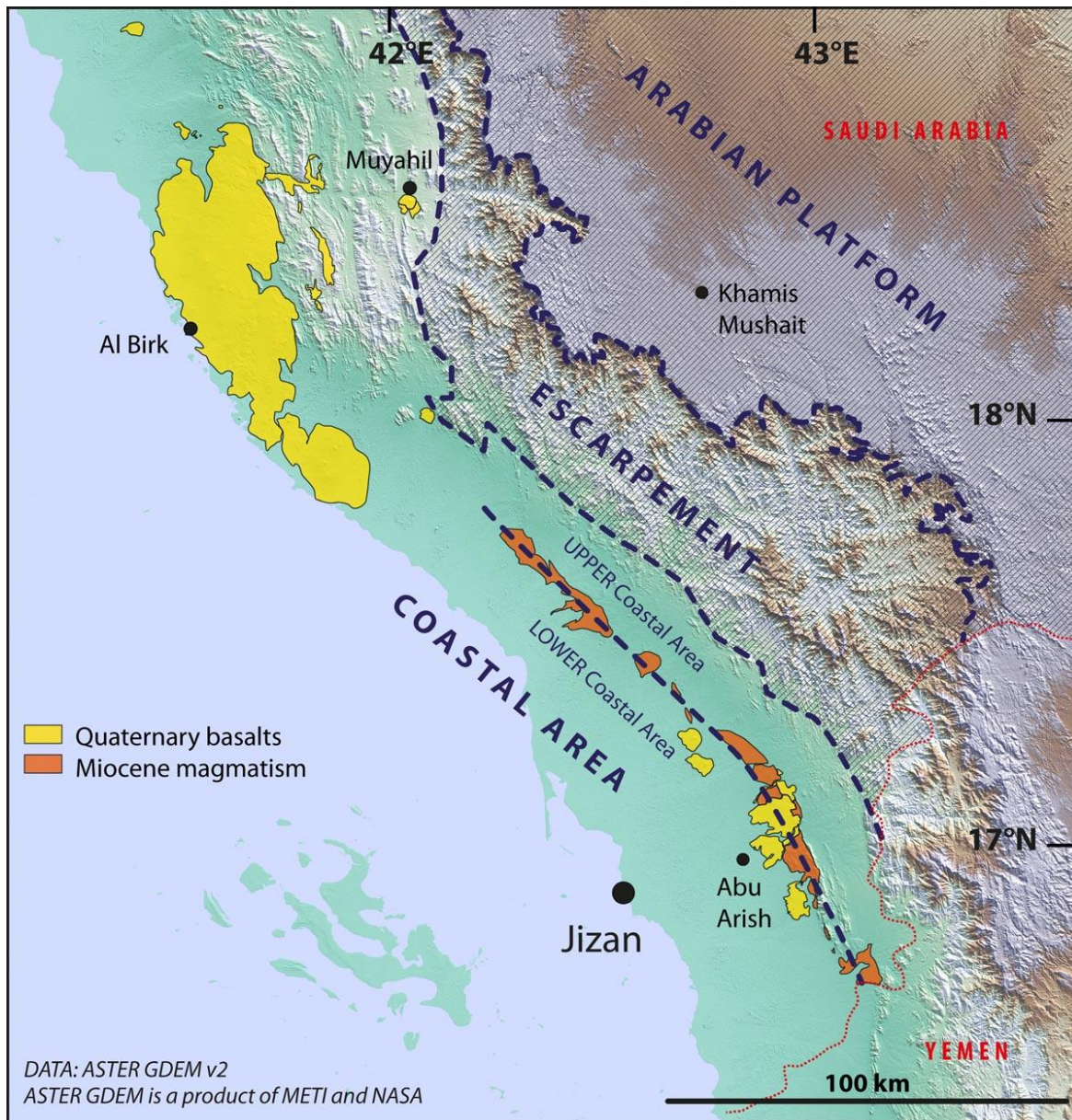


Figure 2. Map showing broad-scale landscape zones characterised by DISPERSE during the May-June 2012 fieldwork. Map prepared by Maud Devès.

The ‘Lower Coastal Area’

In the area extending east and northeast of the town of Jizan there are few major topographical features in the first 20–30km inland from the coastline, apart from the salt dome of Jizan that rises to about 40m (Figure 3). Several depressions that might be associated with karst processes were observed along the coast (Figure 4, see WP212). This ‘Lower Coastal Area’ is covered by Quaternary fluvial, aeolian and marine deposits. Several wadis have incised through these deposits creating wide and shallow river beds that are today heavily cultivated (Figure 5). Outside of these wadi beds, the Lower Coastal Area is dominated by vast areas of sand dunes and sparse shrub vegetation (Figure 6).

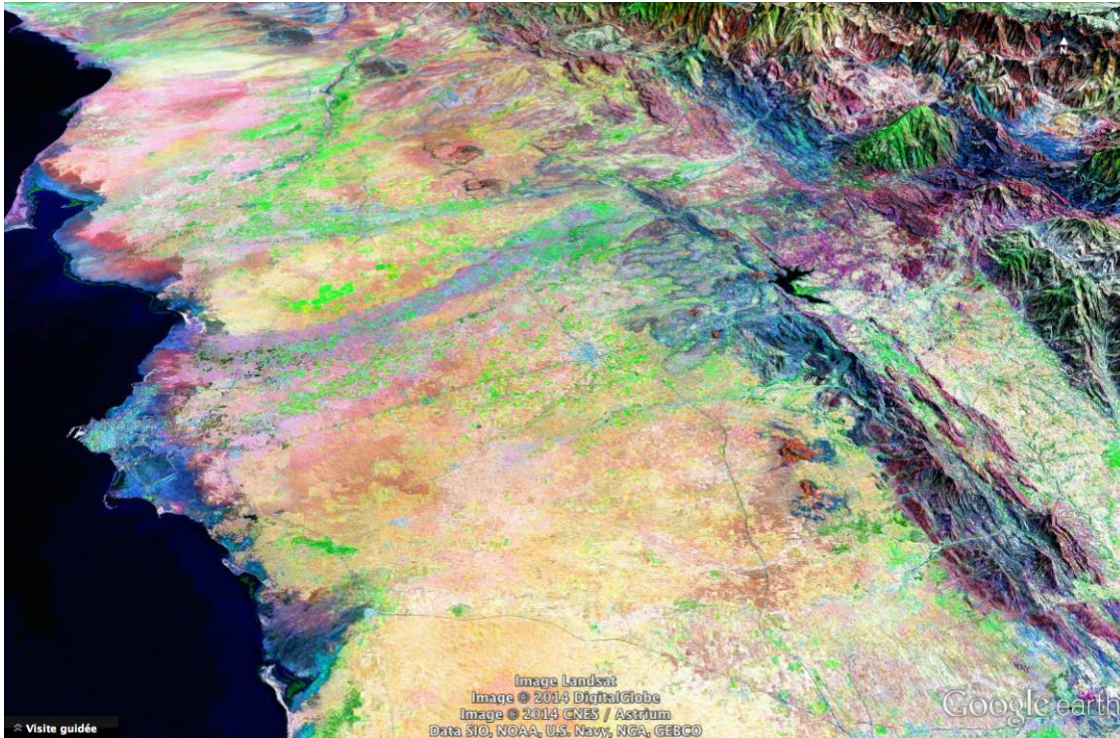


Figure 3. False colour image of the Lower Coastal Area. Yellow numbers refer to Waypoints. The dark purple area running from NW to SE with a concentration of Waypoint numbers is the main section of the Magmatic Belt. The light yellow area to the south is a large area of sand dunes. Wadis dissecting the Lower Coastal Area are identifiable as blue-green strips. The scale in the bottom left is 13.1km. Data from LandSat ETM and ASTER GDEMv2. ASTER GDEM is a product of METI and NASA. Image prepared by Maud Devès.

The ‘Magmatic Belt’ and the ‘Upper Coastal Area’

About 30 to 40km from the coastline, the wider coastal plain is crosscut by a marked topographical and geological barrier that results from episodes of magmatism and of tectonic deformation, defined here as the ‘Magmatic Belt’. The first stage of magmatic intrusion occurred during the Miocene. It was followed by the eruption of basalts during the Quaternary which built isolated volcanic edifices north east of Sabya and nearby Keyr Ayash and more widespread volcanic fields near Abu Arish (Figure 7). The Magmatic Belt is aligned roughly parallel to that of the Red Sea Rift. This specific spatial distribution, as well as the timing of these events, strongly suggests that this magmatism has occurred in relation with the opening of the Red Sea.

Xenoliths were observed in some of the Quaternary lavas, which suggest an interaction of the magmas with the mantle (Figure 8, WP147). Several field observations support the idea of a Quaternary or, at least Miocene, period of deformation of the area. It is clear that the Miocene and older layers have been deformed. The stratigraphy observed at outcrops along the incision made by a wadi across the Magmatic Belt also shows that the Quaternary lavas overlie alluvial sediments that lie above the current river level, potentially raised through uplift (Figure 9, WP 157). The magmatic and deformation history in this area has been so far poorly studied; further work is required to understand under which regional tectonic and structural context the deformation takes place, by which melting mechanisms the magmas have been produced, why magmatism has occurred in two stages, and eventually how this deformation and the magmatic events have changed the landscape seen by humans in the last million years.



Figure 4. Annotated Google Earth image showing depressions about one kilometre wide representing potential sinkholes located several kilometres inland from the modern coastline. The scale in the bottom left is 800m.



Figure 5. Cultivated river bed in the Lower Coastal Area. Photo by Maud Devès.



Figure 6. View of sand dunes in the Lower Coastal Area. Photo by Maud Devès.

This deforming ‘magmatic belt’ plays a distinct and key role in shaping the landscape of the coastal area. The morphology of the belt varies along the strike, creating a variety of landscapes at different scales. The southernmost part of the belt is dominated by deformed diabase, andesites, schists and granites. Deformation has created numerous elongated sedimentary basins in the middle of a quite complex topography (Figures 10 and 11), with isolated volcanic cones immediately to the west of the main magmatic belt (Figure 12). In the area of Abu Arish in the Upper Coastal Area (Figure 13), the Quaternary lavas have covered the underlying topography. Enclosed sedimentary basins are found at the edges of the lava flows, or where rivers have incised (Figures 14–16).

Generally speaking, the Magmatic Belt is an area of topographic complexity located between two vast sedimentary plains. Complex topography may be used by hominins for protection but also strategically while hunting, and an area of such topography may therefore be attractive to early hominin populations. The magmatic belt is also a boundary for stream catchment, with the

present-day topography utilised in the building of the modern Jizan dam. Similar damming and capture of water flowing from the escarpment to the coast may have also occurred through natural processes in the past, creating areas more attractive to animal and hominin populations. This attractiveness is enhanced by an abundant source of raw materials for tool manufacture in the lava flows. This complex topography also may trap and protect areas of sediment, potentially preserving archaeological and palaeoenvironmental archives *in situ*.

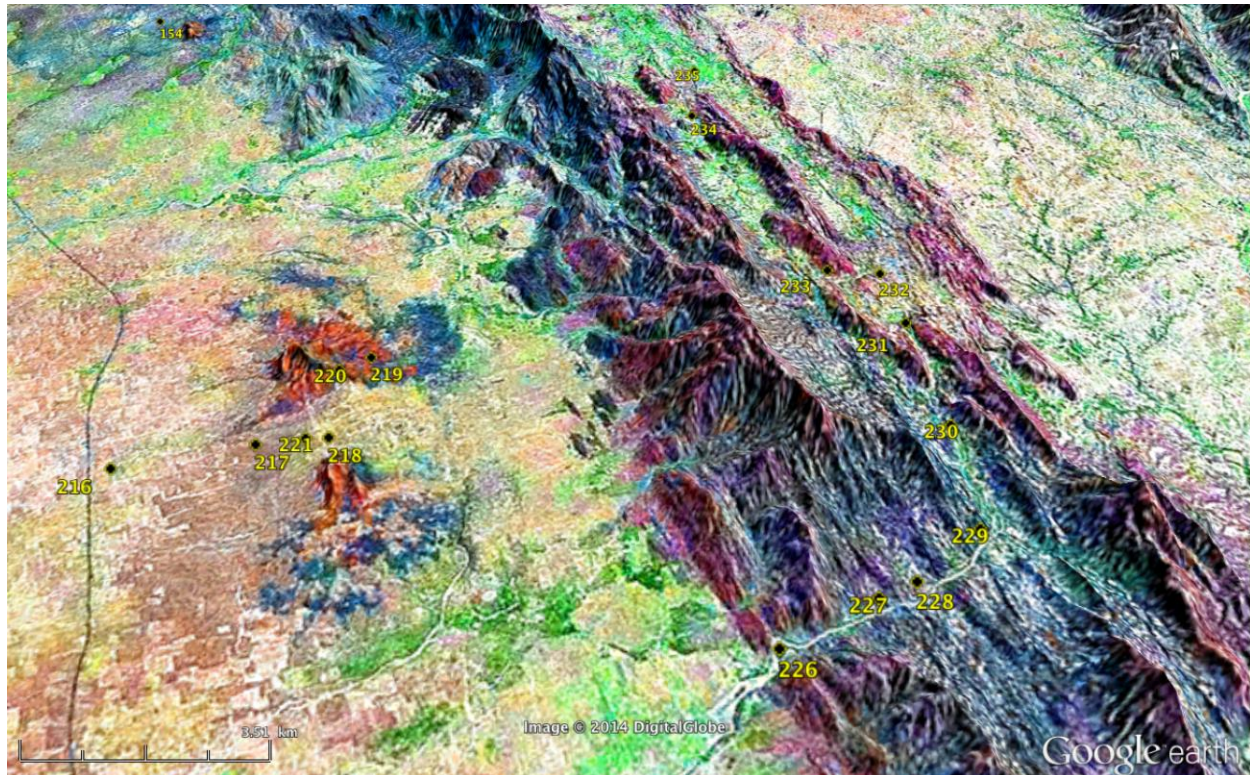


Figure 7. False colour image of the Magmatic Belt. Yellow numbers refer to Waypoints. The isolated patches of orange to the left of the image are volcanoes. The scale in the bottom left is 3.5km. Data from LandSat ETM and ASTER GDEMv2. ASTER GDEM is a product of METI and NASA. Image prepared by Maud Devès.

The Upper and Lower Coastal Areas, as well as the numerous enclosed sedimentary basins within the Magmatic Belt itself, exhibit differences in lithology and soils. It is worth noting that different soils can have different nutrient potential for vegetation, and thus animal grazing. From field observations made during this reconnaissance, it could be suggested that the soils derived from granitic rocks were more successfully cultivated than the soils derived from the schists. The latter are also often associated with medium-scale roughness whereas the areas with granitic soils are usually smoother. Whether this is due to differences in lithologies or to different deformation, and therefore sedimentation and erosion histories has to be investigated further. Exploring the influence of such differences on the vegetation and attractiveness to animal populations, and therefore hominin populations, will form an important part of future landscape characterisation in DISPERSE.



Figure 8. Xenoliths observed in the basalts of the Sabya volcanoes, apparently containing olivine and pyroxene minerals suggesting a mantle origin. Photo by Maud Devès.

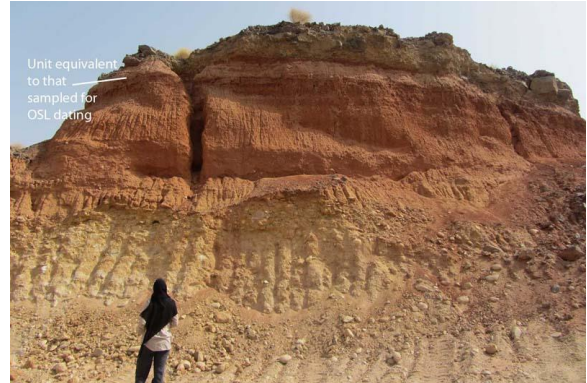


Figure 9. Exposed wadi sediments overlain by lava flow at WP157. A sample for OSL dating was taken from the unit indicated, just below the lava. Photo by Matt Meredith-Williams.



Figure 10. An enclosed sedimentary basin with folded schists in the distance, illustrating one of the distinctive landscape types in the southernmost part of the Magmatic Belt. Photo by Maud Devès



Figure 11. Another enclosed sedimentary basin in the southernmost part of the Magmatic Belt with deformed granites in the distance. Photo by Maud Devès.



Figure 12. Another type of landscape feature in the southern Magmatic Belt comprising an isolated volcanic cone with an eroded basaltic lava field in the foreground. Photo by Maud Devès

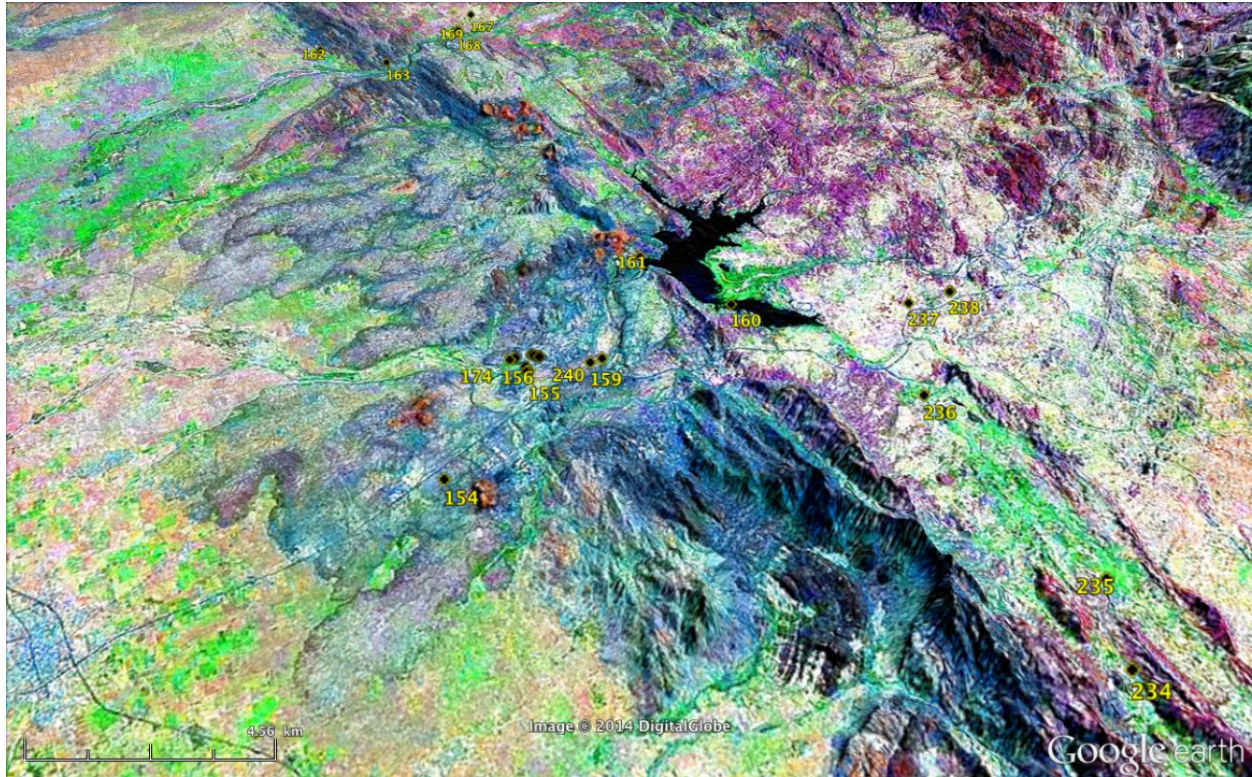


Figure 13. False colour image showing a closer view of the landscape around Abu Arish along the southern edge of the Upper Coastal Area. Yellow numbers refer to Waypoints. The isolated patches of orange to the left of the image are Quaternary volcanoes. Conventions are as in Figures 3 and 7. The black area near the centre of the image is the lake formed by the modern Wadi Jizan dam. The scale in the bottom left is 3.5km. Data from LandSat ETM and ASTER GDEMv2. ASTER GDEM is a product of METI and NASA. Image prepared by Maud Devès.



Figure 14. WP160. View of typical landscape features along the southern edge of the Upper Coastal Area, showing a flat sedimentary plain and stream catchment near the Wadi Jizan dam. The lake created by the dam is visible in the distance. Photo by Maud Devès.



Figure 15. WP258. Another typical landscape feature along the southern edge of the Upper Coastal Area, in this case showing a sedimentary basin enclosed by lava fields. The lava fields have created a natural trap for sediment and water that supports green vegetation in an otherwise dry landscape. Photo by Maud Devès.



Figure 16. WP154. Lava field along the southern edge of the Upper Coastal Area, showing the rough boulder-strewn nature of the surface topography. Photo by Maud Devès.

Al Birk and the Coastal Lava Flows

In the region of Al Birk, the landscape is also dominated by a superposition of Quaternary lava fields and volcanic cones on deformed pre-Permian schists, yet the proximity of these flows to the present-day coast results in distinct landscape characteristics. Again, present-day deformation and volcanic activity is probably related to the opening of the Red Sea, although further research into this relationship is required.

The Al Birk coastal area encompasses a wide variety of landscapes, from sandy beaches to coral terraces, volcanic cones or lava fields, mangroves, cultivated river beds or enclosed sedimentary basins as well as palaeolake sediments (WP304). Within the wider landscape there are various scales of topographic complexity and various lithologies and soils.

Sea level change over the last 2Mya would have dramatically altered the landscape as experienced by hominin populations, and is something which urgently requires further research as part of DISPERSE. Several levels of emerged coral terraces were observed along the coast (e.g., WP 287/288), which correspond to eustatic changes but which have also certainly been affected by tectonic and isostatic deformation, and a potential coral (or wadi calcrete) outcrop was observed at 40m asl (WP275 & 276), and has been sampled for further analysis and dating.

The landscape of the region extending north east inland from Al Birk to the escarpment is dominated by folded schists cross-cut by one main wadi which flows from the escarpment. In Muyahil, an isolated Quaternary volcanic cone lies in the middle of an enclosed sedimentary flat, located on one of the few N–S routes through the deformed schist, which elsewhere forms a barrier to movement.

The Escarpment

The escarpment in itself is characterised by steep slopes and narrow valleys. It is hard to conceive a great potentiality for human settlement or dispersal across this landscape, apart from specific areas such as that of Wadi Lajab. This area of Nubian sandstone and its numerous springs provides a particularly well-watered area in the middle of otherwise largely inhospitable schist geology. Wadi Lajab, however, appears difficult to access from the coastal plain, and the valleys that are closer to the edge of the escarpment or the front folds are potentially better targets for archaeological investigation into the use of the landscape by early human populations. No detailed observations were made in the escarpment zone during this fieldwork.

The Arabian Platform

The Arabian platform is by definition a vast area, and exploration of the area around Khamis Mushayt was limited. Due to its higher elevation, the plateau receives more rainfall in comparison to the coastal plain, which is testified in the more abundant vegetation. The geology is dominated by old crystalline rocks such as pre-Permian granites, granodiorites, and Nubian sandstones. It was cursorily observed that the landscapes associated with these different lithologies exhibited different features, but more survey is needed before any firm conclusions can be made. One important observation which can be made is that from the edge of the escarpment, the topography slopes gently eastward which controls the drainage pattern. Folds on the path of the rivers have been heavily incised, suggesting that deformation may have taken

place quite recently. These areas are also important because they are ideal places for water catchment and therefore may have been attractive to hominin populations.

Objective 2. Archaeological Reconnaissance

Lithics and artefacts were observed at 20 waypoints during the course of this fieldwork as surface finds (locations and waypoint descriptions are listed in full by landscape area in Appendix 1. All locations yielded tools consistent with Palaeolithic technology, although closer technological classification is not possible with the limited observations. Most sites also yielded later, potentially Neolithic lithic artefacts as well as pottery, indicating that the surface scatters are palimpsests. No artefacts were found in stratified deposits.

Few interpretations of the patterning of archaeological sites in the landscape can be made at this very preliminary stage, given the limited nature of the archaeological data. Yet there appears to be a low-density scatter of lithics from a range of periods across the landscape in a range of settings. Sites were recorded on terraces overlooking wadis (e.g., WP163, WP167, WP220), associated with lava flows and volcanics both inland next to wadis (e.g., WP168/9, WP310) as well as near to the coast associated with coral terraces (e.g., WP287/288). A single find-spot was located close to a seasonal lake/potential sinkhole near to the coast (WP212).

With such brief, broad-scale fieldwork, the find locations from this season will necessarily be biased towards areas of high artefact visibility, such as deflated surfaces on wadi terraces and lava flows, rather than towards areas where artefacts may be buried under sediments and only visible through time-intensive survey of stratified sequences along wadis and quarries. Future fieldwork must seek to redress this bias to obtain a true understanding of the distribution of artefacts in the landscape. Direct observation of these landscape zones and their distinct sedimentary environments has allowed a basic understanding of the sedimentary taphonomy of these areas, and the potential impacts this will have on the location, visibility and potential preservation of sites, which will be key in planning more detailed survey and interpreting the results

Objective 3. Location of Areas for Palaeoenvironmental Reconstruction

A number of areas of exposed stratigraphy, primarily facilitated by bulldozing or quarrying, have been observed throughout the fieldwork, and these may hold potential for palaeoenvironmental and local-scale landscape reconstruction, as well as potential for the future location of stratified archaeological sites. These sequences include a lacustrine sequence underlying terrestrial sediments at the eastern edge of the Al Birk lava fields, close to Al Shuquaiq (WP304) and a series of profiles exposed through wadi floodplain sediments in an area to the east of Abu Arish (around WP157), one profile of which has been sampled for OSL dating. Observations of sediment sequences close to the coast consisting of cycles of marine sedimentation and coral development (WP292 and 299) as well as coral terraces overlying lava flows (WP287/288), and potentially further inland (WP275 and 276) will provide key information for the dating and identification of palaeoshorelines, and their relationship to the local landscape and artefact distributions.

2.4 Key Areas and Themes Identified for Future Research

Whilst the identification of areas to target for future work is an ongoing process, which will continue to develop over the coming months, at this preliminary stage, the reconnaissance fieldwork has identified a number of specific key areas for further archaeological, palaeoenvironmental and geological/tectonic/volcanic investigation during 2012–14.

Further Volcanic and Tectonic Research

The ‘magmatic belt’ in the region of Jizan and Abu Arish is a key area of study to understand the tectonic and magmatic processes occurring in the region and their impact on hominin landscapes. The coast of Al Birk, because of its proximity to the coastline, is an important area to understand the role of sea level changes in the evolution of the landscape. The Farasan Islands are an ideal place to understand salt tectonics, a key process in the region that may also play a role in the deformation observed on the coastal plain. During this fieldwork, we did not have the time to explore properly the processes occurring on the Arabian Platform but this would be important. Future work will therefore require undertaking further visits to each of these areas.

Further Archaeological and Palaeoenvironmental Research

Al Birk Lava Flows: The lava flows around the Al Birk area appear to have been heavily exploited for their raw materials during the Palaeolithic, as noted during earlier surveys. Detailed archaeological survey in transects across the lava flows from the coast will be carried out in order to assess the spatial patterning of lithic artefacts and sites across the area. This will be supplemented by targeted survey of visible palaeoshorelines, as marked by coral terraces and marine terraces to identify stratified sites. This will be carried out in close cooperation with the geomorphological survey of features related to coastal landscape evolution through the mapping and dating of coral terraces and marine sediment sequences, in order to understand the relationship between the development of coastal environments and Palaeolithic occupation.

Palaeolake Sediments at WP304: Palaeolake sediments are a key palaeoenvironmental indicator in semi-arid environments as they mark periods in which there was greater humidity than at present, marking places which were potentially attractive to animal and hominin populations. The lake sediments identified at WP304 therefore hold important potential both for environmental reconstruction and archaeological exploration. Future work should include coring of the sediments with commercial drilling equipment to trace the depth and extent of the lacustrine sediments, alongside the cleaning and sampling of existing sections within the quarry to further understand the stratigraphy and to identify any areas of *in situ* archaeology related to the lake environments.

Magmatic Belt and Upper Coastal Area: The topography and complex drainage patterns of the area, as well as abundant sources for raw material and numerous observations of archaeology on exposed surfaces, indicates good archaeological potential for locating both further surface sites on wadi terraces and lava flows as well as stratified sites within wadis. The barrier to drainage that is the topography of the Magmatic Belt may also have blocked and re-routed wadis through tectonic and volcanic processes, trapping water and producing lakes and conditions attractive to hominin and animal occupation. Further systematic survey has the potential to locate both further

surface sites as well as *in situ* deposits for archaeological and palaeoenvironmental reconstruction, tied to volcanic-driven landscape changes.

Palaeolithic Factory Site and Neolithic Structures WP310: The site at WP310 holds what appears to be extensive evidence for Palaeolithic and Neolithic occupation on the plateau/platform. A more extensive investigation of the valley has the potential to identify a range of Palaeolithic sites within their landscape settings, as well as evidence for past environmental conditions in the form of potential seasonal lakes observed at the southern end of the valley.

Al Bathah Sandstone Landscape: The sandstone area on the escarpment close to Al Bathah, Asir, incised by wadis, holds great potential for the existence of rockshelters, which may yield archaeological sediments. The location of these valleys on the platform is within an area currently more relatively humid than the coastal plain, and thus rendering it potentially more attractive during periods in the past to hominin populations. Further survey should be carried out to assess the archaeological and palaeoenvironmental potential of the area.

3. Conclusion

This reconnaissance fieldwork has allowed us to understand, and begin to characterise several landscape units on the basis of geomorphological, tectonic and lithological observations, as well as the timescales at which the underlying tectonic and volcanic processes may have acted on the landscape. We have also located a number of sites with significant archaeological and palaeoenvironmental potential. Overall, our preliminary observations outline the substantial potential for the development of future research foci and directions in southwest Saudi Arabia, which can contribute both to the wider understanding of the archaeology of the Arabian Peninsula, as well as contributing to the DISPERSE project's aim to investigate the impact of dynamic landscapes on early hominin evolution and dispersal.

4. Acknowledgements

We thank HRH Prince Sultan bin Salman bin Abdul Aziz, President of the Saudi Commission for Tourism and Antiquities, KSA, and Dr Ali Al Ghabban, Vice-President, as well as Mr Jamal Omar, for granting permission to undertake the fieldwork and for supporting our work more generally. Grateful thanks are also extended to the staff of the SCTA offices in Jizan, Sabya, Abha and the Farasan Islands. We also thank the Farasan Border Guard for their cooperation and assistance.

DISPERSE, 'Dynamic Landscapes, Coastal Environments and Hominin Dispersals', is an Advanced Grant awarded by the European Research Council (ERC) for a 5-year programme of research (2011–2016) under the Ideas Programme of the 7th Framework Programme, involving collaboration between Prof. Geoff Bailey at the University of York and Prof. Geoffrey King at the Institut de Physique du Globe de Paris.

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6. Appendix 1. Detailed Waypoint Descriptions by Area

6.1 The Magmatic Belt and Upper Coastal Area

The magmatic belt forms a major topographical feature which divides the coastal plain into two areas. The area of the Magmatic Belt and Upper Coastal Area, between Al Shugayri in the north and Ahad Al Masariyah in the south was extensively explored during this fieldwork in order to understand the complex magmato-tectonic history of the region. The landscape of the magmatic belt is characterised by folded schists and deformed granites which enclosed a number of sedimentary basins, and is associated with a number of isolated volcanic cones to the west of the line, such as the Sabya volcanoes (see Figure 3). The landscape in the Upper Coastal Area is characterised by broad sedimentary plains which are incised by numerous rivers, and, closer to the magmatic belt, enclosed areas of sediments surrounded by rough lava fields (see Figure 4).

WP147, 149, 151, 152 - The Sabya Volcanoes

The two volcanoes at Sabya are marked topographic features in an otherwise flat landscape, and occurring slightly west of the main magmatic belt. Whilst no finds were recorded from the CASP survey, lithics were observed by Dr Anthony Sinclair during previous visits to the area. During the current fieldwork, the southern side of the southern volcano was visited (Figure 17), as well as the wadi valley between the two volcanoes, although sandstorm conditions during the latter visit hampered observations. The area directly to the south and east of the southern volcano is undergoing extensive development, including the building of an electricity plant, which will destroy any archaeology except that closest to the volcano slopes. As previously discussed, the presence of xenoliths gives important insights into magmatic processes suggesting involvement of the mantle of the lithosphere or of the asthenosphere (Figure 8).



Figure 17. WP147. South-eastern side of the southernmost Sabya volcano. Photo by Maud Devès.



Figure 18. Well-weathered flake from WP147 found at the foot of the southernmost Sabya volcano. Photo by Robyn Inglis.

WP 147

GPS: 17°11'45.20"N, 42°44'54.92"E

A single well-weathered basalt flake, probably Palaeolithic, was found on a sandy substrate c.100m from break in slope at base of volcano, close to a wadi cut (Figure 18).

WP149

GPS: 17°11'22.67"N, 42°44'40.99"E

A single potential quartzite flake was observed stratified in colluvial deposits at the foot of the volcano exposed in a road cutting. It was associated with a smaller flake of quartzite, yet it is unclear as to whether these are anthropogenic.

WP151 & WP152,

GPS: 17°11'14.14"N, 42°44'41.64"E

GPS: 17°11'14.35"N, 42°44'40.42"E

A large flake/potential handaxe (WP151) and other Palaeolithic flakes (WP152) were observed on deflated surfaces of an area at the base of lava flows from the volcano. The area was dissected by small wadis and gullies and is one of the few areas undisturbed by development to the south of the volcano.

WP154

GPS: 16°59'33.68"N, 42°54'25.31"E

A single well-weathered basalt flake/handaxe was observed in the lava fields to the east of Abu Arish, in the vicinity of CASP site 217-81.

WP155, 157, 172, 173, 174, 175, 176

2x1 km area around WP157, GPS: 17° 1'21.43"N, 42°55'42.34"E

A number of profiles of up to 10m of sedimentation, underlying lava flows, were recorded in the area of WP157. Whilst no artefacts were recovered, the profiles show shifting environments in the wadi floodplain, and may preserve both archaeological material and palaeoenvironmental information. A sample of sediment was removed from top of profile WP157 for OSL dating (see Figure 9).

WP163/164

GPS: 16°59'33.68"N, 42°54'25.31"E

A lithic scatter was observed on the deflated surface of the wadi terrace (Figure 19), c. 50m from the wadi. Artefacts observed consist of four or five potentially Neolithic flakes on green-grey sedimentary rock, relatively fresh, spread over an area of 10m. A scatter of very fresh knapping debris of greyish metamorphic material was also visible close to one or two sherds of ceramics.

WP165

GPS: 17°39' 6.94"N, 42°41'18.39"E

On a terrace overlooking a wadi now flooded with the building of Wadi Bayish dam, extensive lithic scatters were observed on a deflated surface, with finds including Palaeolithic flakes and cores made on basalt and Neolithic chert flakes.

WP167,

GPS: 17° 9'49.39"N, 42°55'23.56"E

A heavily-weathered endscraper (Figure 20) and basalt flake of possible Palaeolithic age was found on the deflated surface of a wadi terrace, 500m from the main channel. This scatter also yielded potential flakes on green chert and flakes made from pale sedimentary/metamorphic rock. These are probably of Neolithic age and perhaps more recent.



Figure 19. Scatter of raw material and multi-period lithics on deflated surface of wadi terrace at WP163/164. Photo by Robyn Inglis.



Figure 20. Weathered endscraper from WP167. Photo by Robyn Inglis.

WP168 and 169

GPS: 17°9'21.85"N, 42°55'7.54"E and 17°9'19.98"N, 42°55'7.57"E

A low-density scatter of lithics was observed across the slopes at the northern end of a lava flow that extends down to the wadi edge. There are rare well-weathered Palaeolithic basalt flakes, with some sharper, Neolithic flakes on greenish chert, as well as rare pottery sherds.

WP220

GPS: 16°52'30.87"N, 42°57'5.89"E

A scatter of multi-period artefacts was observed covering an area of sediment immediately to the southern edge of the volcanic cone, dissected by small wadis and gullies. These included well-weathered Palaeolithic basalt flakes and Neolithic flakes on chert and quartz, as well as decorated pottery rim and body sherds.

6.2 Lower Coastal Area

The Lower Coastal Area was not extensively surveyed during the reconnaissance, given its extensive disturbance by modern development and agriculture, as well as the relatively low potential for archaeological visibility given the massive quantities of Quaternary sedimentation (including sand dunes and cultivated wadi sediments, see Figures 5 and 6), as well as lack of major topographic features. The only noticeable topographic features are the salt dome of Jizan and several kilometre-wide depressions as observed from Google Earth, and in the field. The latter might be sinkholes created by karst processes of dissolution of the underlying carbonate layers (Figure 21, see also Figure 4).

WP212

GPS: 16°49'45.37"N, 42°39'27.23"E

A single well-weathered, flake of potentially Palaeolithic age was found near the edge of the dry lake/sinkhole, as well as a scatter of sharper, more recent flakes in the dunes closer to the road.



Figure 21. WP212. The figure is standing on the edge of a possible sinkhole. See also Figure 4 for a Google Earth aerial view of this feature. Photo by Maud Devès.

6.3 Al Birk Area

The landscape around Al Birk is dominated by multiple lava flows which appear to contain an almost continuous low-density scatter of heavily-weathered Palaeolithic artefacts on the local basalt, as observed by the CASP. Given the low resolution of the CASP maps it was not possible to locate the exact sites identified by the Survey. Instead, the edges of the lava flows were examined at a number of points along the coast and inland where they could be linked to other geomorphological features such as coral terraces, which inform as to long-term and short-term landscape and palaeoenvironmental development, and which may preserve *in situ* stratigraphy and archaeological sites.

WP275 and 276

GPS: 18°28'38.90"N, 41°29'27.23"E

A number of artefacts were observed overlying and surrounding a potential coral outcrop (or wadi calcrete) in a wadi adjacent to a lava flow at around 40m asl, 3km from the current shoreline (Figure 22). These consisted of Palaeolithic basalt flakes and cores, as well as a granite hammerstone. The coral/calcrete was sampled for further analysis and dating potential.

WP287/288

GPS 287: 18°10'20.85"N, 41°33'55.82"E

GPS 288: 18°10'22.18"N, 41°33'52.51"E

A coral terrace on a small promontory south of Al Birk was investigated as a potential location for the CASP site of 216-208. Whilst this could not be confirmed, the setting does share some geomorphological features with the site, although Bailey *et al.* (2007) place the location of 216-208 further south along the coast. This is probably a result of the relative abundance of artefacts

along the shoreline and a consistent coral terrace height within the area, as identified by previous surveys.



Figure 22. Outcrop of coral/wadi calcrete at WP 275 at 40m above sea level and 3 km from coast. Photo by Maud Devès.



Figure 23. Scatter of worked basalt flakes on the surface of a fossilised coral terrace at WP 287/288 near Al Birk. The coral overlies a volcanic lava flow, visible in the distance. Photo by Maud Devès.

At WP287/288, a coral terrace is present about 1–2m above the sabkha sediments (Figure 23), and about 50m from the current shoreline, marked by mangrove vegetation. This terrace overlies a lava flow (e.g. Bailey *et al.* 2007, contra Zarins *et al.* 1981), the contact between which can clearly be seen at WP289, around 300m away, where the terrace is cut by a small wadi.

On top of the coral terrace there was a medium density scatter of basalt flakes, showing heavy or moderate weathering. On the slopes of the lava flow above the coral terrace, there was a low-density occurrence of heavily-weathered Palaeolithic basalt flakes, usually visible in small sediment basins trapped between the boulders, including one which may be a point (and may have once had a tang, although this is uncertain given its heavy weathering. This distinction in weathering between the two areas (the lava flow and the terrace) may represent a difference in age (as suggested between Acheulean and MSA, Zarins *et al.* 1981), but this cannot be confirmed without more comprehensive survey and technological analysis.

WP292

GPS: 18° 4'12.57"N, 41°37'22.16"E

A c. 5m section of sediments at the base of a lava flow c. 500m from the present coastline has been exposed through quarrying (Figure 24). The profile appears to be capped by coral, which forms the top 1m of the sediments, below which there are 2m of apparently marine sand sediments, another 1m band of coral, and further marine deposits to the base. The top layer of

coral extends across the landscape for around 400m, with outcrops visible to the West and East of the main section. Set back from the marine sediments by around 50m, directly under the lava flow, a profile exposed by further quarrying shows the contact between the lava and underlying aeolianite. It is unclear how this section relates to the coral/marine sediments exposed in the quarry.

A small number of Palaeolithic weathered flakes and cores of basalt were observed on top of the coral terrace, including a large potential handaxe, along with a potential Neolithic core on greenish chert.



Figure 24. Exposure of marine sediments at WP 292. Note lava flow in background and to the right of the image. Stone artefacts were recovered from the surface of the terrace where the two figures are standing. Photo by Robyn Inglis.

WP299

GPS: 17°50'17.88"N, 41°49'29.67"E

A sediment profile is exposed in a quarry cut below a lava flow, and capped by 50–75cm of coral (Figure 25). The stratigraphic relationship between the lava flow and coral is unclear from the observations made. On the boulders of basalt which make up the lava flow, four or five circular structures were observed, 6–7m in diameter and potentially Neolithic or later. These were constructed out of basalt boulders, and were associated with pottery sherds. Isolated Palaeolithic basalt flakes were scattered on the lava flow and also on the coral terrace, although these may have been reworked due to the presence of a track.



Figure 25. Lava flow and exposure of sediments at WP299. Circular stone structures are present on the lava flow next to the figure in a white shirt. The top of the exposed section is composed of coral. Photo by Robyn Inglis.

WP302

GPS: 17°49'17.44"N, 41°55'47.53"E

Attempts to locate the CASP site 216-211 in a 'volcanic plug' were hampered by the bulldozing of large areas of sediments in the area at the foot of the volcano. Yet, the removal of large amounts of sediments by such bulldozing has exposed large profiles of aeolianite, potentially preserving an entire landscape beneath the lava flow, which could be dated, and investigated for archaeological and palaeoenvironmental reconstruction.

WP303

GPS: 17°53'44.44"N, 41°57'22.53"E

This location was a site visited by Geoff Bailey in 2004, and marked as equivalent to the CASP site 216-216. A small wadi cuts the eastern edge of the lava flow, which itself marks the easternmost edge of the area of lava flows in the region. One or two potential Palaeolithic basalt flakes were observed on the edges of the lava flows, with many fragments of quartzite scattered across the surface and foot of the flows, some showing potential flaking.

WP 304

GPS: 17°50'24.16"N, 41°57'9.60"E

WP304 is a disused quarry adjacent to the highway, approx. 130m x 80m across, and 12m deep. The top 0.5m is characterised by alluvial sediments. These are highly variable and in places extend to 1.5m, being composed of sediments ranging from fine layers of silt to sorted gravels. There is considerable carbonate concretion of these layers forming a calcrete. Below this, up to 7m of heavily silty sediment is dominated by rhizolith formation and concentrations of carbonate concretion.

Underlying this sequence there are 2m of exposed lacustrine sediments, with the final 2m of sediments down to the base of the quarry obscured by collapsed sediments (Figure 26). The lacustrine sediments appear to show cyclical shifts between deep-water sediments and periods of shallower water and formation of carbonate (possibly also salt) pan formation. There are also

intermediate phases that appear to show rich organic deposition. Carbonate nodules are present in some layers. Samples were taken from one carbonate layer and one organic layer close to the top of the lacustrine sequence for further analysis and dating (Figure 27).



Figure 26. WP304. View looking East into the quarry, showing the extent of the deposits exposed. A lava outcrop is just visible on the lower right of the image as a series of black protrusions from below disturbed sediments. Photo by Robyn Inglis.

Figure 27. WP304. Sequence through the lower section of the quarry sediments showing location of samples. Note the major distinction between laminated fine-grained water-laid sediments at the base of the section, which appear to represent lacustrine conditions, and terrestrial sediments dominated by rhizoliths at the top of the section. Photo by Robyn Inglis.

In the centre of the quarry there is a lava outcrop at the same depth as the lacustrine sediment exposure (rising up 4m from the base of the quarry). Although obscured by section collapse and quarry morphology, it is suggested on the current observations that the lacustrine sediments may have met the lava outcrop forming a shoreline for the lake.

This location is considered a high priority for future work given the potential for environmental reconstruction. The presence of a palaeoshoreline is another key target, as these zones are known to be areas of high potential for archaeology. Future work is likely to involve excavation in the quarry to further expose and record the visible sediments, as well as a concerted effort to expose undisturbed shore deposits in the hope that archaeological sites can be identified. It would also be desirable to undertake a program of coring in order to determine the extent and maximum depth of the lake. This might also highlight areas of high archaeological potential for future investigation.

6.4 Arabian Platform Area

The area of the Arabian Platform around Khamis Mushayt and Abha was only briefly visited, and aside from the general observation that there are distinct geologies associated with distinct landscapes and sedimentary settings, few conclusions can be drawn as to its nature and

formation. The locations which were visited, however, showed good potential for the preservation of many more archaeological sites than were recorded in the CASP, as well as a number of interesting features related to the volcanic, geological and tectonic history of the area. Areas targeted focussed on topographic features such as granite outcrops and wadi valleys.

WP306

GPS: 18°10'20.12"N, 42°45'46.27"E

A granite outcrop was visited to locate the CASP site 217-218. This area is now under military control and inaccessible. However, brief survey of a small area close to the perimeter fence yielded a number of potential flakes and one potential small biface on granite and quartz, on exposed bedrock with very little sediment cover.

WP309

GPS: 18°1'24.27"N, 42°52'32.44"E

An area of sandstone extends along the edge of the escarpment, near to Al Bathah. Although the area visited had been heavily disturbed in its use as a tourist destination, a single, weathered Palaeolithic flake was observed close to the viewpoint over the escarpment providing a tentative indication of past occupation. The topography of the area, especially where wadis have cut through sandstone (Figure 28), holds good potential for the presence of rockshelters containing sediments and archaeological material.

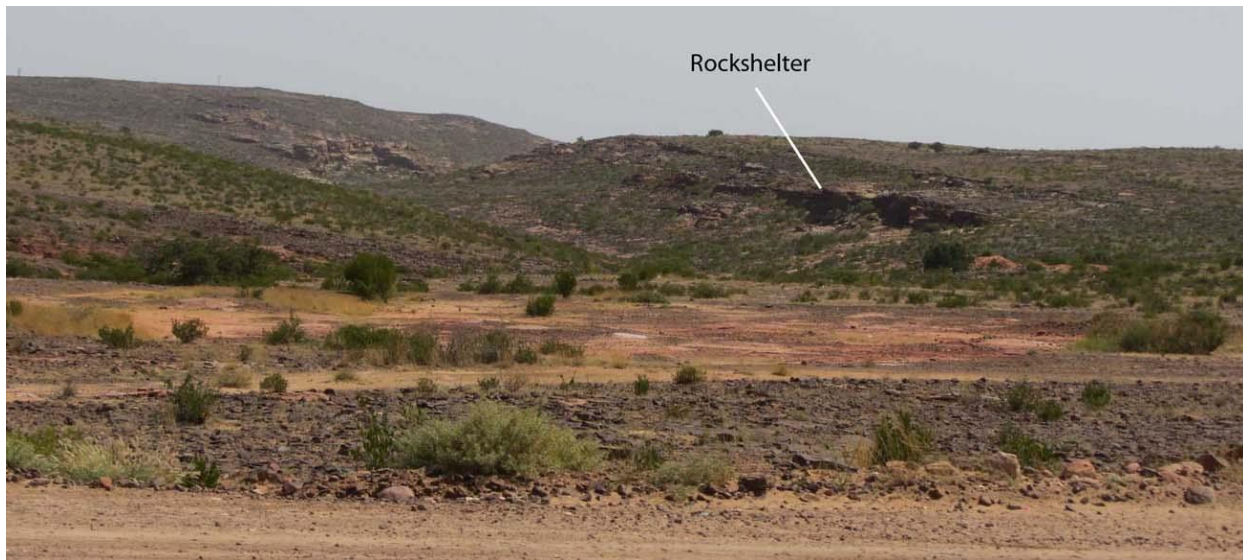


Figure 28. Wadis dissecting a sandstone landscape close to WP307–WP309. Note the shallow rockshelter in the centre right of the image. Photo by Robyn Inglis.

WP310

GPS: 18°29'49.42"N, 42°54'59.65"E

On the eastern slopes of the western edge of a valley that cuts through a granite outcrop, there is a smaller sub-valley between the main sloping valley walls and a linear outcrop of granite (Figure 29). This outcrop has been extended artificially to dam the small tributary that flows from the slopes into the main wadi, forming a pool. Multi-period finds were observed, with a high-density of Palaeolithic flakes and tools (and lower density Neolithic finds) spread across the

slopes of the valley sides for at least 300m. These slopes are covered by boulders and cobbles of igneous rock of unknown character. This site may represent a potential Palaeolithic factory, with lithics ranging from large flakes to potential handaxe roughouts.

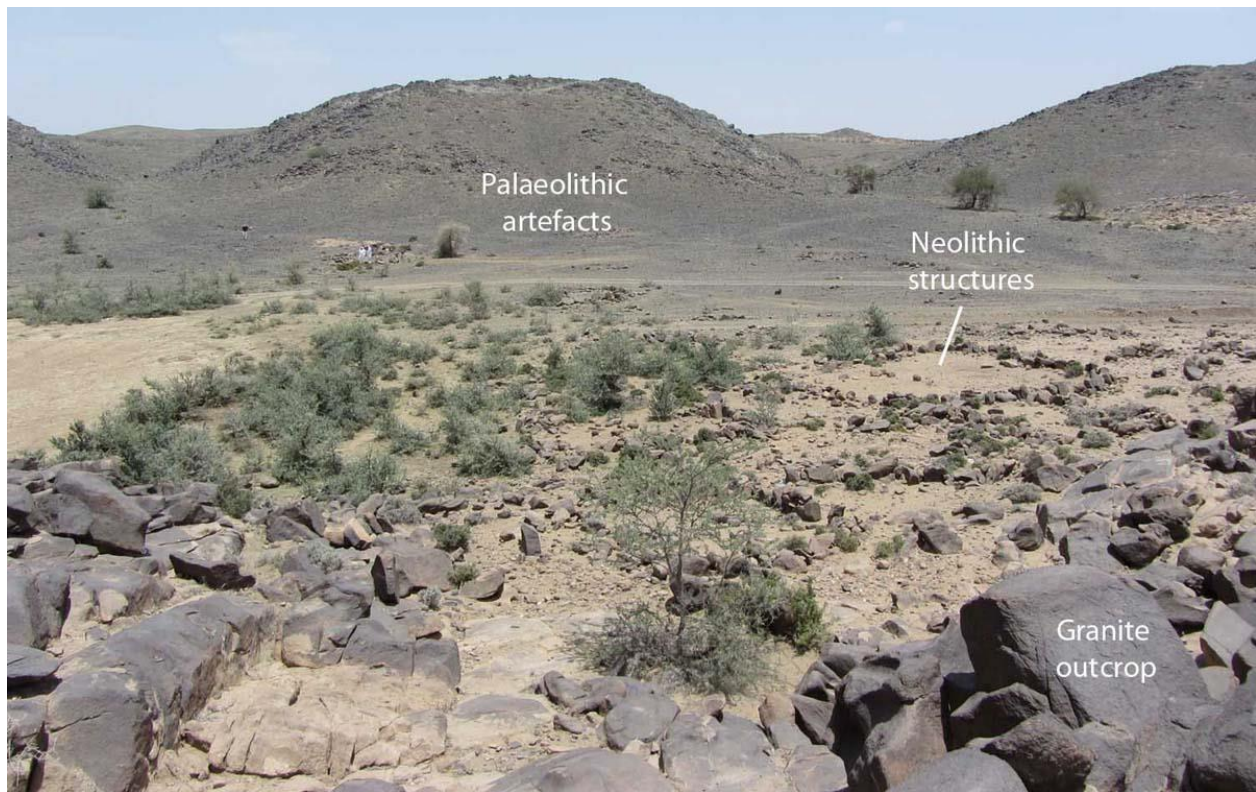


Figure 29. View looking West from the top of a granite outcrop at WP310. Note circular structures in the foreground and to the right of the image. Palaeolithic artefacts were found on the slopes in the middle distance that rise to the hills at the edge of the main valley. A pool created by a dam is immediately to the left of the image. Photo by Robyn Inglis.

On the surface, comprising boulders of igneous rock, at the base of the small sub-valley, and on the footslopes of the granite outcrop, there are a number of round enclosures constructed out of boulders. These structures are 5–6m across, and contained knapping debris and artefacts made from schist, greenish chert and quartz. These structures are visible on Google Earth and clusters of them continue along the granite outcrops that run along the eastern edge of the main valley. A low density scatter of lithics is present on the top of the granite outcrop which overlooks the main wadi, with a single undiagnostic flake made from granite, as well as smaller, potentially Neolithic flakes on greenish chert and schist. Upstream, close to the entrance of main wadi into the valley, potential lake-basin deposits were observed from the road.

6.5 Fieldwork on the Farasan Islands

As part of this fieldwork season three days were spent on the Farasan Islands. Continuation of the investigation into prehistoric Holocene coastal resource exploitation was one of the key aims of this passage of work.

Collagen Preservation and Amino Acid Racemization Dating

Amino Acid Racemization is a new dating technique that may be able to provide dates independently of radiocarbon dating, and possibly more accurate dates. The technique measure changes in shell structure that are dependent on the passage of time and the temperature of the burial environment. In order to calibrate the method, the temperature of the burial environment needs to be measured. For this purpose, temperature loggers were buried into a shell mound (GPS: 16°40'16.05"N, 41°58'48.11"E, Figure 30new). These will record temperature every 30 minutes over a year. In this case the temperature will allow the preservation of collagen to be predicted. Collagen degrades over time, being influenced by temperature – where higher temperature results in faster degradation. By determining the temperature within a site it will be possible to predict collagen preservation, for example in bones, or amino-acids in shells. Radiocarbon dating measures the carbon content of shells or other materials, and is stored in the collagen. If the collagen has degraded, then using this technique becomes harder. Likewise DNA analysis relies on the preservation of DNA in collagen. In addition temperature measurements will help to predict the degradation (racemization) of amino-acids,

which will help increase the accuracy of amino acid racemization (AAR) dating. This will be an important experiment for predicting collagen survival in archaeological sites in this kind of environment.



Figure 30. Installing temperature loggers in a shell mound on the Farasan Islands. Photo by Matthew Meredith-Williams.

7. Appendix 2. Members of the Field Team

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