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Nubian Complex reduction strategies in Dhofar, southern Oman

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ABSTRACT

Between 2010 and 2012, the Dhofar Archaeological Project has located and mapped 260 Nubian Complex occurrences across Dhofar, southern Oman. Many of these lithic assemblages are technologically homologous to the Late Nubian Industry found in Africa, while others may represent a local industry derived from classic Nubian Levallois technology. The purpose of this paper is to describe the various reduction strategies encountered at a sample of Nubian Complex sites from Dhofar, to explore inter-assemblage variability, and, ultimately, to begin to articulate technological units within the "Dhofar Nubian Tradition." To achieve this aim, we have developed an analytical scheme with which to describe variability among Nubian Levallois reduction strategies. From our analysis, we are able to discern at least two distinct industries within a regional lithic tradition. Demographic implications of the enduring Dhofar Nubian Tradition are considered in light of new evidence found throughout the Arabian Peninsula.

1. Background

1.1. The Afro-Arabian Nubian Technocomplex

The "Afro-Arabian Nubian Technocomplex" encompasses the African and Arabian Nubian Traditions, which, in turn, consist of a series of technologically related lithic industries that are distinguished by the presence of the Nubian Levallois core reduction strategy (Guichard and Guichard, 1965; Marks, 1968; Van Peer, 1992; Rose et al., 2011). Nubian Levallois technology was first recognized in northern Sudan in the 1960s, and has since been discovered throughout the Middle and Lower Nile Valley (Van Peer, 2000; Van Peer et al., 2003, 2010; Chiotti et al., 2009; Olszewski et al., 2010), eastern Sahara oases (Wendorf et al., 1994; Smith et al., 2007a), and the Red Sea hills (Van Peer et al., 1996). To a much lesser extent, this technology appears in the Horn of Africa at K'One Crater (Kurashina, 1978) and Gorgora Rockshelter (Clark, 1988) in Ethiopia, and Hargeisa (Clark, 1954) in northern Somalia.

Nubian Levallois technology is also found extending across southern Arabia. Nubian Complex occurrences are reported from the Hadramaut Valley in central Yemen (Inizan and Ortlieb, 1987; Crassard, 2009; Crassard and Thiébaut, 2011) and Dhofar, southern Oman, where a dated assemblage at Aybut al Auwal confirms the presence of the Nubian Complex in Arabia over 100,000 years ago (Rose et al., 2011). Given its wide geographic spread across Northeast Africa and South Arabia and its variability over time, these sites can now be designated, in broadest terms, as belonging to a coherent Afro-Arabian Nubian Technocomplex (or "complex" for short; see Clarke (1978) for a discussion of lithic techno-typological units).

African Nubian Complex toolmakers were most likely anatomically modern humans (AMHs), although only a single skeleton has been found associated with such an assemblage. An AMH child was discovered at the chert quarry of Taramsa 1 in the Lower Nile Valley in Egypt, dated to 68.6 ± 8 ka. The skeleton is associated with a Late Nubian assemblage belonging to Activity Phase III at the site (Van Peer et al., 2010). Also compelling is the apparently exclusive presence of AMH remains in North Africa from approximately 150 ka onward (Smith et al., 2007b; Hublin and McPherron, 2012), since no alternatives to AMH have been found in this part of Africa. In contrast, skeletal and genetic evidence raise the possibility of late-surviving archaic populations in sub-Saharan Africa (Hammer et al., 2011; Harvati et al., 2011; Lachance et al., 2012). In light of these findings, Balter (2011: 20) speculates that North Africa was the, "original home of the modern humans who first trekked out of

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the continent." Hence, the spread of the Nubian Complex into Arabia may correspond with an AMH dispersal out of North Africa (Rose et al., 2011).

Different industries are recognized within the Nilotic Nubian Tradition, including an Early Nubian Industry falling within MIS 5e (~130–115 ka) and a Late Nubian Industry dated to MIS 5a, between ~85 and 74 ka (Vermeersch et al., 1998; Mercier et al., 1999; Van Peer et al., 2010). The Early Nubian Industry is defined by the predominance of Nubian Levallois cores with bilateral preparation (Type 2) in conjunction with Lupemban bifacial foliates (Guichard and Guichard, 1968; Van Peer et al., 2003), while the Late Nubian Industry shows a much higher frequency of Nubian cores with distal divergent preparation (Type 1), and the absence of bifacial tools (Van Peer and Vermeersch, 2007). An Early Nubian assemblage was found in stratigraphic succession overlying a series of Late Sangoan/Lupemban horizons dated to MIS 6 at Sai Island in northern Sudan (Van Peer et al., 2003). In the Early Nubian level, Lupemban bifacial tools were found together with Nubian cores, leading the excavators to conclude that the Early Nubian Industry developed locally from the Lupemban in the Middle Nile Valley. The same co-occurrence of Lupemban bifacial tools and Nubian Levallois cores was noted at Arkin 5, also in northern Sudan (Chmielewski, 1968).

There is a Late Nubian horizon overlying an Early Nubian level at Sodmein Cave (Van Peer et al., 1996; Mercier et al., 1999). At Taramsa 1, exploitation pits containing both Early and Late Nubian assemblages were found stratigraphically isolated from one another by an MIS 5d sand layer with an OSL age of 117 ± 10 ka (Van Peer et al., 2010). In both cases, the two industries are separated by a long chronological hiatus extending from MIS 5d through MIS 5b (~115–85 ka). It is noteworthy that, although there are no known Late Nubian sites during this time span in Africa, the Nubian Complex assemblage at Aybut Al Auwal in Dhofar, southern Oman was dated to 106 ± 9 ka (Rose et al., 2011).

After MIS 5, there are a variety of new industry types found throughout the Nile Valley such as the Khormusan (Marks, 1968) and the Taramsan (Van Peer et al., 2010). Both show diverging technological trajectories, yet appear to stem from a common Nubian Levallois base. In the case of the Taramsan Industry, the preferential Nubian Levallois method developed into a reduction strategy of continuous blade production, while the Khormusan exhibits a decrease in Nubian Levallois, accompanied by an increase in preferential centripetal Levallois cores. Despite this shift in Levallois method, Khormusan cores tend to maintain the same morphology as the preceding Late Nubian Industry, their distinctive triangular and sub-triangular shapes clustering with these assemblages. As such, these industries are considered part of a long-term Nilotic Nubian Tradition.

1.2. Geography and climate of Dhofar

The Governorate of Dhofar occupies the southwestern corner of the Sultanate of Oman, stretching across an area of roughly 100,000 km^2. The region is divided into four general ecological zones: 1) Salalah coastal plain, 2) Jebel Qara escarpment, 3) Nejd Plateau, and 4) Rub' Al Khali desert (Fig. 1A).

Dhofar encompasses a unique microclimate within Arabia; moisture brought by the Indian Ocean Monsoon accumulates along the Jebel Qara–Jebel Samhan escarpment, resulting in relatively high precipitation in the mountains (200–350 mm per annum) and cool temperatures between the months of June and September. The high grasslands atop the escarpment reach 1000 m in elevation and are mantled in a dark brown clay soil that supports a subtropical cloud forest belonging to the Somalia–Masai center of endemism, while date and coconut palms, bananas and other tropical fruits, and grasses are cultivated along the coastal plain (Platel et al., 1992; Ghazanfar and Fisher, 1998).

Northwards, past the current watershed divide, the escarpment levels off onto a deeply incised limestone plateau called the Nejd, which is the eastern margin of a one thousand-kilometer-wide plateau that spans central Yemen to southern Oman, extending some 150–300 km from the coast to the interior Rub' Al Khali basin. Around its southern border, the Omani Nejd is a barren scabland marked by an intricate series of minor wadis dissecting the plateau. These smaller drainage systems converge into larger and more deeply incised canyons that run northward across the central plateau, roughly parallel to one another. As they reach the northern Nejd, the wadis empty onto a gently undulating plain of Quaternary alluvium that flanks the Rub' Al Khali desert.

The drainage channels incising the Nejd Plateau formed during periodic pluvial phases throughout the Quaternary (Platel et al., 1992). While much of Arabia presently experiences an arid/hyper-arid climatic regime, the palaeoenvironmental record indicates that northward migrations of the Inter Tropical Convergence Zone, and associated monsoon rains, brought increased precipitation to large portions of the Arabian Peninsula over the course of MIS sub-stage 5e (~130–115 ka), sub-stage 5c (~110–100 ka), and sub-stage 5a (~90–70 ka). Terrestrial evidence for such humid episodes is found throughout the Peninsula within fluvio-lacustrine deposits (Maizels, 1987; Sanlaville, 1992; Preusser et al., 2002; Preusser, 2009; Petit-Maire et al., 2010; Waldmann et al., 2010), speleothems (Burns et al., 1998, 2001; Bar-Matthews et al., 2003; Fleitmann et al., 2003, 2011; Vaks et al., 2006, 2010; Fleitmann and Matter, 2009), and deep sea cores from the Arabian Sea (Rostek et al., 1997; Saraswat et al., 2005; Saher et al., 2009; Govil and Naidu, 2010). Recently discovered terrestrial archives from central and eastern Arabia indicate a later pluvial across eastern and central Arabia between roughly 60 and 50 ka (McLaren et al., 2008; Parton et al., 2013).

There are three separate Eocene chert-bearing formations found across the Nejd (Platel et al., 1992). Fine-grained, large, banded chert slabs and smaller plaquettes occur within the Mudayy member, which is the highest quality on the plateau, outcropping in the southern and central regions. Mudayy chert ranges from tan to dark brown and is typically free of inclusions. Chert nodules, spheroids, and plaquettes are all found embedded within the overlying Rus formation, which has scattered exposures constrained within the southern Nejd. The Rus formation includes two distinct members: the lower chalky Aybut member and upper Gahit member. Aybut chert is yellowish orange, outcrops in rounded nodules and seams of varying sizes, and is often poor quality due to mineral inclusions and post-depositional displacement that has left much of it highly fractured. Thin, high quality grey chert plaquettes are found within the Gahit member, typically occurring as flat spheroids embedded in a marly-carbonate matrix.

In three seasons of survey, 260 occurrences were mapped in Dhofar that bear evidence of Nubian Levallois technology. At present, Nubian sites have only been found in the interior – on the Nejd Plateau and the southern margins of the Rub' Al Khali (Fig. 1A). No evidence of Nubian technology has been found south of the Nejd; not on the Salalah coastal plain, the seaward slopes of the Jebel Qara–Jebel Samhan escarpment, nor the high grasslands atop the escarpment. The continental shelf off the coast of Dhofar is particularly narrow, not exceeding five kilometers. Lower sea levels during the Late Pleistocene would not have exposed any significant new landmass, and therefore the possibility that such sites are now submerged can be rejected.

Nubian occurrences are typically found on desert gravel plains and just back from dry riverbeds. While the sites are distributed across the entire Nejd Plateau, the greatest concentration was

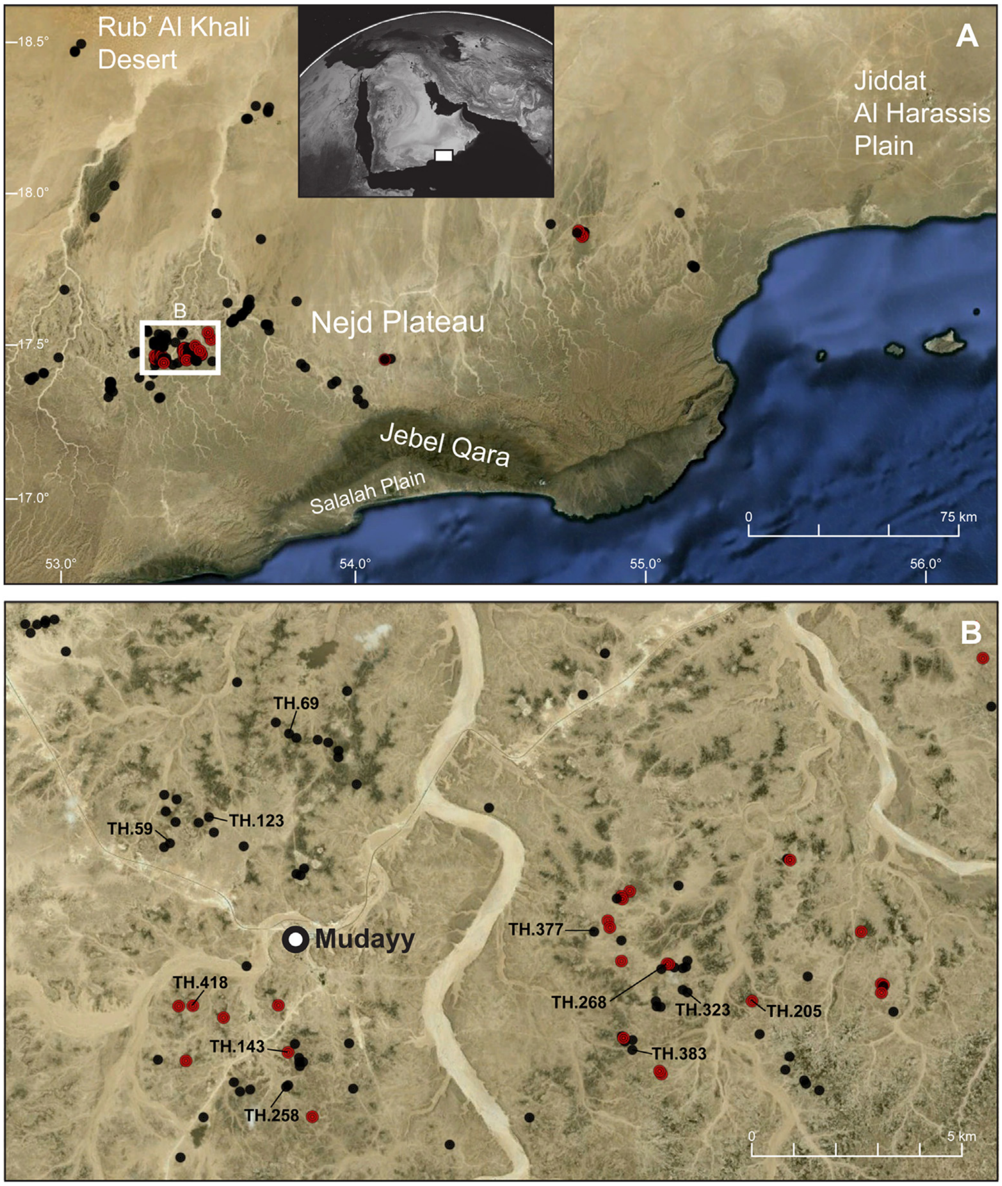

Fig. 1. Map of Dhofar (A) and close-up of the Mudayy area (B) showing Arabian Nubian Complex site distribution; Classic Dhofar Nubian sites in black and Mudayyan sites in red; sites mentioned in the text or figures are specifically labeled (basemaps courtesy of Google Earth©). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

found in the vicinity of the village of Mudayy (Fig. 1B). This small settlement on the western Nejd is built around a series of groundwater fed springs, which are presently among the few permanent sources of freshwater on the plateau. Moreover (as the name implies), there is an abundance of high quality Mudayy chert in the area, with fresh outcrops continually being exposed by fluvial and aeolian erosion.

2. Materials and methods

2.1. Nubian Complex assemblages

The lithic assemblages analyzed here were chosen based on the integrity of the paleo-landscapes upon which the scatters were found (i.e., stable desert pavements, artifacts in primary position as judged from spatial context, and refits made in the field) and homogeneity of the assemblages (i.e., evidence for discrete knapping events indicated by refits, homogenous technology, and consistent weathering/patina on artifacts). Assemblages were collected systematically in 1 × 1 sq m units. The following sample of localities, all from the region around Mudayy, meet these conditions and represent the range of Nubian Complex variability thus far encountered in Dhofar: TH.69, TH.258, TH.268, TH.377, and TH.383c (Fig. 1B). Most of this material was collected during the 2012 field season; in the time available, we are only able to present a limited sample of the total artifacts. Consequently, this paper will not provide a site-by-site report of these assemblages; rather, it will describe the basic range of Nubian core reduction strategies we have observed thus far, using a select sample of representative material. It is specifically these reduction methods and their resulting products that define the Dhofar Nubian industries, not the types and proportional occurrences of tool classes. As such, we include only a cursory description of retouched tools.

2.2. Technological classification

Our classificatory scheme was developed to describe the range of Nubian core reduction methods and systems by which these were achieved. We recognize three hierarchical tiers to conceptualize these modes of reduction (*sensu* Van Peer, 1992): 1) "Core Reduction Strategy," 2) "Method," and 3) "Organizational System."

Core Reduction Strategy is the broadest descriptive category and distinguishes Levallois from non-Levallois reduction. Decades of research have been spent defining and debating the Levallois concept; however, it is not the purpose of this paper to wade into the complexities of this issue (e.g., Boëda, 1982, 1988, 1990, 1995; Van Peer, 1988, 1992; Usik, 2004, 2006). To avoid becoming mired in semantics of whether Levallois "blades" and débordant

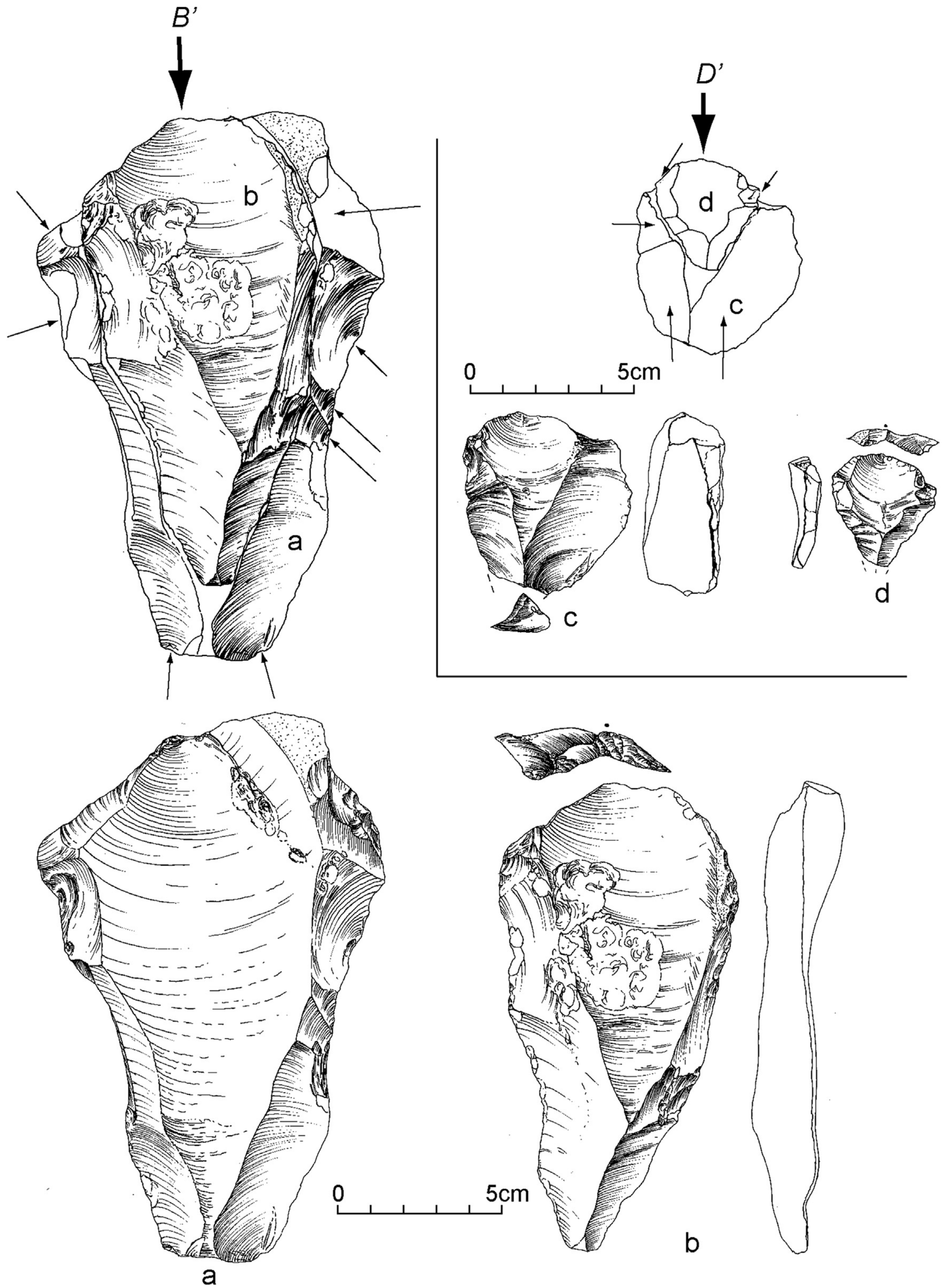

Fig. 2. Type 1 Nubian (a,b) and micro-Nubian (c,d) Levallois cores with refit points from TH.383c and TH.205, respectively.

elements are classified as Levallois products, or whether recurrent Levallois cores can be distinguished from rejuvenation of preferential Levallois cores, we acknowledge that there are different ways of defining this reduction strategy, and have deliberately chosen a narrow definition of the term. As per Usik (2004, 2006), the Levallois strategy presented here exclusively refers to preferential core reduction in which specific preparation of a working surface and striking platform is designed to produce, in principle, one predetermined endproduct. Such cores, evidently, can pass through different cycles of rejuvenation. Contrary to a wider conception of the term, we exclude recurrent Levallois. Therefore, non-Levallois strategies include all other modes of core reduction that produce recurrent blanks from one or more striking platforms, on either flat (cordiform, rectangular, triangular, etc.) or volumetric (cylindrical, pyramidal, globular, etc.) shaped cores.

The next analytical tier is Method. Within the Levallois strategy, different methods are used to create various preferential endproducts. The Nubian Levallois method is based on the production of elongated Levallois points or pointed flakes (Fig. 2). In Dhofar, we have documented both Nubian and preferential centripetal Levallois cores, although Nubian is, by far, the predominant method. Such cores are highly standardized and distinguished by an array of morphological features, each of which is essential for the piece to be classified as Nubian Levallois. First and foremost is the steeply angled median distal ridge that serves to control the distal lateral convexity of the core's primary working surface and is responsible for producing the desired endproduct (e.g., Rose et al., 2011: Fig. 10). As this is the most essential characteristic of Nubian Levallois technology, the creation of the median distal ridge is termed "Nubian technique" and is currently undergoing detailed interregional study (Groucutt, personal communication). The angle of the Nubian distal ridge can be grouped into four general degrees of

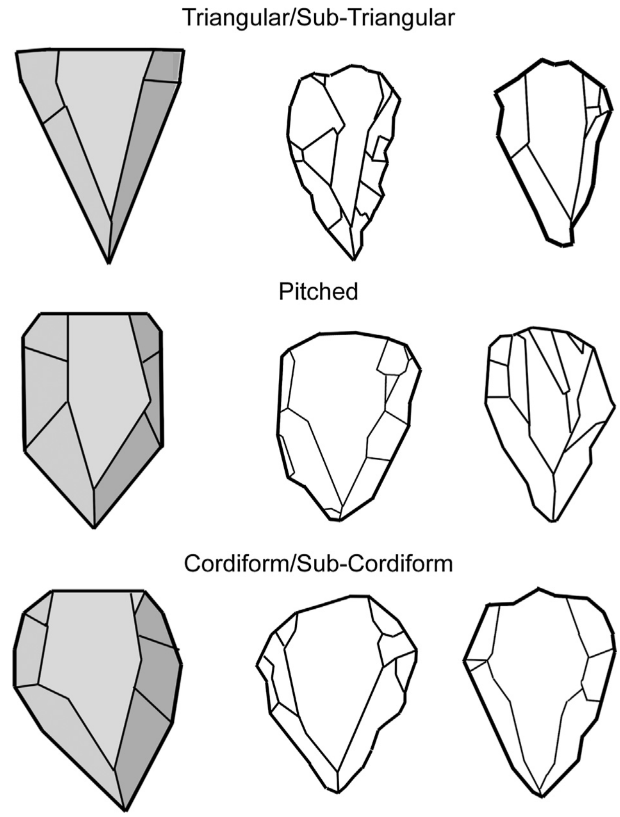

Fig. 4. Nubian Levallois core shapes.

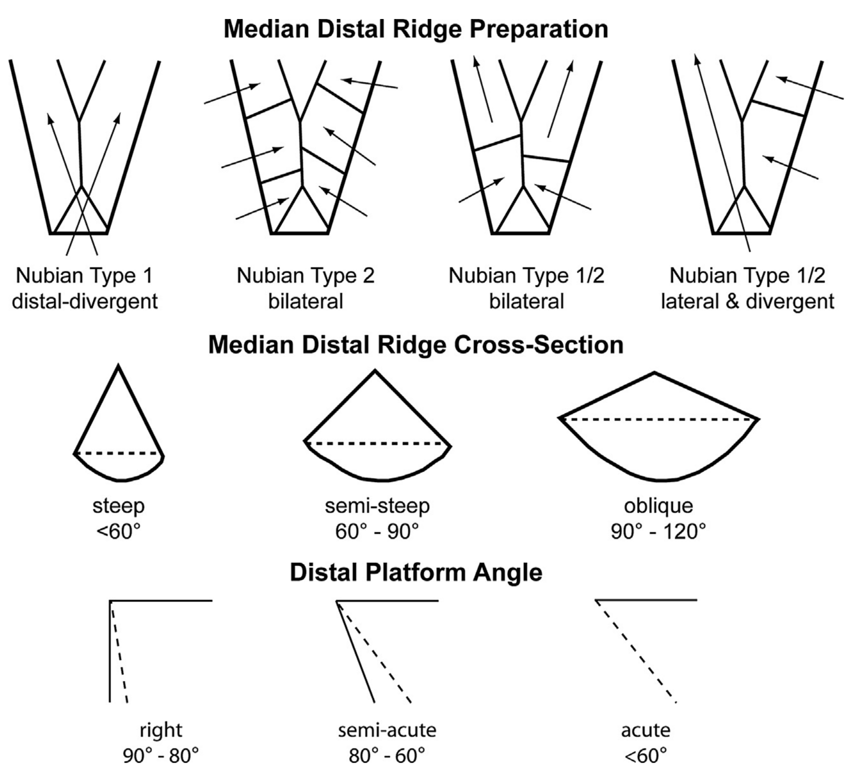

Fig. 3. Schematic showing recorded observations for characterizing Nubian Levallois medial distal ridge variability, including organizational system, distal ridge cross-section, and distal platform angle.

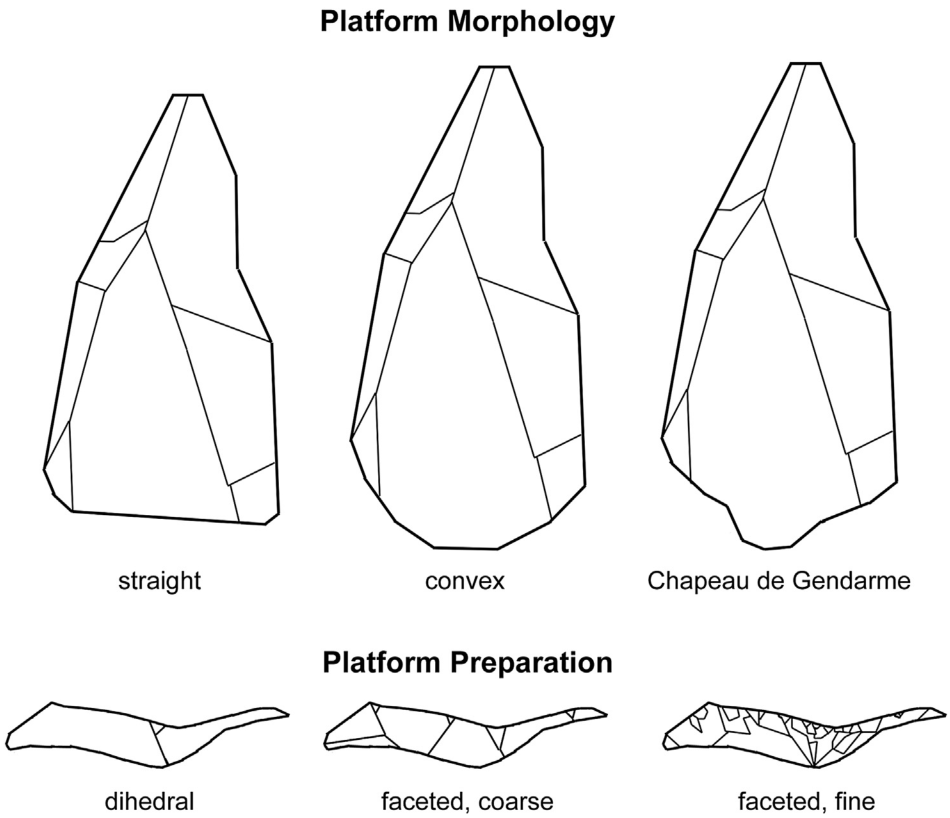

Fig. 5. Varieties of striking platform modification as seen on Nubian Levallois blanks. Top depicts morphology in plan view; bottom shows methods of preparation in profile view.

steepness: steep (<60°), semi-steep (60°–90°), oblique (90°–120°) or flat (>120°) (Fig. 3). The last group falls outside of Nubian Levallois, *sensu stricto*, grading into bidirectional cores or recurrent cores with opposed, faceted platforms. The opposed striking platform used in the preparation of the distal ridge varies from right angle (90°) to acute (50°) and tends to be quite limited within this range (Fig. 3).

Core morphology is another essential feature of the Nubian Levallois method. The shape of the core's primary working surface is a result of the particular imposition of preparation scars and, hence, dictates the shape of the preferential Levallois endproduct. In the case of Nubian Levallois, we recognize a range of three sub-types including triangular, cordiform, and pitched (Fig. 4). Pitched shapes are defined as having more or less parallel elongated lateral sides with a convergent distal end; triangular cores exhibit the greatest width at the base, with lateral sides converging from proximal to distal end; cordiform shaped cores are widest about one third above the proximal end and have convex-converging lateral edges.

Finally, the core must have a prepared main striking platform. The platforms are shaped through dihedral removals, coarse faceting, or fine faceting, and result in Chapeau de Gendarme, convex, or straight butts on the blanks struck from the core (Fig. 5). Each of these three conditions (i.e., steep distal ridge, triangular core shape, prepared striking platform) must be present for a core to be classified as Nubian Levallois; such a rigid definition is necessary to prevent any unwarranted broadening of this particular reduction strategy. Furthermore, a strict definition enables us to identify features in assemblages that vary from the typical Nubian Levallois reduction strategy, which may represent local industries of the parent technocomplex. The core classificatory scheme and recorded core attributes are listed in Table 1a and b, respectively.

Table 1
a. Core classification scheme. b. Nubian core attributes recorded in this analysis.

a.

Strategy	Method	Organizational system
Levallois	Nubian	Nubian, Type 1
		Nubian, Type 2
		Nubian, Type 1/2
		Nubian, unsuccessful
		Nubian, indeterminate
		Nubian, early stage
	Centripetal	Preferential radial
	Convergent	Preferential converging
	Bidirectional	Preferential opposed
Non-Levallois	Centripetal	Radial
	Convergent	Converging
	Bidirectional	Opposed
	Unidirectional	Simple unidirectional
		Unidirectional parallel
		Unidirectional convergent
	Multiple platform	Alternating
		Crossed

b.

Shape	Platform preparation	Distal ridge angle	Distal ridge preparation	Distal platform angle
Triangular	Faceted, fine	Steep	Distal-divergent	Right (90°)
Pitched	Faceted, coarse	Semi-steep	Distal-parallel	Semi-acute (60°–90°)
Cordiform	Dihedral	Oblique	Distal-convergent	Acute (<60°)
Rectangular	Straight	Missing	Lateral-distal	
Irregular	Cortical	Overpassed	Bilateral	

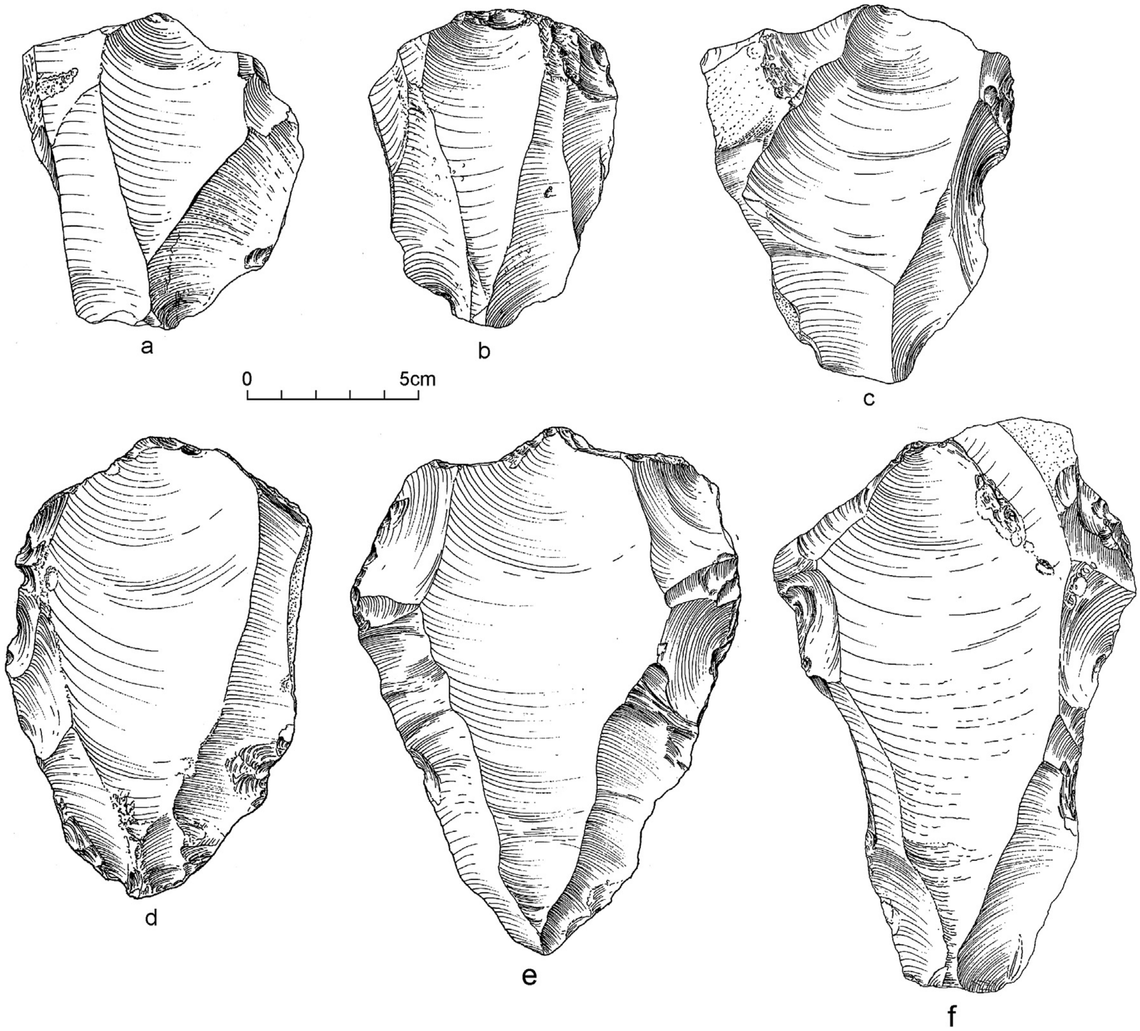

Fig. 6. Nubian Type 1 cores from (a) TH.59, (b) TH.123, (c) TH.123, (d) TH.59, (e) TH.383c, and (f) TH.323.

2.3. Organizational systems

The final hierarchical tier we consider is Organizational System, which describes the different physical ways the core reduction strategy is achieved. Within the Nubian Levallois method, there are two established systems used to form the median distal ridge: Types 1 and 2. The primary working surface of a Nubian Type 1 core exhibits two distal-divergent removals, creating the steep distal ridge (Fig. 6). Although the endproduct is of the same morphology, the median distal ridge on a Nubian Type 2 core is achieved through bilateral shaping of the primary working surface (Fig. 7). These classifications reflect the final state of the core; however, Nubian Complex toolmakers were able to switch from one type to another during phases of re-preparation (e.g., Fig. 6e,f).

The Nubian Type 1 and Type 2 methods are not mutually exclusive; in some instances, the primary working surface of the Nubian core exhibits a combination of partial-distal and lateral shaping (Figs. 3 and 8). Researchers working in the region around Abydos, Egypt have also noted this intermediate type (Chiotti et al., 2007, 2009; Olszewski et al., 2010), referred to as “Nubian Type 1/2.” In Hadramawt, Crassard (2009) articulates a range of composite sub-types called modalities “B2,” “B3,” “B4,” “B5,” and “constructed points” (Crassard and Thiébaut, 2011), which are now recognized as organizational systems within the Nubian Levallois method (Crassard, personal communication). Type 1/2 systems are apparent in different combinations; for instance, there are variants of Type 1 cores that have lateral and bilateral supplementary preparation, yet still retain the prominent distal platform with distal-divergent removals. In Hadramawt, these composite types equate to modalities B4 and B5. This variety of intermediate forms demonstrates that Type 1 and Type 2 organizational systems are fluid and may be used in different combinations, while still achieving the same preferential Levallois endproduct.

At one particular site included in this analysis, TH.383c, we were able to refit a number of Nubian Levallois cores and blanks that were collected in proximity to one another. The scatter was located at the base of a low inselberg (Jebel Markhashik), where high quality Mudayy member chert slabs are, to this day, being exposed from the side of the eroding hill. A wide range of Nubian Levallois organizational systems are represented at TH.383c and provide a detailed reconstruction of the sequence of removals used to prepare the Nubian Levallois primary working surface.

As is typically the case with Nubian cores, the initial modification of the selected raw material begins with the creation of the distal and then the main platform. This sequence is apparent on many of the early stage Nubian cores in the TH.383c assemblage, where the toolmaker’s first step was the formation of the distal platform. The classic Type 1 organizational system used to create

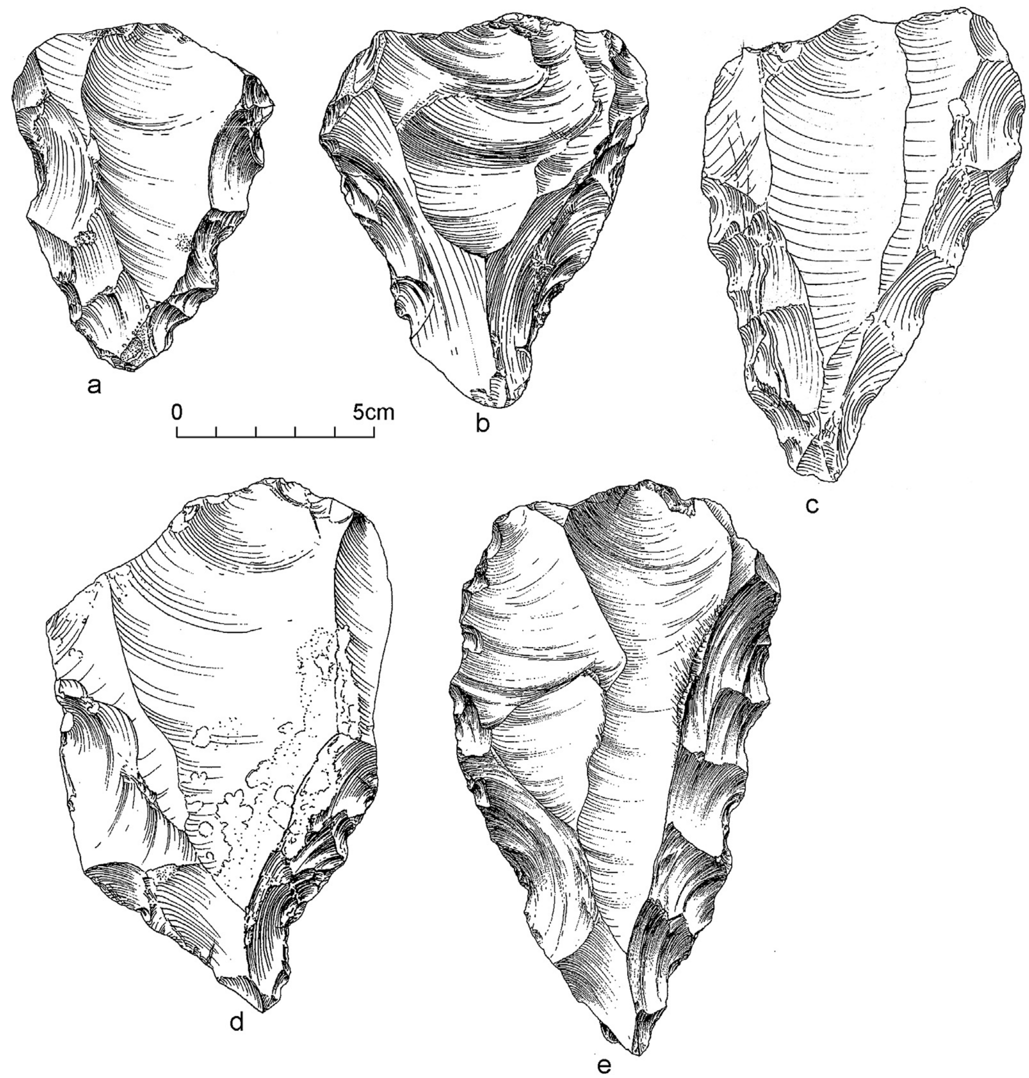

Fig. 7. Nubian Type 2 cores from (a) TH.59, (b) TH.123, (c) TH.59, (d) TH.383c, and (e) TH.258.

the median distal ridge is exemplified on core refits #582 (Figs. 9 and 10) and #564 (Figs. 11 and 12). From the opposed face of the core (Figs. 10 and 12), scars indicate a series of short, broad flakes struck from the sides of the core, prior to removal of the débordant blades. This lateral treatment across both faces is a kind of crest preparation technique to set up for the controlled removal of blades from the distal platform. The same cresting technique was observed within the African Nubian Complex, enabling flintknappers to move between Types 1 and 2 (Chiotti et al., 2009). Consequently, the débordant blades (Fig. 9a,c,d) have a lateral-crested scar pattern from this specific system of preparation. After each preferential Levallois point was struck from core refit #582 (Fig. 9b′,e′), the convexity of the working surface was restored through the removal of the débordant blades; in these cases, crested by earlier preparation, resulting in the characteristic Nubian Type 1 distal-divergent scar pattern on the primary working surface of the core (Fig. 9f). The débordant blade refit onto core #564 (Fig. 11a) is lateral–cortical and shows only bidirectional dorsal scars, indicating that this specimen was also Type 1 in the previous cycle of preparation.

Core refit #365 (Fig. 13) is a Type 2 organizational system, with bilateral flaking used to create the steep median distal ridge. Prior to these bilateral preparation flakes, unidirectional-convergent flakes were struck from the main platform, resembling the “constructed point core” modality reported in Hadramawt (Crassard and Thiébaut, 2011). The first conjoin (Fig. 13a) is a preferential Levallois point with prominent Chapeau de Gendarme butt. Following that, a unidirectional-convergent flake was struck from the edge of the main platform to restore convexity, which exhibits a crossed scar pattern (Fig. 13b). There is no evidence for the prior removal of distal-divergent blades, suggesting that this specimen has not been transformed from a Type 1 organizational system. The presence of unidirectional preparation flakes illustrates the variety of systems for achieving convexity of the core’s primary working surface within the Nubian Levallois method.

Core refit #106 (Fig. 14) is an example where the core has been transformed from Type 2 into Type 1. The core exhibits a combination of lateral and distal flaking, also apparent on the refit débordant blade (Fig. 14a) that has both bidirectional and lateral dorsal scars. From the #106 conjoin, and numerous other Nubian Levallois cores in Dhofar with Type 1/2 preparation, it is apparent that the Type 1 and Type 2 organizational systems may occur in a number of different combinations. The various composite Type 1/2 systems, found in both Africa and Arabia, suggest that the discrete character of the Type 1 and Type 2 categories, introduced

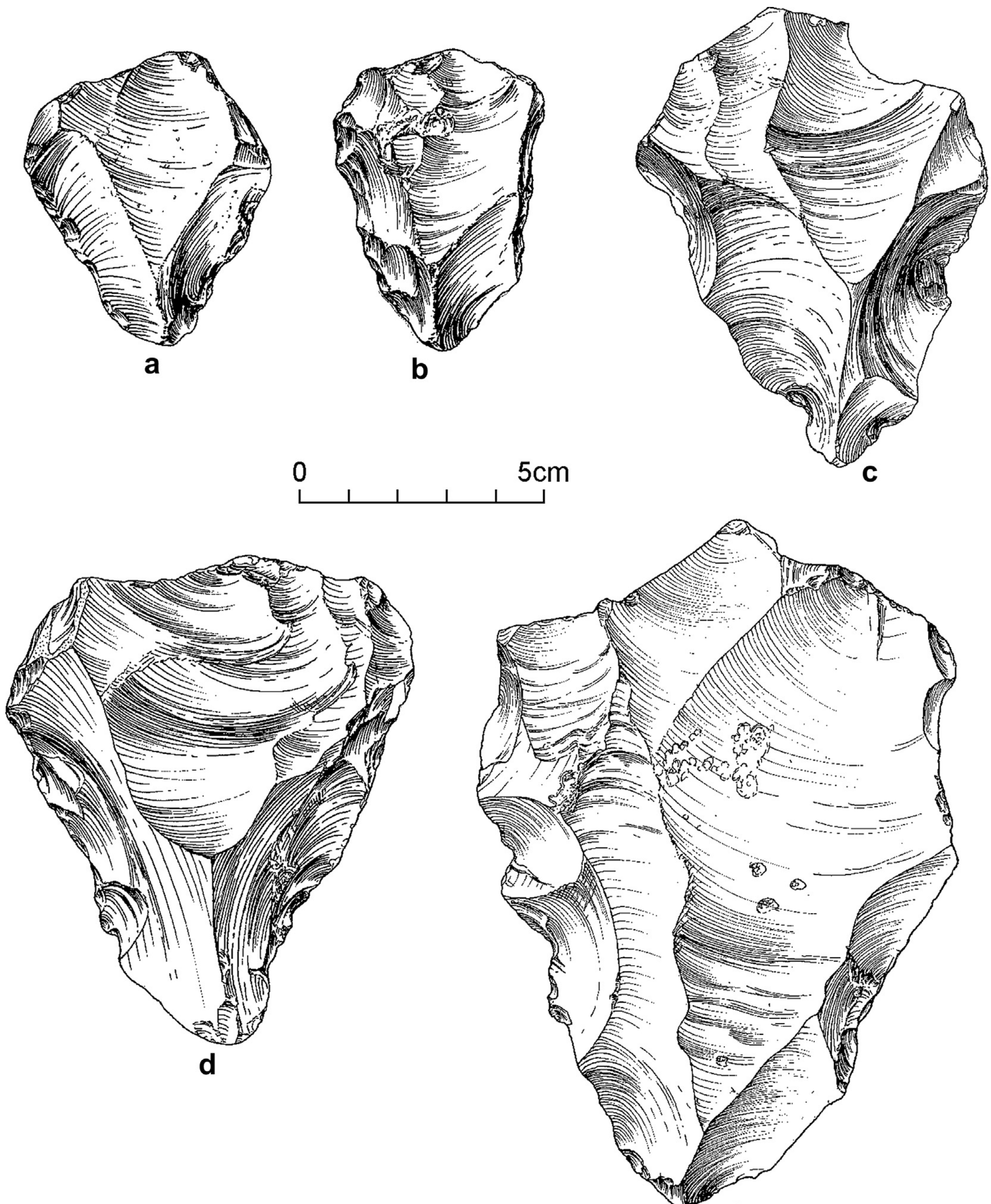

Fig. 8. Nubian Type 1/2 cores from (a) TH.69, (b) TH.69, (c) TH.123, (d) TH.123, and (e) TH.143.

by Guichard and Guichard (1965), are greatly exaggerated. Instead, we consider these organizational systems as gradients within a broad Nubian Levallois spectrum.

3. Analysis

3.1. Typology

Table 2 presents the total artifact counts of the five assemblages, divided into cores, tools, and debitage. Despite systematic surface collections of 100 sq m or more, samples of retouched tools were extremely small. At TH.69, retouched tool density was only 0.35 per sq m, while at TH.377 it was less than 0.07 tools per sq m. The frequency of tool types is shown in Table 3. In addition to preferential Levallois endproducts, retouched tools including sidescrapers, burins, denticulates, endscrapers, and notches are present. It is noteworthy that bifacial tools are absent, which are diagnostic elements exclusive to the Early Nubian Industry.

Table 2
Artifact class by site.

	Cores		Debitage		Tools		Total
TH.69	172	9.8%	1503	85.9%	74	4.2%	1749
TH.258	20	30.8%	40	61.5%	5	7.7%	65
TH.268	206	26.9%	542	70.7%	19	2.5%	767
TH.377	45	25.1%	126	70.4%	8	4.5%	179
TH.383c	115	13.7%	693	82.3%	34	4.0%	842

Table 3
Tool types by site.

	Levallois points		Levallois flakes/blades		Sidescrapers		Endscrapers		Burins		Denticulates		Notches		Retouched pieces		Total
TH.69	21	28.4%	18	24.3%	34	45.9%	0	0.0%	1	1.4%	0	0.0%	0	0.0%	0	0.0%	74
TH.258	5	50.0%	5	50.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	10
TH.268	0	0.0%	3	18.8%	0	0.0%	4	25.0%	0	0.0%	3	18.8%	0	0.0%	6	37.5%	16
TH.377	3	12.5%	14	58.3%	3	12.5%	2	8.3%	0	0.0%	1	4.2%	1	4.2%	0	0.0%	24

The low density of retouched tools in Dhofar is in marked contrast to Nubian sites from northern Sudan, where tool densities at even quarry sites (e.g., 1033 Upper and Lower) have densities of between ~3 and 5 tools per sq m, and smaller surface scatters have densities often exceeding 10 pieces per sq m (Marks, 1968: 249–257). On the other hand, the very low number of retouched tools found in Dhofar is paralleled at Late Nubian sites in the Egyptian high desert and in the Lower Nile Valley (Vermeersch, 2000, 2002),

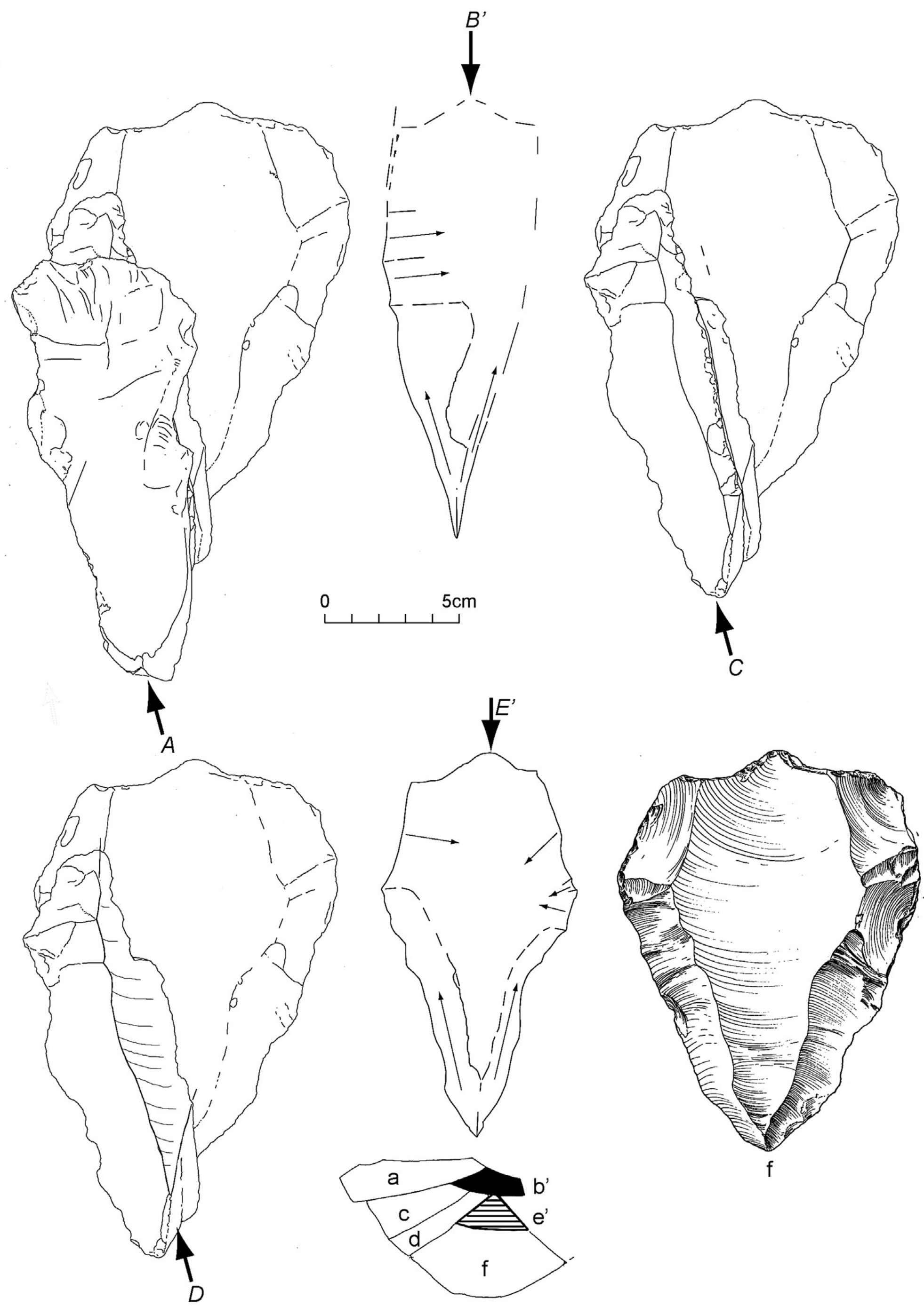

Fig. 9. Illustration of Type 1 core refit #582 from TH.383c, showing successive stages of distal preparation.

regardless of distance to raw material sources (Olszewski et al., 2010). Therefore, the paucity of retouched tools within Dhofar Nubian assemblages is not unexpected, yet remains unexplained.

3.2. Technology

The core types shown in Table 4 include all Levallois and non-Levallois reduction methods. In all of the assemblages, Nubian cores account for nearly the entire Levallois component, followed by trace numbers of preferential centripetal Levallois cores. These occur in a wide range, with Nubian Levallois cores most frequent at TH.69 (90.1%) and least so at TH.268 (14.1%). Among non-Levallois methods, unidirectional (including simple, parallel, and convergent) and bidirectional cores are, by far, the most common. Bidirectional cores occur in a relatively high frequency at TH.268 (17.5%). Typically, such cores are diminutive (4–8 cm in length) and have a flat working surface with alternating removals from opposed, faceted platforms (Fig. 15a–c). These types are common throughout Dhofar, and in some cases, bidirectional cores are Nubian-like, albeit with non-traditional shapes and/or lacking the steep median distal ridge (Figs. 15d,e and 16a,d). At TH.268, these types are found in place of classic Nubian technology, suggesting that they are not simply unsuccessful Nubian Levallois cores. Since these do not produce preferential endproducts, we do not classify them as Levallois. Indeed, this distinction is critical as they may represent a technological shift from preferential to continuous systems of reduction.

Given that the shape of the Nubian core is partially a function of its organizational system, it is also noteworthy that TH.268 differs slightly in this descriptive category, with cordiform shapes absent from the assemblage (Table 5). This pattern may result from greater emphasis on distal rather than bilateral preparation; consequently, producing fewer cordiform and pitched shapes.

Table 4
Core types by site.

	TH.69		TH.258b		TH.268		TH.377		TH.383c	
Levallois	158	91.9%	15	75.0%	33	16.0%	35	77.8%	68	59.1%
Nubian Levallois	155	90.1%	14	70.0%	29	14.1%	35	77.8%	65	56.5%
Type 1	47	27.3%	2	10.0%	13	6.3%	13	28.9%	29	25.2%
Type 2	13	7.6%	3	15.0%	5	2.4%	9	20.0%	4	3.5%
Type 1/2	42	24.4%	3	15.0%	3	1.5%	9	20.0%	17	14.8%
Early stage/undetermined	53	30.8%	6	30.0%	8	3.9%	4	8.9%	15	13.0%
Indeterminate Levallois	0	0.0%	0	0.0%	4	1.9%	0	0.0%	2	1.7%
Centripetal Levallois	3	1.7%	1	5.0%	0	0.0%	0	0.0%	1	0.9%
Non-Levallois	8	4.7%	5	25.0%	124	60.2%	8	17.8%	30	26.1%
Unidirectional	5	2.9%	4	20.0%	80	38.8%	2	4.4%	17	14.8%
Bidirectional	3	1.7%	1	5.0%	36	17.5%	3	6.7%	12	10.4%
Radial	0	0.0%	0	0.0%	0	0.0%	2	4.4%	1	0.9%
Crossed	0	0.0%	0	0.0%	8	3.9%	1	2.2%	0	0.0%
Precore	0	0.0%	0	0.0%	13	6.3%	1	2.2%	3	2.6%
Core Fragment	6	3.5%	0	0.0%	36	17.5%	1	2.2%	14	12.2%
Total	172		20		206		45		115	

Table 5
Core shapes by site and organizational system.

Site	Organizational system	Triangular		Pitched		Cordiform		Rectangular		Irregular		Total
TH.69	Type 1	11	23.4%	9	19.1%	16	34.0%	3	6.4%	8	17.0%	47
	Type 2	6	46.2%	4	30.8%	3	23.1%	0	0.0%	0	0.0%	13
	Type 1/2	13	31.0%	15	35.7%	9	21.4%	3	7.1%	2	4.8%	42
	Total	30	29.4%	28	27.5%	28	27.5%	6	5.9%	10	9.8%	102
TH.258b	Type 1	1	33.3%	0	0.0%	2	66.7%	0	0.0%	0	0.0%	3
	Type 2	5	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	5
	Type 1/2	2	66.7%	0	0.0%	0	0.0%	1	33.3%	0	0.0%	3
	Total	8	72.7%	0	0.0%	2	18.2%	1	9.1%	0	0.0%	11
TH.268	Type 1	10	90.9%	0	0.0%	0	0.0%	1	9.1%	0	0.0%	11
	Type 2	0	0.0%	5	100.0%	0	0.0%	0	0.0%	0	0.0%	5
	Type 1/2	1	33.3%	1	33.3%	0	0.0%	1	33.3%	0	0.0%	3
	Total	11	57.9%	6	31.6%	0	0.0%	2	10.5%	0	0.0%	19
TH.377	Type 1	6	46.2%	3	23.1%	1	7.7%	3	23.1%	0	0.0%	13
	Type 2	7	63.6%	1	9.1%	3	27.3%	0	0.0%	0	0.0%	11
	Type 1/2	4	44.4%	3	33.3%	2	22.2%	0	0.0%	0	0.0%	9
	Total	17	51.5%	7	21.2%	6	18.2%	3	9.1%	0	0.0%	33
TH.383c	Type 1	16	50.0%	7	21.9%	6	18.8%	1	3.1%	2	6.3%	32
	Type 2	2	50.0%	1	25.0%	1	25.0%	0	0.0%	0	0.0%	4
	Type 1/2	6	35.3%	5	29.4%	3	17.6%	0	0.0%	3	17.6%	17
	Total	24	45.3%	13	24.5%	10	18.9%	1	1.9%	5	9.4%	53

Fig. 10. Photograph of Type 1 core refit #582 from TH.383c.

Tables 6 and 7 describe the distal morphology of the Nubian cores in terms of distal ridge angle and distal platform angle. Flatter, less prominent median distal ridges differentiate TH.268 from the other Dhofar Nubian assemblages. In addition, the angle of the opposed platforms at TH.69 and 383c are more often 90-degree and semi-acute, while TH.268 tends toward semi-acute and acute. From these observations, it appears that the assemblage from TH.268 shows less emphasis on the creation a steeply angled median distal ridge. Many of the specimens still qualify as Nubian cores, having the essential steep distal ridge angle, but they tend to be more oblique than the classic Nubian assemblages. As such, we propose that the Levallois cores at TH.268 represent a derived form that developed out of Nubian technology, grading into flat bidirectional cores with faceted, opposed platforms. Thus, while the dorsal preparation of the core closely resembles the Nubian technique, the flattening of the distal ridge angle changes the nature of the dorsal preparation from one producing a preferential, pointed endproduct to a working surface that produces multiple products within a single stage of core reduction. Our reasons for placing the TH.268 as chronologically later than the other Nubian sites are elucidated in Section 4.2.

Table 6
Median distal ridge platform angles by site and organizational system.

Site	Organizational system	Steep		Semi-steep		Oblique		Missing		Overpassed		Total
TH.69	Type 1	18	38.3%	23	48.9%	3	6.4%	0	0.0%	3	6.4%	47
	Type 2	6	46.2%	4	30.8%	1	7.7%	1	7.7%	1	7.7%	13
	Type 1/2	4	12.5%	20	62.5%	3	9.4%	2	6.3%	3	9.4%	32
	Total	28	30.4%	47	51.1%	7	7.6%	3	3.3%	7	7.6%	92
TH.268	Type 1	0	0.0%	1	20.0%	4	80.0%	0	0.0%	0	0.0%	5
	Type 2	0	0.0%	0	0.0%	1	100.0%	0	0.0%	0	0.0%	1
	Type 1/2	0	0.0%	1	50.0%	1	50.0%	0	0.0%	0	0.0%	2
	Total	0	0.0%	2	25.0%	6	75.0%	0	0.0%	0	0.0%	8
TH.383c	Type 1	18	62.1%	7	24.1%	1	3.4%	2	6.9%	1	3.4%	29
	Type 2	3	75.0%	0	0.0%	0	0.0%	0	0.0%	1	25.0%	4
	Type 1/2	7	43.8%	6	37.5%	0	0.0%	0	0.0%	3	18.8%	16
	Total	28	57.1%	13	26.5%	1	2.0%	2	4.1%	5	10.2%	49

Table 7
Opposed platform angles by site and organizational system.

Site	Organizational system	90-degree		Semi-acute		Acute		Total
TH.69	Type 1	11	25.0%	20	45.5%	13	29.5%	44
	Type 2	4	30.8%	2	15.4%	7	53.8%	13
	Type 1/2	4	9.8%	16	39.0%	21	51.2%	41
	Total	19	19.4%	38	38.8%	41	41.8%	98
TH.383c	Type 1	1	5.3%	10	52.6%	8	42.1%	19
	Type 2	0	0.0%	0	0.0%	2	100.0%	2
	Type 1/2	0	0.0%	3	27.3%	8	72.7%	11
	Total	1	3.1%	13	40.6%	18	56.3%	32
TH.268	Type 1	0	0.0%	1	50.0%	1	50.0%	2
	Type 2	0	0.0%	0	0.0%	2	100.0%	2
	Type 1/2	0	0.0%	1	50.0%	1	50.0%	2
	Total	0	0.0%	2	33.3%	4	66.7%	6

Within the Dhofar Nubian assemblages, platform preparation is a prominent feature, appearing on all of the cores and more than 50% of the debitage (Table 8). Unfaceted or cortical debitage result from Nubian core preparation, or are products of non-Levallois reduction methods. Modified butts on Levallois blanks range from dihedral to finely-faceted convex or Chapeau de Gendarme in shape. We recognize one type that commonly appears in the Dhofar Nubian – the dihedral Chapeau de Gendarme. While the morphology is that of a classic faceted Chapeau de Gendarme, this form was achieved by just two deep removals across the main striking platform of the core, resulting in a blank with prominent Chapeau de Gendarme morphology but lacking the fine-faceting.

Table 8
Debitage platform types by site.

	Flat/unprepared/cortical		Dihedral/faceted-straight/faceted-convex		Dihedral-Chapeau/faceted-Chapeau		Total
TH.258	23	41.1%	27	48.2%	6	10.7%	56
TH.268	295	71.4%	106	25.7%	12	2.9%	413
TH.377	59	48.0%	48	39.0%	16	13.0%	123
TH.383c	420	64.2%	169	25.8%	65	9.9%	654

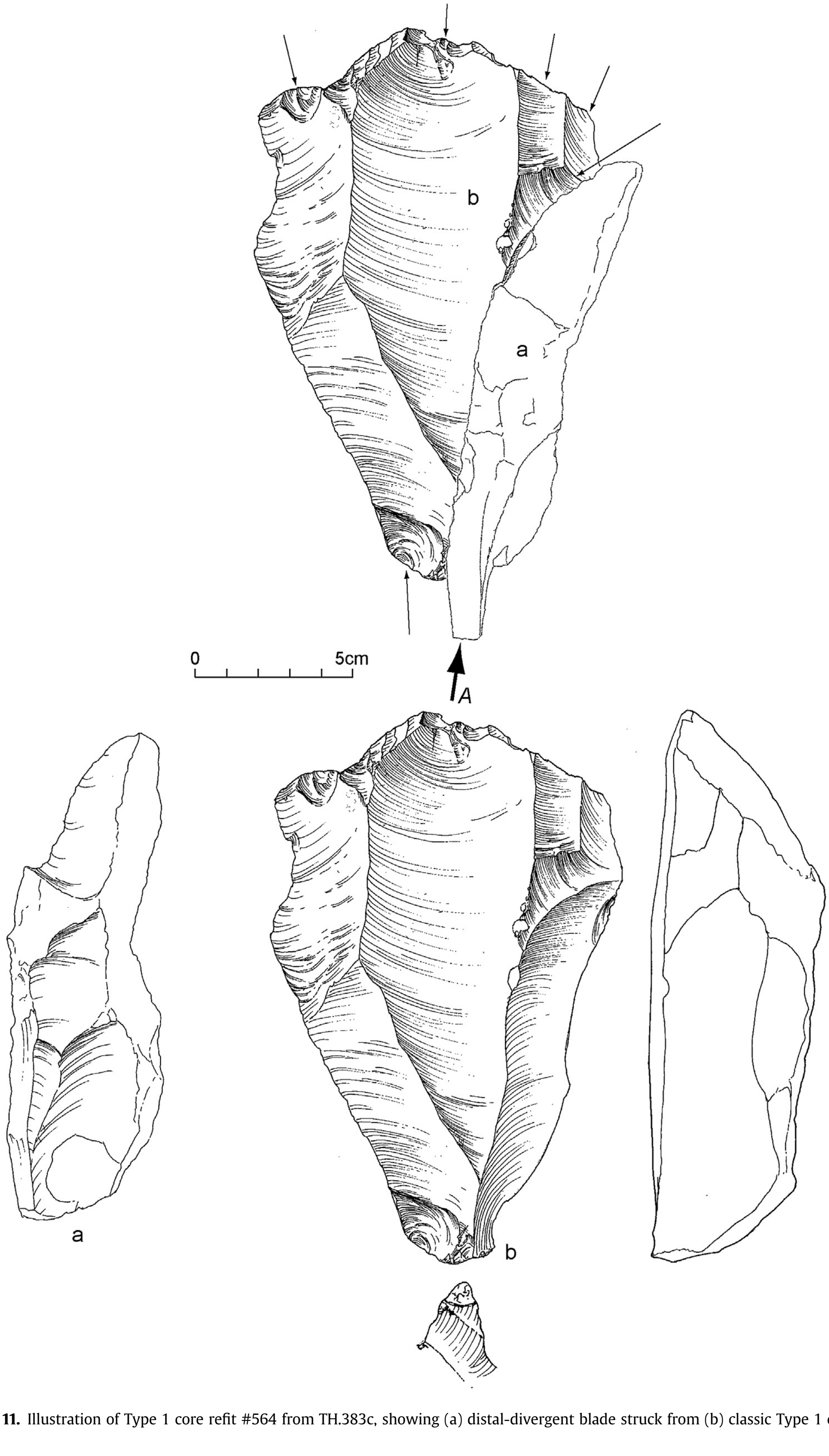

Fig. 11. Illustration of Type 1 core refit #564 from TH.383c, showing (a) distal-divergent blade struck from (b) classic Type 1 core.

Here again, the TH.268 debitage is differentiated from the other Dhofar Nubian assemblages, with a higher frequency of unmodified/cortical platform types. Dihedral and faceted butts still occur in large numbers (~29%), however, Chapeau de Gendarme platforms drop considerably (<3%). So, while the other Dhofar Nubian sites employ a limited number of platform modification strategies resulting in a high percentage of faceted, often Chapeau de Gendarme butts, TH.268 debitage are more often straight

Fig. 12. Photograph of Type 1 core refit #564 from TH.383c.

faceted, unmodified, or cortical, indicative of the wider range of reduction strategies found within the TH.268 assemblage.

3.3. *Quantitative analysis*

It was observed in the preceding section that TH.268 is qualitatively different than the other assemblages. This difference extends beyond technology, apparent in size and proportion of the Levallois cores and products as well (Fig. 16a,d,e). While the Nubian Levallois cores at TH.258, TH.377, and TH.383c fall within the same general size range (henceforth, referred to as the "Classic Dhofar Nubian" sites), TH.268 and, unexpectedly, TH.69 are substantially different. We employ basic statistical analyses to test whether these diminutive Nubian cores are simply the smallest end of the reduction continuum, or if they represent a distinct category altogether. In other words, did Nubian Complex toolmakers deliberately choose small plaquettes over the larger and equally high quality chert nodules?

The simplest representation of these metric differences is apparent from the two size types compared in Fig. 2 and depicted in a scatterplot of Nubian core length versus width across all assemblages (Fig. 17A). The cores from TH.69 and TH.268 cluster together in a tight group at the smallest end, while the other assemblages show almost no overlap in size ranges. In addition to the scatterplots of cores and endproducts, these differences are also represented in a standard deviation plot (Fig. 18A) of core lengths that exhibits two groups averaging around 7 and 12 cm. Two-tailed independent samples *t*-tests, assuming unequal variance, upholds this observation. In comparing all of the assemblages to one another, the Classic Dhofar Nubian sites are not significantly different, while TH.69 and TH.268 statistically differ from the others at *p*-values beyond 0.002 (Table 9). This observation must be tempered with caution, as the standard deviations are substantial.

Table 9
Descriptive statistics and combinations of two-tailed independent samples *t*-tests for Nubian core length × width between the five assemblages considered in this study.

Site	Sample size	Mean	Standard deviation
Nubian cores (length × width)			
TH.69	151	2910.1548	950.2911
TH.258	13	9018.3846	2993.3549
TH.268	19	2880.7527	766.8736
TH.377	35	8798.6695	2599.3346
TH.383c	64	10,752.1955	3622.8493

Two-tailed independent samples *t*-tests (Nubian cores)

	TH.258	TH.268	TH.377	TH.383c
TH.69	0.0000	0.8796	0.0000	0.0000
TH.258	–	0.0000	0.8175	0.0818
TH.268	–	–	0.0000	0.0000
TH.377			–	0.0026

Metric analysis of Levallois endproducts displays the same pattern as the cores, with specimens from TH.69 and TH.268 appearing to be somewhat smaller than the other assemblages. This trend is represented in a length*width scatterplot (Fig. 17B) and standard error plot (Fig. 18B). As was the case with the cores, *t*-tests comparing length*width of Levallois endproducts indicates that TH.69 is significantly different (Table 10). TH.268 is excluded from this test, as there is only one complete specimen; however, it is noteworthy that the single TH.268 Levallois endproduct falls within the lower size range. Both the Nubian cores (technological process), and Levallois points/flakes (technological endproduct) at TH.69 and TH.268 belong to a statistically distinct, smaller size class. This suggests the cores did not start out significantly larger, since the cores have only produced small endproducts. Therefore, we surmise that these are not just one end of the typical Nubian reduction continuum, but a separate group altogether. The term "micro-Nubian" is proposed for these small cores. Based on the average sizes depicted in Fig. 18, micro-Nubian cores are typically less than or equal to 8 cm in length. For now, our findings support the legitimacy of micro-Nubian cores as a distinct sub-type, although the efficacy of this category must be verified through additional metric analyses of Dhofar Nubian assemblages.

Table 10
Descriptive statistics and combinations of two-tailed independent samples *t*-tests for Levallois endproduct length × width between the four assemblages considered in this study (TH.268 sample not adequate for inclusion).

Site	Sample size	Mean	Standard deviation
Levallois endproducts (length × width)			
TH.69	21	1642.9689	651.4190
TH.258	7	5202.9203	1103.1842
TH.268	1	n/a	n/a
TH.377	12	4694.4615	2152.1109
TH.383c	43	6194.2378	2531.6604

Two-tailed independent samples *t*-tests (Levallois endproducts)

	TH.258	TH.268	TH.377	TH.383c
TH.69	0.0001	n/a	0.0004	0.0000
TH.258	–	n/a	0.5060	0.0975
TH.268	–	–	n/a	n/a
TH.377	–	–	–	0.0534

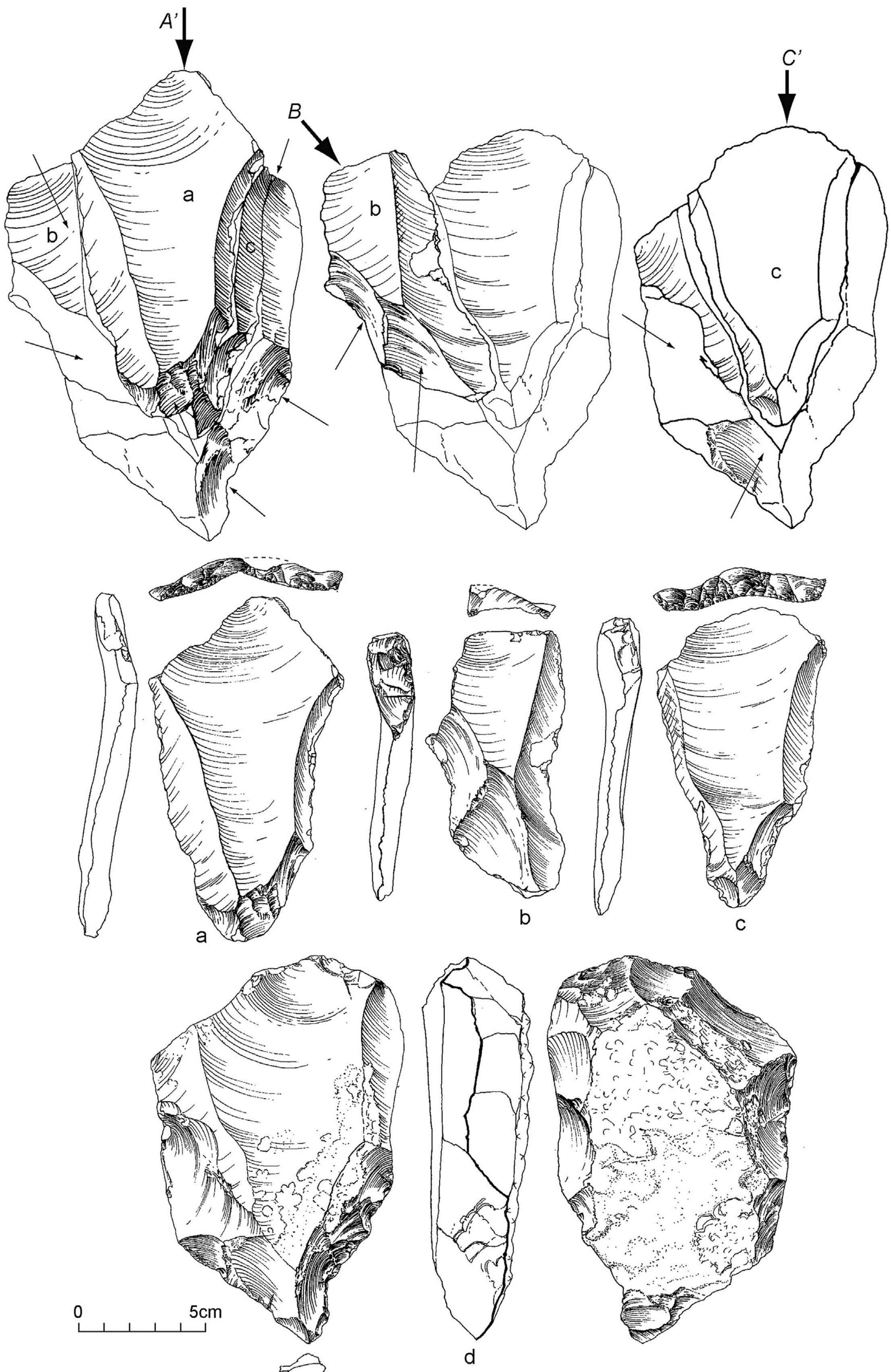

Fig. 13. Illustration of Type 2 core refit #365 from TH.383c, with (a,c) Levallois points and (b) technical preparation flake refit on (d) classic Type 2 core.

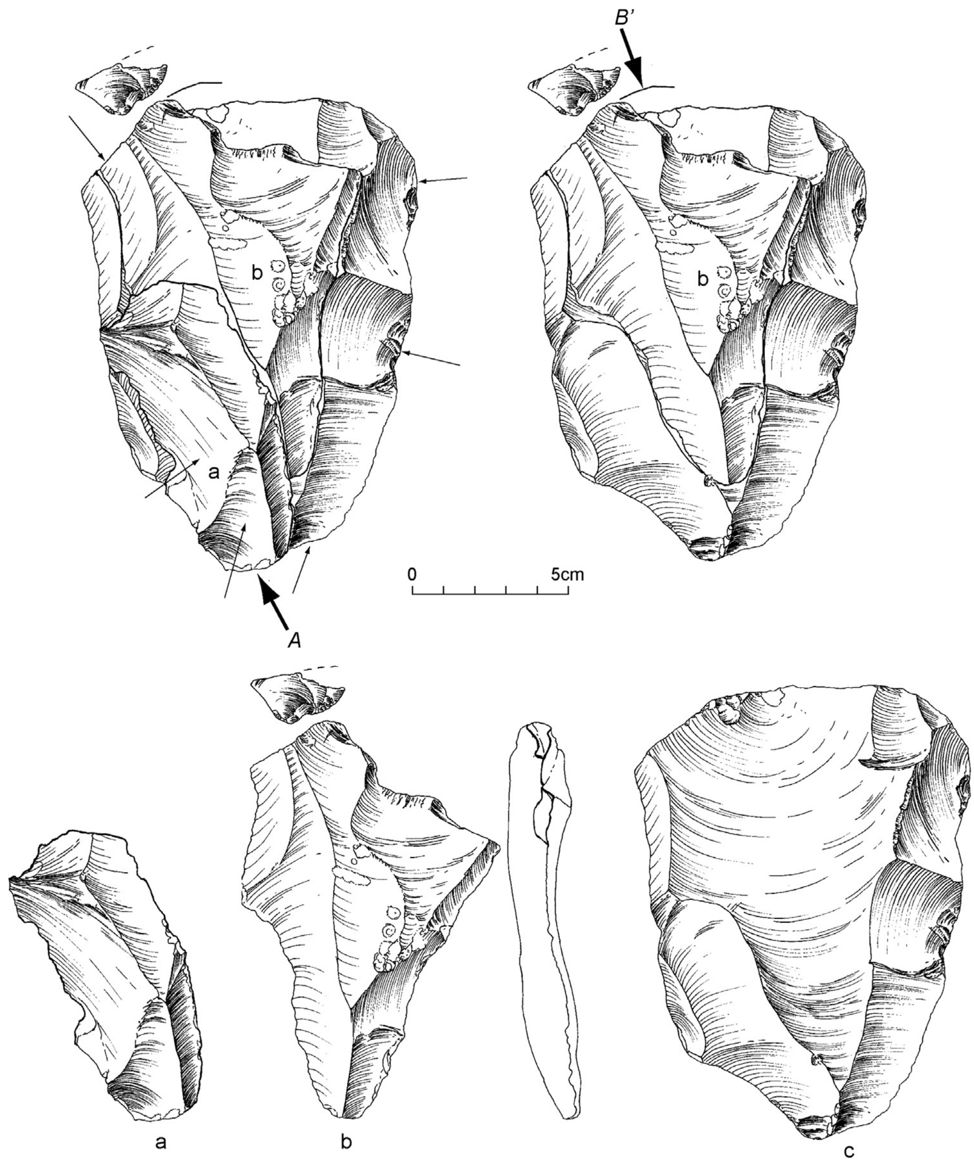

Fig. 14. Illustration of Type 2 to Type 1 transformation core refit #106 from TH.383c, showing (a) distal-divergent blade with lateral-bidirectional scar pattern, (b) subsequent Levallois point with partially crushed striking platform, and (c) classic-appearing Type 1 core.

4. Synthesis

The Nubian Complex reduction strategies described in this paper come from detailed analyses of only five of the 260 Nubian lithic scatters mapped on the Nejd Plateau to date. Our study is an initial attempt to characterize some variability within a regional grouping we call the "Dhofar Nubian Tradition," however, much work analyzing the collected material remains to be done. Emphasis has been placed upon Nubian core technology, since this was the main criterion by which the Nubian Complex was initially defined (Guichard and Guichard, 1965), and it has remained a major focus of Nubian studies ever since.

Based on the study presented in this paper, we observe the following: 1) the Classic Dhofar Nubian sites are technologically the same, with a preponderance of Type 1 cores but evidence for fluid transformation between Type 1, Type 1/2 and Type 2 organizational systems, 2) TH.258, TH.377, and TH.383c are metrically homogenous in their size and proportions, 3) TH.268 and TH.69 fall outside of this range and indicate a bimodal distribution in the size of Nubian Levallois core types found across Dhofar, with standard Nubian cores above 10 cm in length and micro-Nubian below 8 cm in length, and 4) TH.268 has a much wider array of reduction strategies, with fewer Nubian Levallois cores (of which all are micro-Nubian) and an increase in unidirectional and bidirectional cores.

4.1. Classic Dhofar Nubian Industry

Of the five sites chosen for this study, four are characterized by the presence of large numbers of typical Nubian cores – the "Classic Dhofar Nubian Industry". The fifth (TH.268) was chosen specifically because Nubian cores are noticeably smaller in size and are accompanied by additional unidirectional and bidirectional core types. Our analysis shows that the Classic Dhofar Nubian assemblages exhibited not only a high standardization of process within the Nubian Levallois method, but three of the four (TH.258, TH.377, and TH.383a) also have high metric standardization in Nubian cores and endproducts (Fig. 18).

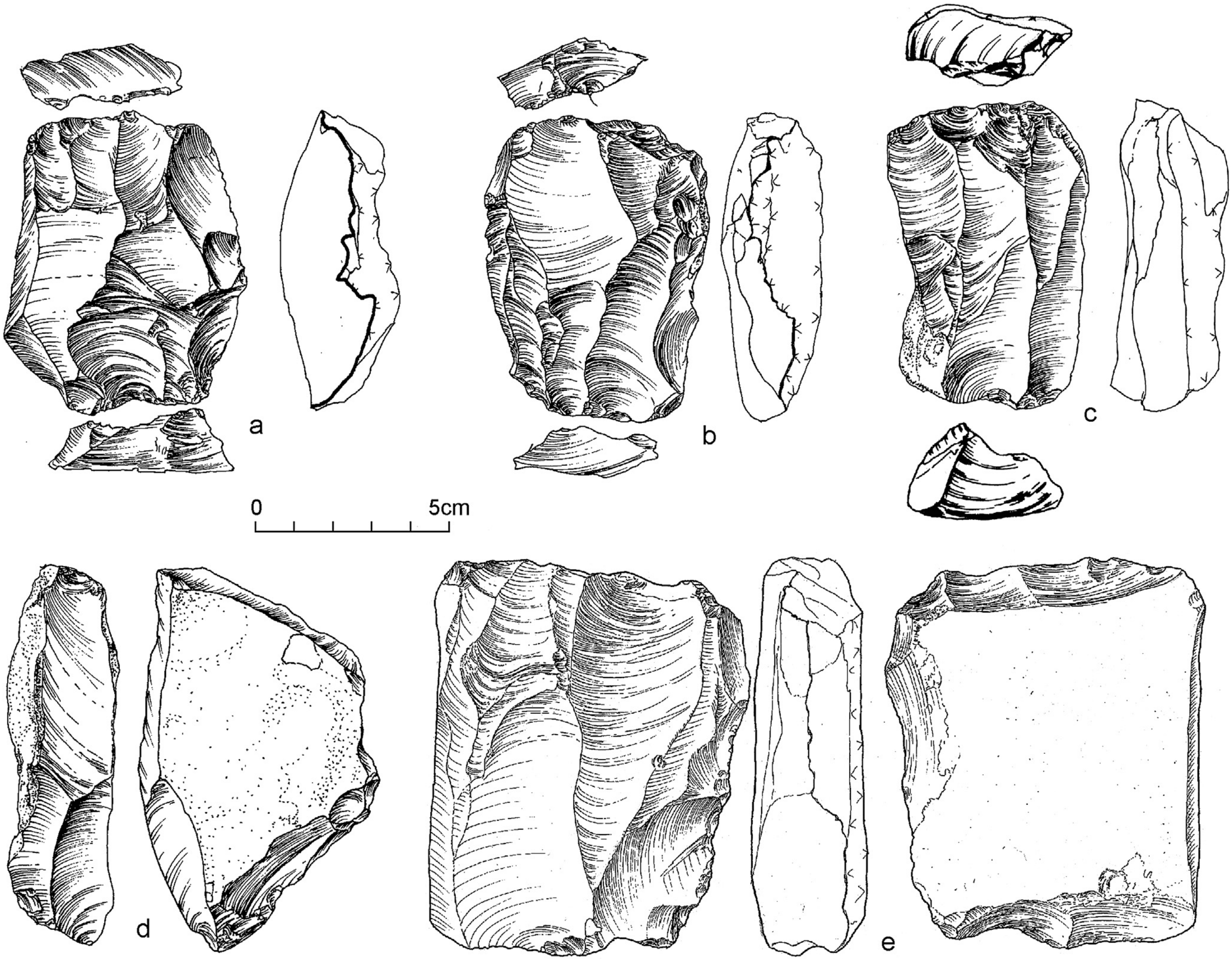

Fig. 15. Flat, opposed platform bidirectional cores from (a) TH.268, (b) TH.268, (c) TH.268, (d) TH.268, and (e) TH.59.

Of the four Classic Dhofar Nubian assemblages, TH.69 differs from the other three in core and endproduct size, which are much smaller; however, core thickness is fully comparable to Nubian dimensions at the other three typical sites. Since these four sites are technologically the same, except for the size of Nubian products, it is not clear whether TH.69 is contemporaneous with the Classic Dhofar Nubian, or whether it is temporally distinct. The dimensional differences are extreme; there is no overlap at one standard deviation for length and width with any of the three classic Nubian assemblages (Fig. 18). Still, an explanation for this diminution of Nubian cores is not altogether clear. TH.69 is the only site studied that was located some distance from a raw material source, with the nearest outcrop located slightly less than a kilometer away. The technology is clearly representative of the Classic Dhofar Nubian, with a frequency of Nubian Levallois cores comparable to, and exceeding, all other Nubian sites analyzed to date.

The distance to raw material might logically suggest that the small size of the Nubian cores resulted from more intensive core re-utilization, leading to smaller cores, as well as smaller and more numerous Levallois byproducts and debitage. This distance from raw material effect on core and byproduct size has been documented in the southern Levant (e.g., Munday, 1976; Marks, 1988) and seems equally plausible in this context. In favor of this explanation, we note that a large number of the Nubian cores at TH.69 had undersides showing partial flake scars rather than cortex, suggesting successive stages of core re-preparation, and there is considerably more debitage, relative to cores, than any of the other sites in this study (Table 2). The disproportionately higher frequency of debitage may, in part, also be a function of taphonomy. At other sites, smaller chips and flakes are not present, while TH.69 was relatively undisturbed and contained artifacts both on the surfaces and buried within a ~5 cm compacted sandy surface veneer.

So, the argument can be made that toolmakers at TH.69 carried small chert nodules to the site. We speculate that the anomalous position of TH.69, approximately one kilometer from an outcrop of large chert slabs, would have encouraged increased efficiency in blank production, since exhausted raw material could not be as easily replaced. This may have eventually led to a modification of the Nubian core, so that both the distal and proximal platforms could produce useable blanks. Such bidirectional cores generate more pointed products per core than do the preferential Nubian Levallois cores. Thus, the production of smaller cores from smaller packages would have permitted the establishment of sites further away from immediate sources of the previously required large plaquettes. In turn, this may have enabled an increase in the ability to exploit a larger percentage of the landscape on a regular basis, rather than merely as individual movements into the hinterlands,

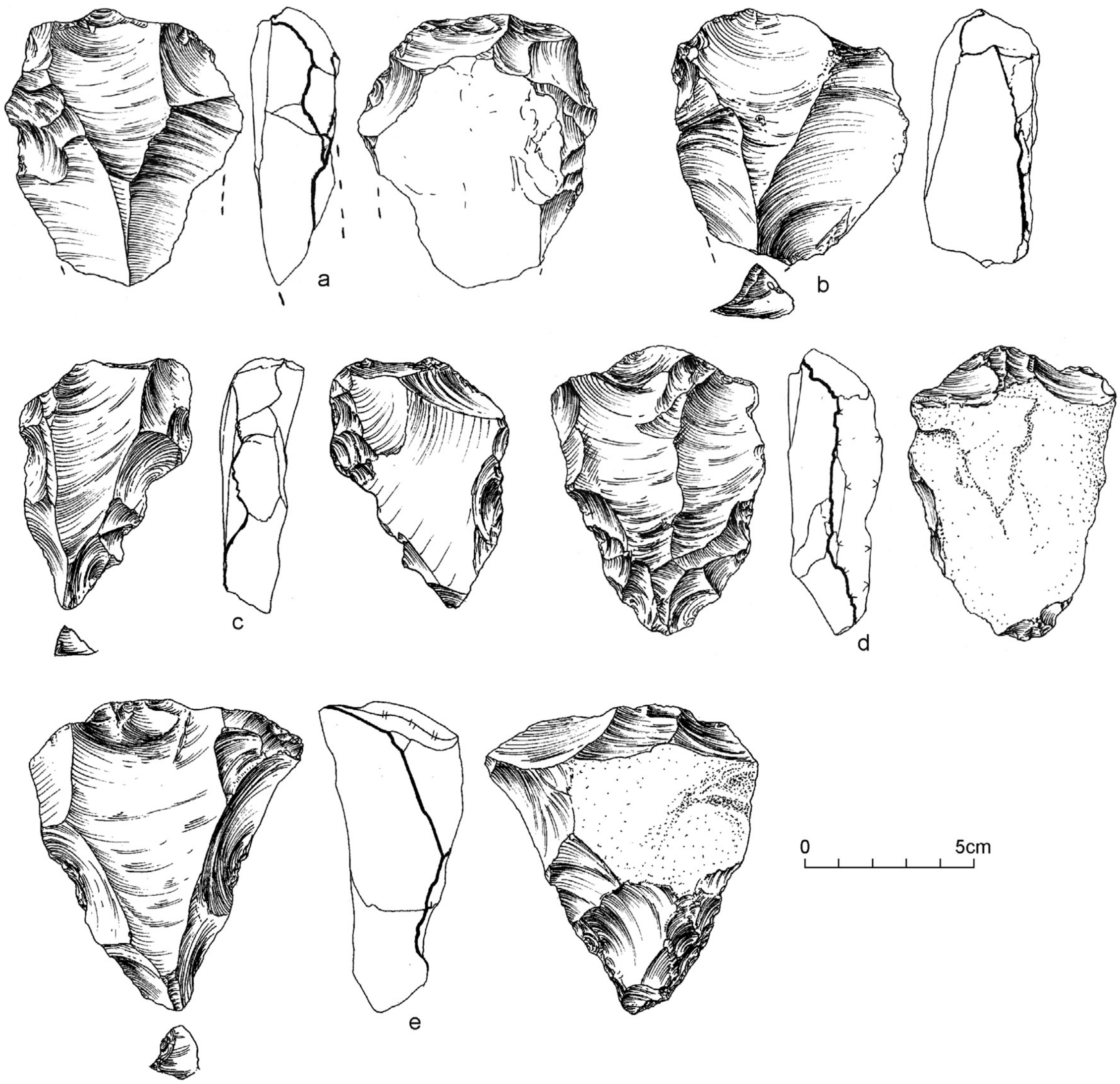

Fig. 16. Micro-Nubian cores from (a) TH.268, (b) TH.205, (c) TH.205, (d) TH.268, and (e) TH.268.

which are represented by the numerous isolated Classic Dhofar Nubian cores collected across the plateau (Rose et al., 2011). This explanation is tentative, given that only one Classic Dhofar Nubian site, Aybut Al Auwal, has been dated. When, however, the entirely different TH.268 assemblage is considered, a technological trajectory begins to emerge, with TH.69 as a first step in the transformation of Nubian Levallois technology away from its classic form.

4.2. Mudayyan Industry

TH.268 is just one example of at least 30 assemblages mapped across the Nejd Plateau (Fig. 1) composed of micro-Nubian cores, flat, diminutive bidirectional cores with opposed faceted platforms, and unidirectional-parallel cores. This technology is sufficiently different from the Classic Dhofar Nubian, and the same suite of core types are found repeated across the landscape, to be recognized as a distinct industry we call the "Mudayyan," based on the nearby village of Mudayy. Mudayyan assemblages are often found at the top of inselbergs, while Classic Dhofar Nubian sites occur at the base of hills around older chert outcrops, suggesting both a shift in settlement pattern and a temporal difference as the later toolmakers exploited more recently exposed outcrops. Nor are they as widespread as the Classic Dhofar Nubian; Mudayyan sites are primarily concentrated within a ~20 km radius of the Mudayy springs. This more limited distribution may suggest a drier climate, at which time groups were increasingly bound to permanent water sources. Although Nubian Levallois technology is present in these assemblages, it is in the minority, accompanied by non-Levallois strategies such as single platform unidirectional-parallel and opposed platform bidirectional core reduction. When present, Levallois cores and endproducts are exclusively micro-Nubian, with flatter distal median ridges and more acute distal platforms.

It is noteworthy that the weathering on all of the Classic Dhofar Nubian assemblages is consistently darker than that seen at Mudayyan sites. The former assemblages often have a heavy black varnish with manganese oxide staining, are slightly rounded from aeolian abrasion, and have undergone chemical dissolution that produces a pockmarked and discolored surface. Mudayyan assemblages, in contrast, have sharp arêtes and typically exhibit a glossy brown veneer. Along with the apparent shifts in technology, differential weathering between the Classic Dhofar Nubian and the Mudayyan artifacts adds credence to an interpretation of temporal, rather than contemporaneous variability.

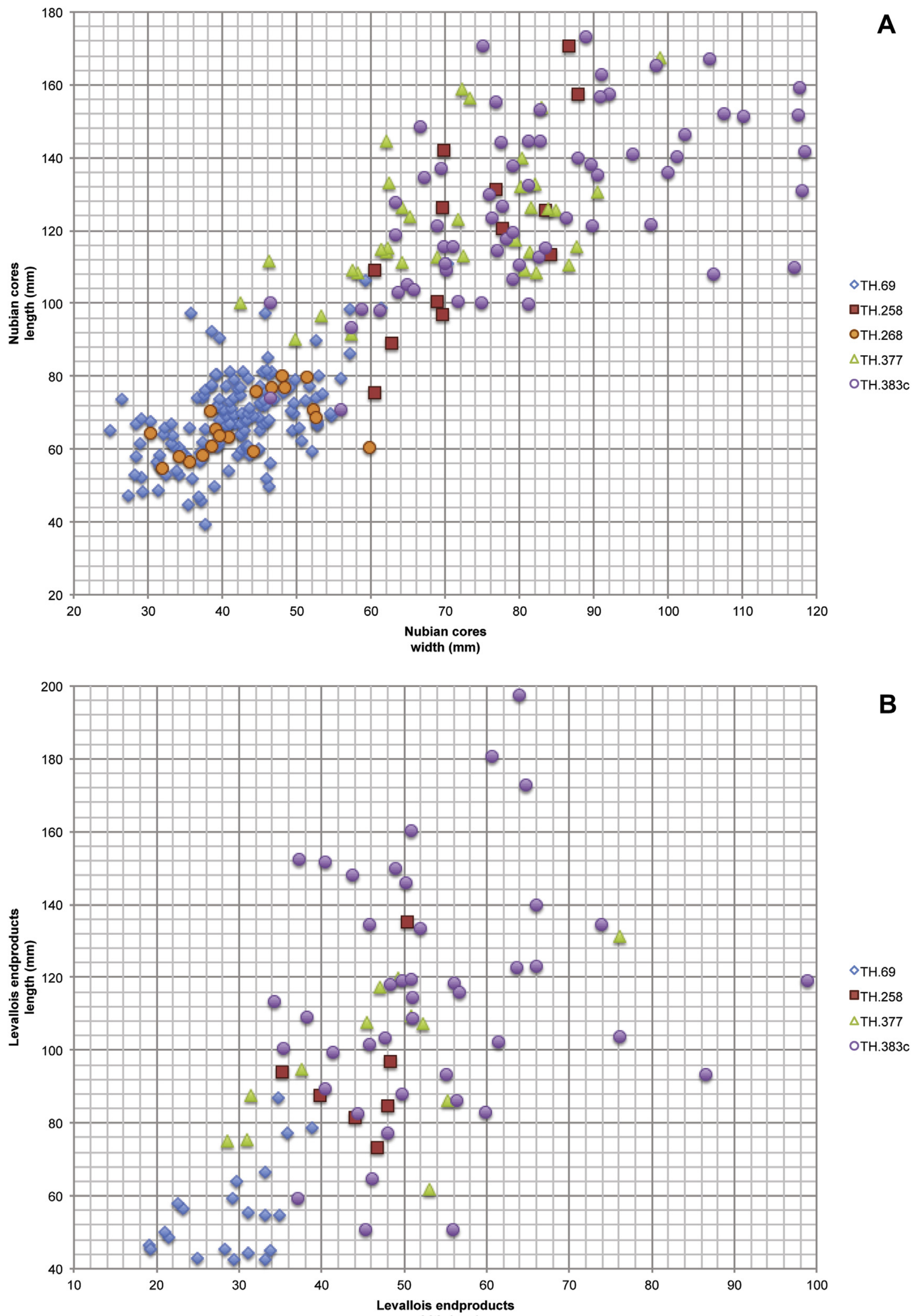

Fig. 17. Scatterplots of length versus width of Levallois (A) cores and (B) endproducts at Dhofar Nubian sites.

Found at the end of the 2012 field season and therefore not included in our lithic analysis, the site of Umm Mudayy (TH.418) is composed of a series of discrete scatters of Classic Dhofar Nubian and Mudayyan assemblages, among others, in lateral stratigraphic position (Fig. 19). The Umm Mudayy complex is situated on a high terrace (20 m) above the Mudayy spring. The site occurs on a chert outcrop, where large slabs are eroding from the sides of a small hill rising up from the terrace. This process is ongoing, as unexposed

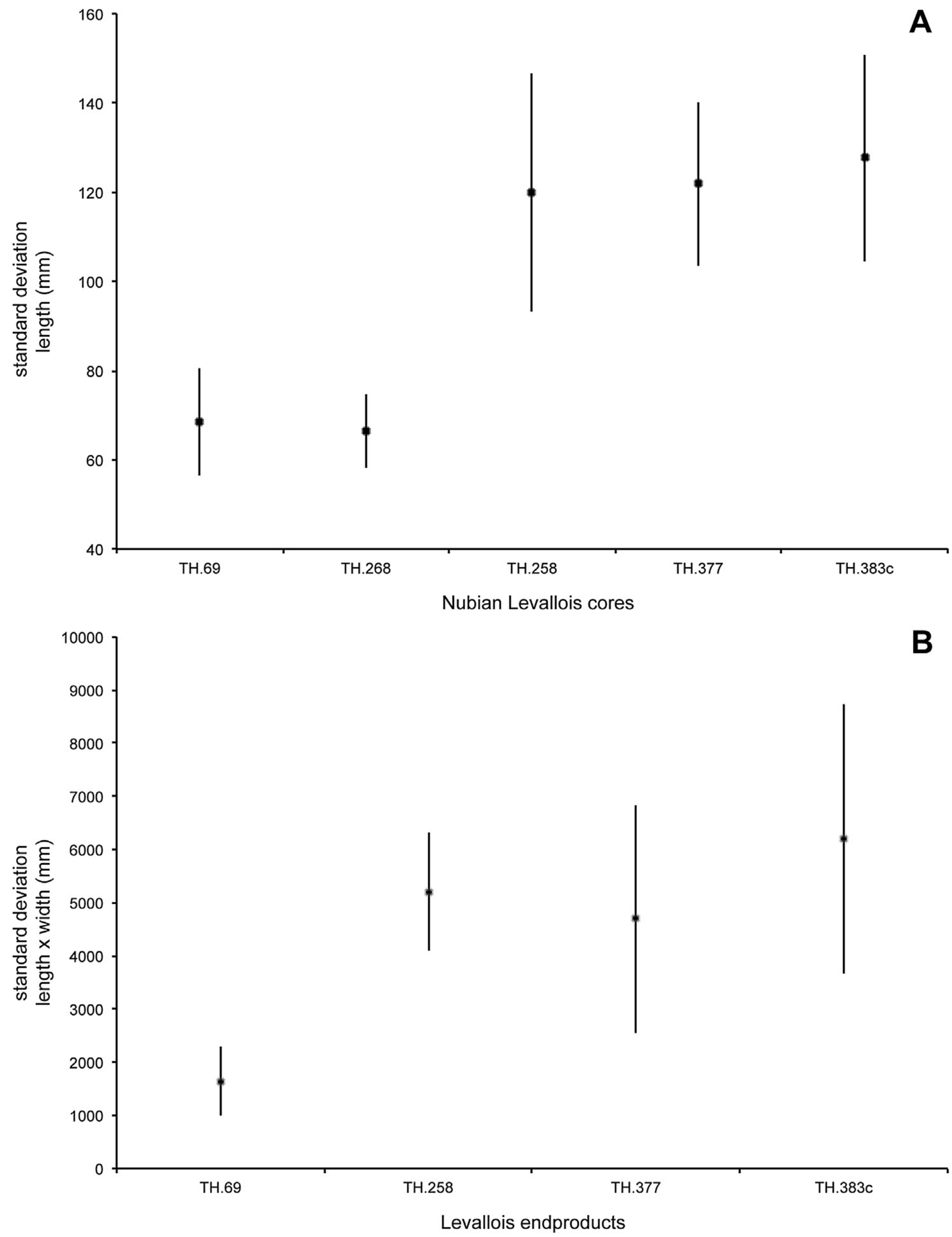

Fig. 18. Standard deviation plot of Nubian (A) core lengths and (B) Levallois point length*width at Dhofar Nubian sites.

chert slabs were found embedded within the actively eroding inselberg. Systematic collections were made at intervals radiating outward from the present extent of the outcrop. Neolithic bifacial tools were noted directly on the chert exposure, which have a white or light pink patina and no signs of abrasion or rounding. Light brown and only slightly more weathered Nejd Leptolithic blades and blade cores were found around the base and flanks of the hill. Mudayyan artifacts, with a somewhat heavier glossy burgundy patina, but still sharp arêtes, were collected from an area situated about 15 m out from the inselberg. Furthest away, a Classic Dhofar Nubian assemblage was collected approximately 30 m from the inselberg; this material exhibited the typical heavy black patina, manganese oxide staining, and partial chemical dissolution commonly seen on Classic Dhofar Nubian artifacts. From this, we conclude that prehistoric flintknappers exploited the chert outcrop during successive phases of re-occupation, and the resulting scatters indicate the diminishing position of the inselberg as the bioclastic limestone matrix eroded over time. While Umm Mudayy provides the clearest example of this phenomenon, similar observations were made at Jebel Sanoora (TH.143), Mudayy as Sodh (TH.123), Jebel Markhashik (TH.383), and Jebel Kochab (TH.268). In every case, Mudayyan and Classic Dhofar Nubian assemblages were found adjacent to one another, the Mudayyan being closer to the actively eroding outcrop, and exhibited similar patterns of differential weathering.

The observed technological shift, from highly standardized classic Nubian Levallois technology to a dominance of "Nubian-like," bidirectional core reduction strategies, required some amount of time. As such, it is possible to recognize an enduring tradition, beginning with the appearance of Nubian Complex toolmakers in Dhofar on or before MIS 5c. This tradition must have persisted for enough time to account for the technological shift away from its

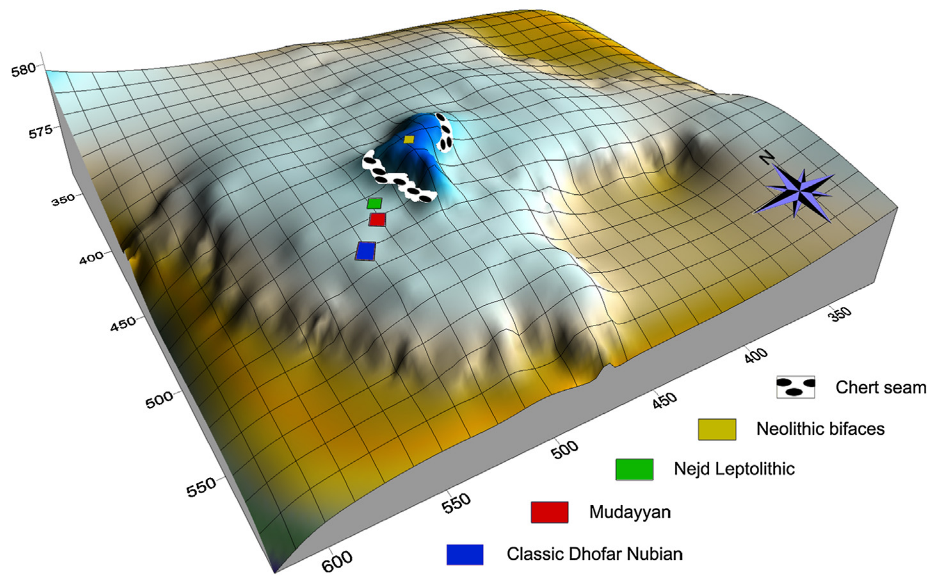

Fig. 19. Digital elevation map (top) of Umm Mudayy (TH.418) showing present extent of chert outcrop in relation to collection areas.

original African form, as well as the striking differences in weathering between Classic Dhofar Nubian and Mudayyan assemblage types. The identification of these two industries is a first attempt at discerning variability within the Dhofar Nubian Tradition. With so many assemblages still requiring study, additional taxonomic categories are bound to emerge.

5. Discussion

The appearance of Nubian Levallois technology in Dhofar during MIS 5c, which later developed locally into the Mudayyan Industry, raises a number of still unresolvable questions. Did the increasing aridity in Northeast Africa from MIS 5d to MIS 5b (Blome et al., 2012), at which time discharge through the Nile Valley was greatly reduced, provide a stimulus for greater mobility on the part of local inhabitants that led to the abandonment of their northern range in Egypt and concentration in southern Arabia? The apparent absence of Nubian Complex occurrences in Africa at this time might suggest so, although there are still too few numeric age estimates to adequately assess this possibility. Did Nubian Complex toolmakers spread into Arabia directly from Egypt through Sinai and/or across the northern Red Sea, or was there an intermediate stage of southern movement through the Horn before crossing into Arabia via the southern Red Sea? In the northern scenario, we would expect to find Egyptian Late Nubian sites in northwestern Arabia and Sinai, which, for the time being, does not seem to be the case. As for the southern scenario, only efforts to describe and date sites in the Horn with Nubian Levallois technology, such as K'One 5, will resolve the role of East Africa in the Nubian expansion.

If there was no Nubian Complex occupation in Egypt during the MIS 5d–5b hiatus, from where did the Egyptian Late Nubian, dating no earlier than MIS 5a, come? Did it spread north from Sudan or was there an expansion of Arabian Nubian Complex toolmakers back into Africa? Certainly, the striking similarities between the Classic Dhofar Nubian and Egyptian Late Nubian, as compared with the Sudanese Late Nubian, might indicate such a scenario. Again, greater chronological resolution in African and Arabian Nubian assemblages is required to answer these questions.

It seems overly simplistic to expect the expansion of Nubian Complex toolmakers into Arabia was a single migration or event; rather, it was more likely a process of recurring bidirectional movements across the Red Sea linked to consecutive phytogeographic range expansions and contractions. At the same time, the presence of technologically distinct, non-Nubian industries elsewhere in Arabia from MIS 5a to MIS 3 indicates separate, autochthonous culture groups and/or input from other adjacent regions (Marks, 2009; Armitage et al., 2011; Petraglia et al., 2011; Delagnes et al., 2012). In the case of the Wadi Surdud stratified assemblages in Yemen, dated to ~60–40 ka BP (Delagnes et al., 2012), and Jebel Faya successive assemblages B and A, bracketed within MIS 3 (Armitage et al., 2011), both archaeological sequences are thought to be the products of local lithic traditions. Clearly, Late Pleistocene demography in Arabia was far more complex than one population emanating from a single source area.

For now, it is clear that the Afro-Arabian Nubian Complex exhibits a robust archaeological signature on both sides of the Red Sea, in terms of site density, distribution, and long-term technological variability, always based on the core principal of opposed platform exploitation. This is likely the result of populations who were well and truly established in their respective regions for an extended period of time. Perhaps we have made too much of tracking routes of expansion and the timing of sea crossings into Arabia. The Red Sea may be more of a barrier for scholars today than it ever was for humans in the Middle Stone Age.

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