

**New York University**  
**Excavations at Amheida 2011**  
**Geological survey**

Pr. Jean-Paul Bravard, Université de Lyon (Lumière - Lyon 2)  
Dr. Ashraf Mostafa, Assiut University  
Dr. Romain j. Garcier, Université de Lyon (Ecole normale supérieure)

**Introduction**

The El Deir team of geographers visited the site at Amheida for a few days in late January 2011, under the Partner University Fund convention between New York University, the Université de Poitiers and the Université de Limoges.

The purpose of the visit was to liaise with Amheida geologist Dr. Katherine Adelsberger, and exchange ideas about the Holocene and historical evolution of the site environment, based on joint fieldwork observations and comparison with the Deir site in the Kharga oasis. The relevance of such observations for archaeological research might be high, for a number of questions pertaining to changing environmental conditions and human occupation on the site remain unanswered as of yet. Head of excavations Pr Dr. Paola Davoli summarized them so:

- Changing building functions: there was a Roman bathhouse on the site. However, it was destroyed at the beginning of the IVth C. AD and the buildings and materials were reused for other purposes (most notably, a school building). It is unclear why.
- Erosion: how come some buildings have been entirely eroded to and some, arguably of the same period, are still standing?
- End of human occupation: archaeological evidence indicates that the city was left by its inhabitants at the end of the IVth Century AD. No explanation can be given or derived from archaeological or written sources yet.

These questions may point towards changing environmental conditions/water availability as one important controlling factor of human occupation on the site if cultural explanations cannot provide conclusive arguments.

**1. Tasks and observations**

27th January was devoted to a general tour of the site, with a presentation of the archaeological excavations by Dr Paola Davoli, and a tour of existing spring mounds. Attention was directed at the south-western and eastern parts of the site.

29th January was devoted to the identification and sampling of yardangs indicative of former playa formations.

30th January was devoted to an exploration of the Northern part of the site (north of the former city).

GPS points of interest are coded following K. Adelsberger's terminology (AM: reported observation/GS: measured geologic section). When given, coordinates are in UTM 36N, WGS 84 format. JPB has made written descriptions and drawings of cuts (w/ indication of the location of sampled charcoals).

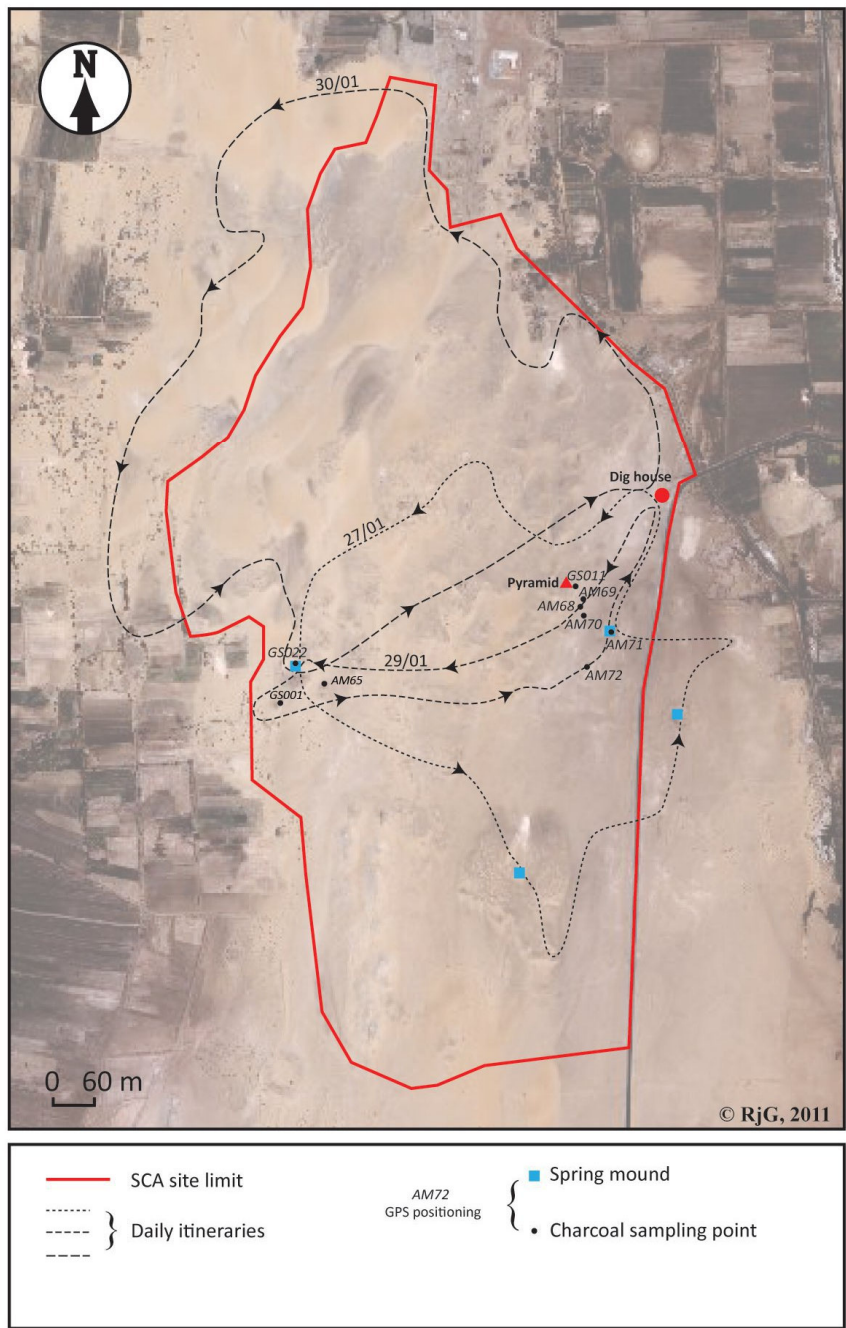


Figure 1: Location sketch of fieldwork research

One main feature of the Amheida site is the presence of yardangs - that is, streamlined hills constituted by a combination of wind-related erosive processes (abrasion and deflation). On the site, yardangs are made of semiconsolidated materials (compacted and/or bedded sand, silt, fragmented shales).

### *Western side*

The first yardang to have been studied [GS001 - 2845004,07m N 85047,01m E] displays the following stratigraphy:

- a top unit, about 1 m thick, constituted of a disturbed silty/sandy deposit, without clear stratification, and rich in pieces of ceramics [unit 1]. Charcoals have been sampled in this unit.
- a second, intermediate unit, constituted of stratified sandy layers indicative of dunes [unit 2], about 1,80 m thick. In some places, a reddish layer appears, indicative of a shale-derived wind-blown deposit.
- a base unit of compact, un-stratified, grey shale/silt, approximately 2,5m thick, thereafter called [unit 3]. This unit is devoid of ceramics.

These units are considered to be indicative of a former Holocene playa, which extension is currently not precisely known yet.

Just north of the yardang, a well area (about 15 m wide) has been surveyed [GS 022]. It is located on the western part of the site and is currently filled with sand. The rims of this circular area are made of stratified units (the same as the previously analyzed yardang's). However, on the eastern side of the margin, unit 1 has been protected from deflation by a man-made 20-50 cm cover of reddish clay from the Mut formation, probably extracted from the well area. Where this protective red layer is present, the top 20-30 cm of unit 1 underneath are indisputably a layer of tilled light brown soil, indicative of agricultural land use. This level may be dated (charcoal), which will provide the age of the soil (and the terminus post-quem of the reactivation works in the well area).

The presence of discordant Mut formation sediments can only be explained by human activity. The same observations (man-hauled bedrock sitting atop more recent formations) have been made near suspected wells or spring mounds elsewhere on the site. In a few occurrences, the red clay sits on top of yardangs (for example, near AM72), especially in the zone north of the pyramid (near the pottery ovens), where it has provided the same kind of protection against wind erosion due to its cohesiveness. Two, non mutually exclusive, explanations for the presence of extensive clay-clad areas can be advanced: (1) shales from the Mut formation have been dug out of the well area and put on its rim to deepen the well and increase a dwindling water outflow and (2) the clay-rich Mut shales, mixed with sand, may have been used as inputs to pottery/brick making activities.

Just east of the well area, a small butte has been analyzed [AM65; 2845063,10m N 85099,00m E]. The butte, a former sand dune, is about 2 m high. It is topped by a ruined mudbrick building (a tomb?). A charcoal has been sampled there, just below the floor of the building.

### *Eastern side*

On the eastern side of the site, similar features have been observed: 1) silty-sandy yardangs with the same structure as in the western side, shaped by deflation. Dating the units is possible. 2) areas where former spring mounds have been excavated to feed irrigation canals younger than the former playa level.

To the east of the main contemporary road, one butte has been surveyed. It is about 3 m above the base level and a mudbrick wall has been identified on top of it. The butte is constituted of hardened wind-blown sand.

### *Southern spring mound and traces of irrigation*

A large spring mound, with two vents, has been surveyed at the south-eastern edge of the site inside a large horse shoe-type depression. The upper surrounding area displays features of ancient spring mounds, but the lower spring mounds have been active during the Holocene, with live vegetation still standing. Lateral terraces sloping to the north (and rich in ceramics) were probably related to the former playa. This area has been deflated and a more recent (and lower) irrigated perimeter was clearly fed by canals, which originated from the spring mounds and delivered water to the north. This perimeter is to be dated .

Also a fine sheet of carbonated sediment is present below the north vent, indicative of standing water or water seeping through the ground.

### *Northern area*

Remnants of the former playa have been observed, as well as spring mounds dug into well. One of them is drained by a large canal related to an agricultural perimeter opened into the Mut shale, well below the former playa level. Shifting dunes mask part of the area. A detailed survey is still to be performed.

## **2. An evolutionary scenario for environmental conditions on the site**

It is too early to provide reliable conclusions after this short survey. 16 samples for radiocarbene will be sent to JP Bravard then to Lecce laboratory. The dates will allow to provide a chronology of the following main stages:

- Extensive agricultural perimeters, and good alluvial soils, existed during the Antiquity, probably since the Early Pharaonic period. They belonged to a unique playa unit or to different smaller playa units separated by outcrops of red shale belonging to the Mut Formation.
- Natural spring mounds allowed the irrigation of those perimeters but their discharge may have decreased progressively. Some of those spring mounds have been dug to reactivate the discharge of transforming them into wells.
- Desertification affected the site. This statement was deduced from the observation of landforms, which demonstrated the occurrence of deflation during the Antiquity. The period of deflation is still to be determined and could be correlated with the reactivation of spring mounds.

## **3. Directions for further research**

Based on the radiocarbene dates, the first hypothesis will be discussed (confirmed or modified). It will be then possible to go into the next stages of the field survey:

- Checking the preliminary environmental results with the archaeological data to discuss the relevance of the hypothesis concerning the onset and the history of desertification, as well as land degradation
- On this base, developing a detailed topographic survey, including the three dimensions of the playa which surrounded the site of Amheida, and the successive irrigated perimeters.

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Katherine A. Adelsberger, Knox College

The description that follows is based upon observations during the 2011 season that have built upon, and in some cases have slightly altered the details of, previous work at Amheida, conducted by the site topographers as well as myself. It should be noted that a Munsell color chart was not available during this survey, and colors are therefore described as closely as possible based on observer bias. In addition, because the region of Amheida is one of active dune activity, local geology has been described as best as possible using current sedimentary exposures. Future dune movements may provide additional opportunities to describe and correlate local outcrops. Also, this field report reflects initial data and impressions at the end of the 2011 season, which are subject to revision through additional data collection and analysis.

Geologic survey during 2011 built upon the geologic survey of 2010 (Figure 1), and focused on a much finer-scale investigation of units that were described on a macro scale during the previous season. Survey was aided from 1/27 – 1/29 by the visiting team of geologists from the El Deir project, who were instrumental in the verification and discussion of multiple hypotheses concerning water resources at Amheida. Survey included additional documentation of GS001-GS009, units of exposed dune and interdune stratigraphy to the southwest of the site, as well as a newly described recent spring deposit.

This year's investigations reveal several areas of probable well-digging and irrigation during periods of the past, and a paleosurface several meters above the modern surface that was anthropogenically altered.

## **Stratigraphy**

### *Southwest (GS001-GS006)*

Reinvestigation of these units has led to a new interpretation of the origin of some of the units previously examined. The stratigraphy here has been divided into three major units. Unit 3 is the lowermost unit and consists of bioturbated sand. This unit does not show features of aeolian deposition alone, leading to the hypothesis of sand deposition and later bioturbation by roots in a playa environment, potentially during the Early Holocene given that the Early Holocene was significantly more humid than later periods. Unit 2 lies above Unit 3 and is composed of medium-fine well-sorted sands. The southernmost sequence contains cross-bedding in Unit 2 indicative of dune formation, whereas units to the north exhibit increasingly horizontal bedding indicative of sand sheets. This sequence is consistent with the presence of dune/interdune environments, where sand sheets would be deposited alongside dunes. The more northerly sands also exhibit increased Mn and Fe staining, bioturbation, and root casts, suggesting increased influence by water compared to the units farther south. In all cases, dune/interdune deposits are capped by water-lain materials containing gastropods, including *Melanoides turberculata*.

The transported nature of the red capping clays investigated last year have been confirmed by their identification as Mut formation shales, local bedrock in this area. These red caps are thickest directly adjacent to a gap in preserved outcrops, and the thickness of the Mut decreases with distance

from this gap. The Mut present here is also “chunky” and is visibly the result of physical digging or removal from its bedrock position. In some areas directly adjacent to the gap, pieces of Mut shales are included within sandstone flows, suggesting that sand was wetted in the vicinity after Mut shales had been heaped in the vicinity. All of these lines of evidence suggest the digging of a large well, the location of which is suggested by the local geomorphology.

The nearby dune deposits, particularly GS001, also reveal evidence of human usage of this area in the form of a massive 0.50 m section of massive sand overlying the well-structured dune forms within the rest of the outcrop. This, combined with the presence of ceramic fragments and charcoal in this layer, suggest the presence of a tilled layer, resulting from local agriculture that was likely made possible by local well-digging for irrigation. The presence of this tilled surface approximately 3m above the modern surface indicates significant deflation between the final period of land use and modern times.

#### *Southeast (GS007-GS010)*

To the southeast of the Temple hill (Figure 2), two large hills reveal the same general stratigraphy found to the southwest. Both large hills have been determined to contain a cap of transported bedrock material, similar to the revised interpretation of the southwestern units at the site. This cap occurs on top of sand deposits. The presence of some areas of highly oxidized sands and pieces of ironstone suggest that this transported material may have been sourced in a spring mound.

The isolated yardang present to the south of these large hills provides yet another outcrop, described as GS010. A similar stratigraphy is revealed, although in this case the cross-bedding of Unit 2 dune sands is more obvious. The inclusions of sandy silt and shale described in the previous report occur in the uppermost levels of Unit 2, and suggest Mut formation inclusions in sand. Repeated occurrences of Mut inclusions may suggest multiple episodes of anthropogenic digging through bedrock or activation of springs and subsequent transport of these pieces. The chunky cap of material is now interpreted as the result of local removal of bedrock during a period when the top of the sand layer was at or near the land surface.

These lines of evidence are consistent with the local presence of a previous spring mound or other feature that would have been excavated to access local groundwater. The extensive network of channels and a larger canal that are currently present between these outcrops also suggests a local source of groundwater, and potentially a more recent excavation into the same groundwater source. Evidence for modern irrigation is present slightly south of the described units, including a plastered mat set over canal features and plant roots preserving original organic material. Obtaining an estimate of the timing of these features would inform the last viable period of groundwater irrigation in this portion of the site.

#### *East (GS011-GS013)*

These units have also been reinterpreted based upon the stratigraphy described thus far, to suggest local excavation of bedrock, although in this case Mut formation material appears to be mixed with charcoal and sand. In this area there is also no obvious evidence for surface water on or below the removed Mut formation deposits, and there is no obvious geomorphic area where bedrock has been removed, as for the digging of a well. However, because these units are more proximal to the site of Amheida proper, it may be worth some investigative digging in an effort to identify a potential well site. It is possible that this area represents a storage or disposal area for Mut formation materials that had been altered in order to make use of them for some purpose, such as brick- or pottery-making. Material sourcing studies may support this hypothesis in the future.

## **Spring Mounds**

*M1*

Reexamination of this large horseshoe-shaped mound allowed for a reevaluation of previously described stratigraphy, which confirms a likely historic period of activation in this area. A series of well-cemented canal features appear to lead away from this mound and run north for a considerable distance, in some cases leading into enclosed areas that may have been used for water storage. There are also squares of ridges evident that, although highly eroded, are reminiscent of modern irrigation squares used in the oasis. The canals themselves are associated with organic materials including tree trunks, potentially palms, and are preserved several centimeters above the modern surface, suggesting some antiquity to their usage. If mapped in detail, these features may aid in the identification of the paleosurface as well as whether M1 was actually a viable historic source of water. Dating of associated organic materials would be helpful in identifying the period of utilization of the irrigation features, and would also provide some bounding dates for the determination of the rate of deflation in the oasis during the Late Holocene.

## **Current Hypotheses**

The evidence identified during the 2011 season at Amheida suggests a series of events associated with local water, culminating in the abandonment of irrigation and a need to dig wells. At some point prior to occupation, during the Pleistocene but also potentially continuing into the Holocene, spring activity was frequent and led to the deposition of iron-rich precipitates and sands. The landscape was significantly deflated, followed by the deposition of dune and sheet sands. On the surface created by these sands, early farmers tilled the sediment and had access to adequate surface water, either through continued spring discharge or through irrigation.

The primary uncertainty in this scenario involves the relationship between natural spring discharge and the deposition of dune sands. It is evident that surface water was available for farming, but that water could have been obtained through irrigation. It also seems that, at some point, digging into spring features was necessary to keep the water flowing, as indicated by the Mut formation caps on many outcrops. The capping nature of these deposits suggests that digging post-dated at least initial periods of irrigation. Digging of springs may have been required in order to maintain flows, or it may have simply tapped into groundwater sources in the form of a well, without natural flow. In either case, people would have been accessing and utilizing the nature of local bedrock that allowed for the upwelling of groundwater and spring formation, likely due to small-scale fracture and weakness associated with the nearby Budkhulu anticline.

In order to test the above hypotheses, Dr. Bravard and colleagues collected a series of charcoals for radiocarbon dating, in order to verify the periods of occupation of the surfaces we have identified as being irrigated and/or present immediately prior to bedrock excavation. The results of these investigations will likely provide a time frame for irrigation in this portion of Amheida. See the report independently submitted for details of this portion of the 2011 investigation.

## **Future Work**

Though short, the 2011 field season suggests a number of future investigations. Most importantly, elevation data must be obtained for the sites where charcoal was collected, in order to tie future radiocarbon dates to the local stratigraphy and geomorphology. However, other hypotheses would also benefit from verification of at least one episode of well excavation. The most likely area

for this work would be in the GS001-GS006 area to the southeast, where the area of bedrock excavation is evident and the amount of bedrock removed suggests multiple periods of spring clearing and Mut formation removal (Figure 3). Clearing the sand from this area, with an archaeologist involved in case of artifact discoveries or feature identification, would both support our hypothesis of spring excavation as well as potentially reveal additional information regarding the timing and methodology of spring excavation.

Additionally, areas to the southwest may indicate more recent spring activation, and these areas need to be described in terms of stratigraphic and topographic features. Finally, grain size data may aid in distinguishing between the various sand units identified here as units 1, 2 and 3. These analyses can be completed in-country with the help of a few undergraduate students as long as some sort of laboratory space can be cleared within the house. Other investigations, including GPR and excavations into the southern plain, may also be useful, but should probably be pushed back in light of recent discoveries.

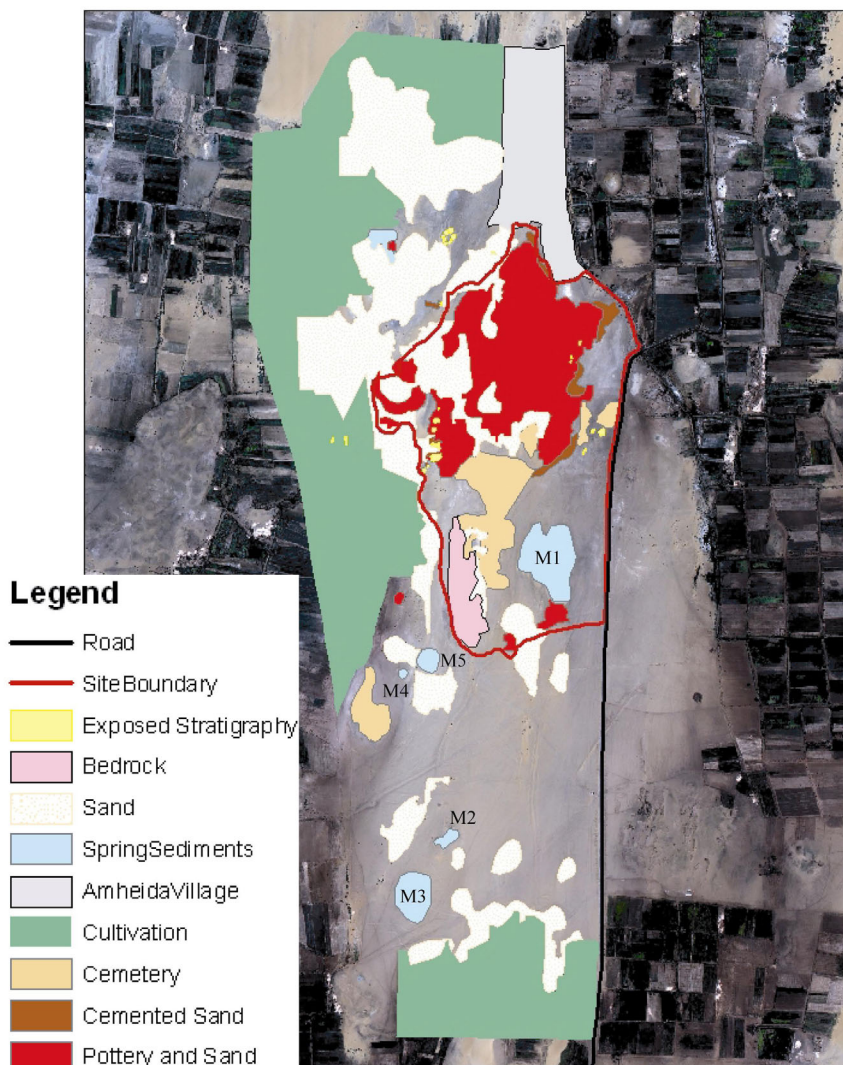


Figure 1. General map of the Amheida area, with exposed bedrock units displayed over aerial photography. Mapped units based upon work by site topographers, updated to represent 2010 geological investigations. Spring mounds are labeled by identifying numbers (M1, etc).



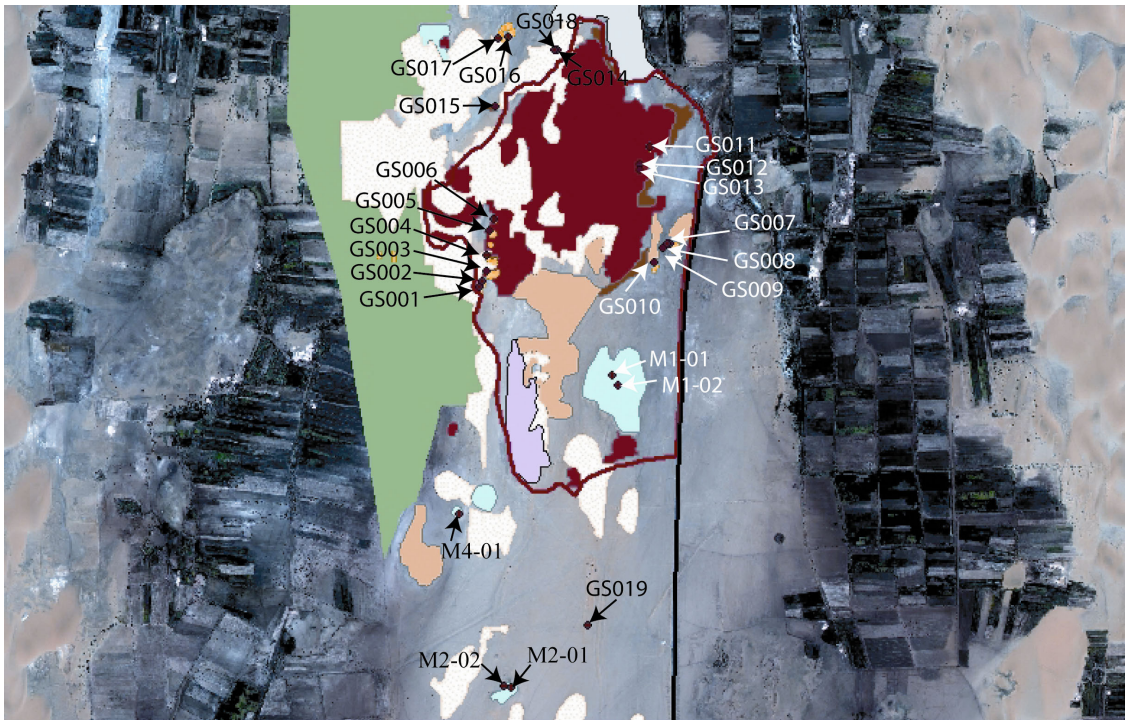


Figure 2. The locations and numbers assigned to geologic sections (GS) described during the 2010 field season and sections described at spring mounds (M).

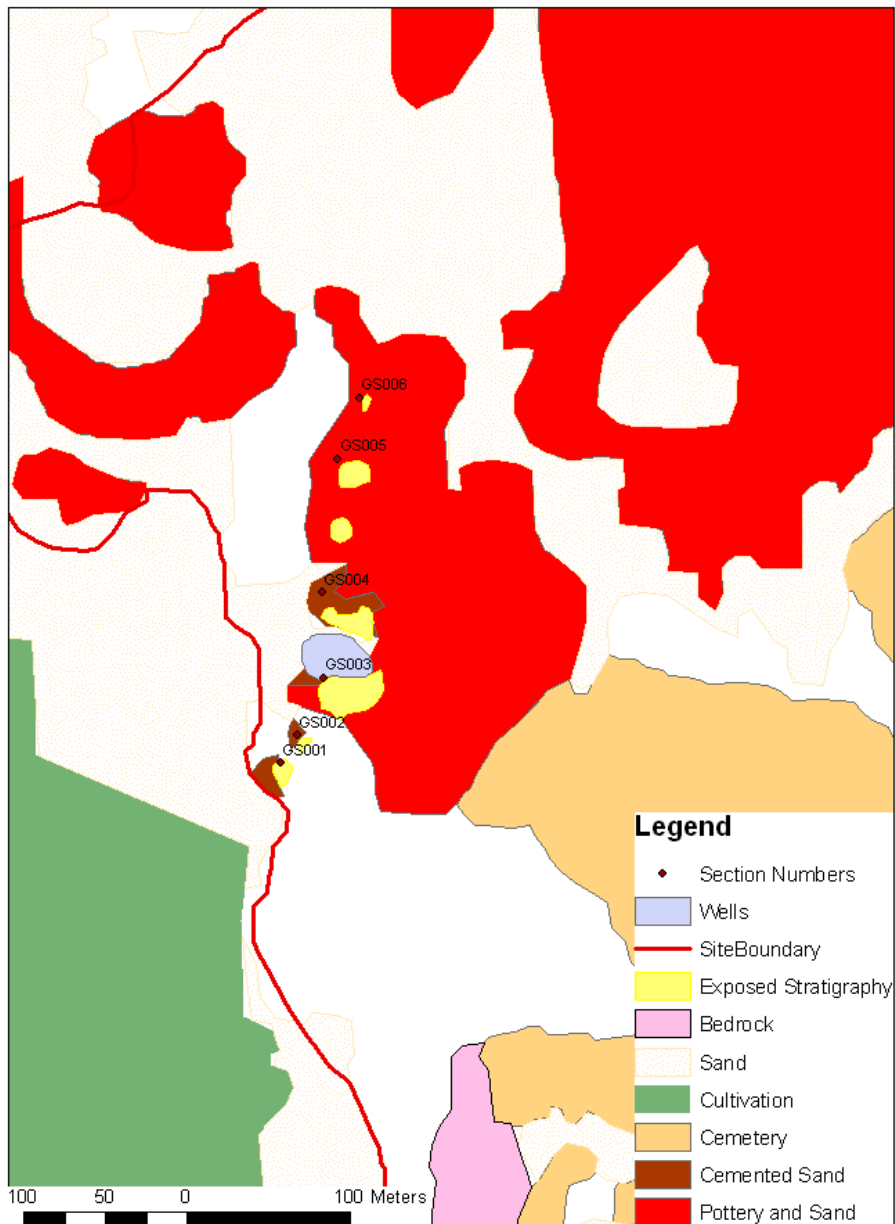


Figure 3. A zoomed view of the southwestern area of interest, GS001-GS006. The blue area outlines the likely area of bedrock excavation that produced the areas defined here as “exposed stratigraphy”, or transported bedrock material. Clearing this area of sand may reveal areas previously excavated in order to obtain ground water, including potential well features.