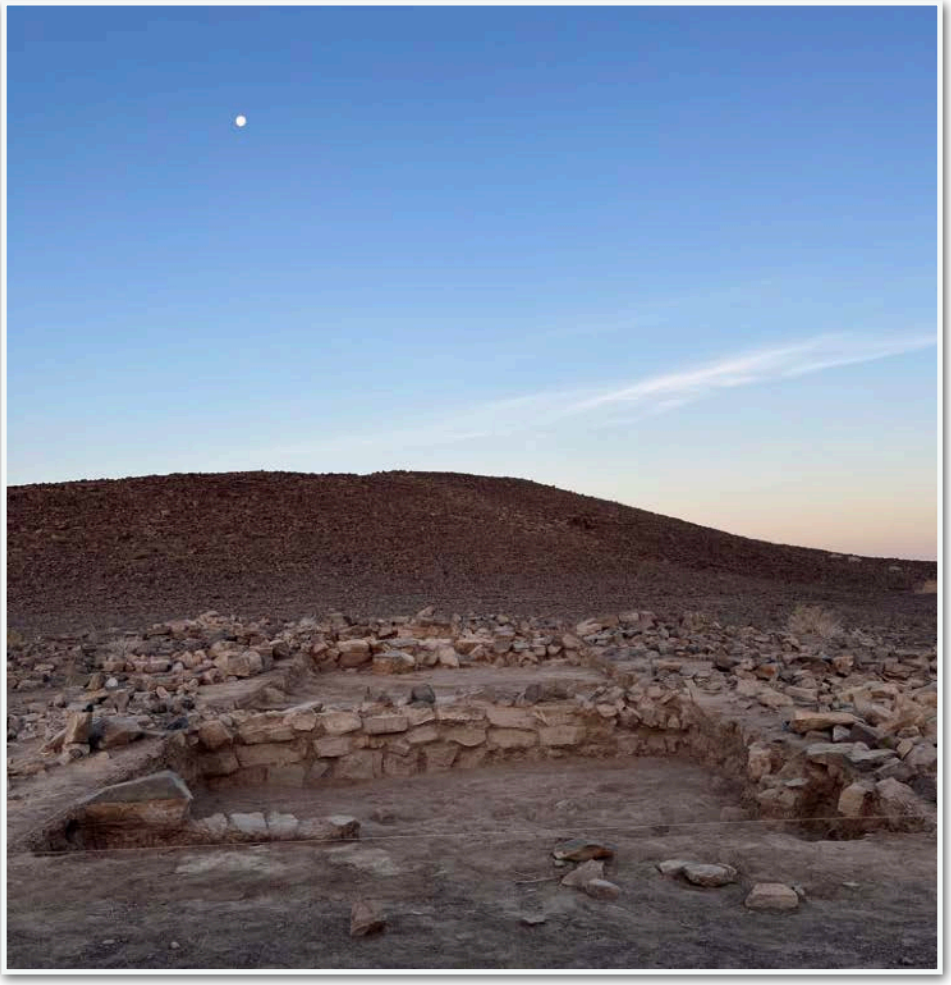
Bat Archaeological Project
Preliminary Report of the 2022-23 Season



by

Jennifer L. Swerida, Eli N. Dollarhide, Reilly S. Jensen, and Asma Bint Rashid al-Jassassi

June 2023

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Executive Summary

The Bat Archaeological Project (BAP) conducted its 2023 season of excavations and survey from 27 December 2022 - 4 March 2023. Our research concentrated on five specific areas: 1) archaeological excavations of Umm an-Nar period houses at Rakhat al-Madrh (رخة المدره); excavations and mapping of Umm an-Nar period and Iron Age architecture at the Khutm Settlement; 3) test excavations at Operation A, near the proposed site of the Bat Visitors Center; 4) geomorphological and geophysical analyses at Rakhat al-Madrh; and 5) an expanded arts outreach and experimental archaeology program to further engage the local community.

At Rakhat al-Madrh, excavations revealed domestic architecture and activities connected with three Umm an-Nar houses situated around a central depression. Building on the results of BAP's previous two years of work at the site, this season explored two new houses, including one especially large building with multiple phases of activity. Excavations at RaM continued to discover botanically-rich domestic contexts. A second season of geomorphological and hydrological investigations continued to support the interpretation that Rakhat al-Madrh's environmental and archaeological conditions are unlike the rest of Bat and unique for Bronze Age Southeastern Arabia. Possible human manipulation of flooding events in the basin could have enabled the cultivation of flood crops and provided abundant vegetation for animal pasturing. Botanical analysis suggests wheat, barley, goat grass, cyperaceae, and palm were all grown at the site in the third millennium BC.

Test excavations and survey at Khutm Settlement and Operation A shed further light onto the use history of the greater Bat landscape. Identification of an Umm an-Nar complex of house, platform monument, and tomb at the eastern end of the Khutm hillside provide new insights into both ritual and domestic behaviors in the third millennium BCE, while newly discovered material culture further supports an Iron Age II date for the fortress identified by BAP in 2022. At Operation A, test excavation results suggest that the site was originally an extension of the Bat Necropolis into the wadi valley and has been revisited multiple times by the site's later populations. BAP strongly recommends further excavations at Operation A prior to construction of the Bat Visitors Center.

The project also expanded its community outreach program by partnering with the Bat office of the Ministry of Heritage and Tourism as well as local partners in the Bat Community. A 'Bat Community Day' event hosted by BAP

and Healthy Village Bat welcomed over 200 participants to celebrate the heritage and history of Bat's community. The project also hosted visits to the UNESCO site from two school groups and, at the request of the Ministry, conducted a two-day Pottery Workshop on traditional ceramic production techniques for HMT staff and community members.

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 Dr. Amina Abdullah al-Balushi, Director of World Heritage Sites Ms. Ibtisam al-Mamari, Director of Excavations and Collections Mr. Ali al-Mahroqi, Mr. Ibrahim al-Maqbali, Ms. Samia 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 wonderful support to our mission.

We are also grateful to local staff members working in the field and offices, particularly to Ministry of Heritage and Tourism Representatives at Bat. Mr. Mohammed al-Kaabani, Mr. Mohammed al-Essai, Mr. Suleiman al-Jabri, Mr. Badr al-Badi, and Ms. Sumaia al-Marmarri in particular.

Our project was financially supported by the Omani Ministry of Heritage and Tourism, the US National Endowment for the Humanities (grant RFW 279340-21), the Penn Museum Field Funds of the University of Pennsylvania, and a research grant from New York University Abu Dhabi. Logistical support was provided by Alexandra Sandu and Raya Lakova at the Humanities Research Fellowship Program for the Study of the Arab World at New York University Abu Dhabi, and the Near East Section of the Penn Museum, University of Pennsylvania.

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

Jennifer L. Swerida, Eli N. Dollarhide, and Reilly 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 new PhD dissertations on the research at Bat (Swerida 2017; Nathan Staudt 2017; Dollarhide 2019).

Now in its 16th season, the Bat Archaeological Project (BAP) 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 landscape. This focus incorporates and expands on the results of our 2019, 2020, and 2022 seasons, which highlighted Bat's early Bronze Age settlement areas. The project has received a major grant from the US National Endowment for the Humanities which will support fieldwork through 2024 to answer three primary questions:

- (Q1): Where and how did Umm an-Nar 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 Umm an-Nar 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 and al-Khutm, as well as in the area of Rakhat al-Madrh, 7 km southeast of

Bat, in the winter of 2023. 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, professional training, and outreach materials.

1.2 Research Programs of the 2022-2023 Season

The 2022-2023 season of the Bat Archaeological Project began on 27 December 2022 and ended on 4 March 2023. 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 (Figure 1). The ten-week season was dedicated to seven goals:

(1) to understand the function of the Bronze Age building at Rakhat al-Madrh and the subsistence strategies practiced by their builders/inhabitants;

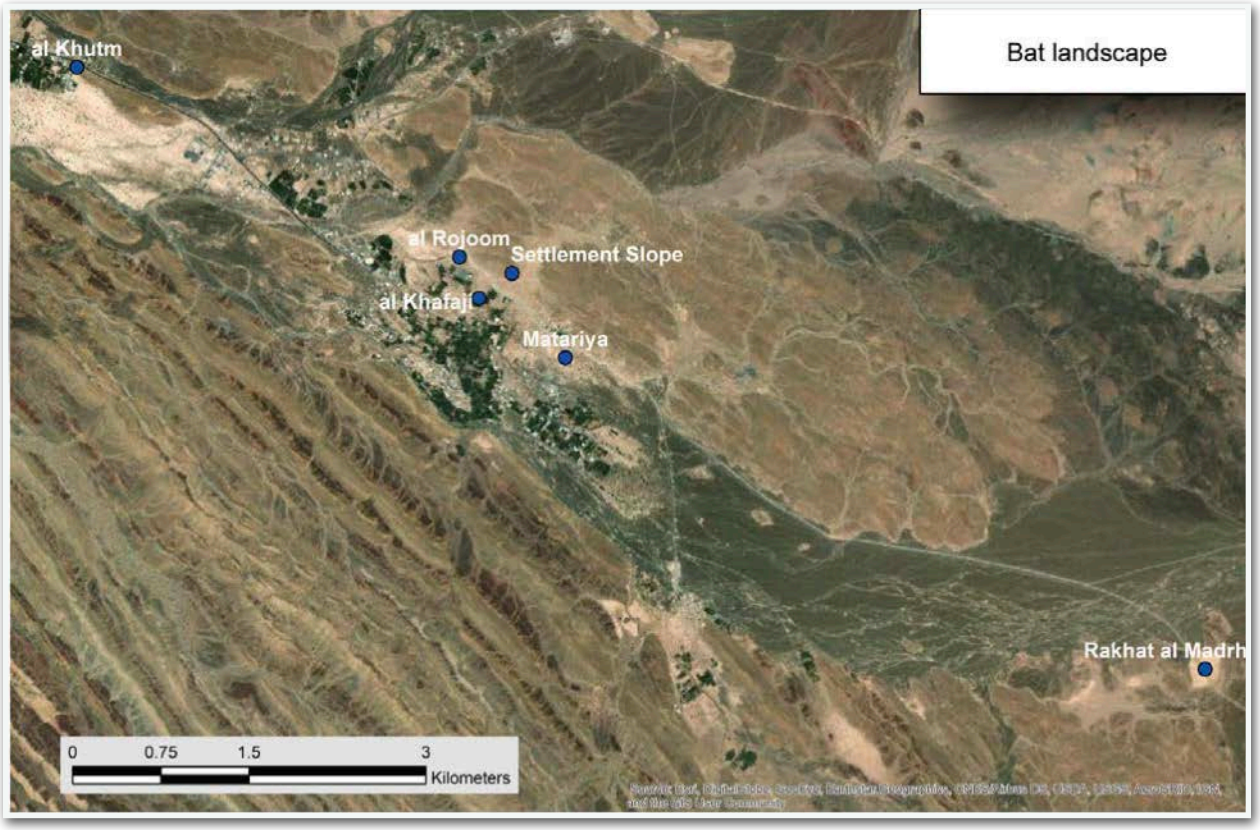

Figure 1. The Bat Landscape. Research this season focused on, Rakhat al-Madrh, the Khutm Settlement, and the Visitor Center location near to al-Rojoom, in addition to outreach with the modern Bat's local community.

(2) 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;
(3) to conduct artifacts and ceramics analysis to temporally and materially link Bat's environs;
(4) to map and re-evaluate ancient structures endangered by modern development behind the Khutm tower;
(5) to map and conduct test excavations on the "Operation A" location of archaeological remains in close proximity to the proposed Bat Visitors Center location;
(6) to engage local community members, especially students, in the research process and more effectively communicate project results;
(7) to complete an environmental resiliency survey to better understand Bat's modern landscape;
(8) and to use these results and strategies for inform the site's development for tourists.

1.2.1 BAP team members

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

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

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

Survey & excavation team
Ms. Gabriela Daza, University of Pennsylvania, USA
Ms. Anna Hoppel, University of Pennsylvania, USA
Ms. Qi Liu, University of Pennsylvania, China
Mr. John Burgess, University of Pennsylvania, USA
Ms. Josephine Schmollinger, University of Pennsylvania, USA
Mrs. Cindy Srnka, University of Pennsylvania, USA
Dr. Amy Karoll, New York University Abu Dhabi, USA
Mr. Paul Rissman, Independent Scholar, USA

Specialists
Dr. Jesse Casana, Dartmouth University, USA — Remote sensing specialist
Dr. Petra Creamer, Emory University, USA — Remote sensing specialist
Mr. Robert Bryant, University of Pennsylvania, USA — GIS specialist
Dr. Abigail Buffignton, College of William & Mary —Archaeobotanist
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. Max Engel, Heidelberg University, Germany
Dr. Laurence le Callonnec, Sorbonne University, France
Dr. Stephane Desruelles, Sorbonne University Abu Dhabi, UAE
Mr. Aleksandre Prosperini, Independent Scholar, France

2. Archaeological Survey

Eli N. Dollarhide

2.1 Introduction

In 2023, BAP conducted an abbreviated systematic archaeological survey program. Following last season's successful completion of a long-term survey project to identify remains in the core archaeological zone in and around Bat's towers and the surrounding modern oasis (i.e., the Bat "heartland"), this year's survey moved to focus on the area surrounding Rakhat al-Madrh (Figure 2).

Last season's geomorphological investigations resulted in the discovery of another alluvial depression ~3.8 km due west of RaM that bore many similarities, ecologically and hydrologically, to Rakhat al-Madrh. This second depression, tentatively identified as RaM B, was the location of BAP's systematic survey in 2023 in order to assess the area's archaeological potential as a future excavation site and to provide comparative detail regarding the occupation and geomorphological setting of RaM. The area between the 2023 Survey Zone and Rakhat a-Madrh was also opportunistically surveyed and determined to have few archaeological remains

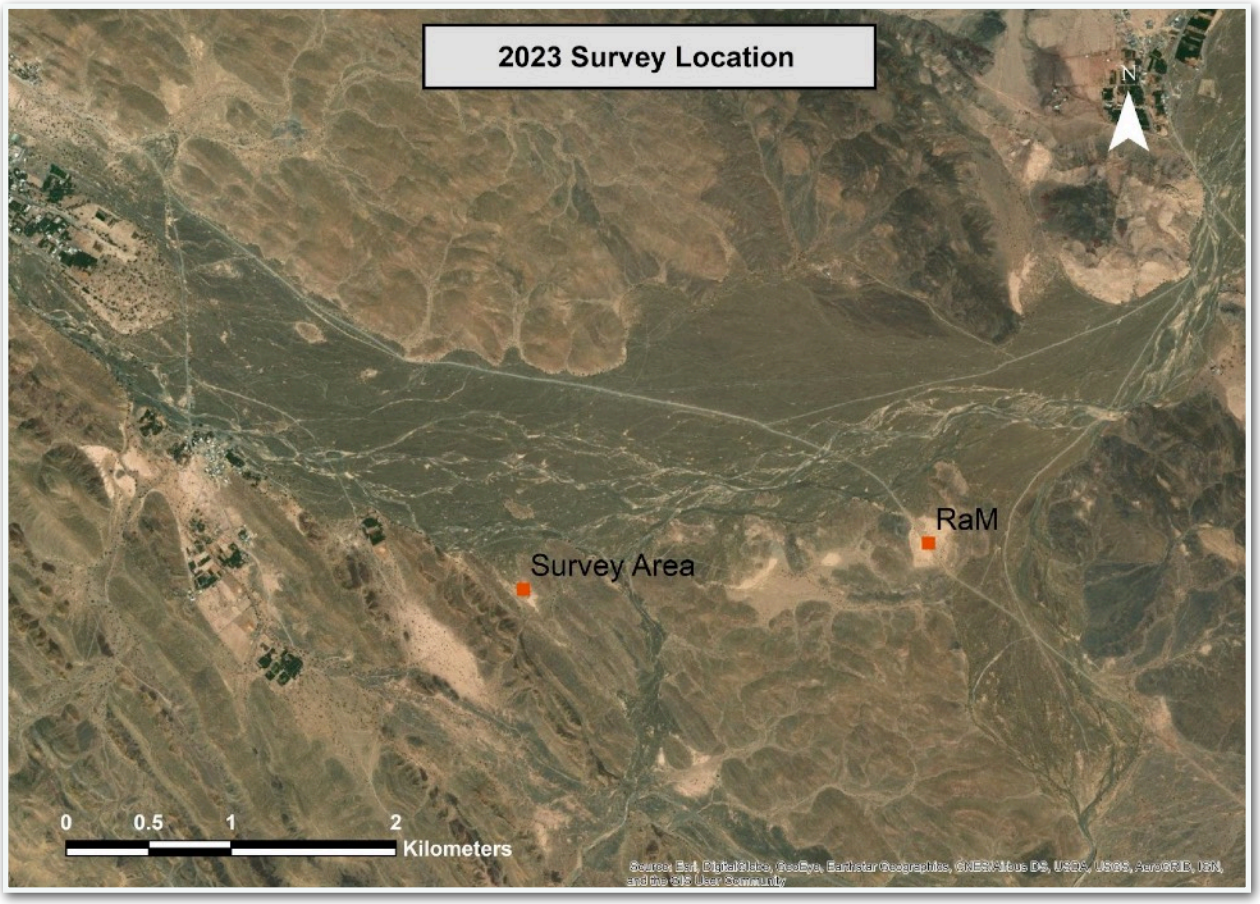

Figure 2. 2023 Survey area in relation to Rakhat al-Madrh.

2.2 Methodology

Pedestrian survey at RaM was conducted on 17-18 January 2023. Six transects were walked by a team of four people each five meters apart. Each transect was given a lot number (from East to West: 232001, 232002, 232016, 232019, 232022, 232025). Each identified feature was assigned an individual lot number, measured on two axes, photographed and recorded with GPS coordinates. Identified features were recorded using a Juniper Geode and iPad with Survey123 and ESRI FieldMaps. All artifacts were collected. Individual artifacts collected from within each transect were assigned the same lot number as the transect in which they were found. Artifacts found within identified features were assigned the lot number of their find location. More than three artifacts not located within or adjacent to an identified feature were marked as a "scatter" and also assigned an individual lot number.

All available evidence was used to assign a potential period to each feature identified in the field. Following artifact analysis, chronological assignments were reevaluated and updated as needed in the GIS.

2.3 Results

Ultimately, 24 archaeological features were identified (Figure 3). Of these, only three could be confidently marked as Umm an-Nar in date (Figure 4). Lot 232004 appears to

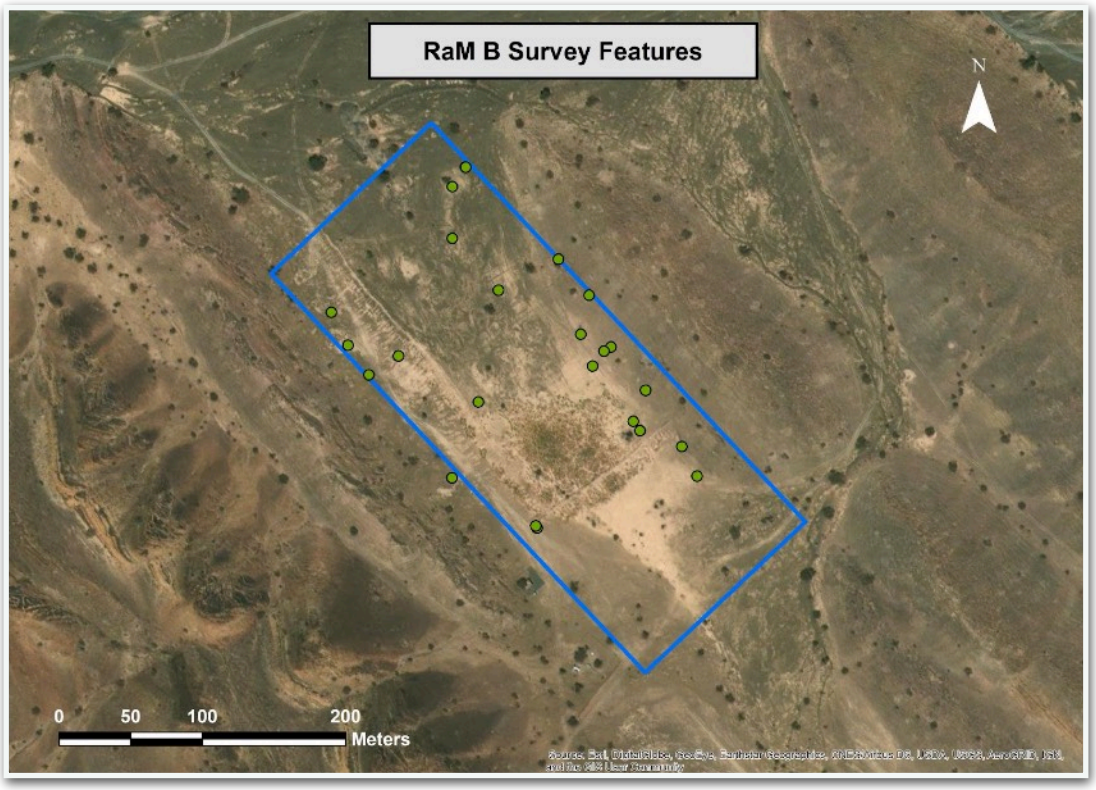

Figure 3. Map of the systematic survey area outlined with 24 archaeological features marked.

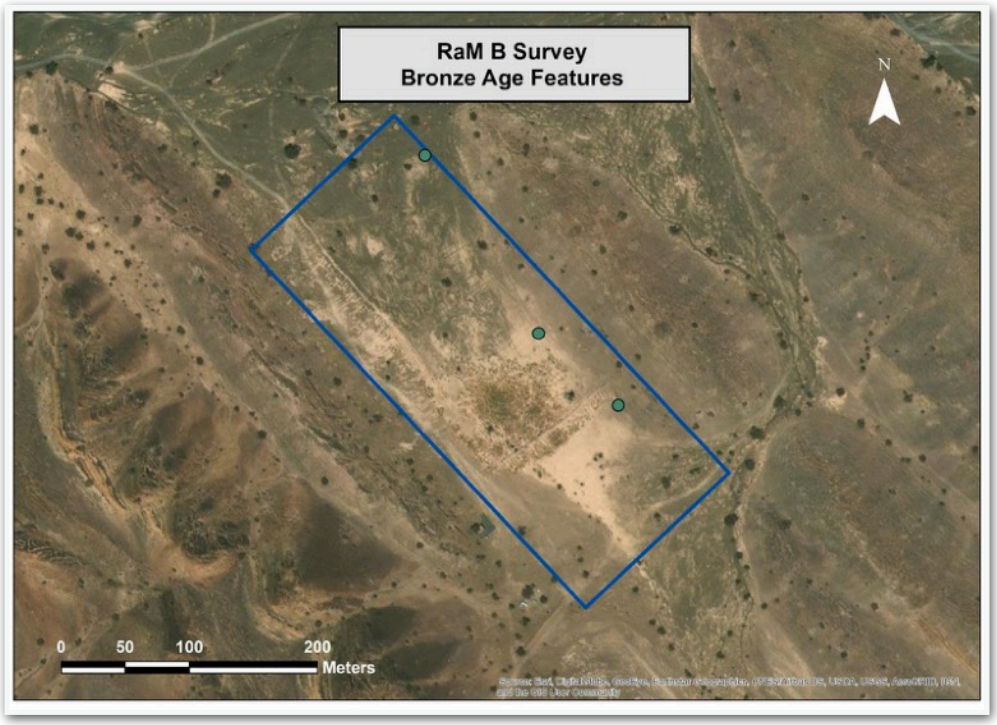

Figure 4. Bronze Age Features Identified in the Survey Zone.

have been made with Umm an-Nar architectural stones repurposed into a shooting blind or other shelter (Figure 5). Other Umm an-Nar remains included lithic debitage collected across the survey area (Figure 6) and several sherds of Umm an-Nar domestic fabric (Figure 7).

The remaining 21 identified features were artifact scatters and stone concentrations. Most of these concentrations were buried under alluvium, preventing further interpretation. Some large-scale modern industrial excavation was located within the 2023 survey zone (Figure 8). Activities like this, whether related to natural resource prospection or collection soil and gravels, cause concern for the preservation of the entire Rakhat al-Madrh area and its archaeological record.

Figure 5. Feature 232004, a rectilinear structure constructed with schist blocks consistent with Umm an-Nar architectural styles.

Figure 6. Lithics from Transect Lot 232001 (above); Ceramics from Lot 232001, including examples of glazed modern wares and fine Umm an-Nar domestic fabrics (below).

2.4 Conclusion

While a few features were located, ultimately RaM B appears not to have been a primary area of Bronze Age occupation. This finding further reinforces the special nature of Rakhat al-Madrh. The ongoing geomorphological investigation at Rakhat al-Madrh will further clarify what physical aspects of the RaM distinguish it from surrounding areas.

Figure 7. Evidence of industrial excavation within the RaM B Survey Area.

3. Rakhat al-Madrh

Eli N. Dollarhide, Jennifer L. Swerida, Paul Rissman, Amy Kroll, and Robert C. Bryant

3.1 Introduction

A third season of excavations at the Umm an-Nar settlement of Rakhat al-Madrh resumed in 2023. 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 ʻAmlah during winter 2017 (Dollarhide 2019; Dollarhide *et al.* 2017). 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 8). 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, Dollarhide, & Jensen 2021 for further comparisons).

Two previous seasons of excavation at the site conducted during BAP's 2019/20 and 2021/22 field seasons confirmed the domestic nature of two of these structures: RaM 1 and RaM 2. This previous work suggested that the stone architecture visible on

Figure 8. Aerial photo of Rakhat al-Madrh with structures highlighted. RaM 2, RaM 3, and RaM 4 were targeted for excavation during 2023.

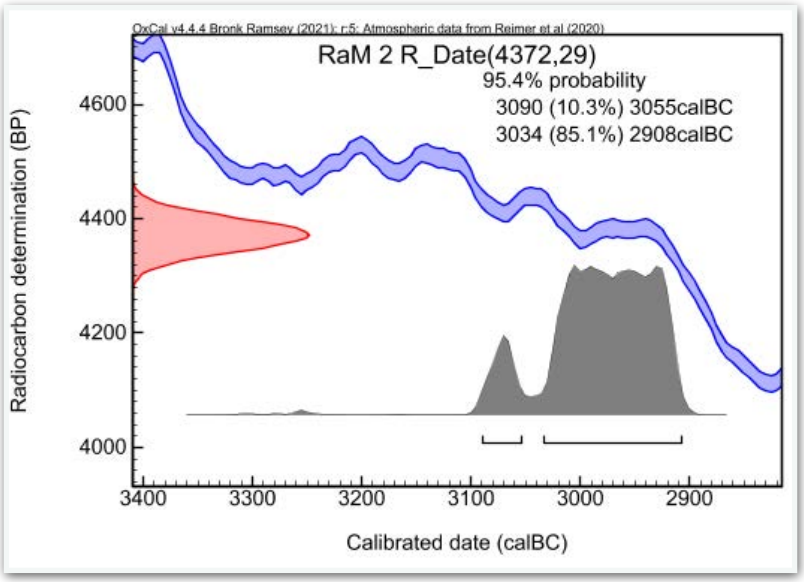

Figure 9. C-14 Calibration curve from RaM 2 (Sample Lot 221551); OxCal v4.4.

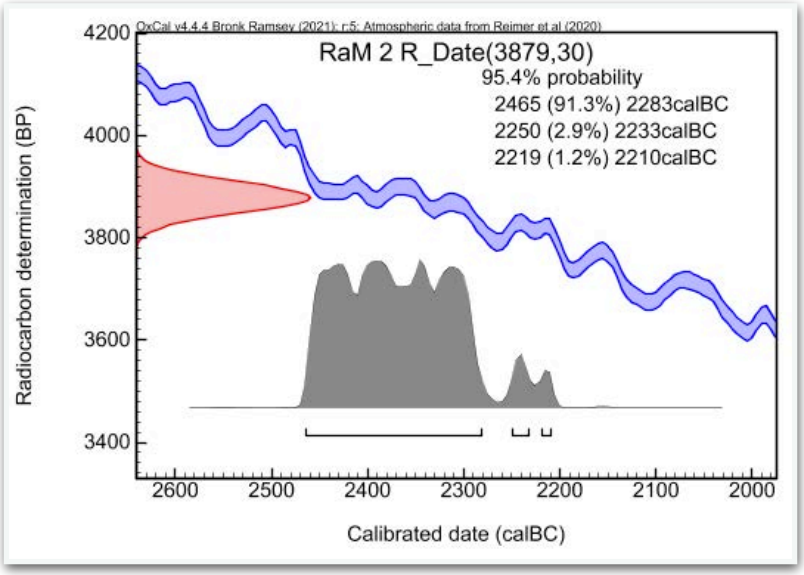

Figure 10. C-14 Calibration curve from RaM 2 (Sample Lot 221555); OxCal v4.4.

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.

These previous excavations at RaM 1 and 2 revealed a substantial quantity of charred material and subsequent C-14 dates. An initial date based on a charcoal sample collected from within one wall confirmed a middle Umm an-Nar date (2576-2460 cal. BC) for RaM 1's construction. Additional charcoal material from 2021/22 excavations produced dates of 3034-2908 cal. BC (Lot 221551; from a level below RaM 1's walls; Figure 9) and 2465-2283 cal. BC (Lot 221555; from within compacted mudbrick related to the building's primary occupation; Figure 10). This early date suggests that the RaM Area was already occupied during the Hafit period. The C-14 evidence suggests a potential 750 year occupation of the site.

Additional evidence of RaM's occupation was revealed through artifact and architectural analysis. Ceramics recovered from RaM 1 and 2's excavations last season revealed a variety of domestic Umm an-Nar wares and styles consistent with Middle Umm an-Nar types known elsewhere from Bat (see Swerida, Dollarhide, & Jensen 2021). Architecturally, excavations at both structures suggest alterations occurred over the course of their occupations, both enlarging the structure through the addition of enclosed courtyards and further compartmentalizing the space inside the structure. BAP's excavations at RaM 2 also revealed charred, botanical-rich contexts associated with an oven. Identification of these botanical remains (which included carbonized

seeds, animal dung, and phytoliths) included wheat, barley, goatgrass, cyperaceae, and palm. The analyses of these botanical remains are the subject of an ongoing research project being led by Dr. Abby Buffington (College of William and Mary).

These botanical identifications further add to our understanding of Rakhat al-Madrh's unique environmental setting, which 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, which began in BAP's 2022 season and continued in the 2023 program. The results of these investigations appear in Chapter 8 of this report.

This season archaeological excavation at Rakhat al-Madrh continued with the following primary goals:

1) Understand the function of the site and the subsistence strategies practiced by its early Bronze Age inhabitants in light of new agricultural and water management evidence at the site;
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 and how climatic shifts impacted human occupation;
4) Align these newly discovered remains with BAP's long-term goal of interpreting the wider Bat landscape.

3.2 Excavation Strategy

In order to achieve these goals, excavations were carried out at three of Rakhat al-Madrh's structures: RaM 2 and RaM 3, and RaM 4. Trenches in each of these structures were laid out on a grid system, first established in Rakhat al-Madrh's 2020 excavations This system is based around a cardinal grid of 5x5 m squares (running North-South/ East- West). The datum and backsight for total station use established during the BAP 2022 season were maintained to record excavations this season (Table 1). All elevation and coordinate data were collected with a Leica semi-robotic total station using these coordinates.

Recording at each structure followed standard BAP protocol; namely, providing a unique "lot number" to identified stratigraphic/dirt units; features; architecture; scientific samples; or artifacts of note. Lots this season from RaM excavations began with the prefix "233" followed by a three digit identifier (e.g., 233001). Photographs of

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

Table 1. Rakhat al-Madrh datum and backside locations.

each lot were taken and notes recorded by excavators on lot recording forms and in individual notebooks alongside starting and finishing elevations.

Excavations at RaM Began on January 22, 2023 and continued through February 10, 2023.

3.3 RaM 2

Excavations continued at RaM 2 this season to further define the building's architecture and function and were conducted from January 22-9 February (Figure 11). Initially two trenches were opened: A and B, each 4 x 5m. These locations were selected to provide

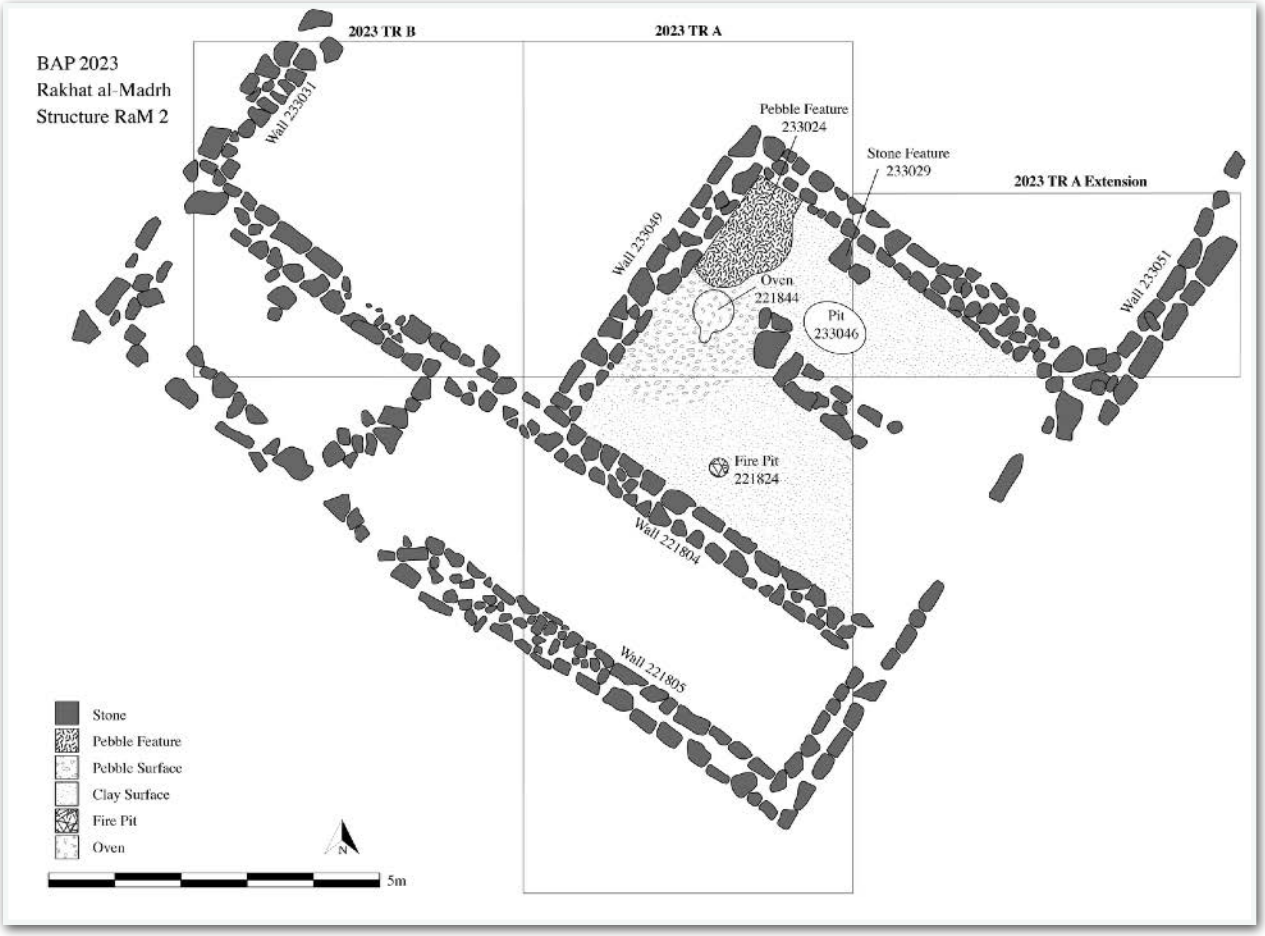

Figure 11. Plan of RaM 2 with 2022 and 2023 trenches outlined.

continuity with 2022 excavations and explore the possibility of additional botanical or pyrotechnic features as revealed immediately south of Trench A in 2022. On 5 February, an additional extension was made to Trench A along its southern boundary, running 2.75 x 6 m. In-field recording noted this additional area as Trench A extension.

3.3.1 Trench A and A Extension

Excavation in Trench A and its extension began by removing a level of ~5 cm of aeolian silt, finishing on a layer of alluvial wash defined by dried mud patches and micro deposits of small rounded gravel, indicating the interior of the RaM 2 structure must have intermittently flooded at various times after its abandonment. Beneath these levels, a hard-packed, packed clay rich layer appeared (Lots 233016 and 233014, 233017, 233018), ~35 cm below the surface. This level represents an Umm an-Nar occupational layer within the RaM 2 structure, equivalent in depth and composition to the occupational surface revealed during BAP 2022 excavations. This level generally extended across both sides of Wall 233049, indicating that the entirety of Trench A was interior space. All significant features and finds within RaM 2 were associated with this surface. Small gravel appeared within some of the surface's divots indicating that the structure may have also been occasionally flooded even during its primary Umm an-Nar occupation.

Last season's excavations at RaM 2 revealed an oven (Lot 221844) rich in botanical remains and charred sheep/goat dung. Excavations surrounding this oven in Trench A continued to discover several concentrations of wood charcoal, ash lenses, and other features associated with pyrotechnic activity and production (Figure 12). This included several fire pits, including one well-preserved stone-lined feature (Lot 233046; Figure 13). All of the pyrotechnical features were sampled for botanical analysis and radiocarbon dating.

Among these fire features, Lot 233016/233024 stands out. The feature consists of a 1.8 x 0.97 m concentration of burnt and broken wadi cobbles, large chunks of wood charcoal, and distributions of ash located at the corner of Lots 233049 and 233042. This feature abuts the oven uncovered (see Figure 14) and it seems likely to have been associated with the ovens activities. The function of the broken stones is unclear. They may have served as additional heat insulation for the oven or simply an aspect of a trash deposit associated with the oven's production activity.

Figure 12. Lithic flakes from 233004, an ash lens found within RaM 2 Trench A.

Artifacts were generally rare in Trench A, as is the case across most of the RaM structure excavations thus far. Several diagnostic sherds were removed from the occupational surface that stretched across the trench. A fragment of technical ceramic, likely a piece of a crucible, was found with lot 233014 along

Figure 13. Stone-lined fire pit 233046, surrounded by baked sediment.

Figure 14. The broken stone and ash feature (Lot 233016/233024) abutting Walls 233049 and 233042.

with several small round copper fragments, providing further evidence of craft production within the interior of the structure. Several pieces of Umm an-Nar domestic ware pottery were found within Lot 233016.

Architecturally, Trench A further confirmed the presence of mudbrick superstructure above the stone foundations visible. Several pieces of mudbrick melt were found attached directly on Wall 233032 during its excavation. Unusually, a small stone feature (Lot 233029; see Figure 11 RaM 2 plan) was identified abutting Wall 233032. These two worked stones were at the same elevation as the abutting wall and may have been simply a very small wall or served as buttressing/support for the interior wall of 233032.

3.3.2 Trench B

Excavation in Trench B occurred concurrently with operations in Trench A and A Extension and largely mirrored Trench A's progression (Figure 15). After the removal of topsoil, the same hard-pack clay surface was identified ~27-33 cm below the surface across the trench. This area of the occupational surface was richer in ceramics artifacts then Trench A. However, those recovered were highly fragmentary and the

Figure 15. Aerial photograph of the hard-pack clay rich occupational surface in Trench B and Wall 221804.

identification of their Umm an-Nar date was based entirely on the sherds' characteristically fine fabric.

Architecture in Trench B consists of two Umm an-Nar walls: Lots 221804 and 233031. Both were made primarily of schist blocks, faced on both their interior and exterior surfaces. A few examples of conglomerate, sourced from the immediately surrounding RaM hills, were also used as architectural material Following the discovery of Wall 233031, it became clear that most of Trench B was also interior space. Some mudbrick melt was identified in the southwestern corner of the trench, likely from the collapse of Wall 221804. No other features were identified.

3.4 RaM 3

Excavations at RaM 3 began on 22 January and concluded on 10 February 2023. RaM 3 is the largest of the four known structures surrounding the central depression in the RaM Basin (Figure 16). A 5x15 m excavation unit running east-west through the center of the building was planned to sample interior and exterior contexts and to clarify architectural relationships. This excavation unit was sub-divided into three contiguous 5x5 m trenches designated as Trench A in the east, Trench B in the center, and Trench C in the west. Excavated contexts in all three trenches were recorded in Lot series 233200. All trenches share a similar stratigraphic composition that consisted of: (1) an uppermost layer of fine silt and sand; (2) a thick layer of compact clay associated with the primary use of the RaM 3 building; and (3) an underlying layer of clay that is the natural matrix of the depression.

3.4.1 RaM 3 Trench A

The easternmost trench of the RaM 3 excavation unit, Trench A, was positioned to capture the eastern edge of the building and some possible exterior architectural features visible from the unexcavated ground surface. It was hypothesized that multiple building phases would be represented in this area and that sediment would be deposited above Umm an-Nar levels by water activity in the depression.

The fine silt and sand topsoil in Trench A (Lots 233209, 233216, and 233217) continued for a depth of approximately 25 cm and contained few sherds of Umm an-Nar and Islamic pottery. This sandy silt was deposited in lenses that sloped gently downhill toward the depression to the east. Topsoil removal clarified the locations and extents of several stone features. The most prominent of these is a large stone wall running north-northwest to south-southeast—Wall 233221—across the western edge of the trench and extending into Trench B that formed the eastern extent of the RaM 3 building (Figure 17). This wall is composed of two parallel rows of large stones that form the interior and exterior wall face. These stones are dovetailed in some areas and in others are separated by a core of chipped stone rubble. The facing stones are large, roughly hewn blocks of the local limestone set into a mud mortar and average 45x35x15 cm. The wall is preserved 3-4 stone courses or approximately 1 m in height and likely originally supported a mud brick superstructure. Wall 233221 is significantly larger than that found in the average Umm an-Nar domestic structure at Bat (cf. Swerida 2017; Swerida and Thornton 2019a).

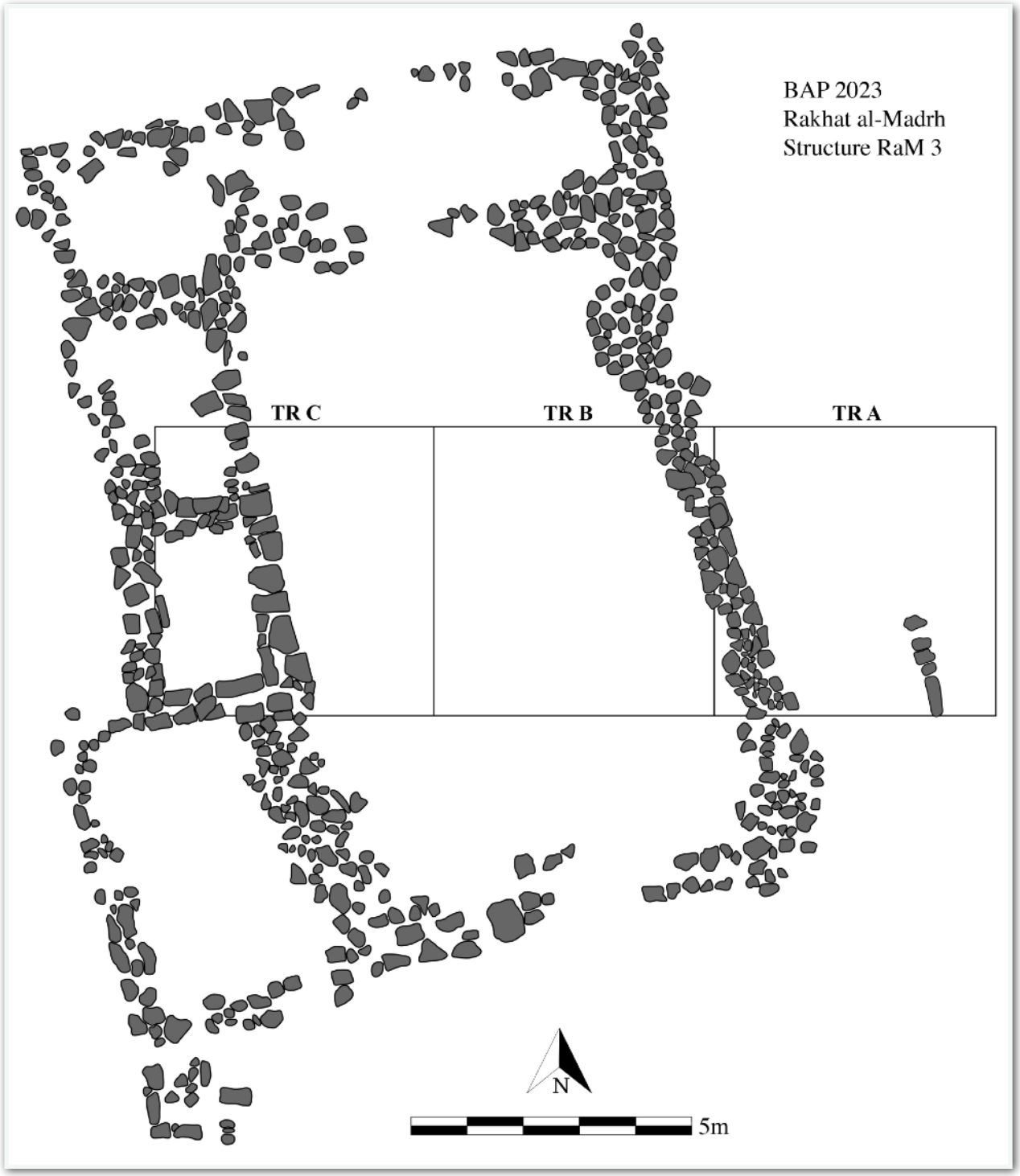

Figure 16. Plan of RaM 3 with trench locations outlined.

The other stone features in Trench A were less substantial and well-formed than Wall 233221. A roughly linear concentration of stones running north-south across the trench, Feature 233222, may reflect an episode of collapse from Wall 233221 downhill to

Figure 17. Wall 233221 from east.

the east. The stones of this feature were jumbled, of varying sizes, and rested in silt. A C14 sample of wood charcoal collected from within the silt surrounding Feature 233222 (Sample 233227) may provide an approximate date for the collapse. A second irregular stone concentration, Feature 233223, was uncovered in the northeastern quadrant of the trench. The stones composing this feature were extremely large, ca. 50x40x35 cm, but had no clear alignment and rested on silt. No clear source or function for Feature 233223 was identified. A C14 sample of wood charcoal collected from the silt surrounding the stones may provide a date for the feature's formation. Stones from both features were gradually removed as it became clear they were tumbled rather than architectural.

Two final stone alignments, Features 233224 and 233225, in Trench A have characteristics that make them more convincing as intentional features. The smaller of the two, Feature 233225, was composed of three flat, relatively thin (ca. 15 cm) limestone blocks all resting at the same elevation and forming a stone square. These stones rest within the sandy silt of topsoil Lot 233209 and were likely arranged by visitors to the site well after the abandonment of RaM 3, possibly during the same visitation episode(s) when the Islamic ceramics collected in Lot 233209 were deposited. Farther to the south, a stone alignment, Feature 233224, consisting of four small limestone blocks

and one large, vertical limestone slab was uncovered emerging from the eastern end of the south baulk. These stones form a short, 2 m long, wall running north-south. The stone blocks rest on the top of the clay layer beneath the silt topsoil, suggesting that they date to a later period than the RaM 3 building but predate Feature 233225. The large, vertical slab is the southernmost of the excavated stones and served as a windbreak for a fire pit, Feature 233220, located immediately to its east. Similar relationships between vertical stone slabs and fire pits were found in RaM 2. C14 samples collected from wood charcoal within the fire pit (Samples 233219 and 233252) may provide a date for this feature and the neighboring Wall 233224, while a soil sample from the pit fill (Sample 233219) may provide insight into the burned materials.

Below the topsoil, contexts to the east of the RaM 3 structure were composed of a dense, light brown clay excavated in 10-15 cm units as Lots 233250, 233251, 233256, and 233262. The space between Walls 233221 and 233224 also contained fragmentary clumps of mud brick in Lots 233250, 233251, and 233256. It is probable that this bricky matrix is the result of collapse from Wall 233221 downhill to the east. The presence of Wall 233224 would have protected this bricky material from floodwaters and created better conditions for preservation. A modest collection of ceramic sherds stylistically dating to the Wadi Sûq and Umm an-Nar periods was collected from the fill of Lots 233250 and 233251.

Lot 233256 ended on a layer of clean clay with no further trace of mud brick collapse. It is likely that this layer is associated with the final use phase of the RaM 3 building. The clay contained a larger collection of ceramics than found in the layers above, all stylistically datable to the Wadi Sûq and Umm an-Nar periods (Figure 18). A shallow fire pit, Feature 233258, was uncovered at this layer just east of Wall 233221 at the southern end of the trench. C14 samples collected from wood charcoal within (Sample 233257) and just east of (Sample 233260) the fire pit may provide a date for this feature, while a soil sample from the pit fill (Sample 233259) may provide insight into the materials burned within the pit.

The final layer excavated in Trench A was Lot 233262, which brought contexts level with the foundations of Wall 233221. All ceramics recovered from this layer stylistically date to the Umm an-Nar period. Sherds were particularly common in the northeast corner of the trench. A reddish discoloration in the center of Trench A may suggest pyrotechnic activities, although no feature was identified. A C14 sample of wood charcoal (Sample 233264) was collected from the clay matrix may provide an approximate date to the contexts. Additionally, a C14 sample of wood charcoal extracted from between the bottom and middle courses of stone in the east face of Wall 233221 during final cleaning (Sample 233281) may provide a date for the wall's construction.

3.4.2 RaM 3 Trench B

Trench B was situated almost entirely within what appeared from the unexcavated ground surface to be a large central courtyard within the RaM 3 building. The 'courtyard' was bordered by Wall 233221 to the east and continued into Trench C to the

west. It was hoped that this location would provide information on the structure's date and use. The surface in this trench was slightly higher than that of Trench A to the east, as contexts sloped uphill to the west away from the depression.

Figure 18. Ceramics from Lot 233256.

Comparable to contexts excavated in Trench A, the sand and silt topsoil in Trench B was deposited in thin lenses likely by seasonal flooding events. This layer continued for a depth of 30 cm and was excavated as Lots 233203, 233210, 233226, 233249, 233254, and 233255. Collectively, the lots contained little material culture. Ceramics were a sparse mixture of Islamic and Umm an-Nar sherds, while Lot 233210 contained a possible hammer stone (Artifact 233211).

Prominent in the layer of sandy silt were a collection of five features that likely represent stone-lined burials—Features 233202, 233228, 233229, 233230, and 233231 (Figure 19). These features are all roughly rectangular in shape with a central cavity and, with one exception, a large "headstone" at one of the two narrow ends. All were

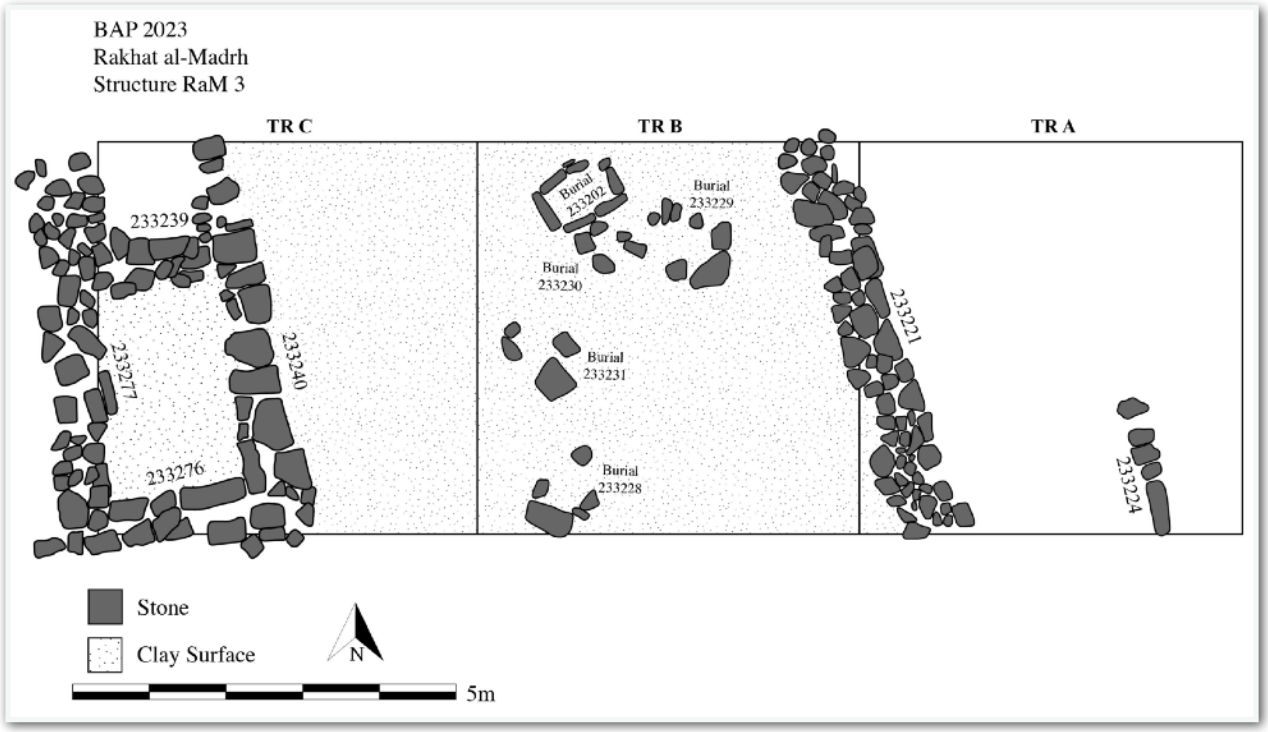

Figure 19. RaM 3 excavation plan with burial locations.

small, averaging 1.2x0.7 m, which suggests that they were intended as burial structures for children or adolescents. Alignments and the position of the "headstone" varied. Four of the five features (233228, 233229, 233230, and 233231) were clearly disturbed and had displaced or missing stones, likely the result of seasonal flooding from the RaM Depression. Excavation in and around these features found no material culture or preserved human remains.

Feature 233202 was the best preserved and possibly the most recent of the probable burials, as suggested by its more precise construction than the other surrounding examples (Figure 20). This feature was the first of the collection to be excavated as the most likely of the set to contain preserved contexts. Excavation was carried out with caution in order to determine if Feature 233202 was a burial, its possible date of origin, and if human remains were preserved within. The small chamber was constructed of six vertical stone slabs—two on each long side and one on each short side—and contained an interior surface of small stones (Lot 233205). Above the stone surface, the chamber was filled with the same sandy slit as the surrounding topsoil matrix. The fill immediately below the cobbles (Lot 233208) was a compact clay mixed with sand and ash. A C14 sample was collected from wood charcoal (Sample 233206) found loose in the matrix and a soil sample (Sample 233207) was collected from the fill. No material culture was recovered from the chamber, either above or below the interior stone surface. A single fragment of what appears to be enamel from an adult upper incisor was recovered from Lot 233208 below the surface. No other possible human remains were identified. The stone slabs forming the chamber walls were embedded into the layer of dense clay below the silt topsoil.

Figure 20. Feature 233202 above (left) and below (right) stone surface (Lot 233205).

Floating within the sandy silt layer of the courtyard fill were a number of ephemeral, small fire pits—Features 233214, 233246, and an unnumbered area of poorly defined burning (Figures 21 & 22). These pyrotechnic features are not associated with a formal surface and are found at varying elevations within the silt layer. They likely reflect passing visitations to the site following the abandonment of the RaM 3 structure, possibly associated with the burial activities. Soil samples 233213 and 233215 were collected from the fill of Feature 23314; no charcoal large enough to sample was found. Multiple C14 samples of wood charcoal were collected from Feature 233246 (Samples 233233, 233234, and 233248), as well as a soil sample (Sample 233247). These samples may provide an approximate date for the visitation(s) and characterize the burned materials.

Excavations in Trench B were halted at the top of the dense clay layer encountered at the bottom of Lots 233254 and 233255 due to lack of time. These lots contained a small collection of Umm an-Nar pottery and likely represent the final use phase for the RaM 3 building. More limited excavations continued in a 1.5x1.5 m sounding in the southeast corner of the trench, abutting the west face of Wall 233221 (Figure 23). This sounding was excavated in order to probe the depth of interior contexts within the suspected 'courtyard', clarify the construction of Wall 233221, and determine if activity in this location predated the visible RaM 3 architecture.

Within the sounding, excavations proceeded in arbitrary 20 cm passes as Lots 233254 (still in the silt layer), 233261, 233272, and 233280. Below the silty topsoil, the clay of Lots 233261 and 233272 was cut by a large pit (Feature 233269) extending into the sounding from the southern baulk. This pit likely dates to the final use phase of the

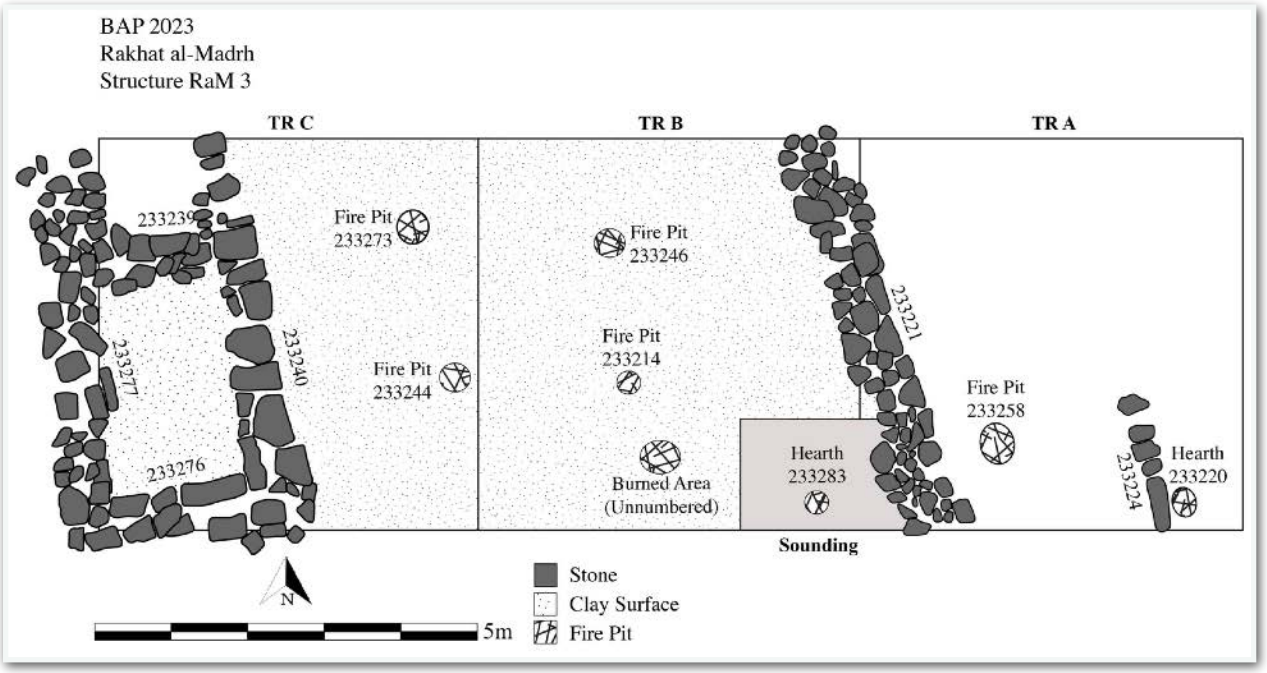

Figure 21. RaM 3 plan with fire features and location of sounding.

Figure 22. Ephemeral fire feature 233214 (left) and C14 sample collection from fire Feature 233246 (right).

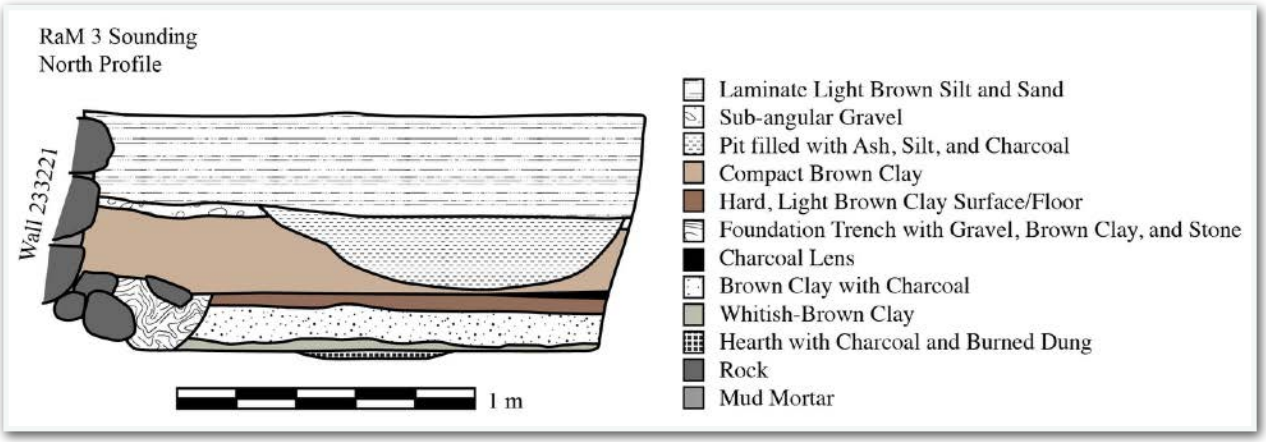

Figure 23. North profile of RaM 3 Sounding.

RaM 3 building and contained substantial quantities of large wood charcoal pieces and ash. Samples of the charcoal (Lots 233263 and 233267) were collected for C14 and wood grain analysis and a soil sample (Lot 233268) was collected for archaeobotanical analysis. Outside of the pit, the clay matrix of the courtyard space (Lots 233261 and 233272) contained ceramic sherds stylistically datable to the Middle or Late Umm an-Nar period (Figure 24). The courtyard fill ended on a packed clay floor (Lot 233286) approximately level with the foundations of Wall 233221. A thin lens of burned material rested immediately atop the floor, a C14 sample (Lot 233287) from which will provide a

date for the original use phase of the RaM 3 building. A soil sample (Lot 233288) was also collected from the contexts just above the floor for phytolith analysis to determine the environmental conditions of the RaM 3 building's primary use phase.

Excavation in the sounding continued below the floor level (Lot 233280), into contexts that predate Wall 233221 and the RaM 3 structure as it is currently understood. This lot also revealed that Wall 233221 was constructed in a rubble-filled foundation trench that cut into earlier contexts (Figure 25). The matrix below the RaM 3 floor was a compact, medium-brown clay with occasional charcoal flecks. A small collection of ceramic sherds was recovered from the fill, including three sherds stylistically datable to the Umm an-Nar period and one sherd from a Black-Slipped Jar imported from the Indus (Figure 24). Excavation ended on a layer of hard-packed, whitish-brown clay

Figure 24: Ceramics from Lot 233272 (above) and Lot 233280 (below) in RaM 3 Sounding.

Figure 25. Foundation trench of Wall 233221 from west.

that likely served as a floor surface. Cutting this surface was a small, unlined hearth (Feature 233283; Figure 26). The hearth was full of what appeared to be charred sticks and animal dung. A C14 sample was collected from the wood charcoal and burned dung (Sample 233282), which will provide a reliable date for the use phase predating the RaM 3 structure. A soil sample was also collected from the hearth contents (Sample 233284) for archaeobotanical and phytolith analysis. A second C14 sample was collected of wood charcoal (Sample 233285) found on the floor surface at the bottom of the sounding. This sample is almost certainly associated with the hearth Feature 233283 and provides an additional source for dating the pre-RaM 3 phase.

3.4.3 RaM 3 Trench C

The westernmost Trench C was situated to capture the remaining length of the RaM 3 courtyard and portions of two rectangular rooms at the western edge of the building. These spaces were excavated with the goals of determining the function(s) and use date(s) of the courtyard and small rooms. This trench has the highest elevation of the RaM 3 units due to the building stepping up the edge of the RaM Depression.

The western end of the RaM 3 courtyard in Trench C had a similar composition to the portion excavated in Trench B. Approximately 30 cm of sandy silt topsoil (Lots 233204, 233235, 233236, 233241, and 233243) rested above a layer of compact clay. Ceramic finds were limited to a single, heavily worn sherd that likely dates to the Umm an-Nar or Wadi Sûq period. An ephemeral fire pit (Feature 233244) was uncovered in the southeastern quarter of silt layer. There was no identifiable surface associated with

Figure 26. Hearth 233283 at bottom of Sounding.

this pit, comparable to those in the silt layer of Trench B. A C14 sample of wood charcoal (Lot 233242) and soil sample (Lot 233245) were collected from the pit fill. A second small, pyrotechnic pit (Feature 233273) was found at the bottom of the silty topsoil, cutting into the clay layer beneath. This pit likely dates to the final use phase of the RaM 3 building. A C14 sample (Lot 233274) may yield a date for the feature's use and a soil sample (Lot 233275) may provide insight into the burned materials.

The western edge of the courtyard was marked by a large stone wall—Wall 233240—that runs parallel to Wall 233221 and was hypothesized to be one of the original walls of the RaM 3 structure. The space in the courtyard immediately east of Wall 233240 was filled with a jumble of stones of varying sizes (Lot 233278). Excavation revealed the stones to have no clear alignment and to be resting in silt. This stone concentration was initially thought to be collapse from the walls composing the western end of the building. The upper layers of the stones were thus removed to clarify the east face of Wall 233240. However, as the removal progressed it became clear that the stones were piled against the east face of Wall 233240 rather than collapsed from it. The stone feature was most likely created to provide support to the neighboring wall to prevent it from collapsing downhill to the east.

The stones of Lot 233278 continued below the silty topsoil and into the underlying clay, giving the feature a date of origin during the use life of the RaM 3 building. A sherd of a jar form stylistically datable to the Middle Umm an-Nar 2 period was found in the lowest excavated layer of the stone feature and provides a terminus post quem for its formation.

Figure 27. Wall 233240 from north; stone feature 233278 visible on left.

The western half of Trench C is organized by four stone walls: Walls 233239, 233240, 233276, and 233277. The north-northwest by south-southeast Wall 233240 forms the western edge of the courtyard and is constructed of stones comparable in size to those of the parallel Wall 233221—ca. 45x35x15 cm. However, in contrast to the dovetailed construction style of Wall 233221, Wall 233240 is built of a single row of wide stone slabs (Figure 27). The thinner width of this wall may be due to its position as an interior, rather than exterior,

edge to the courtyard. While it is not yet possible to definitively confirm that the two walls were built in the same construction event, the similarities in their orientations and the scale of the stones used to create them supports the interpretation that both Walls 233221 and 233240 were original to the RaM 3 structure. Two small, rectangular rooms are formed at the western end of the building by two short walls—Walls 233239 and 233276—that bond with the west face of Wall 233240 and the east face of parallel Wall 233277, which runs just within the southwest corner of Trench C. All three of these walls are constructed of dovetailed limestone blocks somewhat smaller (ca. 35x30x15 cm) than those used in Walls 233221 and 233240. The bonded corners confirms that all four walls (Walls 233239, 233240, 233276, and 233277) were built in the same construction episode.

Excavation in the two rooms lining the western edge of Trench C was restrained by stone collapse. The northern room defined by Walls 233239, 233240, and 233277 (running outside the trench limit) is the smaller of the two and, below a ~10 cm layer of sandy silt topsoil (Lot 233239), was found to be completely filled with fallen stone. Due to limitations of space and time, excavation did not continue in this room. Instead, efforts focused on the southern, larger room defined by Walls 233239, 233240, 233276, and 233277. This space was also covered by a layer of sandy silt and fallen stone (Lot 233237). Once cleared of stone collapse, the room contained an additional 25 cm of sandy silt (Lots 233253, 233266, and 233271), which contained a small collection of ceramic sherds stylistically datable to the Wadi Sûq and Umm an-Nar periods. The layer of silt beneath the stone collapse suggests that the room's surrounding stone walls were originally several courses taller than their current preserved height and the stones collapsed some time following the abandonment of the RaM 3 building, after the room had begun to fill with sediment. Below the silt, excavation continued through approximately 20 cm of the clay room fill (Lot 233279) and stopped on a packed clay surface which may be a floor. While no features or artifacts were directly associated with the floor, the clay fill above it contained a small collection of ceramic sherds stylistically datable to the Umm an-Nar period. The foundations of the room's walls were not identified in excavation and it is possible that further room contexts are yet to be excavated.

3.4.4 RaM 3 Summary

Excavations at RaM 3 revealed a structure with more monumental characteristics and clearer evidence for a multi-phase occupation than has been found at the other buildings around the RaM Basin. The RaM 3 location has at least four use phases represented in the excavated contexts, judging by ceramics and associated material culture and behavioral contexts:

1) Early Islamic visitations and probable burial activities;
2) Wadi Sûq visitation or reuse of structure;
3) Umm an-Nar construction and maintenance of RaM 3 structure;
4) Umm an-Nar occupation prior to the construction of RaM 3.

The date ranges for these phases will be confirmed and clarified by the results of related C14 analyses. Furthermore, the varying construction styles of walls visible from the modern ground surface suggest that additional use phases or sub-phases are

represented in portions of the RaM 3 structure not included in the BAP 2023 excavation area.

The scale of the RaM 3 masonry, especially that of the easternmost Wall 233221, is more akin to that seen in Umm an-Nar tower monuments than that found in most Umm an-Nar settlement architecture (cf. Swerida & Thornton 2019b). The reason behind the presence of such large scale construction at RaM And the function served by RaM 3 are yet to be determined. The differences in the building's scale may relate to its location, the date of its construction, or the role that it played in the RaM Community. RaM 3 is set at some distance from the other structures around the basin and is situated at an elevation approximately 20-30 cm lower than its neighbors. It is possible that the larger scale of the RaM 3 architecture may be due to an increased risk of flooding caused by its slightly lower position on the landscape. A construction date later in the Umm an-Nar period than the other RaM Buildings may also contribute to the differences in scale. The presence of a Middle Umm an-Nar 2-style (ca. 2400-2200 BCE) jar sherd in the stone packing against the east face of Wall 233240 suggests a date slightly later in time than the Middle Umm an-Nar 1 C14 date (2576-2460 cal. BC) collected from the first phase of RaM 1 (Swerida *et al.* 2020). Alternatively, the monumentality may reflect an elevated social status of its occupants or importance of the role the building played in the functioning of the RaM Community. Further research is necessary to evaluate each of these tentative interpretations.

Future excavation by BAP will continue to explore the nature, extent, and duration of cultural activity at RaM 3. Excavations will continue within the courtyard space and the southwestern room in Trenches B and C to further explore the use of space within the building. We will also expand excavation and surface cleaning efforts beyond the area within the defined trenches to clarify the building's floorpan and structural history. This research will contribute to BAP's overall goals at Rakhat al-Madrh of understanding the site's function, the lifestyles and subsistence strategies of its occupants, and its role in the wider Bat landscape across time.

3.5 RaM 4

Excavations at RaM 4 began on January 22, 2023 and concluded on February 10, 2023. The structure is situated between a conglomerate scree slope to the south and a seasonally flooded depression in the north. Surface remains indicated the structure suffered from several taphonomic issues, including the placement of a nearby power line which disturbed large portions of the structure on its surface. Initially, two trenches were opened in the structure to better understand their chronology, function, and preservation in light of surface disturbances. Trench locations were identified and placed to capture what appeared to be the least disturbed areas of the building (Figure 28).

3.5.1 RaM 4 Trench A

Excavations in Trench A began on January 22. After an initial surface cleaning several layers of alluvial wash, 15 cm deep, were removed. A wall was discovered running down the middle of the trench in a north-to-south direction (Wall 233407).

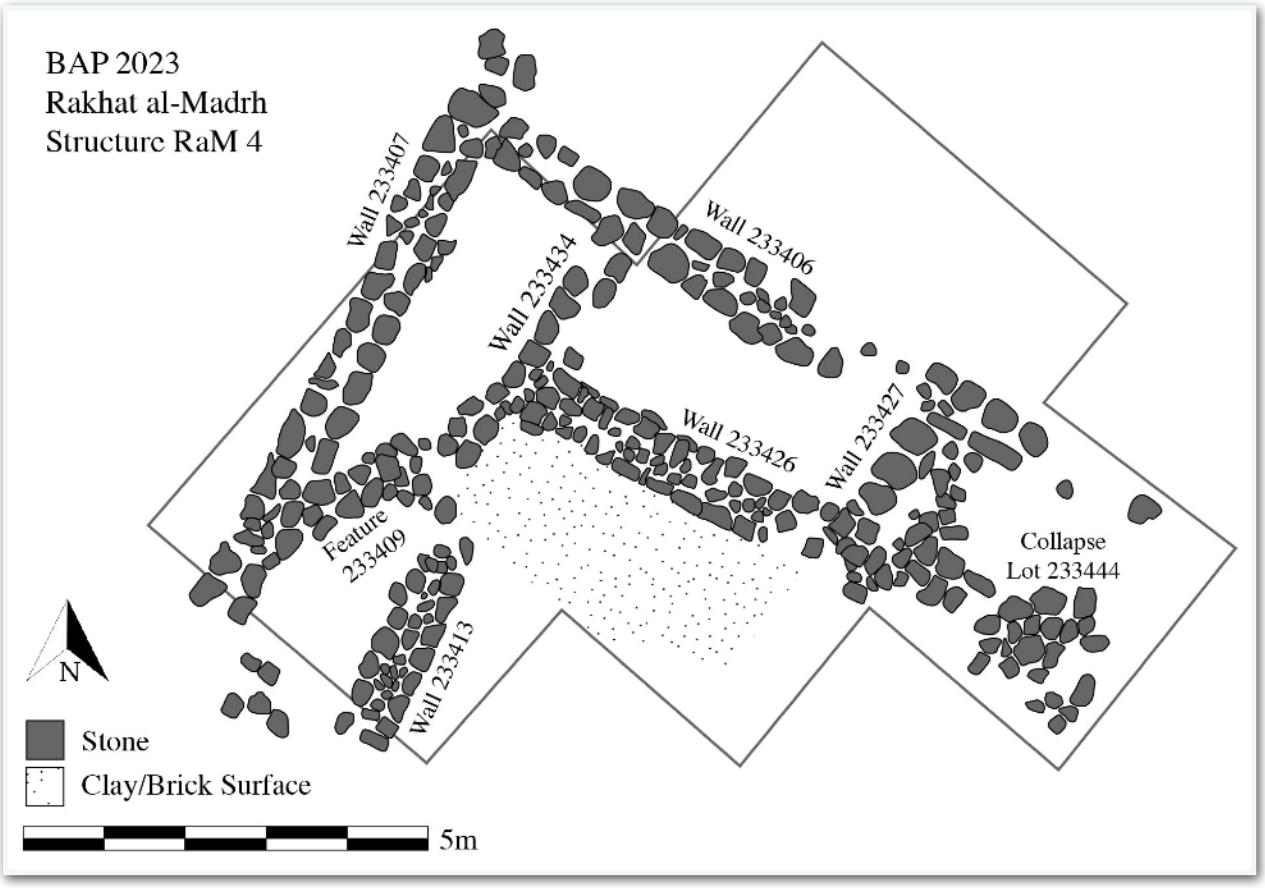

Figure 28. Plan of RaM 4 showing extent of excavations.

Subsequently, two new dirt lots, one to the west (Lot 233404/233412) and one east of the wall (Lot 233410) were excavated in 10 cm passes to expose the interior and exterior faces of Wall 233407. The western face of the wall was finely faced, typical of the Umm an Nar period architecture. Initially, an additional feature appeared and was considered tumble, but later reassessed to be a separate wall (Wall 233409) that was placed on top of Wall 233407 at a slightly different angle, indicating an apparent shift in the function of the building's interior space (Figure 29).

This interior space was further excavated to the lowest depth of Wall 233407 in search of floors or other occupation surfaces. This effort was completed at a depth of 47 centimeters, when a hard and compact clay stratum appeared. It was later determined that this was also alluvial wash, due to the presence of small rounded gravels, that had hardened over time. In the southwest corner of the lot, adjacent to Wall 233407 and the southern baulk, was a dense level of mudbrick melt (Lot 233442) and small stone collapse. Both likely represent the collapse of the mudbrick superstructure that once rested on top of the stone foundation of Wall 233407 (Figure 30).

Figure 29. Wall 233409 resting above Wall 233407.

Figure 30. Lot 233442, a dense conglomeration of mudbrick melt abutting wall 233407.

On January 23, Trench A was expanded 1 meter east towards another Wall, Lot 233413, which was partially visible through the topsoil. Wall 233413 terminated in the northern balk with a relatively large, round boulder that did not match the other stones in the wall. On January 24, Trench A was extended again one meter to the east, beyond Wall 233413, revealing both faces of the wall (Figure 31). The eastern face of Wall 233413 was faced, but the western side was not. After removing several large boulders from Ram 4, the wall appeared to be free floating in the structure. Its orientation loosely matched up with Wall 233406, 233424, 233407, and 233426 (see Figure 28 above) but was not on the same orientation. Based on associated materials and style, it was likely constructed during the building's Umm an Nar occupation, however its higher elevation relative to Wall 233407 indicates it could represent a later alteration of the building.

On January 25, Trench A was extended 4 meters to the north from the westernmost extent of the original Trench A boundaries to excavate a circular stone feature (Lot 233417) resting on Wall 233407 with a depression in the middle. This operation started by clearing the topsoil from the depression (Lots 233418 and 233422). The feature was bifurcated to excavate only the northern half (Lot 233423). Initially, Feature 233417 appeared to bear many similarities with Iron Age tombs excavated in the area. However, it was decided that the feature was either robbed or served a different purpose as there was no cap, osteological remains, or material culture. It was essentially

Figure 31. Wall 233413 exposed in Trench A at the close of excavations, showing unworked, western-facing of the wall.

layer after layer of alluvial wash and small gravels. Under the wash, on the eastern side of the trench, there was a hard-packed surface that stones (later assessed to be Wall 233434) were resting on. The western half of the depression went beneath the stones but was still very soft and might be representative of rodent bioturbation. While excavating the depression, Wall 233434 began to appear in the eastern portion of the lots. Several sherds of Umm an-Nar domestic pottery were recovered from within and around this wall (Figure 32).

While removing feature 233417, a loose, silty matrix was discovered immediately below Wall 233434. Several diagnostic Umm an-Nar wares were recovered from this likely secondary depositional context that was also interspersed with soft, silty, alluvial infilling and rodent bioturbation (Figure 33).

Figure 32. Several fragmentary examples of Umm an-Nar pottery recovered from Wall 233434.

Figure 33. Umm an-Nar ceramics, including sherds from a suspension vessel, recovered from Lot 233430, under Wall 233434.

3.5.2 Trench B

Excavations at Trench B within RaM 2 ran concurrently with Trench A's operations detailed above. Trench B is a 7.5x5m trench roughly following East-West with its longer axis. A later extension to Trench B was created to the south in order to follow and further understand the chronology and construction of Walls 233406 and 233426 (Figure 34).

As in Trench A, the northern portion of the trench is alluvial silt wash, ranging from 15-24 cm deep, overlaying a compact-clay layer. The southern area of the trench is silt mixed with gravel eroded from the scree slope immediately behind RaM 4, which mixes and overlays the compact clay layer. All walls and features in the northern portion of Trench B are associated with the top of the compact clay layer, upon which they were constructed. In the southern portion of the trench some features are resting above gravel wash. The gray compact stratigraphic surface is pockmarked and undulating. No pits were discerned in Trench B. There were significant root disturbances through the trench, with the roots growing along the interface of the silt overlaying the compact gray occupational surface. It is easy to locate this stratigraphic break in the north where the gravel does not reach; it is more difficult when removing silt mixed with gravel from compact clay mixed with gravel in the southern area.

Architecturally, the trench is distinguished by two north-south running walls (see Figure 28, RaM 4 plan above) , an outer east wall (Lot 233406) which runs through into

Figure 34. An aerial photograph of RaM 4 under excavation on 5 February.

trench A and the trench B extension, where it fades out. West of Wall 233406 is a room bounded by Walls 233406 on the east, fragmentary Wall 233413 on the north, Wall 233426 on the west, and Wall 233427 on the south. This small interior space is typical of the other RaM structures excavated around the depression. Excavation revealed Wall 233427 to be sitting above Wall 233426, and thus represents a further compartmentalization of what was once a larger interior space.

West of the room, moving to the west of Wall 233426 is an apparent courtyard. The courtyard contains a number of mudbrick features and melt, which were identified as Lots 233445-233448. These are quite fragmentary and difficult to define due in part to the frequent inundation of this courtyard space and gravels washing down from the nearby scree slope.

The clearest of these features appears to be Lot 233445, where it is possible to identify six individual mud bricks set on their shorter edge, set along the middle portion of Wall 233426. The function of the bricks may have been to support/secure the adjacent wall (see Figure 35 below) . Additional mudbrick melt and matrix were found adjacent to these individual bricks and were interpreted as mudbrick melt.

Artifacts were generally sparse in Trench B, as was the case for RaM 4 as a whole. Several sherds of Umm an-Nar pottery were recovered along Wall 233406. A collection of lithic debitage was also found in this area, though it might be a secondary context, washed from the surrounding hillside. Additional Umm an-Nar ceramics were recovered from within the Wall collapse Lot 233444 but were very fragmentary in nature.

Charcoal samples were collected from within the small storage room on the hard-packed surface (Lot 233432) and from the larger "courtyard space" (Lot 233438 and Lot 233430). C-14 dates derived from these samples may help further clarify the age of the building's occupation.

Figure 35. Mudbrick outlines visible in Lot233445 abutting to Wall 233426, shown on the surface (A) and in aerial view (B).

4. Al-Khutm Settlement Excavations and Mapping

Jennifer L. Swerida and Robert C. Bryant

4.1 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. The settlement was first identified by Dr. Charlotte Cable (2012) and was systematically surveyed and mapped by BAP between 2013 and 2015 (see Kondo & Swerida 2013; Hatfield & Cable 2014; Swerida 2017). BAP returned to the Khutm Settlement during the winter 2022 field season to begin a larger program of study at the site (Bryant, Smith, & Swerida 2022). The results of the 2022 survey, test excavation, and photogrammetric mapping served as a guide for BAP's 2023 research activities at the settlement.

This season our archaeological research at Khutm Settlement was conducted with the following objectives:

- Confirmation of the preliminary dating of the settlement activity to the Umm an-Nar and Iron Age II periods;
- Test the hypothesis that the large building identified at the eastern end of the settlement was an Umm an-Nar period house complex;
- Investigate the depth of deposit and establish a stratigraphic record in the extremely large building encompassing the western half of the hillside, tentatively interpreted as an Iron Age fortress;
- Align these newly discovered remains with BAP's long-term goal of interpreting the wider Bat landscape.

4.2 Test Excavations

A total of three test trenches were excavated at the Khutm Settlement during the BAP 2023 field season (Figure 36):

1) Test Trench B: a strip trench sampling a large building at the eastern end of the settlement;
2) Test Trench C: a test trench-turned salvage excavation of a destroyed Umm an-Nar tomb;
3) Test Trench D: a deep sounding within an extremely large building believed to be an Iron Age II fortress at the western end of the site.

Note that Test Trench A was excavated at the Khutm Settlement by BAP during the winter 2022 field season (Bryant, Smith, & Swerida 2022).

4.2.1 Methodology

Consistent with the methodology established in the 2022 excavation in this location, the test excavation units were oriented roughly in line with the site's visible architecture, at a 45° angle to the site-wide grid established by BAP in 2014. Test trenches are assigned the prefix "KS" to signify "Khutm Settlement" followed by a unique letter to

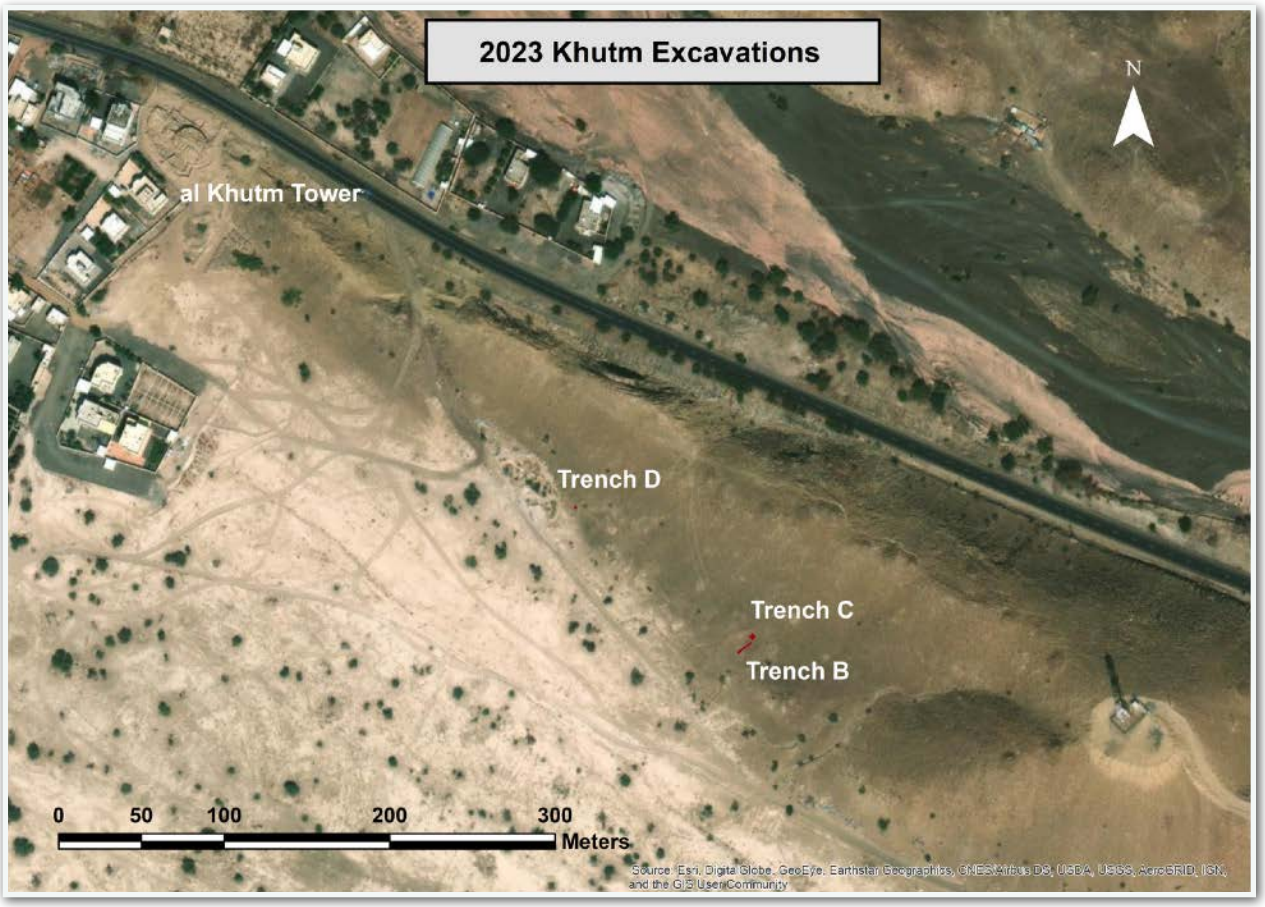

Figure 36. Location of Umm an-Nar house complex and tomb in the al-Khutm Settlement.

differentiate them from the standard numbered 5x5 m units excavated elsewhere on the Bat landscape—for example, KS Test Trench A. The locations of each test trench and the excavated contexts within them were recorded on paper forms and in digital records.

During excavation, all Khutm Settlement contexts or "lots" (dirt context, feature, artifact, or sample) were given a unique number consisting of the project season prefix (23-) plus a unique number beginning with 230001. 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. All spatial records were collected with reference to the Master Datum established at the site during the BAP 2014 season (Table 2).

Master Datum: N 2574233.8000m E 471147.2000m Z 474.4000m	Backsite: N 2574245.7507m E 471147.2111m Z 476.1843m
Projection: WGS 84 / UTM 40N	EPSG: 32640

Table 2. Khutm Datum and Backsite specifics.

4.2.2 KS East: Umm an-Nar Complex Excavations

A large, rectilinear building complex located on the eastern end of the Khutm Settlement was selected for test excavation during the 2023 BAP season. The building had been identified by BAP during the 2014 survey of the site and is associated exclusively with Umm an-Nar period ceramics (Hatfield & Cable 2014). In 2022, a 2x2 m test trench—KS Test Trench A—was excavated abutting the building's exterior wall but failed to yield datable contexts (Bryant, Smith, & Swerida 2022). This season, a 1.5x10 m strip trench—KS Test Trench B—was excavated through the center of the northern portion of the building to probe interior contexts (Figure 37). A secondary 5x5 m trench —KS Test Trench C—was also opened to the northeast of the strip trench in order to collect salvage excavation data on a destroyed Umm an-Nar tomb. Excavations took place 2-8 January 2023 and were directed by Dr. Jennifer Swerida.

Primary Goals:

- Confirm Umm an-Nar construction and use date for the visible architecture;
- Better understand the function of the visible architecture;
- Probe contexts for potential for future excavation;
- Salvage excavation of a destroyed Umm an-Nar tomb identified just north and uphill of the building complex.

4.2.2a Test Trench B (Strip Trench) Results

In order to further explore the date, preservation, and function of a large building complex located at the eastern end of the Khutm Settlement, a 1.5x10 m strip trench—KS Test Trench B—was excavated to bisect what was thought to be the building's courtyard and the interior of a large room. The trench was aligned on a northeast-southwest trajectory to better align with the architectural spaces and natural hillside than would an excavation unit aligned with cardinal north. Previous survey and excavation of this building produced a collection of ceramics stylistically consistent with the Middle Umm an-Nar 1 period (Swerida, Dollarhide, & Jensen 2021). This test trench was excavated with the hope of clarifying the date and function of the architectural compound.

Excavation in the northeastern half of Test Trench B revealed a very shallow stratigraphy composed of an upper desert pavement of angular gravel above a thin layer of light brown silt with further gravel. The silt layer rests directly on a bedrock of

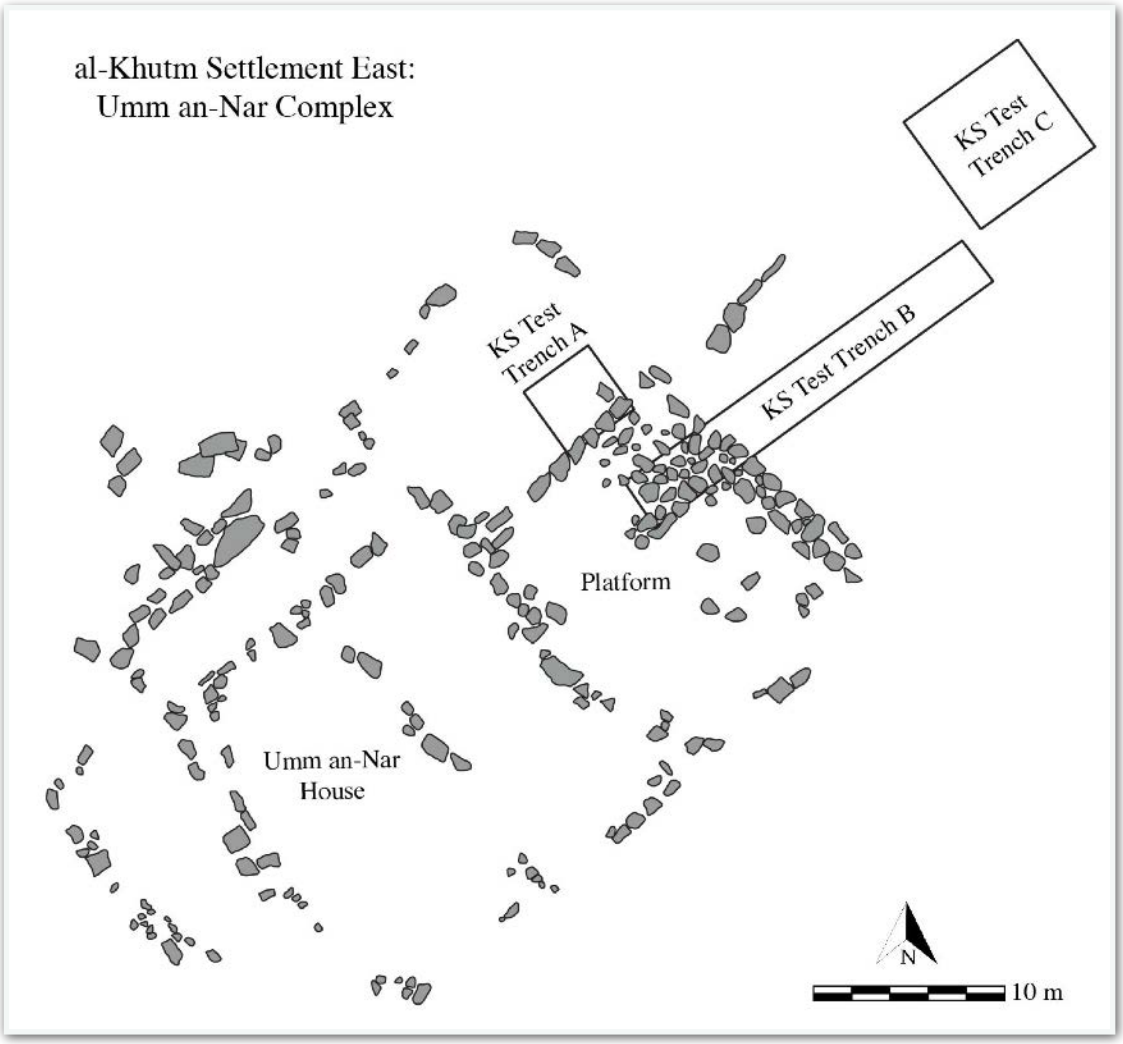

Figure 37. Plan of al-Khutm Settlement East architecture and test trench locations.

soft, friable limestone that shatters into thumbnail-sized chips when struck or brushed, before grading into the stable limestone that forms the bedrock of the hill. Depths of contexts ranged from 5-25 cm with little material culture. All ceramics collected are stylistically consistent with the Middle Umm an-Nar 1 (see Swerida, Dollarhide, & Jensen 2021). While it is not possible to confirm the hypothesis that this space functioned as an Umm an-Nar courtyard uphill from the building's interior rooms, no evidence was found to the contrary. It is likely that contexts in this area are heavily disturbed by erosion down the hillside.

A V-shaped cut in the bedrock approximately 1 m northeast of the building complex's interior walling was filled with a yellow-grey loam typical of pit fill (Lot 230008). While it is unclear if the V-shaped depression was intentionally cut into the fractious limestone bedrock of the hill or is a natural void, the charcoal flecking in the fill suggests that the space was used as a rubbish receptacle by occupants of the Khutm Settlement or visitors to the site. Analysis of a C14 sample (Lot 230007) collected from

charcoal in the probable pit fill may provide a date for the related activity. Analysis of a soil sample (Lot 230009) could also reveal the types of materials that were once contained within the pit. No other material culture was recovered from this context.

The southwestern half of Test Trench B was situated to bisect what appeared from the modern ground surface to be a large room at the northeastern end of the building complex. Excavation quickly determined that rather than a room, this space was more likely the stone foundations of a roughly square platform. A stone alignment (Lot 230013) that was expected to form the building's northeastern exterior wall was instead revealed to be the face of an 8.8x8.1 m probable platform feature with an interior space packed with irregular stones. The matrix between the stones is a mix of light brown silt and dense, brown clay that contained few Umm an-Nar sherds. Similar square stone platforms of uncertain function are known from Umm an-Nar contexts at Bat and elsewhere in the Hajar inner piedmont. Such platforms are most often associated with tower monuments, such as the platform at Bat's Kasr al-Khafaji (Swerida & Thornton 2019a) and Kasr al-Rojoom (Frifelt 1985). Less commonly, large stone platforms are found at Umm an-Nar sites as lone monuments, such as Structure 1[1] at al-Khashbah (al-Jahwari & Kennet 2011: 203-5), or as architectural complexes, such as Amlah 5b (de Cardi *et al.* 1976: 114-115). Of these parallels, the Khutm platform is closest in size and proximity to the al-Khafaji platform, where excavation found that the stone foundations once supported a mud brick superstructure (Swerida & Thornton 2019a: 9-10). It is possible that the dense clay encountered between the stones of the Khutm platform is an indications that it once supported a comparable mud brick surface.

Figure 38. Umm an-Nar platform abutting the edge of a house.

Overhead imagery of architectural features visible on the modern ground surface of the Khutm Settlement eastern complex shows a direct relationship between the platform and stone walling to the southwest (Figure 38). Although it has not yet been possible to excavate the southern portion of the complex, BAP is confident in our interpretation of this area as an Umm an-Nar house due to parallels between the building layout and Umm an-Nar houses excavated elsewhere on the Bat landscape at the Settlement Slope, al-Khafaji, and Rakhat al-Madrh (Swerida 2017; 2022;

[1] Also referred to as "al-Hind" by Yule (2011: 384) and Weisgerber (1980: 100) and as "Building IV" by Schmidt and Döpper (2017).

Swerida & Thornton 2019a; 2019b; Dollarhide, Rissman, & Swerida 2022). A comparable relationship between an Umm an-Nar platform and house has not yet been documented at Bat or other sites in the region. However, the architectural complex around the stone platform at Amlah 5b may provide useful comparisons (Figure 39). Further research is necessary to document the Khutm complex and identify additional parallels in the archaeological record. BAP hopes to return to the complex in future seasons for more extensive excavations.

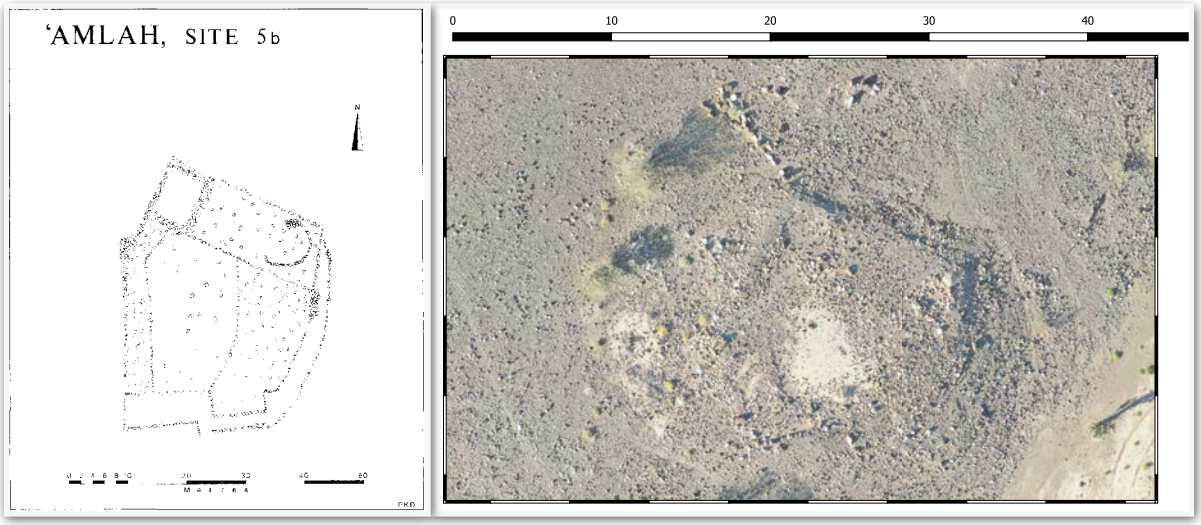

Figure 39. Amlah 5b plan (de Cardi *et al.* 1976: Figure 13) on left and overhead imagery of the complex as it survives today on right.

4.2.2b Test Trench C – Tomb Salvage Excavations

During excavation of Test Trench B it became apparent that a small mounded area to the northeast was the remains of a destroyed Umm an-Nar tomb. The mound was composed of angular gravel, silt, and occasional small limestone blocks. This area attracted attention due to the unusually high concentration of Umm an-Nar jar sherds on the surface. Closer inspection revealed that several of the limestone blocks were shaped semi-circular facing stones typical of Umm an-Nar tomb construction (Figure 40). As it was clear from the modern ground surface that the tomb structure was either absent or destroyed and the tomb contents were actively eroding down the Khutm hillside, the decision was made to conduct a brief salvage excavation of the remaining tomb mound to record any surviving material. Salvage excavation units were recorded in the 230500 Lot range.

The tomb mound appeared from the surface to have a circumference of approximately 5 m, however the original structure was probably larger judging by the average size of Umm an-Nar tombs on the Bat landscape. The curvature on the recovered tomb facing stones is consistent with tombs with a circumference of 8-10 m. A total of 14 facing stones were identified during excavation, all in displaced positions either within the mound or eroded slightly downhill to the southwest. It is probable

Figure 40. KS Tomb facing stones.

that most of the original stones used in the tomb construction were repurposed by later occupants of the Khutm Settlement.

Salvage excavation found that the mounded area was composed primarily of silt and angular gravel with significant quantities of ceramic sherds, pockets of ash, and occasional small bone fragments. No stratigraphy was discernible below the gravel desert pavement on the surface of the mound. A C14 sample (Lot 230503) collected from charcoal flecks found within the ash pockets may provide an approximate date for the tomb's use. The collection features a large number of black-on-red funerary ware sherds from jars of various sizes, which is typical of Umm an-Nar tombs throughout the period. The most common motif is of an undulating double lines with vertical hatching filling the space between lines (Figure 41). Also included in the tomb's ceramic collection was a large sherd of a small grey ware jar likely imported from southeastern Iran.

All human bone recovered from the tomb salvage excavations was extremely fragmentary and disarticulated. The bone was extremely brittle and only identifiable in in a small number of instances (Figure 42; Table 3). All bone fragments were collected and are stored in the MHT for future analysis by BAP bioarchaeologist Dr. Selin Nugent.

Lot Number	Bone Fragment Count	Description
230501	13	Unidentified frags = 3; Unidentified long bone = 9; Unidentified flat bone = 1
230502	7	Unidentified frags = 6; Unidentified flat bone = 1

230503	23	Unidentified frags = 9; Unidentified long bone = 12; Rib frag = 1; Adult molar frag = 1
230504	82	Unidentified frags = 56; Unidentified flat bone = 5; Unidentified long bone = 17; rib frags = 2; distal radius = 1; metacarpal = 1
230506	189	Unidentified frags = 145; Unidentified flat bone = 16; Unidentified long bone = 25; Rib frag = 3
230508	1	Unidentified long bone = 1

Table 3. Summary of bone fragments collected per Test Trench C lot.

Figure 41. KS Test Trench C – tomb salvage excavation ceramics.

Excavation also revealed that the mounded tomb remains were situated on a small, roughly flat, elevated area of bedrock to the northeast of the Umm an-Nar complex. This location would have been behind and slightly above the square platform

Figure 42. Sample of KS Tomb bone preservation.

encountered in Test Trench B. The relative heights of the tomb and platform would determine their visibility from elsewhere on the Khutm hill or the neighboring wadi plain.

4.2.2c Summary

Test excavations at the Khutm eastern complex were successful in accomplishing most of the season's primary goals. Results provide a new understanding of the visible architecture, including the presence of a monumental platform abutting the side of an Umm an-Nar house and adjacent tomb. The concentration of these three features—platform monument, house, and tomb—in one small area is thus far unique in the archaeological record of the Umm an-Nar period. Further research is necessary to fully document and interpret the significance of this area of the Khutm Settlement.

The construction and use dates of the architectural features in the eastern complex at present rely on stylistic associations.[2] All features share construction and layout styles with other well-dated Umm an-Nar buildings on the Bat landscape, including the Middle Umm an-Nar houses at the Settlement Slope and Rakhat al-Madr (Swerida & Thornton 2019a; Dollarhide, Rissman, & Swerida 2022), the Middle Umm an-Nar 1 platform and houses at al-Khafaji (Swerida & Thornton 2019b), and various tombs in the Bat necropolis (Böhme & al-Sabri 2011; Döpper 2015; Gentelle & Frifelt 1989; Miki *et al*. 2019). The ceramic collection from both test trenches also fits entirely

[2] Forthcoming C14 analyses will provide use dates for the Umm an-Nar tomb and pit feature 230008, however further excavation is needed to determine a scientific date for the construction and use of the complex.

within the Umm an-Nar tradition of local manufacture and regional imports (see Swerida, Dollarhide, & Jensen 2021). However, it is possible that some of the ceramics recovered in Test Trench B were washed downhill from the destroyed tomb in Test Trench C. Further excavation of the complex is necessary to confirm its Umm an-Nar construction and use dates.

A shovel test probe into the hypothesized house section of the complex found a matrix depth of at least 30 cm, suggesting that cultural contexts may be preserved below. BAP hopes to return to this area of the Khutm Settlement in future seasons.

4.2.3 KS West: Fortress Sounding

A deep sounding test trench was also excavated at the western end of the Khutm Settlement hill, in an area identified in the BAP 2022 season as a probable Iron Age fortress (Figure 43). This sounding—Test Trench D—was excavated with the goals of:

- Confirming the Iron Age II date for the fortress;
- Investigating the depth of deposit within and below the fortress structure;
- And establishing a stratigraphic record in the extremely large building encompassing the western half of the hillside.

The location selected for the sounding was within a space defined by walls to the south, east, and west, thought to be a room or foundations for a small, fortified tower (Figures 44 & 45). Excavations were conducted by Robert Bryant and Qi Lui from 4-16 January 2023.

Excavation determined the space to be a collapsed interior space within the Iron Age structure, with Bronze Age contexts below. It is possible the fortification wall is above the visible surface in the East and South profiles, but it is not yet possible to determine how many courses it went down. Bronze Age contexts were ephemeral and dated by a small ceramic collection recovered from the clay wash. Below the Bronze Age

Figure 43. KS Test Trench D – Fortress Sounding from the west (left) and south (right).

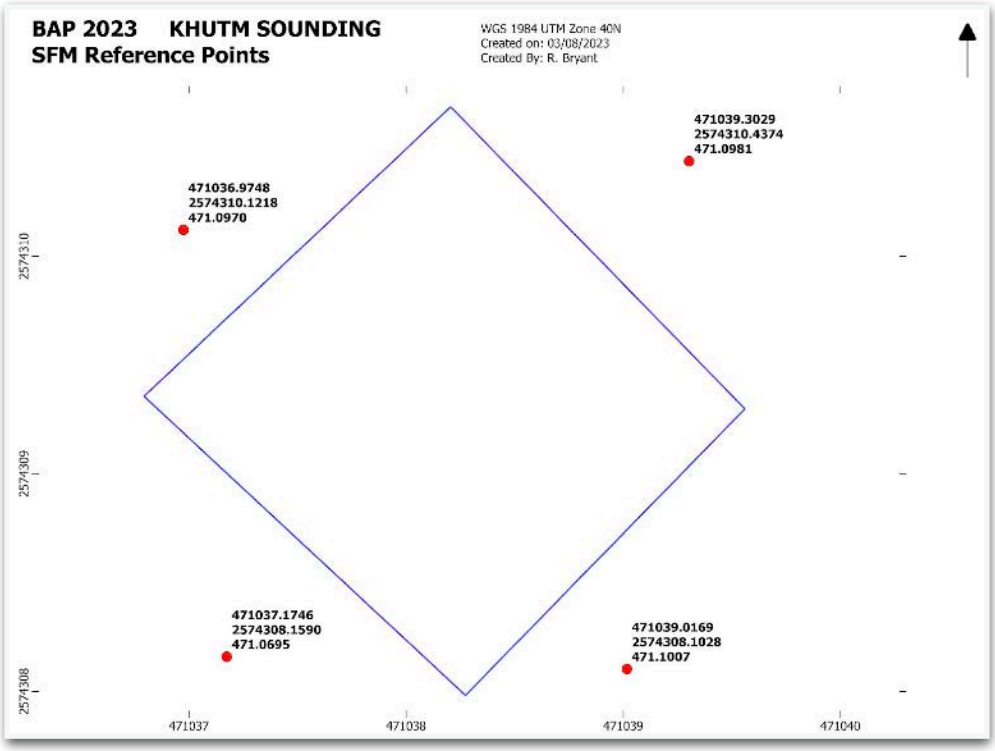

Figure 44. Coordinates for photogrammetric reference points on Khutm Sounding.

Figure 45. Overhead image of Khutm Sounding with overlay of visible architecture.

levels, the matrix quickly deteriorates into several heavy flooded layers of gravel, silty clay, and hard packed clay intermixed with numerous snail shell deposits until it hits a hard sterile packed clay layer. The final lot covers only half the trench because the clay was too dense to continue digging by hand with a pickaxe and shovel. Excavation ended at an arbitrary point within a sterile layer approximately 40-50 cm thick.

Overall, the Test Trench D sounding produced sufficient ceramics and C-14 deposits to speak to the surrounding context. These results successfully accomplished the goals for the sounding and provided the unexpected result of identifying an Umm an-Nar occupation at the western end of the Khutm Settlement.

4.2.3a Features

Pit feature 230101 within the initial sounding depth Lot 230100 was the only discernible feature. It cuts into the south profile and has a hard, packed ashy bottom. C-14 and soil samples were collected, however the feature is likely either historic or Islamic period—above the visible wall collapse in the profile.

Floors identified in Section were not given feature numbers. There appear to be two separate cultural surfaces visible in section. The first is at the bottom of Lot 230103 and is traceable in both the East and South profiles. Some ceramics were found just above it in the balks indicating an Iron Age context. The second surface below, straddling Lots 230108 and 230109, may or may not be an intentional cultural surface. Cultural materials were collected from within the associated contexts. The undulating nature of the feature suggests it wasn't a prepared surface but rather a naturally occurring surface further cemented by cultural habitation. It is also surrounded in the north balk by two layers of gravel deposits. There are some other white patchy layers found within the trench at different depths, but they were determined to be pooled water surfaces rather than anything cultural.

Remnants of collapsed mudbrick were identified near the surface and remain visible in section. These did not appear to have any contextual association within the trench. An expansion of the trench could make this determination.

4.2.3b Ceramics

The sounding contained a limited amount of ceramic material, but enough to temporally separate contextual layers. A total of 21 sherds were found. Ceramics from surface Lot 230100 were expectedly Iron Age types, which suggests that the surrounding architecture likely dates to the same period. In the underlying Lot 230102 there were three nondescript red ware sherds, which may be associated with the Iron Age contexts in Lots 230100 or 230103.

The majority of the ceramic assemblage (12 sherds) came from Lot 230103, in stratigraphic layer V, and can be stylistically dated to the Umm an-Nar period (Figure 46). Notable examples from this layer are a large black-slipped Indus jar sherd and two sherds from a single Umm an-Nar funerary jar. Lot 230108, immediately below Lot 230103, produced two sherds: one Umm an-Nar sherd decorated with an undulating

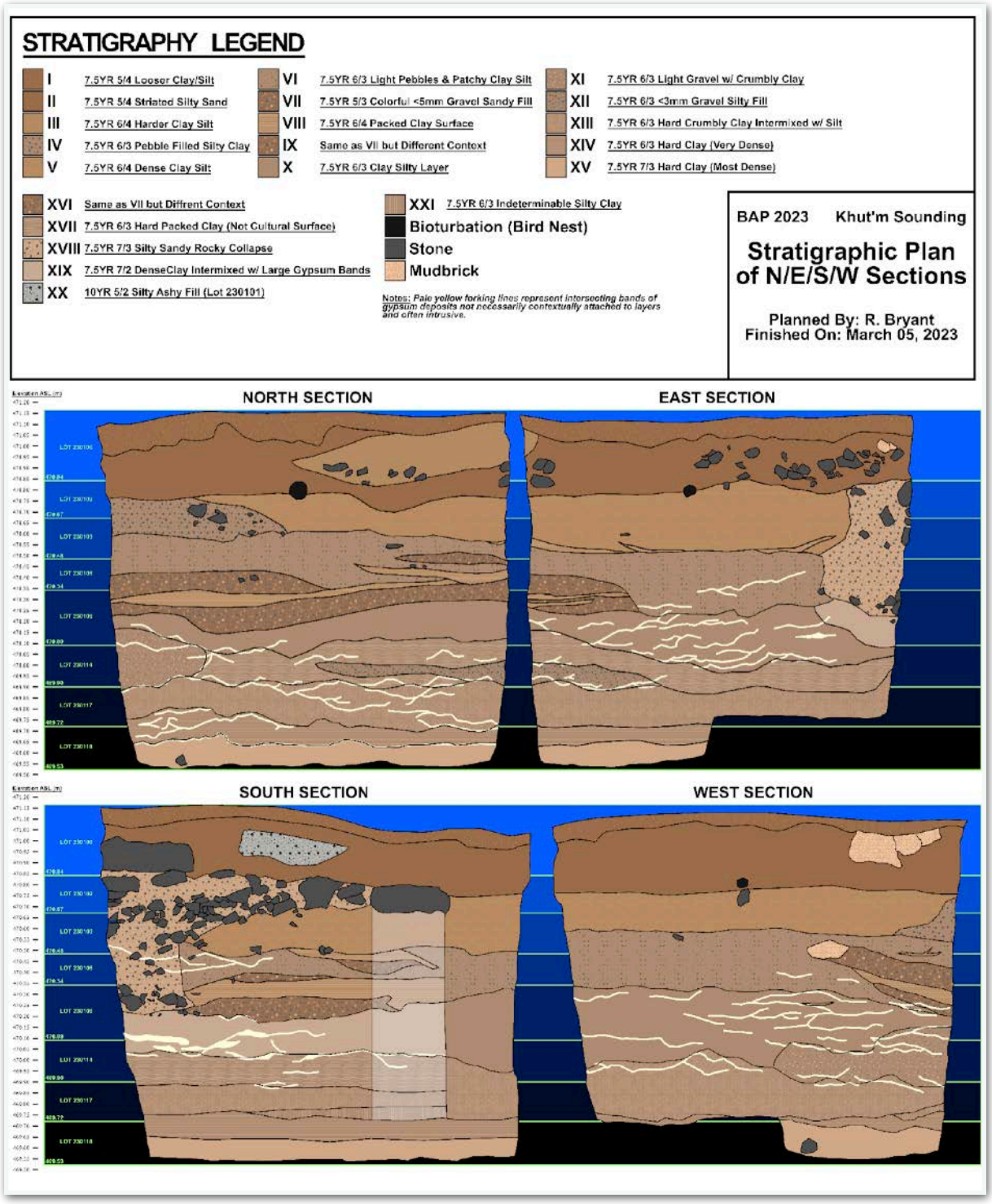

Figure 46. KS Fortress sounding profiles.

ladder motif and second painted black-on-red domestic ware sherd. Bronze Age ceramics do not start appearing until below the surface associated with the Iron Age architecture in Lot 230103, indicating an Umm an-Nar presence in this area of the site prior to the construction of the Iron Age fort.

Below the Umm an-Nar contexts, stratigraphy in the sounding is sterile aside from a single C-14 sample found within Lot 230114.

4.2.3c Samples

Several excavated layers within Test Trench D contained a tremendous amount of melanoides snail shells. Approximately 70% of shells were collected. These tend to appear below the main cultural layers, where it appears that periods of regular flooding occurred which would create the necessary environment for this species of shell to survive.

These flooding periods are also probably the cause of the spider webbing of gypsum crystal deposits seen throughout the trench. This white material is water soluble and probably precipitated through time throughout the cracks in the soil. The geomorphology team also confirmed the gypsum identification of the material and further report on the geological implications of the sounding (see Chapter 8).

Several samples of C-14 were collected throughout the trench but some were associated with screened dirt rather than found in situ. One sample was collected from the bottom of Lot 230114 at a depth of 469.95 m and represents the deepest cultural context encountered in the sounding.

4.2.3d Notes on Soil Texture/Composition

The stratigraphy encountered in Test Trench D surprisingly flat for an area abutting a rocky hillside. No gradient associated with the hillside to the north is present in the trench profiles. The only area with an identifiable gradient is a collapsed corner in the southeast corner of the trench, seemingly associated with the fortification walls (Lot 230109).

Aside from intermittent gravel layers associated with flooding events, the stratigraphy follows a 10YR munsell yellow/tan/brown color overall with only subtle variations between layers. Texturally the layers exhibit the most difference. The first 20-30 cm sees a looser sandier/silty topsoil. Below the surface layer, contexts transitioned to harder packed clay soils, generally crumbly and intermixed with silty sand. Often, the gypsum follows the boundaries between soil layers. Some layers appear more striated than others, which suggests lighter regular flooding periods followed by hard layers of gravel and packed clay associated with a much more torrential flooding event.

4.2.3e Summary

This space represents a collapsed outer Iron Age fortification or terracing wall with some of the original interior cultural surface remaining. Collapse is most evident in the section of the southeast corner (see Figure 46). Although there is some evidence for cultural layers beneath the main Iron surface, they are not stratigraphically associated

with the visible surface architecture and probably represent vague human deposition through colluvial wash from up the slope.

This site has seen intensive flooding periods as evidenced through the interchanging layers of gravel, silty clay, and packed clay with many snail shells associated with standing water. Furthermore, the interlocking tunnels of gypsum that snake throughout the bottom half of the trench are indicative of regular flooding that either tricolated through previously damaged layers, depositing gypsum crystals over time when the soil dried. As these layers do not exist during or after the Iron Age phase of the trench, it is likely that this area saw more rainfall or human-directed inundation prior to the Iron Age period. Lot 230103 appears to have the best context for cultural materials, although it is broken up by the southeastern collapse.

Results of the Test Trench D sounding revealed unanticipated depths of deposit, an Umm an-Nar cultural phase, and confirmed the Iron Age II date for the large fortress architecture. The Iron Age deposits were shallower than expected, suggesting either a relatively short occupation or damage to contexts through erosion. The shallowness of both the Iron Age and Umm an-Nar levels indicate that horizontal excavations are more likely to produce coherent cultural information than deep soundings. BAP looks forward to further horizontal excavation in this extremely important site.

4.3 Opportunistic Survey

Over the course of the BAP 2023 field season, several opportunities arose for opportunistic survey at al-Khutm. While walking between excavation units and the surrounding terrain, the locations of notable ceramics and archaeological features were documented, as well as damages to the site. Special note was taken of the area that was at the time under consideration to be converted to visitor parking for the recently restored Khutm tower, south of the Khutm hill ridge.

Diagnostic ceramics and locational information on stone features were collected in four broad areas—Lots 232032, 232033, 232034, and 232035—at the western end of the Khutm hill ridge (Figure 47). The terrain is the same sloped limestone hillside grading into silt as the the better-known portions of the Khutm Settlement, however this portion of the hill is disturbed by modern a modern dirt road crossing the hill crest and forking into two tracks that skirt the bottom edge of the Khutm hill. These areas are all located to the west of the systematically surveyed Khutm Settlement, where stone architecture is visible on the modern ground surface. Survey was opportunistic, rather than systematic, and only diagnostic sherds were collected.

Ceramic collections in the two easternmost opportunistic survey areas—Lots 232032 and 232033—included diagnostic sherds from both the Umm an-Nar and Iron Age II periods. This mixed assemblage reinforces the occupational history suggested by the results of Test Trench D. All sherds collected from the western opportunistic survey areas—Lots 232034 and 232035—stylistically date to the Iron Age. Several fragmentary stone walls identified in Lots 232033 and 232034 suggest that the dirt roads have disturbed structures associated with the Khutm Settlement.

Figure 47. Map of Khutm Settlement opportunistic survey.

A particularly notable discovery was the identification of a collection of five probable Iron Age tombs—Lots 232036, 232037, 232038, 232039, and 232040—half way up the hillside in Lot 232035 (Figure 48). These features are rectangular structures approximately 3x2 m in size and constructed of unworked local limestone blocks. Features 232036 and 232037 are particularly well preserved, however none of the identified tomb structures was intact. It is likely that the Iron Age sherds found downhill from these features were eroded from the tomb contents. No evidence of human remains was visible from the surface. It is possible that some contexts remain preserved within the tombs.

4.4 Conclusions

BAP's 2023 research at the Khutm Settlement has produced promising results and achieved the stated goals. The expected dates for the eastern complex and western fortress were preliminarily confirmed through contextually secure and stylistically diagnostic finds. Excavations in the eastern complex produced an entirely Middle Umm an-Nar ceramic and architectural assemblage. A more precise, scientific date range will be obtained from the C14 sample collected from the tomb. Similarly, the Iron Age II date for the western fortress is suggested by ceramics collected from the modern ground surface in association with the large-scale architecture and from the first cultural level in the Test Trench D sounding. Ceramic finds from Layer V of the sounding also indicate the presence of an earlier Umm an-Nar period occupation in this part of the site. C14 samples from multiple stratigraphic layers will provide an absolute chronology for the site.

The nature of occupation in the eastern complex is clarified by the results of this season's research. Rather than the hypothesized housing complex, excavation and surface imagery suggest that the built expanse is composed of an unusual house, platform, tomb architectural set. While further excavation is necessary to fully determine the function of these structures, this new understanding of the Umm an-Nar phase of the Khutm Settlement expands the known corpus of third millennium BCE settlement compositions.

Figure 48. Tomb Feature 232036 from the southwest (above) and north (below).

Excavation and survey in the western fortress revealed the existence of deeper stratigraphic deposits and more extensive architecture than expected. The sounding reached a depth of 1.7 m, with two clear cultural layers and evidence for repeated flooding events prior to construction of the Iron Age fortress. Both cultural layers appear to be relatively shallow, suggesting that this area of the site is a promising candidate for future horizontal excavation. The results of overhead imagery and opportunistic walking survey also demonstrate that the Iron Age construction and activity continued further to the west than was previously thought. It is highly likely that the Iron Age occupants of the site utilized the full southern face of the Khutm hill from the tower at the far western end to the eastern end of the fortress. 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 (Bernardini *et al.* 2020; 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.

5. Operation A Excavations

Jennifer L. Swerida

5.1 Introduction

Operation A is a circular collection of low mounds located at the northern edge of the wadi plain along the Wadi Sharsah. While this area of the wadi plain is largely flat and featureless, the location is significant due to its proximity to the Bat necropolis ca. 500 m to the north, Kasr al-Rojoom ca. 350 m to to southeast, and the monumental "Operation B" less than 50 m to the west. This site is also of particular interest to BAP and the MHT due to its proximity to the proposed location of the Bat Visitors Center on the southern end of the wadi plain, approximately 200 m away (see Figure 49). While preliminary explorations have been conducted at Operation A by both BAP and the German Mission to Oman, the period of occupation and nature of Operation A remained undetermined. BAP returned to Operation A during the winter 2023 field season to document changes to the site in the years since it was last visited and reassess interpretations in light of advances in our understanding of the Bat archaeological landscape.

This season our research at Operation A was conducted with the following objectives:

1. Document changes to the site since it was last a target of research in 2007;
2. Test the hypothesis that the collection of small mounds were at one time a single domestic structure;
3. Determine the date(s) of occupation;
4. Probe the potential for larger scale excavation at the site;
5. Align these newly discovered remains with BAP's long-term goal of interpreting the wider Bat landscape.

Records were collected according to a new Master Datum stabbed at the site this season (Table 4). During excavation, all Operation A contexts or "lots" (dirt context, feature, artifact, or sample) were given a unique number consisting of the project season prefix (23-) plus a unique number beginning with 231001. 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.

Master Datum: N 2573081.7100m E 473811.1800m Z 489.0500m	Backsite: N 2573089.7300m E 473811.1800m Z 488.4600m
Projection: WGS 84 / UTM 40N	EPSG: 32640

Table 4. Operation A Datum and Backsite specifics.

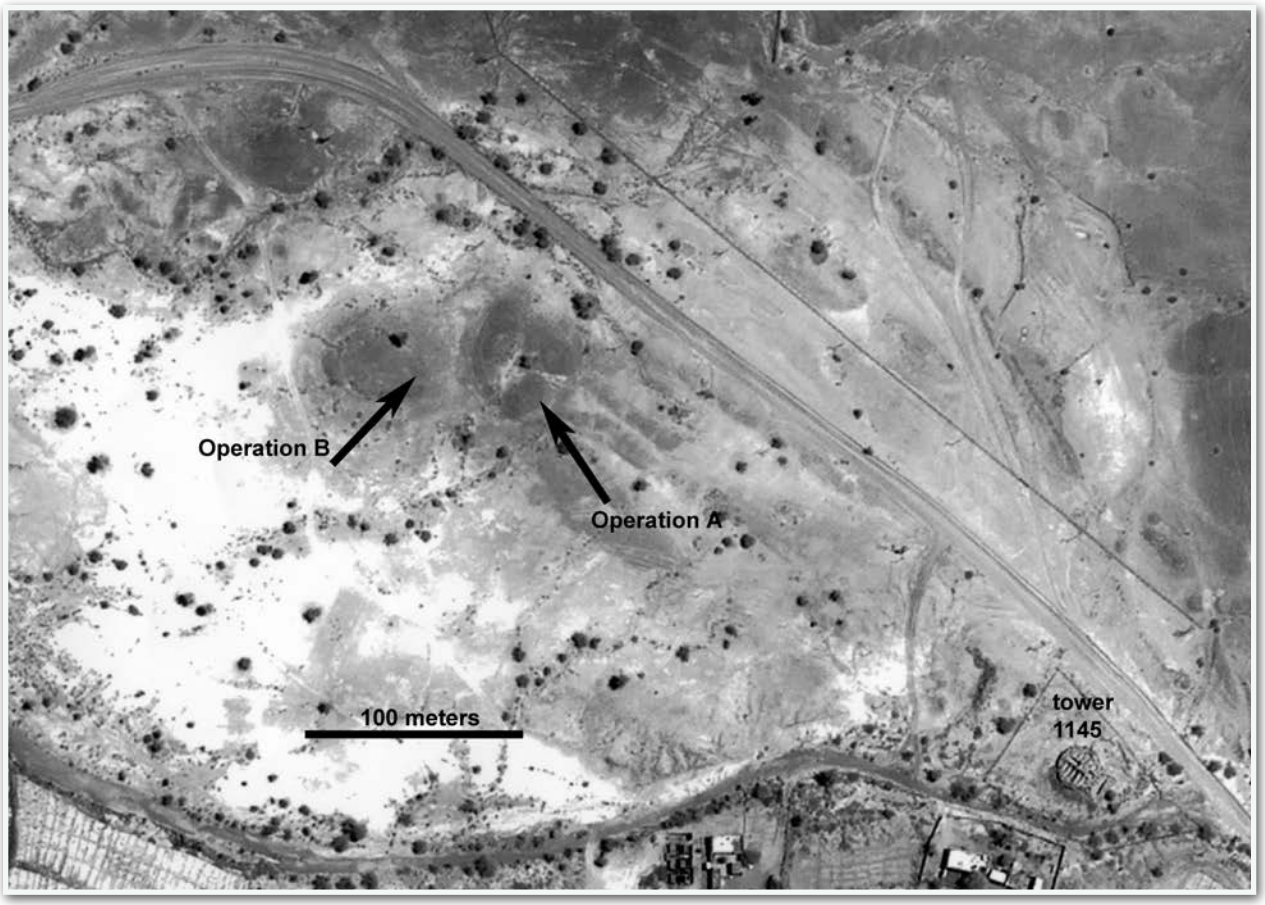

Figure 49. Aerial photograph of Operations A and B (Possehl & Thornton 2007: Fig. 4).

5.2 History of Research

BAP first documented Operation A in 2007, during the project's first excavation season (Possehl & Thornton 2007), based on the results of magnetic prospection previously conducted by the German Mission to Bat. The German magnetometric survey documented two large circular structures on the wadi plain, each approximately 50 m in diameter and corresponding with two small hillocks (Figure 50). BAP, then directed by Dr. Gregory Possel and assistant directed by Dr. Christopher Thornton, imposed a 5x5 m grid across both sites and excavated in a total of 19 grid units: 11 at Operation A and 8 at Operation B. Excavations were conducted under the expectation that the sites were the locations of third millennium BCE domestic settlement and with the stated goal of "learning more about habitation at the site" (Possehl & Thornton 2007:2).

Excavations targeted the narrow strip between the two mounds, including portions of the southwestern edge of Operation A and the northeastern edge of Operation B (Figure 51). Results revealed Operation B to be a stone tower monument surrounded by a ditch feature, comparable in scale and construction style to the stone phase of Matariya tower. Later excavations by the German Mission to Bat confirmed these findings and date the monument's use to 2900-2300 BCE (Döpper 2018), roughly corresponding with the Early (2800-2500 BCE) and Middle Umm an-Nar (2500-2200

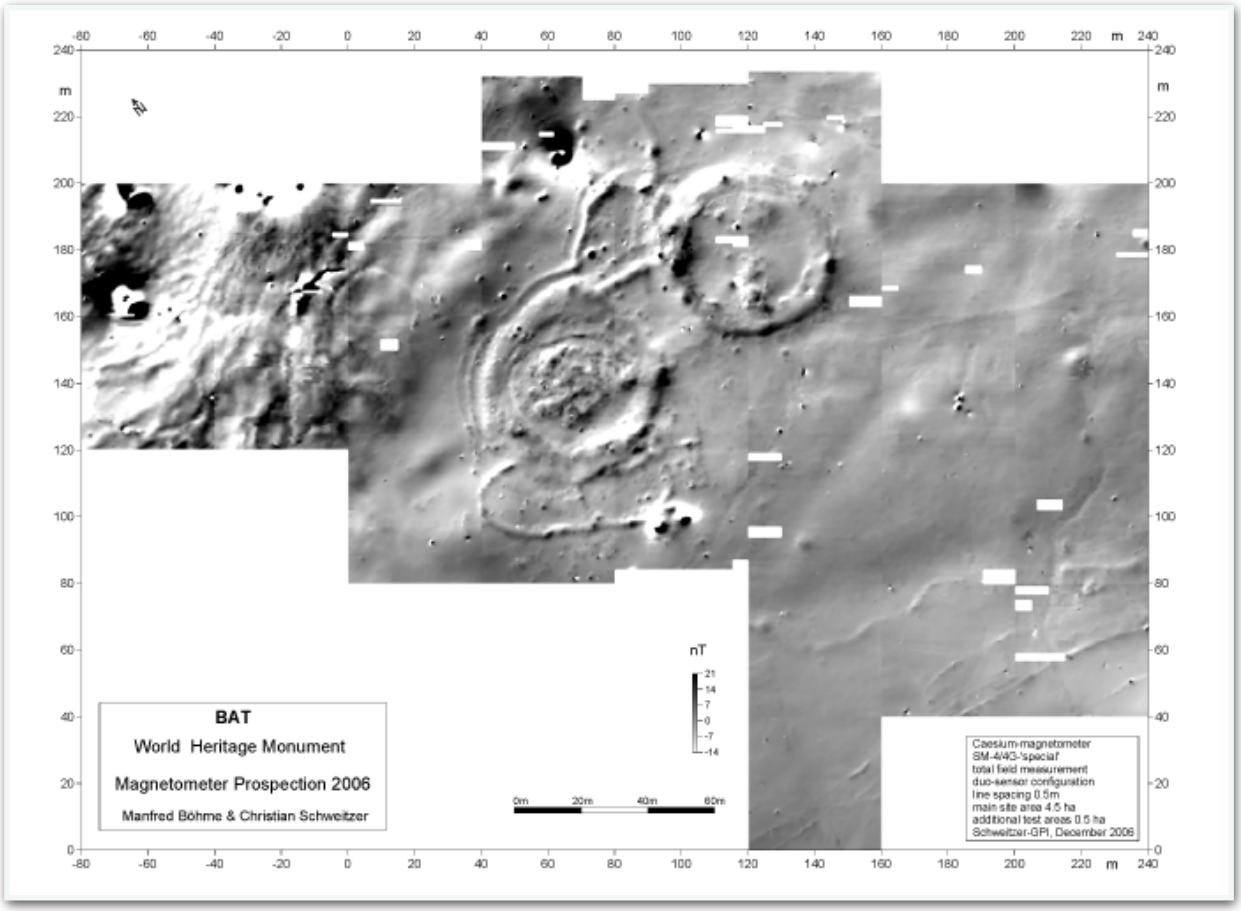

Figure 50. Results of the 2006 magnetometer survey by the German Mission to Bat.

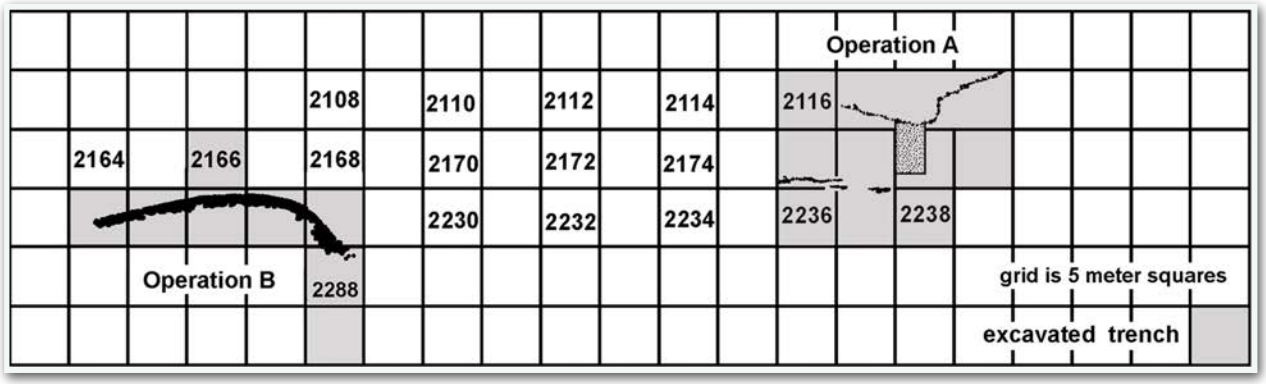

Figure 51. Site grid and trench layout of the BAP 2007 excavations (Possehl & Thornton 2007: Fig. 6); note that the site grid is 30° off of north.

BCE) periods. At Operation A, BAP uncovered a series of small stone walls and clay or cobble surfaces at the southern end of the mound (Possehl & Thornton 2007: 3-4). Recovered artifacts include a small assortment of lithic tools and ceramic sherds

stylistically datable to the Umm an-Nar, Iron Age, and Islamic periods.[3] The preliminary interpretation of the site was a place "where people lived and worked" (Possehl & Thornton 2007: 4).

BAP returned to Operations A and B in the winter 2022 field season as part of an intensive walking survey documenting the Bat archaeological landscape between the well-documented tower and tomb monuments (Smith 2022). This survey found the sites heavily disturbed by erosion from the nearby wadi and changes to water drainage across the landscape from modern construction activities. High concentrations of ceramics were documented in the immediate vicinity of Operation A and in the field to the southeast, however very few ceramics were found on the mounds themselves. Similarly, unusually high numbers of lithic tools were recovered on the surface to the south and east of Operation A, at a density of over ten times that of other otherwise productive areas of the Bat landscape (Smith 2022: 10-11). Based on these findings, BAP determined that Operation A would be a promising location for further research, especially given the threats to the site from erosion.

5.3 Site Documentation & Excavation Results

During the winter 2023 field season, BAP conducted a program of site documentation and preliminary excavation at Operation A that began on 8 January and concluded on 12 January. Changes to the site and archaeological features visible from the modern ground surface were documented through photographs and drone- and total station-enabled mapping. Excavation probed the preservation and nature of contexts within the mound through a 2x11 m strip trench.

5.3.1 Site Documentation

A visual survey of the Operation A site revealed significant damage to the site due to erosion and human activity. It is likely that the site was once a single hillock on the Bat wadi plain. Since the site was last excavated by BAP in 2007, a depression in the center of the site has deepened and erosion has carved channels between the three mounds. This erosion activity is made worse by off-road vehicular traffic that occasionally crosses the plain. Overhead images show recent tire tracks crossing various portions of the Operation A mounds and the space between Operations A and B (Figures 52 & 53). The tire tracks are especially common and deeply carved around the edges of the mounds and in the low-lying areas most impacted by erosion.

As a result of erosion activity, traces of architecture that were not visible in 2007 are now visible on the modern surface of the site (Figure 54). These include several linear wall fragments and circular features. While it is not possible to determine a date or function for most of these fragmentary remains without further excavation, they provide important information for guiding possible future excavations at the site. Two exceptions are large, semi-circular walls visible at the top of the northwestern and southeastern mounds. These walls have similar in scale and construction style to Umm

[3] Sherd periodization reevaluated by BAP in 2020; see Swerida, Thornton, & Jensen 2021.

Figure 52. Operations A (right) and B (left) from above.

Figure 53. Operation A with strip trench visible on left from above.

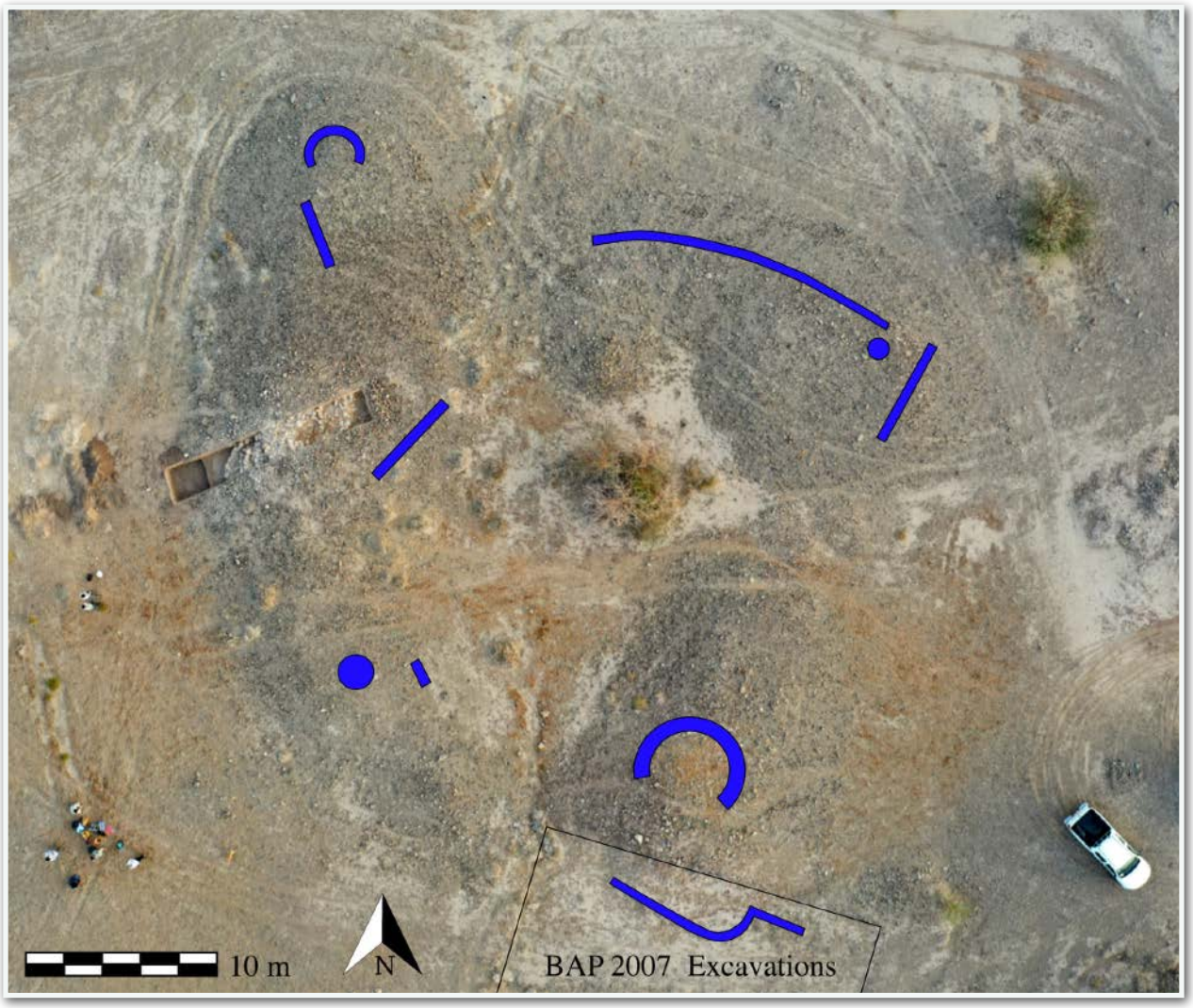

Figure 54. Plan of Operation A surface architecture.

an-Nar tombs known elsewhere on the Bat landscape (cf. Böhme & al-Sabri 2011; Frifelt 1985; Miki *et al.* 2019) and may suggest the presence of similar mortuary structures.

5.3.2 Excavation Results

In order to probe the contexts within the Operation A mound, a strip trench was excavated into the west-facing side of the site and into the wadi flat beyond the edge of the mound (Figure 55). This location was selected due to its proximity to linear features detected in the magnetic survey (see Figure 50) and to provide data complementary to the BAP 2007 excavations at the southeastern end of the mound. The trench originally measured 10x2 m and was later expanded an additional meter to the west, becoming an 11x2 m step trench. The results of this small excavation unit are intended to guide potential larger scale excavations at the site in future seasons.

Excavations revealed the surface of the mound to be composed of a layer of

Figure 55. Overhead photograph of Operation A from the west with Strip Trench at center right.

rounded pebbles and small cobbles in a loose, light grey-brown silt. This matrix gradually grades into a light brown silt as contexts move off the mound and into the flat of the wadi plain. At the eastern end of the strip trench, on the top of the mound, excavation quickly encountered a pebble surface (Lot 231015) on which was found a small assortment of ceramics stylistically datable to the Iron Age and Islamic periods and a fragment of a marine shell (Figure 56). It is possible that this is the final use surface of the Operation A occupation.

To the west and downhill of the surface, excavation revealed a series of roughly concentric, curving stone alignments (Lots 231016, 231017, and 231018) that step down the side of the mound (Figure 57). The stones are unworked, of varying sizes, and do not appear to be set in any sort of mortar. The curvature of the stone alignment(s) is also notably smaller and sharper than the mound it is embedded within. No datable material was collected from the fill above and within these stone features. Stylistically, the scale and construction style are comparable to Wadi Sûq tombs known elsewhere on the Bat landscape (see Williams & Gregoricka 2016).

West of the curving stone features, excavation revealed a deeper stratigraphy that suggests the whole of Operation A is situated on a human-made clay mound. Below the silt and cobble topsoil, excavators encountered a layer of soft, light grey-brown silt that is probably accumulated wind-blown sediment that was caught against the side of the

Figure 56. Marine shell fragment from pebble surface (Lot 231015) in Operation A Strip Trench.

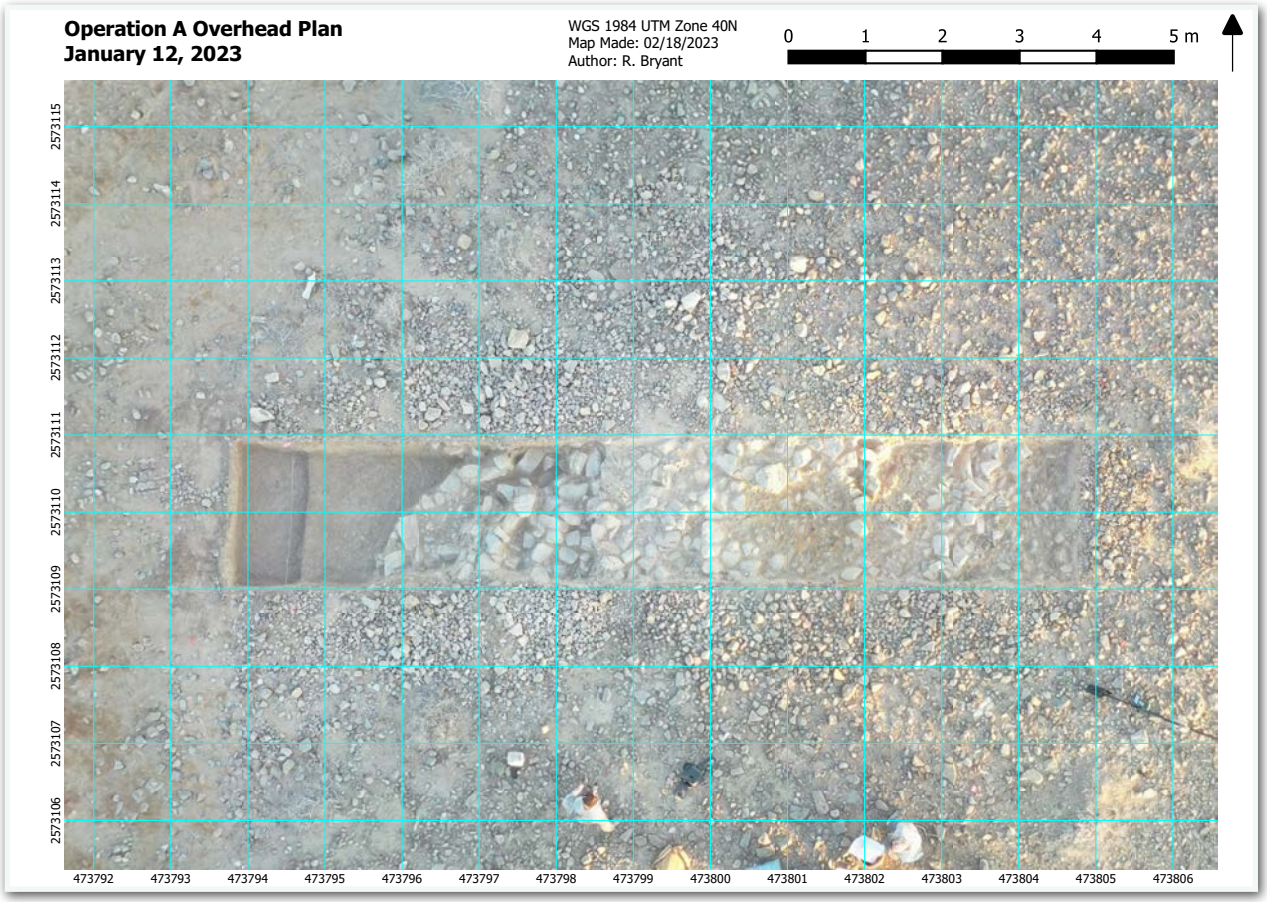

Figure 57. Operation A Strip Trench from above.

mounded terrain and architecture. Just beneath the westernmost and lowest stone feature (Lot 231016) is a layer of compact grey-brown clay sloping downhill to the west along with the rest of the Operation A mound. At the western end of the trench, a layer of crumbly, dark brown clay was instead found below the wind-blown silt. The

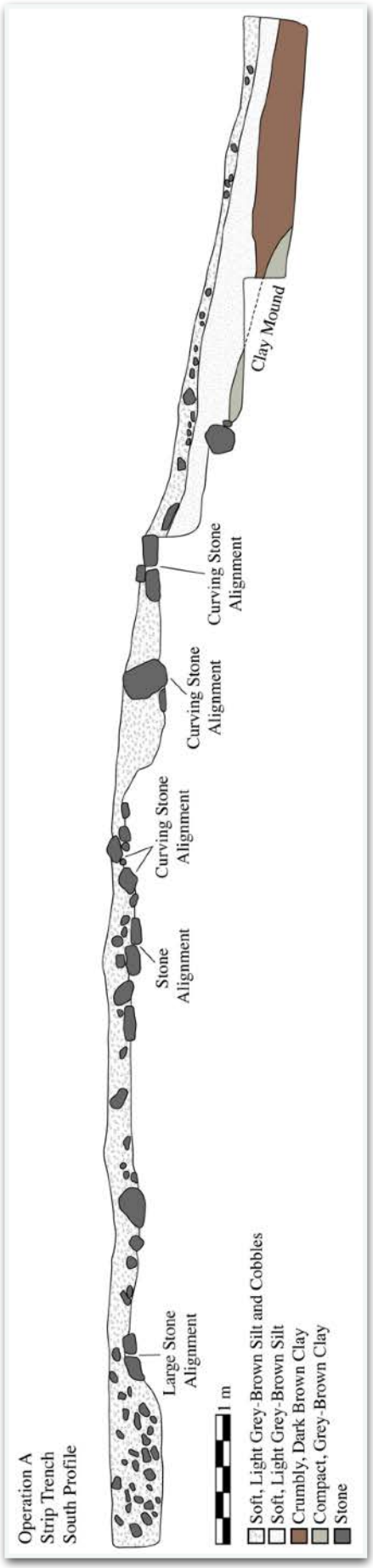

Figure 58. South profile of Operation A strip trench.

compact, grey-brown clay was only encountered in the eastern end of a 2 m sounding excavated at the far western end of the trench (Figure 58). Several ceramic sherds stylistically datable to the Umm an-Nar period were recovered from this matrix. This stratigraphy suggests that the crumbly, dark brown clay has accumulated around and partially atop a mound of the compact clay. Comparable packed clay mounds are known to exist at Bat below tower monuments Kasr al-Khafaji (Swerida & Thornton 2019b) and Kasr al-Rojoom (Frifelt 1981).

5.3.3 Summary and Interpretations

The documentation and excavations at Operation A have clarified the site's morphology and revealed multiple phases of cultural activity. The presence of Islamic sherds on the surface of the mound and in the areas excavated by BAP in 2007 likely reflects recent visitations to the site, a possible reuse of the mound surface, and agricultural activity in the wadi plain. It may be that the walls extending to the southeast that were uncovered by BAP in 2007 relate to this later phase of activity. Ceramic finds from excavated contexts also confirm an Iron Age and Umm an-Nar presence, while the curving stone features suggest Wadi Sûq activity as well. It appears that the mounded location on the otherwise flat wadi plain drew the attention of Bat's residents time and again over the site's history.

The function of the Operation A mound has also been brought into question by these results. The original interpretation of the site following BAP's 2007 excavations was as the location of domestic settlement. However, the stone walling visible on the modern ground surface and revealed within the mound through excavation stylistically has more in common with funerary architecture than domestic structures. The presence of Iron Age and Umm an-Nar pottery, along with Wadi Sûq and Umm an-Nar funerary-type architecture suggest that the Operation A mound's primary use was as a small necropolis rather than a settlement. The clay mound underlying the probable mortuary architecture is also noteworthy, given the

association of such features with Umm an-Nar monumental architecture. It may be that Operation A was created during the Umm an-Nar period as an extension of the cemetery to the north. The mound would have been necessary to elevate the tombs above the seasonal floodwaters that gradually covered the wadi valley in sediment.

More research is necessary to confirm this interpretation and the dating of each of the site's use phases. The date and nature of what appears to be liner stone architecture in various parts of the site is also yet to be determined. While excavation of isolated mortuary contexts is beyond the current scope of the BAP research program, we look forward to exploring the contents of Operation A in future seasons.

5.4 Site Management Recommendations

Based on the results of the BAP 2023 test excavations at Operation A, BAP strongly recommends that the site be protected from further damage from cars driving off-road. Such vehicular activity accelerates erosion and risks damaging underlying archaeological features. Protection may take the form of fencing or additional signage marking Operation A as an archaeological site.

We also recommend that Operation A be excavated in advance of the construction of the Bat Visitors Center. The earth moving and construction equipment necessary for the construction has the risk of damaging a site so close to the planned Visitors Center location. Additionally, the proximity of the site to the planned Visitors Center location will make it and the neighboring Operation B locations of interest to tourists. As one of the first areas of archaeological features visitors will encounter as they depart the Visitors Center to view the Bat landscape, it is important that Operation A be clearly presented and interpreted. The Bat Archaeological Project is eager to work with the MHT to plan research at the site and provide excavation and interpretation expertise.

6. Artifact Analysis

Eli N. Dollarhide, Inna Mateiciucová, and Antonín Přichystal

6.1 Ceramics Analysis

The analysis of ceramics during this year's field season examined 628 sherds collected during 2023. An additional 378 sherds collected during BAP's 2022 field season were also examined this year, completing BAP's 2022 artifact analysis program.

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, Dollarhide, & Jensen 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 Sûq	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 5. Chronological framework utilized in this season's ceramic analysis.

All sherds were photographed in the context of their find lot. Particularly significant or complete examples were also illustrated and individually photographed.

6.1.1 2022 Excavation Ceramic Analysis

Pandemic restrictions prevented a full analysis of the ceramic corpus collected during BAP's 2022 field season. Pottery sherds collected during 2022 survey operations were prioritized to obtain chronological information on newly discovered sites. These survey sherds were fully analyzed and reported in BAP's 2022 report (Dollarhide *et al.* 2022).

Thus the pottery collected during BAP's 2022 excavations was analyzed at the start of our 2023 season. This included ceramics from the Settlement Slope, Rakhat al -Madrh Structures 1 and 2, and sherds collected on the surface of the Khutm Settlement area (including mortuary features). The results of this analysis are presented by sherd count in the table below.

A few trends and significant examples were evident in this collection. As has been true of all RaM exploration so far, all ceramics recovered from the site in 2022 were attributed to the Umm an-Nar period, further confirming the period as the area's dominant—if not exclusive—period of occupation post-Neolithic. More chronological variability was found at the Settlement Slope, where several examples of Wadi Sûq and Late Bronze Age were found. Additionally, several pieces of an Umm an-Nar large, globular storage jar with black painted whirled designs was also found at the site. A surface collection from a tomb near the Khutm Settlement revealed several classic Umm an-Nar funerary ware pieces from a single small vase (Figure 59).

Figure 59. An in-field photo of diagnostic ceramics from Lot 230504 from the Khutm Trench C (Tomb) excavations.

Bat Lot #	Site	Date	Periods Represented	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Glazed	Total Diag	Non Diag	Total Sherd Count
221202	SS	1-Jan	UaN	2	0	0	0	0	2	4	6
221203	SS	3-Jan	UaN	0	1	0	1	0	2	1	3
221207	SS	5-Jan	UaN	0	0	0	0	0	0	1	1
221208	SS	5-Jan	UaN	0	0	0	0	0	0	6	6
221211	SS	8-Jan	UaN	0	1	0	0	0	1	1	2
221212	SS	8-Jan	UaN	0	1	0	0	0	1	1	2
221213	SS	8-Jan	UaN; Islamic	0	0	0	0	0	0	10	10
221216	SS	9-Jan	Uan	0	0	0	0	0	0	4	4
221217	SS	9-Jan	UaN	0	0	0	0	0	0	3	3
221217	SS	10-Jan	UaN (various)	0	0	0	2	0	2	3	5
221218	SS	10-Jan	UaN	0	0	0	1	0	1	4	5
221219	SS	11-Jan	UaN	0	0	0	0	0	0	2	2
221220	SS	10-Jan	UaN	0	0	0	1	0	1	1	2
221221	SS	10-Jan	UaN	0	0	0	3	0	3	1	5
221223	SS	10-Jan	UaN	0	0	0	0	0	0	2	2
221224	SS	11-Jan	UaN	0	0	0	1	0	1	2	3
221225	SS	11-Jan	UaN	0	0	0	0	0	0	4	4
221226	SS	11-Jan	UaN	0	0	0	3	0	3	6	9
221227	SS	11-Jan	UaN	1	0	0	0	0	1	0	1
221227	SS	11-Jan	UaN	0	0	0	0	0	0	2	2
221228	SS	11-Jan	UaN	0	0	0	1	0	1	10	11
221229	SS	12-Jan	UaN	0	1	0	1	0	2	3	5
221230	SS	12-Jan	UaN	0	0	0	0	0	0	2	2
221231	SS	12-Jan	UaN	0	0	0	0	0	0	2	2
221232	SS	12-Jan	UaN	0	0	0	4	0	4	10	14
221238	SS	13-Jan	UaN	0	0	0	4	0	4	6	10
221238	SS	14-Jan	UaN (Middle)	0	0	0	3	0	3	2	5
221239	SS	13-Jan	UaN	0	0	0	1	0	1	6	7

Bat Lot #	Site	Date	Periods Represented	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Glazed	Total Diag	Non Diag	Total Sherd Count
221241	SS	12-Jan	UaN (Middle)	0	0	0	1	0	1	0	1
221242	SS	13-Jan	UaN	0	0	0	1	0	1	0	1
221243	SS	20-Jan	UaN	1	0	0	2	0	3	6	9
221243	SS	13-Jan	UaN	0	0	0	2	0	2	3	5
221245	SS	13-Jan	UaN	0	0	0	1	0	1	4	5
221247	SS	13-Jan	Uan	0	0	0	0	0	0	1	1
221248	SS	13-Jan	UaN	0	0	0	1	0	1	1	2
221249	SS	14-Jan	UaN	0	0	0	1	0	1	0	1
221250	SS	21-Jan	UaN	0	0	0	2	0	2	8	10
221251	SS	21-Jan	UaN	3	2	0	0	0	5	20	25
221253	SS	21-Jan	UaN	0	0	0	1	0	1	8	
221256	SS	23-Jan	UaN	0	0	0	0	0	0	3	3
221257	SS	23-Jan	UaN	0	0	0	0	0	0	2	2
221258	SS	23-Jan	UaN	0	0	0	0	0	0	1	1
221259	SS	23-Jan	UaN	0	1	0	8	0	9	23	32
221261	SS	23-Jan	UaN; WS/ LBA	0	0	0	0	0	0	9	8
221262	SS	23-Jan	UaN	0	0	0	0	0	0	4	4
221263	SS	23-Jan	UaN Middle I	0	0	0	3	0	3	11	14
221264	SS	24-Jan	UaN	0	0	0	0	0	0	4	4
221266	SS	24-Jan	UaN (Middle I/ II)	0	0	0	1	0	1	1	2
221266	SS	24-Jan	Islamic/IA/ UaN	0	0	0	3	0	3	1	5
221268	SS	24-Jan	UAN	0	0	0	0	0	0	2	2
221297	SS	20-Jan	UaN	0	0	0	0	0	0	2	2
221501	RaM 1	16-Jan	UaN	0	0	0	0	0	0	3	3
221502	RaM 1	16/17 Jan	UaN; WS	0	0	0	0	0	0	10	10
221508	RaM 1	19-Jan	UaN	0	0	0	0	0	0	1	1

Bat Lot #	Site	Date	Periods Represented	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Glazed	Total Diag	Non Diag	Total Sherd Count
221511	RaM 1	20-Jan	n	0	0	0	0	0	0	1	1
221514	RaM 1	23-Jan	UaN	0	0	0	0	0	0	1	1
221517	RaM 1	24-Jan	UaN	0	0	0	0	0	0	1	1
221525	RaM 1	25-Jan	UaN	1	1	0	1	0	3	12	12
221536	RaM 1	26-Jan	UaN	0	0	0	0	0	0	2	2
221537	RaM 1	27-Jan	UaN	0	0	0	0	0	0	2	2
221543	RaM 1	28-Jan	UaN	0	0	0	0	0	0	2	2
221545	RaM 1	28-Jan	UaN	4	3	0	1	0	8	4	12
221547	RaM 1	28-Jan	UaN	0	0	0	1	0	0	0	1
221042	RaM 2	31-Jan	UaN	0	0	0	0	0	0	1	1
221801	RaM 2	16-Jan	UaN; IA	0	0	0	0	0	0	5	5
221802	RaM 2	16-Jan	UaN	0	0	0	0	0	0	1	1
221805	RaM 2	25-Jan	UaN	0	0	0	0	0	0	1	1
221808	RaM 2	17-Jan	UaN	0	0	0	0	0	0	3	3
221809	RaM 1	17-Jan	UaN	0	0	0	0	0	0	1	1
221821	RaM 2	25-Jan	UaN	0	0	0	0	0	0	1	1
221844	RaM 2	1-Jan	UaN	0	0	0	2	0	2	0	2
221849	RaM 2	1-Feb		0	0	0	0	0	0	1	1
221803	RaM 2	16/17 Jan	UaN	0	0	0	2	0	2	4	6

Bat Lot #	Site	Date	Periods Represented	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Glazed	Total Diag	Non Diag	Total Sherd Count
221813	RaM 2	18-Jan	Uan	0	0	0	0	0	0	1	1
221818	RaM 2	19/20 Jan	UaN	0	0	0	0	0	0	2	2
221819	RaM 2	20-Jan	UaN	0	0	0	0	0	0	1	1
221821	RaM 2	26-Jan	UaN	0	0	0	0	0	0	2	2
221836	RaM 3	27-Jan	UaN; Islamic	0	0	0	0	0	0	3	3
221901	RaM 2	25-Jan	UaN	0	0	0	1	0	1	1	2
221903	RaM 1	26-Jan	UaN	0	0	0	0	0	0	1	1
221904	RaM 1	27-Jan	Unknown	0	0	0	0	0	0	1	1
KHUTM											
220001	KS Tomb	31-Dec	UaN	2	5	0	10	0	17	1	17
221501	KS	5-Jan	UaN	0	0	0	0	0	0	5	5
221502	KS	3-Jan	UaN	0	0	0	0	0	0	5	5
221507	KS	9-Jan	UaN	0	0	0	0	0	0	1	1

Table 6. BAP 2022 Excavation Ceramic Analysis by Sherd Count.

6.1.2 2023 Survey Collection

BAP's small scale survey program this year included artifact collection in the Khutm area and at the secondary alluvial depression of RaM B. Both sites were limited in the ceramics collected. At RaM B, most of the collected pottery was datable to the late Islamic and Modern/Ethnographic periods. A few exceptions occurred in the eastern transects, where sherds of a large Umm an-Nar storage jar and several fragments of other Umm an-Nar domestic wares were also recovered. At Khutm, a range of Iron Age ceramics were uncovered, notably several bowl rim fragments. In total, 119 sherds were examined from BAP's 2023 survey collections (Figure 60).

Figure 60. Ceramics from Survey Lot 232001 at RaM B, showing primarily Late Islamic and Modern examples (left); Survey Lot 232034 at Khutm, showing several Iron Age II/III bowl fragments in an orange fabric (right).

Bat Lot #	Site	Date	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted /Glazed	Diag Total	Non Diag	Total Sherd Count
232001	Survey - RaM B	18-Jan	UaN; Islamic; Modern	0	5	0	1	0	6	6	12
232002	Survey - RaM B	18-Jan	Islamic; UaN	0	1	2	0	1	4	8	12
232022	Survey - RaM B	18-Jan	Modern; Islamic; UaN	0	0	0	0	0	0	11	11
232003	Survey - RaM B	18-Jan	Modern; Islamic; UaN	0	0	0	4	0	4	0	4
232016	Survey - RaM B	18-Jan	Islamic; UaN	6	5	0	1	1	12	17	29
232019	Survey - RaM B	18-Jan	Islamic; UaN	3	0	0	0	8	11	15	26
232020	Survey - RaM B	18-Jan	Modern	0	0	0	2	0	2	3	5
232031	Survey - KS	19-Feb	Iron Age	1	0	0	0	1	2	0	2
232032	Survey - KS	19-Feb	Iron Age; UaN	1	0	0	1	0	2	2	4

232033	Survey - KS	28-Feb	Iron Age; UaN; Unkown	3	0	1	0	0	4	0	4
232034	Survey - KS	28-Feb	Iron Age	4	3	0	0	1	8	0	8
232035	Survey - KS	28-Feb	Iron Age	0	2	0	0	0	2	0	2

Table 7. 2023 BAP Survey Ceramic Analysis by Sherd Count.

6.1.3 2023 Excavation Collection

Ceramics from the following 2023 excavation areas were examined as part of this season's artifact analysis: Operation A; Khutm Settlement (Trench B, C, D); and Rakhat al-Madrh. Ceramics were examined in the context of their find areas and are reported by sherd count in the following tables.

Several locations yielded particularly interesting examples. The tomb excavations conducted at the Khutm Settlement revealed a remarkably fine Umm an-Nar small funerary vase with black chevrons; a suspension vessel; and at least two different types of Indus-style ceramics (including a black-slipped storage vessel). Excavations at RaM 4 also recovered several fragments from Umm an-Nar period suspension vessels. One of these yielded multiple sherds from a single vessel spread across three excavation lots (233411; 233417; 233430) indicating some mixing of contexts across the RaM 4 structure.

Generally, the ceramics from Operation A were Bronze Age and poorly preserved, many so fragmentary that additional hand analysis beyond count and fabric examination was impossible. Lot 231024 was one exception to this, where a string-cut footed base was found along with a likely Late Bronze Age small vase rim based on comparanda. Illustration of these finds is ongoing.

The pottery from this season's RaM excavations was overwhelming datable to the Umm an-Nar period (Figure 61). This was exclusively the case at RaM 2 and RaM 4. The structure of RaM 3 was more chronologically diverse with a handful of modern, Iron Age, and potential Wadi Sûq sherds found within building's excavation.

Figure 61. Typical Umm an-Nar Ceramics, including suspension vessel fragments, from RaM 4 (Lot 233430).

Bat Lot #	Date	Site	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted / Glazed	Diag Total	NonDiag (excavation)	Total Sherd Count
231001	8-Jan	Op A	UaN	1	0	0	0	0	1	2	3
231002	8-Jan	Op A	Iron Age	0	0	0	0	0	0	3	3
231004	8-Jan	Op A	UaN; unknown	3	0	0	0	0	3	3	6
231005	8-Jan	Op A	UaN	0	0	0	0	0	0	3	3
231007	8-Jan	Op A	UaN	0	1	0	0	0	1	2	3
231007	9-Jan	Op A	UaN	0	0	0	0	0	0	2	2
231010	9-Jan	Op A	UaN	0	0	0	0	0	0	2	2
231013	10-Jan	Op A	UaN	0	1	0	0	1	2	4	5
231022	10-Jan	Op A	UaN	1	0	0	0	0	1	0	1
231020	10-Jan	Op A	UaN	2	0	0	2	0	4	3	7
231024	10-Jan	Op A	UaN; LBA?	1	2	0	3	0	6	11	17
231025	10-Jan	Op A	UaN	0	0	0	4	0	4	9	13
231027	10-Jan	Op A	UaN	1	0	0	0	1	2	0	2

Table 8. 2023 Operation A Excavation Ceramic Analysis by Sherd Count.

Bat Lot #	Date	Site	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted/ Glazed	Diag Total	Non Diag	Total Sherd Count
230001	2-Jan	Khutm Strip	UaN; Islamic; Modern; Unknown	1	4	0	4	0	9	55	64
230002	2-Jan	Khutm Strip	UaN	1	0	0	3	0	4	24	28
230003	2-Jan	Khutm Strip	UaN; unknown	7	0	0	0	0	7	24	31
230004	2-Jan	Khutm Strip	UaN; unknown	0	1	0	0	0	1	7	8
230005	2-Jan	Khutm Strip	UaN	0	0	0	0	0	0	1	1
230010	3-Jan	Khutm Strip	UaN	0	2	0	0	0	2	1	3

Bat Lot #	Date	Site	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted/ Glazed	Diag Total	Non Diag	Total Sherd Count
230011	4-Jan	Khutm Strip	UaN	0	0	0	0	1	1	3	4
230014	4-Jan	Khutm Strip	unknown	1	0	0	0	0	1	1	2
230015	5-Jan	Khutm Strip	UaN	0	1	0	0	0	1	2	3
230508	20-Jan	Khutm Tomb	UaN	3	0	0	0	1	4	20	24
230101	5-Jan	Khutm Sound	Iron Age	1	0	0	0	0	1	3	4
230102	8-Jan	Khutm Sound	Unknown	0	0	0	0	0	0	3	3
230103	6-Jan	Khutm Sound	Unknown	0	0	0	2	2	2	0	2
230103	9-Jan	Khutm Sound	Unknown	0	0	0	0	0	0	1	1
230103	15-Feb	Khutm Sound	Unknown	0	0	0	0	1	1	0	1
230103	9-Jan	Khutm Sound	UaN	1	0	0	0	4	5	2	6
230108	9-Jan	Khutm Sound	UaN	0	0	0	0	2	2	0	2

Table 9. 2023 Khutm Settlement Trench B, C, D (Khutm Strip Trench/Tomb/Sounding) Excavation Ceramic Analysis by Sherd Count.

Bat Lot #	Date	Site	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted / Glazed	Diag Total	Non Diag	Total Sherd Count
233014	4-Jan	RaM 2	UaN	1	0	0	0	0	0	1	2
233015	5-Jan	RaM 2	UaN	0	1	0	0	0	0	2	3
233036	7-Feb	RaM 2	UaN	0	0	0	0	0	0	1	1
233039	7-Feb	RaM 2	UaN	0	0	0	0	0	0	1	1
233041	7-Feb	RaM 2	UaN	0	0	0	0	0	0	3	3
233043	9-Feb	RaM 2	UaN	0	0	0	0	0	0	2	2
233204	23-Jan	RaM 3	Modern; Islamic	0	0	0	0	0	0	2	2
233209	25-Jan	RaM 3	UaN	0	1	0	0	0	1	0	1

Bat Lot #	Date	Site	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted / Glazed	Diag Total	Non Diag	Total Sherd Count
233210	25-Jan	RaM 3	UaN; IA	0	0	0	0	0	0	6	6
233217	29-Jan	RaM 3	UaN	0	0	0	0	0	0	1	1
233223	30-Jan	RaM 3	UaN	0	0	0	0	0	0	1	1
233224	30-Jan	RaM 3	UaN	1	0	0	0	0	1	0	1
233236	1-Feb	RaM 3	UaN	0	0	0	0	0	0	1	1
233250	5-Feb	RaM 3	UaN	0	0	0	0	0	0	1	1
233251	6-Feb	RaM 3	UaN; Wadi Sûq; Technical Ceramic	0	1	0	0	0	1	6	7
233251	7-Feb	RaM 3	UaN	0	0	0	0	1	1	1	2
233253	6-Feb	RaM 3	UaN	0	0	0	0	0	0	1	1
233254	7-Feb	RaM 3	UaN	0	0	0	0	0	0	3	3
233255	7-Feb	RaM 3	Iron Age	0	0	0	0	0	0	1	
233255	8-Feb	RaM 3	UaN	0	0	0	0	0	0	1	1
233256	8-Feb	RaM 3	UaN	1	0	0	0	0	1	0	1
233256	7-Feb	RaM 3	UaN, WS	3	0	0	0	3	6	9	
233261	8-Feb	RaM 3	UaN	1	0	0	0	1	2	4	6
233262	8-Feb	RaM 3	UaN	5	2	0	0	5	12	20	
233262	10-Feb	RaM 3	UaN (Middle)	0	0	0	0	0	0	1	1
233266	8-Feb	RaM 3	WS	0	0	0	1	0	1	0	1
233270	9-Feb	RaM 3	UaN; WS	1	0	0	0	1	2	5	
233272	9-Feb	RaM 3	UaN	4	1	0	0	1	6	12	18
233278	10-Feb	RaM 3	UaN	1	0	0	0	0	1	8	9
233279	10-Feb	RaM 3	UaN; Wadi Sûq; Islamic	2	0	0	0	3	5	13	18
233280	10-Feb	RaM 3	UaN (BSJ)	0	0	0	0	6	6	5	11
233006	24-Jan	RaM 2	UaN	0	0	0	0	0	0	1	
233030	6-Feb	RaM 2	UaN	1	1	0	0	0	2	0	2
233404	22-Jan	RaM 4	UaN	0	0	0	1	0	1	0	1

Bat Lot #	Date	Site	Periods Rep	Rims	Bases	Handles/ Spouts/ Lugs	Decorated Body	Painted / Glazed	Diag Total	Non Diag	Total Sherd Count
233408	22-Jan	RaM 4	UaN	0	1	0	0	2	3	2	5
233411	23-Jan	RaM 4	UaN	0	0	0	3	0	3	1	4
233414	23-Jan	Ram 4	UaN (Middle I)	0	0	0	0	4	4	5	9
233415	24-Jan	RaM 4	UaN	0	0	0	0	0	0	1	1
223417	2-Feb	RaM 4	UaN	0	0	0	0	6	6	1	7
233417	26-Jan	Ram 4	UaN	0	0	0	0	0	0	1	1
233421	26-Jan	RaM 4	UaN	0	0	0	0	1	1	4	5
233430	2-Feb	RaM 4	UaN	2	0	0	6	0	8	3	11
233433	3-Feb	RaM 4	UaN	1	0	0	0	1	2	6	8
233437	5-Feb	RaM 4	UaN	6	1	0	1	0	8	2	11
233424	30-Jan	RaM 4	UaN	0	0	0	0	1	1	0	1
233425	30-Jan	RaM 4	UaN	0	0	0	2	0	0	2	2
233428	1-Feb	RaM 4	UaN	0	0	0	0	1	1	4	5
233443	8-Feb	RaM 4	UaN	1	0	0	0	0	1	2	3
Baulk Clean Op A	10-Feb	RaM 4	UaN	0	0	0	0	0	0	4	4

Table 10. 2023 Rakhat al-Madrh structures 2, 3, and 4 Excavation Ceramic Analysis by Sherd Count.

6.2 Lithics Analysis

6.2.1 Chipped stone artifacts from BAP, Oman[4]

A sample of 44 chipped stone artifacts from Bat Archaeological Project has been analyzed. These artifacts come from various archaeological contexts (burial, settlement, survey), 11 pieces were found during survey (Table 11).

6.2.1a Raw material (for details see report from Antonín Přichystal)

The majority of the chipped stone artifacts were made of red (reddish brown to purple red and pinkish light brown colors) and beige (to greyish light brown) radiolarites or radiolarian chert (grey to beige-light brown, also pinkish). Only three of the artifacts

[4] Report complied by Inna Mateiciucová, Centre of Prehistoric Archaeology of the Near East, Faculty of Arts, Masaryk University, Arna Nováka 1, 602 00 Brno, Czech Republic *(e-mail: inna_mateiciuc@hotmail.com; inna.mateiciuc@phil.muni.cz)*

were made of spongolithic chert, and a further two of a non-specified kind of chert (Tables 12 and 13).

Site	Raw material	Items	Pre-cores and cores	Flakes	Blades	Tools	Type of tools
BAP 23	chert	1	0	1	0	0	
BAP 23	radiolarian chert	8	0	5	2	1	retouched flake
BAP 23	radiolarite	17	0	12	4	1	bifacial point (a pre-form?)
BAP 23	spongolithic chert	1	0	1	0	0	
BAP 23	spongolithic chert?	1	0	0	0	1	fragment of a burin (flake)
BAP 23, KS Tomb	radiolarite	1	0	1	0	0	
BAP 23, RAM 2	radiolarian chert	2	0	0	2	0	
BAP 23, RAM 4	radiolarite	2	0	2	0	0	
BAP 23, survey	chert	1	0	1	0	0	
BAP 23, survey	radiolarian chert	2	0	2	0	0	
BAP 23, survey	radiolarite	7	0	4	1	2	endscraper (flake), unifacially retouched flake
BAP 23, survey	spongolithic chert (type Hayl Ajah)	1	0	0	0	1	endscraper (flake)
Total		**44**	**0**	**29**	**9**	**6**	

Table 11. Proportions of raw material in relation to research activities.

Raw material	Items	Pre-cores and cores	Flakes	Blades	Tools
Radiolarite	27	0	19	5	3
Radiolarian chert	12	0	7	4	1
Chert	2	0	2	0	0
Spongolithic chert	2	0	1	0	1

Spongolithic chert (type Hayl Ajah)	1	0	0	0	1
Total	**44**	**0**	**29**	**9**	**6**

Table 12. Proportions of raw material in relation to basic morphological groups.

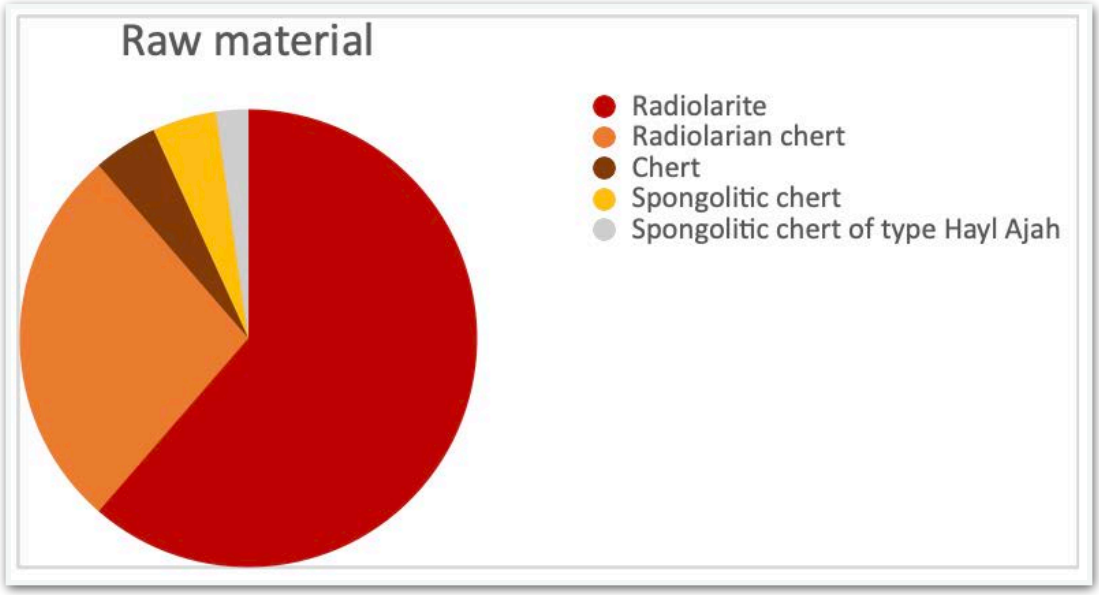

Table 13. Proportions of raw material in the assemblage.

6.2.1b Techno-typological analysis

The general character of the chipped stone industry is one of flake-oriented production.

The main aim seems to have been to produce relatively large, wide or elongated flakes, often with parallel scars on the dorsal side (Tables 14-16). Massive blades (two times longer than wide, or even longer) also occur. Some of the flakes have been further modified by retouching. Most of the flakes bear traces of use-wear on their edges (use-wear retouch) (Table **17**). With the available means (macroscopic inspection) it has not been possible to determine whether these have been created during post-transformation processes, genuinely by using the edges of the flakes for various activities (this depends on the archaeological context). However, since the use-wear retouch often occurs at the ventral side of the flakes, this can be probably taken as an indicator that the use-wear retouch was at least on some of the artifacts (intentionally) created during their use as a working tool. A traseological analysis of the artifacts from primary context could certainly say more about their use.

Length	Items	Min (mm)	Max (mm)	Avg (mm)	StDev (mm)
Flakes	26	21.5	68	34.7	10.3

Flake tools	3	27	48	37.5	10.5

Table 14. Length of flakes and flake tools. Only entire pieces analyzed.

Width	Items	Min (mm)	Max (mm)	Avg (mm)	StDev (mm)
Flakes	26	17.5	46	27.1	7.6
Flake tools	3	22.5	34	29.8	6.4

Table 15. Width of flakes and flake tools. Only entire pieces analyzed.

Thickness	Items	Min (mm)	Max (mm)	Avg (mm)	StDev (mm)
Flakes	26	4.5	24	9.5	4.3
Flake tools	3	9	11.5	10	1.3

Table 16. Thickness of flakes and flake tools.

The flake blanks were mostly struck from unidirectional cores with plain or unprepared platforms. The platform remnants of the blanks are often wide and broad, and the platform remnant angles are almost always acute (less than 80˚). That indicates that the flakes were produced by direct percussion.

Six artifacts were classified as tools: one massive bifacial point (possible a pre-form), one fragment of a burin-like tool, two end-scrapers, one laterally retouched flake, and one fragment of a partly unifacially retouched flake (Table 11).

Site	Raw material	No. of artefacts	Use-wear traces
BAP 23	chert	1	1
BAP 23	radiolarian chert	8	8
BAP 23	radiolarite	17	13
BAP 23	spongolitic chert	1	1
BAP 23	spongolitic chert?	1	0
BAP 23, KS Tomb	radiolarite	1	1
BAP 23, RAM 2	radiolarian chert	2	1
BAP 23, RAM 4	radiolarite	2	2
BAP 23, survey	chert	1	1
BAP 23, survey	radiolarian chert	2	1

BAP 23, survey	radiolarite	7	7
BAP 23, survey	spongolitic chert (type Hayl Ajah)	1	0
Total		**44**	**36**

Table 17. The proportions of use-wear traces in relation to the raw materials.

6.2.1c Comparison with chipped stone artifacts from Hayl Ajah, site 1

The lithic artifacts of the presented assemblage are different to the lithic artifacts found at Hayl Ajah from the viewpoint of raw material, technology, and typology.

a) Raw material

The raw material spectrum of lithic artifacts at Hayl Ajah is much more varied. This is probably due to polycultural occupations during to different periods. In contrast to this, the raw material in the studied assemblage from Bat is quite uniform.

In the studied assemblage from Bat, radiolarites and radiolarian cherts of dark red tones dominate, often in combination with beige-colored parts.

At Hayl Ajah the stone artifacts are also often made of radiolarites. Although dark red radiolarites also occur, they are not found in combination with beige-colored parts. If a dark red radiolarite artifact is double-colored at Hayl Ajah, then rather in combination with a dark green. In addition to the dark red and dark green radiolarites of apparently local or regional origin, radiolarites and radiolarian chert of pastel and bright red colors predominate at Hayl Ajah. Their sources have not yet been found. Artifacts made of radiolarites occur mainly on the surface of Site HA-1 and other sites around Hayl Ajah.

At Site HA-1, beige to light grey chert (spongolitic chert according to A. Přichystal) of very good quality is also very common. From this chert is also made the bladelet industry found *in situ* in Trench 1 at the same site (Mateiciucová *et al.* 2020). Just one artifact from similar raw material was identified in the studied assemblage from Bat (this may also be important). This grey spongolitic chert item (Lot 232025-6, Přichystal No. 41) from Bat was apparently secondarily shaped into an end-scraper (originally Neolithic? artifact reused?). No source of the described good-quality chert has been found yet and we assume that it will not be local.

One radiolarite artifact (Lot 232001-5, 28) could be of much older (Palaeolithic?) age. On the surface of this artifact there is a strong dark varnish with traces of a later secondary preparation.

Basalts and quartzites were not recorded in the BAP assemblage. In contrast, at Hayl Ajah, artifacts made of silicified basalt and quartzite are common.

b) Techno-typological view

The lithic industry from Bat can be characterized as a flake industry. The main target was the production of wide and flat flakes and of massive blades/elongated flakes. Only six pieces can be typologically classified as tools. However, many of the intentionally unretouched artifacts show a visible use-wear retouch on edges (used as tools?). Unretouched flakes were probably used as "tools."

The lithic artifacts made of radiolarite, and chert found at Hayl Ajah are much smaller, often with traces of re-using and sharpening. Many of them can be described typologically as tools (end-scrapers, denticulates, splintered pieces, micro-borers, fragments of bifacially retouched projectile points). Flake artifacts made of basalt and quartzite are also wide or elongated, and in comparison to the BAP flakes more massive (due the raw material?). They could be theoretically dated to the Bronze Age, but because of their thick varnish and some morphological characteristics we prefer to date them preliminarily to the Middle Palaeolithic.

The lithic artifacts found in situ at Hayl Ajah, site 1 are thus completely different and can be described as bladelet and microblades oriented industry using good quality chert.

6.2.2 Petrographic investigation of chipped stone artifacts from BAP, Oman[5]

A collection of 44 chipped artifacts collected by the Bat Archaeological Project at Bat, Oman, has been studied (Table 18). All artifacts have been investigated under a stereomicroscope using water as an immersion liquid, that means without any damage. This method makes it possible to see inside the siliceous raw material, and the classification of raw material is based especially on a basic determination of microfossils, inclusions, coloring pigments, the description of the chert nodule or layer cortex, and occasionally on a relic of the pebble surface or varnish.

Compared to our chipped lithic assemblage from Hayl Ajah (evaluation of more than 300 Neolithic and probably also Palaeolithic chipped lithics), the studied collection from Bat seems to be rather uniform. By far the most dominant raw materials are radiolarites, usually of red-brown to grey-violet colors or light-colored radiolarian chert. It is necessary to emphasize that differentiation between radiolarite (based on a percentage of more than 50 % of radiolarians) and radiolarian chert is partly subjective because in the case of the light-colored varieties it is more difficult to see the circular phantoms of radiolarians. Very likely the source of radiolarites and radiolarian cherts has been the same, and because of the relics of a varnish or pebble surface we can suppose that part—or even the major part—of these raw materials has been collected from secondary position, i.e., has been found in wadi gravels. The group of radiolarites and radiolarian cherts in the studied Bat collection forms supposedly 37 (+ 2?) pieces, corresponding to an occurrence of minimally 84%. Only one piece (no. 41) is comparable with raw material (grey spongolitic chert with orange cortex) prevalent at

[5] Report compiled by Antonín Přichystal, Department of Geological Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic (e-mail:prichy@sci.muni.cz)

Hayl Ajah, apart from two chips are made of layered chert with dendrites or black spots without visible microfossils and two layered spongolitic cherts.

The classification of used siliceous raw materials is one aspect of the petrography of lithic artifacts. The other aspect is their provenance. To answer this question is more difficult. There is no collection (lithotheque) of comparative raw materials used in prehistoric times in Oman yet existing.

As far as radiolarites and radiolarian cherts in Oman are concerned, there are many primary outcrops and secondary deposits. A relatively good source of red-brown radiolarites, for example, exists near Al Ayn. I have not found such variability in colors there as described from archaeological site at Bat.

Site	Lot	Date	No. (Přichystal)	Raw material
BAP 23	232016	1/18/23	1 - 4, 7	grey-violet radiolarite, laminated, no cortex or pebble surface
BAP 23	232016	1/18/23	5.6	red-brown radiolarite, radiolarians filled with white chalcedony
BAP 23	232016	1/18/23	8	radiolarite, raiolarians filled with sheer chalcedony
BAP 23	232016	1/18/23	9, 10	radiolarite - radiolarian chert , dark surface (varnish), collected in secondary position
BAP 23	232016	1/18/23	11	dark grey banded spongolitic chert, monoaxons of Poriphera
BAP 23	232016	1/18/23	12	light grey spongolitic (?) chert, laminated
BAP 23	232011 or 232019?	1/18/23	13	yellowish-red radiolarite
BAP 23	232011 or 232019?	1/18/23	14	radiolarian chert, relict of dark pebble surface, collected in secondary position
BAP 23	232011 or 232019?	1/18/23	15	red-brown radiolarite, phantoms after radiolarians filled with sheer chalcedony
BAP 23	232011 or 232019?	1/18/23	16	banded radiolarian chert with black surface
BAP 23 - KS tomb	230502	1/4/23	17	grey-violet radiolarite, radiolarians filled with white chalcedony
BAP 23	230004	1/2/23	18	grey-violet radiolarite, rdiolarians filled with white chalcedony
BAP 23	232022	1/18/23	19	red-brown radiolarite, numerous radiolarians filled with white chalcedony
BAP 23	232022	1/18/23	20	red-brown radiolarite, radiolarians filled with white chalcedony
BAP 23	232022	1/18/23	21	grey-violet radiolarite

BAP 23, RAM 4	233408	1/22/23	22	red-brown radiolarite, radiolarians filled with white chalcedony, pebble surface
BAP 23, RAM 4	233408	1/22/23	23	grey-violet radiolarite
BAP 23, survey	232001	1/18/23	24	violet-grey radiolarite
BAP 23, survey	232001	1/18/23	25	red-brown radiolarite
BAP 23, survey	232001	1/18/23	26	radiolarian chert, relict of dark surface, collected in secondary position
BAP 23, survey	232001	1/18/23	27	grey-violet radiolarite
BAP 23, survey	232001	1/18/23	28	patinated greenish radiolarite, relict of black surface
BAP 23	232002	1/18/23	29	light radiolarian chert
BAP 23	232002	1/18/23	30	radiolarite
BAP 23	232002	1/18/23	31	light-coloured radiolarian chert
BAP 23	232002	1/18/23	32	light-coloured radiolarian chert
BAP 23	231001	1/8/23	33	red-brown radiolarite with greenish veinlets
BAP 23	231001	1/8/23	34	yellowish radiolarian chert with light reddish schliers
BAP 23	231006	1/8/23	35	layered chert with black dendrites, no visible microfossils
BAP 23, survey	232025	1/18/23	36	red-brown radiolarite, radiolarians filled with white chalcedony
BAP 23, survey	232025	1/18/23	37	violet radiolarite, radiolarians filled with white chalcedony
BAP 23, survey	232025	1/18/23	38	reddish radiolarian chert
BAP 23, survey	232025	1/18/23	39	layered brown-grey chert with dark spots, probably the same as No.35
BAP 23, survey	232025	1/18/23	40	dark brown radiolarite, laminated
BAP 23, survey	232025	1/18/23	41	grey spongolitic chert, usually orange cortex, white monoaxons, dominated at Sint polje
BAP 23 RAM 4	233411	1/23/23	42	yellowish radiolarian chert, in places radiolarians filled with white chalcedony
BAP 23 RAM 2	233004	1/23/23	43	pink radiolarian chert (?), burnt (?)
BAP 23 RAM 2	233004	1/23/23	44	radiolarian chert (?), too small piece to determine

Table 18. Determination of Raw Materials, by Antonín Přichystal, February 2023.

7. Outreach and Engagement

Reilly S. Jensen

7.1 Introduction

Building off the previous season's momentum, BAP dedicated more time than ever before to public-facing events and community programs this season. The outreach organizational team consisted of Reilly Jensen (University of Utah), Cindy Snerka (University of Pennsylvania), and partnered with Sumaiya Al Marmarri (Bat Ministry Office). Together, this team conceptualized and implemented 1 Community Day heritage event in the heart of Bat Village, a robust schedule of primary education field trips and learning activities at the UNESCO World Heritage Site, and a localized sediment and pottery workshop dedicated to community stakeholders and Ministry employees.

To support outreach this season, goals were identified after considering the lessons learned from last year and in consultation with Bat Ministry staff. These were:

1. Create new opportunities to connect archaeologists working in the region with Bat residents to share knowledge about the past;
2. Make learning about archaeology fun and engaging, and encourage learning and appreciation for archaeology and the people doing it;
3. Support local Heritage Ministry Employees and their development as they engage the community and implement stewardship.

7.2 Community and Cultural Engagement Events

7.2.1 Community Day

Conceptualized first within the community at the immediate neighbors-and-friends level, Bat Community Day was a true group effort involving over 200 village participants and at least 10 organizers from Bat Archaeological Project, The Bat Office of Ministry of Heritage and Tourism, and Healthy Village Bat (Figure 62). At the event, participants convened together at an open-air public location and engaged in conversations, shared songs and food,

Figure 62. Flier for the 2023 Bat Community Day event.

exchanged gifts and stories, and created art (cultural heritage postcards and clay sculptures) around the sharing of cultural heritage. Art-making as part of community day included the prompt: *What Does Heritage Mean To You?* in Arabic and in English (Figure 63). Over 100 heritage postcards were created and displayed as an open-air popup art gallery in the community space. Families and children drew pictures and created clay "memory" sculptures to express what Heritage means to them, what they appreciate about their heritage(s), and about living in Bat. Most of these art projects were taken home by their creators, but those left behind on Community Day were collected and scanned for future reference.

Community Day and its activities represent an opportunity to find common ground at Bat, not to excavate, but to build anew. The Bat Archaeological Project invited village residents and sister archaeological missions working in the region to engage and participate in the event, encouraging friendship and collaborative knowledge creation. Community Day events and activities enriched cultural exchanges to solidify relationships between Bat residents and archaeologists. These critical relationships and positive outcomes are required to engender interest in higher education, encourage archaeological stewardship and professional development in field sciences, and allow for agency and complexity within national cultural heritage in Oman (Figure 64).

Figure 63. Prompt for children's heritage activity at the 2023 Bat Community Day event.

Figure 64. Assorted photographs of the Bat Community Day event.

7.2.2 School Visits

Sumaia al-Marmarri and Reilly Jensen worked together to schedule and host site visits to the UNESCO site during the field season for primary-school aged children and their teachers. Sumaia worked diligently with local schools to schedule logistics of these field trips and was integral to the success of the visits. At the site, schoolchildren would explore the site, ask questions to archaeologists working at the site, and then engage in Field Journal Arts activity. The Field journal arts activity was created by Reilly and Sumaia to identify interests and opportunities to share the experiences of children visiting the site. It helped identify what they observed during their visit, asked them to interpret what they think the site was like in the past, and what their hopes for the future of the site are. The field journals the children created at the site serve as a visual record of ideas, interests, desires, and hopes for the site in the future as it is developed for tourism.

Two site visit events were held during this field season: The Al Banah Koranic School visited Rakht Al-Madr on Feb 1, 2023. They brought 8 students, 1 child, and 4 teachers (13 visitors total). They joined Reilly Jensen and Sumaiya al-Marmarri to tour the active archaeological trenches at RaM while excavations were ongoing, safely explore the site with their peers, and complete a Field Journal arts activity to record their experiences (Figure 65 a-c).

The Yanqul Area Koranic School visited Khutum and Bat Necropolis on Feb 2, 2023. They brought around 30 students. They joined Reilly Jensen and Sumaiya al-Marmarri to tour the active archaeological trenches at Khutum, participated in a question and answer excavation session with Badr Ali al-Badi (Bat MHT), explored the UNESCO necropolis of Bat, and completed Field Journals.

Field Journals were created as an inquiry-based arts-integration activity. Each student received a journal. Each journal consisted of a crafted accordion-style notebook with pockets, where students could place notes or drawings in response to a series of prompts (created by Reilly, Cindy, and Sumaia). These prompts were provided in Arabic and in English:

1. Make a picture of where you are.
2. Close your eyes. Listen. Then open your eyes and draw what you hear.
3. Draw a picture of how the site used to look.
4. Find an artifact on the ground that represents your interests or personality. Draw a picture of it. Then, put it back exactly where you found it, and place the picture in this pocket.
5. What questions do you have about this place?
6. Make a picture of the site in the future. What has changed?
7. What do you think other people should know about visiting this place?
8. Draw what the visitors center could look like.

Forty-two field journals were collected and scanned, to be hosted on the BAP website in an online art gallery with permission from their creators and with full credits

Figure 65 a & b. Examples of student field journals responding to site visits to various location on the Bat landscape.

Figure 65 c. Example of student field journals responding to site visits to various location on the Bat landscape.

to each artist. In the future, this activity could be used as an evaluative tool to understand how visitors experience the site and better understand what elements of the site are important to the experience of visitors or communities. These journals assist site visitors in observing archaeological features and the environment surrounding the site, but they also help create meaning by generating ideas and asking people to reflect on how to protect or enjoy it. Many children's responses to questions 6 & 8 involved exhibit galleries, gardens and playgrounds, and improved infrastructure like roads and hotels for visitors (so that they could return again).

Much can be gleaned from using arts-integration to measure theory of change at the site to evaluate community perceptions of archaeology at Bat. These journals (or activities like it) could help external planners understand why and how archaeology is important to individuals at local and regional scales. Perhaps this can be examined in future research, utilized for future site management and visitation planning at Bat, or as a way to include and ensure local stewardship perspectives from future generations in the educational system. The results of the journals are also engaging artistically, and could be used to generate new exhibits or community events at the future Visitor's Center.

The feedback from the teachers and students from their site visit experiences were generally positive. Many people living at or around Bat are curious about the work at the archaeological site and interested in engaging with it. Providing a set time where researchers and Ministry employees could answer specific questions and provide support in accessing the site was critical for BAP to achieve, given the conflicts surrounding winter school schedules of the Omani academic system and the inaccessibility of certain roads to the site.

In one outcome, Reilly and Sumaia received a thank you video from the teachers at the al Banah Koranic School, comprised of moments and memories of the teachers and students and their experiences of the site, expressing appreciation and the desire to return with more students. Creating more opportunities to include perspectives and prioritize sharing the experiences of local visitors and residents is a powerful and immediate way to facilitate stewardship and appreciation for the UNESCO site at Bat, and encourage future generations to value and safeguard it.

7.2.3 *Pottery Workshop*

At the request of local Ministry employees at Bat, Reilly Jensen facilitated a two-day (Jan 30-31, 2023) clay harvesting and pottery-making workshop for MHT employees and for Bat Healthy Village stakeholders. This workshop built on the foundations of last season's contemporary and experimental pottery research, and trained participants to identify, test, harvest, and process clay from the local environment to use for the creation of a local cottage pottery industry.

The first day, participants learned to identify and assess sediment matrices on the landscape to identify appropriate clay sources for harvesting. Then they collected clay to learn how to process, using the Water Extraction Method. Once the clay was appropriately extracted and processed, Reilly demonstrated the coil-method for pottery-making and provided tools and time to participants to create their own pottery throughout the remainder of that week. Certificates of completion were distributed at the end of the workshop on January 31 by Mohammed al Qabani.

The BAP team learned from Mohammed al Issai after the workshop that there is community interest surrounding the creation of a heritage pottery store/workshop/ industry local to Bat. Using the techniques from this workshop, MHT employees have identified and sourced clay outside the archaeological site boundaries to create unique locally crafted vessels. They are now looking into how to integrate this knowledge with the Ministry of Heritage and Tourism goals, and how it might be able to dovetail with Bat Visitors Center initiatives.

8. Geomorphology and Hydrology at Rakhat al-Madrh and Hayl Aja

Tara Beuzen[6], Claude Cosandey[7], Stephane Desruelles[8], Max Engel[9], Eric Fouache[10], Laurence Le Callonnec[11], and Aleksandre Prosperini[12]

8.1 Introduction

Following the third year of excavation by the Bat Archaeological Project of dwellings from the Umm an Nar period at the site of Rakhat al-Madrh (RaM), Tara Beuzen-Waller, Laurence Le Callonnec, Claude Cosandey, Stéphane Desruelles, Max Engel, Eric Fouache and Aleksandre Prosperini took part in the archaeological mission to Bat from February 18th to March 3rd 2023. In the frame of this mission, two areas were studied (see Figure 66), first the RaM topographic basin, 7 km upstream from the Bat oasis on the left bank of the Wadi al Hijr (Figure 66a), and secondly, in the framework of a collaboration between the Bat Archaeological Project (BAP) and the SIPO[13] project we also surveyed the doline[14] of Hayl Ajah (Al-Jabal Al Akhdar near Sint) (Figure 66b).

The objectives of this mission were:

In RaM

1) To open three new trenches (S6, S7 and S8) with a mechanic shovel in order to complete the study of the sedimentary filling of the small basin of RaM initiated in 2022. The aim of this local-scale study nearby an Early Bronze age habitat is to collect paleo-environmental information at the scale of the Holocene and in particular for the Early Bronze age period (Umm an-Nar). One additional trench (S9) was opened in a small morphological depression west of RaM, to compare its sedimentary infilling with the main depression. A total of 348 sediment samples have been collected for several analyses including phytolith, sedimentological,

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[7] French CNRS UMR 8591

[8] Sorbonne University Abu Dhabi, UR « Médiations Sciences des lieux sciences des liens »

[9] Heidelberg University, Institute of Geography

[10] Sorbonne Université Paris, IUF, UR « Médiations Sciences des lieux sciences des liens »

[11] Sorbonne Université Paris, ISTEP UMR 7193

[12] Université de Nice Côte d'Azur

[13] Archaeo-hydrological project SIPO of the Masaryk University (Brno, Czech Republic) directed by Inna Mateiciucová.

[14] The hydrological study (Part 2.3 of this report) shows that the hydrological functioning is not that of a polje, although Bonacci (2013) and Hoffman *et al.* (2016) have called it a polje. This is why we use the term doline, which refers more generally to a karstic dissolution basin.

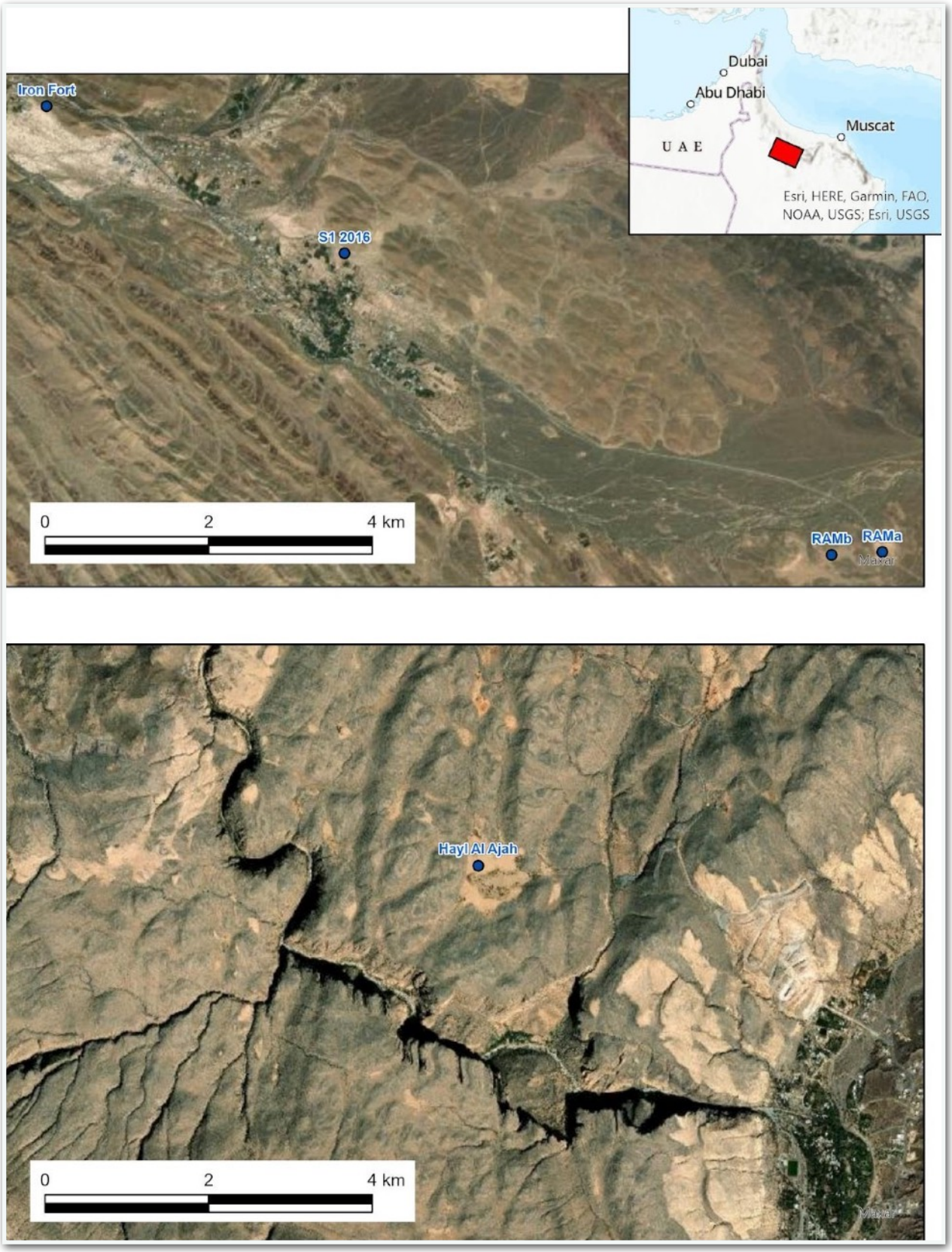

Figure 66. Location of the Iron Fort, of profile S1 in Wadi Sharsah, and of Rakhat al-Madrh (RaM A and RaM B) (a). Localization of Bat Oasis and the doline of Hayl Ajah (b).

geochemical and, potentially, palynological studies.

2) To complete by a sampling for geochemistry and sedimentological analysis on the section S1 previously studied in Wadi Sharsah (Desruelles *et al.*, 2016).
3) To extend the geological and geomorphological mapping of the water catchment area of the RaM Depressions (Figure 67).
4) To interpret the new geophysical data produced by ground-penetrating radar (GPR) and magnetometry from a geomorphological point of view.

In the doline of Hayl Ajah

5) To map the water catchment area and the geomorphological features of the doline in Sint in order to better understand formation of the doline, its hydrological system, and the sedimentation processes.
6) To study the sedimentary filling of the bottom of the doline. A total of 72 (35 samples by L. Callonnec and 37 samples by M. Engel) sediment samples have been collected.

We would like to thank all the members of the Bat Archaeological Project as well as from the SIPO 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.

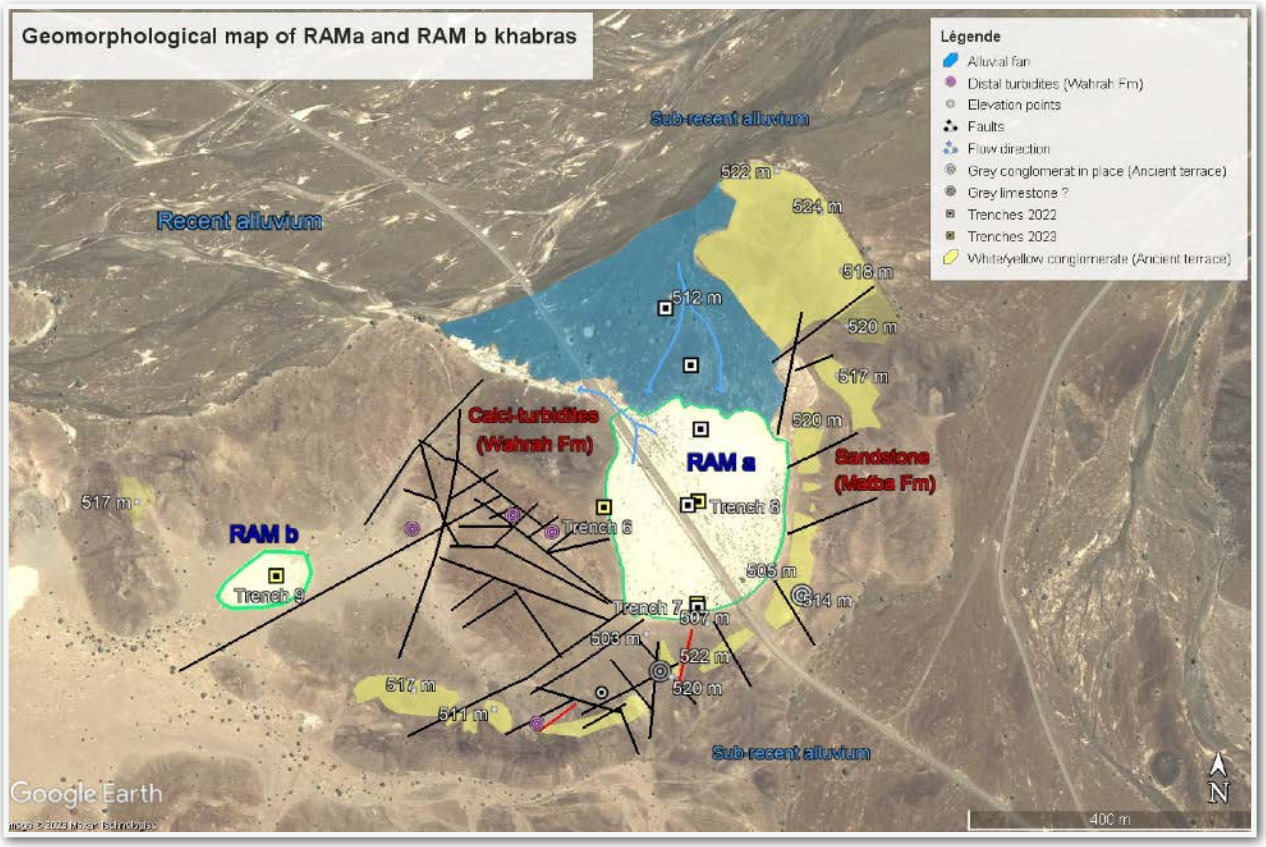

Figure 67. Geomorphological map of the RaM Area, comprising the larger khabra of RaM A in the east and the smaller khabra of RaM B with Trench 9 in the west (basemap: (24/4/2009, Image © 2023 Maxar Technologies).

8.2 Preliminary results from the RaM Basin

8.2.1 Geological and geomorphological study of the RaM Basin

The basin, located at an altitude of 542 m above sea level (asl), is surrounded by hills. The ridge lines to the west of the basin, which rise to an altitude of more than 550 m, are topped by graves of the Hafit period (3200-2700 B.C.). The contact between the bedrock of the slopes and the bottom of the basin is made by thin, gently sloping colluvial deposits. To the north, the alluvial terrace of the Wadi al Hijr is at least 1 m higher and is extended by a lateral fan which suggests the hydro-sedimentary filling of the basin during major floods of the Wadi al Hijr (Figure 67). The alluvial terrace forms a natural barrier to the water that accumulates in the basin during high floods. Drainage is directed to the northwest of the edge of the basin by a small overflow talweg, which is clearly visible on the Figure 67.

The geological mapping of the RaM Depressions and their surroundings is based on the geological map of Ibri (1/100000), Google Earth satellite imagery (24/4/2009, Image © 2023 Maxar Technologies), a drone-based orthophotograph created by the BAP in 2022, and own field observations.

The bedrock framing RaM is located at the boundary of two different formations of Jurassic sediments (Figure 68). In the north-eastern part, the topography is relatively flat and corresponds to dark well-sorted and fine sandstones which can contain muscovite (Figure 69a). They can be attributed to the Upper member of the Matba formation (Mb2) which is observed on the geological map in the wadi (Minoux and Janjou, 1986).

Several hills surrounding the southern part of the khabra consist mainly of proximal and distal calci-turbidites with sand-grade, flat and/or cross-laminations (Figure 69b). Locally, between fault crossing, red to green/white radiolarian or siliceous silts occur alternating with finer grained distal turbidites (Figure 69c). These calci-turbidites are described in the Lower member of the Warah Formation (WaL) (Minoux and Janjou, 1986). The boundary between the Matba and Wharah formations was observed near the road crossing RaM A in the north-east (red lines in Figure 67).

Ancient alluvial deposits *sensu* Minoux and Janjou (1986) are generally found at higher elevations around 511–524 m asl. They surround the depression in the north, east and south. They are discontinuous due to erosion and recent faulting. They correspond mainly to a polygenic, round and very coarse-grained conglomerate (*poudingue*). The lithoclats' granulometry is from sub-cm to >50 cm and corresponds to the erosion of all rock types present in the watershed (peridotites, gabbro, calcareous sandstone, turbidites, radiolarite, cherts, white limestone etc…). They are embedded in a whitish-yellow sandy carbonated matrix (Figure 69d). Coarser grained, unsorted levels alternate with more sandy lenticular beds. The thickness of these deposits fluctuates between less than 20 cm (in the south part) to 10 m (in the north part), where the recent wadi eroded a steep cliff. The conglomerate is described on the geological map as ancient alluvium

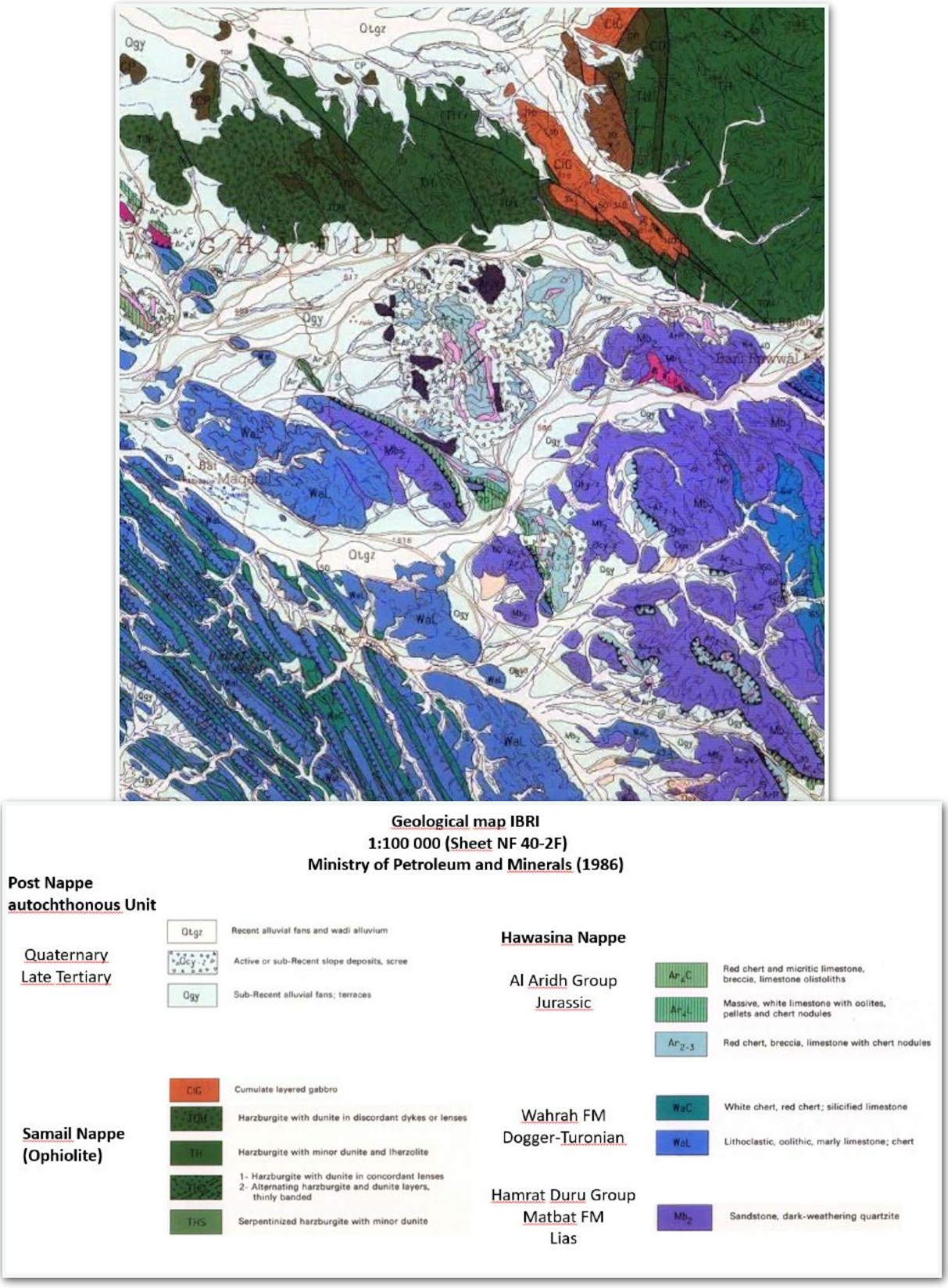

Figure 68. Geological map of the watershed of the RaM khabra extract from the geological map of Ibri (1:100000, NF 40-2F). The red rectangle indicates the studied area (from Minoux et Janjou, 1986).

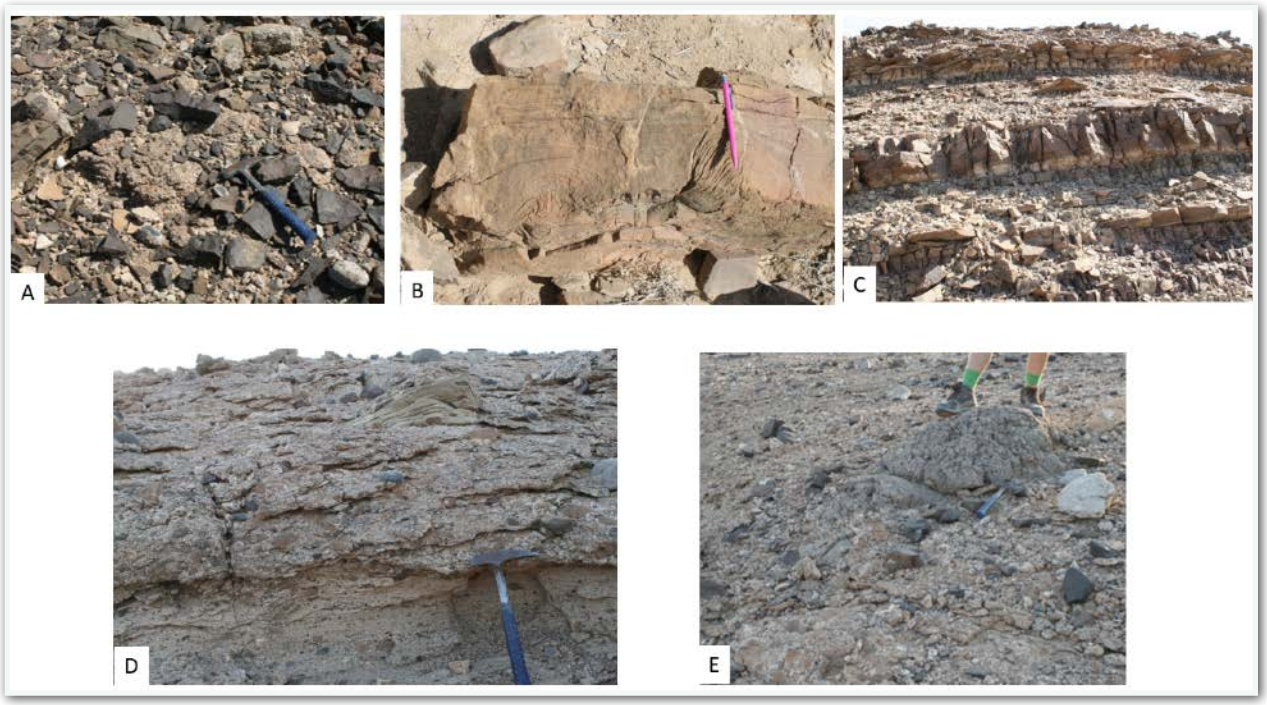

Figure 69. Outcrops and formations observed in the RaM A and b khabra. A: Black sandstone (Matba Fm). B: Proximal calci-turbidites (Wahrah Fm). C: Distal turbidite and hemipelagic sediments (radiolarite and siliceous silt, Wahrah Fm). D: Ancient alluvial terraces (white/yellow conglomerate). E: Ancient alluvial terraces (grey conglomerate).

fan and terraces (Qgx). They built the main relief observed on the north part of the depression.

This first ancient alluvial deposit has been partially eroded by a second whitish grey alluvial conglomerate. The original contact between these two conglomerates was identified at only one location (Figure 69e). Some scattered blocks are present on top of the whitish yellow conglomerate. This second conglomerate contains coarse (few centimeter) rounded to sub-angular grains. The matrix is sandy, carbonated and grey.

Sub-recent and recent alluvium (Qgy and Qtgz) formed by active wadi processes cover the surface at a lower topography outside the depression (valley of Wadi Al Hijr).

The tectonic context (folds, faults and overthrustings) of the study area is quite complex. Old deformations are linked to the thrust-tectonic obduction of the Samail nappe and Hawasina nappe. The main striking direction of this deformation is NW-SE (Figure 68).

The neotectonic faults are linked to the Alpine orogene which affectes the bedrock sediments and also the alluvial deposits. Three main fault deformations are reported on the geological map: NNW-SSE, NE-SW and ESE-WNW (Minoux and Janjou, 1986). Our study of the deformations in the study area shows a major tectonic control of the morphology mainly by the old events (NW-SE). A more recent secondary

fault system (NE-SW) overlaps them. Several micro-fault compartments raise the distal calci-turbidites/chert and radiolarite or also grey mudstone.

This observed pattern suggests that the old deformation pattern seems to control the formation of the morphological depression of RaM A that later evolved into a khabra. We assume that theses faults running across RaM A led to localized tectonic subsidence. In contrast, the formation of the smaller kabhra RaM B seems to be controlled by the more recent Alpidic fault-direction system (Figure 67).

8.2.2 Hydrological remarks on the khabra of RaM (RaM A and RaM B)

The water measurements in Trench S8 (RaM A), as last year, show an increase in moisture with depth (Z) (from 1.15% at the subsurface to 6.2% at 1 m). It is not the case in the RaM B depression (Trench S9): at Z=40 cm, the moisture is 2.2 %, while it is only 0.6 % at Z=1.5 m depth.

This difference in humidity between the two profiles can be considered as proof of a source of humidity from the bottom of the depression, and therefore of a communication between the water table of the wadi and the bottom of the depression of RaM A. But it is not possible to know the form of this communication at the moment.

The surface of the khabra is at an elevation of ca. 542 m asl (Figure 70), and is characterized by a light color on the satellite image underlying on the Figure 67; its extension is ca. 6 ha. The northern part of the basin is closed by a lateral accretionary fan (ca. 1.5 ha) extending from the alluvial terrace of the Wadi al Hijr. A smaller fan related to a very small wadi close to the neighboring hill is embedded in it. It is therefore difficult to distinguish from that of the Wadi al Hijr. A threshold separates the small internal drainage line from the main Wadi al Hijr, but during major rainfall events this threshold may be overflooded.

The watershed of the basin is small. It corresponds to the top of the hills that frame it to the east, south and west. The north-western limit, which opens towards the wadi, is much less clear.

In addition, there is a low point to the northwest of the basin which, even if it is not very marked, allows for its drainage. This drainage explains the absence of endorheic features typical of arid environments, such as the intra-sedimentary formation of secondary evaporites that would lead to sabkha formation.

8.2.3 Geomorphological evolution of the area

The geomorphological analysis allows a reconstruction of the geomorphological evolution of the basin and helps to understand the processes leading to the formation of the khabra as a sedimentary environmental archive:

- The small intramountain basins RaM A and RaM B were created due to tectonic subsidence of a highly faulted zone (see section 8.2.1 and Figure 68).

Figure 70. Contour line of the RaM A area derived from a drone-based digital elevation model created by Paige Paulsen in 2022.

- During the (early to middle[?]) Pleistocene, the valleys and basins were filled by conglomerates ("ancient alluvial fans terraces"- QGx) including rounded pebbles ("poudingue") of different nature (volcanic, plutonic...) deposited by wadis, i.e. the whitish yellow and whitish grey conglomerates identified around RaM A (Figure 67).
- The conglomerates were eroded by supsequent wadis activity until today; ancient wadi deposits only preserved in topographical situations where they are protected by active wadi discharge. One of these settings is the study area, that in upstream direction is surrounded and protected by sub-recent alluvium (Qgy) *sensu* Minoux and Janjou, (1986), which is rarely flooded by the active wadi.
- We assume tectonic subsidence in the areas of RaM A and RaM B to have initiated after the formation of the conglomerates of ancient alluvium. This process created a connection to the Wadi al Hijr in case of RaM A. Consequently,

sediments were brought into this depression, presumably since the Late Pleistocene, raising the bottom compared to the RaM B, whose sedimentary contributions only derive from colluvial deposits of the surrounding calci-turbidites of WaL and whitish-yellow conglomerates (conglomerates and substratum).

- These sediments brought in by the wadi have the potential to carry signatures of Late Pleistocene to Holocene environmental change, the reconstruction of which is one of the main tasks of the geomorphological research activities at Bat

8.2.4 Samples collection and laboratory analyses done in 2022

In 2022a total of 117 samples were collected for the identification of phytolith. They were processed at College of William and Mary (USA) by Dr. Abigail Buffington). Moreover, 122 samples were collected for sedimentological analyses(grain-size analysis, petrographic analysis with X-ray diffraction, microscopy observations and geochemical analyses for organic and carbonates content). Sedimentological analyses were conducted at Sorbonne University Paris (Laboratory ISTEP) by Aleksandre Prosperini. Seven samples were collected for micromorphological studies. The thin sections will be produced in September 2023 and analyzed at AgroPariTech Paris.

Nine charcoal samples and three mollusk shells were collected for C^{14} dating (concentration of organic matter was generally very low), as well as six samples for optically stimulated luminescence (OSL) dating. The OSL dating at Illinois University is still in progress.

As it turned out that sample sizes for phytolith analysis in 2022 were too low in most cases, we decided to open three additional trenches (S6, S7, S8).

8.2.5 Description of the stratigraphic trenches done in 2023

In order to reconstruct the recent paleo-environmental history of this basin, we carried out three stratigraphic excavations in RaM A and one in RaM B. All excavations were described, sketched, and sampled for sedimentological and phytholith analyses. In Trench S8 we took additional sediment samples for a potential pioneer study of the pollen content.

Two further sediment profiles were sampled outside the RaM Area. In Wadi Sharsah, a profile already studied and published by Desruelles *et al.* (2016) was resampled for further analysis of potential pedogenetic processes related to climatic fluctuations. At Khutm, a sounding inside an Iron Age fort sitting on the lower slope of a hill framing the wadi was sampled for mineralogical, sedimentological and phytolith analysis.

8.2.5a Trench 6

Trench 6 is located near one of the excavated Umm an Nar dwellings (RaM 4), at the foot of the slope on the colluvial apron in RaM A. The trench reached a depth of 170 cm (Figure 71). The trench is characterized by sedimentation of sands and silts in slightly

varying ratios. The basis of the profile (F1, F2 : F here for sedimentary facies) shows gypsum precipitation in interstitial pores, with a sandy wedge (F2'). Further up, it contains occasional gravels (F3, F3'), mostly concentrated in a band at ca. 70 cm below surface (b.s.). Between 100 and 50 cm b.s. units are not horizontal, which might be the result of human intervention. A fireplace with high concentration of charcoal was identified and sampled individually at 50 cm b.s. in the left part of the profile. At this depth, terrestrial shells were identified and sampled, too. The uppermost layers (F6–F8) subhorizontally cover the irregular, disturbed surface of F4 and F5 and are again characterized by yellowish silty sand, topped by a thin, muddy polygonal crust at the surface. Samples were taken in increments of 5 cm, totaling to 34x3=102 for phytolith, mineralogy, sedimentology and geochemical studies.

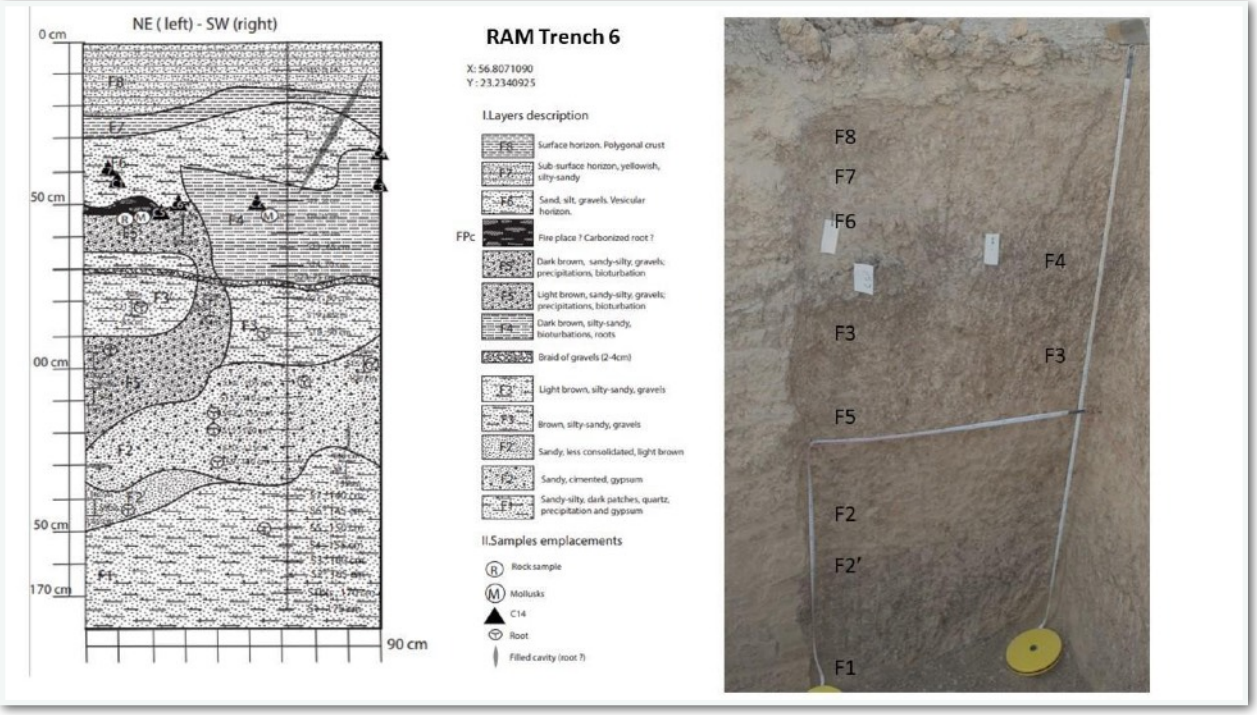

Figure 71. Trench 6 profile.

8.2.5b Trench 7

Trench 7 located near one of the excavated EBA building (RaM 1) at the foot of the slope on the colluvial apron in RaM A. The trench reached a depth of 140 cm (Figure 72). Trench 7 shows large, angular bedrock clasts of up to 20 cm, leading to the preliminary interpretation of weathered bedrock in F1. It is overlain by partially cemented sands and gravel (F2) as well as silty fine sands (F3, F4), followed by a coarser layer with a higher percentage of gravels above a wavy boundary (F5/6). F7 up to 50 cm b.s. represents colluvial sands with numerous carbonate concretions, followed by sandy silt (F8), partly cemented (F9) and surface deposits with a thin, muddy polygonal crust. Samples for phytolith analysis were taken in increments of 5 cm from 125 cm upwards (25), added by one sample per unit for mineralogy, sedimentology and geochemical analyses (7x2=14).

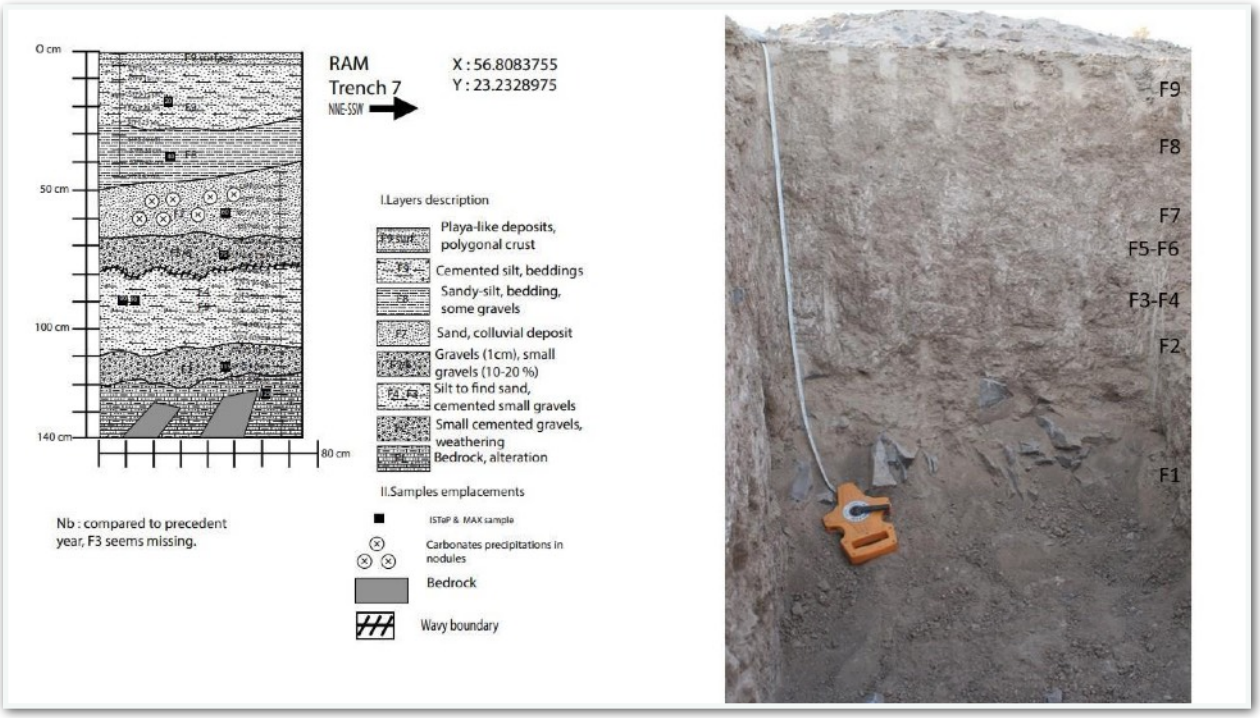

Figure 72. Trench 7 profile.

8.2.5c Trench 8

Trench 8 is located in the central part of RaM A. It reached a depth of 250 cm (Figure 73). The base of the trench is characterized by silt and sand, with crystals of halite and gypsum growing in the interstitial pore space (F0), added by carbonate concretions in F1. First small gravel components occur at 200 cm b.s. (F2). A significant clay component was documented at ca. 180–130 cm b.s.

The overlying unit F5 is coarser and shows gravel components embedded in the silt, along with rizoliths. F6 shows again clay and a seemingly higher content of organic matter and bioturbation. The remaining profile comprises silt with occasional gravel components and bioturbation features (F7), a vesicular horizon of silt and fine sand (F8), as well as a surface layer with a muddy, polygonal crust. Samples were taken in increments of 5 cm from 240 cm (48x3=144) for phytolith, mineralogy, sedimentology and geochemical studies. Furthermore, 12 samples for a potential pollen study were taken.

8.2.5d Trench 9

Trench 9 is located in the middle of the khabra RaM B. The trench reached a depth of 155 cm (Figure 74). The base is represented by a relatively coarse layer of angular gravel, with secondary evaporites (halite, gypsum) (F0). Similar to the stratigraphies of RAMa, the matrix of Trench 9 generally consists of silt and fine sand, but the concentration of angular gravel components is much higher in almost all levels. At

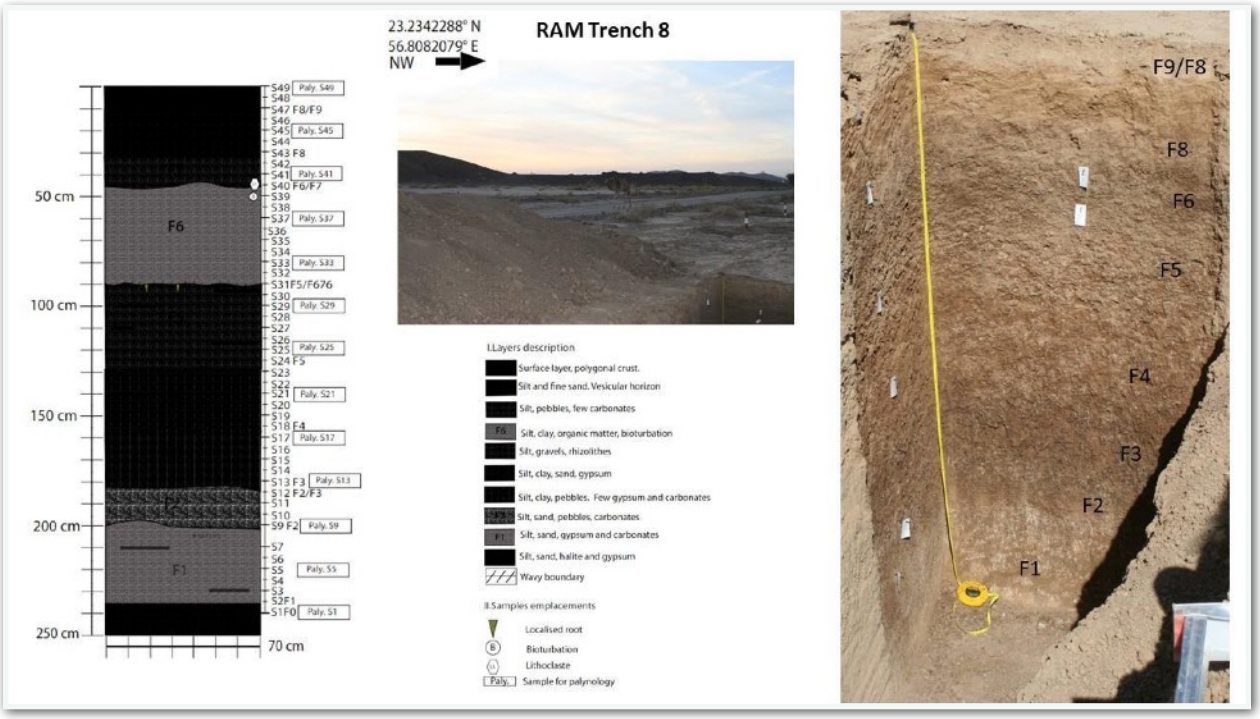

Figure 73. Trench 8.

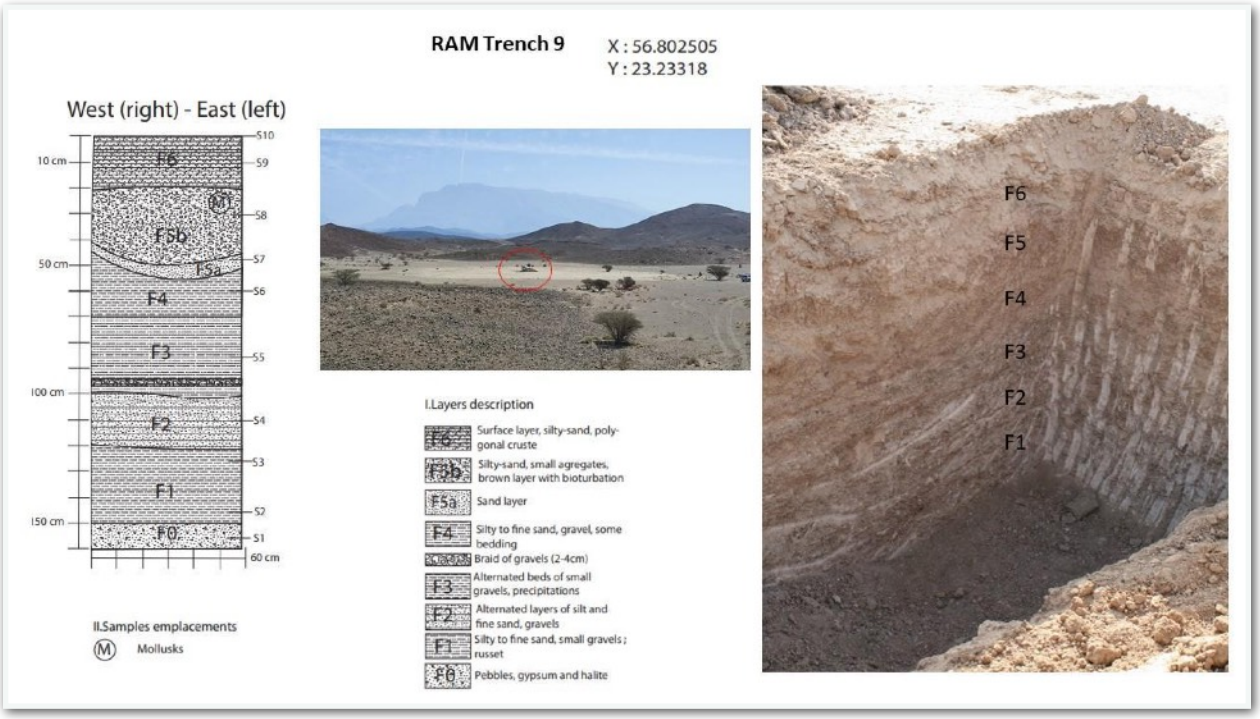

Figure 74. Trench 9 profile.

around 50 cm b.s. there is a peculiar sand layer (F5a), overlain by relatively pure brownish silt with bioturbation features and almost no larger components (F5b). The

top layer is again characterized by a muddy polygonal crust (F6). One sample per unit was taken for mineralogy, sedimentology and geochemical analysis (8x2=16).

8.2.5e Trench S1

Trench S1 is located 143 m northeast of Kasr al-Khafaji (Tower 1146) on the left bank of a small tributary of the Wadi Sharsah. It is described and analyzed in detail by Desruelles *et al.* (2016). In order to find more evidence for potential pedogenetic processes that may be linked to a more humid climate, the northern section of the profile was resampled for mineralogy, sedimentology and geochemical analysis (Figure 75). Even though not all units across the original profile were present in its northern part, all six phases that were previously identified by Desruelles *et al.* (2016) were captured.

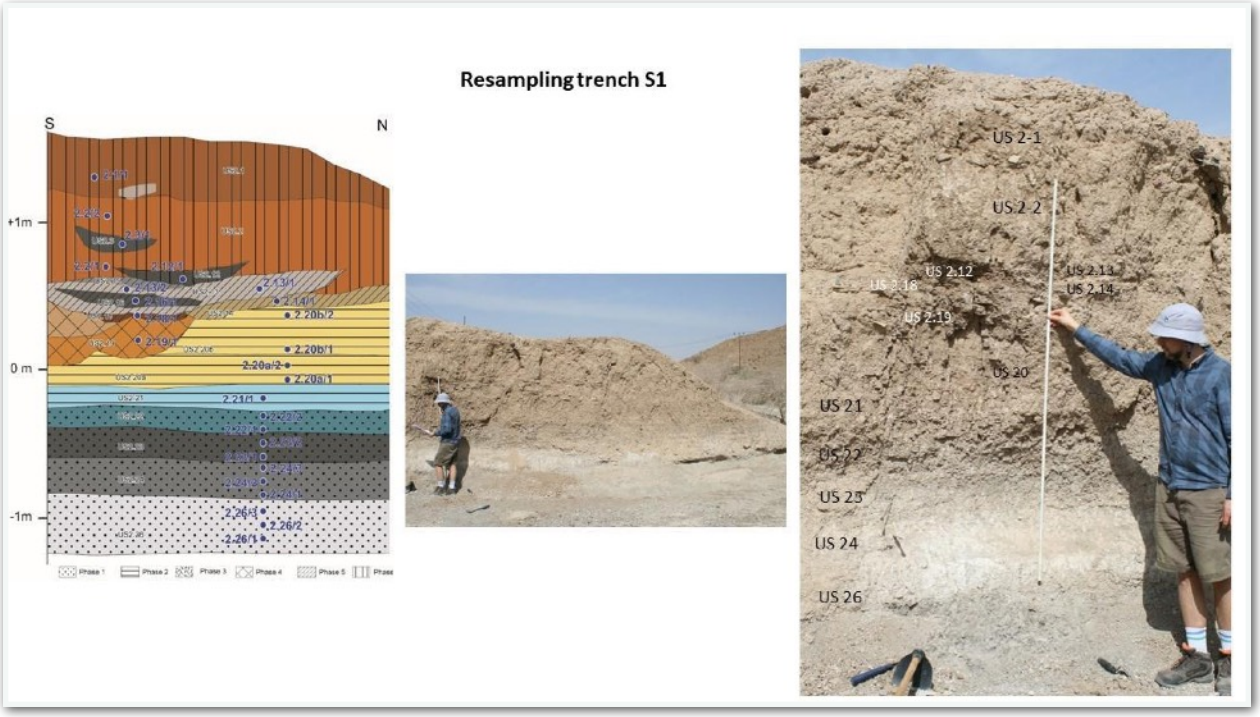

Figure 75. The northern section of Trench S1 in Wadi Sharsah with location of samples (modified after Desruelles *et al.*, 2016).

8.2.5f Trench KH (Khutm)

Profile KH corresponds to the northern section of a sounding created inside an Iron Age fort at the site of Khutm. The site is located at the foot of a low hill just above the wadi and strongly influenced by colluvial processes. These processes deliver poorly sorted sediments ranging from silt to fine gravel, with occasional angular larger gravel components. Several potential channel incisions were documented, such as in Layer 13, IX or VI. Trench KH contains two assumed occupation layers, i.e. Layers IV and V (Umm an Nar), and II (Iron Age), respectively (Figure 76). The main purpose of documentation and sampling of Trench KH was the generation of new phytolith samples to add information to the context of use of the site during the archaeological

Figure 76. Sketch and photograph of Trench KH with separation of individual layers and the location of samples (sketch by Robert C. Bryant, modified).

periods. Close to the base of Layer IV, charcoal was found and sampled for dating. In total 3x19=57 samples were taken for phytolith, sedimentological, mineralogical and geochemical analyses.

8.2.5g Preliminary interpretation of the excavations

The trenches in RaM A show moderate variation of sedimentation patterns, driven by accessibility of wadi inflow through the northwestern opening (sensitivity of the sedimentary archive) and variations in wadi streamflow. However, the matrices in all profiles are moderately to poorly sorted and dominated by silt and sand. Elevated amounts of clays, organic-rich or continuous evaporite layers born from pelagic rain in standing water bodies are entirely missing, indicating that the morphological depression never hosted a permanent lake body. However, spillover inflow from activated wadis may have remained in the depression for days, even weeks, creating ephemeral wetlands (see discussion on paleolakes/paleo-wetlands on the Arabian Peninsula in Engel *et al.* 2017). These ephemeral wetlands may have provided crucial resources for animal grazing and even cultivation of crops, which is being investigated by the phytolith analyses. It has to be tested by geochemical analysis whether the formation of clay in some of the more brownish layers in Trench 8 may be related to incipient soil formation under a more humid climate. A crucial element to any form of paleoenvironmental information derived from the khabra infill will be the OSL and C^{14} age dating results, which are pending at the time of writing.

8.3 Preliminary results from the doline of Hayl Al-Ajah (Al-Jabal Al Akhdar near Sint)

The new collaboration with the SIPO project at the Hayl Ajah near the village of Sint aims at the comparison of two Holocene environmental archives (RaM A and Hayl Ajah) that are only 35 km apart, but show a difference in elevation of 500 m. The collaboration furthermore aims at exploring possible connections between the archaeological records, as recently Hayl Ajah has been proposed to have had the function of a prehistoric refugium during times of aridization, supported by a substantial number of lithic findings of Late Neolithic, some possibly even Middle Palaeolithic and Upper/Epipalaeolithic techno-typological characteristics (Mateiciucová *et al.* 2023).

8.3.1 The geological and geomorphological setting of the doline of Hayl Ajah

The doline[15] is located within the central Al-Hajar Mountains, on the southern slope of the Jebel Kawr at 1019 m asl. The jebel is a high massif of Upper Triassic shelf limestones (800 m thick). These limestones are described as the Misfah Formation (Minoux & Janjou 1986). They consist of relatively tabular, light grey biolithoclastic limestone with large megalodontids still in place (see also Hoffmann *et al.* 2016). Decimeter to meter-scale beds are stacked lacking interbedded marls. Carbonate and/or possibly dolomitic recrystallisation may be abundant, as they are well observed in the megalodont shells. The limestone is overlain by Jurassic cherts and shales of the Nadan Formation, and a contact with the Hawasina ophiolite at the base is described in the geological map (Minoux & Janjou 1986).

The limestones are slightly folded with a general tilt to the NE. The dip is about 10 to 20° and an anticlinal structure has been observed (NW–SE) in the western part of the preliminary geomorphological map (Figure #), which has been produced during the three-day survey and sampling campaign at Hayl Ajah. Based on the mapping campaign, two main directions of fracturation are observed. The primary one is NE–SW and the secondary one is NW–SE. Folds and fractures are consistent with the main thrusting NW–SE direction described for this area (Minoux & Janjou 1986).

Fracturing of the limestone bedrock controls the dissolution of the limestone and the formation of a juvenile karst with very few cavernous landforms. These mostly comprise pipes and swallow holes at the surface (sometimes referred to as ponors[16], or more generally, as swallow hole) and pool, shallow channels which hold water after

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[15] The term polje was used by Hoffman *et al.* (2016). We use the term doline here, which refers more generally to a karstic dissolution basin in a more general sense (e.g., Bonacci, 2013).

[16] Ponors are defined as (1) 'a hole or opening in the bottom or side of a depression where a surface stream or lake flows either partly or completely underground into the karst groundwater system' or 'a hole in the bottom or side of a closed depression, through which water passes to an underground channel' (Field, 2002, pp 144–145). Ponors are usually located in the lowermost positions at the margins of a polje (Bonacci, 2013).

heavy rains and widened fractures like « aven[17] », which provide direct connections to the underground karst system, can be observed. Apart from this, fractures control the main directions of drainage in the underground (pers. comm. J. Otava).

From the steep slopes of the Jebel Kawr to the south-west, the karst plateau is separated by the deep gorge of Wadi Al-Ala' where springs are aligned parallel to major fault lines. In the middle part of the doline, a main infiltration zone is aligning with the principal tectonic structure (Figure 77). Swallow holes are located in the eastern part of this zone whereas small holes and linear infiltration features are observed in the main infiltration area of the central-western part. The doline is filled by aeolian silty and fine-sandy sediments which were transported by colluvial and alluvial processes in the small catchment area, but possibly also over larger distance by wind. Basal terra rossa

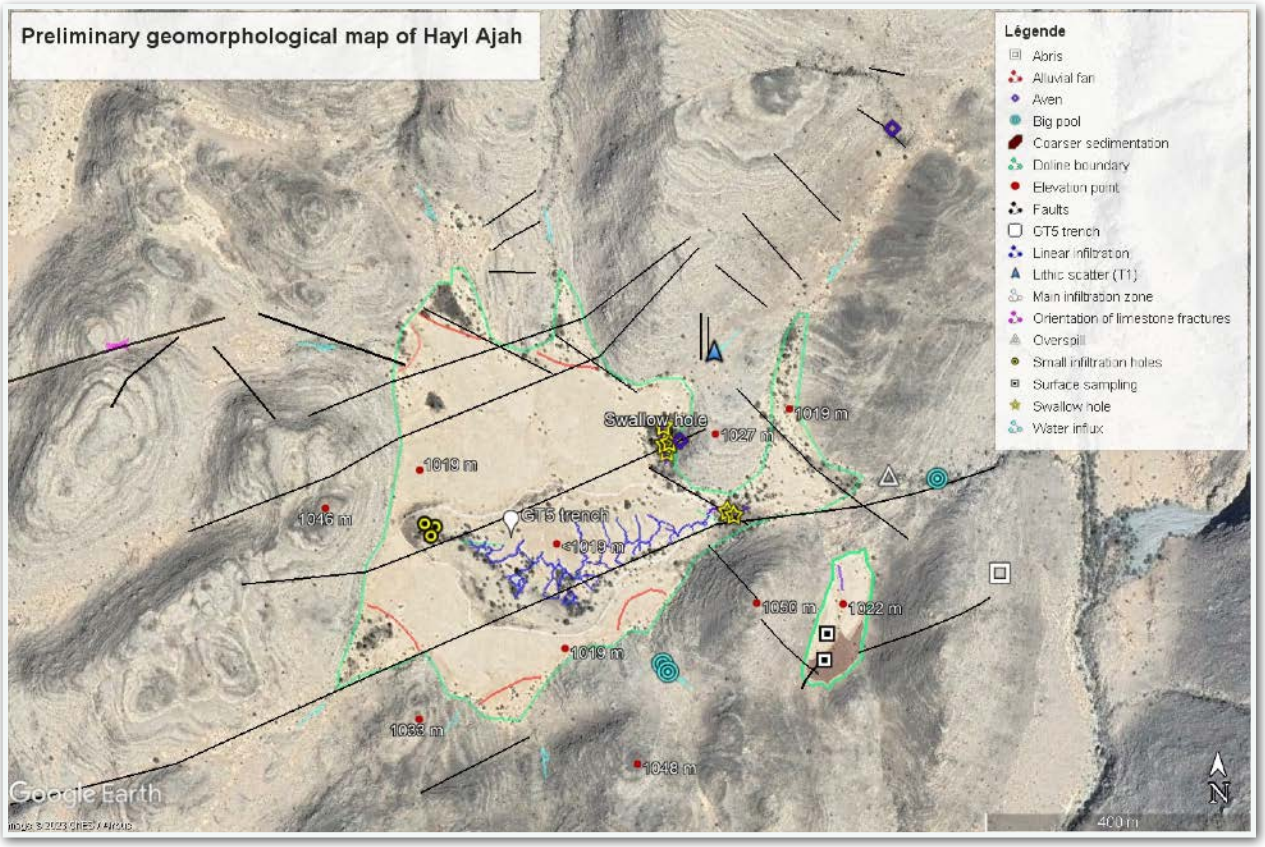

Figure 77. Preliminary geomorphological map of Hayl Ajah with underlying fault systems mapped during the field survey (basemap: (3/2023, Image © 2023 CNES/Airbus).

[17] The term 'aven' refers to 'a hole in the roof of a cave passage that may be either a rather large blind roof pocket or a tributary inlet shaft into the cave system' (Field, 2002, p. 14). In the case of the *aven* discovered in 2023, some metres above the drainage feature an E-W trending fracture can be found.

layers below the silt cover[18] have been described in several surrounding depressions (Mateiciucova *et al.* 2023). However, in the Hayl Ajah doline, this reddish substrate has not been reached yet, neither by the central borehole GC1 of 2018 (depth=4.1 m) (Mateiciucova *et al.* 2020), nor Trench GT5 of this year. To the south-east another NNE-SSW-trending elongated doline is also present (H12 in Mateiciucova *et al.* 2023) but without visible infiltration area.[19] Several small alluvial fans form at the margin of the doline where small wadis enter the depression (Figure 78).

During the survey and mapping activities, two samples of terrestrial gastropod shells, one rock sample and a piece of travertine from an abri to the east of the doline were taken for U-Th dating.

Figure 78. Preliminary geomorphological map of Hayl Ajah.

[18] Near the parking of the depression, a trench dug by the Czech team containing terra rossa and overlying sand and clayey silt layers was sampled for mineralogical, sedimentological and geochemical analyses (2x3=6 samples)

[19] At two sites with diverging surface sediment cover (silty and sandy/gravelly, respectively) samples were taken from the surface and at a depth of 10 cm for mineralogical, sedimentological and geochemical analyses (2x2x2=8 samples).

8.3.2 Trench GT5

Trench GT5 (Figure 79) was dug by the Czech team in the center of the infiltration area, close to previous core GC1, which revealed a peculiar sand-rich section at 325–145 cm b.s., overlain by a brownish silt-dominated layer with elevated content of total organic carbon (TOC) (Mateiciucova *et al.* 2020). This sandy layer and the brownish layer with higher TOC, the latter possibly reflecting more humid conditions and denser vegetation, were also encountered in GT5 at a similar depth. Samples for mineralogical, sedimentological and geochemical analyses were taken at increments of 10 cm from 240 cm b.s. upwards, totaling to 2x26=52.

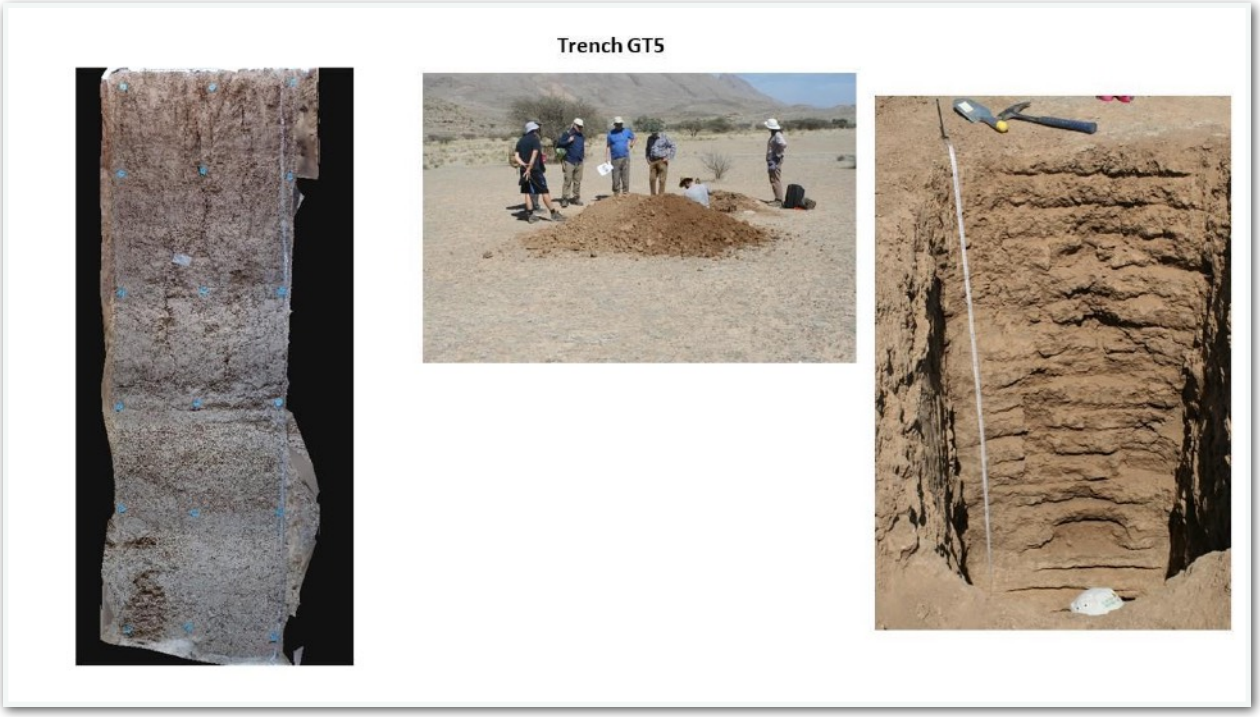

Figure 79. Trench GT5.

8.3.3. Hydrological survey at Hayl Ajah

Apart from karstic environments, the approach to study the functioning of a hydrological object is generally based on balance calculations: Using data measured in the field as much as possible, the aim is to understand the processes by which the inputs (through precipitation or external contributions) are transformed into outputs (throughflow and/or evaporation). This study requires knowledge of the system's input and output data, as well as the various water paths in the basin (runoff/infiltration), such as storage locations and times.

First of all, it should be pointed out that in a karstic environment, the notion of hydrological balance is particularly complex. Indeed, if it is possible to define a catchment area, at least topographically, it is far from being the same for the underground basin.

By definition, the topographic basin corresponds to the surface – i.e. the catchment area – whose gravity drainage leads to the outlet of the area under consideration. In the case of Hayl Ajah, there are several clearly identified outlets: two swallow hole areas, both located at the edge of the slope in the eastern part (Figure 77). An aven, located upstream of a gully feeding the doline, which therefore absorbs part of the upstream flow (Figure 77).

Finally, an infiltration zone in the middle of the basin, very clearly visible on satellite images, which corresponds to a slightly depressed area in which water accumulates and lasts for several days or even longer after rainfall events. And to complete the picture, a low point that can serve as a surface outlet can be seen at the eastern end of the doline (overspill = white triangle in Figure 77).

Regarding the contribution of the slopes, the question is also somewhat complex. The delimitation of a topographic catchment area is still under debate and the northern appendix shown Mateiciucova *et al.* (2023) needs to be verified in the future. Furthermore, there is no impermeable level at the bottom of the basin. This means that part of the runoff that forms on the slopes of the topographic catchment area during intense rainfall, and which infiltrates into these highly faulted and fractured limestone rocks, may only reappear much lower than the altitude of the doline, and is lost for its supply. This is demonstrated by the permanence of downstream flows, such as the one observed in the wadi at Sint village (Figure 80) or those providing irrigation for the small historical wadi oasis in Wadi Al-Ala', below the Hayl Ajah.

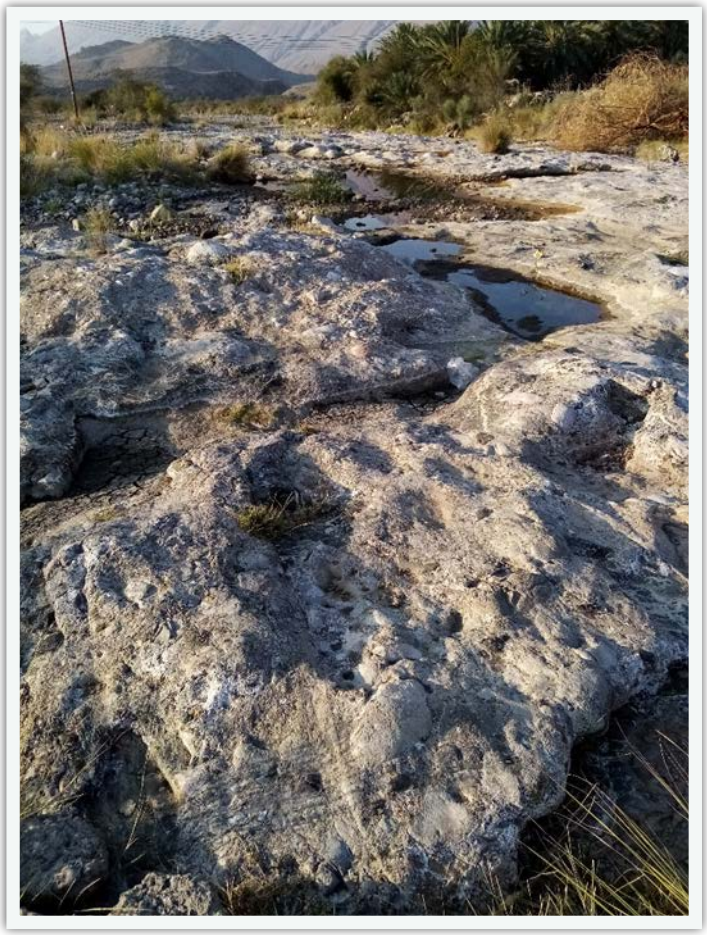

Figure 80. Permanence of flow in the Wadi at Sint.

This completely changes the hydrological conditions compared with a 'real' polje, and is obviously not without consequences for the use that can be made of it by human societies.Thus, the term "polje" will therefore not be retained for this large karstic depression whose drainage system is essentially underground, neither from a geomorphological nor a hydrogeological point of view.

Therefore, the term “doline” is used. Similarly, the term "ponor" will not be retained for the swallow holes at the bottom of the slopes, even if there is no clear evidence that they function as siphons. We will thus use the term “swallow hole.”

8.3.4 How to study the hydrological functioning of the Doline Hayl Ajah?

Apart from karstic environments, the approach to study the functioning of a hydrological object is generally based on balance calculations: Using data measured in the field as much as possible, the aim is to understand the processes by which the inputs (through precipitation or external contributions) are transformed into outputs (throughflow and/or evaporation). This study requires knowledge of the system's input and output data, as well as the various water paths in the basin (runoff/infiltration), such as storage locations and times.

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Finally, an infiltration zone in the middle of the basin, very clearly visible on satellite images, which corresponds to a slightly depressed area in which water accumulates and lasts for several days or even longer. And to complete the picture, a low point that can serve as a surface outlet can be seen at the end of the doline (overspill in Figure 67).

Regarding the contribution of the slopes, the question is also somewhat complex. The delimitation of a topographic catchment area is still under debate and the northern appendix shown Mateiciucova *et al.* (2023) needs to be verified in the future. Furthermore, there is no impermeable level at the bottom of the basin. This means that part of the runoff that forms on the slopes of the topographic catchment area during intense rainfall, and which infiltrates into these highly faulted and fractured limestone rocks, may only reappear much lower than the altitude of the doline, and is lost for its supply. This is demonstrated by the permanence of downstream flows, such as the one observed in the wadi at Sint village (Figure 80) or those providing irrigation for the small historical wadi oasis in Wadi Al-Ala, below the Hayl Ajah.

The dip of these highly stratified layers plays a major role as the circulation of water is conditioned by the spaces between the compact rock layers. When the dip is correct, i.e. in the same direction as the slope, water can circulate gravitationally in the

thickness of the soil and emerge well downstream of its point of fall, without taking into account the surface topography.

Thus, rainwater may emerge in the doline which, topographically, has fallen outside of and higher than the watershed boundary. On the other hand, if the dip is the opposite of the topographic slope, there is a good chance that most of the rainfall will not reach the doline, unless it is collected by a gully.

If sub vertical fractures of the limestone massif are probably even more important for the underground drainage of the Hayl and its surroundings, it is possible that its role on the circulation of runoff water, during rainy episodes, is not totally negligible.

Under these conditions, it is clear that the classical hydrological balance approach is not the most appropriate to understand the hydrological functioning of such an environment. The hydrological approach will then be different. No estimate will be proposed based on the volumes of water likely to enter the doline. Only field observations will be taken into consideration, which will allow us to understand how water circulates and accumulates in the different areas. And it is the geomorphological study that will enable us to understand this functioning.

On the other hand we have to consider during and after heavy rains not only underground drainage of the doline in the direction to resurgences (oasis Amqah and another unnamed oasis to the north). Contemporary inflow of underground water from elevated slopes to the N, NE and NW has to be taken into account as controlled by a combination of subhorizontal bedding and subvertical systems of fractures. The catchment area and the capacity of such underground sources are at least one order of magnitude higher than the the capacity of the surface catchment area alone. Hayl Ajah represents the most distinct local depression of the area.

8.3.5 Field observations

The field observations concerning swallow holes 1 (Figure 67) are as follows: Rather than a single chasm, it is a succession of basins in which the high-water marks bear witness to the presence of water that is absorbed by infiltration (Figure 81).

However, no gully, no notch of the edges of the depressions indicates a somewhat higher-energy runoff, which shows that the drained surface is not very large, and that the absorption flow of the doline is not violent. But while this is probably true for relatively minor rainfall events, for more serious events a part of the water may come from a wider catchment as underground flows, if one considers the ruggedness of the rock surfaces in the research area. The violence of these flows can be seen in the video provided by a local resident.

The zone of Swallow hole 2 (Figure 67) has similar aspects, although it receives a concentrated flow from the linear wadi inflow from the north-east (gully R1). Immediately to the west, a possible topographical threshold (Figure 67) should be

noted, which may limit the inflow of Swallow hole 2 to the area to the east. However, this threshold, if at all, is lower than 1 m, which awaits verification from the drone-based survey led by Robert C. Bryant from the BAP. The potential, very low threshold can be submerged during episodes of flooding, limiting the maximum height of the perched water table that forms in the doline. Regarding the runoff, there are only concentrated runoff forms in the two "gullies" of any importance, i.e. the wadi inflow in the north-east (gully R1) and the one entering the doline in the central-western part (gully R2) (Figure 81).

Figure 81. Flood leashes at the mouth of a swallowhole in swallowhole zone 1

In the case of the northeastern wadi (R1), there is a partial loss in an aven halfway along its course. Moreover, the flows seem to end up either in swallow hole 2, or by surface flow through the overspill of the doline, thus escaping the supply to the central zone (Figure 67).

At the contact between the bottom of the slopes and the sedimentary deposits there are only little traces in the form of small alluvial fans, and we do not see more abundant herbaceous vegetation which would develop during rainy periods. On the other hand, it is on this peripheral strip that most of the shrub or tree vegetation develops, which takes advantage of the water brought in by surface and sub-surface runoff from the slopes. These inputs are able to feed a water reserve that is sufficiently abundant to allow its maintenance. It should be noted that this vegetation is clearly more abundant along the edges of the doline where the dip is conform (Figure 82).

Traces of sheet flow coming from the slope were only clearly identified at the mouth of the gully which drains a small swallow hole to the NNE of the basin (Figure 83).

Figure 82. General view of the doline. We note a greater density of shrub or tree vegetation on the northern bank of the depression, where the dip is mostly conformal.

Figure 83. Traces of sheet flood in the north-western part of the doline, flow from the slope whose limit is marked by the more abundant vegetation.

This may be different for the more central part where there are more abundant vegetation patches upon deeper sediment inside the infiltration zone.

Muddy polygonal crusts can be seen at the surface of the entire doline, showing the stagnation and infiltration of water. These crusts are often thin, but more so in the central depressed part, where deep desiccation cracks can be seen, which testify to the thickness of the clay-rich level (Figure 84).

Figure 84. Surface crusting, desiccation cracks and an initial linear zone of infiltration into the soil resulting from subsurface karst solution, collapse or, most likely, suffosion.

The surface geometry of the doline shows that there is an infiltration zone (Figure 67), in which the surface drainage network was formed by suffosion; this explains why certain gullies are only expressed on the surface by simple depressions that are still not very marked in the landscape, whereas others are deeply cut into the surface, ensuring that the water from the peripheral parts of the doline is distributed in the central area as it arrives. This depressed central part of the doline has a set of gullies with a somewhat anarchic layout that seems to constitute the drainage network of this area (Figure 85–87).

These are small, metric-sized, low-slope channels that can be either open, showing significant clay deposits and traces of runoff, such as floods marks (Figure 85), or be visible in the landscape only as a sunken line (Figure 87).

This network has no outlet outside the doline, except, as we have seen, when the level of the water table that forms there is high enough. A temporary perched water table is formed during rainy episodes (Figure 88).

This water table persists first in a generalized form, then only in the small gullies, until complete infiltration. Based on information by a local shepherd who takes his goats to drink, the presence of water can last up to two weeks after the rainfall event.

8.3.6 Hydrological functioning and water storage in the Doline

These observations make it possible to describe the hydrological functioning of the doline during rainy episodes:

Initially, the rain that falls on the surface of the doline infiltrates despite the relatively low permeability, due to the abundance of infiltration cracks, especially in the central area of infiltration (Figure 67). However, these cracks soon become blocked, the surface closes and a generalized water table is formed, concentrating in the more depressed central part. In addition to this direct precipitation, there is runoff from the slopes.

Figure 85. Central part of the doline with a junction between three canals of infiltration.

Figure 86. Junction of infiltration canals with a high-flood mark.

Figure 87. Tracing of a gully in the process of formation.

Figure 88. Linear infiltration features filled with water after a rain event, Photo: Inna Mateiciucová, Archiv PANE December 2019.

It is only when the level of the perched water is sufficient to cross the threshold which limits the basin to the east, that a surface flow evacuates the surplus water from the system. The quantity of water retained in the basin depends on two factors: (1) the exact geometry of the doline bottom where the water table is located, which determines the volume stored on the surface before overflow, (2) the duration of the rainy episode, to which the duration of the overflow phase is added and prolonged substantially by following underground supply. During this phase, infiltration feeds the water reserve, which is added to the recharge that will result from the infiltration of the temporary perched water table. It should be noted that this volume does not depend on the height of the rainfall, as soon as it has been sufficient to fill the basin.

8.3.7 Preliminary conclusion

The original fault system at the origin of the doline formation explains its capacity to constitute important water reserves at different levels:

- At the surface, the maintenance of a perched water table can be used by the herds for several days;
- the reconstitution of the soil's water reserve allows a vegetation cycle to develop, providing an opportunity for grazing (Figure 88);
- a cropping cycle, such as "flood recession cropping", should be possible;
- the reconstitution of deep reserves allows the permanence of tree vegetation where water inflows are most abundant, along the margins of the doline and in the central depressed zone.

8.3.8 Further studies

Resolving the fine topography of the doline surface would make it possible to specify the overflow levels and the volumes likely to be stored in the basin. The detailed and precise observation of the slopes should make it possible to refine an approach to the runoff coefficient and the slope contributions. Finally, a more systematic interview survey among local shepherds would allow for more precision regarding the location and duration of surface watering points.

It is also important to try and refine our knowledge of rainfall by collecting all the existing data in the region. The installation of an easy-to-use total rain gauge, either on the site itself or in the village, would provide essential data.

9. Environmental Survey

Rebecca Swerida

9.1 Introduction

BAP incorporated a study of ecological resilience across multiple sites during the 2022-2023 field season. The assessment was a continuation of initial efforts started during the 2021-2022 field season to understand current day ecological resiliency and resources. This may inform 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 ancient Omanis 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 flash 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 from the resilient adaptations and lifestyles of the Bronze Age people of Bat.

Increasing our knowledge of modern day ecosystem conditions at archaeologically significant sites in Bat, Oman broadly benefits the understanding of both human and ecological communities of the area in both present day and ancient times. The investigation of ecological integrity and indicators of ecological resiliency have garnered increasing interest and priority in light of climate change impacts as well as increasingly complex anthropogenic relationships with natural resources. We can continue to develop a more thorough and complex picture of the ecological condition, integrity, and resiliency of significant sites by building on previous seasons of observations of habitat characteristics. In addition to adding a second year of abiotic and vegetation habitat condition observations, developing a valuable time series of data, a huge amount of information can be gathered with relatively low resource investment through the use of camera trapping techniques. Deploying trail cameras at significant sites will provide basic information about wildlife usage of the habitat and an understanding of higher trophic level resiliency of the ecosystem. Many research questions can be considered through this investigation such as how ecological resiliency

may vary across ancient settlement sites, by relation to apparent water catchment resources, and in reference to modern and ancient climate conditions.

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 continued to investigate indicators of ecological resilience in areas where evidence has been found of ancient settlement. Archaeological and cultural knowledge of the area informed the choice of study site. Several sites were revisited after initial survey in the 2022 field season and several new sites were added. Each identified site was subdivided into sampling elevation transects based on apparent water availability and management classifications. The following sites and elevation transects were sampled during this field season (Figure 89):

- Settlement Slope: High, Low (including wadi bed)
- Rakha al-Madrh (RaM) A: High, Low
- Rakha al-Madrh (RaM) B: High, Low
- Rakha al-Madrh (RaM) C: High, Low
- Rakha al-Madrh (RaM) D: High, Low
- Khutm: High, Low (including wadi beds)
- Dry Falaj: Falaj Neutral, Falaj Channel, Drainage

Five meter squared sample plots were haphazardly placed within each elevation transect 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. Additionally, sediment samples of representative conditions were collected and processed using graduated sieves for grain size ratio. Each plot and each species encountered was photographed (Figure 90). 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.

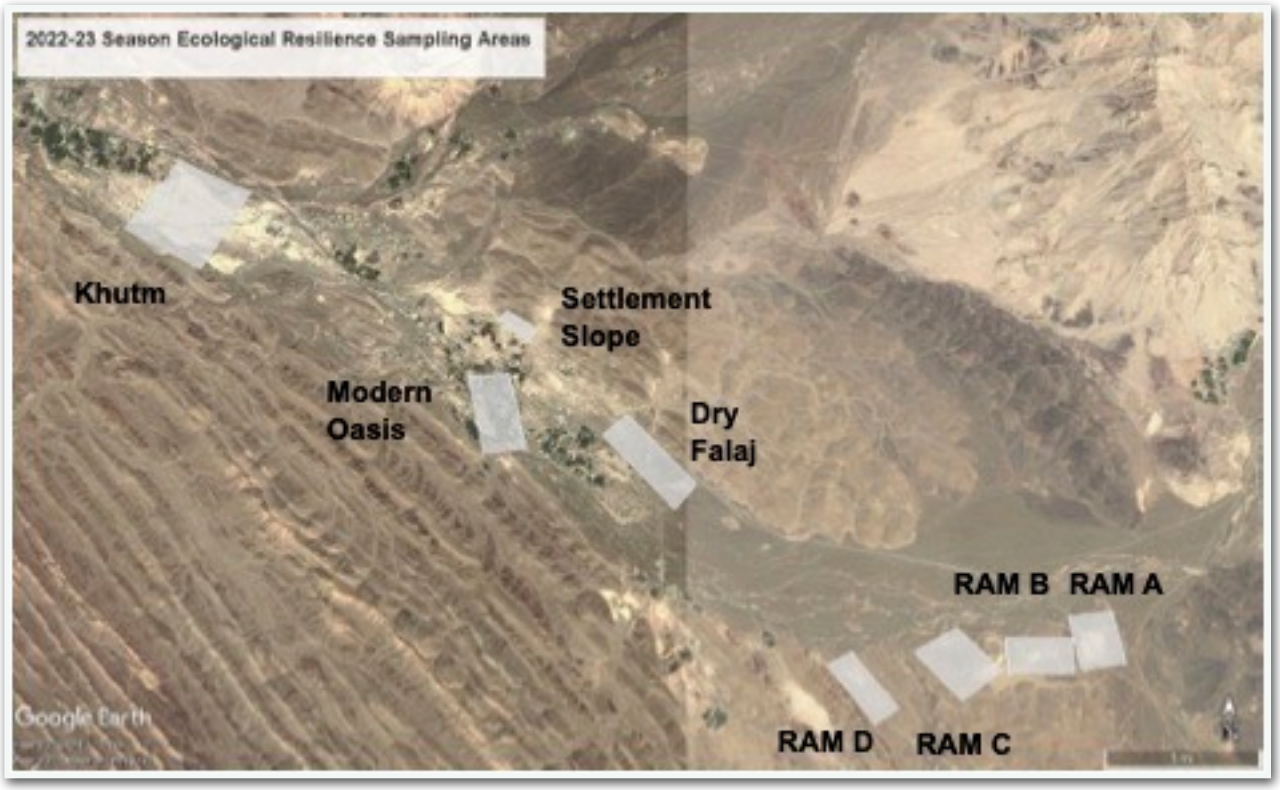

Figure 89. Map of the Bat, Oman region highlighting the areas sampled for assessment of modern day ecological resiliency at areas of ancient settlement.

Figure 90. A sample plot observed at the RaM C Low site containing a *Salsola* species, *Acacia* species and *Rhazya stricta*.

The modern oasis at Bat was generally observed as an example of actively managed and cultivated habitat. Formal plots were not observed at this site, but instead a walking survey was conducted, noting all vegetation species observed.

In addition to observations of vegetation and sediment characteristics at several sampling sites, motion sensitive wildlife cameras were deployed to assess the animal use of each habitat (Figure 91). Cameras were attached to posts in pairs set at approximately chest and knee height in order to capture wildlife activity at various scales for at least 10 days per location. The Browning wildlife cameras were set to high sensitivity so that animal motion within the range of view would result in a rapid burst of 3 photos.

9.4 Preliminary Results

As anticipated, sampling areas with lower elevation, finer sediment, and an assumed higher rate of seasonal moisture accumulation were observed to support the highest coverage and diversity of vegetation. By far the most unique site observed was the modern oasis at Bat, the only site containing standing water at the time of sampling. A total of 54 species were observed during the walking survey. This quantitatively demonstrates the obvious effects and ecological shifts caused by active water resource management and cultivation. The level of water resource management and cultivate at each of the ancient settlement sites surveyed is unknown, but may have resulted in some level of similar ecological change.

Overall, the most vegetative biodiversity at ancient settlement sites was observed at Khutm and the Dry Falaj. Both of these sites encompassed a variety of low elevation habits such as wadi beds, drainage washes, and disused falaj channels. The sites with the fewest vegetation species observed were the RaM D, A, and B sites (Figure 92). Specifically, only 5 to 6 species were observed in the High elevation sampling areas of each site where there was coarser sediment with presumably lower nutrient availability and moisture retention. The average number of stems per plot and the average number

Figure 91. Examples of wildlife cameras at RaM A High (left) and Low (right).

Figure 92. Rhazy stricta, observed at the RaM A Low sampling area. This plant was named for an ancient Arabian physician and is used for traditional medicine today.

of species per plot showed very similar trends across sampling sites. The average percent cover of vegetation per plot showed less difference across sampling sites, but a clearly greater percent cover at lower elevation plots than at higher elevation plots.

The wildlife use of ancient settlement site habitat as captured by the motion sensitive wildlife cameras showed a wide variety of both domesticated and native species. There were fewer observations of wildlife at high elevations than low elevations and a variety between sites. A greater number of cameras should be deployed for a greater length of time to quantitatively assess the wildlife habitat use at each settlement site. This preliminary observation effort resulted in a very useful preliminary assessment showing a variety of species and frequency of observation. Domesticated goats and camels were most frequently observed (Figure 93), followed closely by Arabian foxes (Figure 94). Additionally, several bird species, lizards, rodents and hedgehogs were observed.

A statistical summary of collected environmental data is provided below (Tables 19-22).

Figure 93. Camel captured by wildlife camera at the RaM C.

Figure 94. Arabian fox captured by a motion sensitive wildlife camera at the Settlement Slope.

Sampling Area	Plot Category	Total Plant Species Observed	Mean Plant Species Per Plot	Mean % Vegetation Cover	Mean Stem Density Per Plot
Dry Falaj	Falaj Channel	16	6.6 ± 1.2	11 ± 3.7	156.4 ± 76.7
Dry Falaj	Neutral	11	4.2 ± 1.5	31.2 ± 15.3	22.4 ± 11.4
Dry Falaj	Drainage	26	8.7 ± 1.0	33.3 ± 4.2	29.2 ± 4.1
RaM A	High	5	1.2 ± 0.3	7.5 ± 5.5	3.0 ± 1.9
RaM A	Low	13	3.3 ± 0.6	30.7 ± 4.6	7.1 ± 1.9
RaM B	High	5	1.4 ± 0.5	10.9 ± 5.6	3.9 ± 1.9
RaM B	Low	14	3.4 ± 0.7	29.3 ± 6.2	15.9 ± 2.6
RaM C	High	9	2.8 ± 0.7	15.8 ± 6.8	5.8 ± 1.6
RaM C	Low	11	3.5 ± 0.5	36.5 ± 7.5	10.9 ± 1.92.0
RaM D	High	6	2.0 ± 0.3	13.6 ± 5.3	8.6 ± 1.9
RaM D	Low	8	3.2 ± 0.5	40.0 ± 4.5	9.0 ± 0.5
Settlement Slope	High	9	1.9 ± 0.4	11.3 ± 3.6	5.8 ± 2.4
Settlement Slope	Low	17	5.6 ± 0.4	24.6 ± 6.6	11.6 ± 2.0
Khutm	High	13	4.0 ± 1.1	10.3 ± 6.1	23.2 ± 10.1
Khutm	Low	33	5.0 ± 0.6	47.4 ± 6.0	16.1 ± 2.4
Modern Oasis	NA	54	NA	NA	NA

Table 19. Summary of species diversity, ocular estimation of percent vegetation cover (at multiple canopy levels) and stem density at sampling plots.

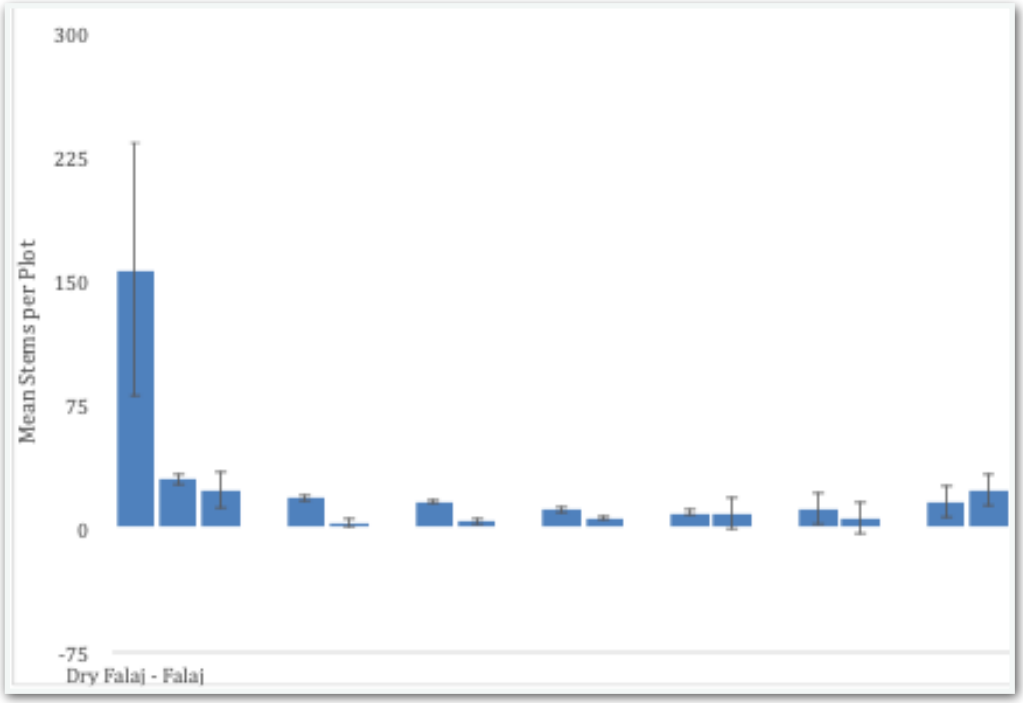

Table 20. Mean (± standard error) density of vegetation stems observed per plot. Note that the Dry Falaj – Falaj Channel plots often included dense grasses within the dry channel.

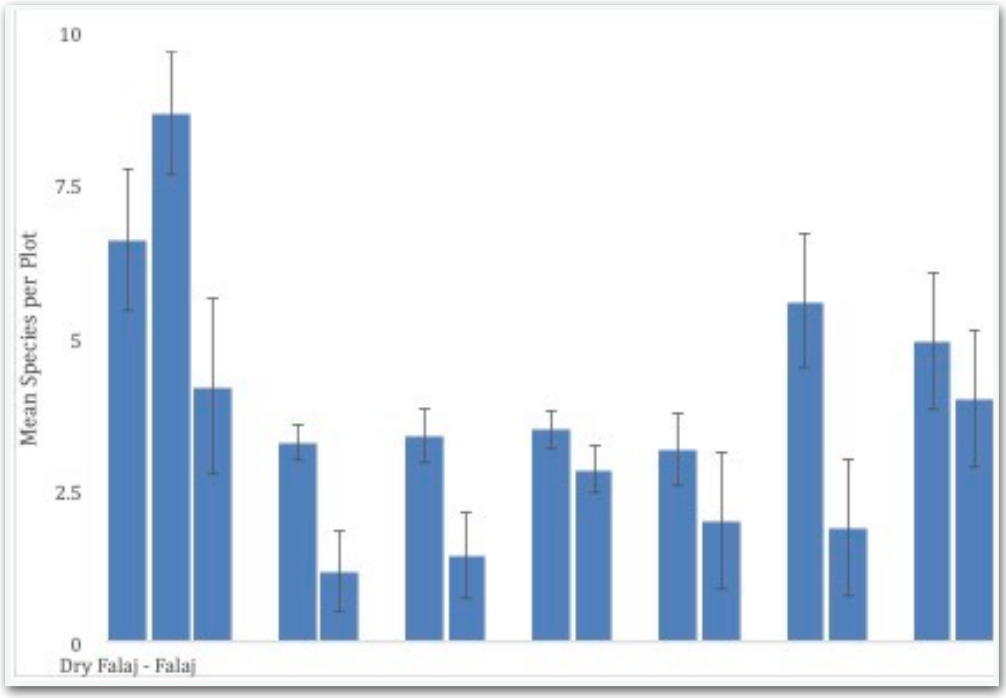

Table 21. Mean (± standard error) plant species observed per plot across sampling areas.

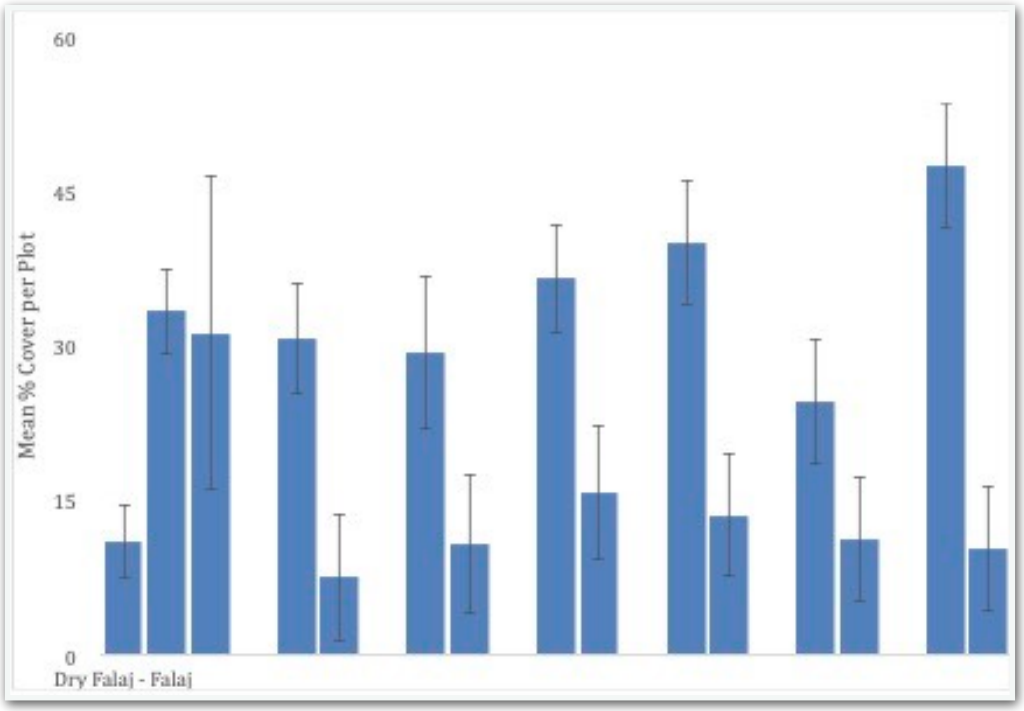

Table 22. Mean (± standard error) density of vegetation stems observed per plot.

10. Bat Site Management and Development

Jennifer L. Swerida

10.1 Bat Visitors Center Location

The Bat Archaeological Project fully supports the proposed location for the Bat Visitors Center on the undeveloped wadi plane. This location is ideal for three key reasons:

1. Construction in this area will not disrupt the modern Bat community;
2. As part of the floodplain, the chances of archaeological materials surviving below the modern ground surface at a level that would be disturbed during construction is very low;
3. The view from this location includes some of the highlights of the Bat archaeological landscape, which would be visible from a viewing platform: al-Rojoom, the necropolis, the Settlement Slope

Despite the low chance of archaeological materials being encountered during construction, it is extremely important that an archaeologist familiar with the site be present during any earth moving activities related to the construction. The responsibilities of this archaeologist should include:

1. Monitoring all construction-related earth moving for signs of archaeological remains;
2. Documenting any disturbed archaeological remains and assessing their significance;
3. Performing salvage excavations on any significant archaeological remains encountered;
4. Providing the Ministry of Heritage and Tourism a full report on documented materials following the construction activities.

10.2 Bat Visitors Center Content

We recommend that the content of the Bat Visitors Center celebrate the full history of Bat, rather than just the Bronze Age remains, and include local perspectives of heritage and stewardship of these spaces. Bat is remarkable in that it has been occupied from the Paleolithic through the modern day. While the locations and ways that people live on the Bat landscape have changed over time, dwelling in and among these archaeological spaces has been and continues to be a central aspect of the Bat community's heritage. These perspectives are useful to provide at the Visitors Center and will help visitors understand that Bat's archaeological structures and artifacts date to many different time periods and are still a part of the story of modern-day Bat.

While content can take many forms, BAP recommends that each major time period should be presented in the context of how it is understood at Bat; including representative images, artifacts, recreations, and bilingual interpretive texts in Arabic and English. BAP is eager to work with the MHT on a contractual basis to develop

detailed content for the Visitors Center that celebrates Bat's unique history. We are prepared to provide recommendations for:

- English-based text for museum exhibitions and on-site signage;
- Period-by-period archaeological artifacts and images for display;
- Historical photographs and artifacts for display;
- Wayfinding tools such as developing routes for public tours and observation point locations;
- Distributable media content and design (maps, pamphlets, audio tours, etc.);
- Restorations/reconstructions for display;
- Community engagement tools, such as arts or heritage based activity or outreach kits;
- Other needs identified by the MHT.

10.3 Site Access

To protect Bat's archaeological remains from damage, visitors should be restricted to walking to driving paths with signage providing information sufficient to understand the date and importance of the materials they are viewing. The importance of protecting Oman's heritage should be communicated at every opportunity in the Visitors Center, on informational signs around the site, and through any guided tour options.

Instructions for self-guided walking and driving tours should be provided via a map to be distributed in the Visitors Center and/or through a simple app that can be downloaded onto smartphones. Parking, short walking paths, and additional viewing platforms should be accessible and clearly marked in the tours at the following locations:

- Al-Khutm tower;
- The Necropolis – NOTE: due the size of the necropolis and the high degree of interest it is likely to attract, shaded seating areas should also be provided at certain locations along the walking trail;
- Settlement Slope houses / al-Rojoom tower;
- Al-Khafaji tower;
- Matariya;
- Al-Sleme tower;
- Husn al-Wardi – only accessible at certain times and via a designated walking path through the oasis and mud brick village; no access on Fridays, holidays, or during Bat community gatherings.

Opportunities for visitors to have closer interactions with the archaeology can include:

- Viewing platforms at the Visitors Center and key locations in the archaeological park with fixed magnifying lenses can provide views of al-Rojoom, "Operations" A and B, the Settlement Slope tower and houses, tombs on hilltops in the Necropolis, etc.;

- Guided tours led by trained MHT personnel can allow visitors closer views of certain areas of the site, such as the Necropolis, than would be permissible in self-guided tours;
- Interactive installations or galleries in the Visitors Center will provide visitors, especially children, opportunities to engage with materials similar to the archaeology (i.e., replica artifacts, play "excavation" space, model tombs).

10.4 Zoning

While it is extremely important to protect Bat's archaeological remains, it is equally important to ensure that site development is to the benefit of the modern Bat community. The community is the first line of defense for the site. It is essential that they be invested in the well-being of the archaeology as collaborators and not feel that it is a source of limitations.

The UNESCO zone and buffer zone should be maintained and no new construction permitted. The Bat Archaeological Project strongly urges **against** any efforts to expand the UNESCO zones to include occupied areas. To do so risks alienating the modern Bat community and would place added restrictions on site development efforts. Instead, the Ministry of Heritage and Tourism should develop its own system of protected zones targeting areas close to known archaeological remains that are not currently occupied. In certain locations, these zones should include areas that are currently threatened by encroaching development. A map of suggested locations to be protected from further development beyond the UNESCO defined zones (Figure 95) is included below.

Regarding existing houses located within the UNESCO zone and buffer zones or in areas selected by the MHT for protection, no families should be required to leave their homes. Bat is a living site. The modern community must be considered equally important as the past communities who created the historical and archaeological remains. Further outward development of these houses should only be permitted after consultation with the MHT. Families living in protected areas may choose to surrender their land and be relocated with the support of the MHT, should an agreement be reached by both parties.

Regarding the mud brick village and Husn al-Wardi, these spaces have historically been and remain at the living heart of the Bat community. They are spaces that are regularly used for both public and private activities, which are important access points for community identity and cohesiveness. As a result, they are highly valued and enjoyed by the community. However, mud brick buildings and oasis spaces are expensive to maintain. The current state of disrepair in the Husn al-Wardi is the result of continued use without regular maintenance or repair. In order to protect the Husn and support the Bat community, the MHT should provide guidelines and support for continued use and maintenance of the space.

Guidelines should include:

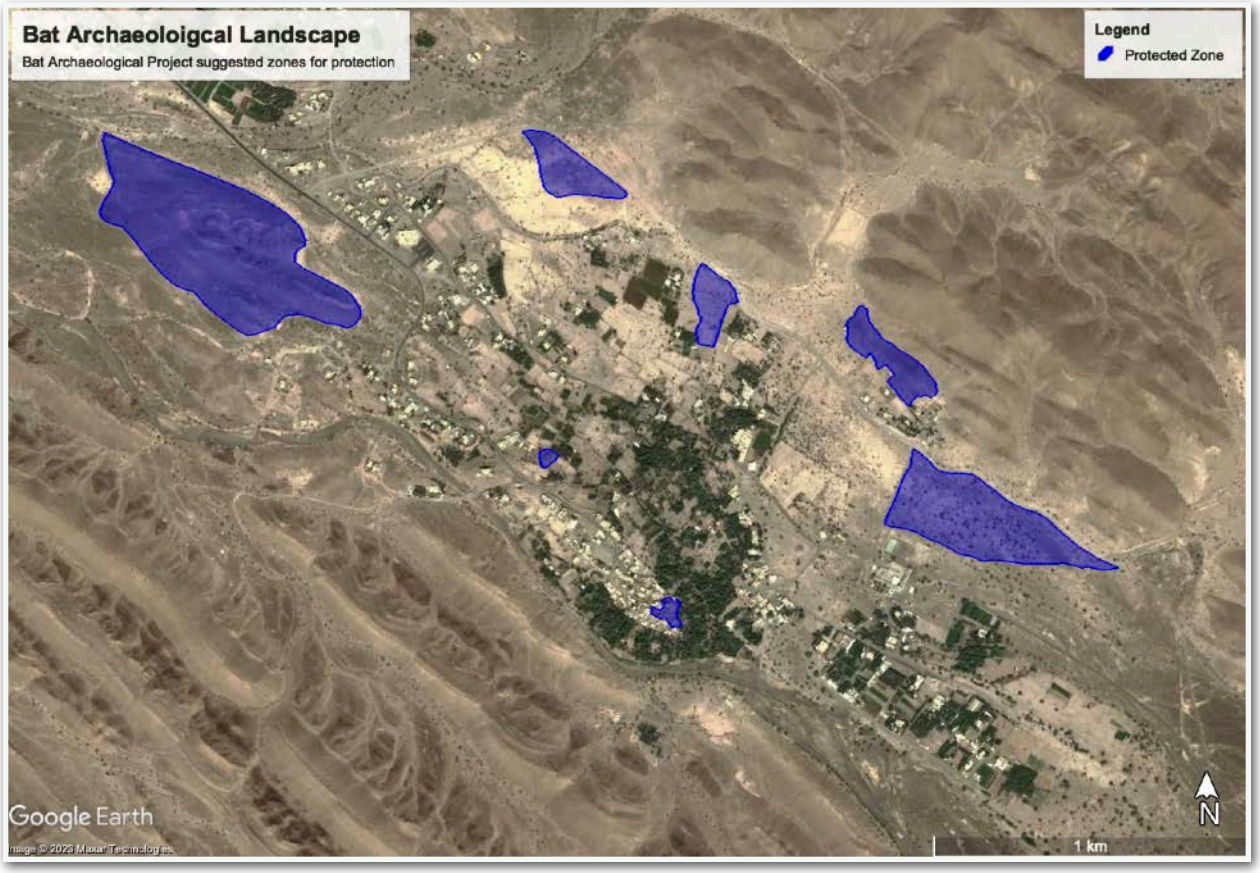

Figure 95. Map of suggested locations to be protected from further development beyond the UNESCO defined zones.

- Instructions for best practice annual maintenance to the Husn al-Wardi, the Sheikh's house, the old mosque, and surrounding buildings, especially those used in community activities;
- Organization of regular cleaning of rubbish from the oasis and mud brick village by community members who participate in activities in the oasis;
- Incentives to avoid further cinderblock construction within the oasis.

If at all possible, the MHT should provide professional and financial support to restoring and maintaining the mud brick and oasis. Craftspeople familiar with mud brick construction and maintenance at historic sites such as the forts of Bahla and Nizwa can be consulted for guidance on best practices. It is important that this guidance come from specialists in Omani heritage, rather than from other regions where mud brick traditions may differ. BAP is happy to facilitate these connections and conversations. This support must be contingent upon the Bat community abiding by the guidelines.

Only select portions of the mud brick village should be made available to tourists. The location of these areas should be mutually agreed upon by the MHT, residents of the mud brick village, and leaders of the Bat community. All tourist areas

and walking paths must be clearly marked and maintained. Privately owned and farmed areas of the oasis should not be open to tourism except at the express invitation of the owners.

10.5 Community Engagement

Based on the outcomes of the Bat Archaeological Project's outreach efforts in the 2023 field season, we suggest that the Bat Visitors Center also provide spaces and functions for the Bat community in addition to outside tourists. While these functions target interests expressed by people living in Bat, they should also be of interest and available to visitors to the site.

The Visitors Center should include:

- A space, interior or exterior, available to community groups where they may host events or hold classes, workshops, or secular convenings;
- A play-space for children with archaeology- or heritage-themed hands-on activities, such as an "excavation" sandbox, drawing stations with prompts asking about Bat's archaeology, or a clay working space with recreation examples of ancient ceramic vessels or educational objects/artifacts;
- A shop where Bat community members work, buy, or sell heritage-centered handicrafts;
- A community kiln and artisan workshop where community artisans can demonstrate and share their craft knowledge, produce the craft, and sell crafts like ceramic vessels to visitors;
- A coffee shop serving food and drink traditional to the Bat region;
- A public library dedicated to Omani history, culture, and archaeology, especially that of the Bat region.

Classes and workshops can be offered through the Visitors Center to visiting tourists, Bat community members/groups, student groups, or ministry employees. Examples of potential events include:

- Collaborations with local interest groups like Healthy Village Bat;
- Heritage or Community Day-type events, where old and new generations can meet to share and create memories;
- Lectures or show-and-tell events hosted by the MHT or visiting archaeologists, such as the Bat Archaeological Project;
- Traditional handicraft workshops hosted by community members or visiting craftsperson's from elsewhere in Oman;
- Educational events for children during school holidays or for visiting school groups.

The Bat Archaeological Project is eager to work with the MHT on a contractual basis to develop detailed content for lectures and trainings to be held at the Visitors Center. We are prepared to provide instructional content for:

- Lectures on the archaeology and history of Bat;
- Trainings for MHT employees and university students on archaeological practice: excavation, survey, recording systems, etc.;
- Educational site-visit content for school visits;
- Other needs identified by the MHT.

Community events in the mud brick village should be encouraged, along with the community's responsibility to protect and maintain the space. If possible, the MHT should provide instruction on mud brick restoration and maintenance to community members prior to events held in the mud brick village.

11. Future Plans

Jennifer Swerida and Eli N. Dollarhide

11.1 BAP Future Research Plans

The results of BAP's 2022-2023 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 2024 and begin preparations for the publication of a monograph documenting our findings from the past three field season.

11.2 2023-2024 Fieldwork

The BAP 2023-2024 field season will continue the project's focus on understanding Bat's ancient remains from the perspective of cultural landscapes and begin preparations for publication of the second BAP monograph. 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 2023-2024, we anticipate our fieldwork to center on five areas: 1) ground-truthing imagery-derived plans across the Bat landscape; 2) completing excavation of Umm an-Nar domestic contexts at Rakhat al-Madrh; 3) documenting and constructing a 3D model of the Bat Hīsn; 4) geophysical and geomorphological prospection at Umm an-Nar contexts across the site; 5) a follow-up on established 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.

11.2.1 Ground-Truthing

Next season, the project will finalize plans and spatial analyses of key locations on the Bat archaeological landscape:

- the Settlement Slope;
- the al-Ahliyah hill complex;
- Rakhat al-Madrh;
- and the Khutm fortress.

These locations have previously been subjects of BAP's photogrammetric modeling project, which uses overhead imagery to construct 3D models and plans of the sites. In order to confirm accuracy of architectural plans derived from imagery, BAP will revisit each site to spot-check architectural layouts and phasing. These 3D models and plans will then be used as the foundation for spatial analyses and as guides for future fieldwork at the sites.

11.2.2 Excavation of Umm an-Nar domestic contexts

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

11.2.1a Rakhat al-Madrh: 2024 Excavations

In 2024, BAP will continue its investigations into the nature and chronology of Early Bronze Age settlement at Rakhat al-Madrh. Excavations are planned to resume at the exceptionally large RaM 3 to reveal the extent and 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 excavate a small test trench against the northern exterior wall of RaM 2 in order to probe the scale of the wall's construction. This Test trench will provide valuable comparative information to the other RaM structures and the relationship of both buildings to histroic flooding events in the RaM Basin.

11.2.1b Khutm Settlement: 2024 Excavations

Building on the promising results of BAP's 2023 work at the Khutm Settlement's eastern complex, a final small test excavation is planned for Winter 2024. This test trench will target interior contexts of the building interpreted as an Umm an-Nar house in the eastern complex. Excavations will probe the quality of preservation and determine building use, dates, and functions. Results will contribute to the planning of larger-scale horizontal excavation at the site in future seasons.

11.2.3 Ḥiṣn al-Wardi documentation and research

In the 2024 field season, BAP will proceed with the research progRaM At the Ḥiṣn al-Wardi previously approved by the MHT and in collaboration with Dr. Aila Santi.

The *ḥiṣn* and mudbrick town of Bat is located in the heart of Bat oasis, on the remains of a Bronze Age tower, on the highest spot above the *wadī*'s bend. Although nowadays sparsely inhabited, it still stands as the symbolic core of the oasis and a unique point of encounter between Bat's most ancient past, Medieval and early modern history.

Although investigations have been recently carried out at the site (by Dr Ruth Young and the Bat Archaeological Project), these have focused on the most recent

occupational stages of the settlement, leaving its early history still mostly unknown. The proposed project is intended to address the issues related to the foundation of the *ḥiṣn* and the mudbrick settlement and investigate the earliest phases of the site's occupation in Islamic times.

Proposed project aims: carrying out the first comprehensive study on the *ḥiṣn* of Bat and the adjacent mudbrick village in order to shed light on its foundation and early history, raise awareness about its cultural and historic value, and explore strategies to develop its tourism potential.

Multi-layered project comprising historical, archaeological, and architectural history research methods:

- Systematic research, collection and study of historical Islamic written sources mentioning the *ḥiṣn* of Bat, its oasis, and/or the surrounding area;
- Excavation of trenches in strategic points of the *ḥiṣn* and its surrounding meant to investigate the earliest historical levels of the fort and obtain precise information about the chronology of its building;
- Constructing 3D models of the *ḥiṣn* and the mudbrick houses composing the core of the village in order to record and for future teaching and tourism purposes;
- Documenting and cataloguing the building fabrics, techniques, and materials attested in the village. An assessment of the vernacular architectural tradition of Bat could turn out to be key for the interpretation of early Islamic contexts in the Arabian Peninsula only known from written sources: in particular the houses of the Prophet's wives in Medina;
- Carrying out a survey aimed at mapping and documenting other fortified mudbrick buildings in the area in order to contextualize the *ḥiṣn* of Bat in its broader medieval and early modern landscape;
- Implementing tourism promotion plans in order to include the oasis of Bat in a broader tourist itinerary offering a comprehensive picture of the long history of the area.

11.2.4 Geophysical and geomorphological prospection

Following a preliminary collaboration with SPARC (Spatial Archaeometry Research Collaborations) at Dartmouth College, BAP is proposing a multifaceted geophysical prospection program to probe the extent of archaeological remains at three key areas of the site where long-term excavation is prohibitive. This research will employ cutting-edge methodologies including: drone-enabled survey with a thermal imaging camera, SWIR sensor surface mapping, and subsurface magnetometry and ground penetrating radar, allowing the project to look underground without excavation. BAP plans to implement these techniques at four 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
4) Al-Ahliyah—to model the densely layered monumental and mortuary architecture constructed across the hill crest. These remains are threatened by encroaching construction up the hillside, making thorough documentation and study especially important.

Geomorphological work focused on the RaM Basin is also planned to continue in BAP's 2024 season.

11.2.5 Outreach and arts engagement

Learning from this season's experiences, BAP will follow-up with our partners in the MHT and the Bat community concerning the continuation of outreach and engagement programs established in 2023. We are eager to consult with our colleagues in the MHT to facilitate development of long-term outreach programs at Bat, including: ceramics workshops, student field-trips to the site, and training opportunities for university students and MHT personnel. The objective of these efforts is to 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.

11.3 2023-2024 Study Season

According to BAP's 5 year research plan, the 2024 season will complete field data collection for this research cycle. Following and concurrent with fieldwork, we will devote time to a study season that will prepare material for publication in BAP's second monograph. During this study season, we will complete secondary analyses and documentation of ceramics, artifacts, and macro-scientific samples collected over the past four field seasons. This work will be conducted partially on-site in Bat and partially in the MHT facilities in Muscat. The monograph will present the results of BAP's investigation into Bat's cultural landscape, as directed by the three interconnected research questions listed above. Publication is planned for 2025.

References Cited

Bernardini, F., Vinci, G., Prokop, D., Barro Savonuzzi, L., De Min, A., Lenaz, D., Princivalle, F., Cocca, E., Kasztovszky, Zs., Szilágyi, V., Harsányi, I., Tuniz, C., and Cattani, M. (2020). A multi-analytical study of Bronze Age pottery from the UNESO site of Al-Khutm (Bat, Oman). *Archaeological and Anthropological Sciences* 12:163.

Böhme, M. & al-Sabri, B.A. (2011). Um an-Nar burial 401 at Bat, Oman: architecture and finds. *Arabian Archaeology and Epigraphy* 22: 113-154.

Bonacci, O., (2013). Poljes, Ponors and Their Catchments. In: Frumkin, A. (ed.), Treatise on Geomorphology, vol. 6: Karst Geomorphology. Academic Press, San Diego, pp. 112–120.

Brunswig, R. (1989). Cultural History, Environment and Economy as Seen from an Umm an-Nar Settlement: Evidence from test excavations at Bat, Oman, 1977/78. Journal of Oman Studies, 10, 9–50.

Bryant, R., Smith, S.L., & Swerida, J. (2022) Khutm Settlement, in Dollarhide *et al.* (eds) Bat Archaeological Project Preliminary Report of the 2022 Season. Report on File, Ministry of Heritage & Tourism, Muscat, Oman.

Cable, C.M. (2012). A Multitude of Monuments: Finding and Defending Access to Resources in Third Millennium BC Oman. PhD dissertation, Michigan State University.

Cable, C.M. (2016). Excavations at Matariya (Tower 1147). In C.P. Thornton, C.M. Cable, and G. Possehl (eds.), The Bronze Age Towers at Bat, Sultanate of Oman. Philadelphia: University of Pennsylvania Press, pp. 49-82.

Cable, C.M., Swerida, J., and Dollarhide, E.N. (2019). Bat Archaeological Project Report of the 2018-2019 Season. Report on File, Ministry of Heritage and Culture, Muscat, Oman.

Cable, C.M., and Thornton, C.P. (2013). Monumentality and the Third Millenium 'Towers' of the Oman Peninsula. In S. Abraham, P. Gullapalli, T. Raczek, and U. Rizvi (eds.), Connections and Complexity: New Approaches to the Archaeology of South and Central Asia. Walnut Creek, CA: Left Coast Press, pp. 375–399.

Cable, C.M. and Thornton, C.P. (2014). Bat Archaeological Project 2014 Report. Report on File, Ministry of Heritage and Culture, Muscat, Oman.

de Cardi, B., Collier, S., and Doe, B.D. (1976). Excavations and Survey in Oman. Journal of Oman Studies, 2, pp. 101-188.

Cattani, M., al-Lawati, H., al-Bakri, S., Tosi, M., Cocca, E., Artigliato, A., Mantellini, S., & Vinci, G. (2017). Excavation at the Bronze Age tower of al-Khutm (Bat, Sultanate of Oman): a preliminary evaluation of the monument. *Proceedings of the Seminar for Arabian Studies* 47: 51-56.

Cocca, E., Vinci, G., Cattani, M., Armigliato, A., Di Michele, A., Bianchi, M., & Genus, I. (2019). Al-Khutm Project 2017/2018: a Bronze Age monumental tower (Bat, Oman). *Proceedings of the Seminar for Arabian Studies* 49: 85-96.

Desruelles, S., Fouache, E., Eddargach, W., Cammas, C., Wattez, J., Beuzen-Waller, T., Martin, C., Tengberg, M., Cable, C., Thornton, C., Murray, A., (2016). Evidence for early irrigation at Bat (Wadi Sharsah, northwestern Oman) before the advent of farming villages. Quaternary Science Reviews 150: 42–54.

Dollarhide, E. (2019). Mapping Magan: The Ancient Social Landscape of North-Central Oman. PhD Dissertation, New York University.

Dollarhide, E., Garrett, Z., and Rissman, P. (2017). Mapping Magan-Bat Archaeological Project: Preliminary Report to Ministry of Heritage and Culture, Oman (Muscat). Report on File, Ministry of Heritage & Culture, Muscat, Oman.

Dollarhide, E.N., Swerida, J., Jensen, R.S., & al-Jassassi, A. (2022). Bat Archaeological Project Preliminary Report of the 2022 Season. Report on File, Ministry of Heritage & Tourism, Muscat, Oman.

Dollarhide, E.N., Rissman, P., & Swerida, J. (2022). Rakhat al-Madrh Excavations, in Dollarhide *et al.* (eds.) 'Bat Archaeological Project Preliminary Report of the 2022 Season'. Report on File, Ministry of Heritage & Tourism, Muscat, Oman.

Döpper, S. (2015). The reuse of tombs in the necropolis of Bat, Sultanate of Oman. *Proceedings of the Seminar for Arabian Studies* 45: 83-92.

Döpper, S. (2018). Towers and ditches in the third millennium BC Eastern Arabia: A view from Building II at Bat, Sultanate of Oman. *Paleorient* 44: 119-132.

Engel, M., Matter, A., Parker, A.G., Parton, A., Petraglia, M.D., Preston, G., Preusser, F., (2017). Lakes or wetlands? A comment on "The middle Holocene climatic records from Arabia: Reassessing lacustrine environments, shift of ITCZ in Arabian Sea, and impacts of the southwest Indian and African monsoons" by Enzel *et al.* Global and Planetary Change 148, 257–267.

Field, M., (2002). A lexicon of cave and karst terminology with special reference to environmental karst hydrology. EPA National Center for Environmental Assessment, Washington.

Frifelt, K. (1985). Further Evidence of the Third Millennium BC Town at Bat in Oman. *Journal of Oman Studies* 7: 89-104.

Frifelt, K. (1989). The Danish Excavations at Bat, 1989: Final Report. Manuscript on file, Ministry of Heritage and Culture, Muscat.

Frifelt, K. (2002). Bat, a centre in third millennium Oman. In S. Cleuziou *et al.* (eds.) Essays on the Late Prehistory of the Arabian Peninsula, pp. 101-110.

Gentelle, P. & Frifelt, K. (1989). About the Distribution of Third Millennium Graves and Settlements in the Ibri Area of Oman. *Oman Studies: Papers on the Archaeology and History of Oman*, pg. 1190126

Ghanzafar, S. A. (2015). Flora of the Sultanate of Oman. Meise, Belgium: Botanic Garden Meise.

Hatfield, R. & Cable, C.M. (2014). Documentation of the al-Khutm Settlement. In Cable, C.M. & Thornton, C.P. (eds.) Bat Archaeological Project 2014 Report. Report on File, Ministry of Heritage and Culture, Muscat, Oman.

Hoffmann, G., Meschede, M., Zacke, A., Al Kindi, M., (2016). Field guide to the Geology of northeastern Oman. Borntraeger, Stuttgart.

al-Jahwari, N.S. & Kennet, D. (2010). Umm an-Nar settlement in the Wadi Andam (Sultanate of Oman). *Proceedings of the Seminar for Arabian Studies* 40: 201-212.

Janjou, D., Minoux, L., Beurrier, M., De Gramont, X., Le Metour, J., and Villey, M. (1986). Geological Map of 'Ibri-Sheet NF40-2F. Ministry of Petroleum and Minerals, Sultanate of Oman.

Kennet, D. (2004). Sasanian and Islamic Pottery from Ras Al-Khaimah: Classification, Chronology and Analysis of Trade in the Western Indian Ocean. Society for Arabian Studies Monographs 1. Oxford: Archaeopress.

Kondo, Y. & Swerida, J. (2013). Archaeological survey at Al-Khutm. In Kondo, Y., Thornton, C.P., & Cable, C.M. (eds.) American-Japanese Bat Archaeological Project Preliminary Report of the 2013 Season. Report on File, Ministry of Heritage and Culture, Muscat, Oman.

Magee, P. (1996). The Chronology of the Southeast Arabian Iron Age. Arabian Archaeology and Epigraphy, 7(2), pp. 240-252.

Mateiciucová, I., Wilding, M., Engel, M., Otava, J., Bubík, M., (2020). First assessment of the research potential of the prehistoric intermountain site Hıayl Al-ʿĀja in the Al-Ḥajar Mountains of Northern Oman (Project SIPO). Journal of Oman Studies 21, 1–23

Mateiciucová, I., Wilding, M., Štefanisko, D., & Trnka, G. (2020): A new lithic site at the sediment-filled depression Hıayl Al-Aja on the eastern side of Jebel Kawr, North Oman. In: K. Bretzke, R. Crassard & Y.H. Hilbert (eds), 2020. Stone Tools of Prehistoric Arabia (Supplement to Volume 50 of the Proceedings of the Seminar for Arabian Studies): 101–119. Oxford: Archaeopress.

Mateiciucová, I., Wilding, M., Otava, J., Šindelář, J., (2023). The Al-Hajar Mts as a prehistoric refugium? On the habitability of karst mountain places in Oman during arid climate periods. Journal of Arid Environments 212, 104951.

Méry, S. (2000). Les céramique d'Oman et l'Asie moyenne. Une archéologie des échanges à l'Âge du Bronze. Paris: CNRS.

Miki, T., Kurounma, T., & Kondo, Y. (2019). Burial Landscape of bat during the Um An Nar Period: Reconstruction through Spatial Statistics. *Journal of Oman Studies* 20: 48-77.

Minoux, L., Janjou, D., (1986). Geological map of 'Ibrī, Sheet NF 40-2F, 1:100,000 – Explanatory Notes. Bureau de Recherche Géologiques et Minières, France.

Nathan-Staudt, S. (2017). Ingenuity in the Oasis: Archaeobotanical, Geospatial, and Ethnoarchaeological Investigations of Bronze Age Agrarian Community Choice in the Northern Oman Interior. (Unpublished PhD Dissertation, New York University: Department of Anthropology).

Pickering, H. and Patzelt, A. (2008). Field Guide to the Wild Plants of Oman. Kew: Royal Botanic Garden.

Possehl, G.L. and Thornton, C.P. (2007). Bat 2007: A report from the American Team. Report on File, Ministry of Heritage and Culture, Muscat, Oman.

Potts, D. T. (1992). The Chronology of the Archaeological Assemblages from the Head of the Arabian Gulf to the Arabian Sea (8000-1750 BC). In R. W. Ehrlich (ed.), Chronologies in Old World Archaeology (3rd ed.). Chicago: University of Chicago Press, pp. 63-89.

Schmidt, C., & Döpper, S. (2017). The development of complexity at third-millennium BC al-Khashbah, Sultanate of Oman: results of the first two seasons 2015 and 2016. *Proceedings of the Seminar for Arabian Studies* 47: 215-226.

Smith, S.L. (2022). Archaeological Survey, in Dollarhide *et al.* (eds.) Bat Archaeological Project Preliminary Report of the 2022 Season. Report on File, Ministry of Heritage & Tourism, Muscat, Oman.

Swerida, J. (2017). Housing the Umm an-Nar: the settlements and houses of Bat. PhD Dissertation, Johns Hopkins University.

Swerida, J. (2022). House, Household, and the Umm an-Nar: Structure SS1 at the UNESCO World Heritage Site of Bat, Sultanate of Oman. In Battini, L., Brody, A., & Steadman, S. (eds.) *No Place Like Home: Ancient Near Eastern Houses and Households*, pp. 181-194. Archaeopress.

Swerida, J. and Thornton, C.P. (2019a). Al-Khafaji Reinterpreted: New Insights on Umm an-Nar Monuments and Settlement from Bat, Oman. Arabian Archaeology and Epigraphy, 30(1), pp. 1-16. doi: 10.1111/aae.12131.

Swerida, J. and Thornton, C.P. (2019b). Umm an-Nar Architecture and Society at the Bat Settlement Slope, Sultanate of Oman. Journal of Oman Studies, 20, pp. 78-111.

Swerida, J., Dollarhide, E.N., Cable, C.M., & Al-Jassassi, A. (2020). Bat Archaeological Project Preliminary Report of the 2019-2020 Season. Report on File, Ministry of Heritage and Culture, Muscat, Oman.

Swerida, J., Dollarhide, E.N., & Jensen, R. (2021). Settlement and Chronology in the Early Bronze Age of Southeatern Arabia: The vies from Umm an-Nar period Bat, Oman. *Paléorient* 47.

Tengberg, M. (2016). Archaeobotanical Studies at Bat. A Short Summary and Recommendations. In Thornton, C.P., Cable, C.M., and Possehl, G.L. (eds.), *The Bronze Age Towers at Bat Sultanate of Oman: Research by the Bat Archaeological Project 2007-2012*. Philadelphia: University of Pennsylvania Museum.

Thornton, C.P., Cable, C.M., & Possehl, G.L. (2016). *The Bronze Age Towers at Bat, Sultanate of Oman: Research by the Bat Archaeological Project 2007-2012.* Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Thornton, C.P. and Ghazal, R.O. (2016). Typological and Chronological Considerations of the Ceramics at Bat, Oman. In Thornton, C.P., Cable, C.M., and Possehl, G.L. (eds.), *The Bronze Age Towers at Bat Sultanate of Oman: Research by the Bat Archaeological Project 2007-2012*. Philadelphia: University of Pennsylvania Museum.

Weisgerber, G. (1980). und Kupfer in Oman. *Der Anschnitt* 32: 62-110.

Whitcomb, D.S. (1975). The Archaeology of Oman; a Preliminary Discussion of the Islamic Periods. Journal of Oman Studies, 1, pp. 123-157.

Williams, K.D. & Gregoricka, L.A. (2016) Excavation of the Wadi Sûq tombs at Tower 1165. In Thornton, C.P., Cable, C.M., and Possehl, G.L. (eds.) *The Bronze Age*

Towers at Bat, Sultanate of Oman: Research by the Bat Archaeological Project 2007-2012. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Yule, P. (2011). *Al-Khashbah 3rd millennium archaeological zone, threatened? h*ttp://heidicon.ub.uni-heidelberg.de/heidicon/141/170/385245.html