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Late Palaeolithic core-reduction strategies in Dhofar, Oman

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Summary
Systematic surveys conducted in the Dhofar Governorate of Oman have produced over 300 surface sites, as well as excavation of *in situ* archaeological deposits. A number of these assemblages have been classified as part of the Nejd Leptolithic Tradition (NLT). This study describes a selection of these assemblages from sites distributed across the southern and central Najd plateau in Dhofar, including both surface scatters and stratified rock shelters. The NLT is broadly characterized by the reduction of blades struck from single-platform cores with flat flaking surfaces, in conjunction with the *façonnage* manufacture of bifacial implements. Based on technological analysis and artefact conjoins, we distinguish three separate core reduction strategies within the NLT. Optically stimulated luminescence (OSL) dates from three *in situ* assemblages allow us to begin to define temporal variability within this technological continuum.

Keywords: Najd plateau, Late Palaeolithic, blade technology, lithic analysis, Dhofar

Introduction: the Nejd Leptolithic Tradition

During the 2004–2011 campaigns of the Dhofar Archaeological Project (DAP), a number of assemblages were discovered throughout the Najd plateau in the Dhofar region of south-western Oman, which can be broadly classified as the Nejd Leptolithic (Rose 2006; Rose & Usik 2009). Three stratified Nejd Leptolithic sites from the southern plateau have since yielded optically stimulated luminescence (OSL) dates with age estimates between approximately 14 and 7 ka BP, representing the first known Terminal Pleistocene occupation in the Arabian Peninsula. This paper describes a selection of Nejd Leptolithic assemblages and aims to define technological variability within this tradition. Given the disparities between these uniquely South Arabian assemblages and coeval lithic industries found in Africa and the Levant, we propose a regionally distinct taxonomic category — the Arabian Late Palaeolithic (ALP) — to describe this technological tradition.

The term 'Nejd Leptolithic' was initially proposed by Rose (2006) to refer to a series of surface scatters that are ubiquitous across the Najd plateau, characterized by the use of recurrent blade reduction strategies. Such assemblages have long been known from southern Arabia; in the 1970s, the Harvard archaeological survey to Oman recorded an extensive blade scatter near Biʾr Khasfah, in the north-eastern portion of the Najd plateau (Pullar 1974). Some 500 km to the north-east, numerous large, high-density blade scatters were mapped throughout the Ḥawshī/Ḥuqf depressions in central Oman (Biagi 1994; Rose 2006; Jagher 2009; Jagher & Pümpin 2010).

Amirkhanov (1994; 2006), Rose (2002), and Crassard (2008*a*; 2008*b*) report potentially related blade assemblages across central and eastern Yemen. Hence, there is a virtually unbroken chain of leptolithic occurrences spanning the Ḥaḍramawt valley in central Yemen, extending into al-Mahrah Province of eastern Yemen, across Dhofar in southern Oman, and terminating south of the Ḥajar Mountains in central Oman. DAP's recent investigations in Dhofar show that it is not one, but a suite of features including blade technology, *façonnage* reduction, and a distinct toolkit that defines the Nejd Leptolithic Tradition. In many cases, the hallmark blade reduction strategy is accompanied by *façonnage* manufacture of soft-hammer foliates, ovates, and lanceolates, 'heavy-duty' bifaces, and a variety of trifacially worked implements. Struck blanks were transformed into an array of unifacial tools, including burins (mainly on truncations), diverse scraper types, partially retouched points, and Fasad points (Pullar 1974; Charpentier 1996; Rose & Usik 2009). As this paper is

primarily concerned with determining variability among core reduction strategies, detailed typological analysis of unifacial and bifacial end products will not be addressed here; suffice to say there is a significant bifacial element within the toolkit, accompanied by a diverse array of burins, end scrapers, and perforators. To date, the only rough chronological anchor for the Nejd Leptolithic Tradition (henceforth NLT) was al-Hatab (al-Ḥaṭab), a collapsed rock shelter in which two stratified leptolithic assemblages were excavated from a 1 m deposit (Rose & Usik 2009). The assemblages date roughly between 14 ka BP and 10 ka BP and they exhibit the full range of aforementioned NLT features in both archaeological levels. Given potential mixing of the artefact-bearing sediments, it is uncertain whether these assemblages are discrete occupations or buried palimpsests and therefore, while al-Hatab documents some form of Late Palaeolithic human occupation on the Najd plateau, no temporal/technological variability can be gleaned solely from this site.

Analytical methods

This paper seeks to identify variability within the NLT through technological analyses of lithic assemblages distributed across the Najd plateau. The artefacts were systematically recovered from two large surface scatters, Wadi Haluf 1 (TH.124) and Jebel Eva (TH.67), and excavated from three *in situ* sites, including al-Hatab (TH.29), Ghazal (TH.47), and Khumseen (TH.50) (Khumsīn) rock shelters.

As the name implies, the primary reduction technique employed by toolmakers was the production of blades struck from single-platform cores. The term 'blade' is a simple descriptive category referring to the metric proportions of a struck blank, defined as twice as long as it is wide. The manufacture of such products is dictated by fundamental principles used to control the core, which remain constant across the diverse cultures that have employed this particular technique (Volkman 1983; Bleed 2002; Monigal 2002). These principles are the realization, control, and maintenance of the core's plane of removal. Through an understanding of these principles, it is possible to distinguish specific modes of reduction based on the blade core's longitudinal and horizontal convexities (Hahn 1993; Hays & Lucas 2001; Le Brun-Ricalens 2005).

Without a strategy to maintain convexity along the plane of removal, the toolmaker will lose control over the core's architectural features and the energy generated by the blow will diffuse in an uncontrolled manner, leading to various types of breakage on the core or the blank. To compensate, various methods are employed to maximize the core's volume and to maintain convexity. Differentiating these core reduction strategies allows us to define more specific analytical units — modalities — that exist within the NLT.

The lithic analyses presented here combine morphological and metrical observations with refitting data, which allow for the recreation of discrete core reduction episodes (e.g. Cahen 1976; Usik 1989; Demidenko & Usik 2003). This information permits the reconstruction of the entire blade production sequence, from decortication to final discard, and allows for a clearer determination between desired end products and by-products of core preparation/maintenance. Ultimately, the data will enable us to begin to articulate variability over time among NLT core reduction strategies.

Results and analysis

The Najd plateau is characterized by a south to north dip, stretching approximately 120 km from the Dhofar mountain chain to the Rubᶜ al-Khālī desert. As it grades northwards, the landscape gradually morphs from highly eroded scablands dissected by small wadis to a flat gravel plain cut by myriad Pleistocene riparian systems. During the 2010 and 2011 fieldwork campaigns, we identified 137 NLT occurrences across the Plateau (Fig. 1), expanded the excavation area at al-Hatab (TH.29), and began work at two newly discovered rock shelters nearby: Ghazal (TH.47) and Khumseen (TH.50). OSL age estimates from these three stratified rock shelters fall between 14 and 7 ka BP. The lithic analysis carried out here demonstrates patterns of technological variation across this time span, permitting the partitioning of the NLT into two distinct industries, the 'Early Nejd Leptolithic' (Terminal Pleistocene) and the 'Late Nejd Leptolithic' (Early Holocene). These categories are applied to surface assemblages collected from the sites Wadi Haluf 1 (TH.124) and Jebel Eva (TH.67), demonstrating that dated and buried assemblages can be used as chronological anchors to articulate temporal variability among NLT surface scatters across Dhofar.

The Early Nejd Leptolithic industry

Early Nejd Leptolithic assemblages were recovered from the lower archaeological unit at al-Hatab (level 2) while a technologically and typologically concordant assemblage

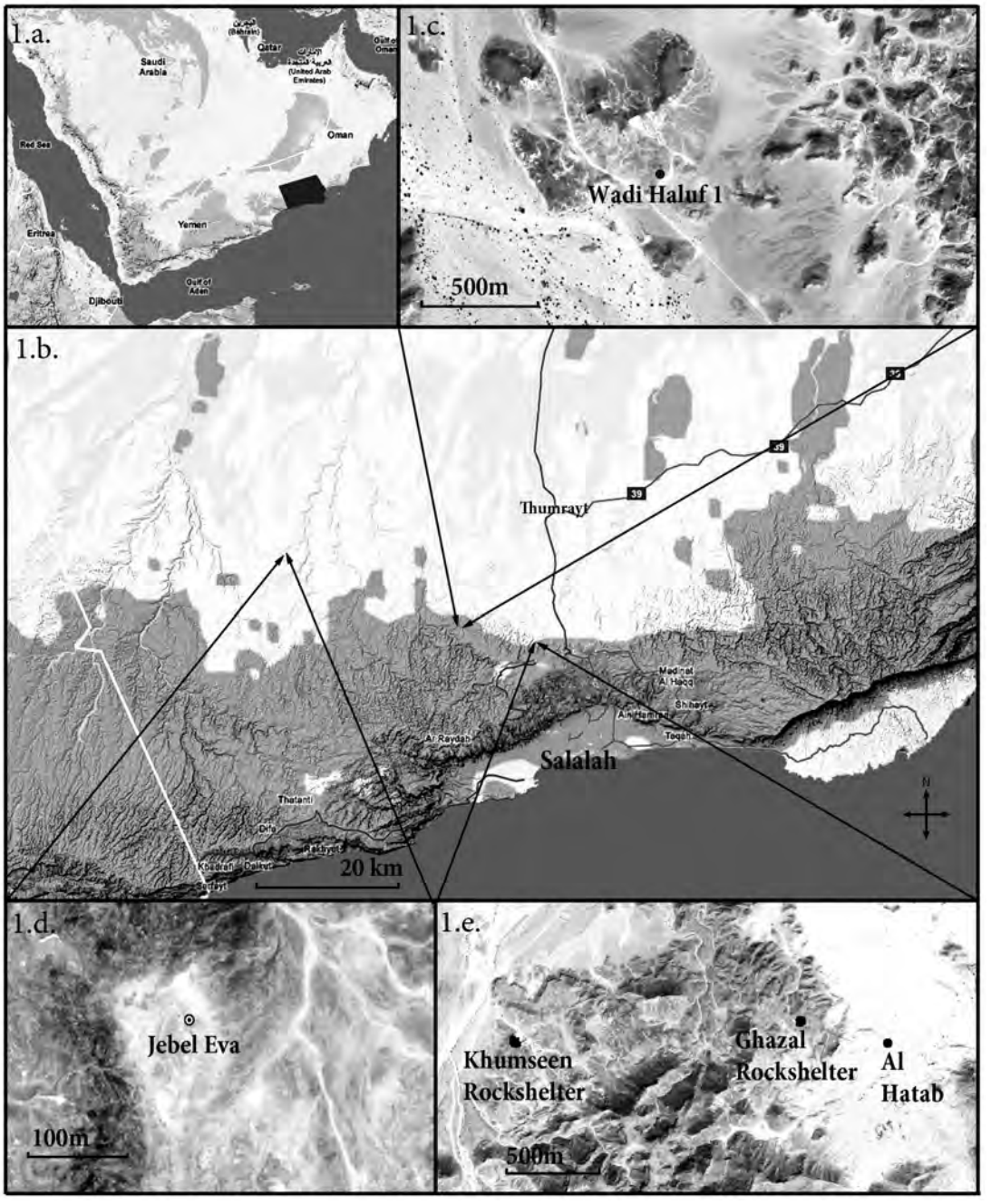


Figure 1. *Maps showing the regions referred to in the text.* **a.** *South Arabia; the area marked on the map delimits the research area of the Dhofar Archaeological Project;* **b.** *the Governorate of Dhofar;* **c.** *an enlarged image of the area around the Wadi Haluf 1 site (TH.124b, N 17.383920° E 53.929160°);* **d.** *an enlarged image of the area surrounding the Jebel Eva site (TH.67, N 17.510233° E 53.317750°);* **e.** *an enlarged image of the area surrounding the stratified leptolithic sites across the southern Najd plateau: Khumseen rock shelter (Th.50, N 17.313517° E 54.042111°), al-Hatab (TH.29, N 17.313417° E 54.061050°), and Ghazal rock shelter (TH.47, N 17.314483° E 54.056617°). (Google Earth, assembled by Y. Hilbert.)*

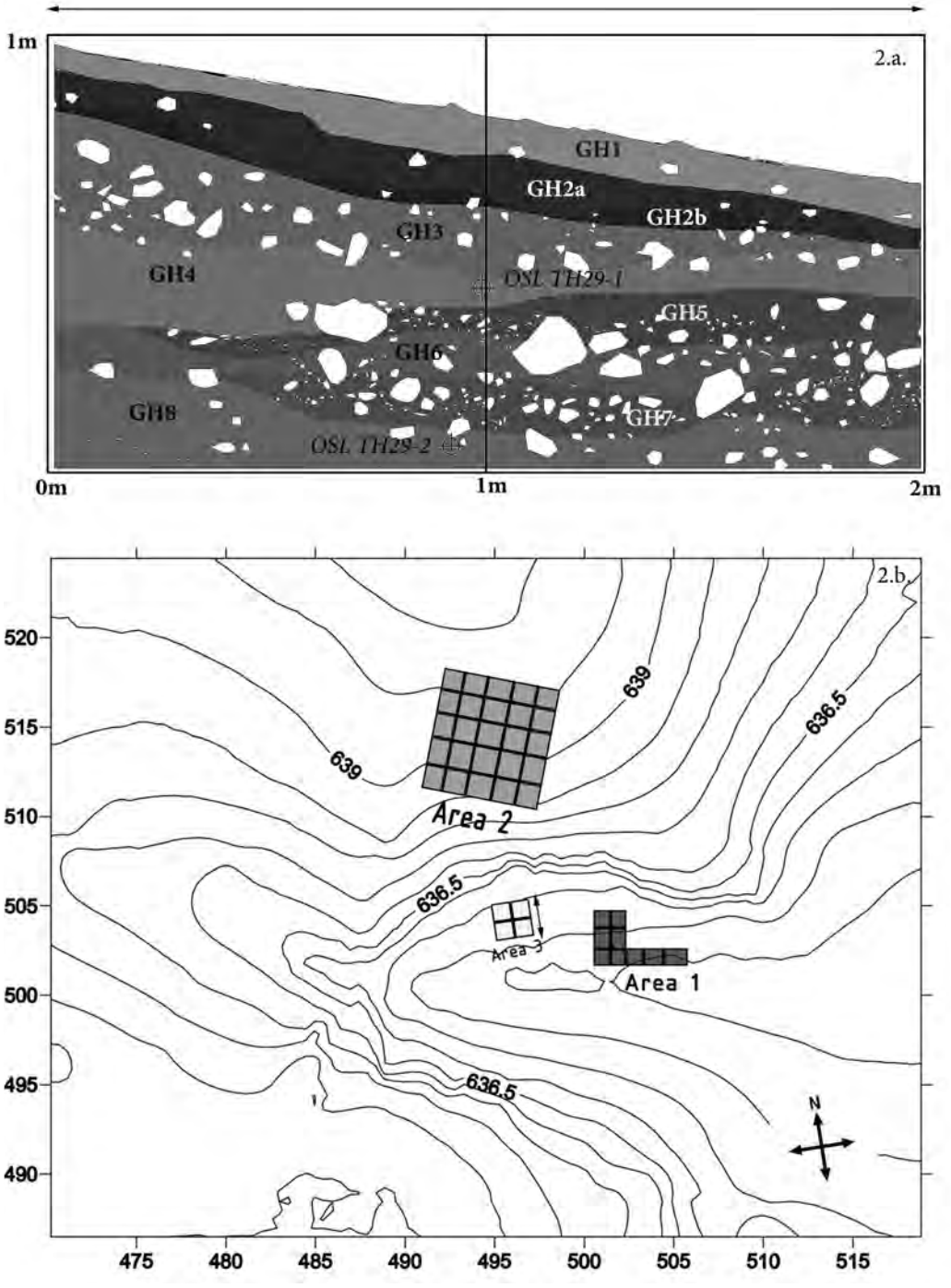


Figure 2. a. *A schematic drawing of the west profile of Area 3 at al-Hatab. The assemblages referred to in the text come from the following: Level 1 was excavated from GH3 and GH4 while Level 2 was excavated from GH5, 6, and 7. Two OSL samples were retrieved from the section and have been labelled TH29-1 and 2 (results pending);* **b.** *a topographic map of al-Hatab showing the different excavation and collection areas. (Drawings Y. Hilbert.)*

was collected from a surface scatter at Wadi Haluf 1. These occurrences, classified as Early Nejd Leptolithic, are located within 15 km of one another in the southern Najd. Al-Hatab is situated along the northern foothills of Jebel Qarāʾ, at the interface between high grassland and dry plateau. There are similar, high-quality chert sources in proximity to all of these sites, and therefore distance to raw material and flaking properties of the raw material can be discounted as factors determining technological variability.

Al-Hatab rock shelter, level 2

Al-Hatab rock shelter has previously undergone archaeological and geo-archaeological investigations between 2004 and 2008. Two OSL age estimates for level 2 are available and yielded results of 13.7± 2 ka BP and 13 ± 1.1 ka BP (Rose 2006; Rose & Usik 2009). New excavations were conducted during the 2010 DAP campaign, at which time a 2 x 2 m sondage, Area 3, was dug adjacent to the old excavation trench in Area 1 (Fig. 2/a). Similar to Area 1, the Area 3 profile revealed an interstratified sequence of colluvial gravels and aeolian sands spanning the Terminal Pleistocene and Early Holocene. OSL samples were taken from the east profile from Area 3: sample 1 (OSL TH 29-1) was taken 40 cm below the surface from GH4 and sample 2 (OSL TH 29-2) was taken 78 cm below the surface from GH8 (OSL results pending) (Fig. 2/b). Results from Area 3 matched the archaeological sequence observed in Area 1: two layers containing artefacts pertaining to the NLT are found in colluvial horizons indicating oscillating wet-dry conditions, separated by a sandy layer devoid of artefacts (GH4 in Fig. 2/b).

The lithic sample analysed here comes from Area 3, geological horizons 5–7. The assemblage is composed of 194 pieces, of which thirteen are cores and five are tools. Given the small sample size and possibly secondary position of the sediments, no refits were possible.

There were 176 pieces of *débitage*. Flakes (n=72, 37%), blades (n=33, 17%), and cortical elements (n=33, 17%) were the most prominent blank type, followed by a small number of *débordant* pieces (as in lateral core trimming elements used to correct and maintain core work surface convexity) (n=7, 4%) and bladelets (not wider than 12mm) (n=6, 3%). The blades primarily exhibit simple unidirectional scar patterns (n=14, 44%), followed by unidirectional-parallel (n=8, 25%) and convergent (n=8, 25%) dorsal scars. Blade striking platforms show little preparation; they are typically unfaceted straight (n=14, 79%). The only exceptions of note were three blades with punctiform striking platforms, and a single blade with a dihedral platform. Blank morphology was marked by parallel (n=13, 40%) and convergent (n=12, 36%) edges. Blanks were exclusively detached from single-platform cores by means of direct hard-hammer percussion. Eight single-platform cores were identified, four of which exhibited unidirectional parallel removals across the working surface, and four with unidirectional-convergent removals. The remaining five cores were either broken or were pre-cores (chert nodules with fewer than three removals). The exhausted cores showed one frontal or a frontal and a lateral plain of removal (both n=2). In some cases, reduction took place from a convex arranged reduction plain encompassing both the core's frontal and lateral portions (n=3) (Fig. 3).

Wadi Haluf 1, locality B

Wadi Haluf 1 is a dense, sprawling complex of surface scatters extending across an area of roughly 300 m^2. It is located some 15 km downstream from al-Hatab on a low terrace (~2 m) within the Wādī Ḥallūf drainage system (see Fig. 1). Flanking both sides of the main channel are heavily dissected table mountains. Over the course of millennia, seasonal rains have carved a broad, flat drainage up to 2 km wide.

The scatter stretches across the foot of a small inselberg, a remnant of the Upper Ḥaḍramawt geological formation (Platel et al. 1992). High-quality Gahit member chert nodules outcrop at the site. Several knapping zones were identified, of which Wadi Haluf 1 locality B was selected due to a number of refits observed in the field, and thus providing potential for studying NLT blade reduction strategies. The collection area is a 3 x 4 m grid divided into 1 m^2 units.

The artefacts were in pristine condition, indicating minimal post-depositional disturbance, such as fluvial transport or trampling. In total, 592 artefacts were recovered, including fourteen cores, six tools, and 496 unmodified blanks. Blades (n=164, 28%) and *débordant* blades (n=107, 18%) are the most frequently recorded *débitage* classes. Blades show similar morphologies to al–Hatab level 2 pieces: most edges are parallel (n=82, 50%) followed by convergent (n=38, 23%). Dorsal scar patterns are predominantly unidirectional (n=110, 67%), with unidirectional-parallel (n=23, 14%) and convergent (n=27, 17%) present to a smaller degree.

As was the case with the al-Hatab Early Nejd Leptolithic assemblage, cores show a single-platform

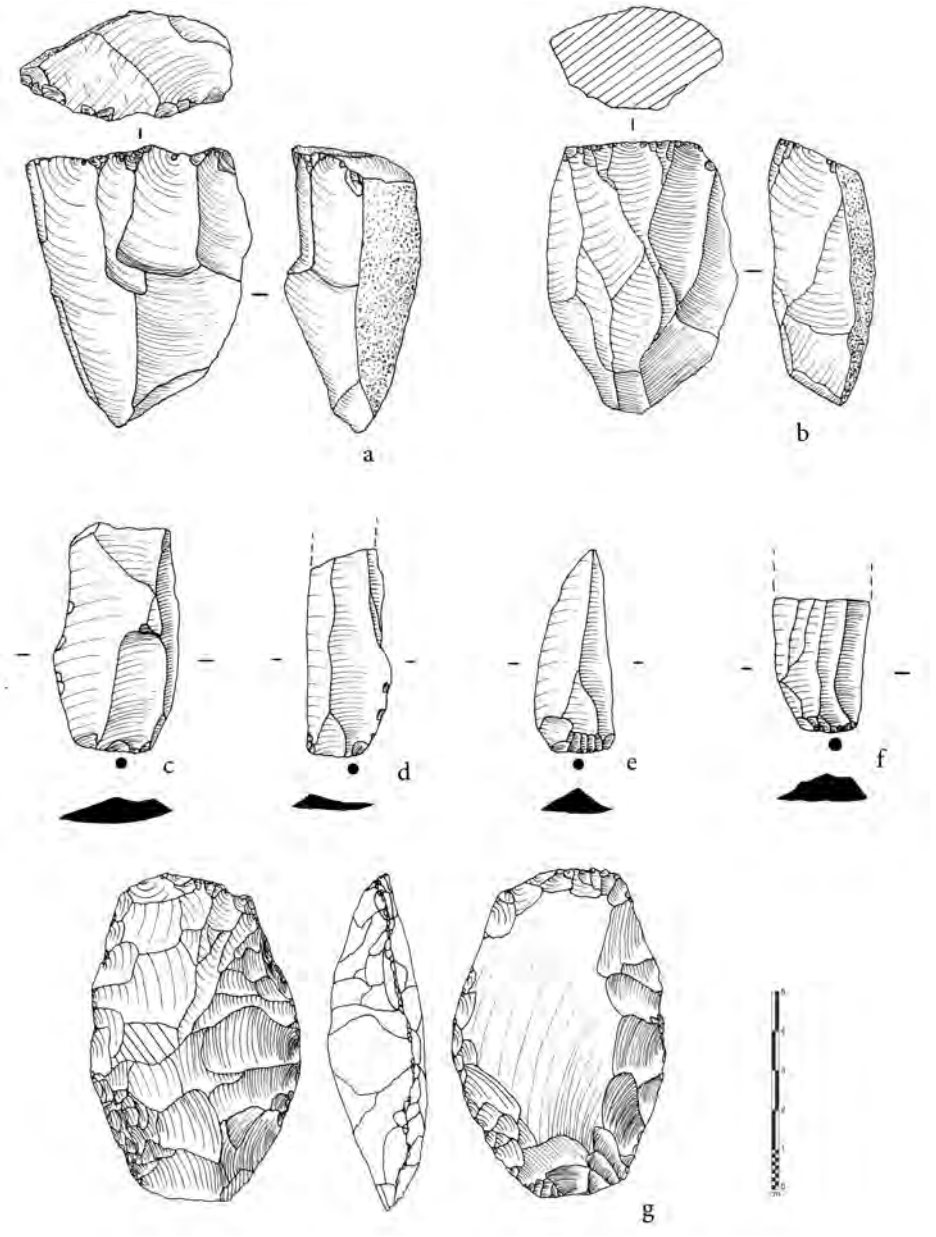


Figure 3. *Artefacts from al-Hatab Level 2 Area.* **a.** *unidirectional blade core with two reduction faces, one frontal and one lateral face;* **b.** *unidirectional-convergent blade core with a convex reduction face;* **c–f.** *blades and blade fragments;* **g.** *miscellaneous bifacial. (Line drawings Y. Hilbert.)*

unidirectional exploitation of frontal, frontal and lateral, or convex working surfaces. There were fourteen separate refits, clarifying the modes of blade reduction used. Two of these refits are described and illustrated here (Fig. 4).

Refit no. 14 shows seven blanks refitted to a single-platform unidirectional core. The core's striking platform was created by the removal of a large cortical blade. From this platform, two *débordant* elements on the same side

of the core's central plane of removal were detached. Subsequently, one *débordant* flake was detached from the other side of the core's plane of removal. Afterwards, one over-passed and twisted, irregularly shaped blade was removed from the centre of the cores, frontal face. Following this step, two blanks were removed; these were not present at the site. The negatives of the subsequent removals indicate that these were regular in shape and represented the desired products of this core reduction. Further reduction along the centre of the plane of removal took place. Two blades were removed of which one was present at the site while the other was not. The last blank removed from the core was a flake from the centre of the core. At this point the dorsal convexity had been exhausted and the flake presented a hinged termination.

Refit no. 1 is marked by two *débordant* blanks refitted to a single-platform unidirectional parallel core. Unlike refit no. 14 from Wadi Haluf 1, this refit depicts isolated aspects of the reduction. The two *débordant* blades are of different size: the larger was reduced during an early reduction cycle, while the smaller probably represents an attempt to restore the core's convexity. The last element that was removed did not considerably alter the mid-cross section of the core: as a result, convexity was not restored and the core was discarded.

The Late Nejd Leptolithic industry

DAP has excavated Nejd Leptolithic assemblages from al-Hatab level 1, Ghazal level 2, and nearby Khumseen rock shelter, level 5 with OSL and AMS (Accelerator Mass Spectrometry) age estimates bracketed between 10 ka BP and 7 ka BP. The assemblages exhibit technological and typological features that clearly belong within the NLT continuum, but they are distinct from the Early Nejd Leptolithic industry. Although still dominated by the production of blade-proportionate *débitage,* an additional reduction modality was observed. The designation 'Late Nejd Leptolithic Inventory' is therefore proposed. A matching surface scatter was identified at Jebel Eva (TH.67) and is included in this description of the Late Nejd Leptolithic Inventory.

Al-Hatab, level 1

Level 1 at al-Hatab occurs in an upper colluvial horizon of varying thickness between 10 cm and 30 cm. Lithic artefacts were found within a sandy gravel matrix (GH 3–4), along with a large number of non-burrowing terrestrial snails. One *Revoilia dhofarense* specimen excavated from Area 1, level 1 was AMS dated to 10,430 ± 140 cal BP (Beta-237899), although this age may, in fact, be up to a millennium younger taking into account the ^{14}C reservoir effect (Rose & Usik 2009).

The artefacts exhibit a small amount of edge damage. Six refits made within level 1 suggest the assemblage, albeit not *in situ*, has not moved far down the slope. The sample analysed here was obtained from the Area 2 sondage excavated during the 2010 field season. There are a total of 730 artefacts, of which 528 are *débitage*, twenty-seven cores, and 175 chips and chunks. Unlike the large number of tools found in Area 1, Area 2 yielded just two tools including a Fasad point fragment and one informally retouched blank. Blades (n=121, 21%) have been struck from single-platform cores (n=14, 54%) using a hard hammer. Blank morphology is analogous to Early Nejd Leptolithic blades, with parallel and, to a lesser extent, convergent edges. Following this trend, blade scar patterns are primarily unidirectional and unidirectional-convergent.

At al-Hatab, level 1, six refits were made, two of which are discussed here (Fig. 5). Refit no. 2 from level 1 consists of two *débordant* blades, both of which were removed from the same edge of the core's plane of reduction. Subsequently, an elongated blank with converging sides was removed from the ventral plane of reduction.

Refit no. 1 shows a cortical flake, a short blade, and a flake with parallel convergent reduction pattern. The ridges from the past removals served as guidelines for the subsequent removals. From this refit one can infer that the core's plane of removal started off flat and, due to the subsequent removals, has become convex.

Ghazal rock shelter, level 2

Ghazal rock shelter is situated approximately 0.5 km west of al-Hatab, at the headwaters of Wādī Dawkah and Wādī Ḥallūf. Like al-Hatab, it is a small collapsed rocky overhang where éboulis blocks fallen from the roof have served to protect and preserve a stratified archaeological deposit. High-quality chert outcrops belonging to the Gahit member of the Rus formation (Platel et al. 1992) are ubiquitous around the site.

The Ghazal rock shelter was excavated during the 2010 and 2011 fieldwork campaigns. Excavations were carried out in 1 m^2, vertical units divided along geological horizons. All excavated sediments were sieved using a 5 mm mesh. A total of fifteen squares were dug to bedrock, exposing six geological horizons. Horizons 3

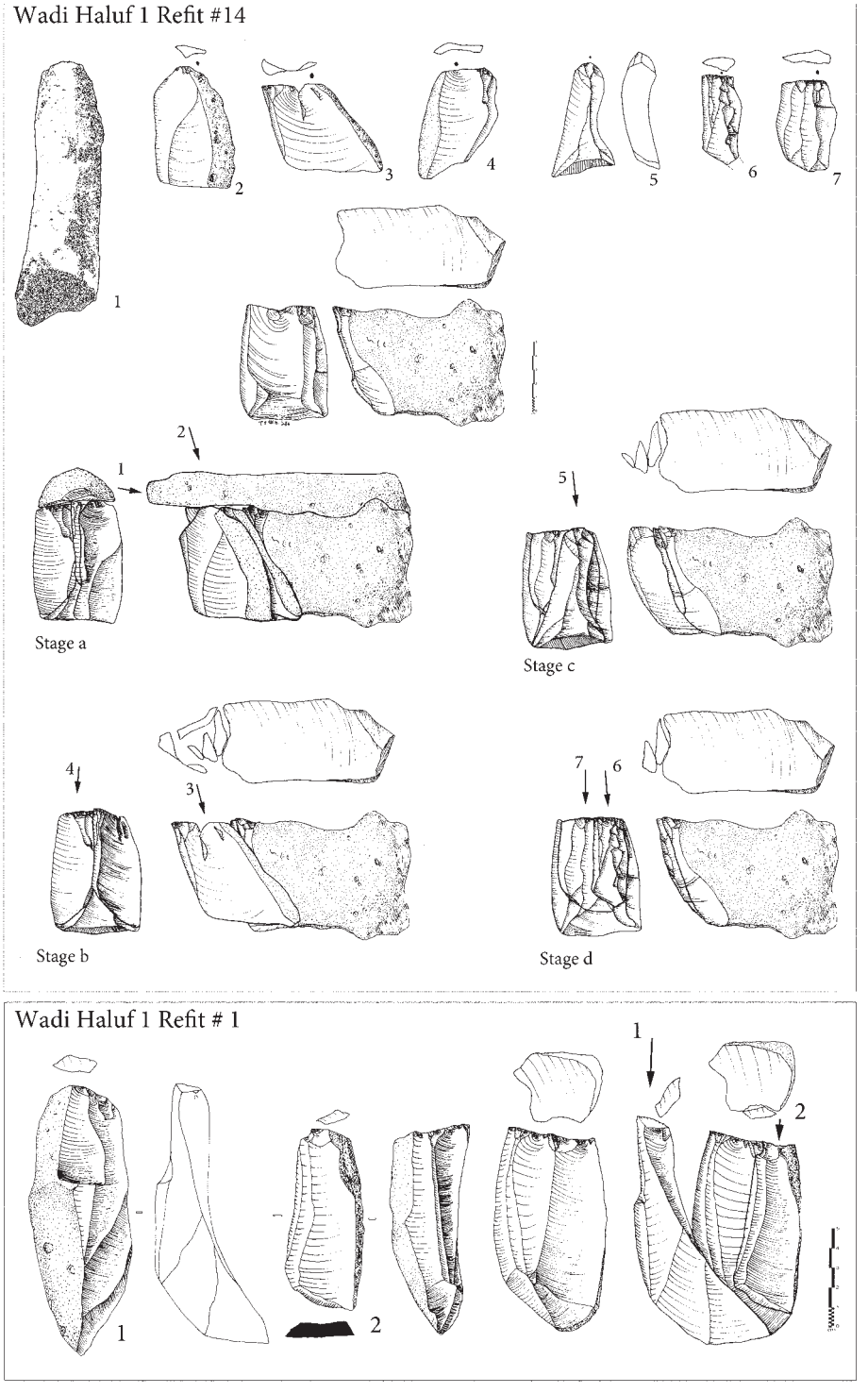


Figure 4. *Refitted cores from Wadi Haluf 1 discussed in the text. Refit no. 14 is presented in four stages labelled a, b, c, and d. The core and débitage involved in refit no. 1 are illustrated. (Line drawings Y. Hilbert.)*

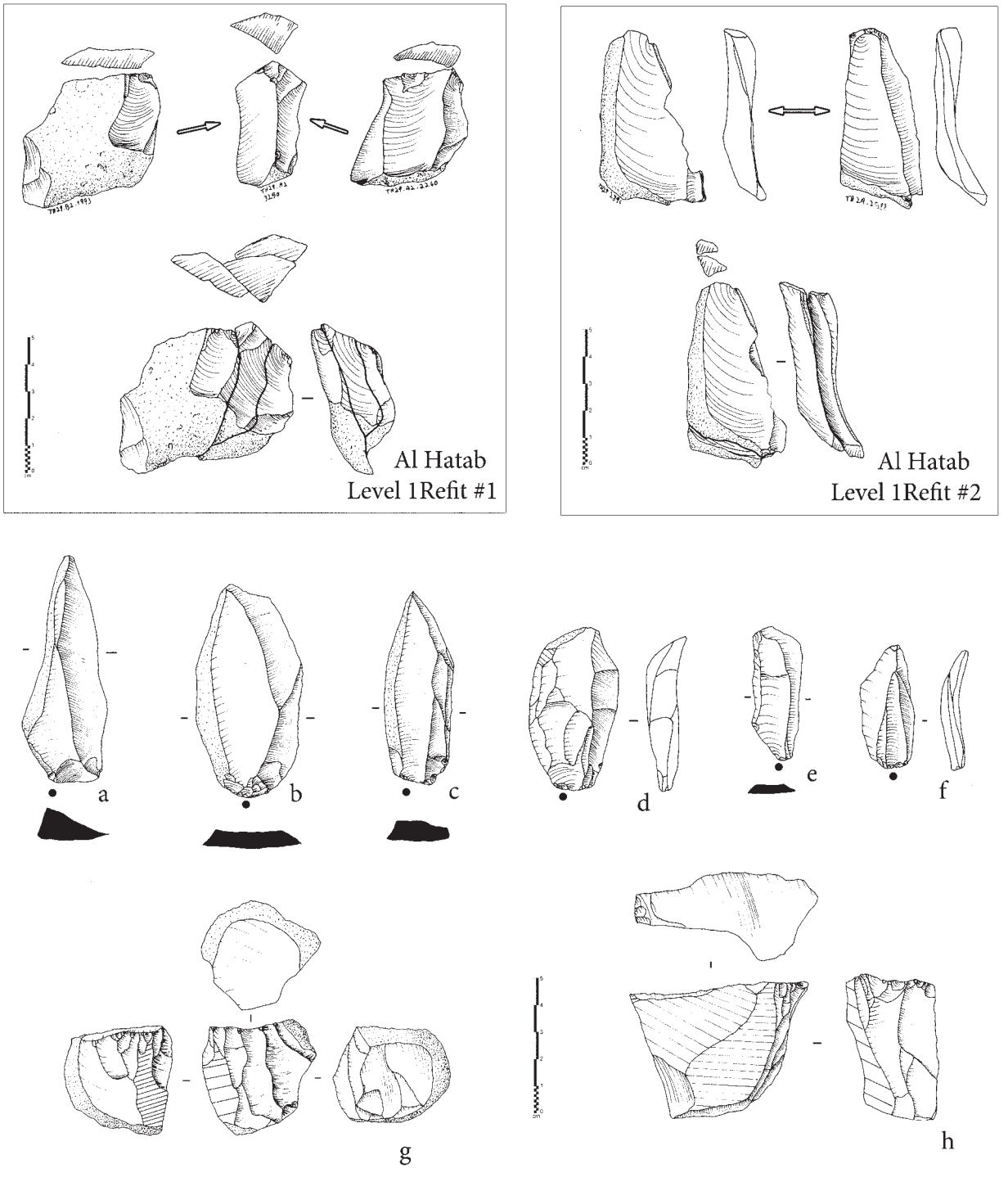


Figure 5. *Refits and artefacts from al-Hatal Level 1, including refits no. 1 and no. 2 discussed in the text.* **a–f.** *blades;* **g.** *unidirectional parallel core;* **h.** *unidirectional core on the narrow edge of a raw material block. (Line drawings Y. Hilbert.)*

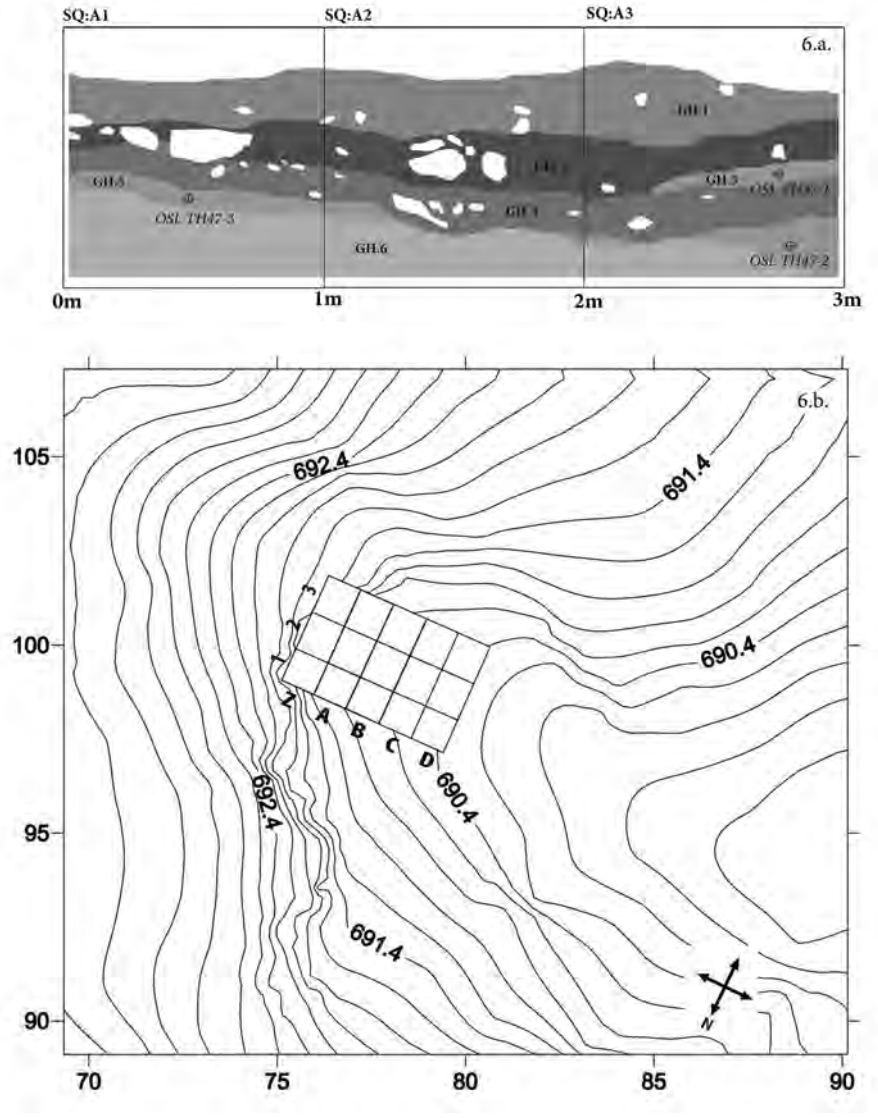


Figure 6. a. *A schematic drawing of the east section of Ghazal rock shelter. The samples discussed in the text were excavated from GH4. Three OSL samples were retrieved from the sections (results pending);* **b.** *a topographic map of Ghazal rock shelter. (Drawings Y. Hilbert.)*

and 5 produced archaeological assemblages belonging to the NLT. Three OSL samples were taken; their position is shown in Figure 6. OSL sample TH47-1 was taken from layer GH3 (32 cm depth), TH47-2 from GH5 (59 cm depth), and TH47-3 also from GH5 (44 cm depth): preliminary results point to an Early Holocene age (numeric ages forthcoming).

Artefacts were manufactured on chert from a local Gahit outcrop. The material has suffered minimal post-depositional modification (e.g. abrasion, varnish, rolling), other than the development of a white patina. Due to the relatively pristine condition of the site, it was possible to make several refits with the level 2 assemblage, which in turn permits detailed reconstruction of the reduction modalities employed by the toolmakers.

A total of 321 artefacts comprise the level 2 assemblage. Of these, fifty-six were debris consisting of chips or chunks. The *débitage* consists of 251 blanks

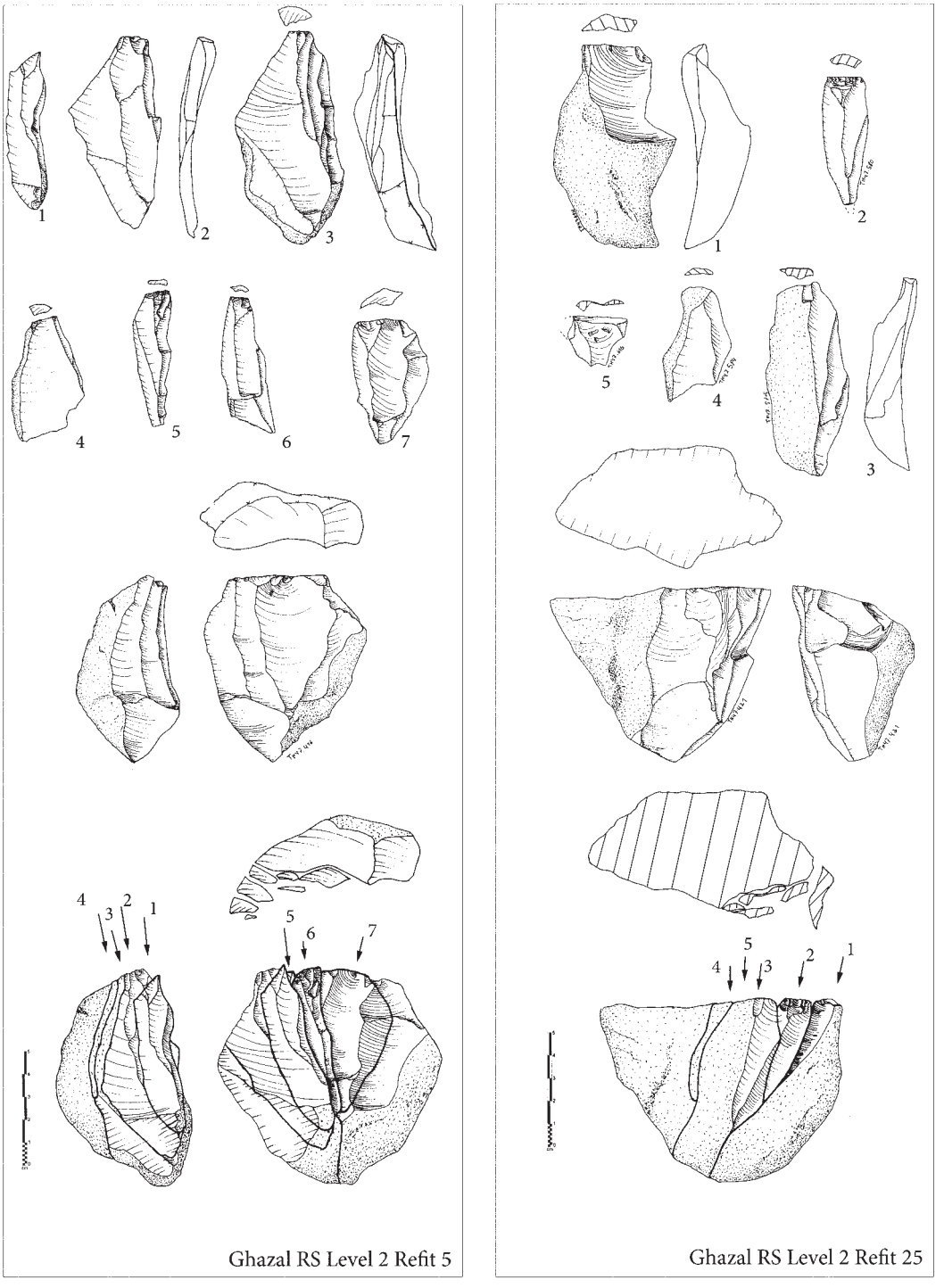


Figure 7. *Refitted cores from Ghazal rock shelter level 2 discussed in the text. Core reduction has been illustrated as follows: blanks have been numbered in order of reduction and cores are showed fully reconstructed, with arrows indicating the direction of the recurrent removals. (Line drawings Y. Hilbert.)*

and fourteen cores, while the only tools recovered were two informally retouched blanks and a burin on a snap. Unmodified blanks include blades (n=57, 23%), flakes (n=82, 32%), *débordant* pieces (n=25, 10%), and cortical elements (n=60, 23%). Blade morphology is similar to al-Hatab level 1: dorsal scar patterns are mostly unidirectional (n=29, 51%) or convergent (n=18, 31%). Most blades have convergent edges (n=23, 41%) followed by parallel edges (n=19, 34%).

The fourteen cores display either a single platform (n=10) or two unopposed platforms (n=3). All are unidirectional and have non-intersecting planes of removal. The twenty-seven refits from level 2 help further to elucidate the reduction strategy, and two particularly significant refits, described below, are depicted in Figure 7.

Refit no. 5 includes seven pieces of *débitage* reattached to a single platform parallel core with a convex plane of removal across its lateral and frontal faces. Flakes and blades from both surfaces have been refitted. Reduction started at the wide central plane and then moved towards the narrow working surface of the core, in order to achieve the required convexity. Once achieved, reduction moved back to the central plain.

Refit no. 25 is marked by the reduction of blanks with a convergent scar pattern from a single-platform core. The core's plane of removal was on the narrow edge of the raw material block. After decortications, reduction shifted to the lateral portion of the core, initiating a second plane of removal. Both *débordant* elements and blades were produced. The abandoned core exhibited an exhausted working surface across both planes of removal.

Khumseen rock shelter, level 5

Khumseen rock shelter is a large overhang located approximately 2 km west of al-Hatab and Ghazal rock shelters. It lies at the bend of a prominent tributary channel feeding Wādī Dawkah. Outcropping from within the Gahit limestone are chert nodules of moderate knapping properties. The site's favourable position and proximity to resources are still enjoyed by the local Bedouin community, a group of whom reoccupied the site between the 2010 and 2011 field seasons, preventing further investigations.

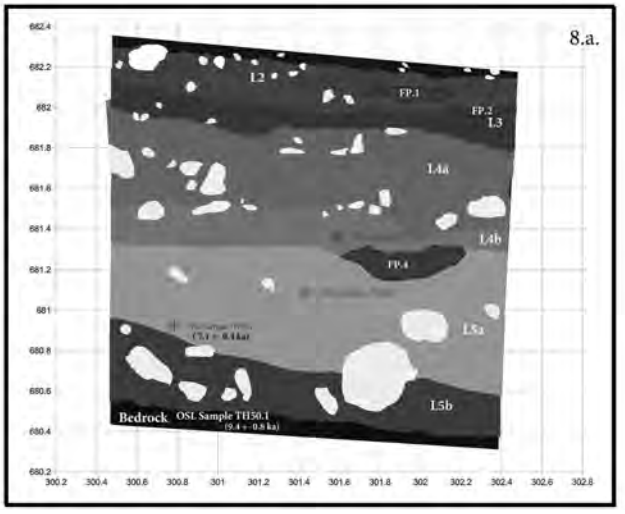
A 2 x 2 m sondage was excavated, which reached just over 2 m in depth and yielded five archaeological levels spanning the entire duration of the Holocene (Figure 8/A). The excavation was conducted in 1 m^2 units, and all sediment sieved through a 5 mm-mesh screen. A Late Nejd Leptolithic assemblage was found in the lowest archaeological unit (level 5). Two preliminary OSL age estimates measured for level 5 indicate that the artefacts were buried between 9.4 ± 0.8 ka (TH50.1) and 7.1 ± 0.4 ka BP (TH50.2), while an AMS date on ash remains from a hearth in the overlying archaeological unit (FP.4 in Fig. 8/A), provides a minimum date of 6845 ± 105 cal BP (Beta-281544).

The level 5 assemblage is composed of 763 lithic artefacts of which 367 are *débitage*, twenty-seven cores, eleven tools, and 358 chips. The blade index of 22% (n=82) is similar to other Late Nejd Leptolithic assemblages. Blank morphology is analogous to al-Hatab level 1 and fits comfortably into the NLT technological continuum. The toolkit included two Fasad point fragments, which are a *fossile directeur* of the Late Nejd Leptolithic (Rose & Usik 2009).

Khumseen rock shelter has eleven refits; of these, refit no. 10 shows a successive volumetric reduction of fourteen blades from a single platform core (Figure 8/B). The refit shows all stages of reduction, decortication, convexity maintenance by *débordant* removals, as well as continued blade production from the core's plane of removal. Ideal convexity, however, was not achieved as all the reattached blanks have hinged terminations. The produced *débitage* was considered unsuitable for use or modification.

Jebel Eva

Jebel Eva is located in the central region of the Najd plateau, near the village of Mudayy (Muḍayy). It is a pristine, high-density surface scatter collected during the 2010 field campaign. Lithic artefacts were found at the foot of a low inselberg, where large American football-sized nodules and plaquettes of high-quality chert belonging to the Mudayy geological member (Platel et al. 1992) outcrop from the base of the inselberg. Around the inselberg is a gravel plain which is dissected by tributaries of Wādī ᶜAybūt. Much like the complex of lithic scatters at Wadi Haluf 1, several artefact clusters were observed. The Jebel Eva sample area was chosen for its clearly demarcated extent. All artefacts were collected in 1 m^2 units inside a 3 x 3 m surface grid. There was virtually no edge damage on the lithic material. A dark brown patination is observed on the assemblage. Fourteen refits were made, indicating minimal post-depositional movement. A total of 418 pieces were recovered, including twenty-two cores and 390 pieces of *débitage*. Seven tools were identified, of which five are informally retouched blades, one pseudo-



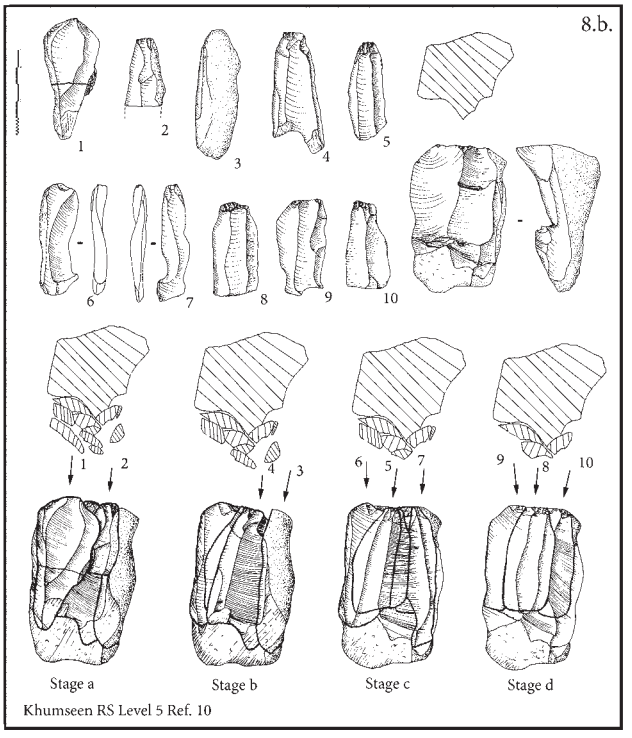


Figure 8. a. *A schematic drawing of the Khumseen rock shelter section. The archaeological samples discussed in the text come from Level 5. Three OSL samples were taken from this level, of which two have yielded results and are shown in the drawing;* **b.** *a refitted core from Khumseen rock shelter level 5. Refit no. 10 is composed of eleven artefacts: ten blades and one core. (Section and line drawings Y. Hilbert.)*

backed knife, and one Fasad point fragment. *Débordant* pieces are the most frequent *débitage* type (n=114, 26%), followed by blades (n=85, 20%) and flakes (n=58, 14%). Blade morphology is marked by unidirectional and unidirectional-convergent scar patterns (respectively n=57, 66% and n=14, 16%). Blade shape is dominated by parallel (n=32, 38%) and convergent (n=21, 25%) edges. Blanks were primarily struck from single-platform parallel (n=8, 38%) and single-platform convergent (n=7, 33%) cores, followed to a lesser extent by platform cores with two non-intersecting platforms (unopposed platform cores) (n=3, 14%).

The Jebel Eva site yielded fourteen refits; two are major reconstructions, while the remaining refits indicate minor steps within the reduction sequences used (Fig. 9). Refit no. 4 shows two *débordant* elements removed from opposite edges of a single-platform core. The amount of cortex on these two converging *débordant* removals indicates that the core experienced only a single reduction cycle. Additional reduction cycles were attempted as the negatives seen on the core suggest, but restructuring of the reduction plane could not be achieved, given the exceeding longitudinal convexity of the core's flaking surface. Refit no. 13 mirrors an identical reduction strategy as seen in refit no. 4. Two successive *débordant* blades detached from opposed edges of the core's plane of removal have set the longitudinal and horizontal convexities. The negatives on the two reattached blanks indicate that a similar cycle was undertaken on the previous nodule.

Nejd Leptolithic Tradition core-reduction modalities

Three distinct reduction modalities have been identified within the Early and Late Nejd Leptolithic industries (Fig. 10). Modalities 1 and 2 both employ a single-platform unidirectional-parallel strategy. Modality 1 is found in Early and Late Nejd Leptolithic assemblages, exemplified at al-Hatab (level 2), Ghazal (level 2), and Wadi Haluf 1. It is distinguished by the intentional removal of *débordant* elements for the maintenance of convexity. Although the identification of the intention to remove preferentially shaped blanks within a continuous volumetric system can be contentious, refits show clear phases of repreparation repeated across multiple cores. In Modality 1, following initial preparation of the core's striking platform via a single blow, cortical flakes are removed from one working surface of the nodule. Subsequently, *débordant* elements are struck from the lateral edges of the working surface

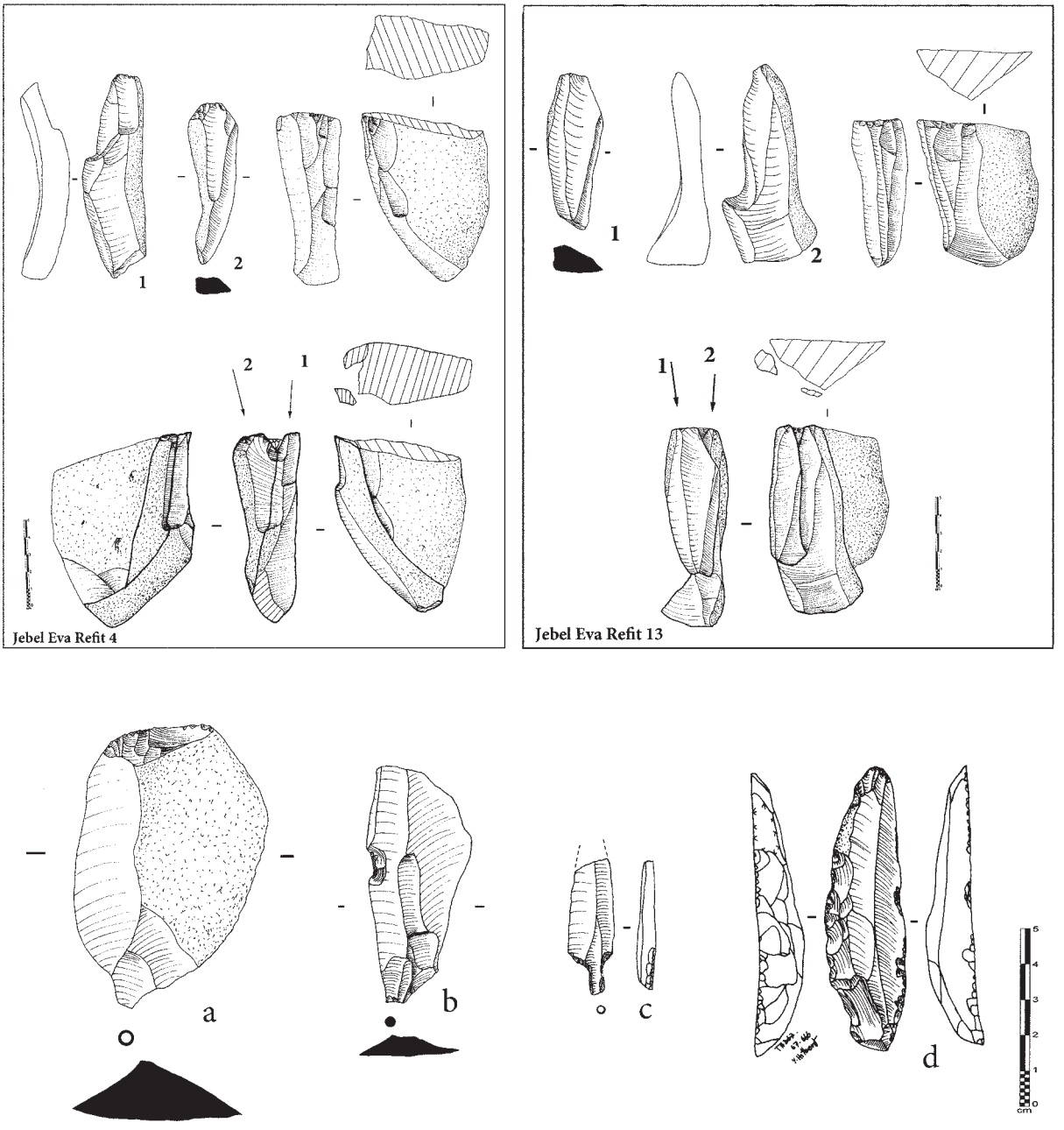


Figure 9. *Refits and tools from Jebel Eva, including refits no. 4 and no. 13 discussed in the text.* **a.** *a simple end scraper on a cortical blank;* **b.** *a simple notch on a blade;* **c.** *a proximal Fasad point fragment;* **d.** *a pseudo-backed knife. (Line drawings Y. Hilbert.)*

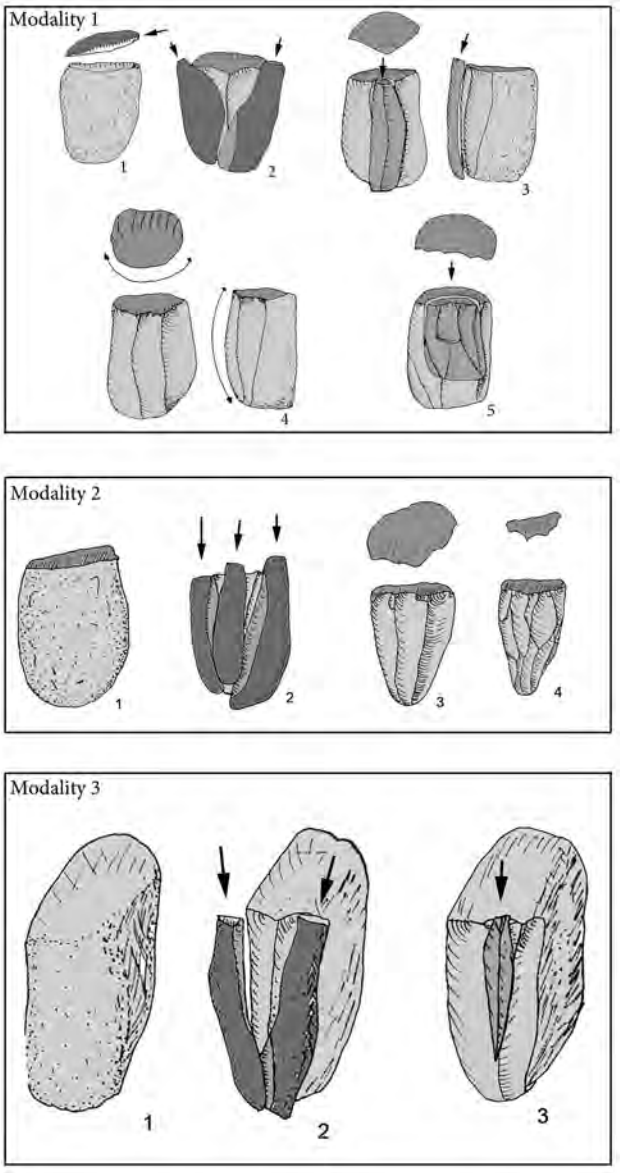


Figure 10. *A schematic representation of the three blade-producing modalities used throughout the Nejd Leptolithic Tradition. Modality 1 characterized by the creation of a core work surface with conductive convexity; Modality 2 marked by the volumetric reduction of the core's volume; Modality 3 characterized by a short cycle of reduction favouring the production of triangular to sub-triangular blades and bladelets. (Drawings Y. Hilbert.)*

to create a keel-like plane of removal. There is often an over-passed removal along the *débordant* guiding ridge, serving to form both the lateral and distal convexity of the working surface, thereby setting up the core for the recurrent removal of elongated blanks. Following the unidirectional-parallel reduction of several blades, convexity of the core's working surface is lost. At this point, the core is either discarded or the cycle is repeated.

Modality 2 appears in both Early and Late Nejd Leptolithic assemblages (al-Hatab (level 1), Wādī Haluf 1, Ghazal (level 2), and Khumseen (level 5) and is characterized by the volumetric reduction of elongated blanks across multiple working surfaces of the core from a single platform. This process results in the formation of a convex and convergent plane of removal for the recurrent production of blades. Although both Modalities 1 and 2 produce the same end product — an elongated blank with unidirectional-parallel scar patterns — the two techniques employ different processes to achieve and maintain convexity across the plane of removal.

Modality 3, confined exclusively to Late Nejd Leptolithic assemblages — al–Hatab (level 1), Jebel Eva, and Khumseen (level 5) — is distinguished by its deliberately short cycle of reduction. Two successive *débordant* removals are used to form a convergent convexity across the working surface, resulting in the preferential removal of an elongated, diamond-shaped blank. This technique produces a single end product, so that the plane of removal must be reformed with each cycle. A matching reduction strategy is reported by Crassard in the Ḥaḍramawt, central Yemen (Crassard 2008*a*; 2008*b*) and designated the 'Waʾshah method'.

Conclusions

Through the study of buried, dated lithic assemblages from the southern and central Najd plateau, as well as homogeneous surface scatters found on predominantly undisturbed landscapes, this paper presents a detailed reconstruction of core-reduction modalities employed within the Nejd Leptolithic Tradition. We identified some degree of temporal variability, allowing for the division of this tradition into two chronological industries: the Early and Late Nejd Leptolithic industry.

Reduction strategies within the Early Nejd Leptolithic industry include the use of modalities 1 and 2 to obtain elongated blanks, along with the *façonnage* manufacture of bifacial implements. Blade blanks were retouched into a variety of tool forms dominated by burins, scrapers, and

retouched points. The stratified assemblage of al-Hatab belonging to the Early Nejd Leptolithic yielded numeric age estimates ranging between 14 and 10 ka BP.

The Late Nejd Leptolithic industry incorporates modalities 1, 2, and 3 in core reduction, with modalities 2 and 3 most frequently employed. Bifacial manufacture is far less prominent than in the preceding phase. Modality 3 is closely related to the Waʾshah technique identified in Yemen; projectile typology, however, suggests local diversification between these two areas of southern Arabia. No Waʾshah points have been found in Dhofar; rather, tanged Fasad points are often observed in conjunction with the Late Nejd Leptolithic. Dating of this industry is based on AMS and OSL age estimates at al-Hatab (level 1), Ghazal (level 2), and Khumseen (level 5), providing an approximate range between 10 ka BP and 7 ka BP.

Core reduction modalities within the NLT do not match any technological schemes outside Arabia and we therefore regard the Late Palaeolithic of Dhofar as a local development. In particular, there is no overlap between NLT blade production and naviform core technologies observed in Levantine pre-pottery Neolithic B and Qatar B industries. The NLT, bracketed between 14 and 7 ka BP, provides evidence for population continuity in Dhofar across the Pleistocene-Holocene boundary, thus refuting the proposition of a 'Levantine Expansion' marked by the spread of Fasad points throughout the Arabian interior (Uerpmann, Potts & Uerpmann 2009). Rather, the presence of a Late Palaeolithic human occupation in Dhofar corroborates the proposed phylogenetic history of mitochondrial DNA haplogroup R0a (Cerný et al. 2010). Based on these archaeological and genetic data, the emerging picture suggests population continuity in southern Arabia across the Pleistocene-Holocene boundary.

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