Bat Archaeological Project
Preliminary Report of the 2022 Season

by

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Table of Contents

List of Figures

List of Tables

Executive Summary

The Bat Archaeological Project (BAP) conducted its 2022 season of excavations and surveys from 26 December 2021 – 24 February 2022. Our research concentrated on five key areas: 1) archaeological excavation at the southeastern end of the Settlement Slope in Umm an-Nar mortuary and domestic contexts; 2) excavation of Umm an-Nar period houses at Rakhat al-Madrh; 3) systematic survey to better understand temporal relationships and artifact density between Bat's different areas; 4) geomorphological analyses at Rakhat al-Madrh; and 5) an expanded arts outreach and experimental archaeology program to further engage the local community.

At the Settlement Slope, mortuary excavations revealed a small but deep Umm an-Nar tomb, unusually located on a hillside with a commanding view of Bat's ancient landscape. A shallow, rectangular platform built into the hillside was discovered adjacent to the tomb and was covered in small bone fragments. The structure may have served as a body processing area utilized before interment. The continued excavations of Structure SS12 on the Settlement Slope revealed the area's Umm an-Nar Middle II and Late Umm an-Nar period occupation and behaviors.

Domestic excavations continued at Rakhat al Madrh, where two Umm an-Nar period houses were excavated and a geomorphological study of the area was conducted. The house excavations revealed ovens, hearths, and botanically-rich contexts within typical Middle Umm an-Nar domestic spaces. Geomorphological and hydrological investigations suggest the area's environmental conditions are unlike any other region occupied in Umm an-Nar Bat. Greater water access from flooding events and the recharge of the basin's water table could have enabled the cultivation of flood crops and provided abundant vegetation for animal pasturing.

A multi-year survey project to better understand the areas between Bat's monuments was completed this winter and resulted in the discovery of a likely Iron Age fortress at Khutm, lithic scatters surrounding Rakhat al Madrh, and a dense area of Umm an Nar artifacts north and east of Operation A. An environmental resilience study continued BAP's investigations of the intersection of the site's ancient and modern landscapes. The analysis of artifacts and samples collected from excavations and survey operations are ongoing.

The project also launched an expanded outreach program, implementing arts engagement strategies to connect with local residents. The program culminated in the creation of an original comic book and experimental pottery production project that was disseminated to the community via Bat's schools after the conclusion of field season.

We deeply appreciate the Ministry of Heritage and Tourism's ongoing collaboration and support of this research.

Acknowledgments

We would like to thank His Excellency Undersecretary for Heritage Affairs Mr. Salim bin Mohammed Al-Mahruqi, Director General of Archaeology and Museums Mr. Sultan bin Saif Al-Bakri, Director of World Heritage Sites Ms. Ibtisam al-Mamari, Director of Excavations and Collections Mr. Ali al-Mahroqi, Mr. Ibrahim al-Maqbali, Ms. Samiya al-Asmi, and all the staff members of the Department of Excavations and Archaeological Studies, the Ministry of Heritage and Culture, Sultanate of Oman for their unwavering support to our mission.

We are also grateful to local staff members working in the field and local offices, particularly to Ministry of Heritage and Culture Representatives at Bat. Mr. Suleiman al-Jabri and Sumaia al-Marmarri Logistical support was provided by Alexandra Sandu and Raya Lakova at the Humanities Research Fellowship Program for the Study of the Arab World at NYUAD. Dr. Charlotte Cable supplied critical guidance in the development and implementation of this season's research program.

Our project was financially supported by the Omani Ministry of Heritage and Tourism, the National Endowment for the Humanities (grant RFW 279340-21), a research grant from New York University Abu Dhabi, and a generous donor to New York University.

The richness of Oman's archaeological record is matched only by the generosity and kindness of its people. We are especially grateful to Bat's modern residents for their hospitality, friendship, and partnership in learning from the region's deep past.

1. Introduction

Eli N. Dollarhide, Jennifer L. Swerida, & Reilly S. Jensen

1.1 Bat Archaeological Project (BAP)

The Bat Archaeological Project (BAP) began in 2007 under the direction of the late University of Pennsylvania Professor Gregory L. Possehl. The first six seasons (2007-2012) focused in part on survey and excavation of the towers in and around Bat, focusing particularly on Kasr Al-Khafaji (Tower 1146), Matariya (Tower 1147), and Tower 1156 (Cable 2018; Mortimer & Thornton 2018; Thornton et al. 2016). The project joined forces for several seasons with the Japanese Team headed by Dr. Yasuhisa Kondo (Research Institute for Humanity and Nature, Japan) in what was known as the American-Japanese Bat Archaeological Project (AJBAP). Several field and study seasons followed with a new focus on third millennium BCE settlement and agriculture and resulted in the completion of three PhD dissertations on research at Bat (Swerida 2017; Nathan Staudt 2017; Dollarhide 2019). Now in its 15th season, the Bat Archaeological Project has shifted its research focus to better understand the complex set of early Bronze Age human-environment interactions evidenced at the site through the lens of cultural landscapes. This focus incorporates and expands on the results of our 2019 and 2020 seasons, which highlighted Bat's early Bronze Age settlement areas. The project has received a major grant from the US National Endowment from the Humanities which will support fieldwork through 2024 to answer three primary questions:

- (Q1): Where and how did UaN communities choose to create places within the Sharsah Valley?
- Q2): What does the organization of settlements and settlement spaces in the Sharsah Valley communicate about UaN social organization?
- (Q3): What kinds, to where, and to what degree is material culture being moved around the landscape?

By combining the results of these interlinked questions, the project aims to understand the cultural processes and socio-ecological strategies practiced by Bat's Umm an-Nar period inhabitants. The resulting reconstruction of an ancient cultural landscape will resituate the critically understudied Omani interior in ongoing debates on connectivity and human-environment interaction in prehistoric societies and build a case study for a persistent, thriving cultural landscape in an arid environment. In highlighting the autochthonous social and technological developments visible at Bat, our results will shift narratives away from basic questions regarding access to water and highlight the complex ways in which Umm an-Nar people transformed different physical spaces into culturally-meaningful places.

To this end, the project conducted surveys, excavations, and environmental research in the Bat heartland, in the southern quadrant of the UNESCO World Heritage Site at Bat, as well as in the area of Rakhat al-Madrh, 7km southeast of Bat, during the winter of 2022. In addition, BAP has assisted the Ministry of Heritage and Tourism by providing technical expertise in several areas:

- Identification of areas for further study in the face of modern development;

- Providing feedback on the ongoing Visitor Center plans;
- Identifying areas for protection;
- Providing interpretive text for visitor signs;
- Participating in regional media events;
- Developing school programs and outreach materials

1.2 Research programs of the 2022 season

The 2022 season of the Bat Archaeological Project began on December 26, 2021 and ended on February 24, 2022. Research focused on several areas: first, at the south end of the UNESCO zone, a 23 ha area bounded by five third millennium towers and the Settlement Slope; second, 7 km to the south east at the satellite settlement of Rakhat al-Madrh; and third, at the Khutm Settlement, located behind the Bronze Age tower. The two-month season was dedicated to ten goals:

(1) to complete the archaeological survey begun in 2018 of the areas between Bat's tower monuments;
(2) to understand the nature of the later Umm an-Nar occupation of the Settlement Slope during through both mortuary and domestic excavations;
(3) to compare third-millennium settlement architecture and contexts between locations within the Bat heartland and between locations inside and outside of the Bat oasis;
(4) to understand the function of the Bronze Age buildings at Rakhat al-Madrh and the subsistence strategies practiced by their builders/inhabitants;
(5) to conduct a geomorphological analysis of Rakhat al-Madrh to understand the site's water history, environmental setting, and gauge potential for ancient water management practices;
(6) to conduct artifacts and ceramics analysis to temporally and materially link Bat's environs;
(7) to map and re-evaluate ancient structures endangered by modern development behind the Khutm tower;
(8) to engage local community members, especially students, in the research process and more effectively communicate project results;
(9) to complete an environmental resiliency survey to better understand Bat's modern landscape;
(10) and to use these results and strategies to inform the site's development for tourists.

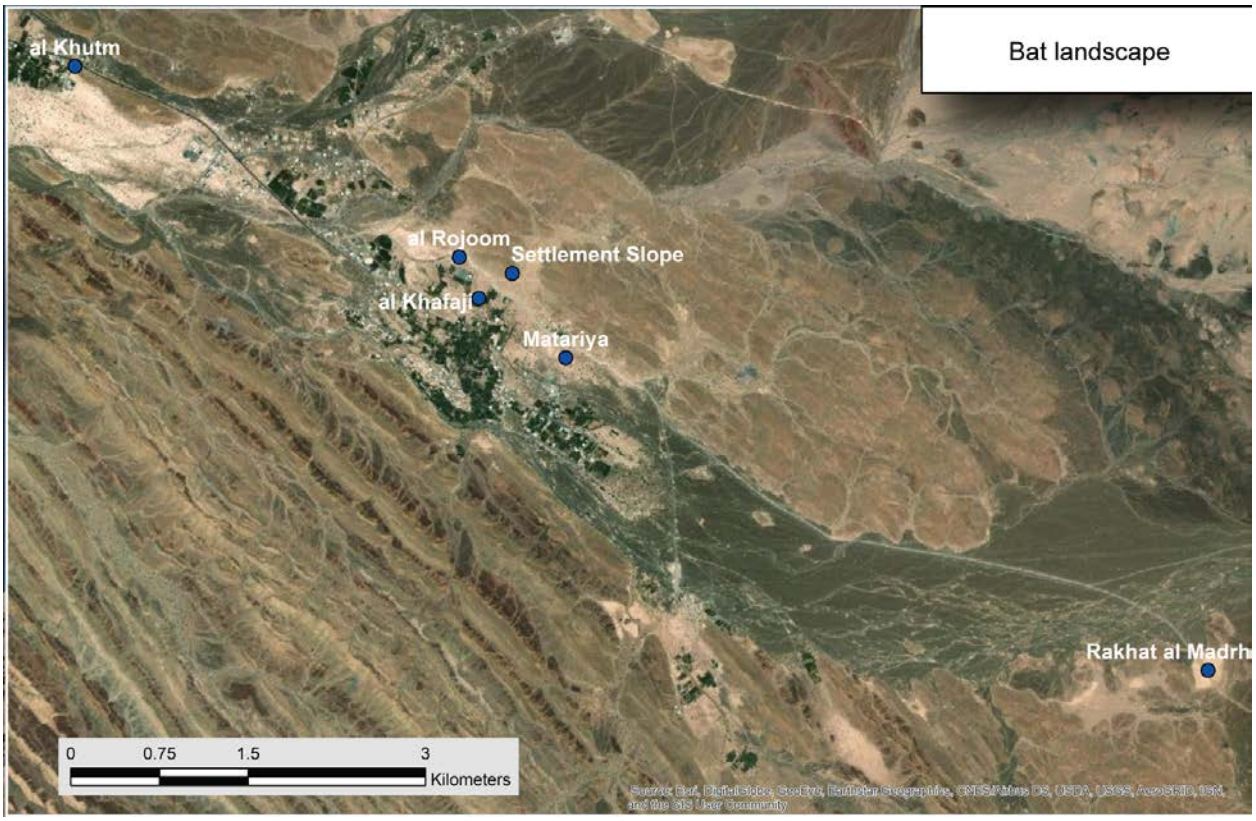

Figure 1: The Bat Landscape. Research this season focused on the Settlement Slope, Rakhat al-Madrh, and Khutm, in addition to outreach with modern Bat's local community.

1.2.3. BAP team members

BAP's research programs this season involved the following members:

Co-directors
Dr. Eli Dollarhide, New York University Abu Dhabi, UAE
Dr. Jennifer Swerida, University of Pennsylvania, USA

Assistant Director
Ms. Reilly Jensen, University of Utah, USA

Survey & excavation team
Ms. Paige Paulsen, Johns Hopkins University, USA
Mr. Freeman Stevenson, SWCA Consultants, USA
Mr. Justin Morgan, University of New England, Australia
Mr. Amir Zaribaf, University of Sydney, Australia
Mr. Robert Bryant, University of Pennsylvania, USA
Mr. Matei Tichindelean, University of California-Los Angeles, USA
Dr. Paul Rissman, Independent Scholar, USA
Dr. Aila Santi, School of African and Oriental Studies London, UK

Ms. Shahd al Naabi, University of Sheffield, UK

Specialists
Dr. Selin Nugent, Oxford Brookes University, UK—Bioarchaeologist
Dr. Stefan Smith, University of Helsinki, Finland—Survey director
Ms. Rebecca Swerida, Maryland Department of Natural Resources, USA—Environmental biologist

Geomorphology Team
Dr. Eric Fouache, Sorbonne University, France
Dr. Tara Beuzen-Waller, University of Tübingen, Germany
Dr. Claude Cosandey, Sorbonne University, France
Dr. Stephane Desruelles, Sorbonne University Abu Dhabi, UAE
Mr. Aleksandre Prosperini, Independent Scholar, France

2. Archaeological Survey

Stefan L. Smith

2.1 Introduction

The third season of intensive and systematic archaeological surveys around Bat was conducted over the course of three weeks from 16 January to 3 February 2022. As in the previous 2020 season, surveys were designed both around work already done and to include new areas. The existing surveys around the Settlement Slope were expanded to the north-west, with 19,500 m^2 newly surveyed, as were those in the area between Matariya and Kasr al-Khafaji, with 30,000 m^2 surveyed around Operations A and B, which geographically constitutes a direct continuation on the other side of Kasr al-Rojoom (Fig. 2a). Meanwhile the hilly landscape on the eastern side of Rakhat al-Madrh was surveyed for the first time, with 22,000 m^2 covered north-east of the previous season's work (Fig. 2b). Finally, a structural survey was conducted over a ca. 14,000 m^2 area on the south-western slope of al-Khutm, with several potential buildings documented (Fig. 2c). Results of the Khutm Settlement survey are discussed in Chapter 5.

2.2 Methods

This season's methodology was slightly different than that of previous seasons, both in terms of planning and execution. However, due to the consistency of the process of fieldwalking, collection, and documentation itself, the derived data can be easily integrated with the earlier work.

The most significant novelty in the survey methodology this season was the integrated use of a rotary-wing UAV (drone) in the planning of the transects. Though drones have been used in previous seasons at Bat to collect aerial imagery of key survey locations after fieldwork, this year saw their targeted use to photograph areas to be surveyed in advance of fieldwork, and the use of the very-high resolution aerial images produced to pinpoint the most desirable orientation and starting point of the transects. This process was found to be most useful at the Operation A-B survey, where the transects were efficiently placed so as to cover the areas around the two main sites, as well as linear features south-west of Operation B visible on the drone imagery (Fig. 3). Without this process, certainly the smaller features would not necessarily have been included in the planned transects, and even if subsequently discovered in the field by accident, would have involved cumbersome re-orientating of the plan, or the addition of oddly-shaped or non-consecutive transects. Instead, these issues of topology could be worked out in advance, and the walking of the transects concentrated on once in the field.

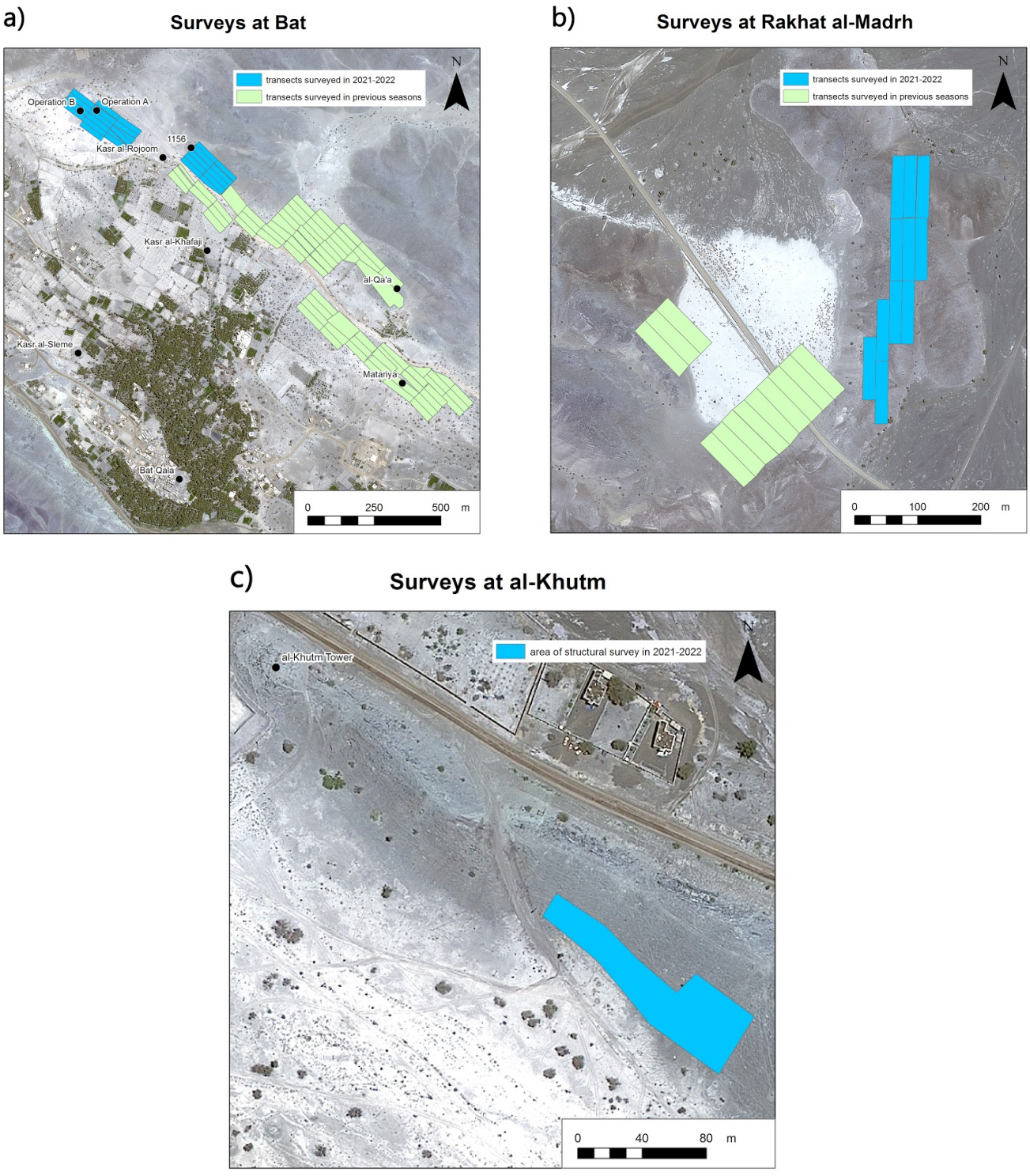

Figure 2: Maps of this season's surveys, in relation to those of previous seasons

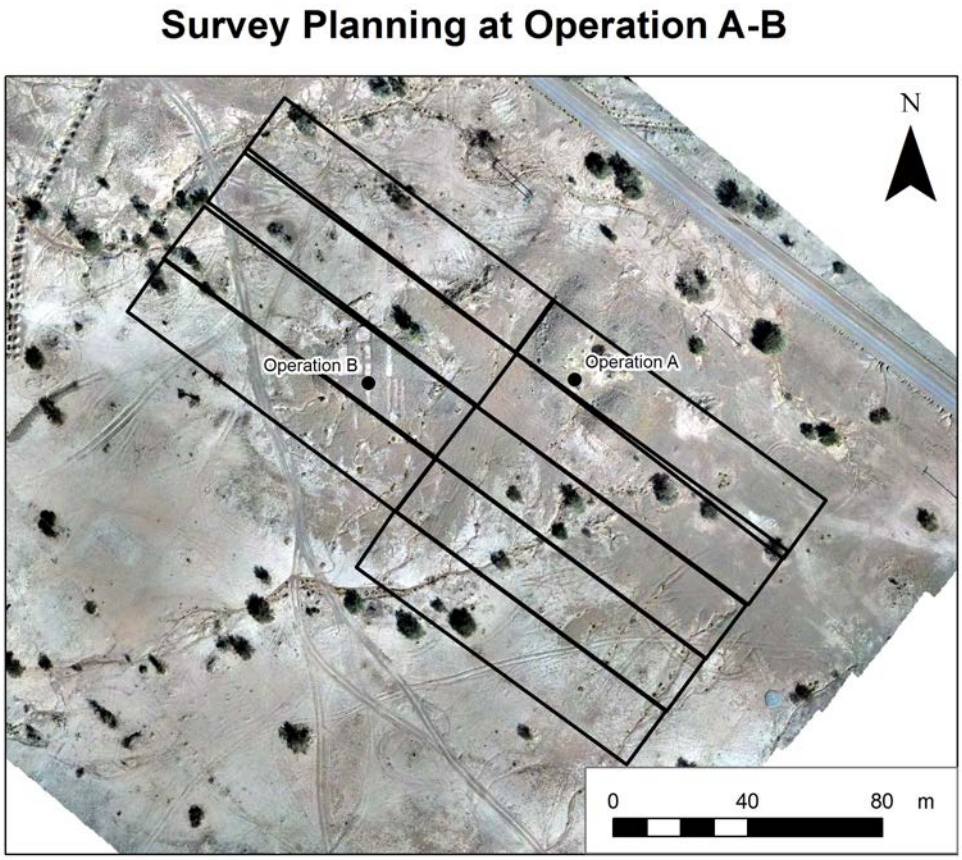

Figure 3: Stitched orthomosaic of drone imagery of the area around Operation A-B, with the initially planned transects marked in black.

A further piece of equipment that significantly increased the speed and accuracy of transect planning was a Juniper Systems Geode GNSS device, accurate to within ca. 1 m. This greatly increased the accuracy of transect corner and feature mapping without having to resort to the time-consuming use of a total station. Coupled with this device, we made use of the mobile application Survey123, from ESRI's ArcGIS mobile applications package, to record artefacts and features discovered during the course of the fieldwalking on a digital form. Although the final output of the collected data remained largely unchanged from previous seasons, the amount of time saved by removing the need for digitisations of paper forms, or the slow input on digital forms on, for example, ArcPad software on Trimble devices, was immense. Additionally, the Survey123 form was created to include presets and options from drop-down menus, plus sections that only appeared when certain criteria were met. For example, the field "feature dimensions" only appeared when it was selected that a feature, and not a transect, was being recorded. This minimised the chances of mistakes being made in the data recording process, again reducing processing time in the lab. Finally, unlike paper or even ArcPad forms, the digital form could easily be edited as needed during the course of the season; thus additional input fields that were found to be of use could be added, or the source of common mistakes discovered and the relevant sections altered to reduce their occurrence.

In terms of execution, due to the smaller fieldwork team this year, the size of the transects was reduced to 20x100 m (compared to 25x100 m in previous seasons). This enabled 5 people to walk the long axis at 4 m distance from each other (so, at the 2, 6, 10, 14, and 18 m marks), each tasked with looking 2 m to their left and right as they proceeded across the landscape. This was found to be an effective method for both visually covering the entire transect and allowing for sufficient speed. Because the collected artefact number is divided by the transects' areas to give a density score, the results from these smaller transects can still be directly correlated with the larger ones.

2.3 Results

2.3.1 Settlement Slope

The 10 transects surveyed along the Settlement Slope yielded the largest density of ceramic artefacts this season. This was to be expected for two reasons – firstly, large numbers of ceramics were also found in the previous seasons' surveys along this slope, and secondly, much of the area surveyed was located next to Tower 1156. Predictably, therefore, the transects with the highest ceramic density are those located close to that site, either directly adjacent to it, or downhill so that slope wash may have been a contributing factor (Fig. 4). The low density of ceramics from the bottommost transects (adjacent to the Bat-Amlah road) may be attributed to the level of wash there being so great that much of the material is in fact obscured by loose sediment. More surprising is the fact that there is a significant difference between the north-west and south-east transect columns, with the latter exhibiting a much lower ceramic density. Part of this may be explained by the increased distance from both Tower 1156 and other features (see below), though since the summit ridge of the Settlement Slope contains a number of cairns, possibly tombs, it might be expected that slope wash would have led to a large number of ceramics here also. However, the slope is much steeper at this point, which might contribute to a greater amount of ceramics being washed down, leading to a lower density on the slope itself. Additionally, human error must be taken into account here, as the difficulty of simply walking along such a steep incline, let alone simultaneously identifying artefacts, may have led to a lower collected rate than elsewhere.

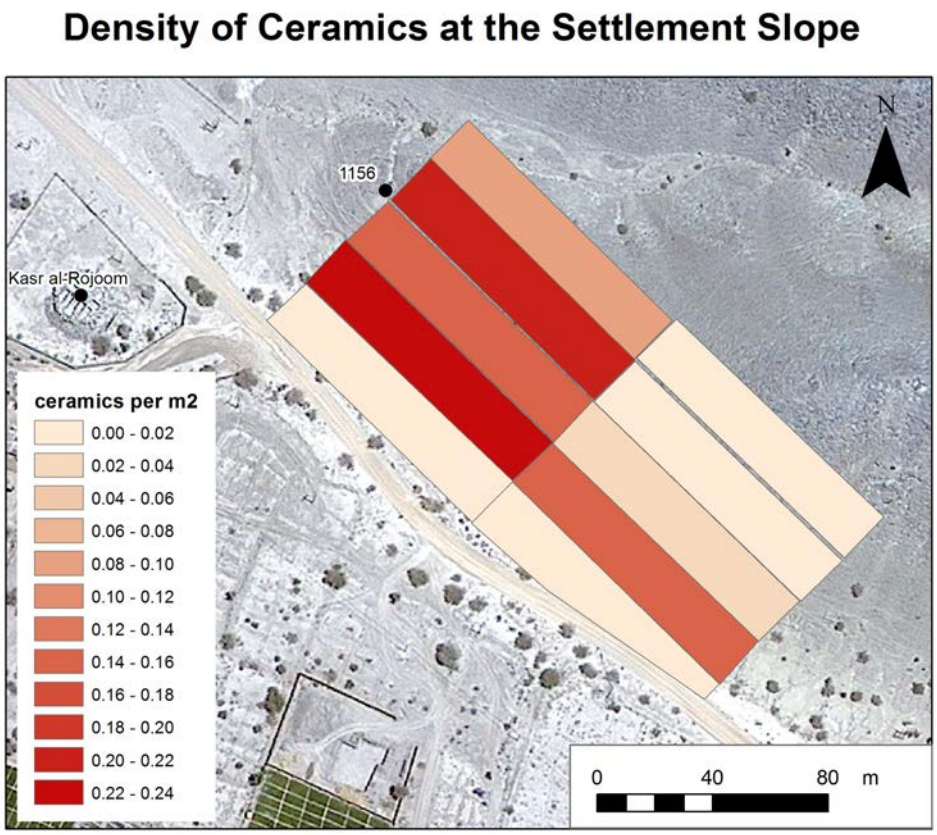

Figure 4: Map showing density of ceramic finds at the Settlement Slope

Lithic finds were relatively scarce at the Settlement Slope, again in keeping with previous seasons' findings in this area (Fig. 5). However, one transect, the closest downhill area to Tower 1156, contained a relatively high density, though in absolute terms still very low (by comparison, around 10 times lower than the highest densities at Operation A-B and Rakhat al-Madrh; see following sections). Whether this can be related to 1156 or not is unclear, especially since the transects closest to that site contain virtually no lithics, which on average are heavier than the typical ceramic sherd, and thus less likely to be affected by slope wash.

Numerous features were identified in this section of the Settlement Slope, most notably large burial cairns on the north-western edge of the summit ridge, and some stone walls running parallel to the slope, largely visible due to exposure by slope wash and rainfall runoff gulleys. Some of these were double-faced, and therefore likely date to the Umm an-Nar period. Two walls akin to the so-called "Brunswig Dams", running perpendicular to the slope, were also identified just north of the Bat-Amlah road, to the south-eastern end of the surveyed area. One set of four walls broadly perpendicular to each other was identified, which possibly could constitute a structure, though this could not be determined with a high degree of certainty.

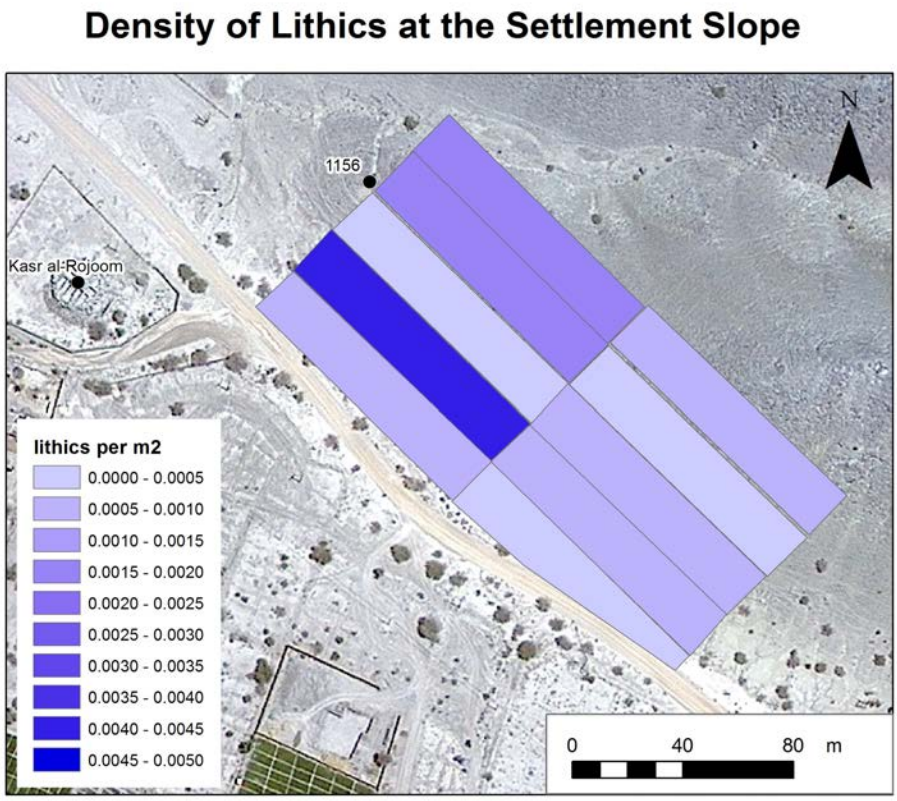

Figure 5: Map showing density of lithic finds at the Settlement Slope.

2.3.2 Operation A-B

The area around Operations A and B are heavily disturbed by slope wash, most of it likely from the Settlement Slope or its vicinity. Therefore, it cannot be expected that a precisely pinpointed artefact distribution analysis is possible. Nevertheless, the 16 transects surveyed in this region exhibit certain patterns which can be interpreted in light of the archaeological landscape, especially in relation to the Operations. It should be noted that the interior of Operation B itself was not surveyed, as it constitutes an area of potential ongoing investigation by another team.

The distribution of densities of ceramic artefacts was found to be broadly similar to that at the Settlement Slope, with some significant variations across the area (Fig. 6). As expected, high densities of ceramics were found close to Operation A, and the density increased towards the direction of Kasr al-Rojoom, to the south-east. Less intuitively, the closest transect to Operation A contained relatively few ceramics, although this might be explained by the particularly intensive slope wash in that section. The lack of ceramics on Operation A itself is more perplexing, but might also be explained by the accumulation of slope wash around and on top of existing structures (see below). The absence of much material around Operation B, meanwhile, is likely explained by previous archaeological work at the site. Overall, in many transects the majority of ceramics were very small bodysherds, indicative of slope wash being responsible for their deposition.

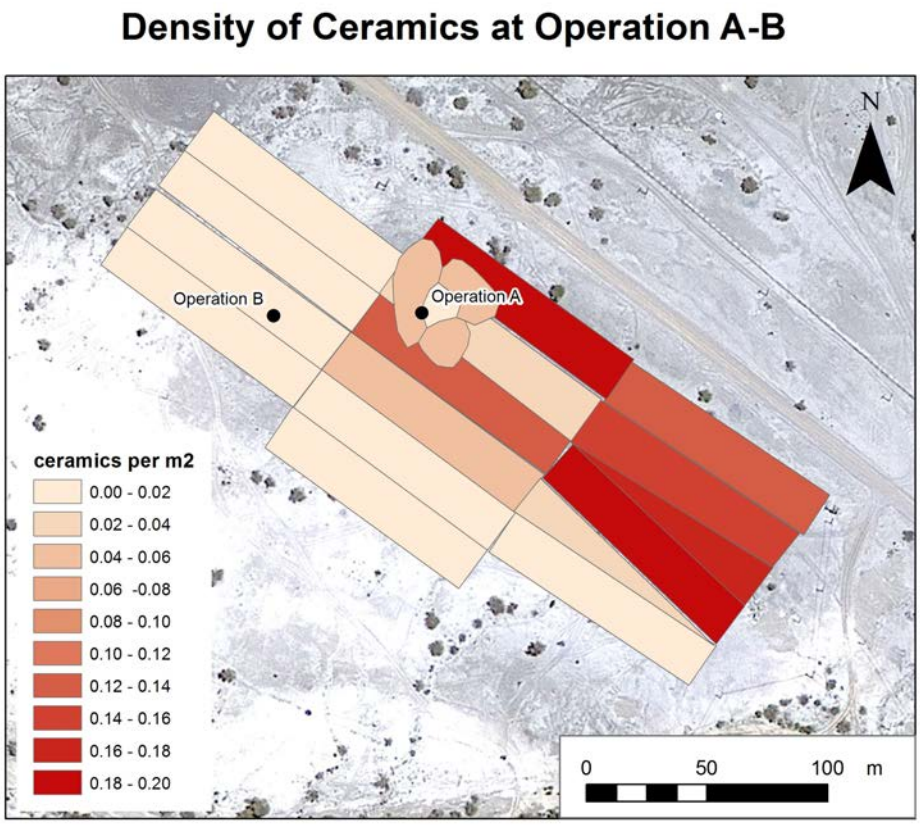

Figure 6: Map showing density of ceramic finds around Operation A-B.

The presence and distribution of lithic artefacts in this area was somewhat unexpected, not correlating to the density pattern of the ceramics, and with the highest density almost on a level with Rakhat al-Madrh (see next section), ten times that of the Settlement Slope. A single transect, the north-easternmost one, contained the vast majority of lithics found over the entire area (Fig. 7). Its location may indicate that wash from the Cemetery is the cause of this lithic density, or that it is related to its proximity to Kasr al-Rojoom. Further targeted investigation of surface lithic scatters in the vicinity of this transect would be needed to say anything more conclusive at this stage.

Apart from the known sites of Operation A and B, several smaller features were identified in the surveyed area. The most significant of these was a single-faced linear wall around 19 m in length, located south-west of Operation A, south-east of Operation B. Furthermore, some circular stone features were identified within Operation A, including one near-perfect circle, ca. 3.7 m in diameter. Also clearly visible were a curvilinear and a linear wall at the southern end of the site, exposed by previous excavations by Christopher Thornton and Charlotte Cable.

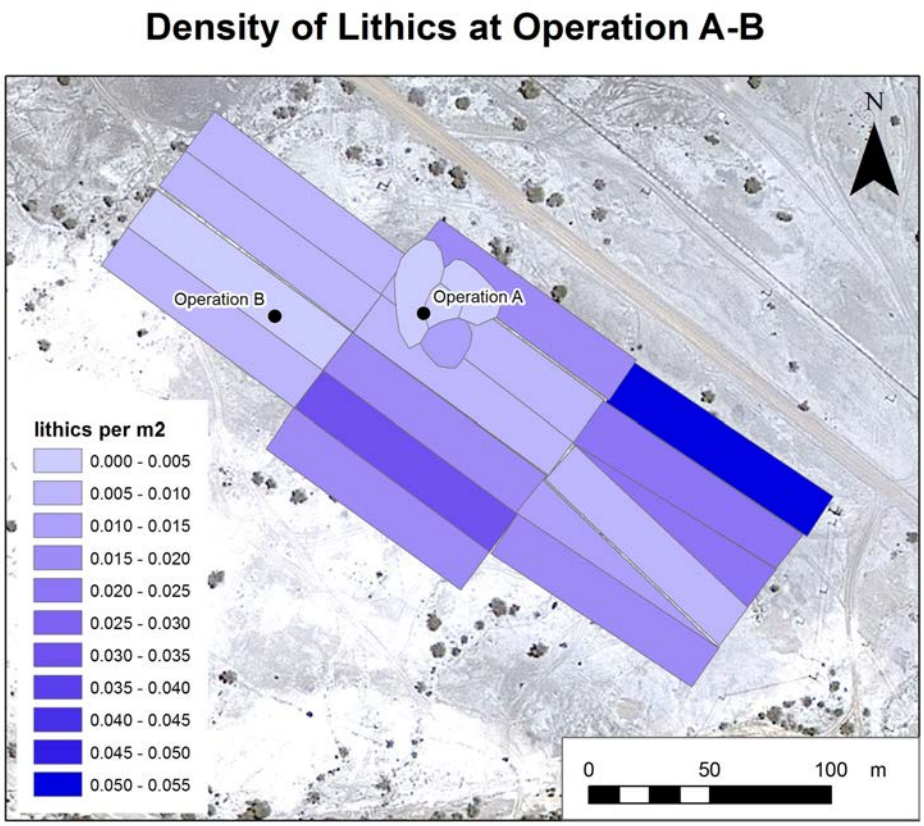

Figure 7: Map showing density of lithic finds around Operation A-B.

2.3.3 Rakhat al-Madrh

The survey at Rakhat al-Madrh was exclusively concentrated on the low hills immediately to the east of the alluvial depression, where cursory visits in previous seasons had sighted features and lithics. The surveyed region comprised 11 transects running parallel to the ridge of the hills, coincidentally lining up with a geographic north-south axis. While ceramics were practically non-existent here, found only within one feature (see below), the density of lithics was found to be high across the whole area, however not uniformly so (Fig. 8). Many were of high-quality raw material, and easily recognisable as distinct, diagnostic stone tools. In general, their density increased to the north-east, with a particularly high volume in one of the easternmost transects; twice as much as the next highest-yielding one. This transect is the only one that touches part of the eastern spur of hills that was otherwise unsurveyed due to the western spur, closer to Rakhat al-Madrh proper, being focused on. This fact, together with anecdotal statements by local people of large numbers of lithics being present on the eastern spur, constitutes a strong recommendation to survey this region next season.

The one transect that does not follow the pattern of lithic density increasing to the north-east is best explained by the presence of 11 features within it. These all comprise small ovals or circles of stones, between 1 and 2 m in diameter. One more unique feature, a circular stone conglomeration with possible concentric stone walls over 3 m in diameter, was located ca. 35 m east of the transect

with the highest lithic concentration. Within this feature were found 14 ceramic sherds; the only ceramics identified in the entire survey area.

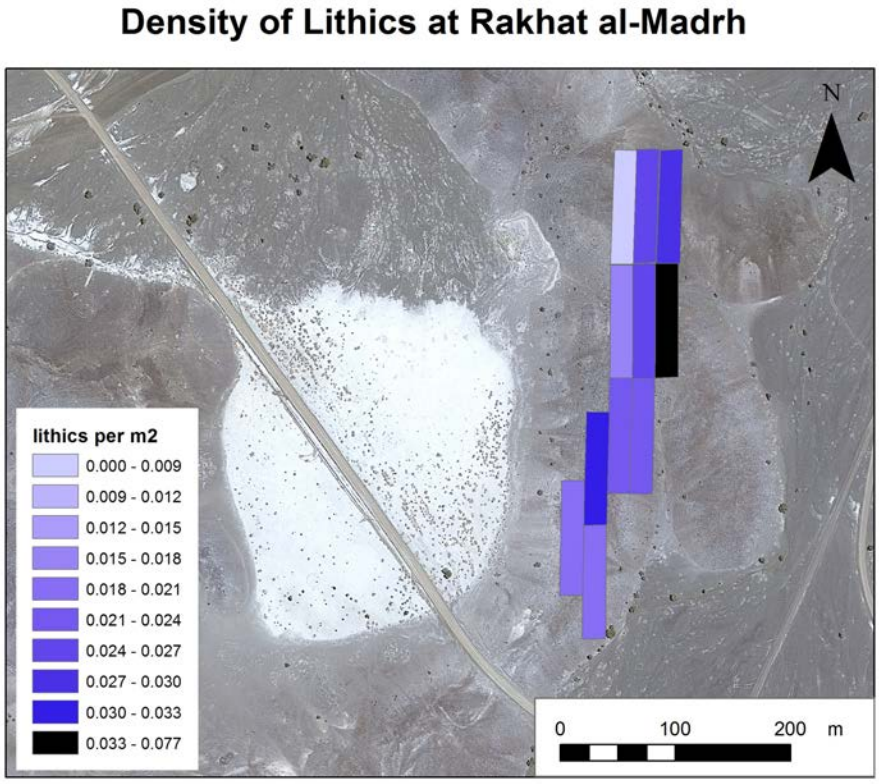

Figure 8: Map showing density of lithic finds at Rakhat al-Madrh.

3. Settlement Slope Excavations

Jennifer Swerida and Selin Nugent

3.1 Introduction

Excavations on the Settlement Slope began on 1 January 2022 and concluded on 24 January 2022. Research targeted two areas at the southeastern end of the hillside: (1) the domestic Structure SS12, partially excavated in the BAP 2020 field season; and (2) an Umm an-Nar tomb located on the crest of a ridge east of and overlooking Structure SS12. Excavations in both locations were recorded in reference to the Master Datum and 5x5 m grid previously established across the entirety of the Settlement Slope (see Table 3.1). They were conducted with the goal of clarifying the lived experience of individuals who resided on and interacted with the Settlement Slope hill during the Umm an-Nar period.

Dates(mm/dd/yy): 01/10/22; 01/11/22 Photos: 690 **Area**: ~15.511 ha	Master Datum N 2569259.2000m E 480350.9000m Z 544.1400m Projection: WGS 84 / UTM 40N	Backsight: N 2569273.3467m E 480350.8925m Z 542.2978m EPSG: 32640

Table 1: Settlement Slope datum and backsight specifics

3.2 Domestic Excavations: Structure SS12

The domestic excavations at Structure SS12 continued research begun at the location during the BAP 2020 field season (Swerida, Dollarhide, and Cable 2020). Excavations were directed by Dr. Eli Dollarhide, Dr. Jennifer Swerida, and Reilly Jensen. Two contiguous trenches (Trenches 561862b and 561863b) were excavated on the Settlement Slope hillside in an area immediately adjacent to trenches excavated in 2020, where it was suspected that the remainder of domestic Structure SS12 was located. Additionally, two trenches excavated during the 2020 season (Trenches 561862a and 561937b) were cleared of backfill and select areas within them were chosen for further excavation. This work was carried out with the goals of:

- Defining the full extent of Structure SS12;
- Identifying room function within the building, which is believed to be a Late Umm an-Nar house;
- Completing excavation of a suspected courtyard space at the western end of the building.

Excavations revealed the northern and eastern portions of the Structure SS12 stone architecture, preserved contexts within the building's western courtyard, and an occupational phase pre-dating the building.

3.2.1 Methodology

Consistent with the methodology established in the 2020 excavations in this location, trenches were assigned unique "trench" numbers with a prefix (56-) taken from the published site grid followed by a unique number—for example, Trench 561862. As the grid is aligned with the sloping terrain, each grid square was bisected east-west to create 2.5 x 5 m trenches stepping up the hillside. The southern trench in each grid square was given the suffix "a" and the northern trench was given the suffix "b"—for example, Trench 561862a is immediately south of Trench 561862b. The locations of each trench and the excavated contexts within them were recorded on paper forms and in digital records.

During excavation, all Settlement Slope contexts or "lots" (dirt context, feature, artifact, or sample) were given a unique number consisting of the project season prefix (22-) plus a unique number beginning with 221201. Lot numbers were continuous across the excavated trenches in this location. Finds data, dimensions, and other characteristics of individual lots were described on a paper-based form. Each lot was also photographed and the images logged. Later, during post-processing, the disparate data sets were partially integrated for spatial visualization.

The building designation—Structure SS12—is consistent with a numbering sequence already established in published research of the Settlement Slope (Swerida 2017; Swerida & Thornton 2019a).

3.2.2 Results

The location of the Settlement Slope domestic excavations was determined based on the results of the BAP 2020 excavations (Figure 9). In 2020, the southwestern portion of Structure SS12, believed to be an Umm an-Nar house, was excavated in three trenches—Trenches 561937a, 561937b, and 561862a—in an area of the Settlement Slope hillside where the terrain is more level than its surroundings and rectilinear stone walling was visible on the unexcavated ground surface. The construction style and layout of this building is comparable to Umm an-Nar period architecture previously excavated on the western end of the Settlement Slope (Swerida & Thornton 2019a). The 2020 excavations revealed that Structure SS12 has at least two construction phases, the latter of which is dated to the Late Umm an-Nar period through C14 and ceramic analysis. In order to expose the full extent of the building and further clarify its function and use history, five additional trenches—Trenches 561862b, 561938a, 561938b, 561863a, and 561863b—were established continuous with those excavated the previous season. It was estimated that the content of these eight trenches would include the full extent of Structure SS12.

Figure 9: Map of the Settlement Slope indicating the location of Structure House SS12 and the 2022 season excavations.

Over the four weeks of BAP's work at the Settlement Slope, two of the 2022 trenches—Trenches 561862b and 561938b—were excavated to at least the level of the Structure SS12 foundations, two of the 2020 trenches—Trenches 561937b and 561862a—were cleared of backfill and key locations within them were targeted for further excavation, and a further three trenches—Trenches 561863a, 561863b, and 561938a—were scraped clean at surface level in order to clarify the building's architectural layout. Excavations revealed the near-full layout of Structure SS12, confirmed the existence of at least two architectural and use phases, and provided further clarity on use of space within the building. As was found in 2020, portions of the excavated trenches were disturbed by erosion. All trenches share a similar stratigraphic structure that consisted of: (1) an uppermost layer of coarse gravel and silt; (2) alternating layers of dense gravel in silt and fine sandy silt that are probably the result of runoff wash from erosion; and (3) a fine, dense, brown clay that is the matrix associated with the use of the building.

3.2.2.1 Trench 561862b

The northwestern-most of the Structure SS12 trenches, Trench 561862b, is situated immediately north of and uphill from the three excavated 2020 trenches. No architecture was visible at surface level in this trench, however, it was expected that the north-south running Wall 201030, previously identified in Trenches 561936b and 561826a to the south, would continue into this trench. It was further

hypothesized that the trench would contain the northern exterior wall and northwestern corner of Structure SS12.

The entirety of Trench 561862b was covered in a ca. 10 cm layer of topsoil consisting of a fine, medium brown silt with dense, coarse gravel. An assortment of ceramic sherds stylistically datable to the Middle and Late Umm an-Nar period, including a part of a suspension vessel (Lot 221201) typical of the Middle Umm an-Nar 1 (Swerida, Dollarhide, & Jensen 2021), were collected from surface lots. No sherds or other finds datable to later periods were recovered.

Below the topsoil, contexts in Trench 561862b were found to be partially disturbed by erosion damage, especially in the center and eastern edge of the trench, where two large drainage gullies were identified. The alternating layers of coarse gravel wash and clay beneath the topsoil contained a mixture of ceramics stylistically datable to the Middle and Late Umm an-Nar period, including a second suspension vessel sherd (Lot 221225) and an example of painted appliqué typical of the Middle Umm an-Nar 2 (Lot 221217). No secure contexts were identified in the layers of gravel wash.

The first feature of note encountered in Trench 561862b was a shallow hearth or fire pit (Lot 221234), located in the center of the trench in a corner formed by stones from the top stone courses of Walls 221222 and 201030. The pit was approximately 50x40x15cm and filled with a mixture of dark gray ash and charcoal. While the feature was most likely the result of an opportunistic revisitation to Structure SS12 by a later (Wadi Sûq, Iron Age, Medieval) group, all the associated pottery is stylistically datable to the Umm an-Nar period. Analysis of C14 (Lot 22136) and phytolith (Lot 22135) samples taken from the feature will provide greater clarity to the building's use history. No further features or secure contexts were identified in Trench 561862b above the level of Structure SS12.

Two stone walls were identified in this trench as belonging to Structure SS12: Walls 221222 and 201030. Wall 221222 is a large (62cm wide) wall, running east-west across the length and just within the confines of the trench. Wall 221222 is preserved 2-3 courses tall, reaching a maximum height of 45 cm, and is constructed of two rows of dovetailed, roughly hewn limestones averaging 50 x 3 5 x 15 cm in size and is held together with a dark brown mud mortar. No evidence of a superstructure was identified. The wall is founded on a layer of dense, coarse gravel that presumably grades into the bedrock of the Settlement Slope hillside. All excavated contexts to the north of the wall were disturbed by erosion. No cultural material was found below the Wall 221222 foundations.

The length of Wall 221222 is broken in two locations—the first in the center of the trench and the second at its far eastern edge—where its stones were dislodged by water erosion down the Settlement Slope hillside. These disturbances in the wall align with drainage gullies identified in the excavated contexts within the building to the south. It is, nevertheless, possible to confirm with near certainty that Wall 221222 is the same feature as Wall 221220, which follows the same course in Trench 561863b to the east and shares identical structural characteristics. Together, these walls form the northern exterior edge of Structure SS12. It is also possible that the building's northwest corner is

located just beyond the western edge of Trench 51862b. The inner face of Wall 221222 is missing a large stone at the point where it meets the trench's western baulk, where a bonded stone projecting to the south may have been dislodged. Additionally, a number of displaced stones roughly equivalent in size to those used to construct Wall 221222 were found in a roughly linear pattern along the western edge of Trenches 51862b and 51862a, aligned with the fragmentary north-south wall 201015 in Trench 51937b to the south. These stones (Lot 221275) may be the remnants of the destroyed western exterior wall of Structure SS12.

The inner face of Wall 221222 is bonded with the interior north-south Wall 201030, first identified in the BAP 2020 season in Trenches 561937b and 51862a to the south. The construction style of this wall is typical of Middle Umm an-Nar period settlement architecture at Bat: well-formed wall foundations constructed of 2-3 courses of roughly worked, dovetailed limestone blocks set horizontally into a mud mortar (see Swerida & Thornton 2019a, 2019b). Wall 201030 is founded on the same layer of dense, coarse gravel as Wall 221222 and forms the western edge of a two room semi-subdivided unit, first identified in the BAP 2020 season (see Swerida, Dollarhide, & Cable 2020) and a common layout for Middle Umm an-Nar 2 domestic buildings at Bat (Swerida & Thornton 2019b; Swerida 2022). No trace of a superstructure was detected atop the portion of Wall 201030 that runs through Trench 561862b, however possible melted mud bricks were identified above the wall in Trench 561862a to the south in the 2020 season (Swerida, Dollarhide, and Cable 2020).

Contexts within Structure SS12 in this trench were significantly impacted by the erosion that damaged the northern Wall 221222. Patches of a packed clay floor (Lot 221255) were identified in the space to the west of Wall 201030, approximately level with the foundations of Walls 221222 and 201030. However, the floor surface was cut by erosion channels along both the east and west edges of the space. Ceramics collected on or just above the floor (Lot 221253) are stylistically datable to the Middle Umm an-Nar, while those from erosion-affected contexts at approximately the same elevation along the west face of Wall 201030 (Lot 221259) are stylistically datable to the Middle 2 and Late Umm an-Nar period (see Swerida, Dollarhide, & Jensen 2021). Excavation was halted at the floor level in the western half of Trench 561862b.

A layer of packed clay that was likely the remnants of a floor (Lot 221243) was also identified in the interior space to the east of Wall 201030 and south of Wall 221222, approximately level with the foundations of both. This context was cut by a large erosion gully (Lot 221257) along the eastern edge of the trench. Ceramics found in association with the clay layer stylistically date to the Middle Umm an-Nar and include a base of a black-slipped jar likely imported from the Indus (Méry & Blackman 2005). Excavations continued a further 10 cm below the level of the possible floor and wall foundations in order to probe the use-history of the space. An additional layer of cultural material in a clay matrix (Lot 221256) was encountered, indicating that the area was in use prior to the construction of Structure SS12's first architectural phase. The limited ceramic assembly collected from this context suggests a use date in the Middle Umm an-Nar 1. Excavations in this area were concluded at an arbitrary level due to time limitations.

3.3.2 Trench 561863b

Trench 561863b is located immediately east of Trench 561862b and north of Trench 561863a (Fig. #). What appeared to be the terminating end of a large, north-south running wall (Wall 221219) visible on the modern ground surface in an erosion-affected area along the far-eastern edge of the trench led us to hypothesize this space contented the northeastern corner of Structure SS12. The trench was excavated with the goal of defining the full extent of Structure SS12, clarifying the building's interior layout, and identifying potential interior use contexts.

Below roughly 15 cm of silt and gravel topsoil, it became clear that the space within Trench 561863b was defined by two stone walls—Walls 221219 and 221220—and erosion damage affected both the eastern and western edges of the space. The north-south running wall originally visible on the modern ground surface, Wall 221219, is situated at the eastern edge of the trench, just within an open and active drainage gully. All contexts east of the wall have been destroyed by the erosion, while the wall has given contexts to its west some protection. Wall 221220 runs east-west along and just within the northern edge of the trench and is broken at its western end by a filled erosion gully (the same gully that damaged Wall 221222 in Trench 561862b). All contexts north of Wall 221220 have been destroyed by erosion; the wall has protected some of the interior contexts to its south. These features serve as the exterior walls of Structure SS12 and form a bonded corner in the northeast. They are each ca. 60 cm wide, are preserved 3-4 stone courses tall with a maximum height of 50 cm, and are founded on the same layer of coarse gravel as Wall 221222. Both walls are constructed in the typical Middle Umm an-Nar style of double-faced, dovetailed stones set in a mud mortar (Swerida & Thornton 2019b). No trace of superstructure was found atop the walls, however clay clumps encountered during excavation just south of Wall 221220 suggest mud brick collapse.

Figure 10: Northeast corner of Structure SS12, bonded Walls 221219 and 221220.

The interior space within Walls 221219 and 221220 constitutes the majority of the northern of two rooms in the Structure SS12 semi-subdivided unit. A possible floor surface (Lot 221227) of dense clay and gravel was encountered approximately 5 cm above the foundation level of the surrounding walls and is likely the same feature as Lot 221243 in Trench 561862b to the west. A small collection of sherds made of the Umm an-Nar domestic ware paste (Swerida, Dollarhide, & Jensen 2021) were recovered from on and just above this surface. However, all sherds from this assemblage are all non-diagnostic and cannot be associated with a particular Umm an-Nar sub-phase. No other artifacts, features, or samples were found in the room. It is possible that this room was cleared out prior to the building's abandonment. Alternatively, any remaining contents in the space may have been displaced by erosion waters.

With exception of a small sounding, excavation in this trench was halted at the level of the Wall 221219 and 221220 foundations. The sounding (Lot 221246) was excavated within and south of the break between Walls 221222 and 221220 in order to probe the relationship between the features and to confirm the gap between them was the result of erosion damage. It was determined that Walls 221222 and 221220 were founded on the same stratigraphic level of coarse gravel and were almost certainly the same feature. The channel of an erosion gully was also identified running downhill to the south of the wall. No evidence of cultural activity was identified below the wall foundations in this area.

3.2.2.3 'Courtyard' Excavations – Trenches 561862a & 561937b

In order to further clarify the function and use history of the space characterized in the BAP 2020 season as a courtyard (see Swerida, Dollarhide, & Cable 2020), portions of two previously excavated trenches—Trenches 561862a and 561937b—were cleared of backfill. These trenches are located immediately south of Trench 561862b, described above, while the 'courtyard' space is located to the west of Wall 201030 and the Structure SS12 semi-subdivided unit. Specific areas within these trenches were then selected for additional excavation.

In Trench 561862a, backfill was removed from the entirety of the trench to the level of the Structure SS12 clay floor (Lot 201072), where the BAP 2020 excavation ended and that is estimated to date to the Late Umm an-Nar (Swerida, Dollarhide, & Cable 2020). Special attention was initially paid to a context previously identified as a rubbish pit (Lot 201070) stretching along the east face of Wall 201030. This context was partially excavated in the previous season and was notable due to its high concentration of Late Umm an-Nar style sherds and C14 samples. However, renewed excavation within this space and that immediately to the north in Trench 561862b revealed that the context was not a pit but rather the southern end of the drainage gully that displaced stones in Wall 221222 to the north. The Late Umm an-Nar materials recovered from this gully were most likely displaced from destroyed contexts within or north of Structure SS12.

Cleaning and shallow excavation (ca. 5 cm) of the clay floor layer in this space (Lot 221251) uncovered a sizable collection of sherds stylistically datable to the Middle Umm an-Nar, including the

base of a suspension jar and a small bowl typical of the Middle Umm an-Nar 2. This collection may be from an earlier floor surface than that identified in the BAP 2020 season. Analysis of charcoal C14 samples (Lots 221252 and 221254) collected from this layer will provide a scientific date for this use phase. An underlying layer of clay mixed with coarse gravel (Lot 221263) contained sparse, non-diagnostic Umm an-Nar sherds and was located below the foundation level of Wall 201030, thus pre-dating the Structure SS12 architecture. Excavation in this space ended at the level of the new surface.

Figure 11: Aerial view of excavations in Trench 56182A and 561937b

Backfill in Trench 561937b, immediately to the south of Trench 561862a, was cleared to the level of the Late Umm an-Nar clay floor (Lot 201043) in the space north of Wall 201013, which forms the southern edge of the Structure SS12 'courtyard' and semi-subdivided unit. Especially noteworthy in this space is a large (75 cm diameter) oven (Lot 221264) located in the center of the courtyard's southern end, in the space defined by Walls 201013, 201015, and 201030. The oven was encircled by a 17 cm wide wall of bricky material, which was preserved at a higher elevation than the surrounding floor. The oven interior was lined with a 1.5 cm thick layer of white plaster and contained a collection of six stones, the largest measuring 20 x 17 x 10 cm, amid a fill of fine, light gray ash and silt. Two C14 samples (Lots 221269 and 221272) of charcoal flakes collected from the oven fill will provide a date for the feature's last use phase, while two soil samples (Lots 221267 and 221273) may provide insight into what was baked in the oven. The top of the oven appears to have been destroyed by erosion activity, making it impossible to determine which floor level(s) the feature was associated with.

Excavation in the Trench 561937b 'courtyard' space was halted on the clay surface, level with that of Trench 561862a to the north.

In order to determine if a second floor layer was also present within Structure SS12, backfill was removed to the east of Wall 201030 in Trench 561862a. A clay floor, partially damaged by an erosion channel, was identified in this interior space in the BAP 2020 season (Lot 201069) roughly level with the Late Umm an-Nar 'courtyard' floor (Swerida, Dollarhide, & Cable 2020). However, after 10 cm of excavation (Lot 221261) no second interior floor was identified. Excavation extended below the level of the Wall 201030 foundations before encountering a layer of soft clay and fine gravel with additional cultural material. This layer is likely the same pre-Structure SS12 context as Lot 221263 in the 'courtyard' to the west and the interior Lot 221256 in Trench 561862b to the north. The context contained a small collection of non-diagnostic sherds made of an Umm an-Nar domestic ware paste (see Swerida, Dollarhide, & Jensen 2021). Charcoal (Lot 221272) and soil (Lot 221273) samples from an oblong ash lens (Lot 221261), approximately 1.5 x 1.25 cm, in roughly the center of the excavated interior space will provide greater clarity on the use date and function of this phase.

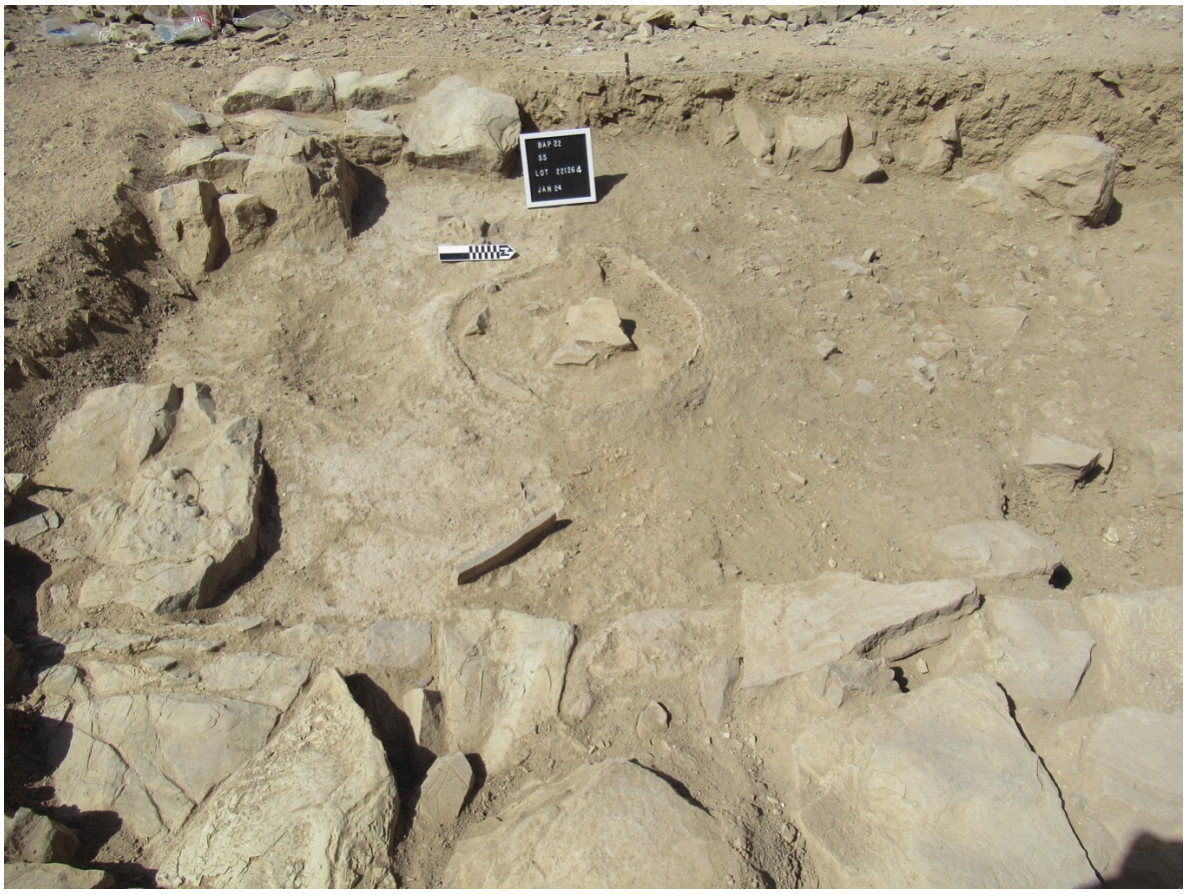

Figure 12: Oven Feature 221264 from east.

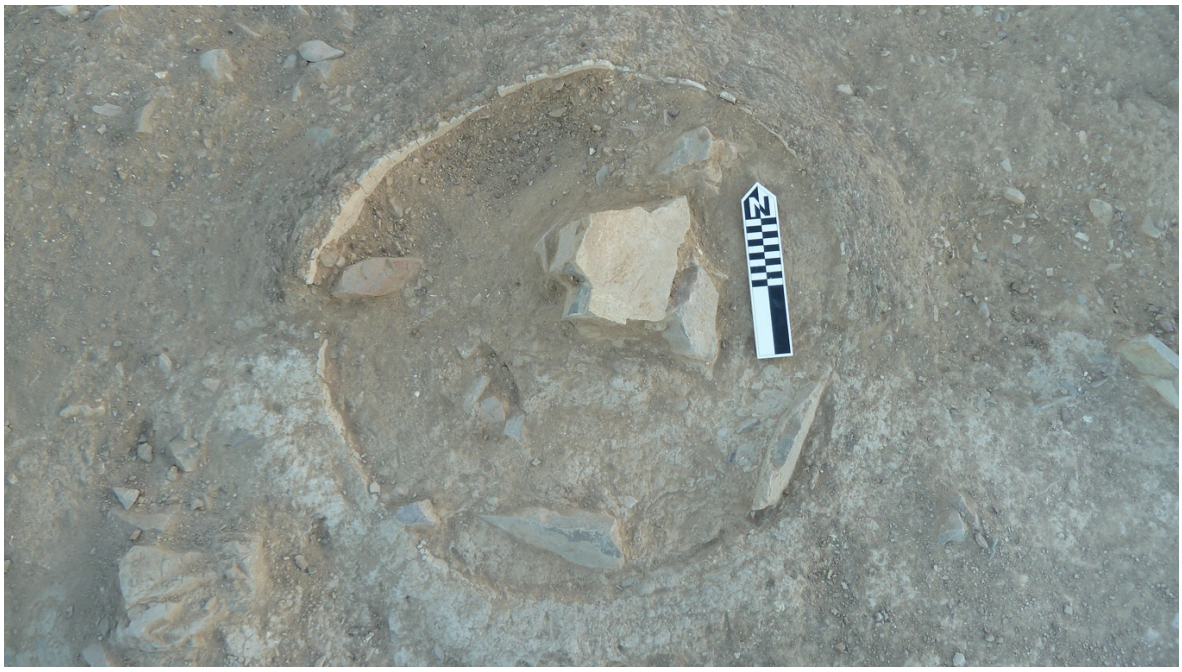

Figure 13: Close-up of oven Feature 221264

3.2.2.4 Structure SS12 Surface Cleaning – Trenches 561938a, 561938b, & 561863a

Additional surface cleaning and targeted studies were also carried out in the unexcavated Trenches 561938a, 561937b, and 561863a, as well as in the area surrounding Structure SS12. These activities include:

- Surface clearing of stone walling associated with Structure SS12 immediately east of the excavated trenches;
- Removal of an acacia tree that obscured the southeastern corner of Structure SS12;
- Areal documentation of Structure SS12 in relation to Tomb on a ridge approximately 50 m northeast of the excavated trenches.

Further stone walling associated with Structure SS12 is visible at ground surface level in the space immediately south of Trench 561863b and east of Trenches 561862a, 561937b, and 561937a. However, the signs of erosion that had exposed this architecture led us to hypothesize that contexts in this area would be poorly preserved. Thus, rather than excavating, the BAP team divided the space into trenches corresponding with the Settlement Slope grid (Trenches 561938a, 561938b, and 561863a) and cleared the surface debris around stones that were already visible with the goal of further clarifying the architectural layout of Structure SS12. The results of this surface clearing enable the near-complete building layout to be planned. Of particular note is Wall 221274 in Trench 561863a, which is now confirmed to be bonded with the exterior north-south Wall 221219 and to serve as the interior wall of Structure SS12 the semi-divided unit.

The southeastern end of Structure SS12 is particularly poorly preserved due to the combined effects of erosion and root activity from an acacia tree. The tree, which was cut back in the BAP 2020

season, has now been removed with the goal of clarifying and protecting the building's surviving southeast corner. The fragmentary north-south Wall 221260 can now be safely assumed to be the same feature as Wall 221219. It appears to be bonded with the interior Wall 221274 and to form an exterior corner with the east-west Wall 201013 in Trench 561937b. There is no visible connection between the southernmost Wall 201029 in Trench 561937a.

The location of Structure SS12 on the Settlement Slope hillside was also considered in relation to the Umm an-Nar Tomb 201201, located roughly 50 m east of the building on an elevated drive of limestone bedrock (Figure 9). Due to the tomb's proximity and prominent location, the monument would have been a dominant feature in the view from Structure SS12. It is possible, if not probable, that the occupants of Structure SS12 and others on the eastern end of the Settlement Slope were interred in this tomb. Overhead and ground-based imagery were collected documenting the visual relationships between the two locations and will contribute to interpretations of the Umm an-Nar lived experience on the Settlement Slope.

3.2.3 Summary

Excavations at the Settlement Slope Structure SS12 successfully achieved all three research objectives for the BAP 2022 season. The near-full layout of Structure SS12 was revealed, room functions determined for preserved contexts, including the 'courtyard,' and the building's use history was clarified.

In its final form, Structure SS12 was composed of a semi-subdivided unit of two rooms running parallel to the hillside in the northeast, a perpendicular walled space previously interpreted as a courtyard to the west of the semi-subdivided unit, and a room running the full width of the building along its southern edge. The interior contexts of the semi-subdivided unit were heavily impacted by erosion, which has destroyed evidence of room use. The possible 'courtyard' space contained substantial quantities of pottery and an oven, suggesting that it was the stage for various domestic activities including food preparation. The characterization of this space as a 'courtyard,' however, is brought into question by the presence of Wall 201015 and its probable continuation along the western edge of the 'courtyard' space, indicated by the displaced stones of Lot 221275. This wall would form a narrow room roughly 2 m wide, which could easily have been roofed. While the contents of the long room along the southern end of Structure SS12 were also damaged by erosion, the room can be confidently identified as the building's entryway due to the presence of a stepped doorway (Lot 201036) in the center of the southern wall (Figure 14).

Figure 14: Structure SS12 stepped entryway, Feature 201036.

The Structure SS12 location experienced at least four occupational phases:

1) A Middle Umm an-Nar 1 occupation predating the construction of Structure SS12. Traces of this phase (pot sherds and an ash lens) were encountered below the wall foundations in the northern half of the building. The precise date and character of this occupation are yet to be determined.

2) The Middle Umm an-Nar construction and occupation of Structure SS12. This phase is represented by the initial building construction and floor surfaces. The architectural style of dovetailed stone wall foundations with a mudbrick superstructure is comparable to well-dated Middle Umm an-Nar buildings elsewhere on the Settlement Slope (Swerida & Thornton 2019a) and at Khafaji (Swerida & Thornton 2019b). No secondary architectural additions or renovations can yet be identified in the excavated remains. The date estimate derived from the building's architectural style is reinforced by Middle Umm an-Nar style ceramic sherds found in association with the interior clay and gravel floor surfaces and the exterior clay surfaces to

the south of Wall 201029 (see Swerida, Dollarhide, & Jensen 2021). Forthcoming scientific dates from C14 analysis will confirm the accuracy of these stylistic dates.

3) A Late Umm an-Nar occupation and extension of Structure SS12. This phase is represented by a secondary floor layer in the western 'courtyard' space, associated C-14 dates placing the use phase at 2235-2127 cal. BC, and a substantial collection of Late Umm an-Nar pottery (see Swerida, Dollarhide, & Jensen 2021). It is probable that the long room running along the building's southern face was added during this phase, as the wall construction style differs significantly from that of the rest of the building (see Swerida, Dollarhide, & Cable 2020). Additionally, a C14 sample from an outdoor activity area associated with this wall produced a date range of 2204-2026 cal. BC.

4) Late (Iron Age-Medieval) revisitations to the Structure SS12 ruins. This phase is represented through pottery and two small fire pits (Features 201008 and 221234) encountered in the upper layers of the building fill. Feature 201008, excavated in the BAP 2020 season, produced a C14 date of 1510-1618 cal. AD.

Given the structural similarities between Structure SS12 and Umm an-Nar domestic buildings previously excavated at the western end of the Settlement Slope and at Khafaji, there is a high likelihood that this building served as a domestic house. The architectural plan of Structure SS12 is similar to the semi-subdivided plans defined in structures at the western Settlement Slope, such as Structures SS1 and SS2. Additionally, the assemblage of Umm an-Nar domestic ware pottery and the cooking installation from the 'courtyard' strongly suggests a household function. Excavations of Structure SS12 are now complete. Future seasons of excavation and survey on the Settlement Slope will explore additional structure on the hillside to further clarify occupational patterns of the Umm an-Nar period at the site.

3.3 Mortuary Excavations: Tomb 201201 and Structure SS13

Concurrent with the Settlement Slope domestic excavations, an Umm an-Nar style tomb located on the top of a ridge immediately east of Structure SS12 was also excavated. This tomb was identified during the BAP 2020 survey as Lot 201201 and was selected for excavation due to its small size, proximity to Structure SS12 and other buildings on the Settlement Slope, and significant location on the hill. Excavation targeted the tomb architecture, interior burial chamber(s), and area immediately surrounding the monument. A rectilinear building—Structure SS13 (surveyed as Lot 201203)—was also identified less than 2 m north of and uphill from Tomb 201201, a situation which makes it unique in Umm an-Nar archaeology. Test excavations and mapping were conducted in this building to probe the potential for future study. This work was carried out with the goals of:

- Comparing the layout and content of a small Umm an-Nar tomb located in a settlement to those of the previously excavated large tombs located in the Bat necropolis;
- Determining the approximate date range of the tomb's use;

- Clarifying the relationship between Tomb 201201 and Structures SS12 and SS13.

Figure 15: Tomb 201201 and Structure SS13 from above.

Excavations revealed the full layout of Tomb 201201, produced scientific samples that will clarify its use dates, and identified promising preservation conditions in the chamber's lower contexts. Full excavation of the tomb burial chambers was reserved for a future season that will focus specifically on the monument. Text excavations of Structure SS13 exposed shallow contexts within the building and promising evidence connecting its function(s) with that of Tomb 201201. All measurements are made in reference to the Settlement Slope Master Datum.

3.3.1 Tomb 201201

Excavations of Tomb 201201 were conducted by bioarchaeologist Dr. Selin Nugent and Dr. Jennifer Swerida. Prior to excavation, portions of the outer tomb wall were visible on the modern ground surface of a relatively flat section of an elevated ridge on the southeastern end of the Settlement Slope hill. A 7x7 m area, Trench 51721, was laid out to encompass the entirety of the tomb structure. This trench aligns with true north, rather than the established Settlement Slope grid aligned with the hillside, because the angle of the terrain differs significantly in this location than that of other excavated areas at the site.

Initial excavations revealed the full extent of the tomb structure. Tomb 201201 is a circular, Umm an-Nar style monument with a preserved diameter of 4.85 m. The stones composing the southern half of the exterior tomb wall are mostly slumped or tumbled downhill, with the few remaining stones likely belonging to the wall's inner face. Based on the curvature of the surviving northern half of the tomb wall, the monument's original diameter was likely ~5.5 m.

The exterior tomb wall (Lot 221003) is approximately 0.95 m in width and is constructed of unworked and roughly hewn local limestone blocks set in a mud mortar. The wall is faced on the interior and exterior, with the space between facing stones filled with one or two rows of unworked stones averaging 30x25x8 cm. The wall is preserved at least four stone courses in height and the quantity of displaced wall stones encountered during excavation suggests the collapse of a comparable amount. While no white 'sugar lump' facing stones were found in situ on the tomb's exterior, chips of pecked white limestone found nearby tumbled down the hill slope suggest that the tomb once featured a bright white facing. It is probable that the white facing stones were reused elsewhere at the site after Tomb 201201 had fallen out of use (Miki et al. 2019).

The area outside of the tomb (Lot 221202) was excavated to the point where the full outer wall was visible, approximately 5-10 cm of depth. Sparse Umm an-Nar and Iron Age pottery was recovered from the silt and gravel matrix. Further sediment remains in this space for future excavation.

Within Tomb 201201, excavations exposed two semi-circular tomb chambers, each approximately 2.95 m long and 1.3 m wide at their greatest extent. These chambers are formed by a central dividing wall that extends from the northeast face of the tomb's outer wall bisects the interior space. The central wall (Lot 221012) extends across roughly three quarters of the tomb interior and is constructed of two dovetailed rows of the same roughly hewn limestone blocks as the exterior wall (stones averaging 35x25x15 cm). The wall is 2.1 m long, 0.6 m wide, and is preserved at least three stone courses in height. Based on comparison with other two-chambered Umm an-Nar tombs excavated elsewhere at Bat (Frifelt 1975; Böhme & al-Sabri 2011), the tomb door would be located opposite the terminating end of the interior dividing wall. Although this section of the tomb exterior wall does not survive, a door in this location would face toward the occupied portions of the Settlement Slope hillside and al-Rojoom tower in the distance.

Excavation within the tomb focused on the northwest chamber, which appeared from the surface to be better preserved and contain more tomb fill than the southeast chamber. Fill within the tomb sloped downhill to the south, leaving a greater volume of sediment and tomb contents preserved in the northern half of the chamber. Tomb fill consisted of a fine brown silt with occasional small, angular rocks and semi-worked stones that had collapsed into the chamber from the tomb walls, which became less frequent at lower elevations.

Amid the stone collapse in the uppermost layer of tomb fill (Lot 221004), excavations recovered a sparse scatter of unidentifiable human bone fragments, a small collection of Umm an-Nar

funerary ware sherds, and a large portion of a painted Umm an-Nar funerary jar (Lot 221005). Bone preservation in this layer was extremely poor, due to sun exposure and stone collapse. Lower layer of stone collapse in the northwest chamber (Lot 221006) contained increasingly greater quantities of human bone fragments in varying states of preservation. All were disturbed by stone collapse and most were extremely friable due to sun exposure. Notable finds from this layer include two concentrations of cranial fragments in the northern half of the chamber, one of which with two adult teeth, and a small cubic softstone vessel (Lot 221008) decorated with three courses of incised concentric rings. The softstone vessel (Figures 16 and 17) is fragmentary on one side and was found amid a scatter of finger bones and skull fragments in the rockfall, suggesting the collapse of the tomb wall displaced both the vessel and the skeleton(s) it was situated near.

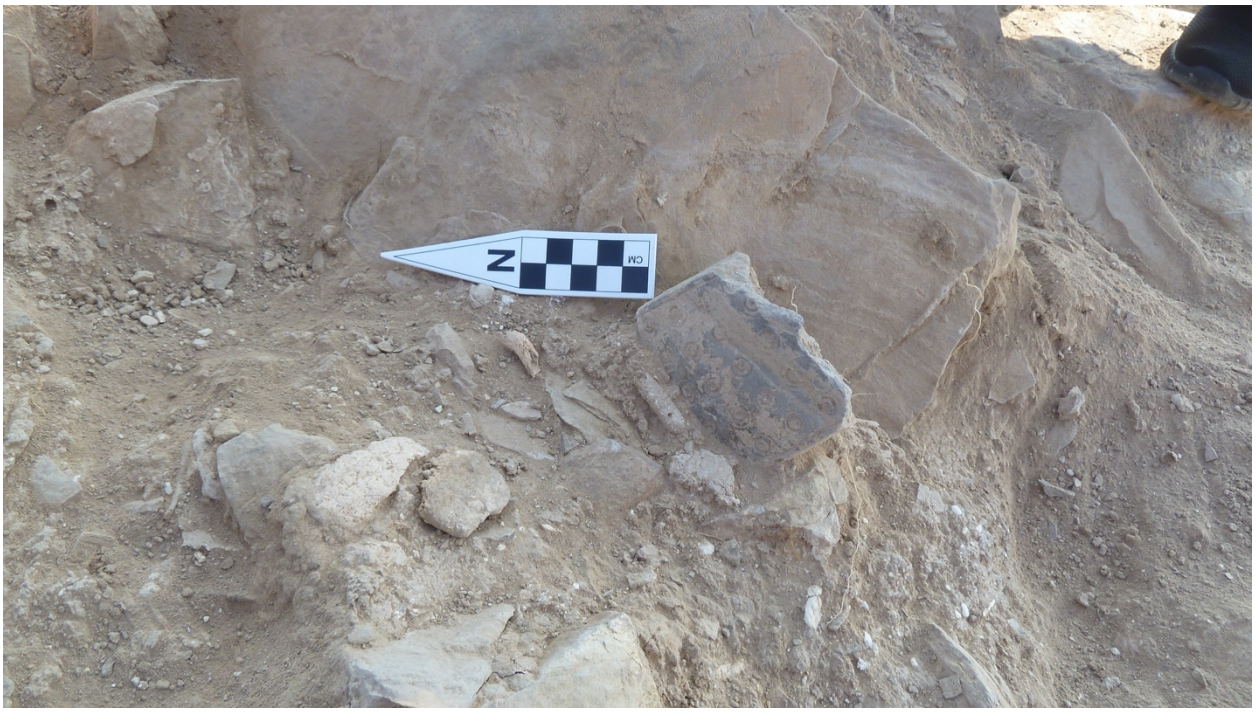

Figure 16**: Cubic softstone vessel in context, amid skull fragments and finger bones.**

Below the two levels of dense rockfall (approximately 30 cm below the modern ground surface), the tomb fill transitioned to a compact, light brown silt with some angular gravel (Lot 221009). This context was excavated for a depth of approximately 15 cm. The human bone continued to be disarticulated and fragmentary, however both the concentration of bone fragments and the quality of preservation increased substantially (Figure 18). Disarticulated bone is typical of Umm an-Nar tombs used over multiple generations (Williams & Gregoricka 2019) and suggests that Tomb 201201 was revisited and its contents disturbed multiple times during its use-life. Judging by the recovered bone, the remains of at least three adults and one child were encountered during excavation. Due to the state of preservation, the true number of individuals represented in the upper layers of fill in the Tomb 201201 northwest chamber may be much higher. A charcoal sample (Lot 221011) collected from the center of the tomb chamber will provide a date within the tomb's use-life, but will

not in isolation determine the full span of use. The fill of Lot 221009 also contained approximately half of a small Umm an-Nar funerary jar (Lot 221010), a collection of 29 Umm an-Nar funerary ware jar sherds, and 49 small, cylindrical shell beads (Figure 19).

Figure 17: Close-up of cubic softstone vessel in context, amid skull fragments and finger bones.

Figure 18: Assorted human bone fragments from Lot 221009.

Figure 19: Cylindrical and flat shell beads from tomb fill.

Excavation in the tomb was closed on an arbitrary level, once probing demonstrated that at least 20 cm of fill remained to be excavated in the northwest chamber. At the closing elevation, the tomb fill was a dense, light brown clay that may suggest body sludge. While no skeletal articulation was identified, the general trend of bone scatters growing denser and better preserved in lower levels suggests that articulated skeletons and funerary goods may be preserved in the layer(s) below. Future BAP excavations will continue to explore the Tomb 201201 northwest tomb chamber, as well as the southeast chamber and the surrounding space on the Settlement Slope hill ridge.

3.3.2 Structure SS13

Structure SS13 is a rectilinear structure located approximately 2 m uphill from and to the northeast of Tomb 201201. The building appears to be a single room measuring approximately 8.5x3.5 m and is oriented northwest-southeast, roughly perpendicular to the slope of the hillside. This situation, immediately next to a tomb on a hill ridge overlooking the densely populated Settlement Slope and the wadi valley below is unique in Umm an-Nar archaeology. In order to clarify the function of Structure SS13 and probe the depth of deposits, a 1x5 m test trench was excavated along the southeastern end of the building. For ease of excavation, the test trench was aligned with the building rather than with the pre-established Settlement Slope grid.

Excavations quickly determined that the interior of Structure SS13 contained only shallow (ca. 5 cm) interior deposits of silt, clay, and dense angular gravel. The building was constructed directly onto the rugged bedrock of the Settlement Slope hill ridge. The exterior wall is preserved only a single course in height and is composed of 1-2 rows of roughly hewn and unworked limestone blocks (averaging 35x25x15 cm), faced on the exterior only. While no northern wall was uncovered during excavation, it appears probable that a large bedrock ridge encountered at the terminating end of the building's eastern wall was used as the northern edge of Structure SS13. Similar examples of Umm an-Nar buildings engaging with the irregular bedrock of a hillside have been documented elsewhere at

the Settlement Slope and at the nearby Khutm settlement (Swerida 2017). A similar construction style is also found in Structure KA3—the large mud brick platform on stone foundations adjacent to the Khafaji tower (Swerida and Thornton 2019a)—raising the possibility that the stone foundations one supported a mud brick platform rather than formed an inclosed room.

A surface collection of Structure SS13 revealed little material culture to suggest the building's use date or function. However, the ground surface within the Structure SS13 walls was scattered with small fragments of bone that can be tentatively identified as human. The preservation of these bone pieces was extremely poor due to sun exposure. The presence of this bone, in concert with the carnelian bead found next to the building in the BAP 2020 survey of the area and the building's proximity to the nearby Tomb 201201 suggests a functional connection with the tomb. It is possible that this structure served as a charnel house or place of preparation for human bodies before they were interred in the neighboring tomb. Future excavation with and in the space around the building will further probe Structure SS13's structural composition, function, and association with Tomb 201201.

3.3.3 Summary

Tomb 201201 and Structure SS13 are unique among the known Umm an-Nar contexts at Bat. Although the tomb follows a layout typical to the site, its small size, significant location on an elevated hillcrest, and close association with Structure SS13 are all unusual. From the vantage point of Tomb 201201, an Umm an-Nar period spectator would have enjoyed a commanding view of the domestic buildings stretching along the Settlement Slope hillside and the Wadi Sharsah valley, including glimpses of the Matariya, Khafaji, and Rojoom towers. A rectilinear building close in size to Structure SS13 and located in a similar elevated situation, although without an adjacent tomb, in the Umm an-Nar settlement of Dahwa 1 has recently been interpreted as being ritual in function (al-Jahwari & Douglas 2021). These similarities, the proximity of Tomb 201201 and Structure SS13, and the presence of bone chips within Structure SS13 suggest that this location may reveal further insight into Umm an-Nar period ritual and mortuary behaviors.

The location of Tomb 201201 and Structure SS13 on the Settlement Slope hill, close to areas of domestic activity, is also worthy of note. The proximity of these buildings to the areas used for day-to-day behaviors suggests that the mortuary/ritual structures were regularly viewed features in the daily life of the Settlement Slope community. The inhabitants would, therefore, have interacted with the tomb and ritual building more frequently than with the famous tombs in the Bat necropolis. Such consistent interaction challenges previous interpretations of Umm an-Nar mortuary practices. Future BAP research on the Settlement Slope and elsewhere in Bat will further probe the relationship between Umm an-Nar domestic and ritual practice.

3.4 Conclusions

The Settlement Slope is an important and long-lived area of occupation on the Bat landscape. The tower monument and domestic architecture on the hillside have long been subjects of archaeological

interest (see Frifelt 1985; Mortimer 2016; Swerida 2017, 2022; Swerida & Thornton 2019b; Swerida et al. 2021). The results of BAP's 2022 season further clarify the site's Umm an-Nar period domestic history and reveal that it was also the stage for mortuary and related ritual activity. Future BAP research at the site will continue to explore the relationship between Umm an-Nar domestic and ritual practices.

4. Rakhat al-Madrh Excavations

Eli N. Dollarhide, Paul Rissman, Jennifer L. Swerida

4.1 Introduction

A second season of excavations at the Umm an-Nar settlement of Rakhat al-Madrh resumed in 2022. The site, which is located approximately 7.5 km southeast of the modern Bat village, was first identified during a BAP survey conducted between Bat and 'Amlah during winter 2017 (Dollarhide 2019; Dollarhide, et al. 2018). This initial discovery and subsequent fine-grained survey (Swerida, et al. 2020) have revealed at least four Umm an-Nar structures at the site (Figure 20). The surface remains of each structure is similar in plan and layout to other excavated Umm an-Nar structures at Bat–featuring long compartmented rooms organized around a central walled courtyard (see Swerida, et al. 2021 for further comparisons).

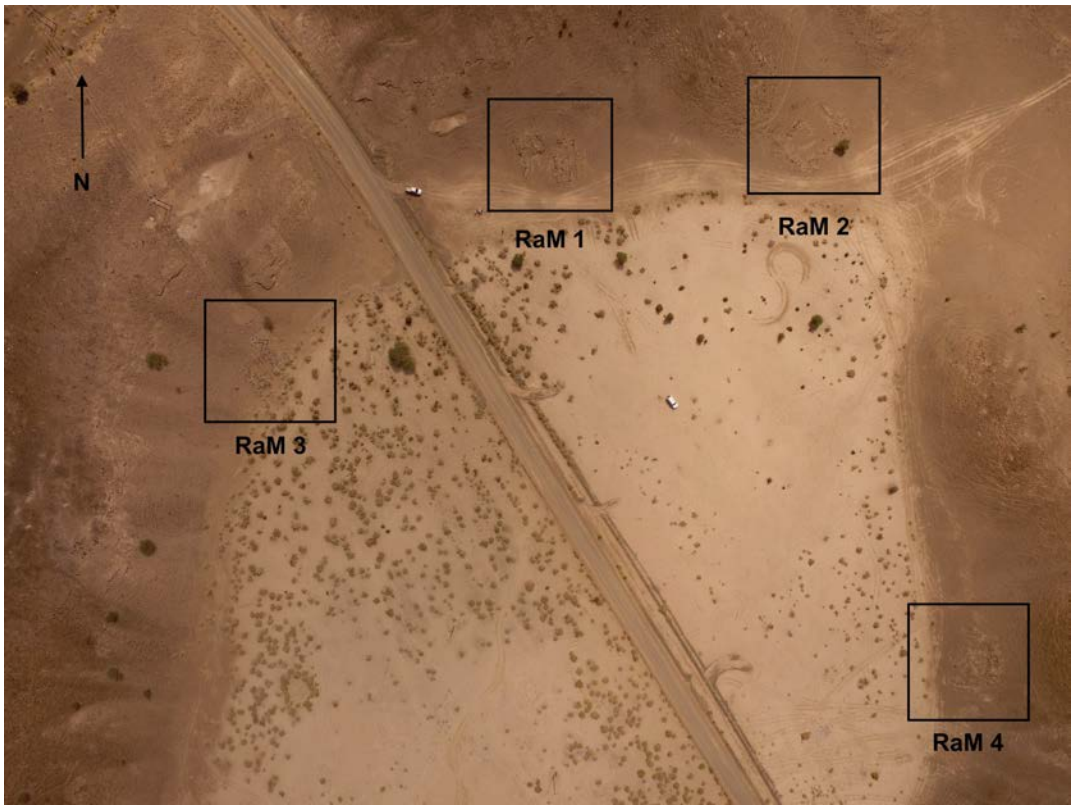

Figure 20: Aerial photo of Rakhat al-Madrh with structures highlighted. RaM 1 and RaM 2 were targeted for excavation during 2022

An initial season of excavation at the site conducted during BAP's 2019/20 field season confirmed the domestic nature of one of these structures: RaM 1. This previous work suggested that the stone architecture visible on the surface was two-three courses tall and served as a foundation for mudbrick walls. Over time, these walls melted and collapsed both within and outside the structure. A C-14 date based on a charcoal sample collected from within one wall confirmed a middle Umm an-Nar date (2576-2460 cal. BC) for its initial construction. Additionally, it became apparent that the walls

of the structure were altered over time and the enclosure or courtyard was likely added or amended after the initial construction of the structure. Though finds were rare in the RaM 1 excavations during the 2020 season, the excavated ceramics were all attributable to Umm an-Nar period forms and fabrics.

The environmental setting of Rakhat al-Madrh differs substantially from Bat's other known Umm an-Nar areas—as well as those of any other contemporaneous settlement in southeastern Arabia. The four structures are situated around the edges of a sub-recent alluvial fan (Janjou et al. 1986)—an area of ancient above-ground water catchment. Record-levels of rainfall experienced in the Bat area during the first weeks of December 2019 further evidenced that the depression at Rakhat al-Madrh continues to hold water in extreme precipitation events in the modern era. In fact, the water from a storm on December 8, 2019 kept the center of the Rakhat al-Madrh submerged under at least 48 cm of water for 5 days. These observations led to the formation of a full geomorphological and hydrological study of the Rakhat al-Madrh basin and surrounding areas. The preliminary results of these investigations appear in Section 8 of this report.

This season archaeological excavation at Rakhat al-Madrh was conducted with four primary goals :

1) Understand the function of the site and the subsistence strategies practiced by its early Bronze Age inhabitants;

2) Develop comparisons between Rakhat al-Madrh and Bat's other Umm an-Nar occupation areas;

3) Investigate the settlement and architectural history of this area to understand diachronic changes;

4) Align these newly discovered remains with BAP's long-term goal of interpreting the wider Bat landscape.

BAP's 2022 investigations at Rakhat al-Madrh began on January 16, 2022 and concluded on February 19, 2022 with backfilling the trenches.

4.2 Excavation strategy

In order to achieve these goals, excavations were carried out at two of Rakhat al-Madrh's structures: RaM 1 and RaM 2. These structures were selected as they are the best preserved contexts visible via surface remains and the orientation of both buildings suggest their occupation was directly linked to the unique ecological conditions of the depression. Surface collection of ceramics conducted during 2020 indicated both structures were occupied during the Middle Umm an-Nar period (2500-2200 BC); this dating was confirmed for RaM 1 via a radiocarbon sample collected during BAP's 2020 excavations. At RaM 1, excavation moved away from the 2020 trenches, which bisected the parallel rooms and walled enclosure *(figure X below)*, and moved to the rear of the building. In this southeastern section three 5x5 meter trenches were opened. At RaM 2, three additional 5x5 meter trenches were selected in order to provide coverage of the building's internal and external walls.

Figure 21: RaM 1's excavation trench at the close of BAP's 2020 season.

Figure 22: Aerial view of RaM 2 prior to excavations this season

The grid implemented in Rakhat al Madrh's 2020 excavation was maintained to facilitate recording. This system is based around a cardinal grid of 5x5 m squares (running North-South/East-West). A new datum and backsight for total station use was established this season (Table 2). All elevation and coordinate data were collected with a Leica semi-robotic total station using these coordinates.

Master Datum	Backsight:
N 2569259.2000m	N 2569273.3467m
E 480350.9000m	E 480350.8925m
Z 544.1400m	Z 542.2978m
Projection:	
WGS 84 / UTM 40N	EPSG: 32640

Table 2: Rakhat al-Madrh datum and backsight locations

Following BAP convention, each context (feature, dirt section, or individual sample) was given a unique lot number. Each lot was photographed, sketched, and planned as appropriate and details about its contents and context were recorded on a paper form. This information is currently in the process of being digitized and made accessible through BAP's recently implemented Integrated Archaeological Database (IADB) system.

4.3 Results

4.3.1 RaM 1

Excavation at RaM1 was led by Dr. Paul Rissman with specific objectives of understanding the building's sequence, construction, and function. Excavation was conducted on a 'room-by-room' strategy in order to preserve context integrity across different areas within RaM 1, which might provide information about the function of different spaces in the structure. Two large rooms were identified: room lot 221524 and room lot 221523. The walls demarcating these spaces were constructed in a style common to Middle Umm an-Nar period domestic structures found across Bat: walls constructed of internally- and externally-faced schist and limestone blocks with mud mortar and fill. This architecture matches the walls uncovered during RaM 1's 2020 excavation season. This general architectural uniformity and lack of artifacts dating beyond the Bronze Age in excavation and surface collection suggest the entire structure was initially constructed during the Umm an-Nar period. Atypically for the Bat landscape, no artifacts dating to other periods (save some modern waste) have been recovered from RaM 1. However, excavation this season did reveal evidence for later, likely 1st millennium AD alteration at RaM 1 in Trench C as discussed below.

4.3.1.1 RaM 1 Sequence and Construction: Trench A and B

The excavation of trenches A and B revealed five Umm an-Nar stone wall foundations of one-to-three courses tall. In several areas within RaM 1, a dense clay-ey matrix indicative of mudbrick melt was observed. This provides indication that the stone coursing observed during excavation were in

fact the foundations for a mudbrick superstructure–another diagnostic architectural feature of Umm an-Nar domestic spaces (Swerida and Thornton 2019).

Figure 23: An aerial view of RaM 1 under excavation in BAP's 2022 season

Several observations this season revealed that the layout of RaM 1 was altered at least three times over the course of its Umm an-Nar occupation. It became clear that RaM 1's walls were built on two different strata. Wall 221520 (which forms the northern portion of the walled enclosure) was in its earliest phase set directly on bedrock (Figure 25). Other walls within the trenches that were excavated to their lowest levels–Walls 221518, 221519, 221521, 221522–were built on a consistent stratum consisting of decayed rock, grey-compact soil, and green-ish inclusions as well as white nodules ranging from pea-sized to larger pebbles. This is illustrated in the RaM1 section drawing. This matrix contained many small charcoal flecks and may represent an occupation of Rakhat al-Madrh that predates RaM 1's construction.

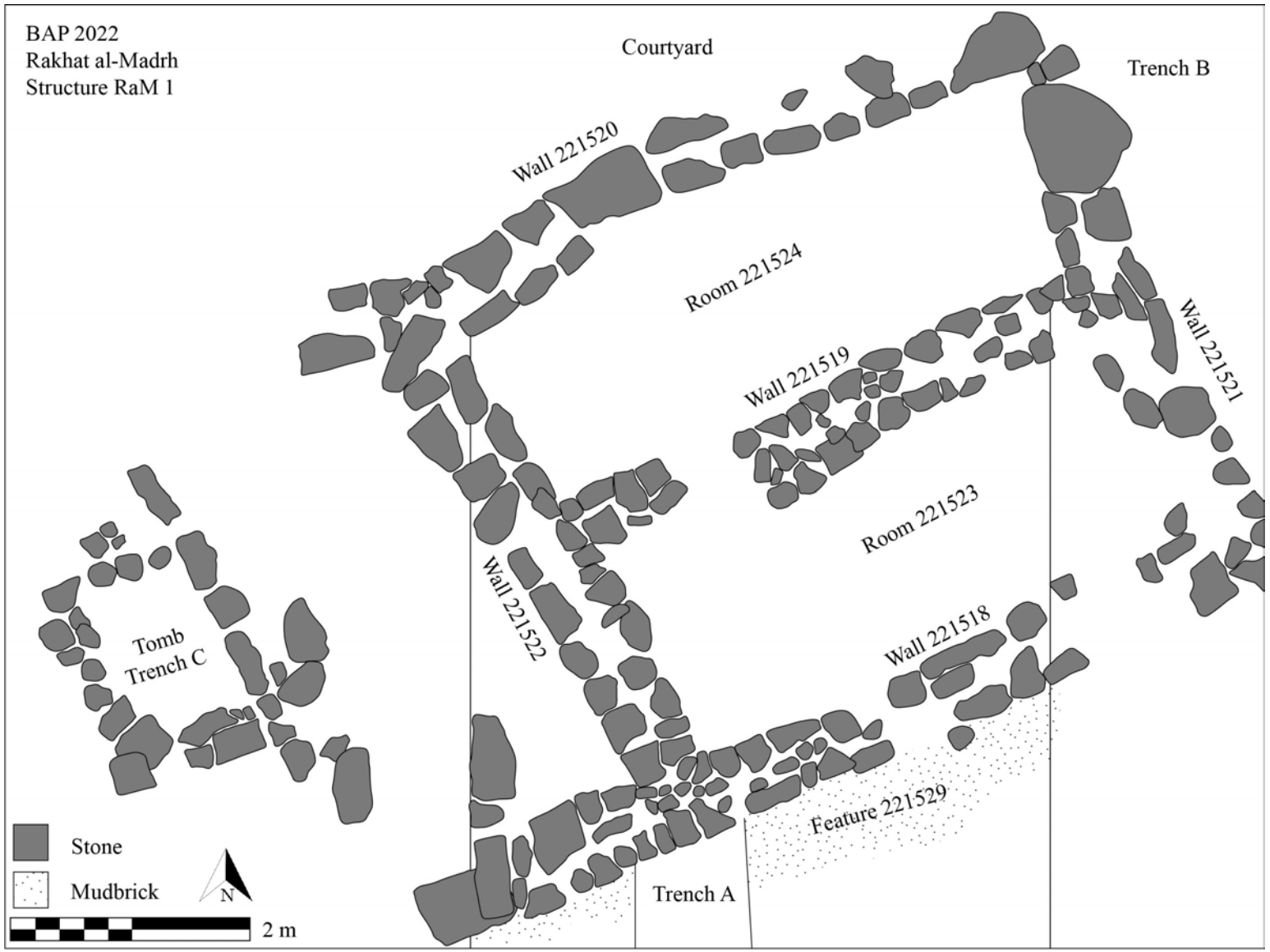

Figure 24: Plan of 2022 RaM 1 excavations

Figure 25: Aerial plan of Wall 221520 resting on bedrock

Additionally, excavation confirmed that the architectural reconfiguration observed during RaM 1's 2020 excavations was also present in the building's northern section. Wall 221520 (enclosure wall) displays two phases. The earliest phase defines the western half of one of RaM 1's rooms (Lot 221524) and is set directly in bedrock. This phase is also associated with a large, flat 'threshold' stone that likely served as the point of entry between the walled enclosure and RaM 1's northern rooms. Later, the orientation of wall 221520 was altered slightly and an additional course of stones added, resulting in a different angle to the wall's eastern section, as visible in the building's plan. Additionally, this first phase of wall 221520 runs below wall 221522 and thus predates it.

The second phase of the building seems to involve the eastern portion of wall 221520, the eastern exterior wall 221521, and the northern portion of wall 221522. The eastern end of wall 221520 is bonded with wall 221521 (Figure 26) suggesting their construction occurred contemporaneously.

Figure 26: Bonded walls 221520 and 221521

The construction of wall 221522 also appeared to have involved two phases. The northern portion of the wall was made with substantially larger blocks and two courses tall, that are set lower than the southern portion of the wall, which is comprised of a single course of eroded and fractured stones (see Figure 27)

Figure 27: Construction style change in Wall 221522

The third phase of building alteration comprises the construction of wall 221519, the southern portion of wall 221522, and wall 221518. Excavation revealed that wall 221519 abuts but is not bonded to wall 221521 nor 221522 (Figure 28 below). Wall 221519 also presents other interpretive challenges. There is a gap between the eastern and western portions of the wall of approximately 63 centimeters. This gap might have facilitated an entry way between rooms 221524 and 221523, as the interior stones are faced as they front each other. However, the two sections do not align and appear to have been constructed at different angles. The eastern portion of wall 221519 also appears to have altered overtime, in a similar fashion to Wall 221522's alteration: an initial construction phase and subsequent alteration with smaller stone size. The initial angle of wall 221519's construction appears to align more closely with the wall western portion.

Figure 28: Wall 221519 abutting Wall 221522

Walls 22518 and 221522 are also bonded suggesting their construction occurred during a single phase. Together, these observations suggest the following construction/alteration phasing:

1. The western portion of Wall 221520 set on bedrock
2. Eastern portion of Wall 221520, the initial construction of Wall 221521, and Wall 221522
3. The initial construction of Wall 221518 and Wall 221519
4. Alteration to Wall 221519

Significantly, this phasing implies that the southern exterior wall of RaM 1–221518–was a later edition in RaM 1's occupational history and represents a large expansion of the building's space. As Wall 221518 continues beyond Trench A, future excavation will offer additional information about the dating of this wall's construction.

Three radiocarbon samples from RaM 1 have been selected for analysis that will provide absolute dating for phases 1, 2, and 3. Elevation data suggests phase 1 will be contemporaneous with the construction of the long compartmented rooms excavated in 2020.

4.3.1.2 RaM 1 Wall Construction Techniques

No Umm an-Nar wall foundation trenches have been found during BAP excavations at any area of the Bat landscape, rendering the methods used to build Umm an-Nar domestic structures unclear. Excavations at RaM 1 this season around walls 221518 and 221519 revealed one previously unknown Umm an-Nar construction technique: the use of mudbrick retaining walls instead of foundation trenches. Two rows of mudbrick and crushed rock/mortar fill were discovered adjacent on either side of wall 221518. These mud bricks were assigned feature lot 221529 (adjacent to wall 221518;see Figure 29) and 221557.

Stratigraphic breaks made it possible to reconstruct the process by which these retaining features were constructed. First, one or two rows of mubrick were positioned approximately 20cm away from either side of the planned wall. In the next stage, this empty 'mold' was filled with either a hard mortar or sand mixed with crushed rock. The crushed rock is uniform in size ranging from about 3-8cm in length. The crushed rock and sand formed a permeable barrier which might have assisted in draining water away from RaM 1's external walls as the structure sits on a slight slope going downhill towards north. Additional excavation in RaM's other structures is required to further support this hypothesis and ascertain whether these mudbrick retainers are a unique feature of all Rakhat al-Madrh's Umm an-Nar occupation.

Figure 29: Mudbricks and rocky fill along RaM 1 external wall 221518

4.3.1.3 RaM 1 Other Finds and Features

Other finds and features at RaM 1 were rare and the building appears to have been cleared out after its occupation. Those objects that were found are all consistent with a middle Umm an-Nar domestic structure. Several diagnostic sherds of Umm an-Nar domestic ware jars were recovered. A large flattened grinding stone (lot 221530) was found underneath a collapsed portion of wall 221518. This context (221515 and 221517) may have represented a deflated occupational surface or floor context, upon which the mudbrick wall stone foundation fell on top of; several sherds of Umm an-Nar domestic ware were found in this context. A stone with embedded copper prills (lot 221549) was found immediately outside wall 221518 and suggests some production activities were also occurring within the space. Unusually, a small circular carnelian bead was found within room 221524. Carnelian beads are usually associated with Umm an-Nar tombs rather than domestic structures and the presence of this bead signals that there is probably an Umm an-Nar tomb located in the Rakhat al-Madrh area.

4.3.1.4 RaM 1 Trench C

A third trench was opened at RaM 1 to investigate a what appeared to be a later period mortuary feature intruding into the structure's Umm an-Nar occupation. Artifacts linking Rakhat al-Madrh to time periods beyond the third millennium BC are rare and thus this feature (Figure 30) was selected for excavation to potentially clarify the area's occupation in later periods. Initial surface cleaning removed a mix of small stone chips and aeolian silt. The stone fragments were composed of limestone, white limestone, flint, and some basalt. The flint and basalt have not previously been found at the site and must have been brought intentionally to the feature.

Figure 30: Feature of rock chips and fragments (lot 221901/Trench C) before excavation

Underneath the roughly circular cap of stone fragments was a rectangular stone feature interpreted as a burial chamber. The chamber re-used an Umm an-Nar wall within RaM 1 as its eastern edge. The chamber measured 1x1.4 meters and was constructed of dry, unworked stone masonry. The feature contained a fine silt fill which ended on a hard, clay matrix upon which several larger stones appear to sit. One lithic and several pieces of Umm an-Nar period domestic ware pottery were removed from the chamber's interior as well as several C14 samples.

The feature most likely functioned as a burial chamber. The orientation of the feature (SE/NW) suggests an Islamic date for its creation and similar features are known from a Late Iron Age cemetery at al Fueda near modern 'Amlah, located just south of Rakhat al Madrh (Yule 1999; Bank and Yule 2000). There, similar tombs contained iron weapons, glazed ceramics, and highly decorated metal bowls. The presence of similar, high-value objects inside this tomb would have made it a likely target for robbing.

Figure 31: Empty tomb chamber in RaM 1 Trench C

4.3.2 RaM 2 Excavations

This season marked the beginning of excavations at a second structure at Rakhat al-Madrh, RaM 2. Work at RaM 2 began with opening two 5x5 m trenches oriented North/South. Trench location was chosen to capture a space that bisected at least two internal rooms and captured some area immediately outside of the structure's external walling—a frequent location for Umm an-Nar period garbage pits.

Surface cleaning and aeolian top soil removal revealed an initial alluvial, sandy wash covering the entirety of both trenches and included the shells of many melanoides. Below this wash, a dense, dark brown clay-ish matrix was uncovered. This matrix was consistent with melted mudbrick found elsewhere at Umm an-Nar houses across the Bat landscape and probably represents the collapse of a mudbrick superstructure set atop the stone foundations preserved today. Below the melted mudbrick a very fine, soft gray brown silt was the predominant soil type. One living surface was uncovered (lot 221830), which was preserved under mudbrick collapse. The feature consisted of a tightly compacted light brown matrix and several large Umm an-Nar domestic ware body sherds were found resting on this surface.

Figure 32: Aerial view of RaM 2 during 2022 excavations

Excavation revealed three typical middle Umm an-Nar stone wall foundations (lots 221804, 221805, 221807). At their best preserved points, the walls were two courses high and constructed with a combination of grey-bown limestone and locally-occurring conglomerate—a stone type not evidenced in Bat's other Umm an-Nar houses but local to the Rakhat al-Madrh depression. Stones were faced on both interior and exterior sides. Across both trenches, they demarcated two long, narrow rooms, similar to the layout of RaM 1's southern section (see Figure 33).

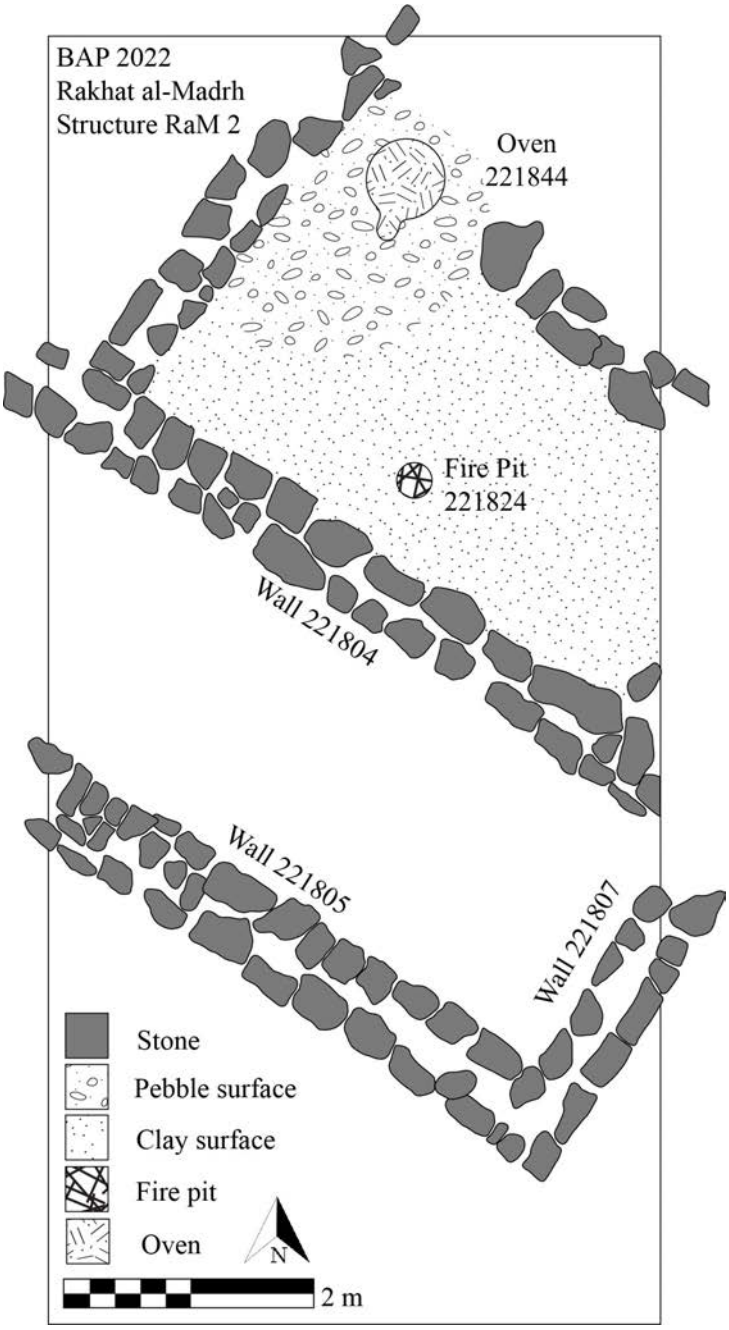

Figure 33: Plan of RaM 2 structure

A square stone feature was identified outside the building, adjacent to wall 221805. Initially assumed to be a later-period grave, the feature was composed of a roughly rectangular stone capping set above a circular pit. The capping stone rested on the modern ground level suggesting the features was a later addition to the Umm an-Nar house. The removal of the capping and excavation revealed a small pit (80x50x20 cm) filled with a mix of soft silt and coarse gravel. No artifacts were found. However, at the bottom of the pit was a concentration of small gravel surrounded by a dense, white chalky

substance (Figure 34). Rather than a burial, it seems likely that the pit served as a later latrine and the chalky substance is the chemical remains of waste deposited within it.

Figure 34: A potential later-period latrine (lot 221815) outside RaM 2

Artifacts at RaM 2 were generally more abundant than RaM 1. Many Umm an-Nar domestic ware sherds were found across both trenches. A small hammerstone was uncovered near wall 221804, below a level of mudbrick collapse (Figure 35). Several worked lithic flakes were also recovered from RaM 2's interior spaces.

Figure 35: Small hammerstone (lot 221821) found in RaM 2

The richest contexts uncovered at RaM 2 were two pyrotechnic features. The first was found coeval to the living surface (lot 221830) near wall 221804. This stone-lined fire pit contained a carbon-rich ashy-lens from which multiple C14 and phytolith samples were extracted. The fire pit/hearth measured 82x79 cm and was oval in shape. The feature rested above the fine silty acultural level found below all excavated contexts in the structure and thus likely dates to the earlier portion of RaM 2's occupation.

Figure 36:Stone-lined fire feature (lot 221824) in RaM 2

An oval-shaped oven (lot 221844) was also found within RaM 2 (Figure 37). The feature was first revealed with an associated ashy lens that extended beyond the northern edge of Trench A. In order to further expose the feature Trench C was partially opened to the north. The oven's upper extent measured 65x65 cm and was topped with a thick layer of baked white clay that ranged from 5-10 cm in thickness. While the top was well preserved, the feature's walls were not and became visible only in plan view. Two Umm an-Nar domestic ware sherds were found inside the oven and several large stones. The feature appeared to have a small 14 cm opening at its southern edge potentially for bellows or ventilation. Several C14 and phytolith samples and one large piece of wood charcoal were collected for analysis. Additionally, several small carbonized seeds were found within the hearth and collected.

A surface covered in small pebbles and ash (lot 221849) was located adjacent to the oven and extended southwest of it. Below the pebbled surface, an additional ash lens was found. This level (lot 221853) contained hundreds of small carbonized seeds. These seeds may have come from cooking activities associated with the oven or from animal dung used as fuel within. An initial analysis of the seeds identified at least three distinct taxa, including *Hordeum distichum* (barley), a legume, and others. A full botanical analysis of these charred seeds is ongoing and two samples of them have been marked for fine-grained C14 dating analysis.

Figure 37: Plastered oven in lot 221844, plan view

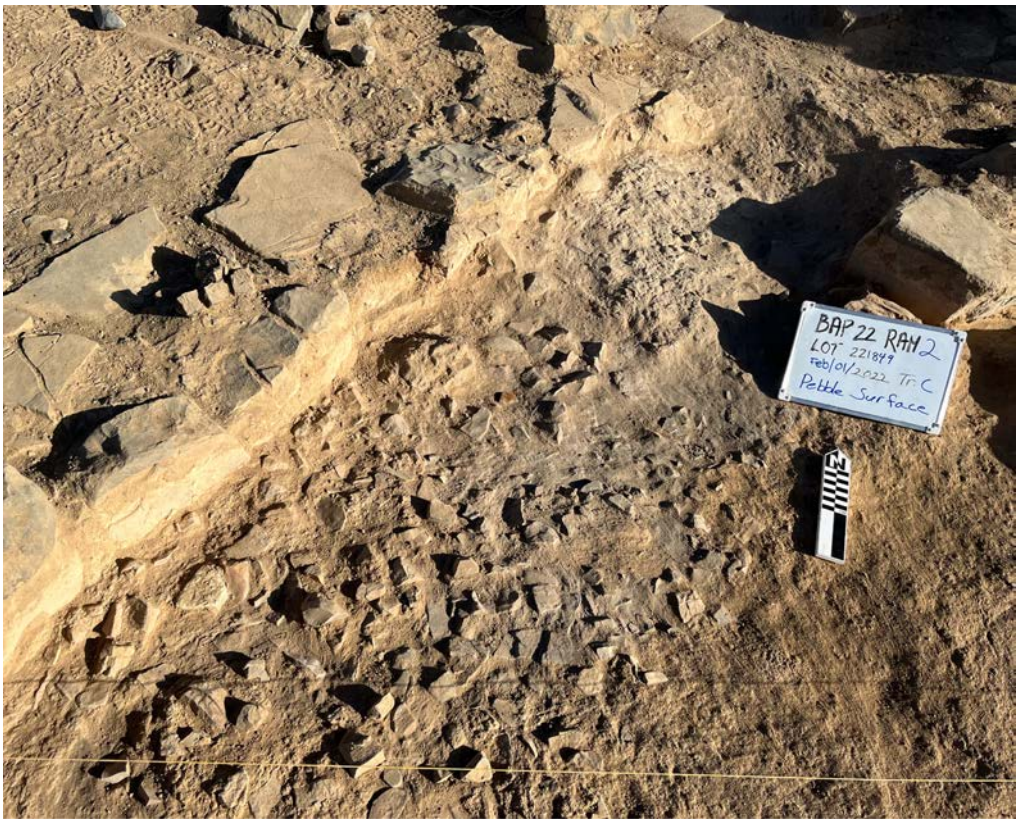

Figure 38: Top of oven and associated pebble surface, from south

Figure 39: Pebbled surface (lot 221849) and ashy lens extending southwest of oven

Figure 40: Profile of oven, showing baked clay at base of feature

4.4 Conclusion

The past two seasons of excavation at Rakhat al-Madrh have revealed a Middle Umm an-Nar period settlement at the site. Domestic architecture is organized around an ancient water catchment area, unlike other Umm an-Nar period settlements in the region. The two houses excavated, RaM 1 and RaM 2, were both constructed with mudbrick set on top of stone foundations. RaM 1 was expanded and further compartmentalized over the course of its Umm an-Nar occupation, creating more interior space and small rooms. Its external walls were supported not by a foundation trench, but instead by mudbrick retaining walls that included a gravel/chipped stone fill to facilitate drainage away from the building. The discovery of a large threshold stone suggests different entry paths for the house's inhabitants to move between the walled enclosure and the structure's interior. Artifacts, including grinding stones, rocks with copper prills, and domestic pottery indicate that production activities, especially those linked to metal working, were occurring inside the space. The house was cleared after its abandonment. An empty, later-period grave built above and into its Bronze Age occupation offers the only evidence so far of use of the house after the third millennium BC.

The layout of RaM 2 appears very similar to RaM 1: long compartmented rooms and a large central enclosure. While additional excavations are required to elucidate RaM 2's occupational history, the house has thus far proven denser in artifacts and environmental data than RaM 1. Two pyrotechnic features: a fire pit and a clay oven were found within the structure and samples for phyotlith, radiocarbon, and anthracological analyses were taken. An ashy lens associated with the oven contained hundreds of carbonized seeds belonging to at least three taxa, including barley, a legume, and others. Ongoing botanical analysis will further identify the species and help understand the ecology of the site and the potential for Umm an-Nar agro-pastoral activities conducted there.

The restricted nature of Rakhat al-Madrh's occupation—limited to the Umm an-Nar period–is atypical for Bat, where many areas settled during the Hafit or Umm an-Nar periods have been continuously or intermittently inhabited since the third millennium BC. One potential interpretation of this situation could link Rakhat al-Madrh's occupation to small climatic shifts and/or increased precipitation. During the third millennium BC, the site's depression may have had greater access to water resources—from flooding events or the water table itself—than today, thus making it a more desirable location for plant cultivation and/or animal pasturing. When water might have been less abundant, after the close of the Umm an-Nar period, Rakhat al-Madrh was abandoned and utilized only intermittently. While this hypothesis requires additional research to be confirmed, the geomorphological and hydrological study completed this season (see Chapter 8) offers further information about Rakhat al-Madrh's environmental conditions over time, suggesting the site's utility for the cultivation of flood crops and animal pasturing in prehistory.

5. Khutm Settlement

Robert Bryant, Stefan Smith, & Jennifer Swerida

5.1 Introduction

The Khutm Settlement is located along the south-facing hillside of the ca. 500 m long limestone ridge, which runs to the southeast of the Khutm tower (see Figure 41). Between 2013 and 2015, the settlement was surveyed and mapped by BAP (see Cable & Thornton 2013, 2014, 2015; Swerida 2017). During the 2022 season, BAP returned to the Khutm Settlement to probe the depth of contexts and document changes to the site and its preservation that have occurred since the 2015 survey. Records were collected according to the Master Datum and 5x5 m grid established at the site during the BAP 2014 season (Table 3).

Dates(mm/dd/yy): 01/12/22; 01/15/22 Photos: 537 **Area:** ~23.422 ha	Master Datum N 2574233.8000m E 471147.2000m Z 474.4000m Projection: WGS 84 / UTM 40N	Backsight: N 2574245.7507m E 471147.2111m Z 476.1843m EPSG: 32640

Table 3: Khutm Datum and Backsight specifics

5.2 3D Modeling

DJI Mavic 4 UAV imagery, and the digital elevation models (DEMs) that can be calculated from it by structure-from-motion processes, were also of great use for the structural survey of the al-Khutm slope. By flying this region at a low altitude of 34 m and manually set to collect images that overlap every ~20-25m, a DEM and high-resolution orthographic model could be created that showed potential walls otherwise unclear either on simple aerial photos or on the ground (see Figure 41). Reconstructed models were georeferenced using large spray painted ground targets with a 1 m diameter. These ground target coordinates were collected using a total station setup on the site's Master Datum. Reconstructions were made with Agisoft Metashape, plans exported with ArcGIS, and models used to plan surface visits to the site. Thus the area to be surveyed was greatly reduced from potentially the entire south-western slope of the al-Khutm hill (up to 57,000 m^2) to a far more manageable 14,000 m^2. Aerial surveys were conducted by Robert Bryant and Stefan L. Smith.

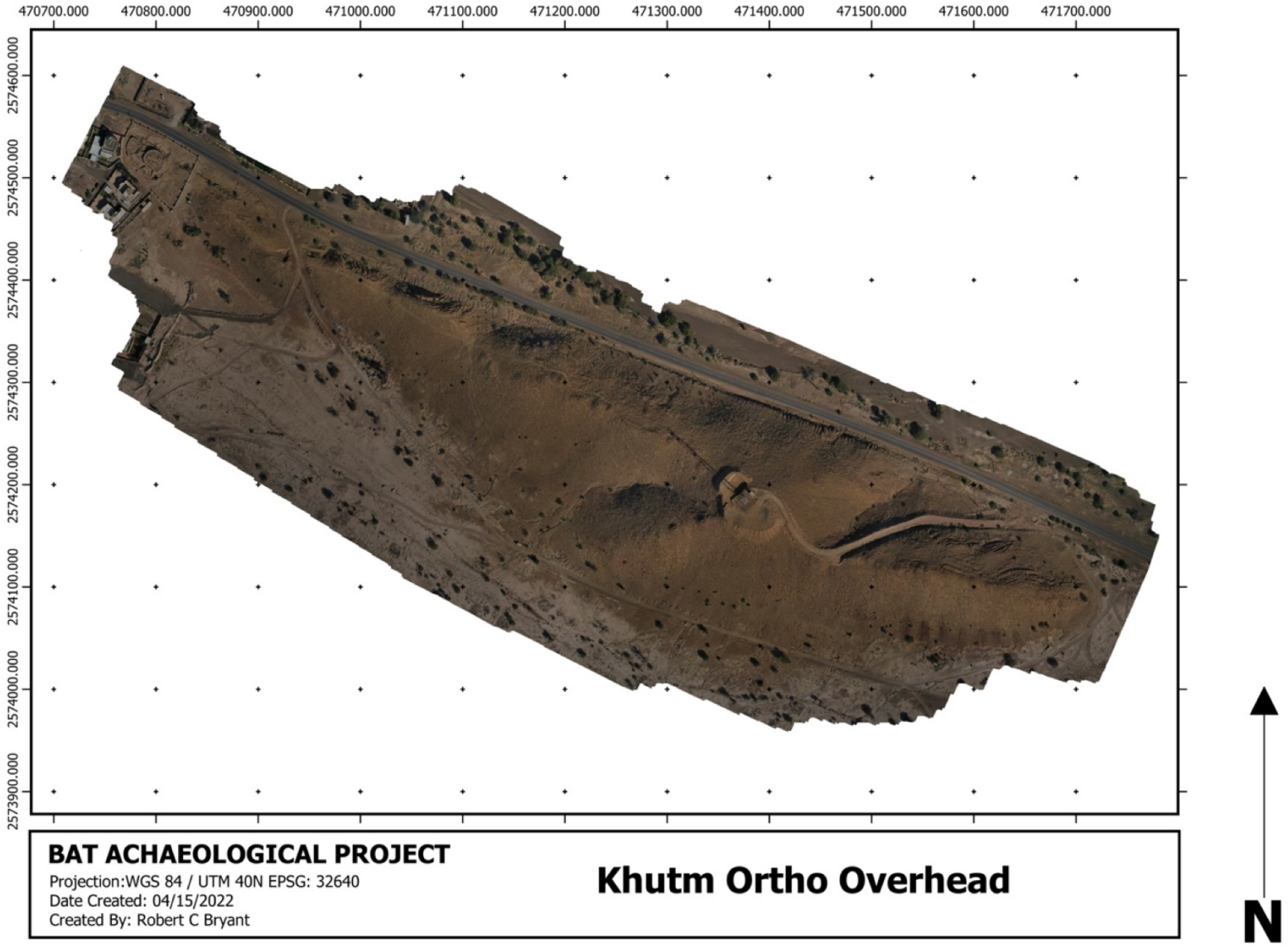

Figure 41: Orthographic model of the Khutm hill, depicting the Khutm tower in the northwest and settlement along the southern slope.

5.3 Test Trench: Sounding A

Excavation of the test trench 'Sounding A' at the Khutm Settlement took place 12-15 January 2022 and was conducted by Robert Bryant.

Primary Goals:

- Establish a Date Associated with Visible Architecture
- Establish a Photogrammetric Methodology for Capturing Trench Data
- Establish a Sounding to Provide Stratigraphic Context for Further Excavation at Khutm
- Better Understand the Existing Structure Wall Abutting Trench

5.3.1 General Summary

After visually surveying the area, we selected a 2x2 m trench near visible architecture in an attempt to dig to the base of the wall in order to look for cultural material and C-14 evidence, which would accurately date the visible wall associated with multiple instances of architecture across the site. The trench square was aligned parallel with the wall, which runs along the southeastern balk, rather than aligned to magnetic North. Unfortunately, we encountered bedrock far sooner than anticipated, at roughly 20-30 cms below the visible surface, which limited the utility of the excavation for establishing a site stratigraphy.

We determined this location and section of wall to be especially promising for a trial of photogrammetric data collection, which uses photographs to calculate high accuracy 3D data of excavated contexts. A shallow trench will more easily prove the success of our methodology compared to something deeper.

Excavation was broken into arbitrary 10-20 cm depths starting from the highest corner of the trench to designate controlled lots and all dirt was screened (100%) through a ¼" wire screen. Most significant cultural material came out of the top 20 cm of excavated dirt from the surface, although a small concentration of ceramics was recovered in the last ~10 cm above bedrock.

5.3.2 Ceramics

A limited collection of ceramics stylistically datable to the Middle Umm an-Nar period were recovered within the top 20 cm of excavation. The presence of fine wares in the upper contexts suggest that at least some sherds are eroded downhill from an Umm an-Nar tomb located approximately 15 m uphill to the north of the trench. Sherds from the ~10 cm layer of silt immediately above bedrock may be associated with the architecture neighboring the trench.

5.3.3 Notes on Soil Texture/Composition

The soil was largely sterile aside from the occasional ceramic sherd. The hope was to find enough charcoal flecking to either take a soil sample for possible floatation or a significant enough deposit of carbon for a direct sample. No charcoal flecking was visible in the soil nor any other features beyond the visible wall remains.

Topsoil had a fine, angular gravel composition (roughly 40-50%) associated with the surrounding colluvium. This contrasted with the subsurface cultural layer of light brown silt with sparse (~20%), fine angular gravel. Cultural material was concentrated in a thin ~10 cm layer of silty soil located immediately above bedrock. This layer took a tanner appearance and contained far less angular gravel than the colluvium layer above and degrading bedrock layer below. This material may be associated with the neighboring architecture.

The bottom degraded bedrock layer had an assortment of naturally occurring colors visible in the surrounding bedrock outcroppings of layered/striated limestone (purple, red, white, gray, brown). The trench was excavated roughly 20 cm into the degraded bedrock layer. In this context, all fill was a sterile, brittle limestone that crumbled at the touch of a shovel into roughly 80% angular gravel.

Extracted sections (Figure 42 and 43) provide some clarity to the site's stratigraphy but the proximity of the bedrock to the surface largely interferes. It does allow us to assume a shallow depth at this particular contour line of elevation going around the site that abuts the southern slope of the hill. It is probable that depths will increase significantly further out into the wadi, where large patches of loose soil and sand can easily trap vehicles.

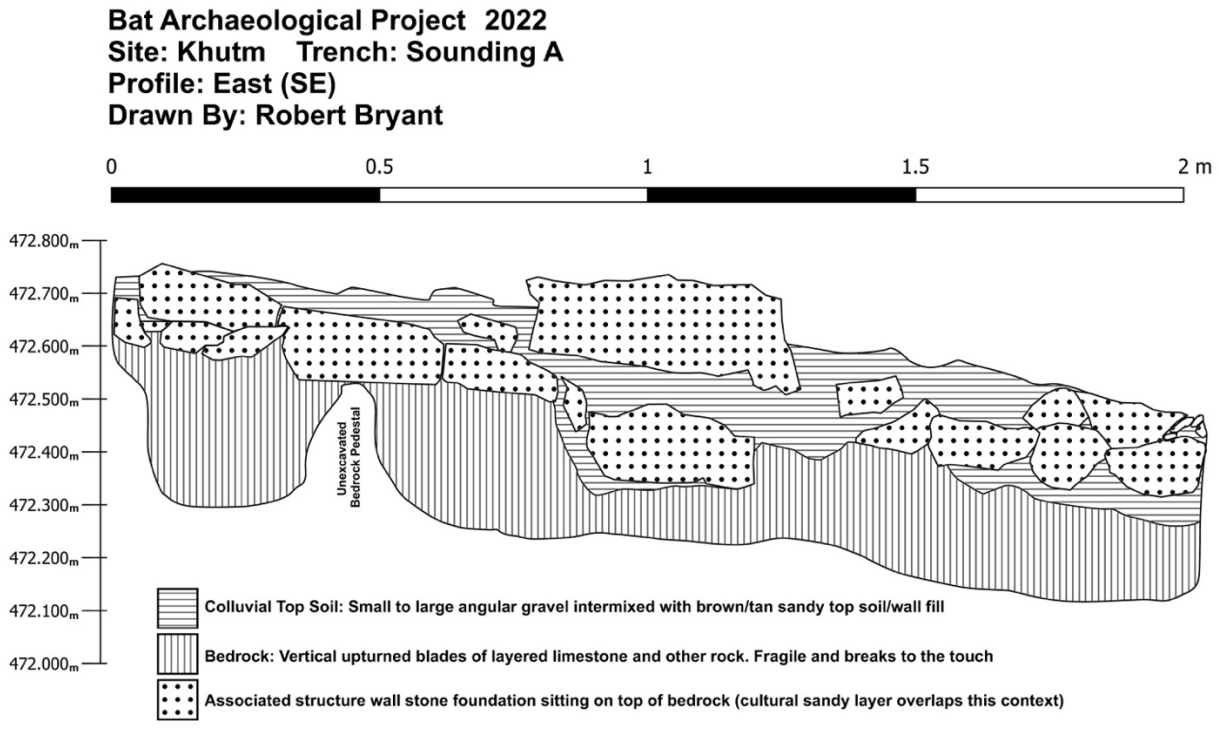

Figure 42: East Profile of Sounding A

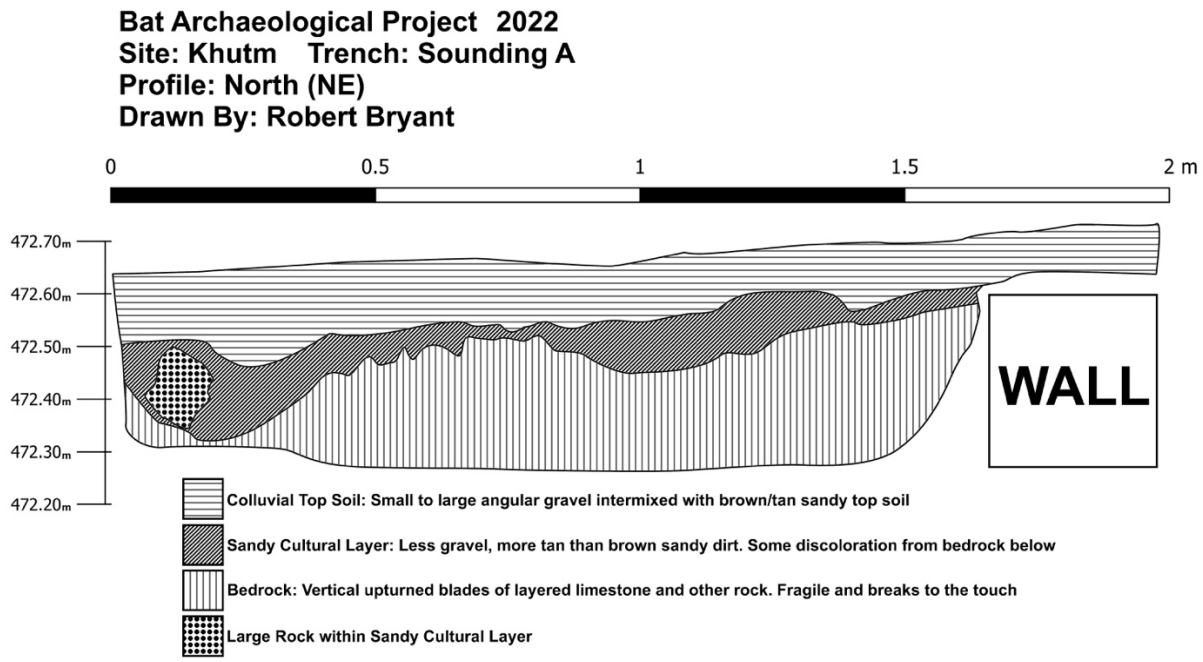

Figure 43: North Profile of Sounding A

5.3.4 Notes on Architecture

The Khutm test trench provides further clarity on the construction style of the stone architecture at the eastern end of the Khutm Settlement. The stone wall located along the southeastern edge of the trench is constructed in the typical Middle Umm an-Nar style of roughly hewn, dovetailed limestone blocks set in a mud mortar (Swerida and Thornton 2019b). The walling visible on the modern ground surface was assumed to be the top of what is usually 3-4 stone courses and our trench was chosen to trace the wall's outer face to its foundations. However, upon excavation it was found that the wall included an additional outer course or earlier phase, which increased the width of the wall foundation in its lowest course where the stones rest on bedrock.

There is a break in the outer course in the trench, probably from taphonomic disturbance. This break allowed for the investigation of the architect's use of bedrock for foundations. The bedrock tends to undulate across the site in vertically upturned outcroppings, similar to those seen on the local limestone hill ridges. This structural wall takes advantage of these undulations by placing stones in the valleys between them in order to create a flat surface to lay a foundation on top of. Based on this small test trench, the Khutm Settlement architecture appears to consist of two or more courses of dovetailed stone blocks that integrate closely with the undulating bedrock and served as the foundations for a superstructure that has not been preserved.

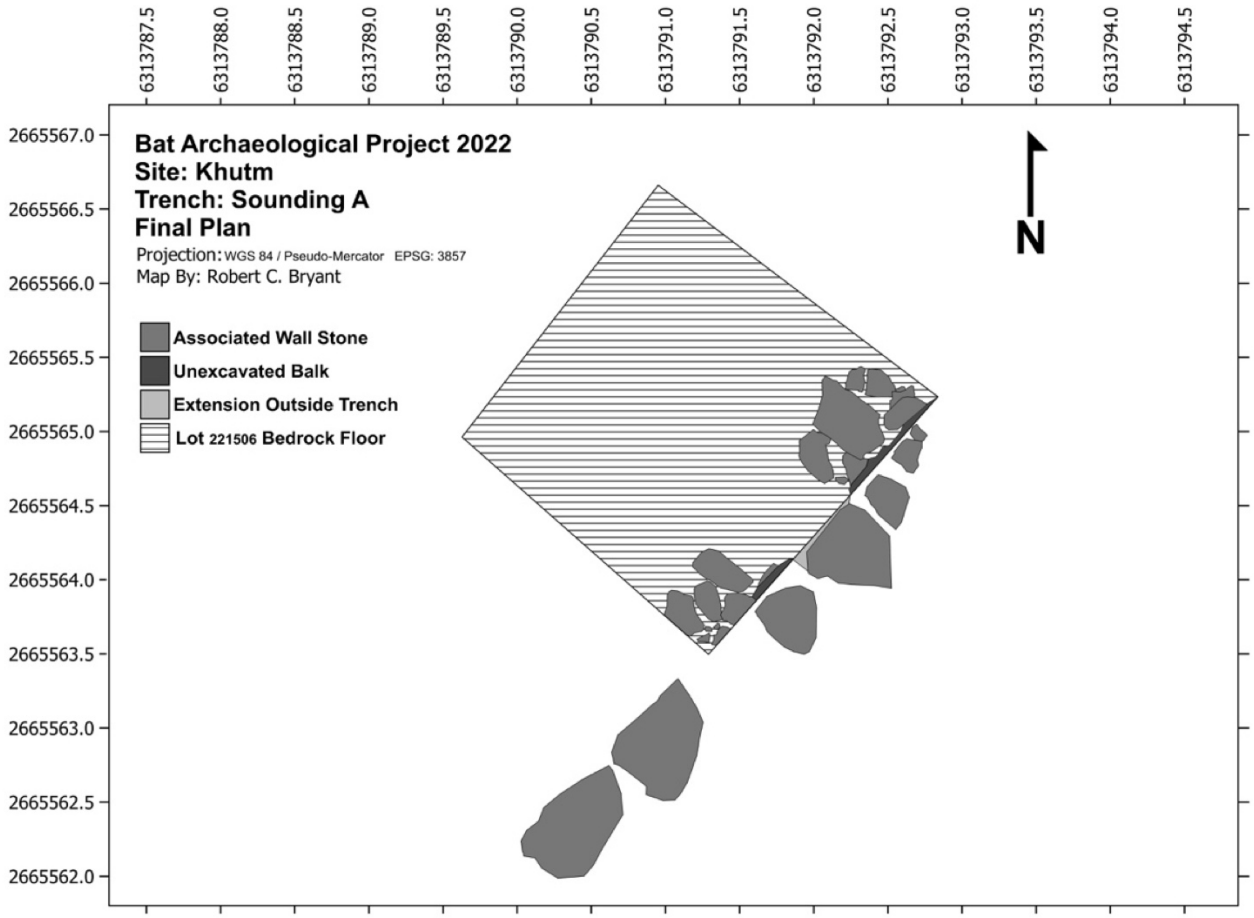

Figure 44: Sounding A plan.

5.3.5 Notes on Photogrammetry

Sounding A was also used as a subject to test an experimental photogrammetric data collection methodology. Photogrammetry is a method of constructing 3D models from overlapping high-resolution digital photographs of the same location. It was hypothesized that depth measurements of excavation contexts taken from photogrammetric models would provide a locational accuracy equal to or greater than those collected by a conventional total station. If proven correct, this method would save time and create a more dynamic record of excavated space. This test was conducted by Robert Bryant.

Eight pieces of rebar were set in regular placements around the outside of the 2x2 m trench as control points to use within Agisoft Metashape. The precise locations of each rebar were shot with the total station once at the outset of the excavation. Depths at the base of each lot were also taken with the total station on 1.5 cm bottle caps to act as controls for the reconstructed models. Two separate cameras were used as comparisons for each set of trench photographs.

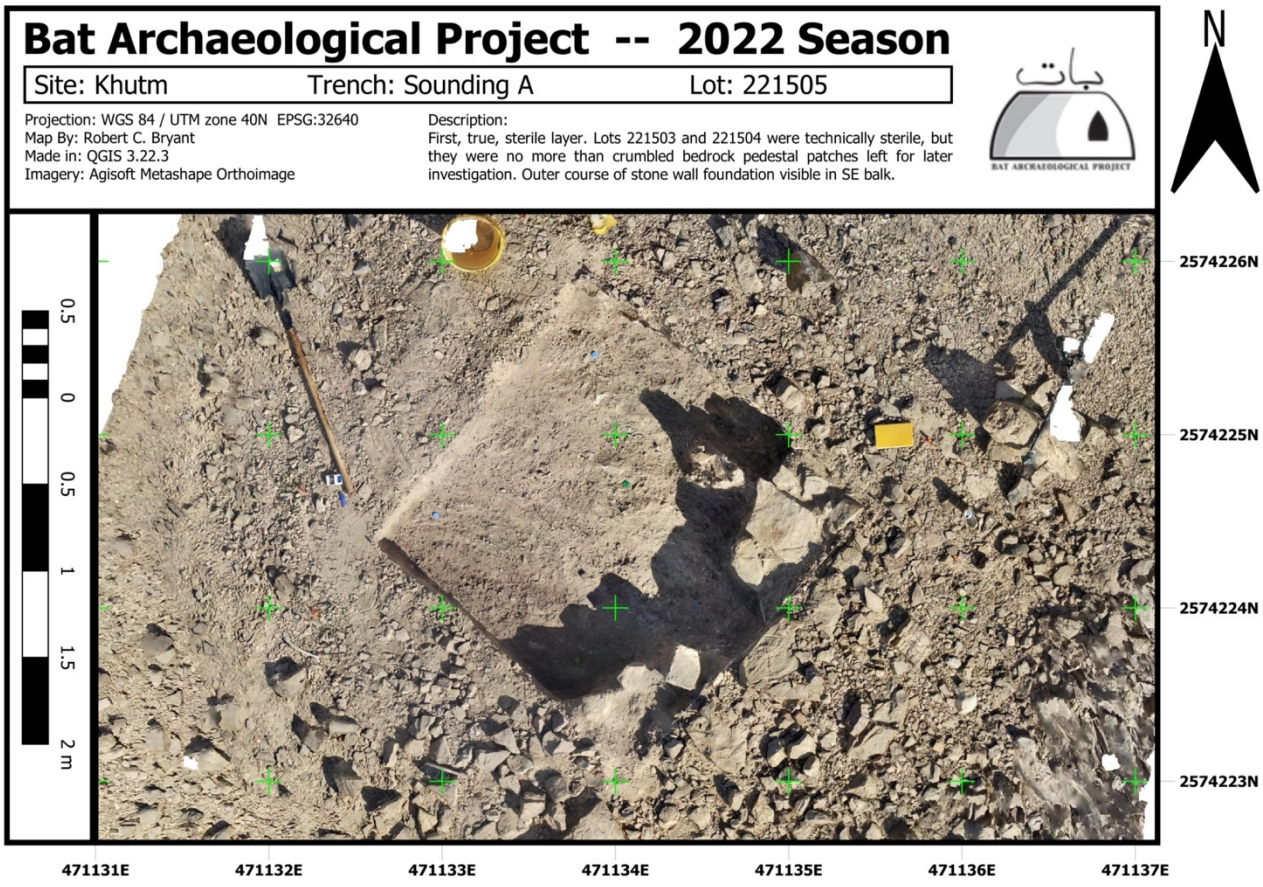

Figure 45: Example of a photogrammetric model of Sounding A

Largely a success, all control points were found to be within 1-2 cm of the reconstructed models' DEM values—well within an acceptable range of error and comparable to the accuracy of points taken with a standard total station. Results of this test and the Khutm Settlement excavations will be presented at the 2022 meeting of the Computer Applications in Archaeology conference in Oxford, UK.

5.4 al-Khutm Survey

A combination of opportunistic and systematic survey was also conducted at al-Khutm during the BAP 2022 field season. This survey was carried out with the goals of:

- Documenting changes in and threats to the preservation of the site;
- Clarifying the occupational history of the Khutm Settlement;
- Identifying promising areas for future research.

5.4.1 Opportunistic Survey

Over the course of the BAP 2022 field season, several opportunities arose for opportunistic survey at al-Khutm. During routine travel to and from the site, damages from recent construction activity,

dumping, and erosion were documented in locations on all sides of the Khutm hill (see Fig 46,47, and 48). Erosion and earthmoving along the south-facing hillside have exposed and in some cases destroyed rectilinear stone architecture and at least one Umm an-Nar tomb beyond what was documented at the site by BAP in previous seasons Additionally, a mound of dirt associated with the installation of street lights along the road just north of the Khutm hill was found to contain a large fragment of a Middle Umm an-Nar suspension vessel (Figure 49). The size and high quality preservation of this vessel suggests the earthmoving that accompanied the streetlight installation destroyed an Umm an-Nar tomb in the vicinity of the Khutm hill.

Figure 46: Dumping along the south face of al-Khutm hill.

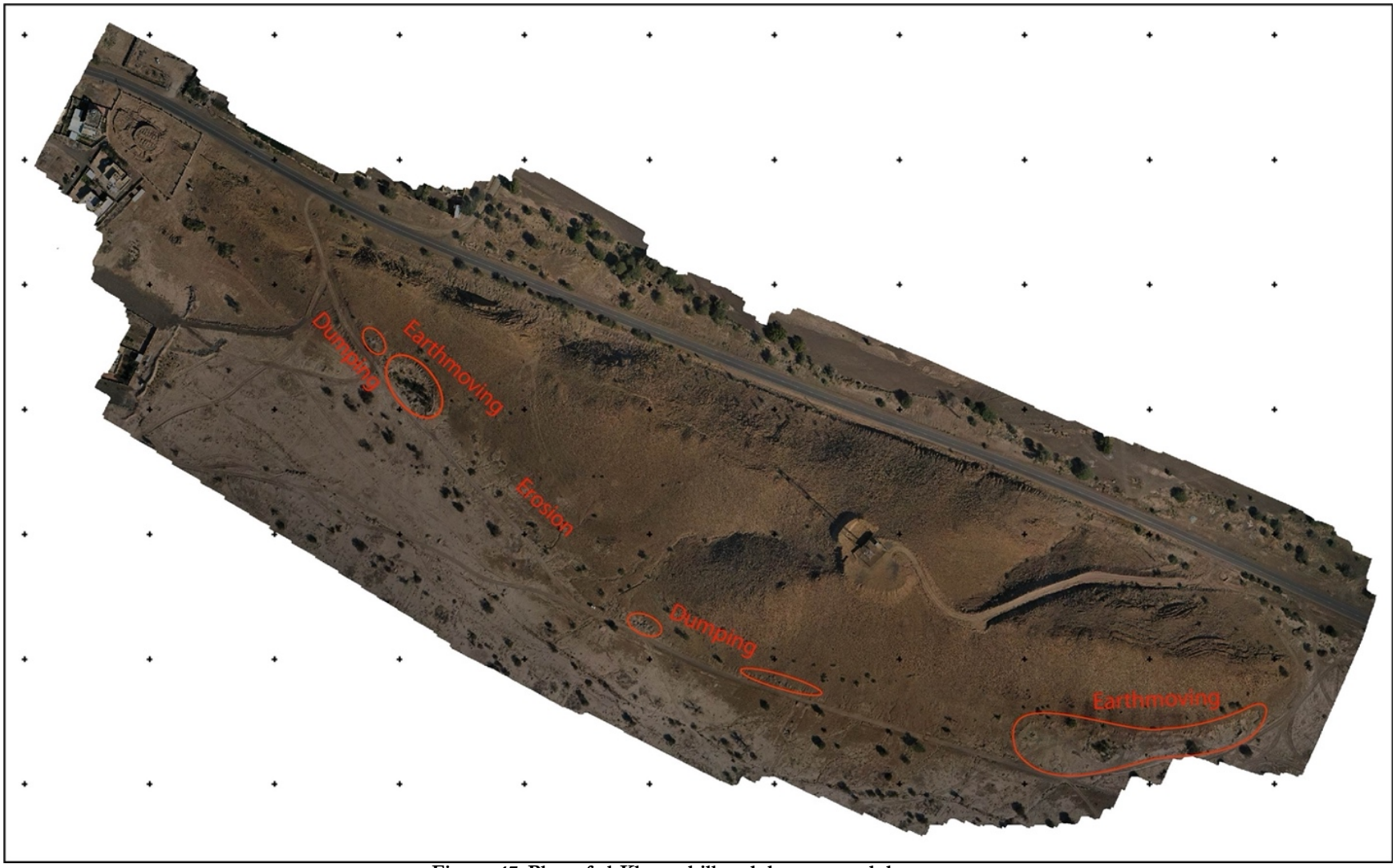

Figure *47*: Plan of al-Khutm hill and documented damages

Figure 48: Bulldozer damage along southeast edge of Khutm hill

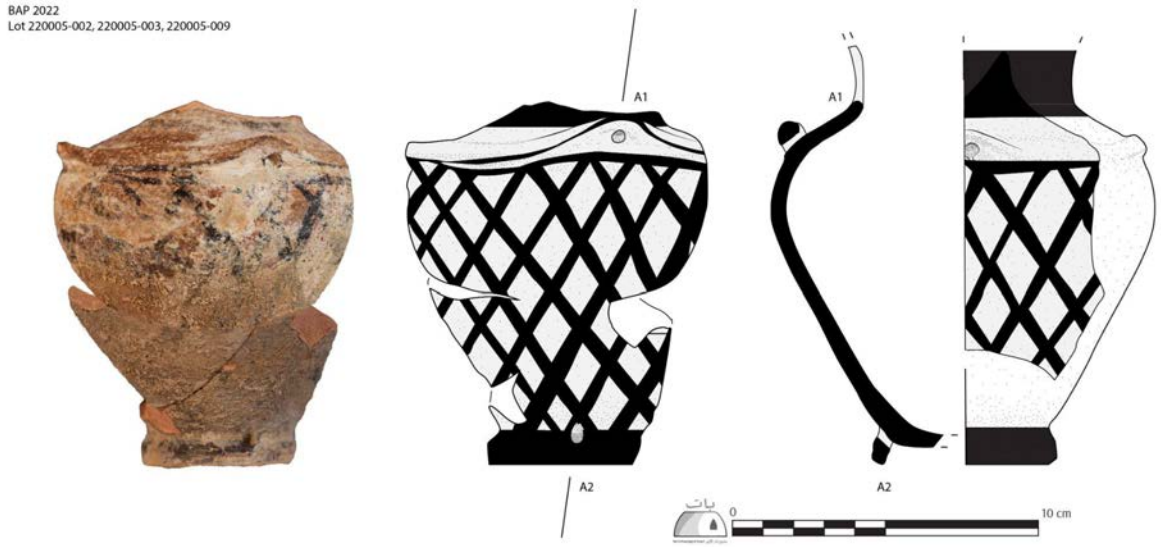

Figure 49**: A suspension vessel found during a rescue survey operation at Khutm during road construction (Lot 220005)**

5.5.2 Imagery-Assisted Systematic Survey

Based on the results of the opportunistic survey, two days of imagery-assisted systematic survey were also conducted at the Khutm Settlement. This survey was designed to determine the extent of certain large stone walls identified on the ground on the south-western side of the al-Khutm slope. As stated in the Methods section of Chapter 2, aerial images and a derived DEM from drone flights were instrumental in identifying the potential extent of the walls—and by extension structures—present, however the ultimate definition of their courses was based on a surface survey. For this, the area previously identified by remote sensing was visited, and any visible walls were followed to determine their extent, with each significant break or section marked by a GNSS point. By connecting these points in ArcGIS, a map of the definite, probable, and tentative walls could be produced (Fig. #).

Several of the individual walls identified appeared similar in size and direction, being comprised of massive blocks between 50 and 100 cm across, and double-faced. This potential single structure was dubbed "Building Alpha", and accordingly marked separately on the GIS. If this is indeed one building, it would measure 10 by 100 meters, with numerous cross walls of smaller-sized stones of at most 40 cm across (though still double-faced). All of these walls appeared to measure about 1 meter across. In addition to "Building Alpha", 13 further individual walls of a smaller width were identified, eight of which likely comprise two buildings of four walls apiece. Two walls to the south-eastern end of the surveyed area appeared in a different orientation to all other walls, being offset by almost 45 degrees. These were comprised of stones of similar sizes to the above, but appeared to be single-faced. They may therefore constitute a different phase of occupation.

5.5.3 Interpretation

Based on the distribution of ceramics collected at the site and the construction style of the recorded stone walling during 2022 and prior BAP surveys, a tentative phasing can be proposed for the Khutm settlement. The material culture and architecture observed at the eastern end of the south-facing hillside are consistent with those of the Middle Umm an-Nar I and II known from numerous locations on the Bat landscape. A largely destroyed Umm an-Nar tomb was also identified in close proximity to a particularly large building at the far eastern end of the settled area of hillside. It is probable that additional Umm an-Nar buildings and tombs remain obscured by surface debris on the hill and beneath the soft silt of the wadi plane.

At the western end of the south-facing hillside, the ceramic and architectural styles notably change and are consistent with the Iron II period. Ceramics include large storage jars, jar lids, and palace war. The extremely large, rectilinear "Building Alpha" in this area is architecturally consistent with Iron Age forts, such as the well-known site of Muweilah in the UAE (Magee 1996; Magee et al. 2002). The size of the surviving and visible portions of Building Alpha suggest that the Khutm fort would have been comparable to if not larger than the Muweilah fortress. Regrettably, a significant area of the building has now been destroyed by earthmoving activity. The temporality of the Iron Age II finds at the western Khutm settlement is consistent with contexts excavated atop and surrounding the Khutm tower at the northwestern end of the hill (Cattani et al. 2017; Cocca et al. 2019). This suggests

that the Iron Age activity at the tower and the fortress on the opposite side of the hill should be understood as a single occupation. Together, these features likely represent an extremely important Iron Age center in Oman.

Figure 50: Probable Iron Age wall destroyed by bulldozing

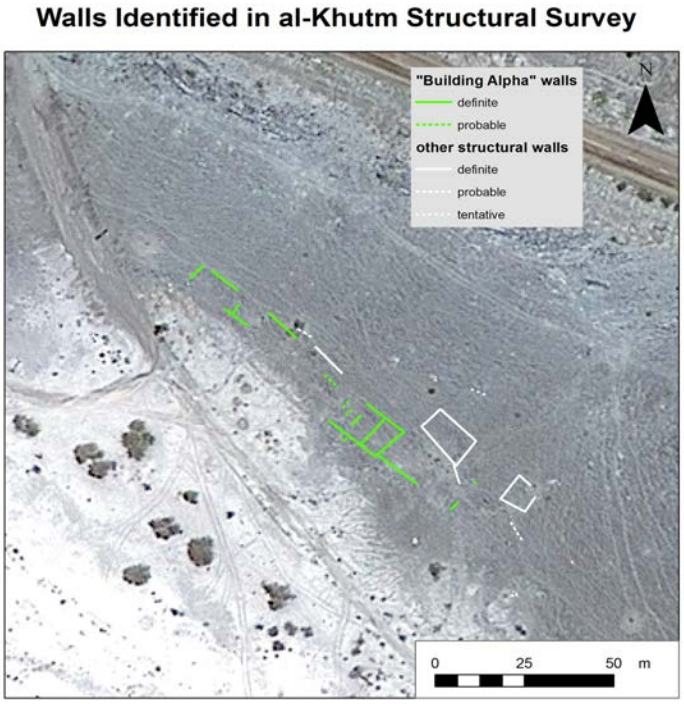

Figure 51: Map showing walls identified by this structural survey of the south-western slope of al-Khutm, subdivided by certainty.

6. Artifact Analysis

Eli Dollarhide, Paige Paulsen, & Amir Zaribaf

6.1 Ceramics

Pandemic restrictions prevented a full analysis of the ceramic corpus collected this season. Instead, survey sherds, containing critical chronological markers needed for site interpretation were prioritized for analysis. The following section thus presents the full report of pottery collected during BAP's 2022 survey operations and additional counts and illustrations for excavated sherds from 2022 as available. A full analysis and interpretation of the 2022 excavation collection will be conducted before the start of BAP's 2023 field season.

The ceramics analysis conducted as part of the Bat 2022 field season utilized a macro-stylistic approach and non-destructive techniques. Sherds were analyzed and sorted according to vessel form, ware/fabric type, surface treatment, and decoration. This information was then utilized to assess the time period in which each sherd was produced, in consultation with previous excavations at Bat and other published archaeological ceramic assemblages from the region.

Sherds from the following chronological periods were analyzed during the 2020 BAP field season (adapted from Swerida, et al. 2021; Thornton and Ghazal 2016; Potts 1992; Magee 1996; Whitcomb 1975; and Kennet 2004):

Early Umm an-Nar	2800-2500 BCE
Middle Umm an-Nar	2500-2200 BCE
Late Umm an-Nar	2200-2000 BCE
Wadi Suq	2000-1600 BCE
Late Bronze Age	1600-1300 BCE
Iron Age I	1300-1100 BCE
Iron Age II	1100-600 BCE
Iron Age III	600-300 BCE
Late Pre-Islamic	300 BCE- 635 CE
Early Islamic	635-1055 CE
Middle Islamic	1055-1500 CE
Late/Early Modern Islamic	1500-1750 CE
Modern/Ethnographic	post 1750 CE

Table 4: Chronological framework utilized in this season's ceramic analyses

6.1.2 Survey Sherds

804 sherds were examined from BAP's 2022 survey operations. Shers were analyzed for form, ware, and period. Significant examples were illustrated and photographed. The table below summarizes this analysis, utilizing a generalized three period system. Additionally, illustrations of a selection of sherds collected during Khutm suvey operations this season and at the Settlement Slope are presented.

Bat Lot Number	Date Collected	Total Diagnostics	Total Sherd Count	Total Bronze Age Sherd Count	Total Iron/Late Pre-Islamic Period Sherd Count	Total Islamic Periods Sherd Count	Time Period Unknown
222013	19-Jan	2	12	12	0	12	0
222047	23-Jan	40	51	51	0	0	7
222050	23-Jan	2	5	5	0	0	0
222055	23-Jan	78	86	86	1	0	4
222061	23-Jan	2	3	0	0	0	1
222062	23-Jan	6	14	14	0	0	0
222063	24-Jan	53	59	59	1	0	5
222069	24-Jan	2	3	3	0	0	0
222072	24-Jan	81	90	79	0	0	2
222074	24-Jan	2	2	2	0	0	0
222076	24-Jan	1	1	1	0	0	0
222079	24-Jan	2	2	2	0	0	0
222071	24-Jan	3	5	5	0	0	0
222080	24-Jan	4	6	6	0	0	1
222082	24-Jan	1	2	2	0	0	0
222084	24-Jan	1	1	0	0	0	1
222086	25-Jan	1	1	0	0	0	0
222088	25-Jan	10	14	14	0	0	0
222089	25-Jan	0	1	1	0	0	0
222090	25-Jan	2	3	3	0	0	0
222091	25-Jan	3	5	5	0	0	1
222093	25-Jan	5	7	0	0	0	0
222095	25-Jan	62	81	81	7	4	9
222098	25-Jan	1	7	7	0	0	0

Bat Lot Number	Date Collected	Total Diagnostics	Total Sherd Count	Total Bronze Age Sherd Count	Total Iron/Late Pre-Islamic Period Sherd Count	Total Islamic Periods Sherd Count	Time Period Unknown
222100	25-Jan	2	4	4	0	0	0
222101	25-Jan	1	1	1	0	0	0
222102	25-Jan	3	3	3	0	0	0
222104	26-Jan	2	2	2	0	0	0
222105	26-Jan	52	69	69	3	3	0
222108	26-Jan	3	7	7	0	0	4
222110	26-Jan	5	5	5	1	0	1
222113	28-Jan	2	2	2	0	2	0
222114	26-Jan	3	3	3	0	0	0
222118	30-Jan	0	1	1	0	0	1
222119	30-Jan	10	11	11	0	0	3
222126	30-Jan	3	3	3	0	3	0
222129	30-Jan	26	26	21	2	3	0
222130	30-Jan	4	4	4	0	0	0
222134	30-Jan	4	4	4	2	0	0
222135	30-Jan	3	3	3	1	0	0
222137	31-Jan	1	1	0	0	1	0
222138	31-Jan	7	7	7	0	0	0
222139	31-Jan	1	1	1	0	0	0
222140	31-Jan	2	4	4	0	0	0
222143	31-Jan	3	3	3	0	0	0
222144	31-Jan	5	6	6	0	1	2
222145	31-Jan	6	7	7	0	1	2
222146	31-Jan	35	40	40	2	1	0
222149	1-Feb	15	18	18	2	2	3

Bat Lot Number	Date Collected	Total Diagnostics	Total Sherd Count	Total Bronze Age Sherd Count	Total Iron/Late Pre-Islamic Period Sherd Count	Total Islamic Periods Sherd Count	Time Period Unknown
222150	1-Feb	40	41	41	2	8	0
222153	1-Feb	21	21	21	4	0	1
222154	1-Feb	22	22	22	0	0	0
222502	2-Feb	0	2	2	0	0	0
222506	2-Feb	1	1		1	0	0
222516	2-Feb	8	8	8	0	0	0
222520	2-Feb	1	1	1	0	0	0
222528	2-Feb	2	2	2	0	1	0
222535	3-Feb	1	1	2	0	0	0
222537	3-Feb	1	2	2	0	0	0
222541	3-Feb	0	1	1	0	0	0
222547	3-Feb	1	2	2	3	0	1
220004 (Khutm)	4-Feb	3	2	2	0	1	
222064	24-Jan	2	2	7	0		1

Table 5: Survey Ceramics Counts and Periods

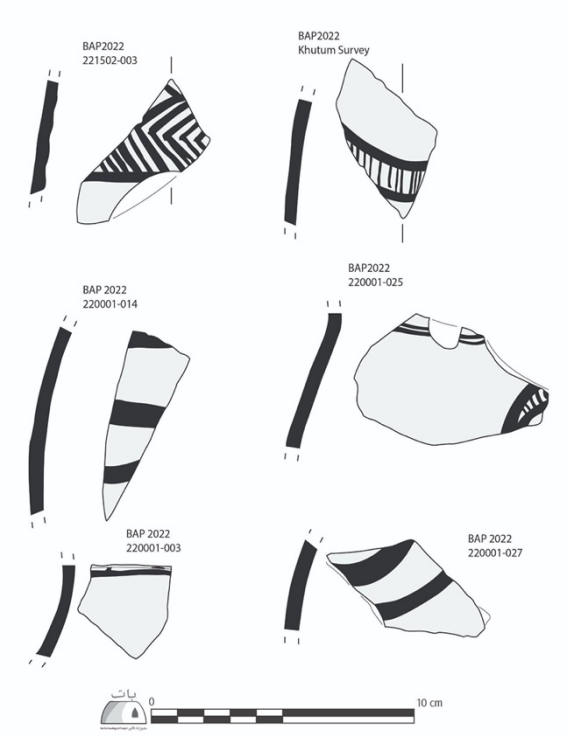

Figure 52:Umm an-Nar decorated body sherds collected at Khutm during survey operations

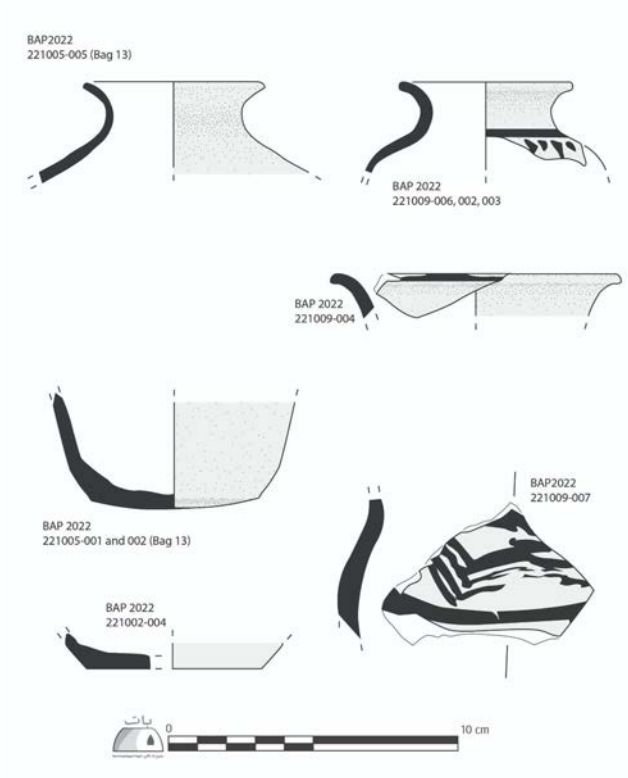

Figure 53: Diagnostic sherds collected during excavation and survey at the Settlement Slope this season.

6.2 Lithics and Small Finds

Stone tools, debitage, and other remains of lithic technology were collected this season as part of excavation and survey operations. All objects collected were identified to type as possible, photographed, and returned to the Ministry of Heritage and Tourism storehouses. These collections will be further analyzed in future BAP season. The analysis of lithics collected during survey operations this season is ongoing and will be reported on in BAP's 2023 report.

Small finds are included in the summarizing table below as applicable and further discussed in the relevant contextual section of this report in which they were collected.

Bat Lot Number	Site	Date Collected	Type	Count	Notes/Description
221548	RAM 1	28-Jan-22	GROUNDSTONE	1	Large grinding stone
221502	RAM 1	17-Jan-22	LITHIC	1	Flake with retouch
221842	RAM 2	31-Jan-22	LITHIC	1	Flake with retouch, long shape, awl?
221503	RAM 1	17-Jan-22	LITHIC	2	Flakes with retouch
221804	RAM 2	25-Jan-22	LITHIC	1	Flake with retouch
221502	RAM 1	18-Jan-22	METAL	1	Large copper fragment
221240	SS	12-Jan-22	METAL	1	Copper fragment
221821	RAM 2	26-Jan-22	GROUNDSTONE	1	Hammerstone
221552	RAM 1	30-Jan-22	BEAD	1	Carnelian bead, circular
221849	RAM 2	1-Feb-22	SHELL	1	Marine shell fragment
221536	RAM 1	26-Jan-22	LITHIC	2	Retouched flakes
221836	RAM 3	27-Jan-22	LITHIC	8	Micro-flakes
221906	RAM 1	1-Feb-22	LITHIC	1	Retouched flake
221803	RAM 2	???	LITHIC	3	Retouched flakes
221804	RAM 2	17-Jan-22	LITHIC	3	Potential core and retouched flake and point
221502	RAM 1	16-Jan-22	LITHIC	1	Flake
221531	RAM 1	25-Jan-22	GROUNDSTONE	1	Potential grinding stone
221517	RAM 1	24-Jan-22	LITHIC	1	Flake with retouch
221593	RAM 1	18-Jan-22	LITHIC	1	Flake with retouch
221545	RAM 1	31-Jan-22	GROUNDSTONE	1	broken hammerstone
221554	RAM 1	1-Feb-22	LITHIC	1	Retouched flake

221549	RAM 1	28-Jan-22	METAL	1	Stone with copper prill

Table 6: Lithic and small finds from Bat Domestic Excavations

Figure 54: A softstone vessel fragment found within the Settlement Slope Umm an-Nar tomb (lot 221208)

Figure 55: Pierced marine shells from the Settlement Slope (lots 220003 and 221228)

7. Outreach and Engagement

Reilly S. Jensen

7.1 Outreach Summary

The outreach goals of the Bat Archaeological Project were developed to support overarching public outreach initiatives of the national Ministry of Heritage and Tourism office in Muscat. These goals support a larger mission to enrich community understanding of Bat and its archaeological landscape as one that is unique, remarkable, and worthy of stewardship. These are as follows: 1. To inspire curiosity and empower communities to engage with the archaeological past (especially those who do not currently engage with it or those who feel disconnected from it); 2. To build positive relationships with community stakeholders; 3. To encourage future opportunities that specifically integrate archaeology into education curricula in Bat.

The project dedicated an Assistant Director, Ms. Reilly Jensen, to assess and identify outreach strategies as a primary outcome and goal of research this season. By using a combination of arts integration and public engagement strategies, Reilly identified a broad public audience that included schoolchildren, their parents, and the wider community. Thanks to the help and expertise of Ms. Asmaa bint Rashid Al-Jassassi, Reilly began building these relationships by visiting with administrators at local village schools to understand the specific opportunities that would attract children and their families. These efforts ultimately culminated in the creation of education-centered art-and-archaeology kits, which included an original full-color comic written in Arabic, and locally harvested wadi clay pottery-kits. Additionally, Reilly extended project reach by incorporating process-based research into contemporary pottery-production and used the culmination of those experiments to build public interest via social media posts online using Instagram.

7.2 Arts Integration Strategy: Outreach Assessment, Planning, and Execution

Arts Integration was utilized strategically this season to explore insights and potential narratives about the landscape and the past. Art is an effective, attractive way to demonstrate a concept or tell a story while connecting with audiences and communities. It can transcend language boundaries, create connections between disparate or conflicting concepts, challenge established perspectives and paradigms, and create new perspectives and insights. Art can serve as a bridge between audiences and disciplines. Thus arts integration is an incredibly effective tool for interdisciplinary communication and successful community outreach.

The most successful outreach branch for the primary audience this season was the creation of an original comic and pottery-production kits for village school children. The research that led to the comic creation was a community-led experiential local-pottery art project that the BAP team created as an after-field community activity. Rooted in trying to understand and identify aspects of pottery production on a Bronze Age Bat landscape, and how to communicate what that material culture might look like to a nonspecialist audience, outreach at Bat began by challenging archaeologists to become pottery-artists using only foraged materials from the surrounding landscape. Reilly and Dr. Selin

Nugent began an intuitive survey sample of clay deposits from across the Bat landscape, collecting clay with explicit permission from land agencies and landowners where appropriate. The project team began rehydrating the clay, forming pots with the processed clay, and test-firing pots to determine the structural integrity and overall quality of clay deposits on the contemporary landscape. The findings yielded one clay collection location that contains professional studio-grade quality clay requiring no extensive processing. This clay held up to initial pit fire tests, producing structurally stable ceramic vessels. After this material had been tested successfully, clay collection and processing began en masse, with the BAP team working together to create contemporary pottery.

Figure 56: Contemporary BAP ceramics pre-firing (left, with Dr. Selin Nugent) and post-firing (right)

This experiential learning process provided an opportunity for archaeologists to deepen their knowledge of ceramic production at the potter stage, including a group appreciation of the skill and finesse executed by craftsmen and potters in the Bronze Age (which was impossible to ignore given the rough aesthetics of BAP pottery when compared to authentic bronze age ceramic sherds). The art-integration process of this project challenged archaeologists not just to assess and analyze pottery as a dataset but helped them envision individual use-life, purpose/function, and variability between vessels and creators, and also included archaeologists as collaborators in the logistical demands, failures, and successes of pottery production. The BAP team worked together to create ceramic and identify, gather, and strategically harvest fire-making materials (that would have been readily available in antiquity), creating a comprehensive understanding of fuel sources from the surrounding landscape. The pottery exploration on an internal team level enriched an understanding of the past and current Bat landscape. It also generated rich research questions for future ceramics specialists to expand upon or illuminate.

Within the wider public-facing communities at Bat, pottery-making became a unique public performance spectacle this season that attracted local interest. It sparked conversations with residents about the qualities, histories, and uses of clay in their family farms, clay used for different purposes (i.e., mudbrick vs pottery), andeven the similarities of hand-movements between pottery-creation and cooking techniques. The collaborative and visible process of pottery making became an attractive opportunity to begin conversations with Omani village residents about the archaeological past and the landscape of Bat. The interest from onlookers and the engagement from social media posts led to the idea of creating a pottery-making opportunity for the local school.

With the help of Ms. Asmaa bint Rashid Al-Jasassi, Reilly visited a local school and met the headmistress to gauge interest in bringing pottery-making activities to the outdoor classroom. She received interest and encouragement from the headmistress to proceed in planning an integrated arts-and-archaeology lesson and pottery-making activity with primary school children; permission letters were sent out to parents to inform and seek consent. In the meantime, the COVID-19 situation was evolving rapidly, and the national government of Oman shut down public infrastructure, closing schools for the majority of the BAP field season. With the dynamic needs and requirements of advancing project COVID-19 outbreak safety measures, outreach ultimately resulted in the creation of take-home comic-and-ceramic-making kits in that disguised technical archaeological research and concepts surrounding bronze age pottery production as the personal childhood memories of a broken, amnesiac Umm an-Nar body sherd looking to reconnect with his long-lost family.

Figure 57: Page 1 (left) and Page 6 (right) of BAP outreach comic. Written and illustrated by Reilly Jensen

Through this narrative arch, Reilly adopted object-oriented ontology to frame an archaeological question about ceramic production in the past and make it available to a community constricted by pandemic protocols. Using vivid visuals and written in Arabic, the comic appealed to a

primary audience of young children to tell a story, and provide instructions and information about coil-making and production of pottery.

Figure 58: Page 5 of BAP outreach comic, written and illustrated by Reilly Jensen

Ms. Asmaa bint Rashid Al-Jassassi and Sumaia al Marmarri from the Ministry of Heritage and Tourism office in Bat distributed these kits after the 2021 field season across two schools in Bat as part of an official Ministry outreach visit. Each kit included: 1). 1 original Comic; 2). 1 locally harvested and processed wadi-clay with illustrated pottery instructions; 3). 1 biodegradable bamboo spoon tool ; 4). 3 original coloring book pages.

Figure 59: BAP outreach art-and-archaeology kit contents

Ms. Asmaa bint Rashid Al-Jassassi reported that children and their teachers were engaged and interested in learning how to make coiled pottery from the local clay provided in each kit. Some children worked collaboratively together to integrate ideas about ceramic designs and the use of their pottery vessels. The results were a success, as they indicate further potential for arts-integrated archaeology projects in Bat to be explored next season.

Figure 60: School children in Bat collaborate to make pottery using harvested wadi clay. Photo courtesy of Asma bint Rashid al-Jassassi

Figure 61: School Children in Bat collaborate to make pottery using harvested wadi clay. Photo courtesy of Asma bint Rashid al-Jassassi

7.3 Social Media Impacts

Reilly wrote and implemented a social media campaign that consisted of Instagram stories, posts and reel releases throughout the season to expand the audience further afield. The content was generated from discussions with members of the project team while conducting research and fieldwork tasks and crossposted in collaboration with individual researcher's social media accounts.

Overall, this campaign reached +93,406% more accounts than the previous field season, reaching approximately 40.2k individual accounts, engaging 918 total accounts, and attracting 422 new followers (most of them are young adult males living in Muscat) to the Project's Instagram profile page (*@batarchaeologicalproject*).

Analytic Insight data from this outreach is presented in the table below:

Date Posted	Reach/Impressions	Content Interactions	Promoted? Y/N
Jan 6 2022	525	68	N
Jan 6 2022	717	140	N
Jan 6 2022	1632	48	N
Jan 7 2022	1220	205	N
Jan 9 2022	950	44	N
Jan 10 2022	619	86	N
Jan 10 2022	2401	123	N
Jan 12 2022	30506	295	Y: Profile visit promo goal
Jan 13 2022	1245	93	N
Jan 15 2022	1432	37	N
Jan 16 2022	1382	89	N
Jan 19 2022	686	81	N
Jan 20 2022	478	48	N
Jan 24 2022	646	58	N
Jan 27 2022	571	66	N
Jan 29 2022	1086	164	N
Jan 31 2022	406	53	N
Feb 1 2022	276	47	N

Feb 2 2022	428	68	N
Feb 7 2022	3488	229	N
Feb 11 2022	488	79	N
Feb 18 2022	577	65	N
Feb 18 2022	476	52	N
Feb 25 2022	505	51	N

Table 7: Summary of Social Media Impacts

The project received messages from young adult users based in Oman inquiring about possibilities for site visitation, expressing interest and need for documents presenting archaeological knowledge that can engage young audiences. Throughout these interactions, BAP fielded online questions from the public about material culture, excavation, and how to identify archaeology. This experience demonstrates a yet-unmet need for public opportunities in Oman to interface with archaeologists working there. Public interest in the project was also promoted via various television news outlets, facilitated by the generous support of the Project's Ministry sponsor, Mr. Suleiman al-Jabri, who confided that social media interest was an essential component of project recognition. The project received multiple spotlights in online news headlines across the Arabian Peninsula, including a televised news story on national television.

7.4 Future Possibilities

Given the success from the initial interest with schoolchildren in Bat, and the complications that inhibited further success during the COVID-19 outbreak, future possibilities should expand to include in-person and culturally-diverse arts-integration projects (such as ceramics workshops, field-trips, classroom exchanges, etc.) that empower children and their families residing in Bat to become experts and stewards of the archaeological resources at Bat and engage with local and international professional archaeologists working to preserve it.

The results tracked from social media interactions demonstrate interest outside Bat from tourists wanting to visit the site, but they don't know where to go or what to look at when they get there. Next season, a potential opportunity exists to work towards creating a community-centered project where schoolchildren could learn about archaeology at Bat from field trips with the BAP outreach team and translate their knowledge to the curation and creation of a free-to-the-public Bat Cultural Landscape Tour. Depending on the circumstances and interests of the community, this could potentially include the creation of interpretive signage and narrative storytelling that incorporates stewardship principles important to the residents of the site (specifically the children of the village). Given the recent momentum towards achieving a Bat Visitors Center, this could help fulfill a significant community need in the region, while still allowing for the vision to develop over time.

These projects were intended to build outreach bridges towards communities in Bat, however, they also contributed to exploratory research into the process of archaeology itself. They sparked interest in new directions, including ceramics-firing research and the potential for a historic mudbrick restoration project in the *husn* at Bat village (*Maqabil*).

8. Geomorphology and Hydrology at Rakhat al-Madrh

Tara Beuzen-Waller[1], Claude Cosandey[2], Stéphane Desruelles[3], Eric Fouache[4] and Aleksandre Prosperini[5]

8.1 Introduction

Tara Beuzen-Waller , Claude Cosandey, Stéphane Desruelles, Eric Fouache and Aleksandre Prosperini, members of the 'MEDEE' program[6], took part in the archaeological mission of the Bat Archaeological Project (directed by Eli Dollarhide, Jenifer Swerida and Reilly Jensen) from February 5 to 18, 2022.

8.2 Geomorphological study of the RAM Basin

The site of Rakhat al Madrh (RAM), excavated by the BAP team in 2022, is located 7 km upstream from the Bat oasis on the left bank of the Wadi al Hijr (Figures 62 and 63).

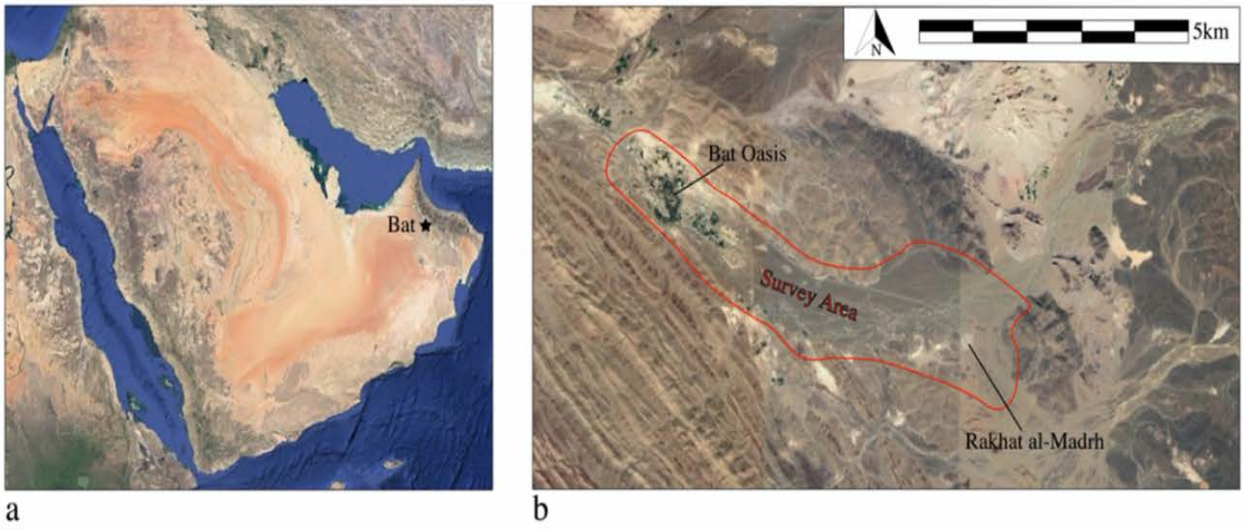

Figure 62: Location of the Bat oasis (a) and the site of Rakhat al Madrh (b).
Source: Google Earth, 2022

The excavated archaeological remains correspond to four houses of the Umm an Nar period (2,700-2,000 BC) each organized around a courtyard. They are located a few meters away from a vast expense of sandy clay-silty deposits, like a "playa", that cover the center of a topographic basin open

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[2] UMR 8591 LGP (CNRS, Univ. Panthéon-Sorbonne, UPEC), Meudon, France.
[3] Sorbonne University Abu Dhabi, UAE and UR Médiations, Sorbonne Université, Paris, France
[4] UR Médiations, Sorbonne Université & Institut Universitaire de France, Paris, France
[5] Université de Nice Côte d'Azur, France
[6] MEDEE (Mer, Désert, Environnement), Geoarchaeological program of the CEFREPA (Kuwait) leads by Eric Fouache and Stéphane Desruelles

on its northern side on the edge of the Wadi al Hijr. The fact that this basin turns into a temporary lake during heavy winter rains and flood from Wadi al Hijr (Fig. 3) and supports steppe vegetation has led archaeologists to consider a link between the remains and pastoral activity.

Figure 63: The Rakhat al Madrh (RAM) Basin. Source: Google Earth, 2022

Figure 64: Temporary pond in the center of the depression after a heavy rainfall event and a flood by the Wadi al Hijr (Bat Archaeological Project. December 24, 2019)

The objectives of this mission were:

1. to make a geomorphological map of the RAM Basin,
2. to reconstruct the sedimentary and hydrological functioning of the basin,
3. to study the sedimentary filling of the basin,
4. to start a palaeoenvironmental study including the human occupation.

8.2.1 Geomorphological context of the RAM Basin

The basin, located at 542 m above sea level, is surrounded by hills with slopes developed within siliceous limestone with marl intercalations from the Wahrah formation, dating from the Turonian (Upper Cretaceous). These siliceous limestones are overlain to the East and Southeast by highly cemented and weathered plio-quaternary fluvial conglomerates[7]. The ridge lines to the west of the basin, which rise to 550 m, are topped by graves of the Hafit period (3200-2700 BC). The siliceous limestones provided the materials for the construction of both the tombs and the houses in the basin.

The contact between the bedrock of the slopes and the bottom of the basin is characterized by gently sloping colluvial deposits. To the north, a fluvial terrace of the Wadi al Hijr stands at least one meter higher and is extended by a lateral spreading cone which suggests the hydro-sedimentary filling of the basin during major floods of the Wadi al Hijr. The alluvial terrace forms a natural dam and limits the evacuation of water that accumulates in the basin during high floods and/or heavy rainfall. Drainage is carried out to the northwest of the edge of the basin by a small talweg. A geomorphological map of the basin was made using a mosaic of aerial photographs taken by drone and a digital terrain model provided by the Bat Archaeological Project. Field checks were also carried out (Figure 65).

8.2.2 Geomorphology and hydrology of the basin

The floor of the basin, bordered by the contour line 542 m (Figure 66), is characterized by a light color on the satellite image (Figure 63). Its surface extension is around 6 ha. The northern part of the basin is closed by a lateral accretion cone from the Wadi al Hijr. A smaller cone related to a very small wadi coming from the neighboring hill is embedded within this larger cone. This small wadi is difficult to distinguish from the wad al Hijr and is about 1.5ha in area.

A gentle threshold separates the small indigenous wadi from the main Wadi al Hijr, but during major rainfall events this threshold can be overcome by the flow of this Wadi. Rounded pebbles deposited in this area by the Wadi al Hijr are clearly distinguishable from the alluvium of the small wadi and the playa sediments (Figure 67). The occurrence of recent floods is evidenced by the presence of flood leashes, such as a canister whose condition clearly proves the length of the transport (Figure 68).

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[7] Minoux L., Jaujon D., 1986.- « Geological Map of Ibri, scale 1: 100 000, sheet NF40-2F, Sultanate of Oman », Ministry of Petroleum and Minerals of the Sultanate of Oman, Bureau de recherches géologiques et minières, Orléans

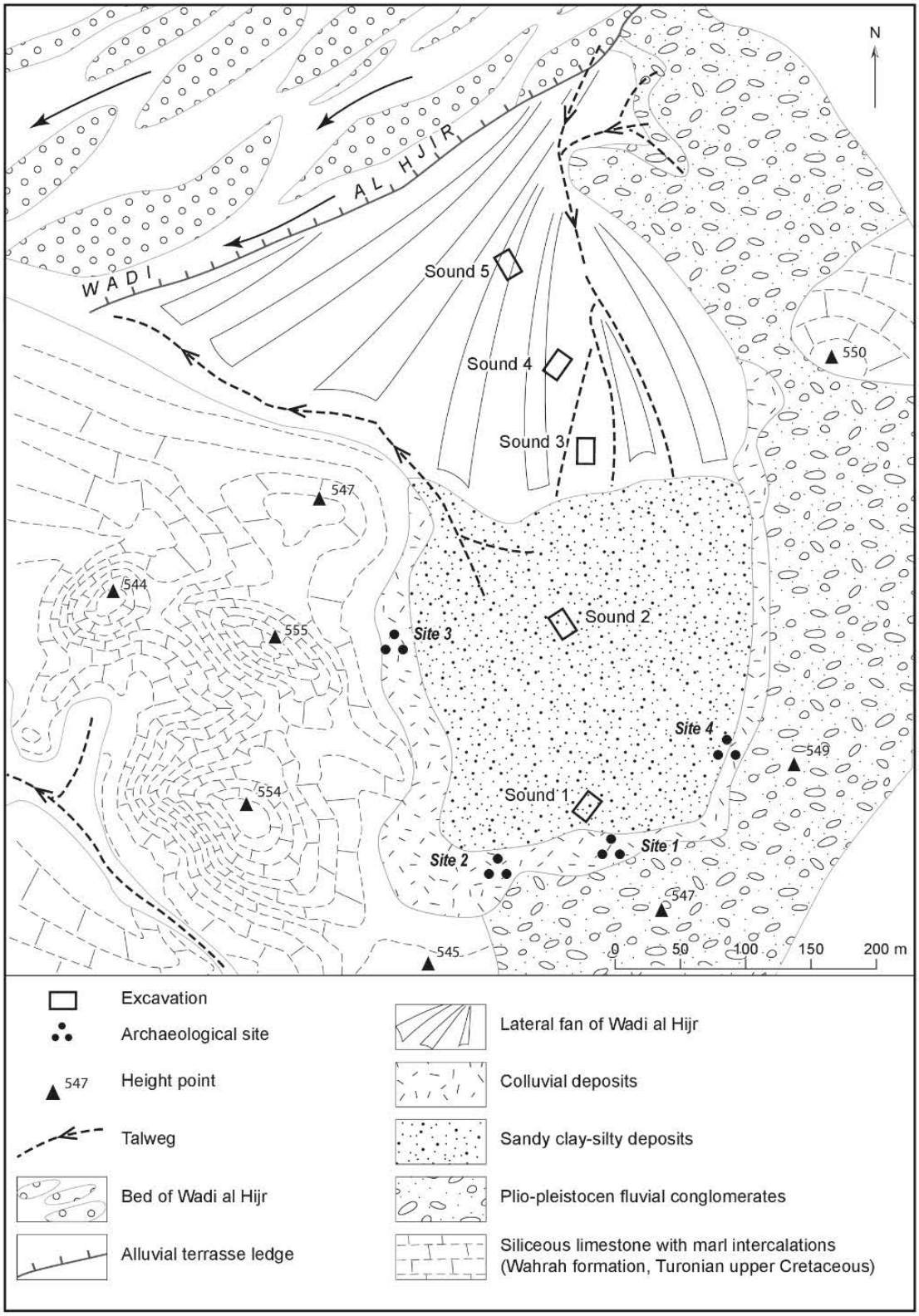

Figure 65: Geomorphological map of the RAM Basin
Computer-aided design: V. Lahaye, Sorbonne Université (Paris)

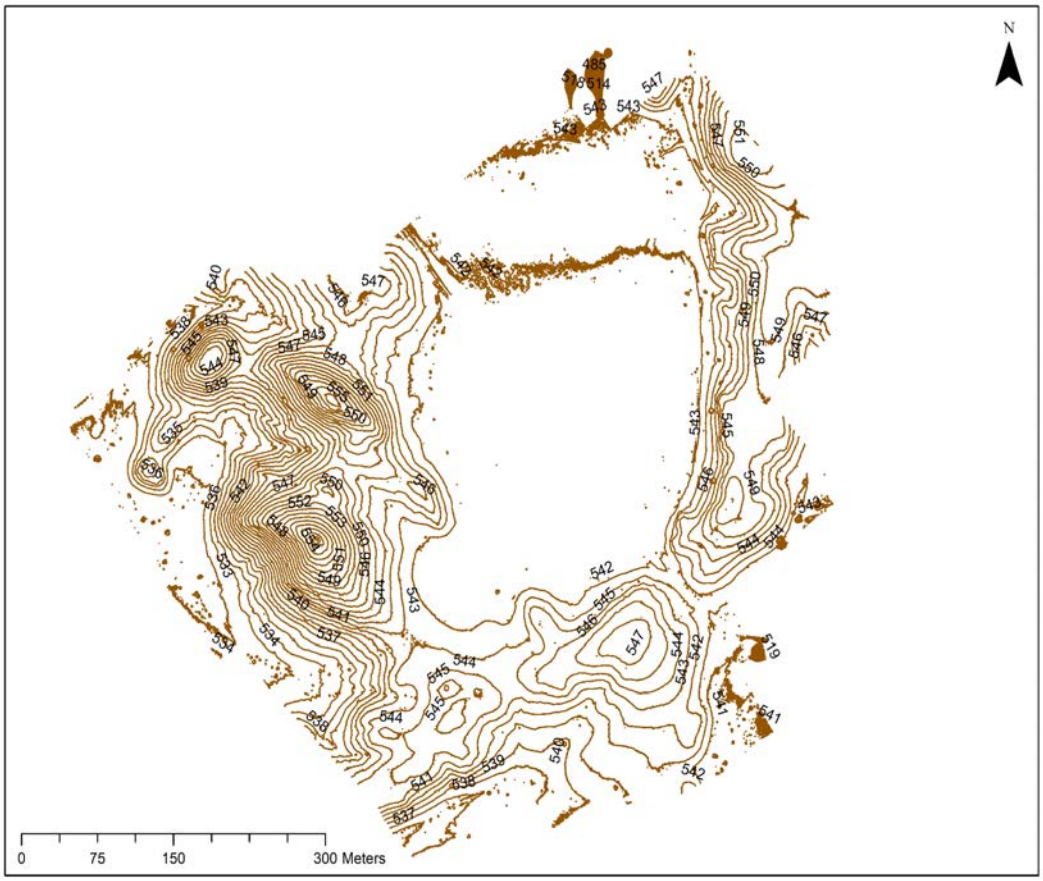

Figure 66: Elevation of the study area

Figure 67: Rounded pebbles related to Wadi al Hijr deposited in the northeast part of the RAM Basin

Figure 68: Canister transported by the flood from Wadi Al Hijr inside the RAM Basin

The watershed of the depression is very limited. It corresponds to the tops of the hills (up to about 555 m) that flank it to the east, south and west and to the threshold (around 543 m in the northwest). The drainage of the basin, allowed by a small talweg in the northwest, explains the absence of endoreism constraints in the sediments (especially salt and gypsum).

The paleotopography during earlier periods of the Holocene may have been different, in particular in the northern part of the basin because the alluvial level that seals the basin is an inherited late quaternary landform. In addition to the ephemeral filling of the basin by overflow and runoff, there is probably a continuous underground sediment and water supply through the basin outlet.

Based on this description, several questions guided our study and the choice of excavation sites:

- Is the basin an ancient valley closed by the current wadi al Hijr?
- Is the present relief related to structural depression that was formed at the same time as the surrounding area?
- Could this depression have been filled by a paleo-lake?

To answer these questions, geophysical surveys are necessary to determine the exact geometry of the basin floor, the bedrock roof, and the surface formations.

8.2.3 Description of the excavations

To reconstruct the paleo-environmental history of this basin, on the scale of a part of the Holocene, we have carried out 5 excavations with an earthmover on a transect south-west/north-east oriented.

All excavations were described, sketched, and sampled for sedimentological and phytoliths analyses. Samples for radiocarbon or Optically Stimulated Luminescence age-dating were collected to determine the chronology of deposition.

8.2.3.1 Excavation E1

E1 is located near one of the excavated houses (RAM1), at the foot of the hill on the colluvial apron. Slope deposits and a few boulders resting on the surrounding bedrock (Plio-Pleistocene conglomerates visible on the nearby hillside) can be seen over 140 cm (Figure 69). Eight lithofacies were identified, plus the embankment.

42 samples (21 x 2) were collected every 5 cm (for phytolith and sedimentology studies). One seed was found, 3 charcoal samples were taken for 14 C dating, and 2 blocks of sediment were collected for a micromorphological study. This excavation allows the observation of the organization of slope deposits and colluvial accumulation.

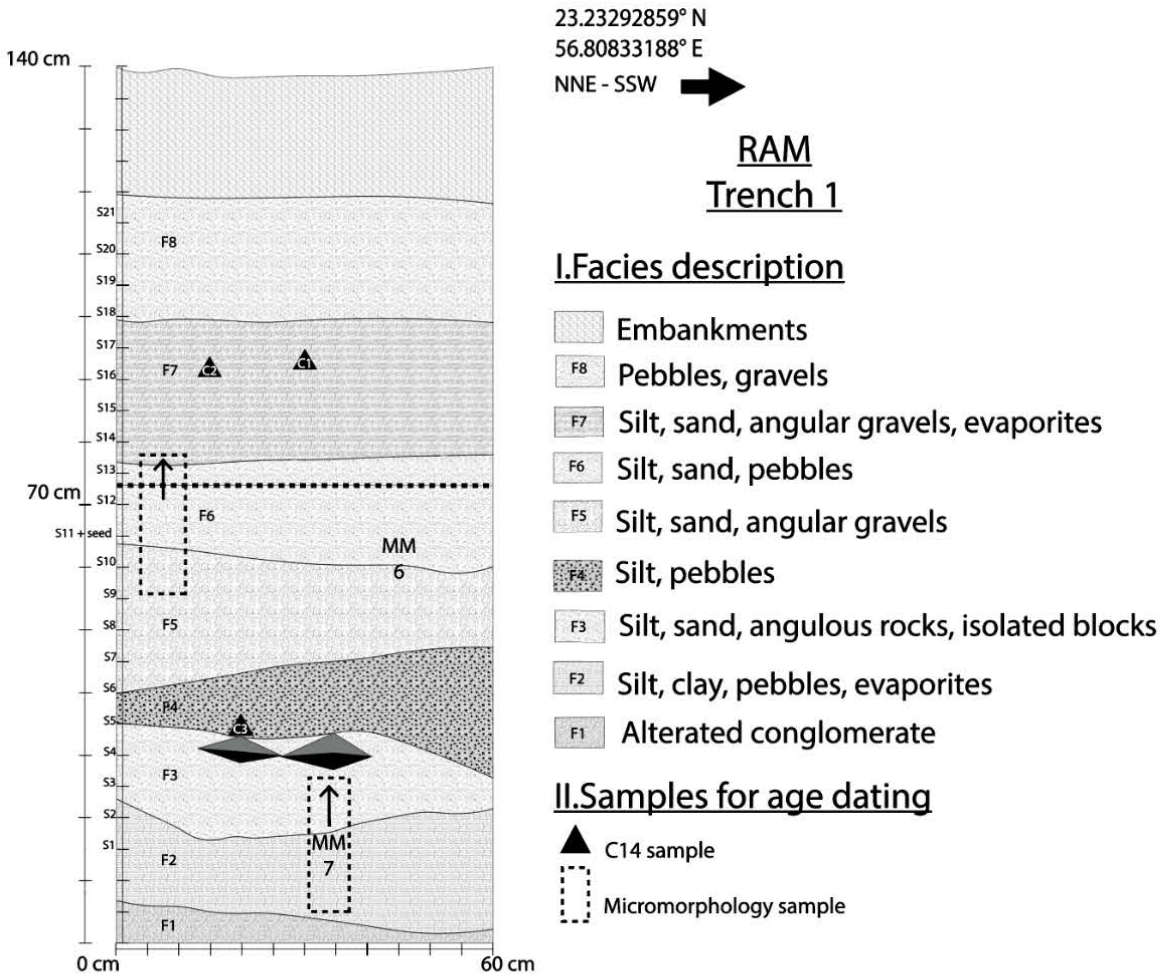

Figure 69: Stratigraphy and sampling of the excavation E1

8.2.3.2. Excavation E2

E2, located in the center of the basin, reached a depth of 280 cm (Figure 70). Eight lithofacies were identified. We observe mainly fine deposits, alternating between sands, silts, and clays. Several paleosoils have been identified. They reflect wetter conditions and pedogenesis. In the lower part of the excavation, the induration of sediments by gypsum could be the proof of a past period of endoreic functioning of this basin.

110 samples were collected, every 5 cm, for the study of phytoliths and sedimentology. 6 charcoal samples were taken for 14C dating, 1 sample for OSL dating and 5 blocks of sediment for a micromorphological study.

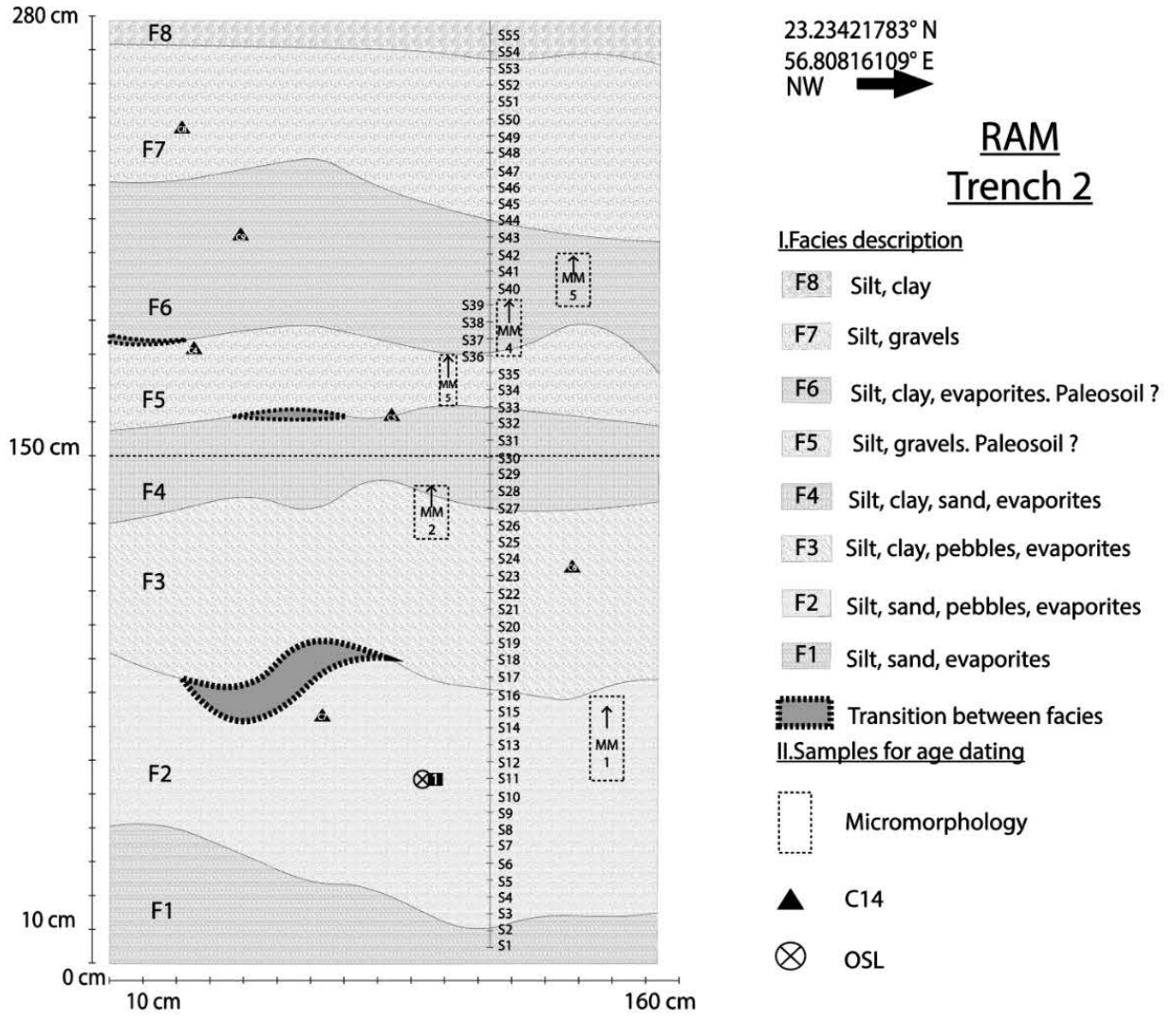

Figure 70: Stratigraphy and sampling of the excavation E2

8.2.3.3. Excavation E3

E3, located on the southern edge of the basin, reached a depth of 220 cm (Figure 71). This area enabled the study of the northern edge of the basin. Eight lithofacies were identified, and among them 3 lenses (F6, F7, F8). This section reveals the influence of lateral sedimentary in the infilling, and a general northwestern bending.

82 samples were collected, every 5 cm, for phytolith and sedimentology studies. 3 samples of mollusks were collected for species determination.

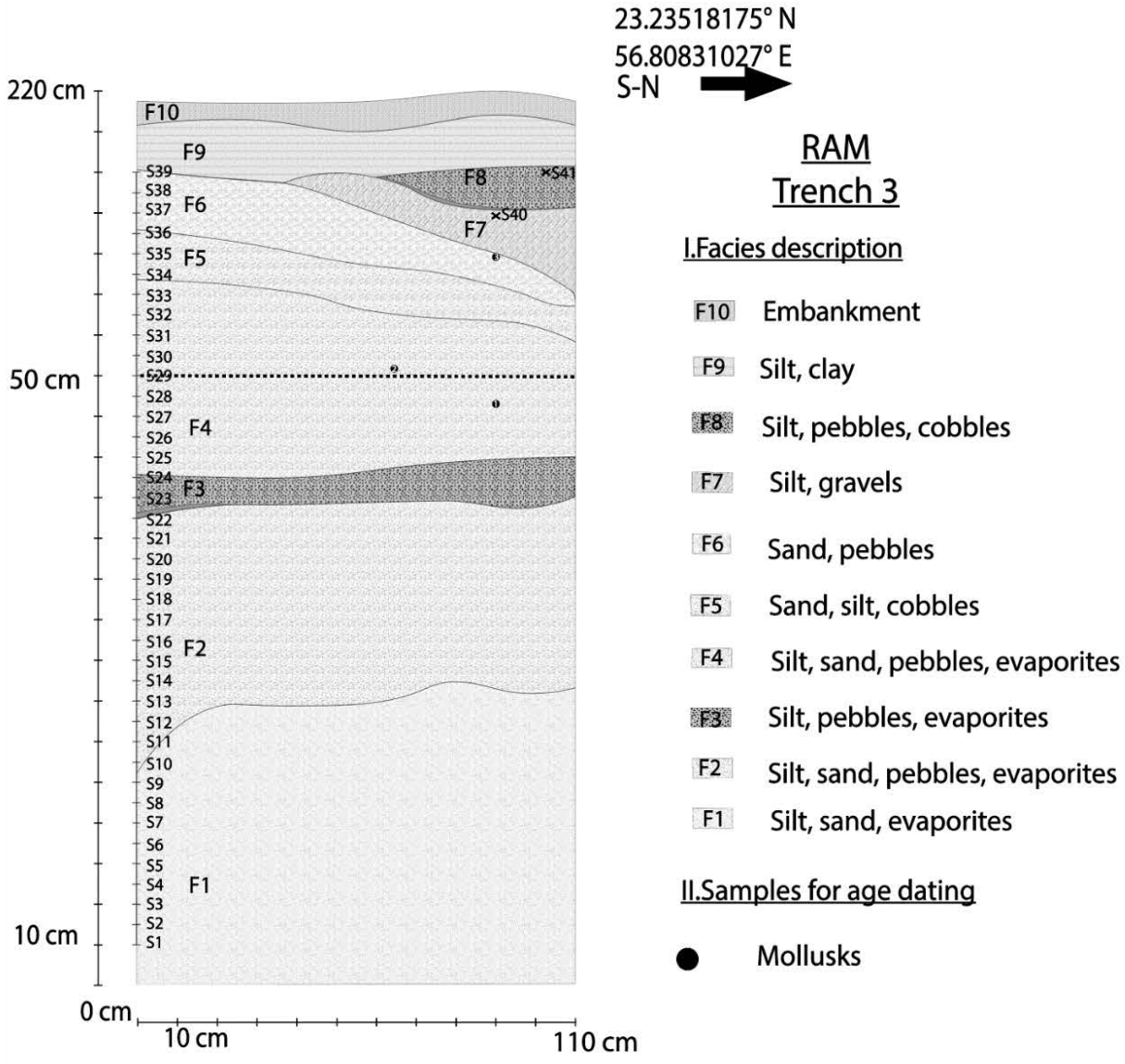

Figure 71: Stratigraphy and sampling of the excavation E3

8.2.3.4 Excavation E4

E4, located at the end of the spreading cone to the north of the basin, reached a depth of 270 cm (Figure 72). It alternates sand and gravel banks. The bottom is more consolidated. Fourteen lithofacies were identified.

Three OSL samples were collected as well as 2 samples for sedimentological analyses.

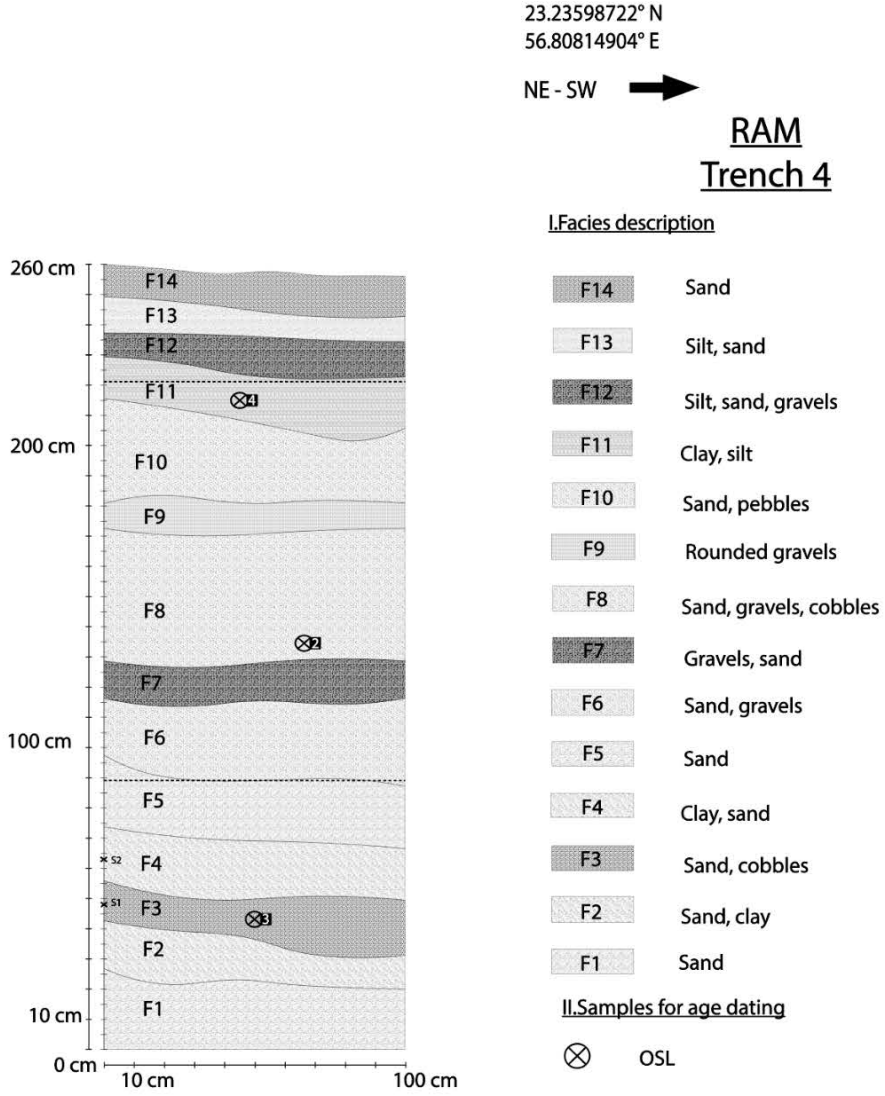

Figure 72: Stratigraphy and sampling of the excavation E4

8.2.3.5 Excavation 5

E5, located further east on the spreading cone, shows banks of pebbles, gravel, and sand over 310 cm (Figure 73). Nine lithofacies were identified.

Two samples were collected for OSL dating and one sample for sedimentological analysis. Mollusk shells were found but not collected in the excavated material.

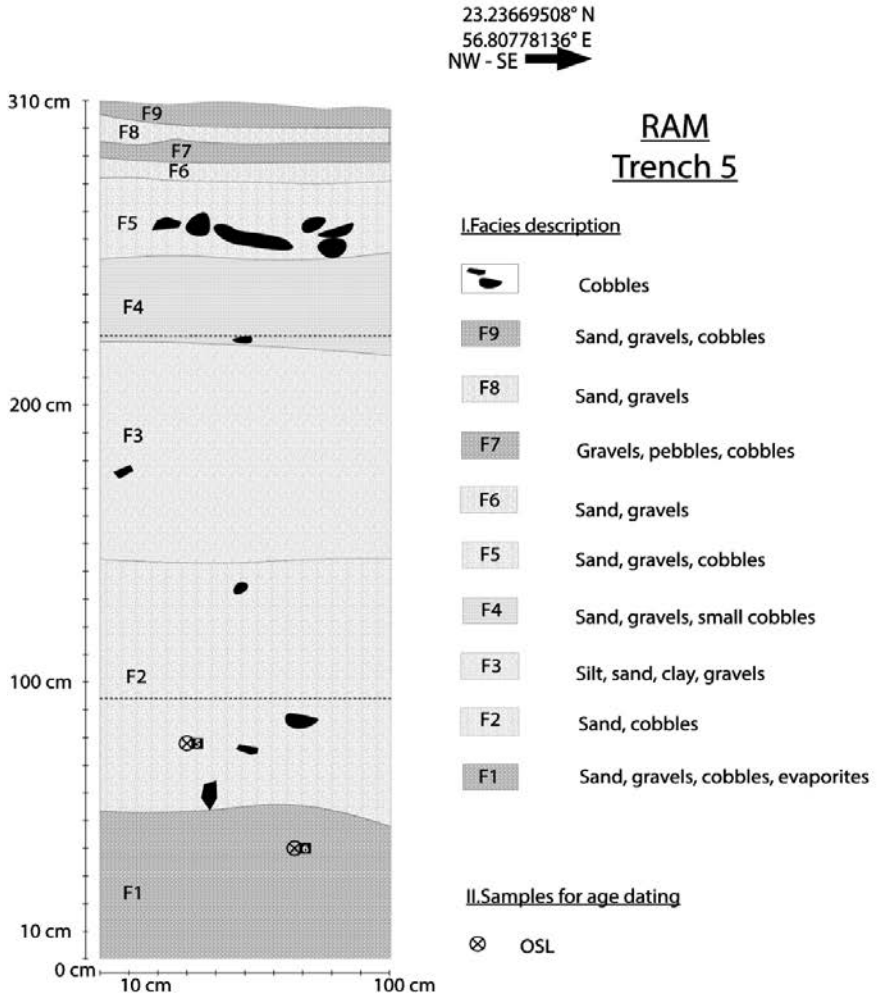

Figure 73: Stratigraphy and sampling of the excavation E5

8.2.4 Preliminary interpretations

These excavations allow five observations:

- The filling of the basin tends to confirm the influence of the Wadi al Hijr on hydro-sedimentary inputs during flood periods. If the wind could have contributed to this filling, this is not shown on the profiles. Micromorphological analyses and grain-size should allow to know more.
- Excavations 2 and 3, in the center of the basin, suggest that the deeper sediments may have been deposited during a wetter period.

- The thickness of the sedimentary fill of the basin exceeds those crossed by our excavations and probably covers a period longer than the Holocene. Three OSL samples were taken as well as two samples for sedimentological analysis.
- E5, which explores the contact zone between the basin and the alluvial fan of the wadi, is mainly composed of coarse elements at depth, which may allow a lateral circulation of water from the river to the basin and ensure a groundwater recharge of the basin.
- The presence of gypsum at the bottom of E2 could suggest a drier phase with at least temporary endoreic functioning at the end of the wetter period.

8.2.5 Samples collection and laboratory analyses

To characterize the sediment depositional environments, sedimentological analyses will be performed. A study of phytoliths will be conducted to reconstruct the vegetation cover during the Bronze age, when the basin of RAM was occupied. Finally, absolute dating will be used to determine the chronology and the rate of filling of the depression. In the excavations dug during the mission:

- 117 samples were collected for a phytolith study, which will be conducted at College of William and Mary (USA) by Dr. A. Buffington.
- 122 samples for sedimentological study (grain-size analysis, petrographic analysis with X-Ray Fluorescence as well as geochemical analyses for organic and carbonates content). Sedimentological analyses will be performed at the laboratory ISTEP (Sorbonne Université, Paris) by A. Prosperini.
- 7 blocks for micromorphological study will be analyzed at AgroParisTech Paris.
- 9 wood charcoals and 3 mollusk shells were collected for species identification.
- 6 samples will be dated by OSL at the University of Illinois by Dr. S. Huot.

Sedimentological and micromorphological analyses as well as OSL dating will be funded by the MEDEE program. 14C dating will be funded by the Bat Archaeological Project

8.3 Hydrological study

8.3.1 Processes of filling the basin

Two processes allow water and sediments to enter and accumulate in the basin: runoff collected in its own watershed and overflow from the Wadi Al Hijr.

8.3.1.1 Inputs from the slopes

Within the limits defined above (§1.2), the catchment area of the basin is about 20 ha. About rainfall, the data available are from the Ibri station (National Center for Statistic and Information of the Omani government).

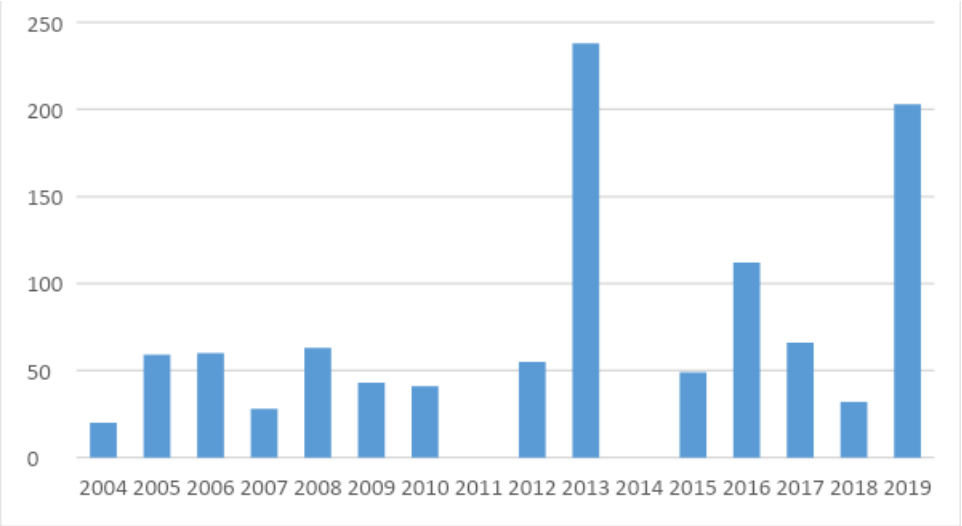

Figure 74: Annual rainfall at Ibri station
Source: National Center for Statistic and Information of the Omani government

From these data, the interannual average is 76 mm (Fig. #), which should not allow for significant water inflow into the basin. However, these average values do not give proper indication in a desert climate because the irregularity of precipitation is considerable. Only extreme events are effective, both from a hydrological point of view and in terms of sediment inputs.

The last extreme event in the RAM Basin area occurred on December 9-10, 2019 with a rain event that totaled 125 mm in 36 hours. Archaeologists from the BAP were able to measure 48 cm of water in the center of the depression 3 days after the rain. A pond held for 15 days, despite possible flowing through the outlet. The persistence of this pond indicates that the lowest points of the basin are below the elevation of the outlet.

It is possible to estimate the order of magnitude of slope inputs during this rainfall event from a runoff coefficient approach: the runoff coefficient depends primarily on the intensity of the rainfall, but also on the nature of the soil and the vegetation cover. Once the quantity of water necessary for the saturation of the surface layer of the soil is retained, all the water runs off.

The soils surrounding the basin are bare. The surface rock cover, heterogeneous, is composed with 2 different types of rock: conglomerates and siliceous cement limestones:

- The permeability of conglomerates (Figure 75) is very low. From the moment the soils are saturated (for a thickness of 10 cm, we will take the value of 20 mm of precipitation), the runoff coefficient is then very high: we can retain the value of 70%, which corresponds to what is usually observed on this type of soil.

Figure 75: Conglomerates in a slope of the RAM Basin

- The situation is different for siliceous limestone, where the surface debris cover a thick sandy level (Figure 76), resulting from the weathering. These sandy formations, which cover about a third of the surface, are very permeable and strongly limit the runoff: unlike pebbles, sands allow infiltration. Values higher than 50 mm/hour for infiltration are usual on this type of surface (which would be 16.5 mm/hour if the impermeable pebble cover is 33%). Without information on rainfall intensity, it is impossible to refine this estimate. However, the runoff coefficient can be considered as low and will be arbitrarily fixed at 20%, without considering a soaking rain.

Figure 76: Surface covering of pebbles in a sandy matrix. The knife sinks at least 10 cm into the sandy deposits on which the limestone blocks rest.

The satellite image shows the influence of each rock type on runoff (Figure 77). Traces of gullying are observed on the eastern slope while none is visible on the western slope in the siliceous limestone. In addition, the presence of some vegetation on the slope indicates preferential water paths, which are not noticeable on the western slopes.

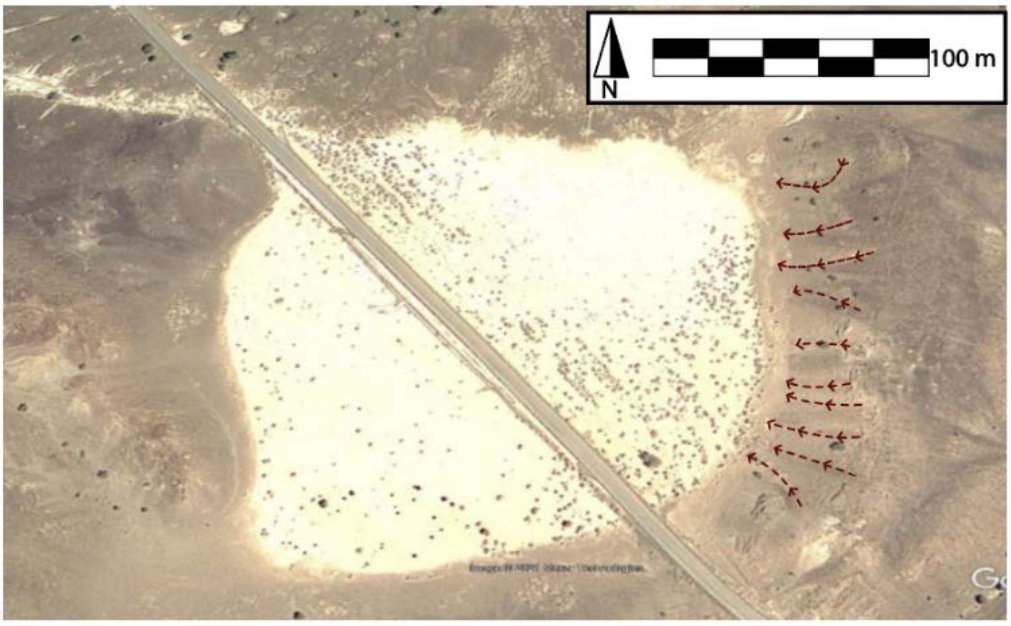

Figure 77: Preferential runoff paths on the slopes of the RAM Basin. Source: Google Earth, 2022

The floor of the basin is composed of clayey deposits with a sedimentary crust on the surface, which presents characteristic drying figures of swelling clays (Fig. #).

Figure 78: Desiccation cracking of the surface crust at the floor of the RAM Basin. The spoon gives the scale.

These different observations allow to propose the following values to estimate the water supply of the basin from its watershed during a rainfall of 125 mm in 38 hours:

- for the part occupied by the conglomerates: (125 mm - 20 mm) * 70 %) *6.3 /7.5 = 62 mm.
- for the part occupied by the siliceous limestone: (125 mm*20%)*6.3/7.5 = 24 mm.
- for the rain that falls directly on the floor of the basin: 125 mm

(*n.b.* 125 mm = precipitation; 20 mm = imbibition; 70% (or 20%) = infiltration coefficient ; 6.3 ha= area covered by the type of rock considered (catchment area - area of the basin / 2); 7.5 ha = surface area of the basin)

Thus about 211 mm could have accumulated on the floor of the basin (62 mm from the contributions of the slopes occupied by the conglomerates; 24 mm from the contributions of the slopes occupied by the limestones, and 125 mm by direct precipitation on the basin floor), where the very clayey soil reduces infiltration, which is particularly low in the lower parts where clay deposits are thicker. Measurements with a single ring infiltrometer gave velocities of 25 mm/h, which are not significant as the ring was surrounded by unsaturated soil. For clay formations, the literature gives infiltration velocity values from 8 mm/h in clayey silts to 2.5 mm/h for silty clays. However, the surface condition also plays an essential role. In the case of the basin soil, if there is a surface crust unfavorable to infiltration, this crust is largely destroyed by the passage of animals. Moreover, the vegetation creates possibilities of preferential infiltration.

If the rain event lasted 36 hours, the infiltration losses could have been at least about 150 mm (4.2 mm/h), so that the inflow at the end of this event, due to rainfall on the watershed, would have been about 7 cm. This estimate is only an order of magnitude, impossible to specify without more information on rainfall and observations of runoff and infiltration. It simply proves that slope inflow alone cannot fill the basin to a level that would allow overflow through the outlet.

In addition, if we want an extreme value, by imagining - which is absurd, but gives an absolute limit - that all the water precipitated on the catchment area would have accumulated, without any loss by infiltration, in the basin, the height of water would have been 125 mm*200/7.5= 333 mm, a little more than 30 cm.

As an additional argument, flood deposits can be observed around clumps of vegetation, proving that the water stagnated at least at the same height (Figure 79). However, these deposits are located at a higher elevation than could have been achieved by watershed rainfall accumulation alone.

Figure 79: Sedimentary deposits on a clump of vegetation

Moreover, the drop in the water level of the pond, of 50 cm in 15 days, observed by the archaeologists could be considered as proof of a very weak infiltration, considering the losses by evaporation. However, what is true for this residual pond is not true for the entire basin. Indeed, this pond is logically located at the low point of the basin, where sedimentation is thickest, and therefore the infiltrability minimum. The fact that the rest of the basin was already out of water 3 days after the end of the rain, while the basin was full of water when the outlet was working, shows on the contrary an infiltration which is far from negligible.

Despite the interest of these observations and calculations, it is difficult to draw conclusions about the respective contributions of the wadi and the watershed to the filling of the basin. To do so, it would be necessary to have extremely accurate altimetry data of the bottom of the basin, which would make it possible to calculate the volume of water stored according to the measured height. The storage in the bottom of the basin, as observed 3 days after the rain, does not give a height of storage in the basin but represents a residual accumulation at the bottom of a depression.

Regarding sedimentary inputs most of the deposition in the RAM basin was found to be from the flooding of the wadi. It would be interesting to extend the study to a comparison with other small basins located to the southwest of the RAM Basin. Despite a much larger catchment area and comparable flat surface at the bottom, these other depressions do not have the same extent of very fine surface material. This observation would tend to confirm the role of the overflow of the Wadi al Hijr.

8.3.1.2 The contributions of Wadi al Hijr: water in the soil

Despite the small size of the watershed, and therefore the low contribution of precipitation, the contribution of the wadi allows a significant recharge of the water reserve of the soils in the basin. This input can even occur in the absence of local precipitation, which increases the frequency of potential water inputs into the basin.

This explains why, despite a long period without precipitation, the water content of the soils measured during the collection of OSL samples in the excavations is far from zero: between 1.8% and 8.2% moisture by weight (the moisture by volume - i.e., related to the volume of soil - depends on the bulk density; it is about 1.5 times greater) were measured, varying with both depth and grain size (Table 8).

	wet weight (g)	dry weight (g)	Difference (g)	H p (%)	Z (cm)
E1					
	107,91	99,31	8,6	7,97	130
E2					
Z 0.80	64,68	59,66	5,02	7,76	80
Z 1.50	65,58	60,35	5,23	7,97	150
F	121,39	111,44	9,95	8,20	223
E4					
A	140,93	138,96	1,97	1,40	42
B	82,23	80,73	1,5	1,82	126
C	60,07	57,36	2,71	4,51	213
E5					
D	334,74	328,55	6,19	1,85	230
E	115,59	111,88	3,71	3,21	267

Table 8: Soil water content (% of sediment weight)

These results show an increase in moisture with depth: this proves that this moisture is not related to recent water inputs, but to the presence of a deep and durable reserve. This humidity can have two origins: surface infiltration from ancient events (which would prove the importance of the infiltrated volumes) or deep contributions from the water table of the wadi. This soil moisture explains the persistence of sparse but prerenal vegetation, essentially made of acacias and Salicornia.

8.3.2 Water around the site

The oasis of Bat drew its water resources mainly from the water table of the Wadi al Hijr, proving the sustainability of the interflow. Since the introduction of mechanical pumping, hydrological dynamics have changed, leading to a drop in the water table.

This interflow is also exploited by wells (Figure 80), as noted by the authors of the Ibri geological map[8]: "The main wadi has a shallow water table that is locally exploited by wells, especially when the bed is narrowed by a cluse. This is the situation in which we find a well about 2 km upstream from the site, on the left bank of the Wadi al Hijr: the water is only 7 meters deep, despite current pumping".

Figure 80: Well upstream of the site

Other water points may exist in the RAM Basin vicinity such as a freshwater pond, corresponding to the outcrop of a small perched water table, are visible nearby 2 km from the site (Figure 81). A well is associated with it, as well as a watering hole not currently used (Figure 82). The water is very close to the surface, in equilibrium with the water table. Not far away, two animal pens seem to be still functional (Figure 83). Goats, sheep, and camels are present in the landscape, attesting to a breeding activity (Figure 84).

[8] Ibid.

Figure 81: Outcrop of a small perched water table

Figure 82: Well associated with the water table

Figure 83: Goat pen still functional

Figure 84: Goats in the pasture

8.4 Conclusion

The location of the RAM Basin near the Wadi al Hijr creates favorable conditions for water resources. The inflow of water during floods ensures the constitution of a water layer on the surface allowing for significant infiltration and the replenishment of reserves. In addition, the very coarse granulometry of

the threshold that separates the underground water table of the wadi from the basin floor allows for the circulation of water. The recharge of a water table at the bottom of the basin is therefore possible.

The proximity of the wadi has another advantage given the sometimes very localized onset of precipitations, floods can be more frequent than local rainfall alone, multiplying the periods of recharge of the water reserve of the soil, and each time, a rapid growth of vegetation. This type of situation could be used by flood crops, but even if not, there are abundant resources for livestock. The results of the micromorphology studies should make it possible to specify things from this point of view. Associated with sedimentological analyses, they will allow to determine the palaeoenvironments and their chronologies. Moreover, the present-time environment shows the presence of water resources and the permanence of a pastoral activity which, if it is still possible today, was obviously possible during the Umm an Nar period with probable more favorable climatic conditions. Lithic tools found near a sheepfold prove the ancient occupation of the area by human populations.

8.5 Perspectives

The results of the grain-size and sedimentological analyses and some of the 14 C dating are expected in November 2022. OSL dating and micromorphological studies should be available in the fall of 2023.

The next campaign (2023) could be devoted to geophysical surveys in the RAM Basin and in the depressions located south of the RAM site as well as in the Hayl Al Ajah poljes, in collaboration between the Bat Archaeological Project and the Czech Archaeological mission of Sint, directed by Inna Mateiciucova (Senior Researcher at Masaryk University).

It could also be interesting to conduct in parallel a systematic and exhaustive search for water points and traces of current pastoral activities. This survey can include work on lithic materials, including recent to modern lithic tools, which are poorly known.

8.6 Acknowledgments

We would like to thank all the members of the Bat Archaeological Project for the support that was given to us in all circumstances in the face of our multiple demands and the excellent team spirit of all the participants.

9. Environmental Survey

Rebecca Swerida

9.1 Summary of Activities

BAP incorporated a study of ecological resilience across multiple sites during the 2021-2022 field season. The assessment can be considered a pilot study leading to future work in linking ancient and contemporary community resilience and environmental management to ecological resilience and climate change. The research was conducted by Ms Rebecca Swerida, MS, an ecologist of the Maryland Chesapeake Bay National Estuarine Research Reserve.

9.2 Survey Strategy and Background

The concept of resilience, or the ability of a system to persist and thrive even in the face of perturbations, can be applied to both natural ecosystems and human communities in ancient and modern times. Ecological and community resilience are gaining increasing consideration in the scientific community as climate change impacts are presenting increasing challenges to multiple facets of life the world over. The current day community of Bat may face environmental challenges increasingly similar to those faced by the area's ancient inhabitants due to predicted impacts of climate change over the next 50 to 100 years and beyond. Evidence could indicate that rates of precipitation were greater during the Bronze age than at present, providing both a vital resource as well as greater flooding and erosion threats. Climate change projections indicate an increase in the amount and variability of precipitation with flashy events adding up to 40 mm annually over the next 100 years (World Bank Climate Change Portal). Even if heat indices, variability and severity of precipitation and flooding do not worsen as predicted, there is much to be learned by examining the resiliency and adaptations of ancient life, including humans, on a larger scope of environmental survey.

Basic indicators of ecological resiliency include the availability and connectedness of habitat, vegetation robustness, biodiversity and soil characteristics among other factors. A natural ecosystem with an adequate level of these attributes can be expected to withstand perturbations and stressors over time, recovering well after acute weather events for example. Both modern and especially ancient human communities are and were highly dependent on the resources provided by the local native ecosystem and become more vulnerable as ecological resilience is reduced. By understanding the level of resilience present in the local ecosystem, environmental managers and municipal planners can have a clearer future visioning of potential challenges to inform their decisions. The choices made by ancient people in response to resource scarcity and spatially variable threats such as flooding and erosion can be understood through archaeological investigation and related to ecological indicators of resilience to serve as lessons for today and the future.

9.3 Methods

This season, BAP began to investigate indicators of ecological resilience in areas where ancient and modern people demonstrated adaptability around natural and managed water resources. The ecological resilience study was conducted at areas identified as examples of modern and ancient

settlement and water resource use and manipulation. Archaeological and cultural knowledge of the area informed these choices. Each identified site was subdivided into sampling strata based on apparent water availability and management classifications. The following sites and strata were sampled during this field season:

- Settlement Slope: Slope, Bank, Wadi Bed
- Rakha al-Madrh: Slope, "Lake" Bed
- Dry Falaj: Falaj No Channel, Channel, Drainage
- Modern Oasis: No Channel, Channel

Figure 85: Sampling plot within the channel strata of the dry falaj site.

Five-meter squared sample plots were placed within each strata at as close to the same density as practicable. Vegetation diversity, density and robustness (ocular percent cover and maximum height), elevation (when possible) and basic soil characteristics at the surface and at depth were observed at each plot. Each plot and each species encountered was photographed. Plant species identification was guided by the Flora of Oman (Ghanzafar 2015) and Field Guide to the Wild Plants of Oman (Pickering and Patzelt 2008) among other references. Culturally significant plants were noted when identified by local professional partners and community members.

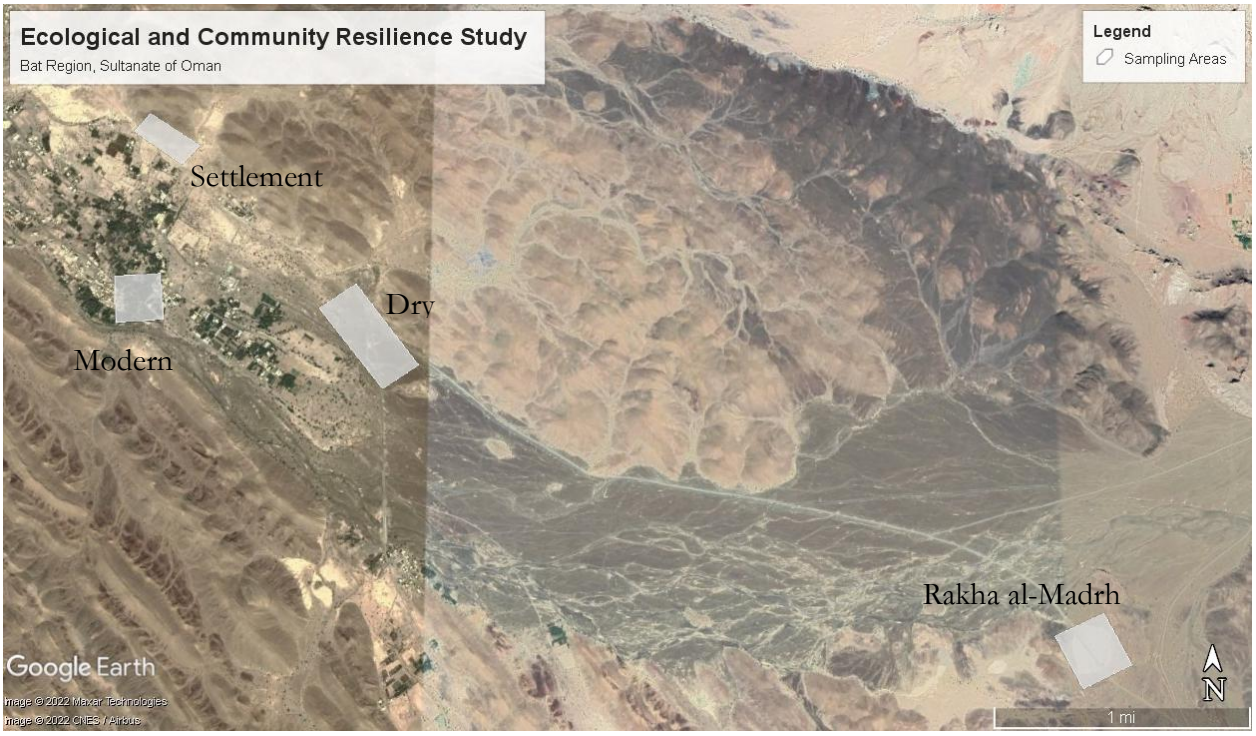

Figure 86: Map showing sampling areas observed for the ecological and community resilience study during the BAP 2021-2022 field season.

9.4 Preliminary Results

Early consideration of the data collected shows a clearly discernible difference between strata containing water resources and those without, as anticipated. By far the most unique site observed was the modern day Bat Oasis, the only site containing standing water at the time of sampling. The Modern Oasis sampling plots contained a total of 45 and 40 plant species in the no channel and channel plots, respectively, and an average of 18.3 and 21 species per plot at no channel and channel plots respectively. These plots represented by far the highest density and vegetative robustness of those observed.

Figure 87: Channel sampling plot within the Modern Oasis

The least diverse and densely vegetated sampling plots were located at the higher elevation slope sites at both Settlement Slope and Rakht al-Madrh. Greater diversity and plant density was observed at each site within the presumably more water rich and protected habitats of the wadi and lake beds. Also as anticipated, sediment and vegetation characteristics were clearly different in areas influenced by water, both naturally and through management and both recently and long ago. Sediment within the active and dry falaj channels, in the wadi bed at the Settlement Slope and the "lake" at Rakht al-Madrh tended to be finer in grain size, less angular and more well sorted than those at areas without assumption of previous standing water. The relatively low vegetation levels at the depression of Rakht al-Madrh was not anticipated. The fairly unique conditions there did support several species that were not observed elsewhere including the parasitic and locally harvested edible *Cistanche phelypaea (L.) Cout.*, also known as *basul* or *dhamin*. Future analysis will be conducted to understand the implications and modern day utility of these observations.

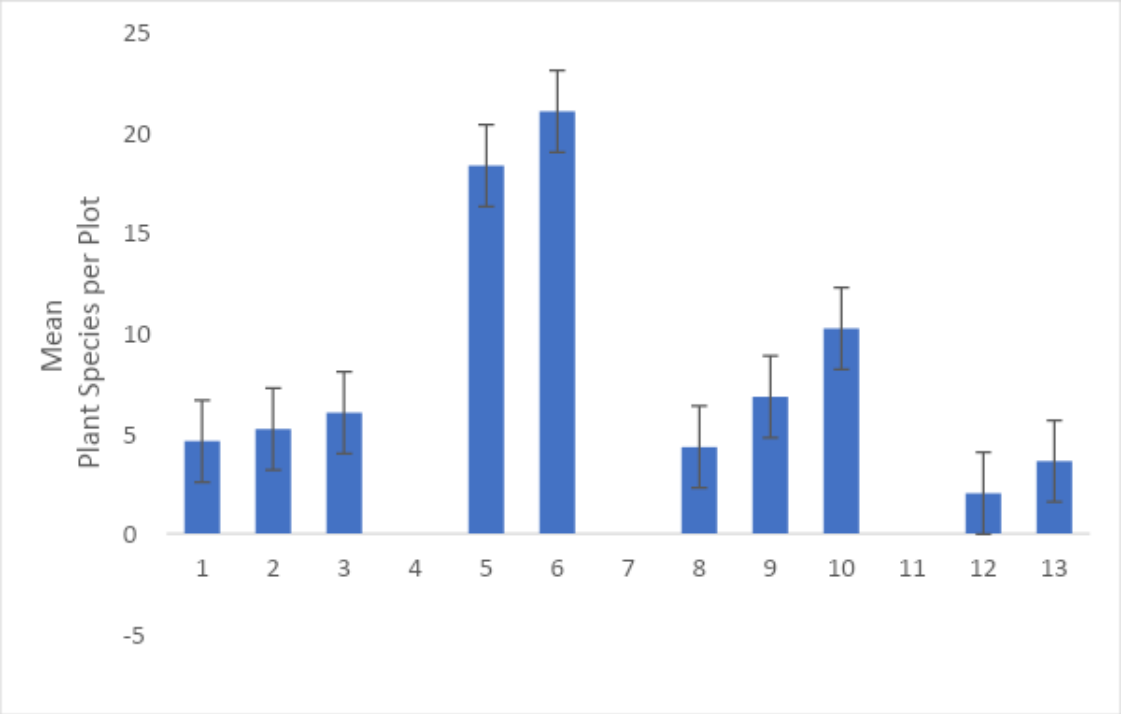

Figure 88: Mean (± standard deviation) plant species observed per plot across sampling areas.

Sampling Area	Plot Category	Total Plant Species Observed	Mean Plant Species Per Plot	Mean % Vegetation Cover	Mean Stem Density Per Plot
Settlement Slope	Slope	10	4.6	7	16.4
Settlement Slope	Bank	13	5.2	22.2	35.4
Settlement Slope	Wadi Bed	16	6	21	27.6
Modern Oasis	No Channel	45	18.3	181.6	277.3
Modern Oasis	Channel	40	21	206.3	355
Dry Falaj	No Channel	13	4.3	16.5	32.8
Dry Falaj	Channel	16	6.8	26.3	98.5
Dry Falaj	Drainage	26	10.2	45.8	65.2
Rakha al-Madrh	Slope	7	2	6	7.4
Rakha al-Madrh	Lake	14	3.6	27	42.5

Table 9: Summary of species diversity, ocular estimation of percent vegetation cover (at multiple canopy levels) and stem density at sampling plots.

10. Future Plans

Eli N. Dollarhide, Jennifer L. Swerida, & Reilly S. Jensen

10.1 BAP Future Research Plans

The results of BAP's 2021-2022 field season presented discoveries in a wide range of areas—geographically and thematically—about Bat's ancient inhabitants. These findings are informing the project's future directions. In collaboration with the Ministry of Heritage and Tourism and sponsorship from the National Endowment for the Humanities, the project will continue its focus on modeling and understanding the ancient cultural landscape of Bat and the Wadi Sharsah in 2023.

10.2 2022-2023 Field Work Season

The BAP 2022-2023 field season will continue the project's focus on understanding Bat's ancient remains from the perspective of cultural landscapes. The project will continue pursuing three interlinked research questions:

- (Q1): Where and how did UaN communities choose to create places within the Sharsah Valley?
- Q2): What does the organization of settlements and settlement spaces in the Sharsah Valley communicate about UaN social organization?
- (Q3): What kinds, to where, and to what degree is material culture being moved around the landscape?

In 2022-2023, we anticipate our work to center on three areas: 1) Excavation of Umm an-Nar domestic and endangered contexts at Bat; 2) geophysical and geomorphological prospection at Umm an-Nar contexts across the site; 3) an expanded outreach and arts engagements program with local communities and groups from around ad Dhahirah, Oman, and the Gulf region to increase access and understanding of Bat's archaeological heritage.

8.2.1 Excavation of Umm an-Nar domestic contexts and other endangered areas

Next season, the project will excavate Umm an-Nar period domestic structures in two areas building on this season's results: Rakhat al-Madrh and the Settlement Slope.

8.2.1.1 Rakhat al Madrh: 2023 Excavations

In 2023, BAP will continue its investigations in to the nature and chronology of Early Bronze Age settlement at Rakhat al-Madrh. Excavations are planned to resume at RaM 2 to reveal the phasing of the building's construction, continue to understand the function of the building's rooms, and look at how the structure's architecture and layout might have mitigated damage during flooding events. Concurrently, BAP plans to begin excavation at RaM 4, located on the north side of the site's basin. Surface survey has previously suggested that RaM 4, while exhibiting signs of an initial Umm an-Nar period construction, was extensively altered over the course of its occupation and later used in later Iron Age periods as a burial site. Excavation at the structure will target contexts that might suggest how RaM 4's changing layout and function relate to the unique climactic conditions of the RaM basin.

8.2.1.2 Settlement Slope: 2023 Excavations

BAP plans to continue to probe the southeastern end of the dense archaeological remains at the Settlement Slope to understand Bat's settlement landscape at the end of the 3rd millennium BCE. In 2023, excavations will target two rectilinear structures identified during previous surveys. Excavations will probe the quality of preservation and determine building use, dates, and functions.

8.2.1.3 Khutm Excavations

Building on the promising and urgent results of BAP's 2022 work at Khutm, a small series of test excavations is planned at the site for Winter 2023. These will focus on two areas: 1) a set of Umm an-Nar period remains believed to be domestic in function and 2) the large-scale Iron Age II/III architecture (identified as 'Building Alpha' in this report) preliminarily interpreted as a fortified settlement. Both areas are threatened by modern construction and erosion. The planned test excavations will probe the depth and quality of preservation at these locations to aid their preservation in collaboration with the MHT and determine their potential for future study.

8.2.2 Geophysical and geomorphological prospection

Following the receipt of a research grant from SPARC (Spatial Archaeometry Research Collaborations) at the University of Arkansas and Dartmouth College, BAP is proposing a multi-faceted geophysical prospection program to probe the extent of archaeological remains at three key areas of the site where long-term excavation is prohibitive. This will include drone-enabled survey with a thermal imaging camera and subsurface ground penetrating radar, allowing the project to look underground without excavation. BAP plans to implement these techniques at three locations:

1) Khutm—to explore the Iron Age remains identified behind the Bronze Age tower last season. Assessing the extent of these remains is critical as the site is under immediate danger from surrounding development and dumping.
2) Rakhat al Madrh—to explore the possibility of other structures around the site's depression. Ground-penetrating radar at Rakhat al-Madrh will also help model the extent and depositional history of the site, which is important assessing human control of water and the potential for ancient agro-pastoral activities.
3) Matariya—to model the extent of the site's remains and examine potential, unexcavated mudbrick structures identified by BAP in 2019.

Geomorphological work focused on the RaM basin is also planned to continue in BAP's 2023 season.

8.2.3 Expanded outreach and arts engagement

Learning from this season's experiences, BAP will expand its outreach and engagement effort sin 2023. The project plans three in-person and culturally-diverse arts-integration projects (ceramics workshop, student field-trips to the site, and classroom exchanges between Omani and American elementary students) that empower children and their families residing in Bat to become experts and stewards of the archaeological resources at Bat and engage with local and international professional

archaeologists working to preserve it. Deliverables to local community and MHT partners include an expanded comic book, a digital and illustrated children's walking tour of the Bat's ancient remains and school program guides highlighting archaeological practice and Bat's rich heritage.

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