

Title:

Evidence for Neolithic settlement in the foothills of the Western al-Hajar Mountains

Running title:

Neolithic settlement in Rustaq

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Abstract

Systematic prospection and excavations in the Rustaq region of Northern Oman, approximately 45 km from the coast in the foothills of the Western Hajar Mountains, have revealed an unexpectedly dense record of Neolithic sites. Besides surface scatters of lithic artifacts, excavation at site Hayy al-Sarh recovered two stratified archaeological horizons (AHs). The upper horizon, AH I, contained pierced marine shells that provided an age of the archaeological material of about 6,800 to 7,500 years cal BP. Typologically the AH I lithic assemblage compares to the Suwayh facies defined at the coast 300 km to the east. Whether the marine shells and cultural affinities point towards exchange with coastal communities or possibly seasonal movement remains an open question at this state of research, but this new evidence for inland Neolithic settlement near Rustaq provides important new data that will help to improve our understanding of spatial patterns of Neolithic demographic variability.

Key words: Neolithic, Rustaq, lithic artifacts, marine shells, excavation

Introduction

Compared to earlier periods of the Stone Age in Southeast (SE) Arabia, the Early to Mid-Holocene archaeological record is relatively well understood regarding chronology and material culture (Charpentier, 2008; Uerpmann et al., 2013). Despite this, important topics such as the Paleolithic/Neolithic transition and the associated shift in subsistence; the relationship between inland and coastal settlements; and how people coped with climatic variability, are still debated (Cavulli and Scaruffi, 2013; Crassard and Drechsler, 2013; Crassard et al., 2013; Drechsler, 2010; Fedele, 2013; Hilbert, 2013; Lézine et al., 2010). In the context of these questions, significant issues include the spatial distribution of sites and the precision of the chronologies. Data from stratified inland sites are clearly underrepresented compared to evidence from the coast where most of the record's excavated sites are located (Mery and Charpentier, 2013). Regarding the precision of chronologies, the influence of the reservoir effect for example is one important topic that is still debated (see Lindauer et al., 2017 for example).

The *Rustaq Batinah Archaeological Survey* (RBAS) project, a joint project undertaken by Durham University UK, Sultan Qaboos University Oman and the Oman Ministry of Heritage and Culture, has sought to contribute fresh data from new areas to the scientific discourse. The RBAS conducted systematic field work on the Batinah plain in northern Oman, which borders the northern foothills of the Western Hajar Mountains. The project aims to study diachronic changes in settlement dynamics from the Stone Age until modern times (Kennet et al., 2016). Systematic survey by the project between 2013 and 2018 recovered a rich prehistoric record including the first evidence for Paleolithic, Neolithic, Bronze Age and Iron Age settlements as well as pre-Islamic and Islamic period settlement in this area (Kennet et al., 2016). The project has uncovered a more or less continuous occupation sequence from the Early Bronze Age until at least the 1970s, broken only by occasional gaps in the record.

The Stone Age work group of the RBAS focused its resources on the foothills of the Western Hajar Mountains in the area around the town of Rustaq (Fig. 1). Here, the RBAS identified a number of promising landscape features, including apparent Pleistocene-age terraces and lithic raw material sources (Parton, 2015). Systematic survey of the different geomorphological features has led to the documentation of Neolithic settlement of so-far unrecognized intensity. Evidence for Paleolithic settlement in the region was also documented, but at a much lower density. In this paper we focus on the presentation of the Neolithic evidence.

Geographic setting

The Batinah plain of northern Oman is a narrow ~35 km wide sequence of alluvial fan and fan-related drainage features, and coastal deposits. The plain is bordered to the south-east by the Western Hajar Mountains, which run in an arc parallel to the coast of the Gulf of Oman and are composed of Mesozoic rocks of the Neotethys margin, Late Cretaceous-Paleogene thrust faults, Paleogene sediments and post-orogenic faults (Glennie et al., 1974; Lippard et al., 1986; Rodgers and Gunatilaka, 2002; Searle and Cox, 1999). Weathered material from the mountains is the predominant sediment source for much of the plain, while rainfall across the mountain catchment activates the northeastwards flow of surface and subsurface drainage towards the coast. Within zones proximal and medial to the mountains, a complex suite of fan deposits are indicative of higher rainfall throughout northern Oman in earlier times. Phases of large-scale fan drainage activation in central Oman and along the western flanks of the mountains have been attributed to incursions of moisture driven by the northward displacement and intensification of the Indian Ocean Monsoon system (Blechs Schmidt et al., 2009; Farrant et al., 2012; Parton et al., 2015). Along the eastern flanks of the

mountains, a series of relict fluvial/alluvial terraces are also indicative of widespread drainage activation during wetter climatic periods.

Geomorphological investigations in the Rustaq area indicate three phases of terrace formation, each of which has been incised by subsequent channel flow. Evidence for the earliest phase is predominantly found proximal to mountain front. These features comprise a series of small hills extending northeast and are composed of coarse, poorly sorted, highly cemented polymict conglomerates. The landforms associated with this older fan system are notably larger than all subsequently formed alluvial features in the region, indicating a period of significantly higher discharge, and/or post-depositional uplift. These earliest deposits have been altered by subsequent fan aggradation and channel flows, which are found either banked against the side of the older, larger fan system, or have incised through the relict fan lobe to leave terraces of stacked, fan channel sediments. These are also observed within the proximal zone as stream flow and sheet-flood deposits. They are typically characterised by stratified fining-up sequences and channelized beds of gravels and gravelly sand, overlain by a thick sequence of silt-sands. The fining-upwards of sediments from gravels to sand is indicative of the waning of alluviation, following a steady decrease in rainfall across the region. Further investigations will aim to elucidate the nature and timing of these phases of drainage activation; however, we tentatively ascribe them to wet phases during the Mid-Late Pleistocene. The third, latest phase of fan aggradation/incision is observed throughout the proximal and medial zones of the Batinah bajada, and corresponds to the dominant drainage features seen across the region today. Although now largely relict, exposures of these deposits are capped by large, well-rounded cobbles indicative of significant wadi flow. Sedimentary exposures of this most recent phase of large-scale wadi activation are typified by multiple fining-up sequences of sub-angular-well-rounded pebbles and cobbles interbedded with coarse ophiolitic

gravels, granules and sands. These are generally weakly bedded with occasional channel fills, indicative of successive phases of channel flow and migration, which we suggest reflect the most recent phase of major drainage activation during the Early-Mid Holocene.

Methods

To approach the potential Stone Age record of an unknown landscape, we hypothesized that the distribution of lithic raw material and water are key factors in shaping land use patterns and consequently the distribution of archaeological material in this landscape. The higher, earlier terraces around Rustaq should thus have been magnets for prehistoric groups exploiting the region during the Pleistocene and Early to Mid-Holocene, due to the availability of lithic raw material, their proximity to wadi channels as well as their strategic advantages. Based on these considerations, we began our prospection on the high terraces. These were often incised by smaller channels creating ridges, which the survey teams used to guide their survey while also surveying perpendicular to them. In contrast, the medium terraces display lower topographic variability and are generally of a low gradient. Survey here was conducted using parallel and perpendicular transects to cover all parts of the terraces. Surface visibility is very high due the absence of vegetation and soil cover in large parts of the landscape, which is typical of the region.

Survey consisted of walking transects across different terraces around Rustaq, with a spacing of approximately 5 m between the three surveyors providing transect bands of 15 m width. Where archaeological material was identified on the ground, GPS coordinates were recorded along with the estimated spatial extent of the scatter, followed by the collection of all identifiable archaeological material. The geomorphological setting of each locus was also recorded, along with the density of

finds, distinguishing between high density (1 or more artifacts per m²), medium density (0.1 to 1 artifact per m²) and low density scatters (<0.1 artifacts per m²).

To test the presence of stratified Stone Age material, we conducted small-scale excavations at selected *loci*. Excavations were conducted in a standard square meter system, where excavation is focused on one ¼ square meter at a time. This allows the artifact distribution to be documented with a ca. 3 cm vertical resolution and a ¼ square meter horizontal resolution. We use this procedure routinely for our test excavations and achieve on average depths of about 20 to 25 cm per day.

Results

Twenty-five days of such field work led to the identification of 18 *loci* featuring Stone Age lithic material, with a total surveyed area of approximately 15 km² and the collection of 1080 stone artifacts. Material from seven of these *loci* was classified as Neolithic (Fig. 2), based on observed typo-technological characteristics. Four of the Neolithic *loci* consist of lithic assemblages of either high or medium density or scatters extending over relatively large areas of more than 1000 m² (Tab. 1; Fig 2).

Surface assemblages

The first high density site was identified at locus L2414 in the center of a flat area belonging to a 'middle' phase terrace southwest of the confluence of the Wadi Sahtan and Wadi Bani Awf (Fig. 2-1). Here 405 stone artifacts were collected from a spatially well-defined scatter of about 20 by 20 m in this area (Fig. 3). The lithic assemblage is dominated by flake production with blades playing a minor role (Tab. 2). The relatively high proportion of angular debris (AD) indicates that lithic production took place at this site. Cores with multiple striking platforms dominate the assemblage, while unidirectional and

bidirectional reduction also occurs (Tab. 3). The vast majority of scars on the cores are of flake size, indicating that flakes were produced using a number of core reduction systems. The most frequent tools in this collection are small bifacial tools, followed by different types of scrapers and borer (Tab. 4). Typical thinning flakes were also found and indicate on-site production of bifacial tools. Other technological observations include a relatively high frequency of faceted platforms (30%) and edge preparation (40%), which likely indicates an emphasis on maintaining lithic reduction and a more economic exploitation of the available lithic raw material. The occurrence of so called platform flakes, technical items detached to maintain the productivity of the core, provides evidence that stone tools were not exclusively imported but also produced at this site. Given the small bifacial tools (Fig. 3), which resemble examples from sites in SE Arabia dated to the 5th millennium BC, we classified this assemblage as Neolithic.

Locus L2416 provided a similar assemblage, this time located on a higher/earlier terrace north of Rustaq near the village of al-Misfah (Fig. 2-2). Again flakes clearly predominate over blades in the assemblage and the frequency of platform faceting (29 %) and edge preparation (38 %) is very similar to L2414 (Tab. 2). Cores feature scars indicating unidirectional reduction and reduction from multiple platforms in equal frequencies (Tab. 3). Regarding the tools, one borer and one notch could be identified amongst other simple retouched artifacts (Tab. 4). Although we recovered no bifacial tools, we classified this assemblage as Neolithic given typo-technological similarities with L2414 and the presence of typical, small thinning flakes indicating that bifacial retouch was practiced at this locus.

Loci L2423 and L2424 are located at a distance of about 100 m from each other on the southwestern bank of Wadi Sahtan (Fig. 2-3/4). The terrace comprises a fluvial conglomerate ridge that overlooks the modern day wadi floor, and features minor channel incision and minor colluvial slope movement near the base of the ridge. The smaller

assemblage from L2424 contains 69 lithic artifacts collected from the slope of the high terrace southwest of L2423. Technologically this assemblage features a focus on flake production (Tab. 2) and is characterized by high frequencies of faceted striking platforms (30 %) and edge preparation (32 %). The documented cores indicate a preference for unidirectional reduction and reduction on multiple platform cores (Tab. 3). Bifacial tools, including bifacial points (n = 5), dominate the tool assemblage (Tab. 4). Two scrapers and one borer are other recognizable types that complement the tool assemblage. The presence of bifacial thinning flakes and a platform flake indicate tool production and maintenance work at the site. The main collection took place on the slope of a high/early phase terrace in an area of about 500 m², but revisiting the site and expanding the search radius revealed that human activities could be traced from the foot slope to the top of the high terrace. Given close proximity to the more extensive lithic scatter documented at locus L2423, in addition to typological similarities, we conclude that L2424 and L2423 are part of one larger site.

Spatially, L2423 is the largest scatter of Stone Age material identified during our surveys in the Rustaq region (Fig. 2-4, Tab 1). Flakes outnumber blades by 40 % (Tab. 2). The frequency of faceting (35 %) matches the other assemblages presented here, while we observe for the first time in our assemblages a relatively low proportion of edge preparation (18 %). The core assemblage provides evidence for reduction from single and multiple platform cores in equal proportions (Tab. 3). Important tool classes present are scraper, bifacial tools, notches and borer (Tab. 4). One interesting observation is that relatively small, finely made tools occur together with larger sized tools (Fig. 4). We initially concluded that such a combination indicates mixing of chronologically distinct assemblages, probably due to deflation. However, observations of surface finds being embedded in relatively well developed pavements and a similar co-occurrence in the excavated assemblage (see below) led us to conclude that the two tool sets, which are at first glance very different, do indeed form a single assemblage. The occurrence of typical

bifacial points in L2423 and L2424 led us to conclude that both assemblages represent a Neolithic occupation.

Excavated assemblages

At L2423 three square meters were opened for test excavation (Fig. 5). Three days of excavations in January 2018 revealed the presence of at least two stratified archaeological horizons. The upper archaeological horizon was labeled AH I, and the lower AH II.

Approximately 15 cm below surface a dense lithic scatter (AH I) was recovered that extended across all excavated trenches. About 20 cm below this a second layer (AH II) was identified, also in all three excavated squares. Although less dense than AH I, AH II clearly points to an earlier phase of occupation given a clear, archaeologically sterile, stratigraphic gap between the layers. Excavation was stopped after reaching AH II in the third square, and thus this layer may not have been completely excavated. Similarly, bedrock was not reached at the site and thus, the potential of the site with regard to spatial extension as well as the time depth covered by the stratigraphy will be fully explored in future excavations.

With respect to the stratigraphy of L2423, the sequence was excavated to a depth of approximately 60 cm and is underlain by dark brown, medium-coarse, very weakly bedded, poorly sorted sands with occasional angular-sub rounded, loosely bedded gravels and cobbles (Fig. 6). These are overlain by a matrix-supported, very poorly sorted, gravelly layer featuring occasional cobbles (ca. 50-35 cm), followed by AH II; a very weakly bedded unit comprising poorly sorted, angular-sub rounded gravels in a medium brown sand matrix. Mollusc shell voids and fragments, and pinhole root voids (typical of grasses) are evident throughout. Overlying AH I comprises finely laminated, pale brown, cemented, fine silt-sands indicative of intermittent wetting at the site.

In AH I we documented 88 lithic artifacts, which represent all parts of the lithic reduction sequence, including cores, blanks, preparation flakes, preforms and finished products (Fig. 7). Technologically the AH I lithic assemblage is dominated by flake production and bifacial reduction (Tab. 2). Dorsal scars on flakes primarily feature unidirectional patterns, while multiple directions are almost exclusively seen on bifacial thinning flakes. On about half of the flakes we identified a lip between the striking platform and the ventral side. This could indicate that flakes have been detached using a soft hammer, which could be a soft stone (e.g. limestone or sand stone) or an organic hammer. The majority of cores feature multiple platforms (Tab. 3). The small tool assemblage includes three bifacial tools and one denticulate (Tab. 4). With regard to the lithic inventory, a small and broken bifacial point with a diamond cross section is very interesting, since it seems to resemble the specimen found on surface at L2423 (Fig. 8).

In addition to lithic artifacts, our test excavation also recovered four shells from AH I (Fig. 9). Three of them were identified as being from the family of Naticidae, probably *Polinices mammilla*, a marine gastropod (pers. comm. E. Neubert). The fourth is fragmented and unidentified. Two of the marine shells are pierced, while one is unworked (Fig. 9A). The corroded state of preservation of the Hayy al-Sarh specimens hinders a detailed analysis of the holes' manufacturing process. Comparisons with experimental results (e.g. Mărgărit et al., 2017) are thus difficult. The holes are located in similar parts of the shell indicating that they have been used in a similar way (Fig. 9B). The specimens range in size from about 12-16 mm by 9-12 mm.

The small lithic assemblage from AH II is composed of one core and five flakes, including three so called chips (Fig. 7), which are flakes smaller than 2 cm (Tab. 2). One of the cores is a relatively large single platform core featuring unidirectional scars. At this stage of research we cannot draw any meaningful conclusions from the AH II lithic assemblage,

given the small sample size. Nonetheless, we are very optimistic that future excavations will increase the archaeological sample from this horizon and allow further conclusions to be drawn.

Given the presence of two stratified archaeological assemblages in an inland location, the presence of marine shells and an excellent chance for developing a sound absolute chronology, we realized that L2423 provides the best research potential among our surveyed localities and hence designated the site with the name Hayy al-Sarh (*Hayy al-Sarh*), after the local toponym.

Chronology

Observed typo-technological similarity among the surface assemblages and excavated horizon AH I at Hayy al-Sarh provides evidence for a period of human occupation of the Rustaq area during the Early-Mid-Holocene. The bifacial, fusiform points with diamond shaped cross sections found at Hayy al-Sarh resemble the short thick fusiform point type (Type 1.B) from Suwayh 1 (Charpentier, 2008). This suggests that the Neolithic finds from Rustaq may represent settlement activity in the region during the 5th millennium BC. To test our typology-based chronology, we submitted one worked and the unworked marine shell (Fig. 9) excavated from AH I for ¹⁴C dating.

Fragments of the two shells of family Naticidae were prepared with diluted hydrochloric acid (1% HCl) and subsequent washing in Milli-Q water prior to leaching in 85% Phosphoric acid. In so doing the extracted CO₂ is reduced to elemental carbon (graphitized) in an AGE III system (IONPLUS) before measurement in a MICADAS AMS system (Kromer et al., 2013). The results, Rus sq.2 N with 6,632 ± 30 BP (MAMS 35993) and Rus sq 3 N with 7,164 ± 31 BP (MAMS 35994) point to a Neolithic age. Without taking into account any reservoir effect, a marine calibration would result in calibrated ages of 5,219 ± 45 cal BC and 5,679 ± 34 cal

BC (2 sigma range 5,118-5219 cal BC and 5,613-5679 cal BC). For this shell species no distinct reservoir effect ΔR has been determined so far. Using a mean value for ΔR of 200 ± 50 years from other shell species from surrounding areas results in calibrated mean ages of 4,970 \pm 50 cal BC and 5,519 \pm 53 cal BC respectively (4,808-4,970 cal BC and 5,410-5,519 cal BC, 2 sigma range).

Discussion

Systematic field work around Rustaq, located in the foothills of the Western Hajar Mountains, has revealed evidence for a Neolithic occupation of the region. The Rustaq Neolithic data adds to the very few stratified, inland records in SE Arabia, which include Buhais 18 (Uerpmann et al., 2000) and Faya 15 (Uerpmann et al., 2012) from the central region in Sharjah; Kharimat Khor Manahil in Abu Dhabi (Kallweit et al., 2005); Jabal al-^o Aluya in the Wadi Adam area (Lemée et al., 2013) and Qarat al-Kibrit 1 (Rose et al., 2014) in the Ad-Dakhliyah region of northern Oman. Existing archaeological data suggests repeated phases of occupation of the interior during the 9th, 8th and 6th to 5th millennium BC interspersed with phases that lack evidence for human occupation (Drechsler, 2010; Uerpmann et al., 2013). Climate change and the abrupt occurrence of brief periods of hyper-arid conditions were potentially key drivers of human settlement in the SE Arabian interior during the early to mid-Holocene (Preston et al., 2015). The coastal archaeological record on the other hand, is much better developed in terms of known stratified sites (Mery and Charpentier, 2013). Evidence from these sites indicates a more stable occupation of the coasts during the early and mid-Holocene. Given rich and diverse habitats such as mangroves, which flourished at this time (Berger et al., 2013), this pattern is not surprising. One key question, however, is the extent to which inland and coastal settlements might be related. Did coastal communities expand into the hinterland during climatically more favorable periods? Or do they represent two parts of a regular, seasonal movement cycle? Or might they be unrelated? Given the very few radiometrically dated and stratified inland

sites from the Early to Mid-Holocene in SE Arabia, these questions are difficult to address at present. The new data from Rustaq, in particular the stratified assemblages from Hayy al-Sarh, can help to refine our models of human land use and behavioral response to climate change during the Early to Mid-Holocene.

Hayy al-Sarh provides evidence for an occupation of the Rustaq area during the first half of the 6th millennium BC. Following Parker et al. (Parker et al., 2016) this dating would place the Hayy al-Sarh AH I occupation in a period of more favorable climatic conditions that followed a brief dry spell between around 8,300 to 7,900 years ago. Given similarities between the AH I lithic assemblage from Hayy al-Sarh and the Suwayh facies defined by Charpentier at the coastal site Suwayh 1 (Charpentier, 2008), the question arises of whether this provides evidence of connectivity between populations occupying the coast and the interior at this time. However, the currently available radiometric data indicates a chronological off-set of about 300 years between AH I (5,500 – 4,800 cal. BC) and the Suwayh facies dated to 4,500 –3,700 cal. BC (Charpentier, 2008). This highlights the problem of drawing broader conclusions about cultural connections and the size of the interaction sphere on the basis of a still poorly-understood lithic techno complex and chronology. Nonetheless, the marine shells from AH I at Hayy al-Sarh do provide clear and irrefutable evidence for a general connection with the coast about 6,800 to 7,500 years ago. The coast is at a distance of about 45 km from Hayy al-Sarh as the crow flies, and is directly connected via the Wadi Sahtan, which extends from the mountain front to the distal alluvial plain. Such a distance could be easily covered by a mobile group within their seasonal movement pattern along this 'riparian corridor'. However, the presence of marine shells does not prove movement between the coast and the mountains, as it may simply indicate trade contacts with other groups. Recent isotopic studies on human remains from Jebel Buhais 18, for example, indicate that the long-preferred interpretation of movement of the Buhais population to the Gulf coast in the west is less likely, despite a relatively

straightforward route to this coast being provided by the Wadi Yudayyah. Instead, the isotopic evidence points to a less obvious connection with the north or east of the peninsula (Kutterer and Uerpmann, 2017).

Regarding land-use patterns in the Rustaq area, Neolithic evidence comes mainly from the inter-mountain valley southwest of the confluence of Wadi Sahtan and Wadi Bani Awf (Fig. 2). Areas further to the northwest, towards the distal reaches of Batinah plain yield a significantly less dense scatter of Neolithic finds. Again, reasons for the observed higher density of Neolithic finds in the mountains compared to the plain remain speculative at this state of research. But one potential explanation, and our current working hypothesis, is that the area southwest of the wadi confluence is a strategic place and may have provided some degree of protection, besides access to a number of different habitats as well as useable lithic raw material, which occurs towards the coast in increasingly smaller cobbles. Given that large parts of the landscape around Rustaq are characterized as well-developed pavements, we argue that surfaces were stable for long periods during the Pleistocene and Holocene, and conclude that the spatial distribution of the Neolithic finds observed today is likely representative of the Early to Mid-Holocene occupation pattern.

In times of wadi activation, this area would probably be difficult to reach from the plain, given a relatively narrow passage between the plain and the mountain wadi. Moreover, towards the mountains, Wadi Sahtan is deeply incised and would provide protection even during periods of little surface water availability. Of course it remains unclear whether protection was a critical point for Neolithic groups occupying these foothills but we have to take into consideration that there is evidence for increased conflict and competition amongst Neolithic groups from Jebel Buhais in the central region of Sharjah Emirate (UAE) (Kiesewetter, 2006). We are convinced that further exploration of the Rustaq Neolithic

record and excavations at Hayy al-Sarh will shed more light on this and other important questions.

While it is certainly too early to draw final conclusions from the Neolithic record in Rustaq, the field work of the RBAS clearly shows that interdisciplinary projects that consider a broad range of archaeological periods and explore regions systematically and free of assumptions regarding the archaeological potential of a study region, can provide unique research and stimulating insights into human prehistory. The rather unexpected discovery of the Rustaq Stone Age record, which until now has remained largely unstudied, thus reminds us that even for relatively well studied periods, our knowledge is in fact, still fragmentary.

Moreover, the recent evidence from Rustaq illustrates that there may be areas, which while supposedly difficult to access and outwardly less promising than other regions, can add significant data to discussions regarding Arabian prehistory. In addition, the unique geomorphological setting of the region; a narrow fluvial plain featuring dense drainage systems that provide hydrological connections between mountain and coastal resources, may provide further opportunities to explore the nature of the human-climate relationship during the early Holocene.

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Tables:

Tab. 1. Neolithic sites described in the text.

Locus	Site type	Area m ³	Total artifacts N	Artifacts/m ²
2414	Open air surface	400	405	1.01
2416	Open air surface	150	116	0.77
2424	Open air surface	500	69	0.14
2423	Open air surface	1250	106	0.08
Hayy al-Sarh	Open air stratified	min. 3	88	29.3
Hayy al-Sarh	Open air stratified	min. 3	6	2.00

Tab. 2. Collected lithic assemblages. *AD = angular debris.

Locus	Archaeological horizon	Cores n/%	Flakes n/%	Blades n/%	Tools n/%	AD* n/%
2414	Surface	29/7	114/28	5/1	63/16	194/48
2416	Surface	9/8	69/59	6/5	9/8	23/20
2424	Surface	7/10	35/51	2/3	13/19	12/17
2423	Surface	7/7	47/44	3/3	12/11	37/35
Hayy al-Sarh	AH I	7/8	75/85	1/1	4/5	1/1
Hayy al-Sarh	AH II	1/25	3/75	-	-	-

Tab. 3. Basic characteristics of the lithic cores in the collected assemblages.

Locus	Archaeological horizon	Cores			
		uni-directional	bi-directional	multiple directions	indet
2414	Surface	7	7	11	4
2416	Surface	4	-	3	2
2424	Surface	3	1	3	-
2423	Surface	4	-	3	-
Hayy al-Sarh	AH I	1	-	3	3
Hayy al-Sarh	AH II	1	-	-	-

Tab. 4. Typological composition of the collected assemblages.

Locus	Archaeological horizon	Tools				
		bifacial	scraper	Borer	denticulated/notched	other
2414	Surface	22	14	7	4	16
2416	Surface	-	-	1	1	7
2424	Surface	6	2	1	-	4
2423	Surface	4	5	1	2	-
Hayy al-Sarh	AH I	3	-	-	1	-
Hayy al-Sarh	AH II	-	-	-	-	-

Figures:



Figure 1. Location of the study region of RBAS' Stone Age work group (rectangle) and Neolithic sites mentioned in the text (star).

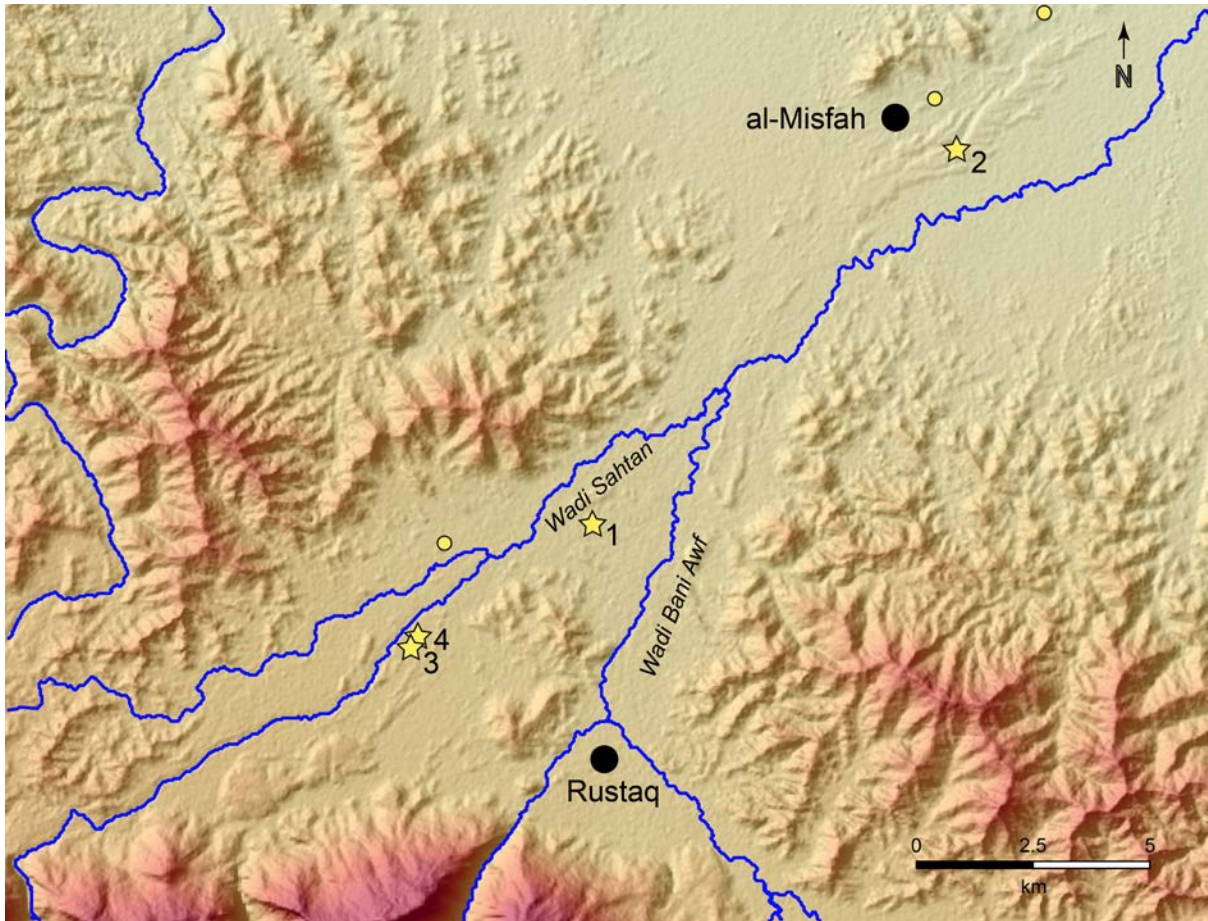


Figure 2. Distribution of Neolithic sites in the Rustaq study region identified by the RBAS project. Sites presented in the text are shown by stars: 1) L2414; 2) L2416; 3) L2424; 4) L2423 (Hayy al-Sarh). Low density sites, which are not discussed here, are shown by circles.

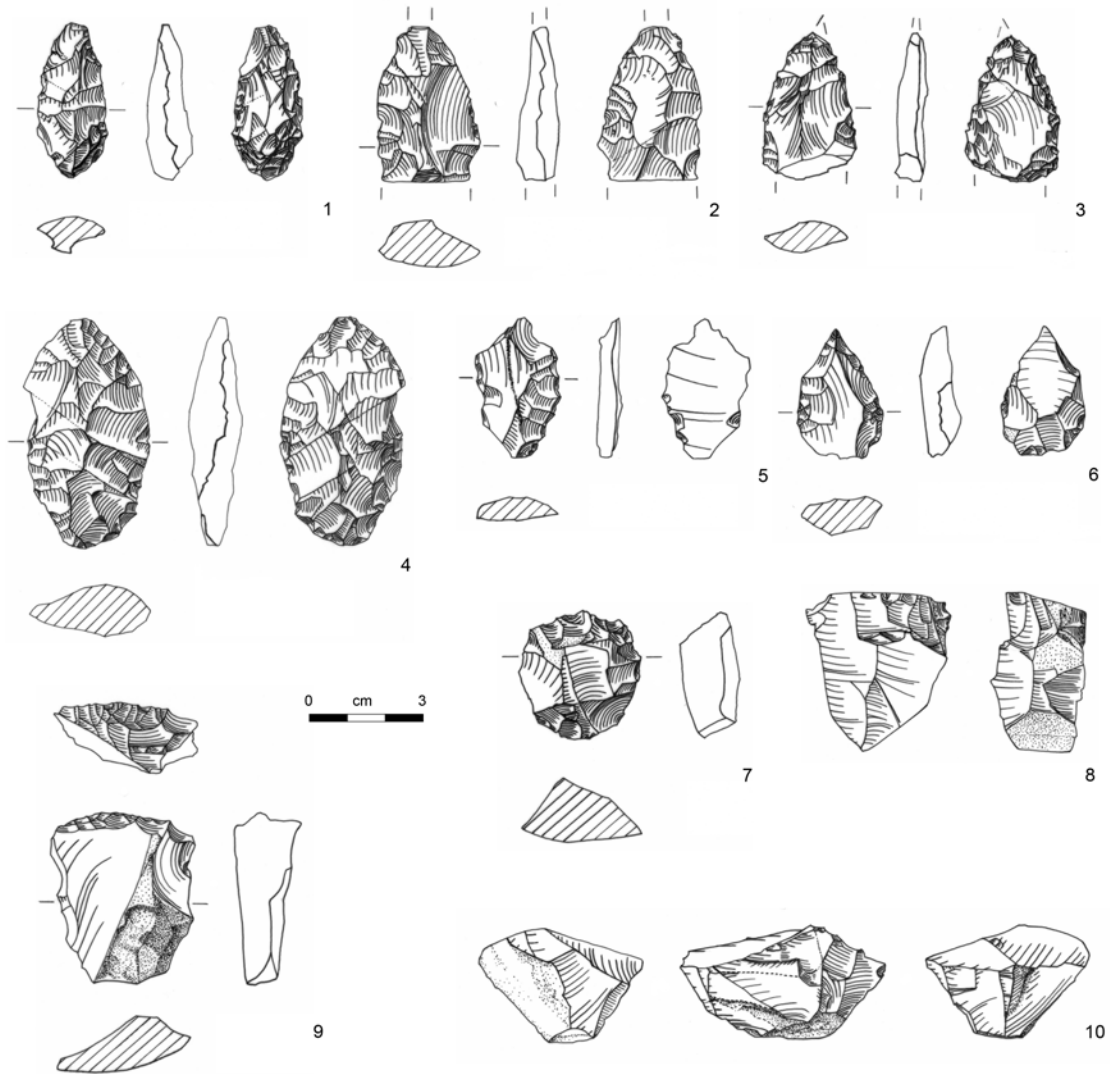


Figure 3. Examples of lithic artifacts from the surface site at L2414. 1-4) bifacials; 5-6) borer; 7, 9) endscraper; 8, 10) cores.

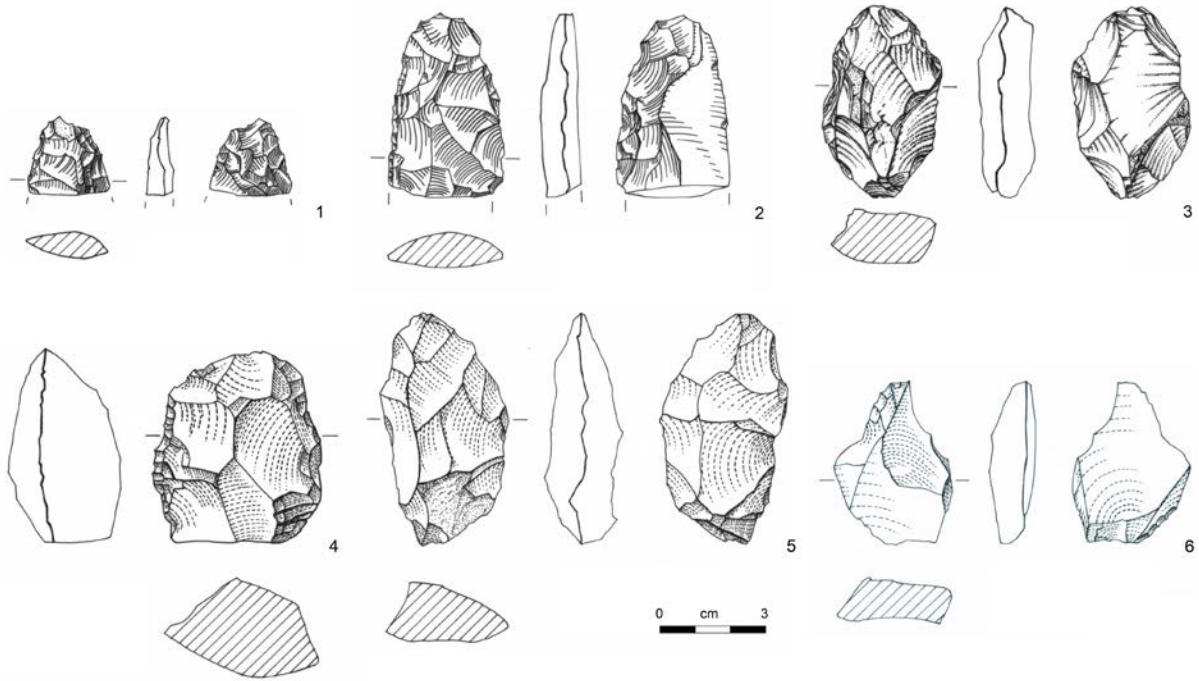


Figure 4. Examples of lithic artifacts from the surface site at L2423. 1) bifacial points; 2-5) large bifacial tools; 6) borer.



Figure 5. Overview of test excavation at Hayy al-Sarh. A) View towards northwest. Please note the location of the excavated trenches in the lower left quarter of the picture. The grayish parts just below the houses indicate the location of the modern Wadi Sahtan. B) Close up of excavation. View towards south.

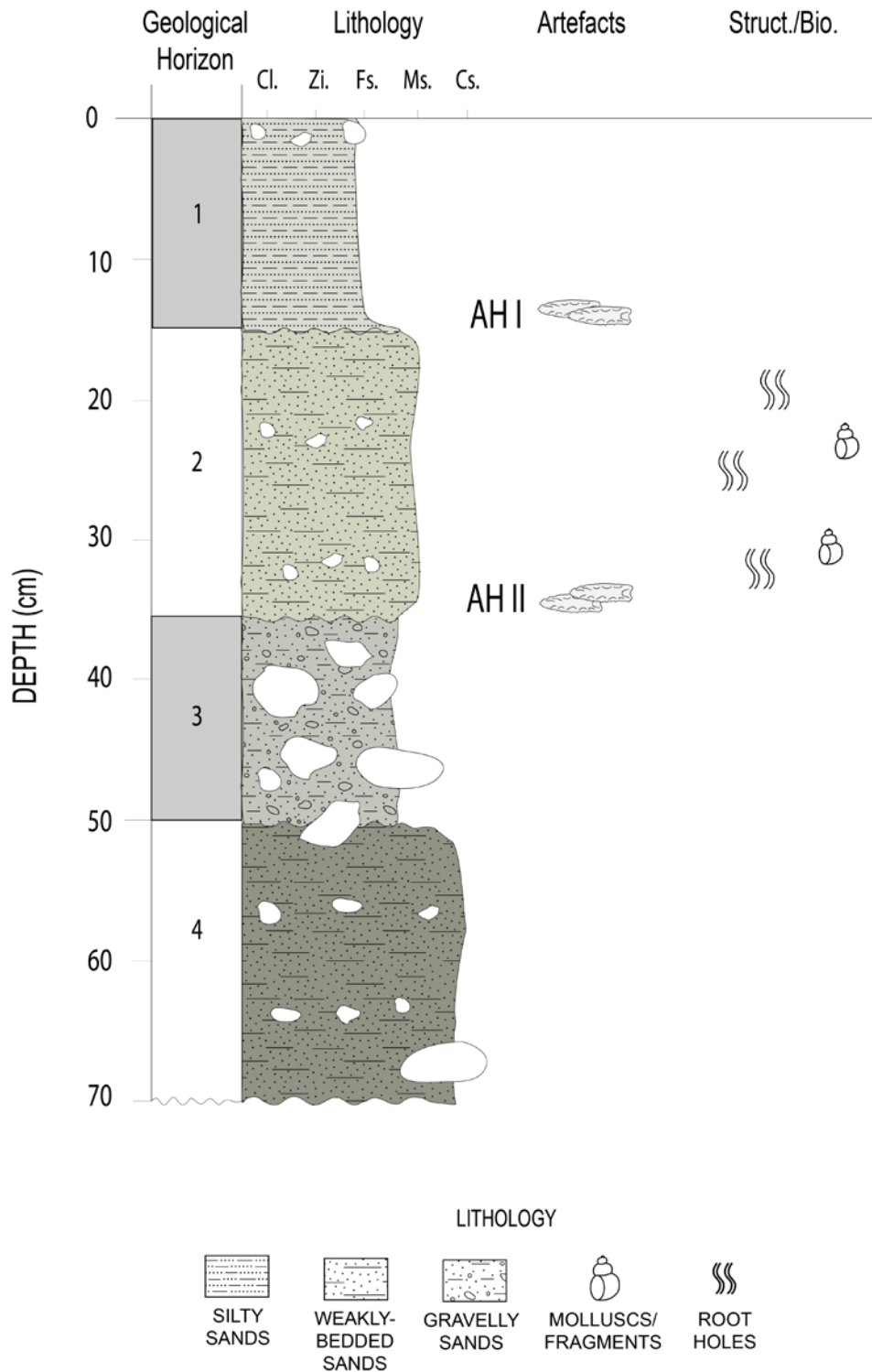


Figure 6. Archaeological and sediment stratigraphy at site Hayy al-Sarh. Please note that the gastropods shown here are terrestrial species which were natural part of the paleoenvironment. The worked and unworked marine shells that were used for dating the site were all found in AH I.

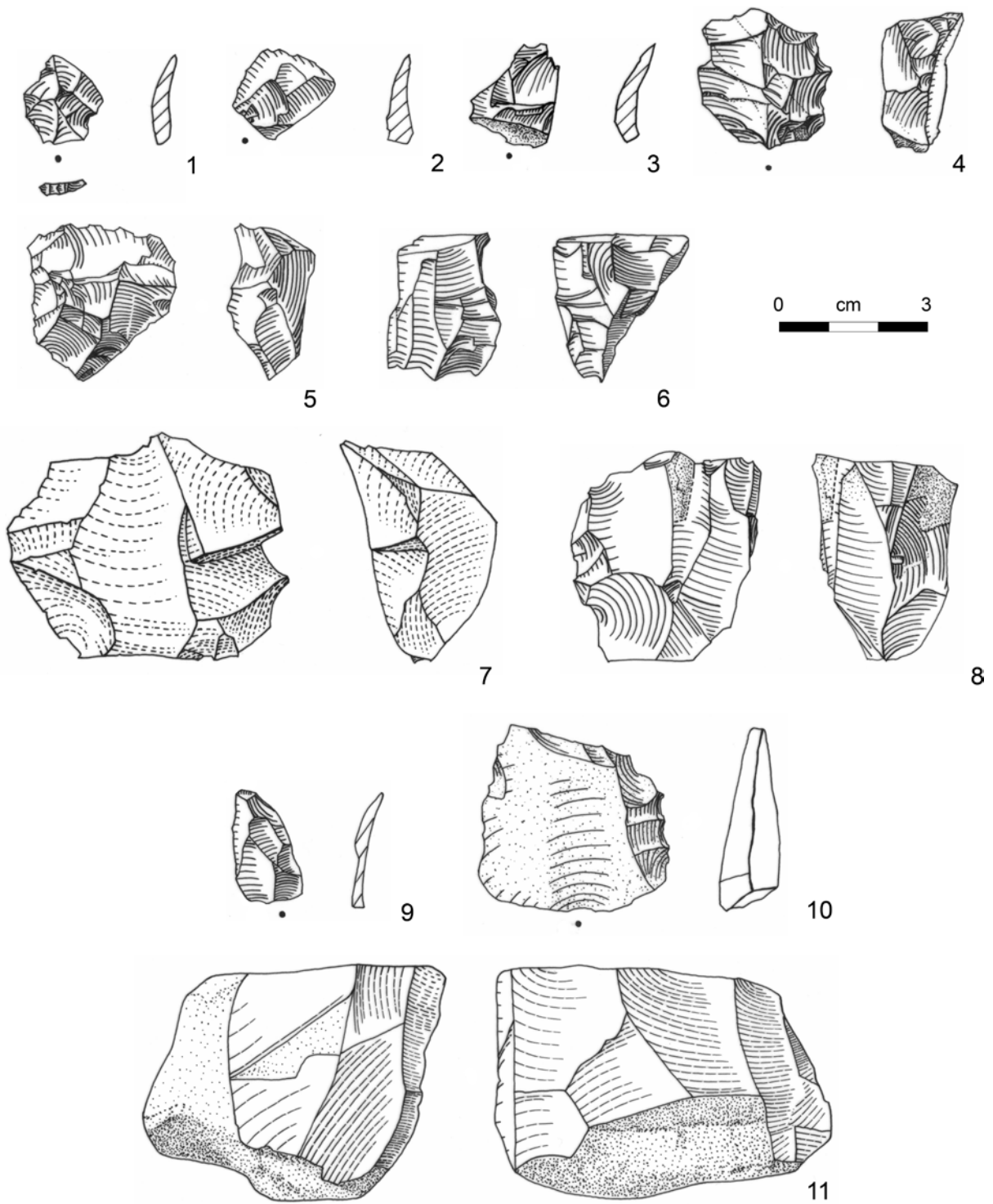


Figure 7. Examples of lithic artifacts from AH I (1-8) and AH II (9-11) at Hayy al-Sarh. 1-3) Bifacial thinning flakes; 4) flake; 5-8) cores; 9-10) flakes; 11) core.

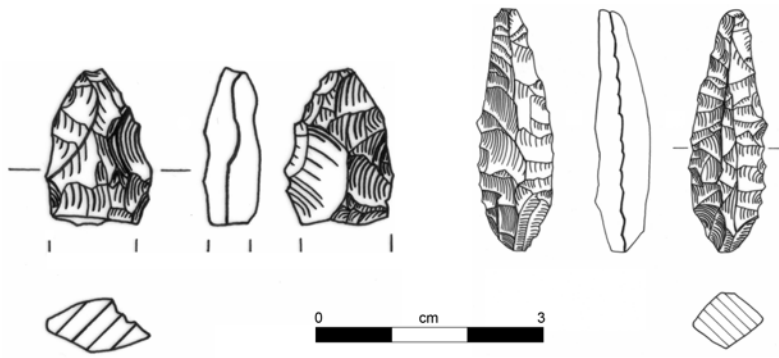


Figure 8. Two fusiform bifacial points, right) from L2423 surface; left) from AH I of the excavation. Please note that the left piece is broken and unfinished.

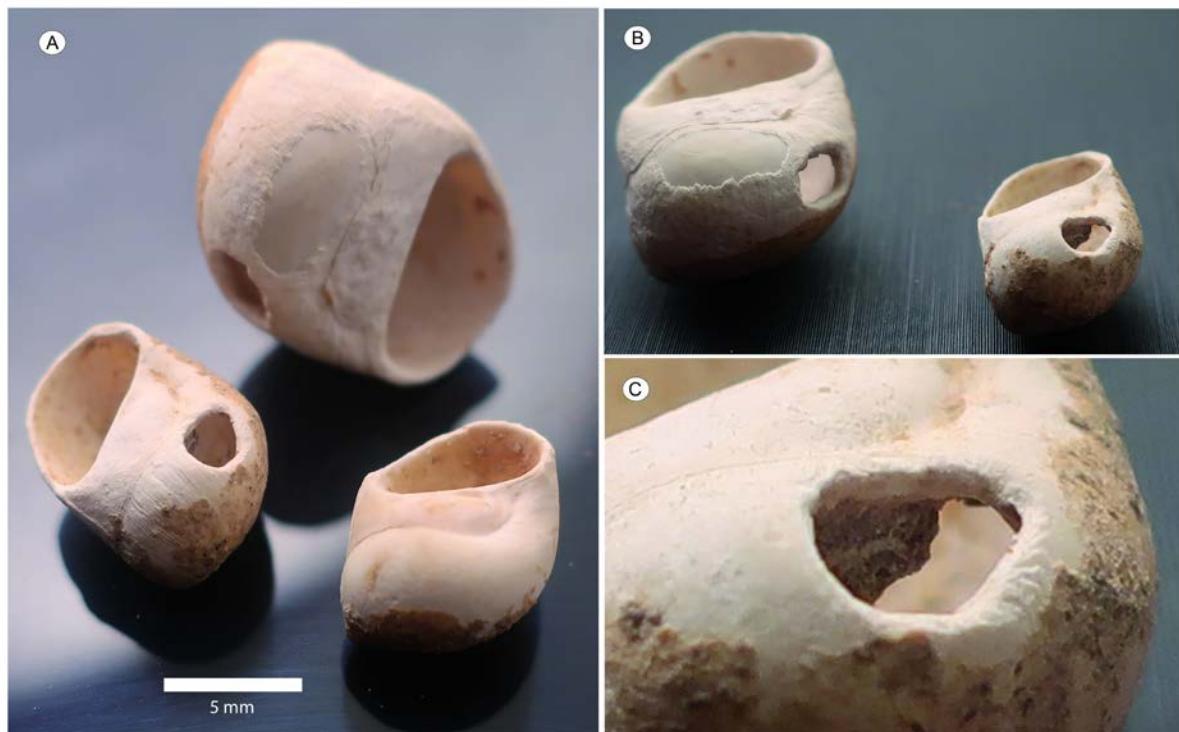


Figure 9. Shells found in AH I of the excavations at Hayy al-Sarh. The shells are from gastropods of the family Naticidae. A) Overview of the two pierced and one complete piece. Please note that the two specimens in the front were used for the radiocarbon dating presented here. B) Close up of the pierced shells showing the identical location of the holes. C) Close-up of one hole showing markings related to the production of the holes.