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Naiyena Engol 2 (West Turkana, Kenya): a case study on variability in the Oldowan

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Abstract:	Recent years have seen increasing interest in the study of Oldowan technological variability, and the observed inter-assemblage diversity has been attributed to a number of causes, including raw material availability, different hominin species, and cultural and diachronic variation. This paper explores technological variability through the study of Naiyena Engol 2, an Oldowan site dated at c.1.8 - 1.7 Ma and located in the Nachukui Formation of West Turkana, Kenya. Site formation processes, stratigraphic and taphonomic aspects of Naiyena Engol 2 are reported, and are followed by a discussion of the lithic assemblage, focusing on flaking techniques and battering activities. Our results show important diversity of flaking techniques within the same assemblage, suggesting that lithic variability is not only an inter-site phenomenon but also may be found within single Oldowan sites. Additionally, the overall low flake productivity of Naiyena Engol 2 is in sharp contrast with patterns observed in other West Turkana assemblages -such as the older site of Lokalalei 2C, thus also supporting the existence of significant inter-assemblage variability during the Oldowan.

Abstract

Recent years have seen increasing interest in the study of Oldowan technological variability, and the observed inter-assemblage diversity has been attributed to a number of causes, including raw material availability, different hominin species, and cultural and diachronic variation. This paper explores technological variability through the study of Naiyena Engol 2, an Oldowan site dated at c.1.8 - 1.7 Ma and located in the Nachukui Formation of West Turkana, Kenya. Site formation processes, stratigraphic and taphonomic aspects of Naiyena Engol 2 are reported, and are followed by a discussion of the lithic assemblage, focusing on flaking techniques and battering activities. Our results show important diversity of flaking techniques within the same assemblage, suggesting that lithic variability is not only an inter-site phenomenon but also may be found within single Oldowan sites. Additionally, the overall low flake productivity of Naiyena Engol 2 is in sharp contrast with patterns observed in other West Turkana assemblages -such as the older site of Lokalalei 2C, thus also supporting the existence of significant inter-assemblage variability during the Oldowan.

Résumé

Au cours des dernières années, l'intérêt pour les études de la variabilité technologique de l'Oldowayen s'est accru. La diversité inter-assemblage, maintes fois observée, est attribuée à différentes causes telles la disponibilité des matières premières, la diversité hominienne, ou encore les variations culturelles ou diachroniques. Cet article explore la variabilité technologique à travers l'étude du site Oldowayen de Naiyena Engol 2, qui appartient à la Formation de Nachukui et est daté entre 1.8 et 1.7 millions d'années. La stratigraphie, les principaux aspects taphonomiques et de formation du site et l'ensemble du matériel archéologique sont présentés, suivis par une discussion sur l'ensemble lithique, axée sur les techniques de taille et autres activités de percussion. Nos résultats montrent une importante diversité dans les techniques de taille, suggérant que la variabilité lithique n'est pas seulement un phénomène inter-sites, mais peut aussi être mise en évidence dans un seul et même ensemble. De plus, la faible production d'éclats à Naiyena Engol contraste fortement avec celle observée dans d'autres sites -dont le site plus ancien de Lokalalei 2C- suggérant aussi une forte variabilité inter-assemblage au cours de l'Oldowayen.

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Introduction

Since the mid 1990's, continuous archaeological research in the Nachukui Formation in West Turkana (Northern Kenya), conducted by the West Turkana Archaeological Project (WTAP), has resulted in the discovery of a wealth of sites attributed to several chrono-cultural time periods (Roche et al. 2003; Roche 2011), from "before the Oldowan" (Harmand et al. 2015), through Oldowan (Roche et al. 1999) to early (Lepre *et al*. 2011) and later (Delagnes *et al*. 2005) Acheulean. The Oldowan is widely represented within this variety of techno-complexes, and distributed in five main site complexes (Fig.1): Nasura and Lokalalei for the early Oldowan (2.4/2.3 Ma, Roche et al. 2003; Roche 2011), and Kokiselei, Naiyena Engol and Kalokodo for the "classic" Oldowan (1.8/1.7 Ma, Roche et al. 2003; Roche 2011). The early Oldowan main sites belong to the Kalochoro Member of the Nachukui Formation (2.35/1.90 Ma), while the more recent Oldowan complexes of sites correspond to the Kaitio Member (1.90/1.65 Ma). Paleogeographically, the later time period corresponds to a major lacustrine episode in the Turkana Basin, which was then occupied by the large Lake Lorenyang (2.1/1.4 Ma), one of the precursors of the present lake (Brown and Feibel, 1991; Feibel 2011; Lepre 2014). The Kaitio Member -the thickest (169 m) of the plio-pleistocene section of the Nachukui Formation- is thus mainly composed of beach deposits of more or less compacted sands. Very few Oldowan sites are located directly on or very close to the lake shore; most are positioned along transversal rivers flowing W/E and draining the margins of the paleo-lake. This is the case for the site of Naiyena Engol 2 presented here.

The static *versus* diverse nature of the Oldowan was the subject of debate for about a decade (Semaw et al. 1997, Roche et al. 1999, Semaw 2000, Roche 2005, Texier et al. 2006) before a consensus emerged about variability within this long techno-cultural entity (Semaw et al. 2009, Roche et al. 2009, Stout et al. 2010, Roche 2011). In West Turkana, the notion of variability is based mainly on observed disparity within technological traits (raw material management, structure of knapping sequences, productivity, etc.) of the lithic assemblages. But it also takes into account the long time span covered by the Oldowan (almost one million years) and the extremely vast territory within which several hominins species evolved. The site of Naiyena Engol 2 is used in this paper as an example of Oldowan variability across sites of the Nachukui Formation and elsewhere, and the flexibility of hominin technical behaviour within a single assemblage. This paper will focus on the technological and petrographic features of the lithic assemblage but, given that this is the first systematic report on the excavations at Naiyena Engol 2, contextual data collected during fieldwork will also be presented, as well as a summary of the faunal assemblage and its bearing for the reconstruction of the paleoenvironmental setting.

The Naiyena Engol 2 site

Naiyena Engol 2 (NY2, FxJh 11, KNM 4087) was discovered in 1991[1] along the Kalomeu river, a small southern tributary of the main Naiyena Engol river (Fig.1). The site is part of the Naiyena Engol main drainage and sequence of lacustrine deposits, as are all Oldowan sites of the major complexes of this age in the Nachukui Formation. Geographically, it is located equidistant (circa 3.5 km) from both the Naiyena Engol and the Kokiselei complexes, and very close to the Kalokodo complex (750 m, Fig.1).

Chronostratigraphy

The Nachukui Formation (>4 – 0,7 Ma) is divided into eight members of different time spans and thickness (Harris et al. 1988). This subdivision was established on the basis of the major volcanic events (tuffs) which separate them. These tuffs are all distinctive by their geochemistry and correlate with those of other sedimentary formations of the basin -known as the Omo Group and including the eastern Koobi Fora and northern Shungura Formations- in which more than 40 tuffs have been identified (Brown and Mc Dougall 2011). This tephrostratigraphic framework provides a good age control, if not a precise date, for most of the site complexes.

NY2 is in the middle of the Kaitio Member (1.90–1.65 Ma), which, although the thickest of all the Nachukui Formation members, covers one of the shortest time-spans. This high rate of sedimentary accumulation corresponds to the longest-lived of the Neogene lakes in the Turkana basin, Lake Lorenyang (Brown and Feibel 1991; Feibel 2011; Lepre 2014). NY2 is

[1] During a later visit to the site, one of the authors (JPB) found a hominin tooth at 160 m SE of the archaeological site, on top of a paleobeach pertaining to the same package of beach facies and consequently falling within the same time range as NY2. However, it is not possible to link this tooth -a left upper first molar currently under study (Prat et al., in prep)- to the context of the archaeological site.

located in an area of low relief and shallow outcrops corresponding to small river bank deposits (Fig. 2A). However, a fairly continuous sequence is exposed downstream from the site, which descends into the fine-grained lacustrine strata of the Paleolake Lorenyang. A long section through these exposures (CSF 98-4, Fig. 2A) places the site respectively at 34,5 m and 43,5 m above two prominent bentonites, both within the lower lacustrine interval. One of these is likely to be the KBS Tuff (1.87 Ma), based on outcrop mapping from the nearest known occurrence of the KBS Tuff (in Kokiselei lagar), around 2 km to the south of NY2 (Fig. 1). The overlying sequence is very similar in character to that seen at the nearby site of Kalokodo 6, and in the Kokiselei drainage to the south, as well as at the other Naiyena Engol sites to the north (see Fig.1). The packages of coarse beach facies and finer mudstones are very similar. At Kokiselei, magnetic polarity studies reported by Lepre *et al*. (2011) demonstrated that the top of the Olduvai Subchron (1.78 Ma) could be recognized within the upper fine-grained interval but, as yet, there is no paleomagnetic data to support a more precise age for the Naiyena Engol sites, including NY2. However, the along-strike continuity of the major sedimentary strata from Kokiselei to Kalomeu, Naiyena Engol and Kalochoro, strongly suggests that the NY2 archaeological assemblage dates between 1.8 - 1.7 Ma, placing this site within the "Classic" Oldowan time period.

Excavation, stratigraphy and depositional context

After recording surface artefacts and faunal remains in the lower parts of the small hills forming the NY2 shallow outcrops, a 2 m^2 test trench excavated in 1996 indicated the existence of archaeological material *in situ*. A larger scale excavation and systematic surface collection were conducted in 1998. In total, 32 m^2 were excavated, distributed on the slopes of two opposite relief features, one in the north, with 3 trenches (N1 to N3, Fig. 2B), and one in the south, with one trench (S, Fig. 2B). The surface material, scattered across approximately 340 m^2 in concentrations lying on the eroded and excavated areas, was collected by square meter, and by 5 x 5 square meters in the higher and non-eroded areas on top of the low hills, where very few artefacts were present. There is a 6 m erosional gap between the northern and the southern trenches (Fig. 2B and 3E) but given the homogeneity of the assemblage across the trenches and the fact all artefacts are embedded in the same sediments, it is most probable that all the archaeological material belongs to the same depositional event.

Observations made in the field, plus sagittal (N-S) and transversal (E-W) stratigraphic sections coupled with artefact projections (Fig. 3C and D), enable discussion of the depositional environment of NY2, while the plan view and general sagittal and transversal cross-sections of the stratified material show the horizontal distribution and the vertical dispersion of all the archaeological material (Fig. 3A, E and F).

The short NY2 stratigraphic sequence is composed of four different depositional layers (Fig. 3C and D), which are part of the same sedimentary episode. From bottom to top the sequence is as follows: first a very dense and indurated yellowish sand (4) is present in the two excavated areas, and overlain by a light grey clay lens (3) which pinches out towards SE. The contact between this clay and the underlying sand is very irregular, as if a fluid (mud flow) had moulded the already indurated sandy horizon; a number of artefacts, captured by the mud flow, are included in this layer. The clay unit is overlain by a light grey fine sand (2) in which faunal remains and some artefacts are embedded. Finally, a dark grey clay (1), present only in the northern part of the main excavation (N1, Fig. 2B), caps the stratigraphic sequence and contains very few faunal remains, which may be intrusive from the underlying sand. As shown in Fig. 3C and D, the archaeological material is scattered across layers 4, and 3 and 2 when present; these different interdigitated very fine sediments (2 and 3 appearing in the form of large lenses) correspond to the same sedimentary environment, likely linked to a river bank overflow. As the archaeological material is largely unsorted (ranging from small flakes to very large cores), a low energy flow is inferred which was able only to deposit the embedding clay and fine sand, and which did not have a major effect on the archaeological material. The presence of several sets of lithic refits in three of the excavated areas (Fig. 4, and see below) strengthens this argument. Therefore, although there is evidence that a small part of the northern side of the site was disturbed (cf. Fig. 3C and *infra*), we conclude that, in general, the lithic assemblage is only slightly redistributed from its primary context. Archaeological material distributions form two slopes: a pronounced N-S trend (Fig. 3E), and a gentler E-W slope. The E-W projections of all materials (Fig. 3F) show that faunal remains and lithics are grouped together, except in the northern area of the main excavation (N1 Fig. 2B, see also Fig. 3C), essentially in squares I36/35, where a small concentration of bones were found in level 2, and a few stone tools were present in levels 3 and 4. This is the only part of the site with spatial dissociation of lithics and fossils. The slope effect in the N-S projection of all materials (Fig. 3F) blurs the cross-section in this part of the site and the superposition of materials from the N1 and S trenches. However, fossils and artefacts are well clustered in trenches N2 and N3. The maximum vertical dispersion of artefacts varies between trenches (i.e. 31 cm in Trench S, 79 cm in Trench N1, 55 cm in Trench N2, and 22 cm in Trench N3). Although a vertical dispersion of 80 cm is not uncommon in the West Turkana sites (see e.g. Delagnes and Roche, 2005) and, more generally speaking, in this type of depositional environment, differential thickness of materials at NY2 might indicate heavier disturbance processes in the NE than in the SW area of the site.

The archaeological assemblage

The NY2 archaeological assemblage (620 lithics and 252 fossil remains - excluding the exceedingly abundant bone splinters retrieved from sieving, see Table 1) is composed of material located in stratigraphic position (320 lithics and 125 fossils) and from surface collection (300 lithics and 127 fossils). The scattering of surface material closely follows the spatial distribution of the stratified collection (Fig. 3B), suggesting that modern erosive processes have not heavily affected the original spatial arrangement of artefacts. Furthermore, the surface material is clearly derived from erosion of the archaeological level, as supported by refits between surface and *in situ* stone artefacts (Fig. 4). Apart from a larger abundance of cores on the surface (13.1% on the surface *versus* 3.9% in stratigraphy), and of debris (23.3% *versus* 8.9%) and unmodified material (17.8% *versus* 7.2%), the relative frequency of categories is similar between the two collections, with a predominance of flakes and flake fragments in both (Table 2 and Fig. 5A).

Stone tool length (Fig. 5B) shows a predominance of artefacts in the 21-40 mm class (47.1%), followed by the 41-60 mm class (21.1%) suggesting that winnowing of the smallest artefacts (< 20 mm) has occurred (these make up only 16.7% of the assemblage, well below expected estimates for on-site knapping episodes). With regards to the fossils (Table 1), almost 42% of the *in situ* stratified remains and 91% of the surface collected material have respectively been determined at a family level, a percentage which drops to 4% for the sieved material, consisting primarily of small tooth fragments and bone splinters.

The faunal assemblage

The NY2 faunal assemblage includes 20 species (Table1, Fig. 6A) in which bovids are dominant. Ungulates are primarily Reduncini (*Kobus* sp. large size) and Tragelaphini (*Tragelaphus* sp. sizes 2 and 3), and predominate over the Antilopini (*Gazella* sp.) and Alcelaphini (*Damaliscus* size, Fig. 6B) groups. This latter group is indicative of open zones while Reduncini and Tragelaphini clearly indicate a more closed wooded environment. Equids are represented mainly by *Hipparion* and only one element (lower molar) indicates the presence of the genus *Equus*. There are many remains of Hippopotamid which likely correspond to one individual of *H. gorgops*, found in the upper layers (3 and 4, Fig. 3C and D) and on the surface; other aquatic elements (fish, crocodile) are scarce. Large mammals are also well represented by a giraffe, larger than *G. stillei* from Koobi Fora and the modern species, and a Rhinocerotid (*Ceratotherium simum*). The suids are represented by at least two genera (*Kolpochoerus* and *Metridiochoerus*, the most commonly known pigs for this time period), with the possible presence of *Notochoerus*. The NY2 fossil assemblage also includes an almost complete hemi-mandible of *Cercopithecus* (which may represent a new species), a few remains of a carnivore and the cane-rat *Thryonomyx*, generally found near river banks or marshes. The faunal association indicates a relatively wooded and bushy environment, not too far from a (perennial?) water source and is strongly suggestive of a riverine setting for the habitat occupied by the NY2 hominins.

Bone and tooth fragmentation is very high and the bulk of material consists of splinters from medium to large mammal bones, along with abundant tooth fragments; a large portion of the assemblage derives from sieving (excavation and surface). Dental material allows taxonomic identification at the family/tribe level, sometimes to genus/species, and occasionally provides information on age at death profiles; ungulates are mostly adult individuals with few young and old animals. Post-cranial material is essentially from size 2 and 3 bovids, with long (limb bones) and short (basipodial) elements which are rarely complete; compact bones are more frequent than spongy bones. Taphonomic processes involve a combination of different agents and preservation of the fossil material, although variable, is not very good overall. Most bones are weathered, with a carbonate crust, and show dry bone breakage; only 10 small shaft fragments of undetermined taxa display green fractures (made on fresh bones). Marks on the bones are rare and all are from surface shaft fragments. One mark is attributed to a carnivore, two are dissolution pits (from insect/termite action, or roots) and one is attributed tentatively to hominid action on a shaft from a size 3 bovid (Fig. 6C); this has short parallel striations, dissymmetric in section with one relatively abrupt side, and interpreted as chop-marks produced by several blows inflicted with a sharp stone tool.

In summary, while it is possible to a certain extent to reconstruct the paleoenvironmental setting at the site from the relatively well diversified and defined faunal association (Brugal et al., 2003; Brugal and Roche, in press), less obvious is the characterization of human-animal interactions. Although hominin action on part of the bone assemblage is likely, especially on several bovid remains, most of the bone assemblage corresponds to a natural background fauna scattered within a relatively closed biotope located not far from a wet area (river or marshes).

The lithic assemblage

A detailed study of the lithic assemblage of NY2 was undertaken on that part of the collection (79,67%) which has not been affected by *in situ* chemical alteration. Weathering of stone tools is a relatively common phenomenon in the West Turkana assemblages, which can even lead to disintegration of artefacts when they are unearthed. When this alteration is not too severe, it is possible to classify the tools broadly (flake, core, etc.), but they are not amenable for technological or petrographic analysis.

The studied lithic assemblage (Fig. 7A) is thus made up of 494 pieces (258 in stratigraphy, 236 from surface collection), of which 12.8% (n=63) are unmodified (see Table 2). There are 39 complete pebbles or cobbles, and 24 angular nodules in the sample of unmodified material. Although the presence of larger rocks in an otherwise fine-grained sedimentary context does not warrant their attribution as manuports (see discussion in de la Torre and Mora 2005), in the case of NY2 the proposal that the presence of some of the natural pebbles and cobbles (Fig. 7B) at the site is due to human agency cannot be rejected; with an average length of 47.8 mm (see details in Table 3), the unmodified pebbles and cobbles are identical in raw material composition and similar in size distribution to hammerstones, cores (Fig. 7C and 7D) and split pebbles (Fig. 7E). Therefore, it is plausible that at NY2 hominins accumulated natural rocks of variable dimensions, some of which remained unmodified whereas others underwent the entire reduction sequence on site.

Raw materials

Due to artefact weathering (see above), raw material identification was made on 69.1% (n= 429) of the whole assemblage (Fig. 5C). Most artefacts are made from lavas, in which phonolite predominates (76,22%), followed by basalt (16,31%), trachyte (5,12%), and isolated pieces of syenite (n=9), and quartz (n=1).

Phonolite predominates in all technological categories (Fig. 5D), although basalt is well represented among unworked (37,5%, n=56) materials, split and broken pebbles and cobbles, and cores bearing isolated flake removals (31,4%, n=35). Indeed, while the West Turkana basalt is a suitable raw material for knapping it is quite a tenacious rock (Harmand, 2005). The types present at NY2 are hard, fine grained basalts, including 61% (n=70) of a porphyritic basalt with olivine crystals. It is possible that the less hard phonolites were favoured for knapping, and the basalts, once transported to the site, were kept to be used mainly as percussive elements.

Four different types of phonolite are present at NY2: small or medium grained aphyric, and small or medium grained porphyritic (for rock description, see Harmand 2005, 2009a,b). Medium grain porphyritic phonolite dominates (64,2%, n=327), but is unequally distributed across technological categories. Interestingly, it represents 60% of unworked phonolite pebbles and cobbles (n=33), 20% of phonolite cores (n=20), but 71,5% of phonolite flakes (n=242). In fact, half of the 28 phonolite cores are made from medium grained aphyric phonolite, whereas only a few flakes (1,4%) of this type of phonolite were identified. So far, we have no verifiable explanation for this discrepancy. As reported elsewhere (Harmand, 2005, 2009a,b), properties of the West Turkana trachyte differ from phonolites and basalts –it is less dense and absorbs blows better - and at NY2, as in many other sites of the Nachukui Formation, it was favoured for percussive activities (i.e. as stone hammers for knapping and likely other percussive tasks as well).

Choice of raw materials based on petrography, size and morphology of the clasts is well documented in West Turkana as early as 2.3 Ma (Harmand 2005; Harmand 2009a, b), as is the recurrent proximity of the site to sources of raw material (i.e. pene-contemporaneous rivers or beaches which are currently visible and identified in the landscape as paleo-conglomerates). Distances between sites and raw material sources range from a few meters to a maximum of 500 m (Harmand 2005, 2009a,b). Nonetheless, in contrast to most other sites of the Nachukui Formation, it has been impossible to identify a source of procurement in the area around NY2, due to a lack of correlated exposures.

However, a general inter-site comparison of raw material composition across several assemblages of the Nachukui Formation (Fig 5E) shows the contribution of phonolite to be an important common feature, even though phonolite does not always dominate potential raw material sources (Harmand 2005). At the Early Oldowan sites of Lokalalei 1, and especially Lokalalei 2C, trachyte is well represented, and forms a greater percentage than in any other assemblage of percussive material and unmodified pebbles and cobbles transported to the site by hominins (Harmand 2005; Harmand 2009a; Delagnes and Roche 2005), although this pattern needs to be looked in the context of the predominance of trachyte at the source area (Harmand 2005; Harmand 2009a,b). The next sites in Fig. 5E (KS1 = Kokiselei 1, NY1 = Naiyena Engol 1, KS5 = Kokiselei 5, NY12 = Naiyena Engol 12 –unpublished data), all lie within the same stratigraphic interval as NY2, and are of classic Oldowan age (i.e. between 1.8/1.7 Ma). Except for NY12, a preference for phonolite is shown in all these assemblages, in proportions which normally follow rock type distribution at the source but are clearly increased by homininchoice. The Early Acheulean site of KS4 (Kokiselei 4, Harmand 2005; Lepre et al. 2011), included here for comparison, follows the same pattern, while the Middle Pleistocene site of Nadung'a 4 indicates a strong preference for rhyolite (68% of the assemblage at the site *versus* 5% at source, Harmand 2005; Delagnes et al. 2006), suggesting a substantial increase of raw material selectivity. As a whole, Kokiselei 5 (KS5), Naiyena Engol 1 (NY1) and Lokalalei 1 (LA1) have patterns of procurement of rock type which are the most similar to NYS. Older than NY2 by at least 0,6 Ma, LA1 is also located in a more fluviatile environment (Roche et al. 2003); among the later Oldowan sites, NY1 is likely the closest in age to NY2, while KS5, which is positioned with more certainty below the top of the Olduvai subchron, is slightly older. This all suggests the existence of a range of behaviours in raw material procurement in West Turkana, and indicates that recurrent rock type preferences are not necessarily patterned temporarily.

Refits

Within the six sets of refits identified in NY2 (Fig. 4), two are between stratified pieces, two between stratified and surface pieces, and two between surfaces pieces. Among the first ones, the refitted pieces came from two adjacent excavation grids: in trench N3 (set #1), they are at the same level and come from layer 4; also in layer 4 but in trench S, the two pieces of set #6 are separated by a longer distance, and a difference in elevation of 10 cm. For the other sets, refit distances between pieces, either stratified or from the surface, are short.

Except for set #1, which includes a flake refitting onto a small flat pebble core, the other sets are made either of two flakes (sets #2, 3 and 4), or two flake fragments (sets #5 and 6). As such, these short refit sequences yield little technological information, but they provide support demonstrating that the assemblage has not undergone heavy disturbance, and emphasize the connection between the surface and stratified material.

Flaking activities

With a cumulative percentage of 51.4%, flakes (n=114) and flake fragments (n=140) predominate in the NY2 analysed assemblage (n=494). The frequency of complete flakes (23.1% of the entire assemblage) is noteworthy, but is however one of the lowest percentages of the West Turkana sites (Roche 2011) in which complete flakes range from 23 to 38% in Early Oldowan, and 23 to 46% in Classic Oldowan age sites (Delagnes and Roche 2005; WTAP unpublished data). In this respect, debitage frequencies in West Turkana sites contrast with other Oldowan sites such as those from Olduvai Gorge, for instance, where flake fracture due to knapping accidents and/or poor quality of raw materials is much more common (de la Torre and Mora 2005b). The average length of flakes (n=114) is 38.4 mm, and mean weight is 16.7 gr. (see Table 3), but there is important metric variation, and the data (length, width, thickness and weight) is not normally distributed (Shapiro-Wilk's normality test= 0.000 for all variables). Although flakes as large as 108 mm and 167 gr. are present in the assemblage (Fig. 8), Fig. 9A and 9B show a predominance of artefacts <40 mm, which make up 69.3% of the whole flakes. In fact, only 3.6% of flakes are >65 mm, and are classed as outliers in normality tests; the rest of the complete flakes (n=110) are strongly clustered in the 20-40 mm metric module, and have an average length of 36.5 mm and 12.8 gr.

A common feature among complete flakes is the abundance of cortex. 67.3% of striking platforms preserve cortex, while only 32.7% are unifaceted, and no bifaceted butts exist (Fig. 9C). The same pattern applies to the dorsal faces of flakes (Fig. 9D), with 71.1% preserving some cortex, either entirely (6.2%), preferentially (19.5%) or across smaller areas of the flake surface (46%). When considered in combination, platform and dorsal cortex (Fig. 9E) highlights the predominance of cortical flakes, in which the typical morphology *en quartier d'orange* (i.e. flakes with cortex cover from the butt to one side of the dorsal face) dominates. This could indicate that either only the first stages of reduction are represented at NY2, or (as analysis of cores shows below) that knapping patterns were characterised by short reduction sequences, in which cores did not undergo full decortication of natural surfaces.

With regards to flaked artefacts (see breakdown in Table 2), the NY2 assemblage yielded a very small number of retouched tools (n=4; 0.8%), an important number of complete (n=41; 8.3%) and fragmented cores (n=6; 1.2%), and intentionally split pebbles (n=8; 1.6%). The percentage of cores does not match patterns in most other West Turkana sites, where cores rarely exceed 3% of the assemblage. In contrast, the frequency of retouched tools does tally with the rest of the West Turkana Oldowan record, in which these artefacts normally fluctuate between 1 and 2%.

The number of retouched tools in NY2 is too small to expand upon here, but they confirm observations from other contemporary Oldowan sequences such as those in Olduvai Bed I, where their percentages are usually very low (Leakey 1971). Likewise, the NY2 retouched tools are non-standardised flake scrapers with limited or more continuous straight or denticulate trimming, once again similar to the poorly shaped retouched tools from the other West Turkana Oldowan sites (Roche et al. 2003; Delagnes and Roche 2005), or from Olduvai Bed I (de la Torre and Mora 2005b).

As with flakes, the mean size and weight of cores (Table 2) is biased by outliers (Fig. 9F); in this case, two very large cores weighing over 5 kg (Fig. 10A and B) form a sample separated from the main population of cores. Fig. 9G shows that the most abundant cores are 41-60 mm in maximum length, with a steady decline of larger ones. A normal distribution of average length (Shapiro-Wilk's normality test=0.057) is evident when the two largest (>5 kg) cores are removed from the sample (n-39), although the T-Test still shows significant differences within the sample (2-tailed sig.=0.00). At any rate, a clear dimensional break exists between the two massive (> 5kg) cores and the more abundant (n=39) sample of smaller ones (average size and weight in mm and gr.; length=71.1; width=52.9; thickness=32.0; weight=184.9).

Cores generally preserve largely cortical surfaces, which suggest short reduction sequences and are consistent with the pattern described for flakes (see above). As cores are slightly reduced, the variability observed in core size is therefore a good reflection of the diversity of the original blanks selected for flaking; cores were flaked from boulders (e.g. the two massive cores), cobbles or pebbles, with very few examples where flakes or fragments were chosen as core blanks. In turn, this blank size variability should explain, at least partially, the remarkable variability observed in flaking techniques.

Four different flaking techniques are documented at NY2: bipolar (i.e. flaking of a core resting on a stationery anvil with a handheld hammerstone), freehand (flaking a handheld core with a handheld hammerstone), stationery core (flaking a core resting on the ground with a handheld hammerstone) and, potentially, passive hammer technique (a handheld core is flaked against a stationery/ passive hammer).

The stationery core technique is represented by at least one specimen (Fig. 10B). Apart from its massive weight (>11 kg) that would make freehand manipulation of this boulder unfeasible, part of the cortical surface contains some battering marks potentially related to placing the core on the ground during the flaking process. The core includes two perpendicular flaking edges with abundant step scars. Despite the huge size of this core (>28 cm length), scar dimensions show that flakes were within the 4-5 cm range typical of the smaller, freehand cores. The boulder surface remains largely cortical and only a few flakes were effectively removed; suitable angles for flaking were lost after an initial set of removals, and the two debitage surfaces were rapidly covered by step scars. No attempts were made to correct flaking angles, remove step scars from debitage surfaces, or find alternative flaking surfaces across the massive boulder. Therefore, it should be highlighted that despite its massive size, flaking principles were applied to the core in Fig. 10B in the same way as in most of the typically Oldowan cores from NY2 (i.e. short reduction sequences, no rejuvenation of surfaces, 3-5 cm flake dimensions), except that in this example such principles were adapted to the larger size of this particular blank by making the core stationary instead of working it freehand.

With a weight exceeding 5 kg and a length of 26 cm making it unsuitable for freehand knapping, some of the flakes from the Fig. 10A core could also have been obtained using the stationery core technique; damage shown in Fig. 10A-5 was probably produced when the core was flaked while resting on the ground. However, chipping is also observed on the edge of the main flaking platform (horizontal plane), perpendicular to the flake scars on the debitage surface (transversal plane), and might be related to the anvil technique. For cores struck with freehand hammerstones, damage on the edge of the main knapping platform is usually present in the form of battering marks. However, in the case of the marks in Fig. 10A-3 and 10A-4, albeit damage is clearly associated with flake removals from the debitage surface, chipping scars of <10 mm across the core edge, rather than battering, were produced. This chipping is interpreted here as caused by striking the core's horizontal plane against a stationery anvil/ hammer, in order to produce flakes from the transversal plane. Even though the dimensions of this core prohibit freehand knapping, the flat morphology of the boulder and its moderate size would make two-hand manipulation feasible when flaking the core against a stationery anvil/ hammer.

While it was possible to observe the *esquillements* typical of bipolar damage in only a few flakes, the bipolar technique is relatively well attested at NY2 among flaked artefacts (n=6). Bipolar pebble blanks (n=3) are virtually indistinguishable from unmodified pebbles available at NY2 (Fig. 7E), and are generally small (see Table 3). These pebbles show a natural flat morphology, and were flaked by bipolar splintering via perpendicular blows from a freehand percussor onto pebbles resting on an anvil. Pebbles flaked by bipolar technique have only a few removals, and such scars are small enough (see Fig. 11A-C) as to cast doubt about whether knapping was oriented toward obtaining flakes or rather shaping (splintering) pebbles. The bipolar technique was also used to knap larger blanks (Fig. 11D), whose larger scars suggest they were used to obtain flake products, and are considered here simply as bipolar cores (n=3). In addition, it is likely that split pebbles (see Tables 2 and 3) may be related with bipolar activities. Apart from being split in half, these pieces lack distinctive features that could allow ready attribution of their fracture to flaking, and hence they are kept as a separate category.

Freehand flaking is the most common technique seen (n=35 cores) in the NY2 assemblage. Nonetheless, the majority of the freehand flaked materials are test cores (n=13, 37.1%), i.e. pieces with random and isolated removals, which once again point to the very low productivity of reduction processes in NY2. Most of the remaining freehand cores can be classified by adapting the ideal reduction schemes proposed by de la Torre (2011; de la Torre et al. 2003). Fig. 9H summarizes the NY2 freehand knapping schemes, where chopper-cores – i.e. unifacial simple partial (22.2%) and bifacial simple partial (16.7%) methods – predominate, followed by flaking schemes based on the rotation of the striking platform around the debitage surface – BP (n=16.7%) and UP (11.1%) – (see Fig. 12A-C). Abrupt-angled flaking – bifacial (BAP=16.7%) and unifacial (UAP=5.6%) –, and alternating exchange of striking platforms (BALP= 11.1%) are also documented (Fig. 12D-E).

None of the freehand schemes documented in the NY2 assemblage shows exploitation of the entire circumference or volumetric reduction of the debitage surface. Instead, flaking is constrained to exploitation of small masses present at naturally-suitable angles, and no reactivation of angles is observed. Thus, it can be stated that freehand flaking is expedient. Chopper-like reduction (USP and BSP; see Fig. 13) prevails, volume remains largely unexploited, and cortex still covers a large portion of the cores.

However, expediency of freehand techniques at NY2 does not necessarily convey unskilled flaking; certainly, step scars on cores and Siret (longitudinal split) flakes are common and reveal the presence of numerous knapping accidents. Indeed, it is observed that many cores were discarded once step scars had formed after only one or two series of removals. On the other hand, many freehand cores bear scars of well-developed flakes and were abandoned when flaking was still viable. Therefore, expedience in the case of NY2 could be linked instead with short reduction sequences, in which cores often were abandoned before exhaustion. The large amount of cortex preserved, the few scars on individual cores, and the fact that most core scars still preserve impact points, all suggest that cores underwent very few series of removals, which is also consistent with the important cortical surfaces observed on the flakes.

As a whole, knapping activities at NY2 are characterised by diversity in flaking techniques, coupled with consistent homogeneity in reduction intensity. Flaking technique diversity, evidenced by the co-occurrence of stationery core, bipolar, freehand, anvil and passive hammer techniques, is – at least partially – explained by core blank size; average dimensions (Table 4 and Fig. 14B) show that bipolar cores are consistently smaller (mean length= 50.5 mm and weight= 46.9 gr) than freehand cores (mean length= 74.9 mm and weight= 210.1 gr), and the size of massive cores determines the use of stationery elements. On the other hand, fixed technical rules were applied regardless of blank size (for instance, massive core flaking schemes are undistinguishable from freehand cores), and are characterised by the unstructured organization of unifacial or bifacial edges with no volumetric management. Likewise, scars on massive cores do not indicate a dimensional break for the flakes produced, and are within a metric module similar to the rest of the NY2 flake sample. More importantly, homogeneity of the NY2 *chaînes opératoires* is evidenced by the consistently low productivity of flaking sequences; massive cores were not more heavily reduced than freehand, despite the surplus of raw materials, and the same applies to freehand cores when compared to bipolar ones.

In short, selection of flaking techniques was clearly related to type of blank; boulders required positioning either the core or the hammer/anvil on the ground, while the smallest blanks were reduced by bipolar flaking, and average-sized cobbles were freehand-flaked. Knapping methods are largely unstructured, and reduction sequences are generally very short which, rather than being related to poor and unskilled management of cores, instead could be linked to the low cost involved in the lithic raw material procurement. However, given that the exact provenance of raw materials for NY2 is unknown, currently it is not possible to elaborate further on this last option. Nonetheless, in other West Turkana localities where potential raw material sources have been located, maximum distance to the site never exceeds 500 m, and yet flaking sequences longer than those seen in NY2 are often documented, both in <2 myr Oldowan (Texier et al. 2006) and in Early Oldowan (Delagnes and Roche 2005) assemblages.

Percussive activities

A total of 13 stone tools (2.6% of the NY2 analysed assemblage) bear traces of percussive activities. All percussive tools were made on cobble blanks and have an average length and weight of 72.15 mm x 228, 85 gr respectively (see details in Table 3). Although the Shapiro-Wilk normality test indicates that size of battered tools does not follow a normal distribution, Fig. 14D shows that they are consistently larger than unmodified rocks present in the assemblage. Size classes of these two categories (Fig. 14C) indicate that cobbles ranging from 81-100 mm were selected mainly as blanks for percussive tools.

All the battered tools identified at NY2 were macroscopically described. In addition, some were subjected to low magnification microscopic analysis with a GX-XTL trinocular microscope equipped with a 0.7-4.5X zoom and 10X eyepieces, and to high magnification microscopic analysis using a XL30 Philips ESEM. Three main groups were identified according to the morphological characteristics of the macro-use traces identified on the tools:anvils, regular hammerstones and hammerstones with fracture angles. An additional category (multi- functional tools) refers to cores with battering traces.

Two of the battered tools were identified as anvils, although they could also be classified as pitted stones, following Leakey and Roe's (1994) definition. These two artefacts are the smallest of the battered tools (Table 3), and show identical use wear patterns (Fig. 15). One anvil/pitted stone is triangular in cross-section while the other is a flat-convex pebble. Both tools have a transversal fracture, which potentially could be associated with the formation of a depression. The two anvils have one primary battered surface on one plane, consisting of a depression formed by thrusting percussion.

From a morphological point of view, there are differences between the depressions on the two anvils. One anvil has an elongated depression that is 2 mm in depth with a concave cross-section over an area of 25.9 mm^2 (Fig. 15A and SOM5). The presence of 'V'-shaped incisions along the contour (Fig. 15A-1) of the depression is indicative of thrusting motions applied on the tool. There are no other signs of battering on the rest of the anvil. The anvil in Fig. 15B shows an incipient depression covering an area of 7.5 mm^2 that is irregularly shaped and also irregular in cross-section (Fig. 15B). The small size of the tool (25x20x13 mm and 6.3 gr) and the superficial nature of the wear traces suggest a short activity. This anvil has a secondary area of small battering of 3.6 mm^2 on the contact edge between the horizontal plane (HP) and the transversal plane (TP), probably related to breakage of the blank.

Despite some macroscopic differences between the depressions on the two anvils, microscopically both tools share similarities. Under the SEM, the inner areas of both depressions display a pattern characterised by stepped fractures and the development of small pits (concavities with a diameter smaller than 1 mm) (Fig. 15A-2, 15B-1 and B-2). The V-shape fractures mentioned above could be associated with the initial rupture of the cortical area and formation of the depression.

Although the small size of these anvils makes them suitable as passive or active elements, clustering of the battering in narrowly defined depressions, coupled with the absence of similar pits elsewhere on the anvils, point to their use as passive elements. However, this is inconclusive as experimental work (e.g. Jones 1994) has shown that similar depressions can also be formed on active elements. From a functional perspective, the association of pitted stones with bipolar knapping has been suggested in other Early Stone Age sequences such as Olduvai (Jones, 1994), as well as with other pounding activities such as nut-cracking (Goren Inbar et al. 2002). The knapping products described above indicate that bipolar flaking definitely took place at NY2, and therefore it is plausible that the two pitted anvils were associated with this flaking activity.

Nine of the battered artefacts are regular hammerstones. With an average length of 78.85 mm and mean weight of 254.1 gr (see Table 5), regular hammerstones at NY2 show three types of macro wear traces. Some (n=2) show battering marks produced by thrusting percussion (Fig. 16A) causing step fractures (Fig. 16A-2), and small pits resulting in the detachment of small superficial flakes (Fig. 16A-1). Battering marks are concentrated along the proximal end and part of both transversal planes, indicating rotation of the hammerstone along the horizontal plane during use. In the case of Fig. 16A, intensity of battering caused the detachment of an oval flake located on the horizontal plane.

Other regular hammerstones (n=3 and all angular cobbles) have a few superficial marks on their surface.. The location of use-wear traces on these tools is unusual: along angular areas, scattered along horizontal planes unsuitable for knapping activities, or across small (< 20 mm) elongated areas of battering. The diffuse and shallow nature of such battering marks is likely related to sporadic use of these hammerstones.

Another set of regular hammerstones show flake-like fractures (n=4). Three are elongated rounded cobbles, while the fourth is a small angular cobble. All bear flake-like fractures at opposite ends of the cobble. Such fractures are no larger than 10 mm in diameter, and are oval/circular in morphology, concave in cross-section and show no directionality (Fig. 16B). Such fractures are associated with diffuse and isolated impact points, rather than heavy battering.

A third group of battered artefacts are hammerstones with fracture angles (n=2), as defined by Mora and de la Torre (2005). The piece in Fig. 16C shows two areas of activity; one end of the cobble contains heavy battering associated with two elongated and parallel fractures, and a second, less invasivebattering area on the left lateral plane is also associated with a large fracture of the cobble.

In addition to artefacts used solely as battering tools, several cores (n=5) show percussive marks on their surface that suggest multipurpose use both as flake reservoirs and battering artefacts. For example, one core has two oval hammerstone fractures on the plane opposite the flaking area, which are associated with isolated impact points on a convex surface of the blank, similar to those observed on regular stone-knapping hammers. Another multifunctional tool is a test core on a flat cobble that exhibits an abraded area on the plane opposite the knapping platform. The abraded area, characterised by a textural change with respect to the natural surface, has a frosted appearance - following Adams' et al. (2009) terminology- and superficial crushing of the crystals which is not observed on other parts of the blank. Abrasion documented on this tool is probably linked to its use as a passive element in an activity that is difficult to ascertain. Furthermore, it is worth mentioning the presence of impact points on the massive core in Fig. 10A. In this example, a set of deep impact points, conical in cross-section, are clustered in the central zone of the core, covering a total area of 1.6 cm^2 of the horizontal plane used as a knapping platform (see Fig. 10A-6). The location of these impact points in the centre of the horizontal plane suggests that this battering is not related with flaking of the core edge, but rather could be linked to the use of this massive blank as a passive element in other battering activities.

Discussion

The composition of the NY2 lithic assemblage contrasts with other West Turkana sites, such as the Early Oldowan site of Lokalalei 2C (Delagnes and Roche 2005) where more organized and longer debitage sequences allow for high productivity of small-sized (3-5 cm) flakes. Instead, NY2 resembles other pene-contemporaneous classic Oldowan sites within the Nachukui Formation (e.g. Naiyena Engol 1 and Kokiselei 1, Roche et al. 2003), as well as sites at Koobi Fora (Isaac et al. 1997) and Olduvai Bed I (Leakey 1971), where limited production of non-retouched small (3-5 cm) flakes from relatively unstructured cores (e.g. chopper-like flaking schemes) predominates. Therefore, NY2 is considered here as a typically Oldowan site which shows no transitional features to the Acheulean, despite its stratigraphic and geographic proximity to Kokiselei 4, which at 1.76 Ma (Lepre et al. 2011) is the world's earliest Acheulean site. As such, NY2 poses interesting questions with regards to technological variability at the onset of the Acheulean which, however, will not be elaborated on here (see recent discussions by de la Torre and Mora 2014).

Although NY2 is clearly an Oldowan assemblage, it has yielded a wide range of knapped and percussive artefacts. This variety becomes particularly evident when considering the relatively small size (total n=623, studied n=494) of the collection. Regarding the knapped assemblage, variety is evidenced in the number of techniques employed for flake production, among them stationery core, freehand, bipolar and passive hammer techniques. Known under a variety of terms – e.g. block-on-block or anvil technique (Crabtree 1972), *percuteur dormant* (Bordes 1961) and others (see terminological review by Mourre and Colonge 2010) –, until recently, the use of static passive hammers against which cores are struck was unreported (Harmand *et al.*, 2015) in pre-Acheulean assemblages, where bipolar (Merrick 1976) and freehand (Toth 1982) techniques predominate. Prevalence of bipolar and freehand techniques in the Oldowan, geared to the production of flakes usually under 5 cm, also explains the regular absence of static massive cores in pre-Acheulean contexts. Nonetheless, the presence of at least one massive core at NY2 is unrelated to large blank production. Flake removals on this static core conform to the same metrics, reduction patterns and flaking schemes as those in freehand production. In other words, the variety of flaking techniques evidences flexibility in management of the variable size of initial blocks, but knapping followed specific rules with regards to flaking methods and intensity of reduction.

Flaking methods and reduction intensity are often linked, and the NY2 lithic assemblage constitutes a good example of such interrelation; dominant flaking schemes at NY2 (e.g. chopper- like reduction) seek to exploit only surfaces with suitable angles close to the core edge that do not enable long knapping series, as no management of volume is achieved and suitable flaking angles disappear early in the reduction sequence. With a predominance of cortex, low scar counts and little evidence of rejuvenation, flake and core features point precisely to very short reduction sequences, and are in agreement with the unstructured character of knapping schemes.

In NY2, the shortness of reduction sequences is not necessarily related to an inability to overcome knapping obstacles (e.g. loss of suitable angles), as a large number of cores were abandoned before flaking accidents occur. Therefore, other explanations should be sought; there is a sharp contrast between NY2 and other West Turkana sites such as Lokalalei 2C, where reduction sequences exceed 50 flakes per core and indicate high flaking productivity (Delagnes and Roche 2005). The fact that Lokalalei 2C is >0.5 Ma older than NY2 (Roche *et al.* 2003) and yet shows better management of lithic resources, contributes to both challenging the existence of temporal trends in performance maximization, and downplaying the role of skill (at least from the point of view of long-term cultural transmission patterns throughout the same depositional basin) in explanations of knapping variability and reduction intensity (Roche 2011).

An alternative explanation for low core productivity could be a surplus of raw materials available in the immediate surroundings of NY2. The presence of massive cores such as that in Fig. 10B (which, given its weight, was unlikely to have been transported from a great distance), and small natural cobbles and pebbles similar to those used for flaking, seems to suggest that raw materials were locally available. In this scenario, it is reasonable to argue that low productivity is related to raw material proximity. Nonetheless, it would be unadvisable to establish too straightforwardly a causational link between the two elements; at Lokalalei 2C (Delagnes and Roche 2005), as in many other West Turkana sites (Harmand, 2005), raw materials were also locally available, and yet cores were reduced to exhaustion.

Percussive tools at NY2 represent only 2.6% of the analysed assemblage. This low percentage follows the pattern of other earlier West Turkana sites such as Lokalalei 2C, where hammerstones represent 0.7% of the whole assemblage (Delagnes and Roche 2005)-, and Lokalalei 1, with 3.0% of tools associated with percussive activities (Kibunjia 1994). Despite the low frequency of battered artefacts, both hammerstones and anvils are present at NY2. Regular hammerstones are probably related to flaking activities. Although *esquillements* on flakes were identified only sporadically at NY2, the presence of two pitted stones potentially might be related to bipolar reduction. Several experimental programmes (i.e. Le Brun-Ricalens 1989, Jones 1994, Roda *et al.* 2012) have reported the formation of depressions on both active and passive elements during percussive activities. Although it cannot be ruled out that the NY2 pitted anvils were active elements, heavy clustering of marks in well-defined depressions in both pitted stones suggests they were more likely to serve as anvils during bipolar flaking. In addition, a number of cores bear battering marks that evidence their use as multi-functional artefacts, something which has been documented widely in other Early Stone Age sequences (e.g. Leakey 1971; de la Torre and Mora 2005) and more recently at the 3.3 Ma site of Lomekwi 3 (Harmand et al. 2015; Taylor et al. 2015).

Conclusions

The Nachukui Formation contains an important record of Early Oldowan and Oldowan sites covering a large chronological time period, from 2.34 to 1.7 Ma. This region of West Turkana provides the rare opportunity to study the technical behaviour of early hominids in its continuity, and to consider subsistence patterns through time during several climatic phases and subsequent environmental changes. Among the sites documented so far, Naiyena Engol 2 has yielded a rich and diversified lithic and faunal assemblage captured in sands and clay lenses, corresponding to an overflow along a small river channel, probably reflecting a relatively short period of time for its accumulation. While post-depositional disturbance may have partially affected the original position of artefacts and bones, the presence of several refit sets makes it possible to consider the lithic assemblage as a whole. Hominin action on bones is very rare and the functional relationship between stone tools and the bone assemblage has not yet been clearly established. The faunal material, however, indicates that NY2 hominins occupied a wooded and bushy setting, not far from water and knappable stone sources. Moreover, a study of paleosol carbonate stable isotopes of the sub-contemporaneous sites of the Kokiselei Complex and other localities within the Kaitio Member (Quinn et al. 2013) suggests hominin preference for more wooded habitats during lithic-related activities and for ecotone between woody and grassy habitats for differential access to terrestrial ungulate carcasses.

The composition of Oldowan lithic assemblages (mainly flaked and detached pieces) is often dependent on site formation processes and preservation conditions, especially for small pieces more amenable to winnowing processes. Thus, inter-assemblage comparisons that rely only on a formal breakdown of categories (size, morphology, etc.) are bound to be biased. In contrast, detailed technological analysis of assemblages (including raw material procurement and variable flaking techniques) is arguably more efficient in showing similarities and differences in the ways hominins behaved to accomplish the same technological goal, i.e. to produce stone tools. In the Oldowan, this usually amounts to producing flakes from a block of raw material, occasionally to retouching some of them or other blanks, and to the use of rock blanks for various pounding activities. However, even such simple tasks can be accomplished through different chaînes opératoires, as there are a variety of options and criteria to select from to transform the raw materials available in the environment, all of which accounts for the variability within this vast Oldowan techno-complex. Variability is used here as a general term which can be understood differently whether applied to intra-site pattern or inter-sites comparison. As we have demonstrated for NY2, the fact that several *débitage* techniques are used in a single assemblage to produce flakes which have the same morphometric characteristics, and notwithstanding the size, morphology and petrography of blanks, accounts for a certain flexibility in technical behaviour. However, the low productivity of flakes at NY2 contrasts with high flake production at older sites such as LA2C, and thus questions the role of the maximization of skill and performance through time. To this diachronic perspective, a synchronic one can be added with the example of Naiyena Engol 10 (NY10), another site of the Naiyena Engol complex (Fig.1, and unpublished data). This site is likely the only one of all known Oldowan sites inWest Turkana to be located on a paleobeach, and the lithic assemblage (n=1055) is made up, in roughly equal proportions, of flakes (whole and broken) and of flaked (and unflaked) small flat beach pebbles. Cores sensu stricto are rare, yet chopper-cores or core-tools are common, both being related to a very simple operational and technical pattern involving the removal of a few unifacial adjacent flakes along one edge of a pebble. Aside from the low productivity of flakes, the assemblage of NY10 shares few similarities with NY2 and other sub-contemporaneous Oldowan sites in West Turkana. It is likely that the technical variability observed at penecontemporaneous sites are responses to different site settings and raw materials, thus highlighting the adaptability and flexibility of the hominins and their capacity to adapt their technical behaviours. Considered more broadly, variability may also be related to hominin diversity during the Oldowan time period and/or to expected idiosyncracies within and between groups of Early Pleistocene hominins.

The major aim of this paper has been to provide new evidence concerning variability within Oldowan assemblages and to show that hominin technical behaviour is often more flexible than traditionally thought, without dismissing the overall skill limitation of stone-knapping during this time period.

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FIGURES

Figure 1. Location of the NY2 site in relation to the other West Turkana archaeological sites

Figure 2. A) Stratigraphic position of NY2 (section C.Feibel, Rutgers University) ; general view of the excavation and detail. B) The 1998 excavated areas positioned on later (2009) aerial georeferenced photograph of the outcrops (geomatics and aerial photo: G. Davtian, CNRS, UMR 7264; CAD, C.Duval, CNRS, UMR 7055).

Figure 3. A) Plan view of artefact and bone distribution at NY2. B) Density of fossils and artefacts at NY2. C) S-N stratigraphic section and stratified material projection along line I. D) W-E stratigraphic section and stratified material projection along line 33. E) Sagittal (North-South) cross-section of all stratified material in NY2. F) Transversal (East-West) cross section of all stratified material. Vertical gap in squares F-K is due to the slope effect between Y=31 and Y=37.

Figure 4. Refit sets of artefacts from NY2. Set # 1: flake on a small flat pebble; sets # 2,3,4: two flakes; sets # 5 and 6: two flake fragments.

Figure 5. A) Breakdown per category of surface (n=236) and *in situ* (n=258) studied lithic artefacts (see absolute frequencies in table 2). B) Length classes of the same material but excluding unmodified rocks (n=431). C) Breakdown per raw material category of the lithic artefacts studied for raw material identification (n= 429). D) Breakdown of raw material per artefact category. E) Breakdown of raw material among West Turkana archaeological sites.

Figure 6. Taxonomic distribution of NY2. A) Per family or class size (NISP). B) Per larger ecological group and size (% NISP). C) Bone splinters (Bovid size 3, NY2-98-I29s) with marks (x27) possibly chop marks attributed to hominin action. Note the V-shaped profile of the marks, and alteration of the surface (weathering).

Figure 7. A) The entire studied lithic assemblage of NY2. B) Unmodified cobbles and pebbles. C) Small cores (1 and 2) compared to natural pebbles (3-5). D) Larger cores (1-3) and unmodified cobbles (4-6). E) Natural pebbles (1-3) and pebbles flaked using bipolar technique (4-6).

Figure 8. Examples of dimensional variability among complete flakes in the NY2 assemblage.

Figure 9. A) Scatter plot of length and width (mm) of complete flakes. B) Flake length classes. C) Types of flake striking platforms (C, cortical; PC, partially cortical; UF, unifaceted). D) Cortex percent on flake dorsal surfaces. E) Toth's (1982) flake types, as an index to measure butt and dorsal cortical areas. F) Scatter plot of length and width (mm) of complete cores. G) Core length classes. H) Knapping methods employed in freehand core reduction at NY2 (see definition details in de la Torre, 2011: 773). USP: unifacial simple reduction. BSP: bifacial simple partial reduction. UAP: unifacial abrupt partial reduction. BAP: bifacial abrupt partial reduction. BALP: bifacial alternating partial reduction. UP: unifacial peripheral reduction. BP: bifacial peripheral reduction.

Figure 10. A) Massive core (length=267 mm; weight= 5,756.5 gr) reduced by Unifacial Abrupt Partial flaking on one surface and Bifacial Simple Partial on another edge (see nomenclature in de la Torre 2011). 10A1; Horizontal Plane (HP) of the boulder used as the main flaking platform. 10A2; Transversal Plane (TP) used as the main debitage surface, in contact with HP. 10A3 and 10A4; Chipping across the edge of the main flaking platform. See 3D model of this core in SOM1 for further details of the damage. B) Massive core (length=286 mm; weight= 11,160 gr) displaying Bifacial Abrupt Partial exploitation (solid arrows) on one edge and Unifacial Abrupt Partial (dashed arrows) from a separate flaking platform.

Figure 11. Pebbles (A-C) and core (D) flaked using bipolar technique from the NY2 assemblage (an interactive model of this core is available in SOM2).

Figure 12. A) Unifacial peripheral core. A rotating model of this core is available in SOM3. B) Bifacial peripheral core. A rotating model of this core is available in SOM4. C) Bifacial peripheral core. D) Unifacial abrupt partial core. E) Bifacial abrupt partial core.

Figure 13. A) and B) Unifacial choppers (USP reduction scheme) from NY2. C) Bifacial chopper (BSP reduction scheme) and D) bifacial chopper with refitted flake.

Figure 14. A) Average length of cores according to technique. B) Length and breadth of bipolar and freehand cores. All data from Table 4. C) Length classes of battered artefacts and unmodified pebbles and cobbles. D) Scatter plot of length and width (mm) of battered artefacts and unmodified pebbles and cobbles.

Figure 15. Pitted stones from NY2. A) Pictures and 3D model of an anvil on a fractured small cobble with a depression on the transversal plane (TP). Note the location of the depression close to the fracture edge (see 3D model of this tool in SOM5 for detailed view of the damage). ESEM details of a V-shape fracture (1) at 35X magnification and (2) 81X magnification of inner surface of the depression with stepped scars. B) Anvil on a small pebble (25x20x16 mm and 6.3 grams). ESEM photographs of the contact between the natural surface and the edge of the depression at 81X magnification (2) and the interior of the depression at 117X magnification (1).

Figure 16. A) Pictures and 3D model of a knapping hammerstone with battering marks along both transversal (lateral) planes and the proximal end (1). (2) ESEM detail of two contiguous steps within the battered area (magnification: 35X). B) Hammerstone with flake-like fracture located on the proximal end. C) Hammerstone with fracture angles. Blue arrows refer to a double parallel fracture.

TABLES

Table 1. Fossils categories according to position from Naiyena Engol 2.

Table 2. General lithic categories from Naiyena Engol 2.

Table 3. Size (mm) and weight (gr) of the main lithic categories from NY2.

Table 4. Mean dimensions (mm and gr) of different core types.

Table 5: Mean dimensions of battered artefacts in NY2.

SUPPLEMENTARY MATERIAL ONLINE

SOM1. 3D model of the massive core from Figure 10A.

SOM2. 3D model of the bipolar core from Figure 11D.

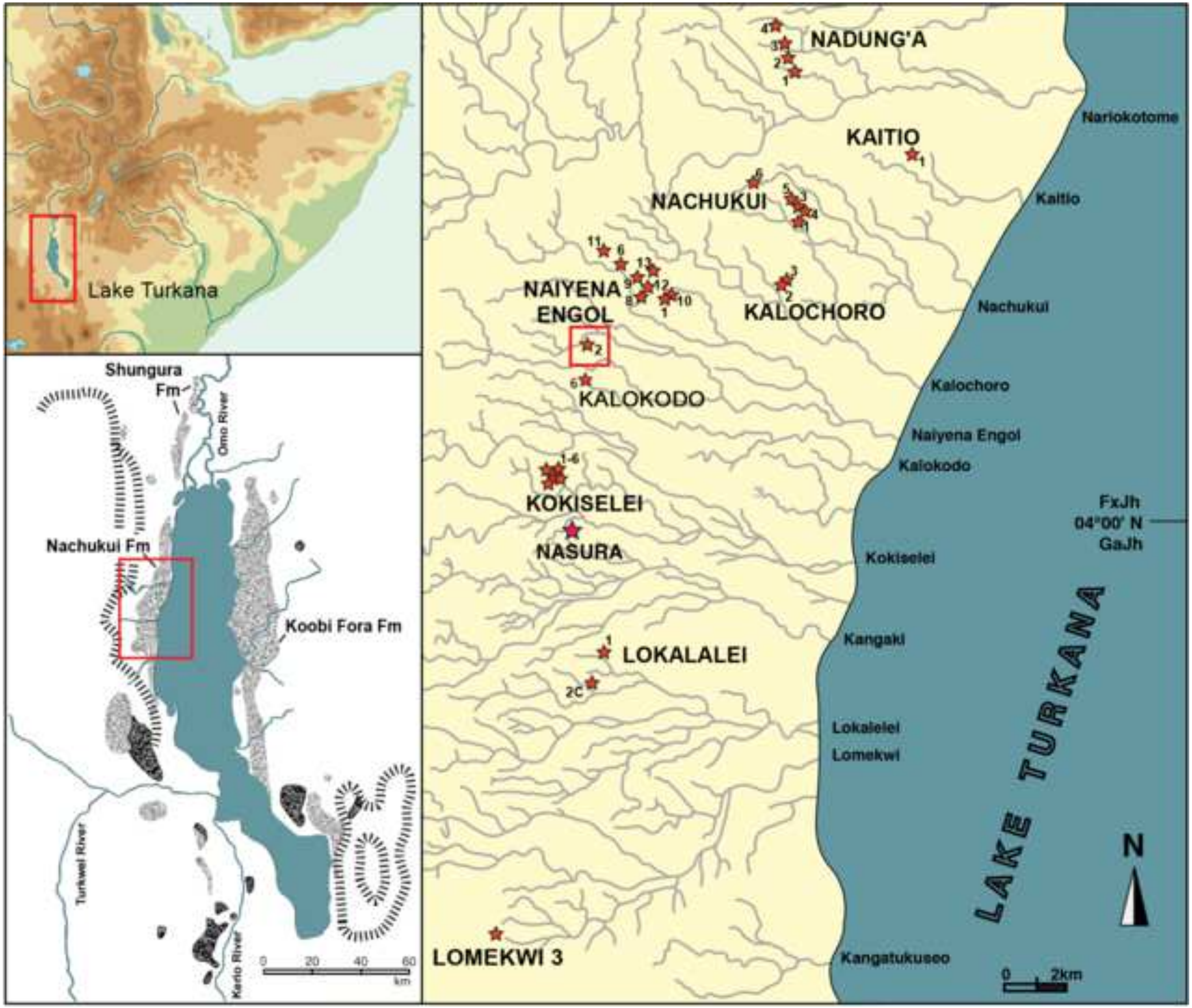
SOM3. 3D model of the unifacial peripheral core from Figure 12A.

SOM4. 3D model of the bifacial peripheral core from Figure 12B.

SOM5. 3D model of the anvil/pitted stone from Figure 15A.

Figure

Click here to download Figure Figure_1.tiff



Figure

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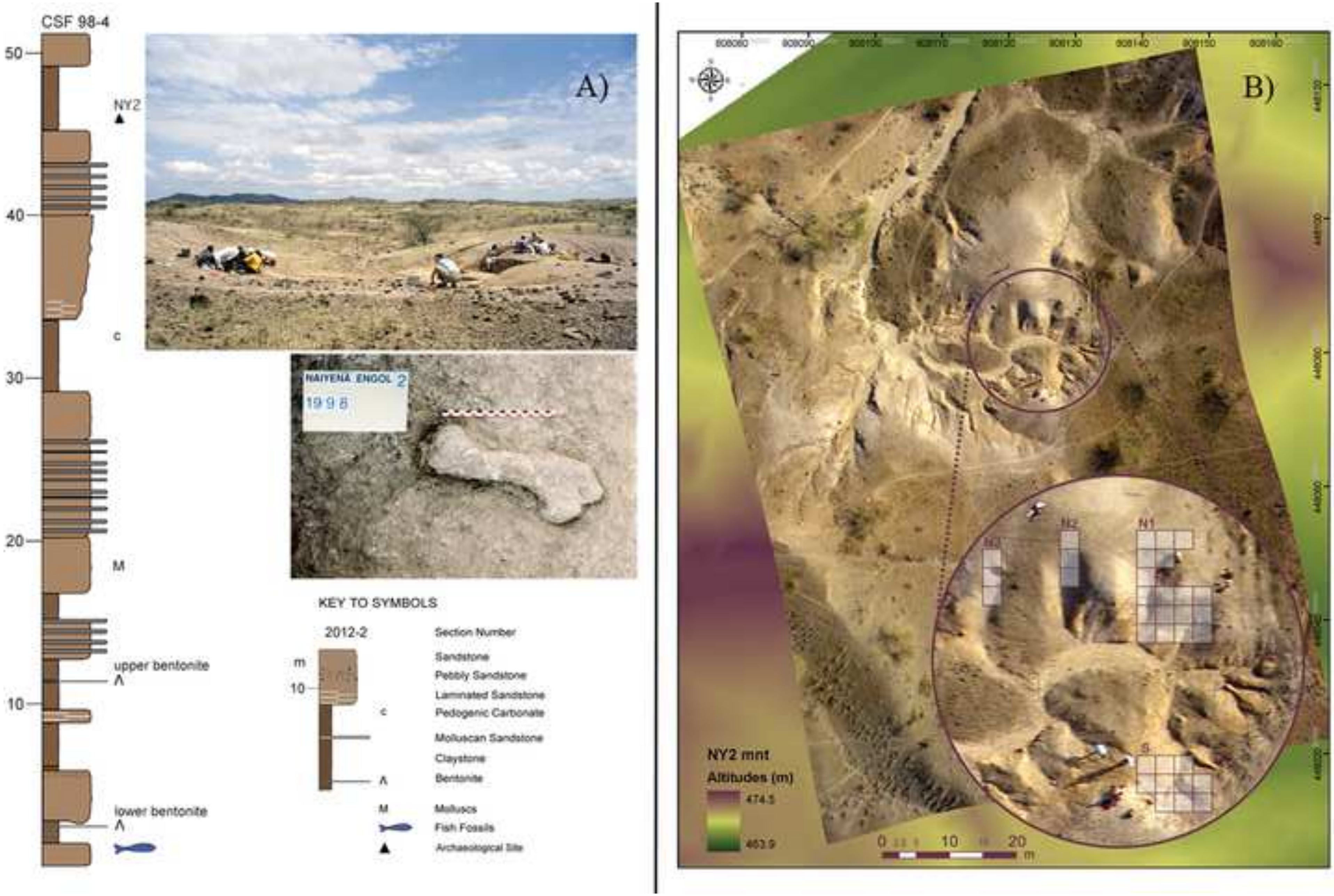

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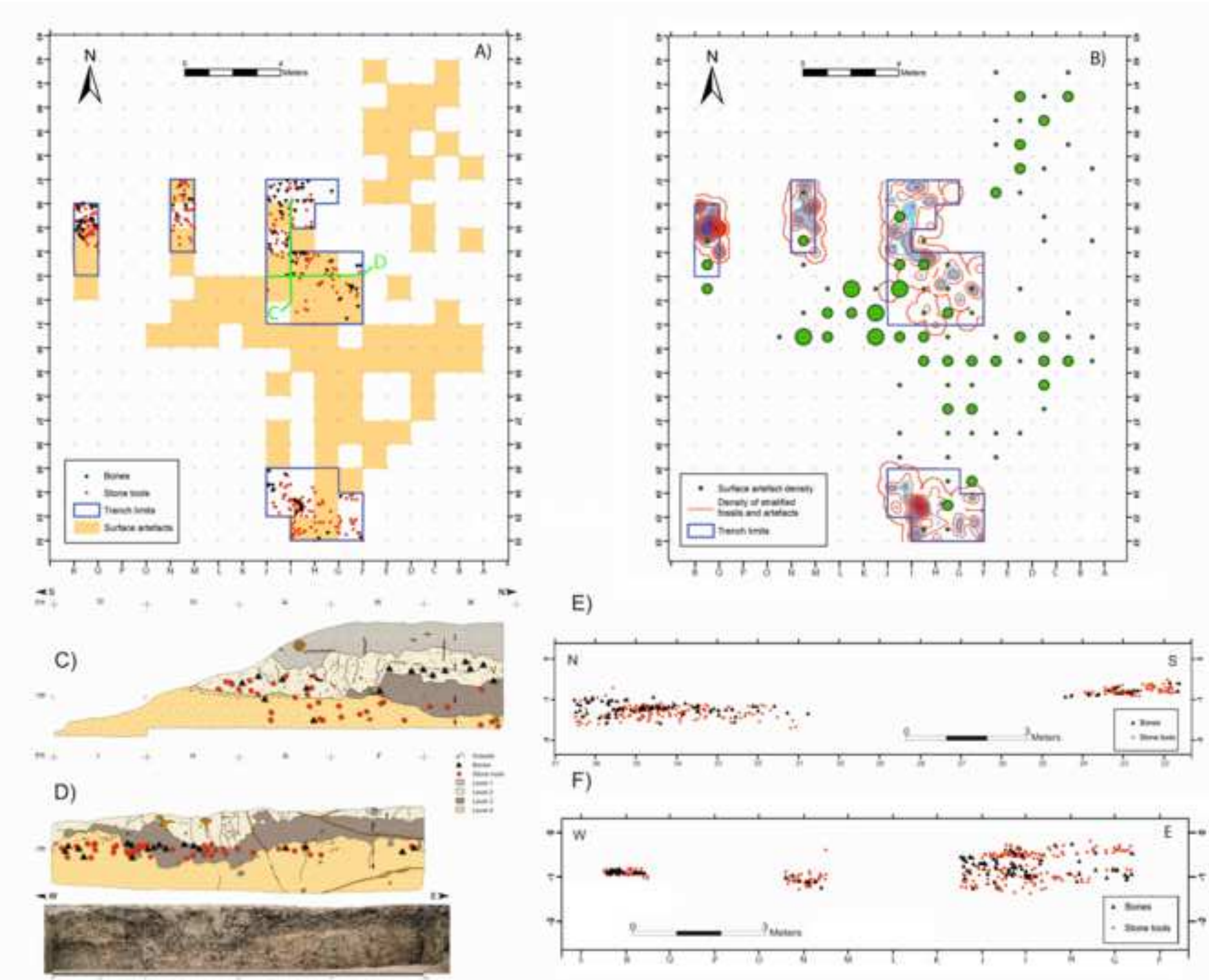

Figure

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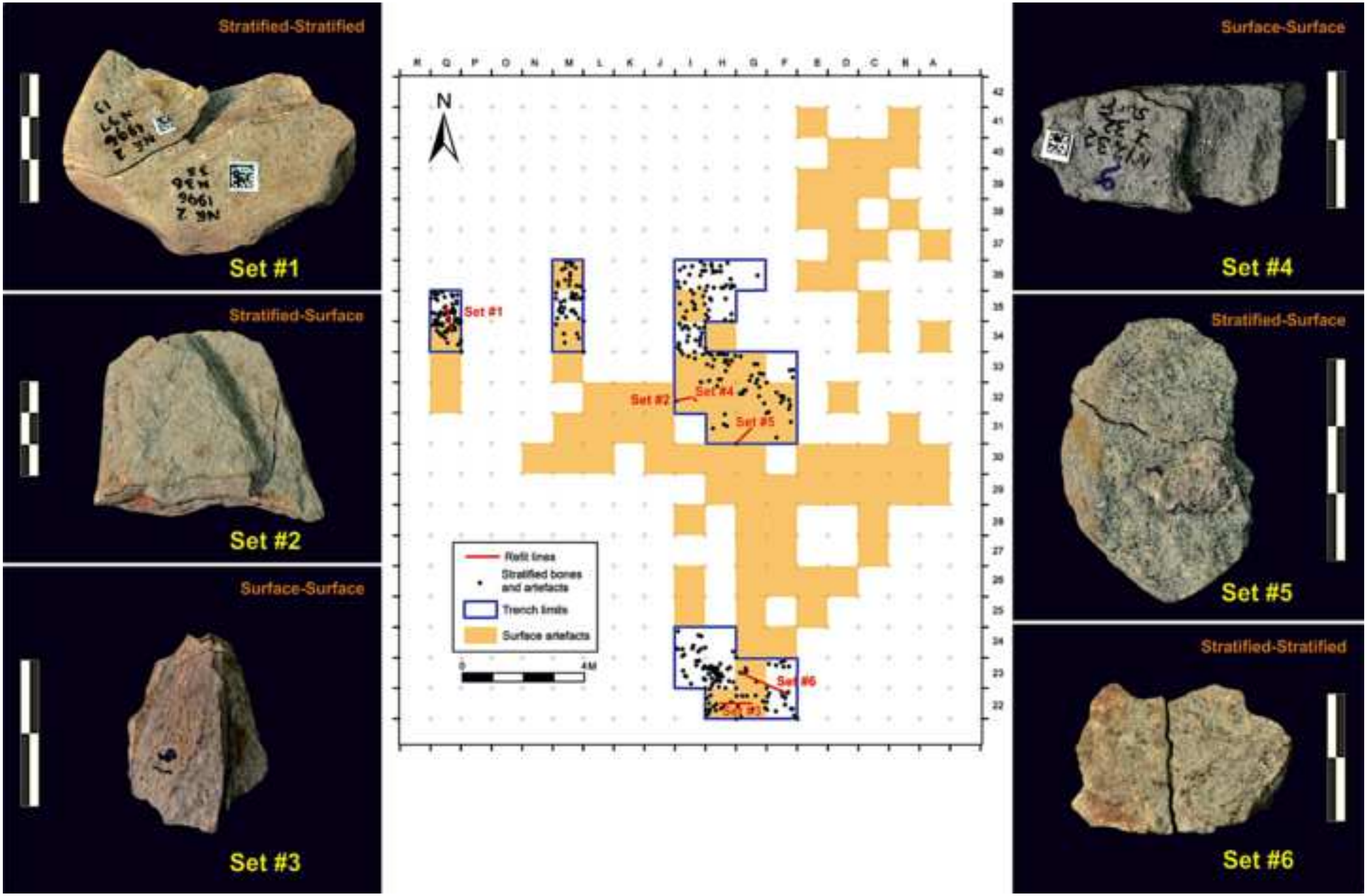

Figure

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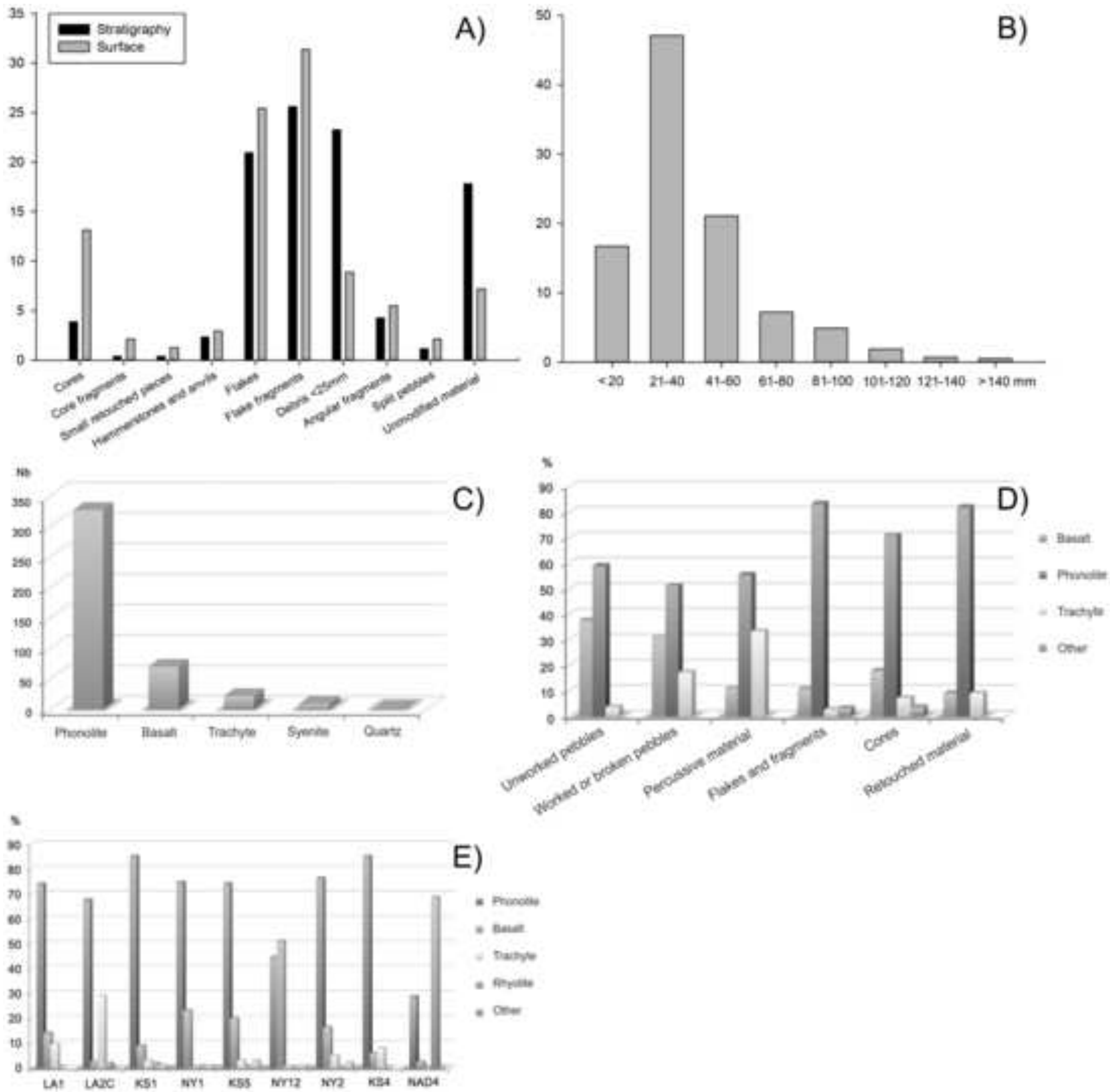
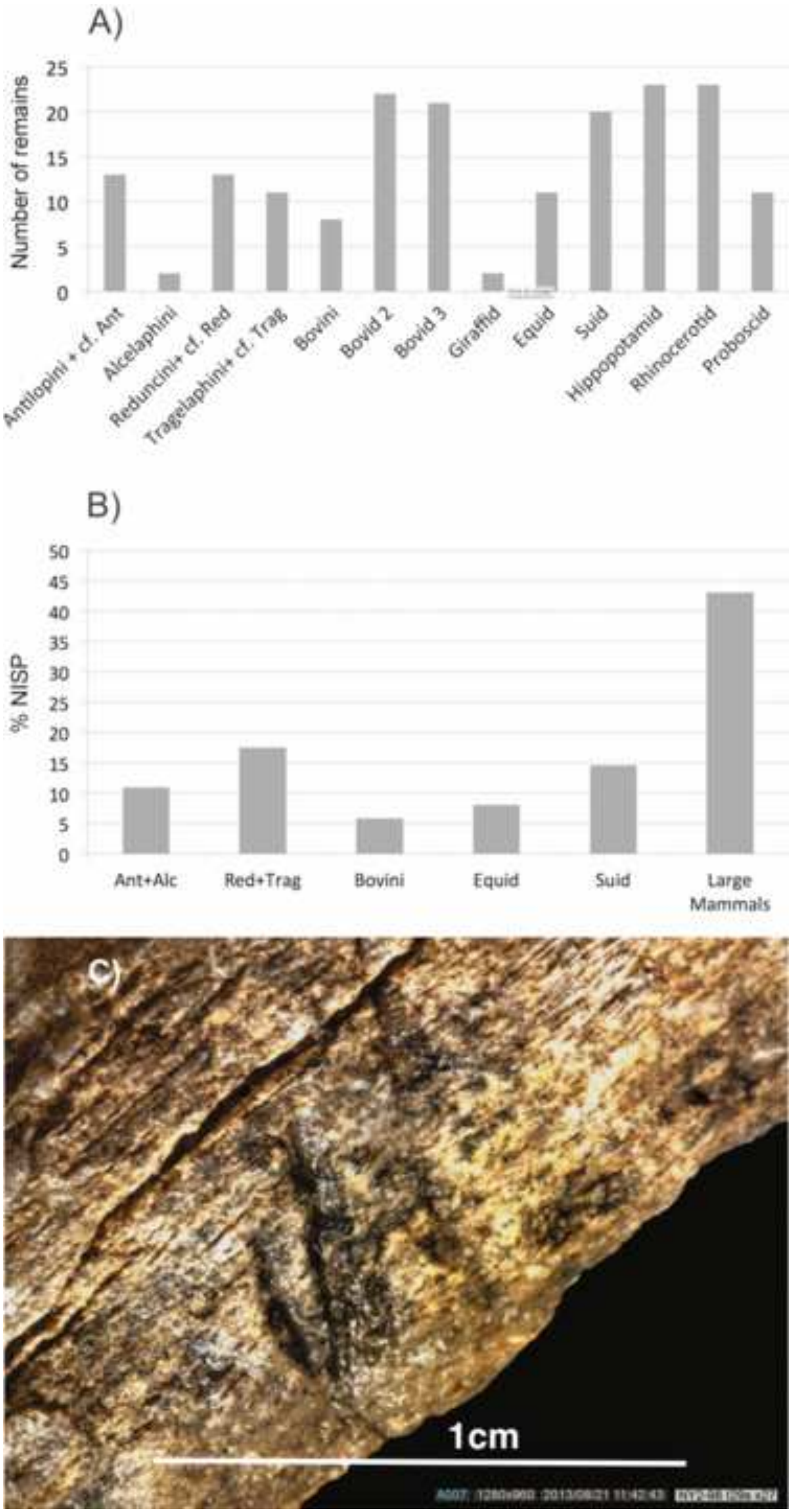
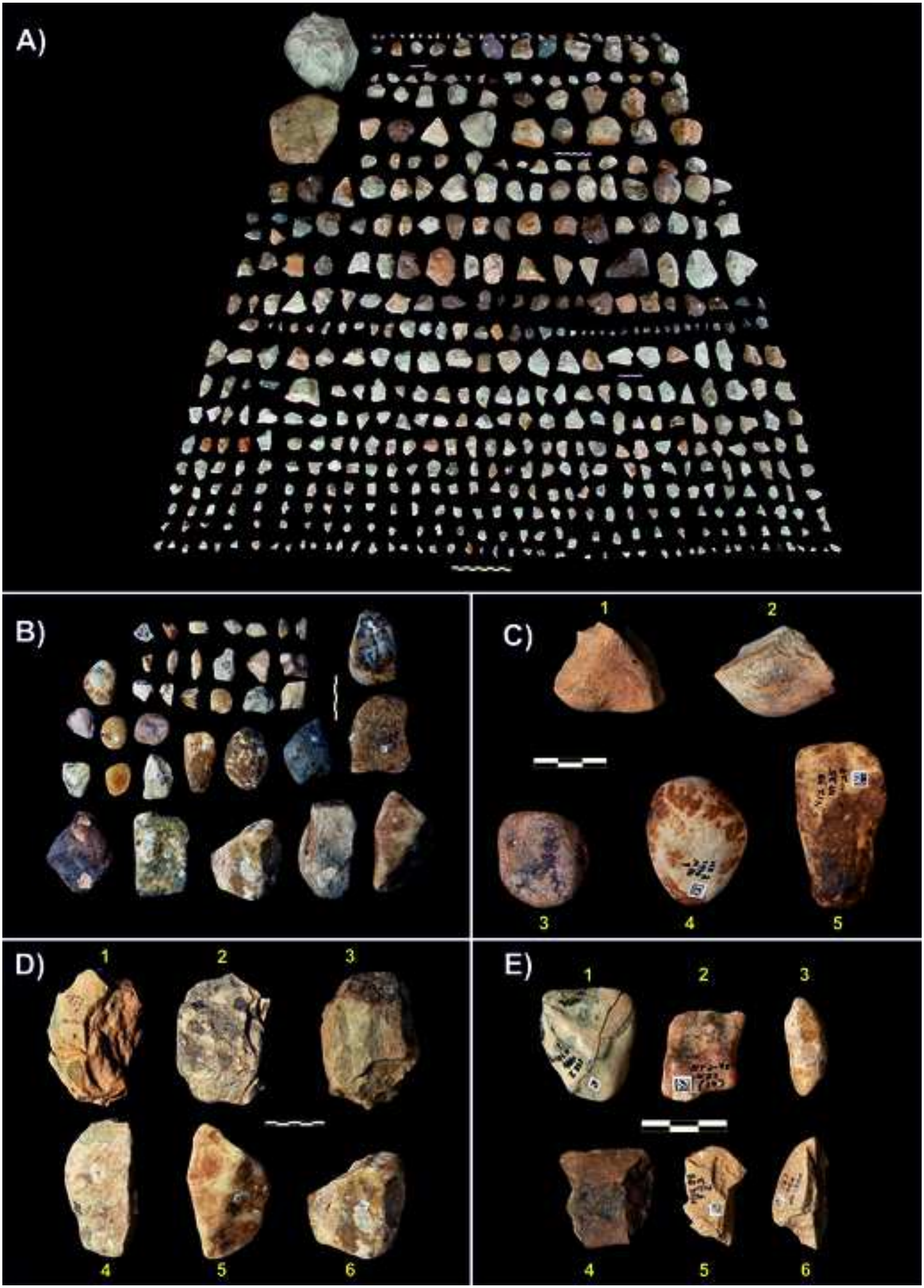



A)
Number of remains
0
5
10
15
20
25
Antilopini + cf. Ant
Alcelaphini
Reduncini+ cf. Red
Tragelaphini+ cf. Trag
Bovini
Bovid 2
Bovid 3
Giraffid
Equid
Suid
Hippopotamid
Rhinocerotid
Proboscid
B)
% NISP
0
5
10
15
20
25
30
35
40
45
50
Ant+Alc
Red+Trag
Bovini
Equid
Suid
Large Mammals
C)
1cm


A)
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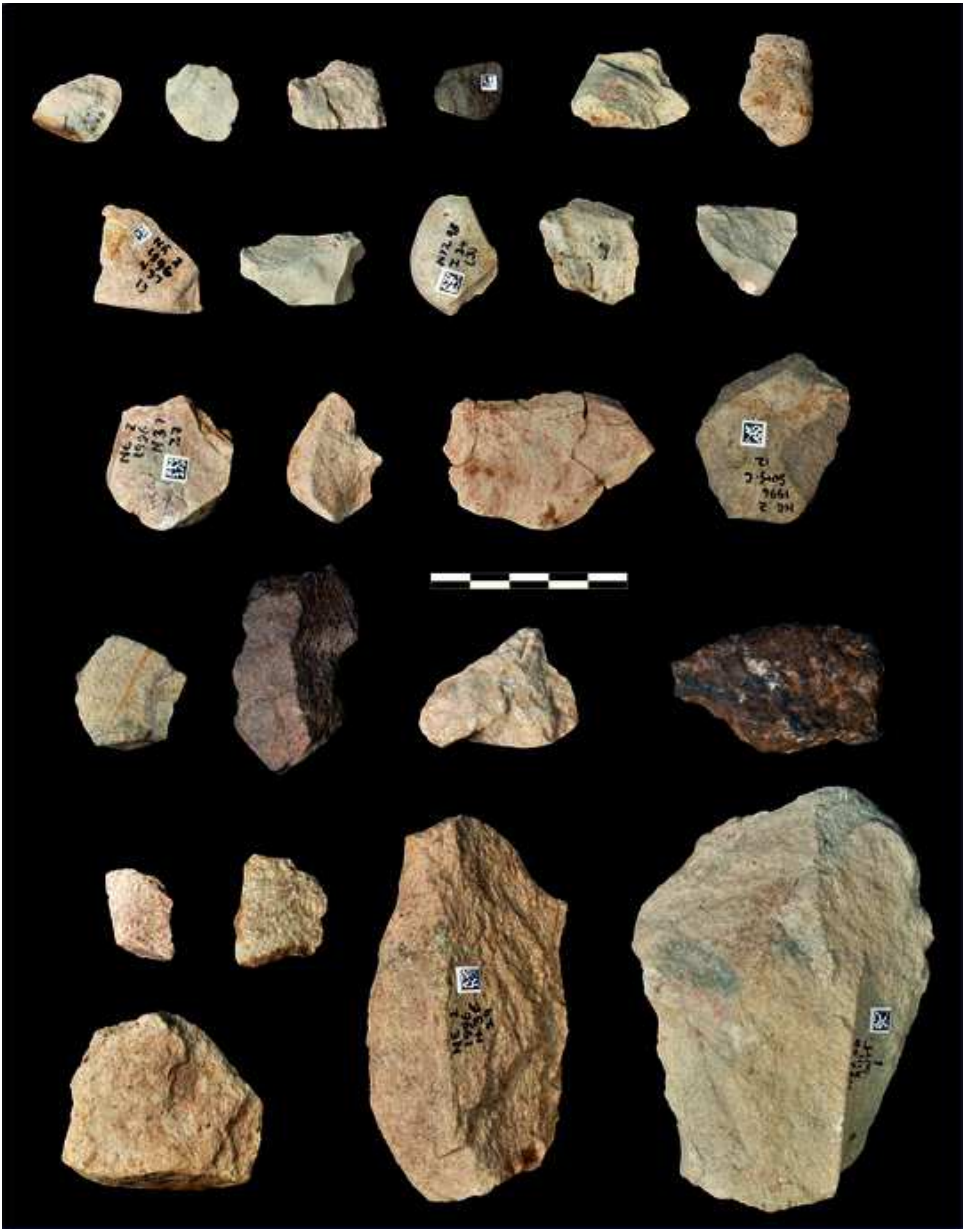

Figure

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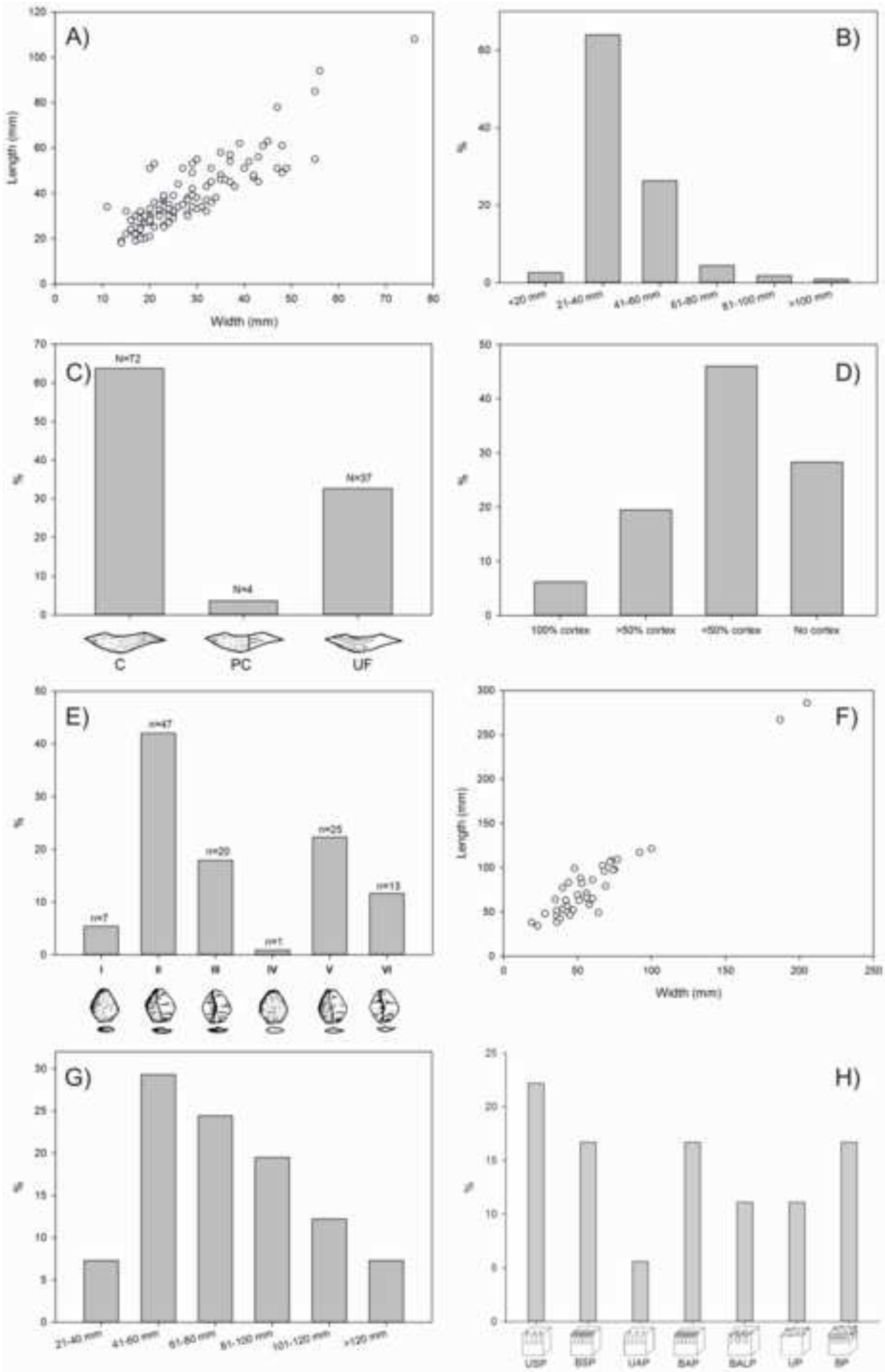

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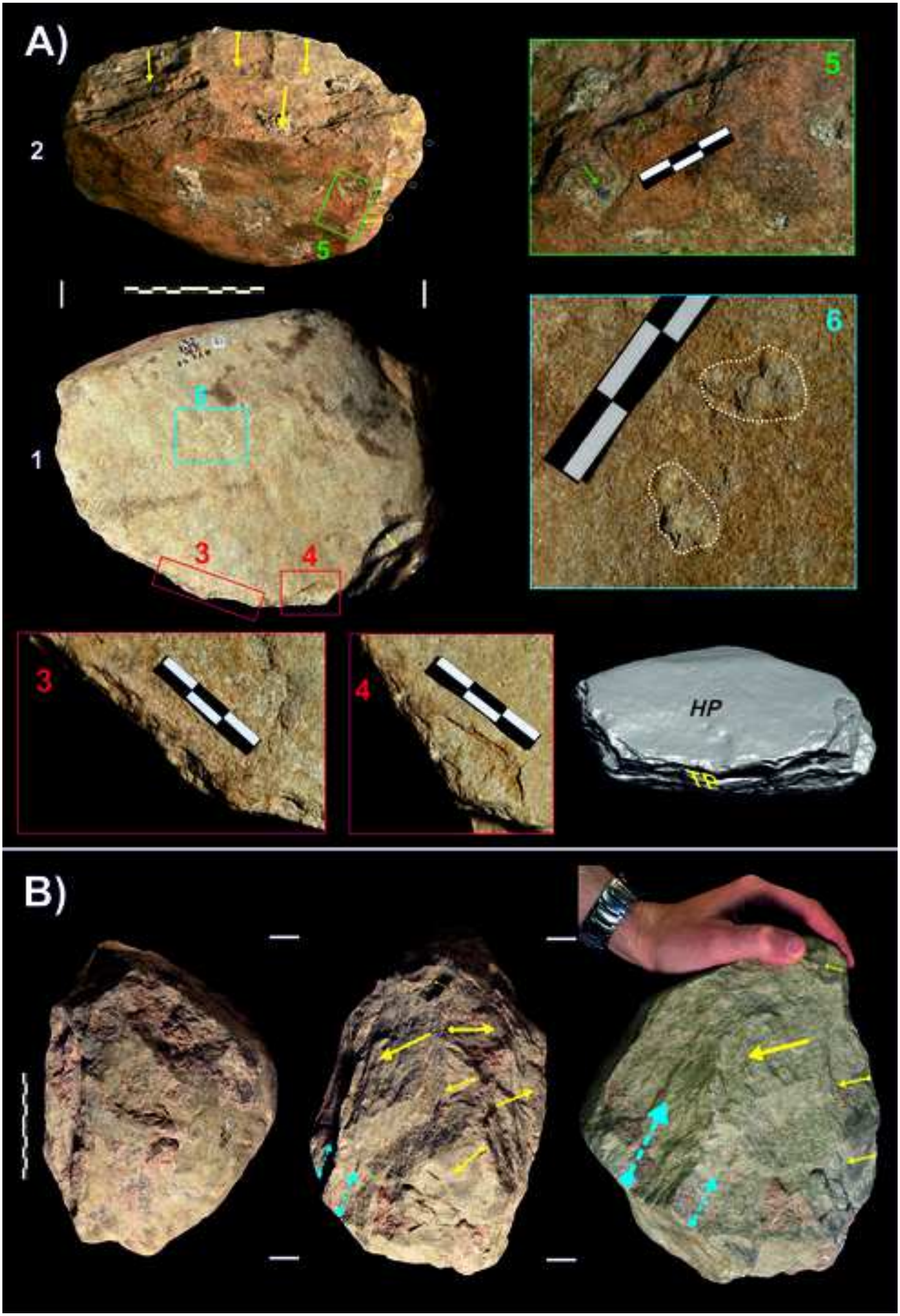

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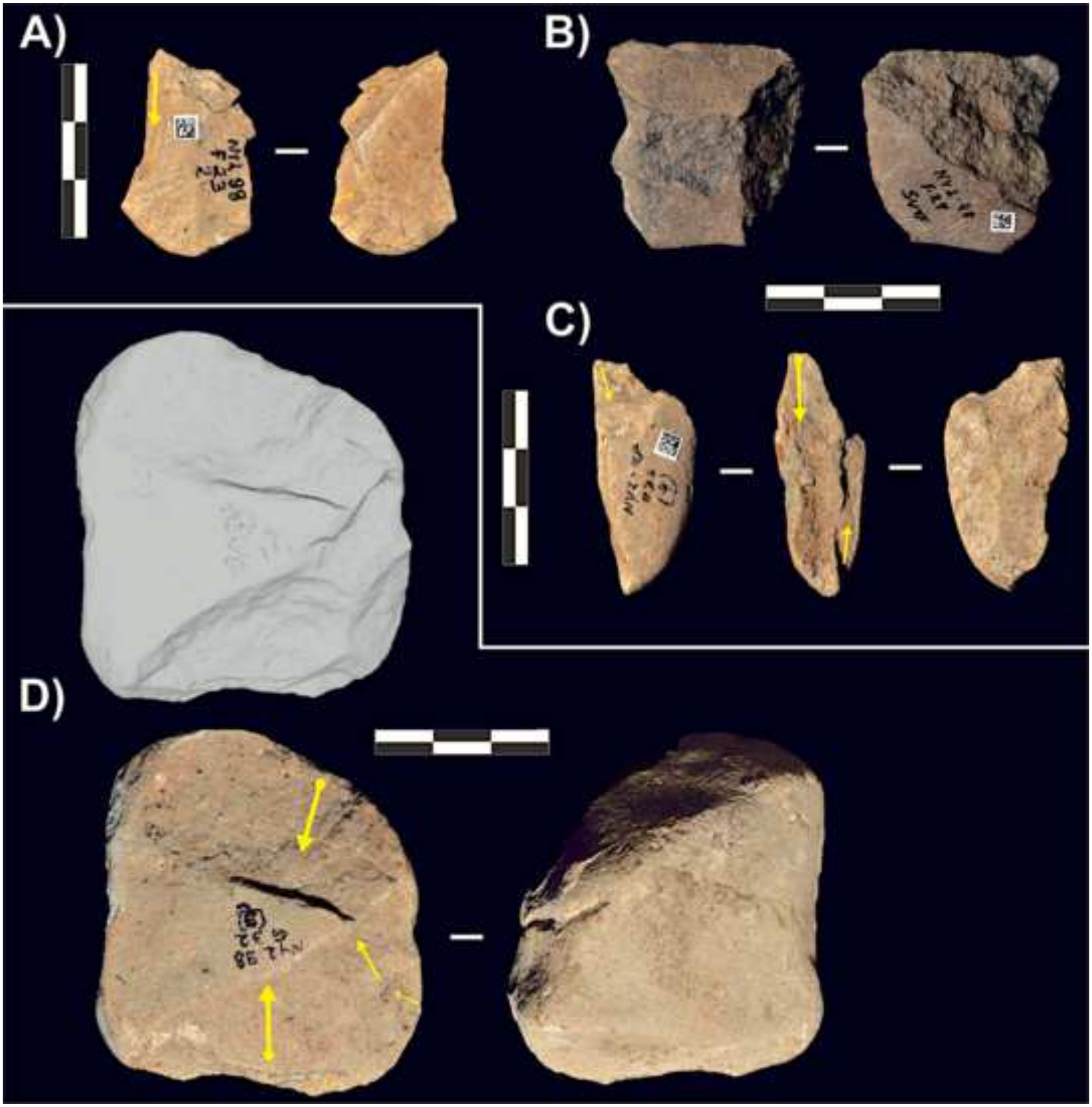

Figure

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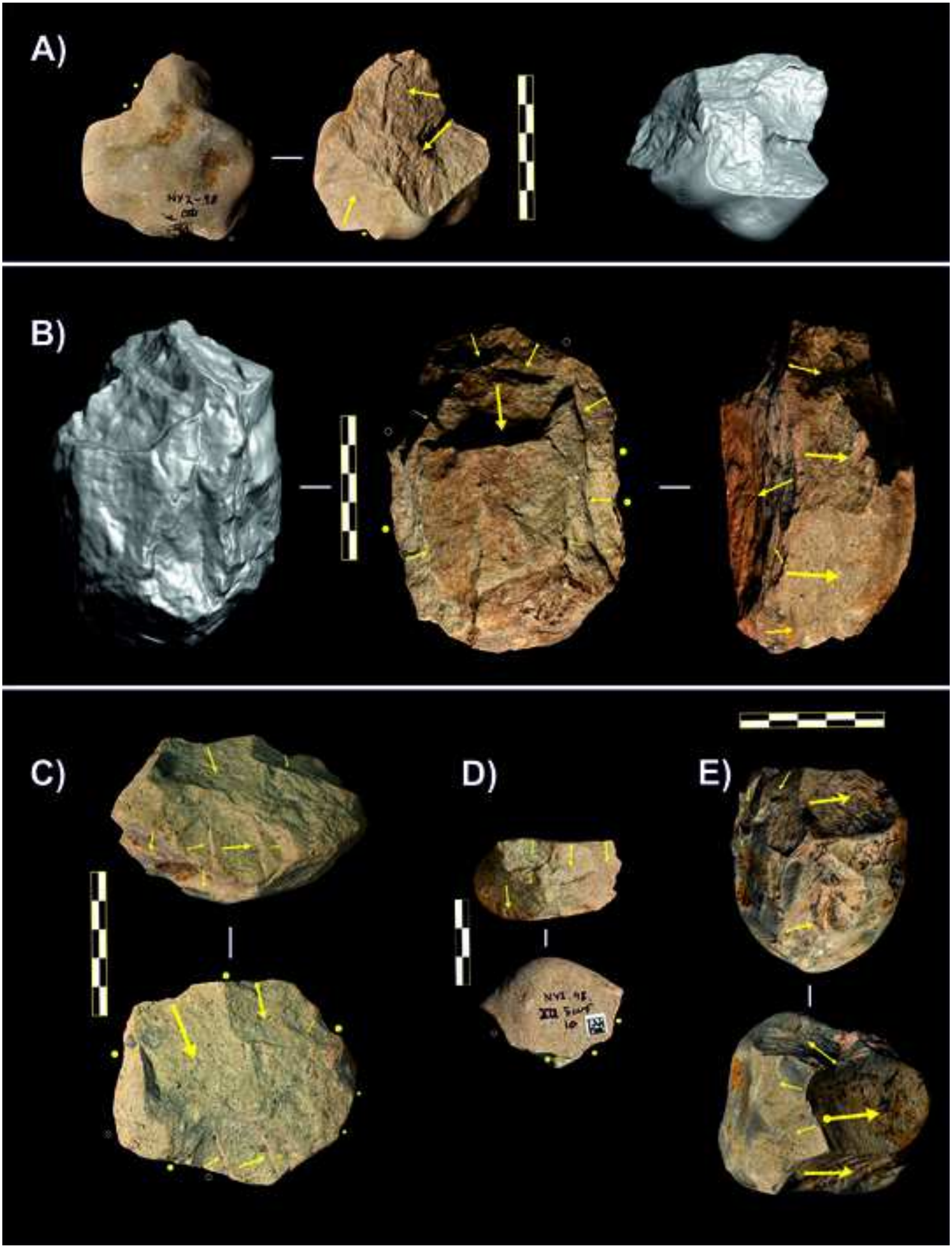

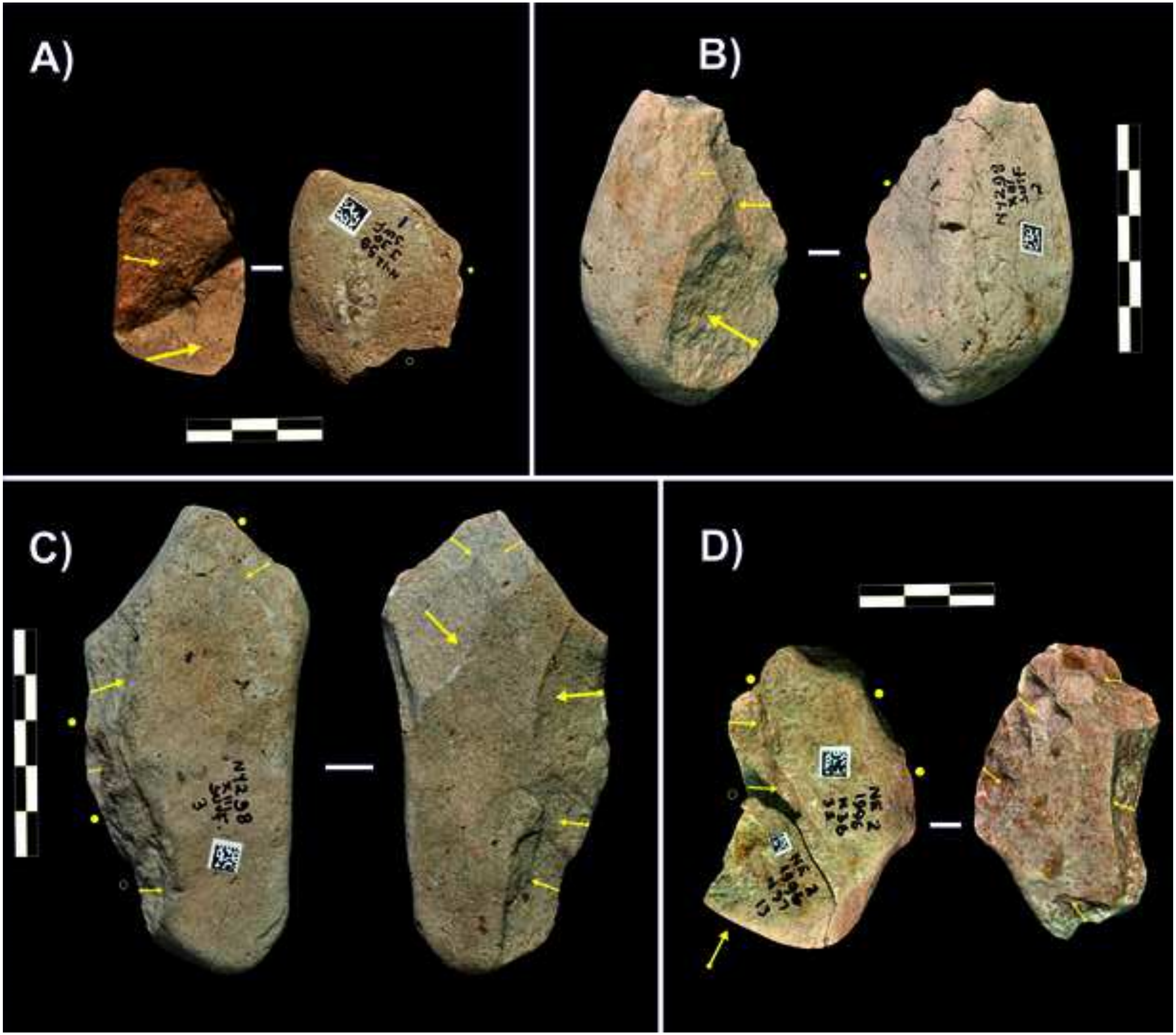
A)
B)
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Figure

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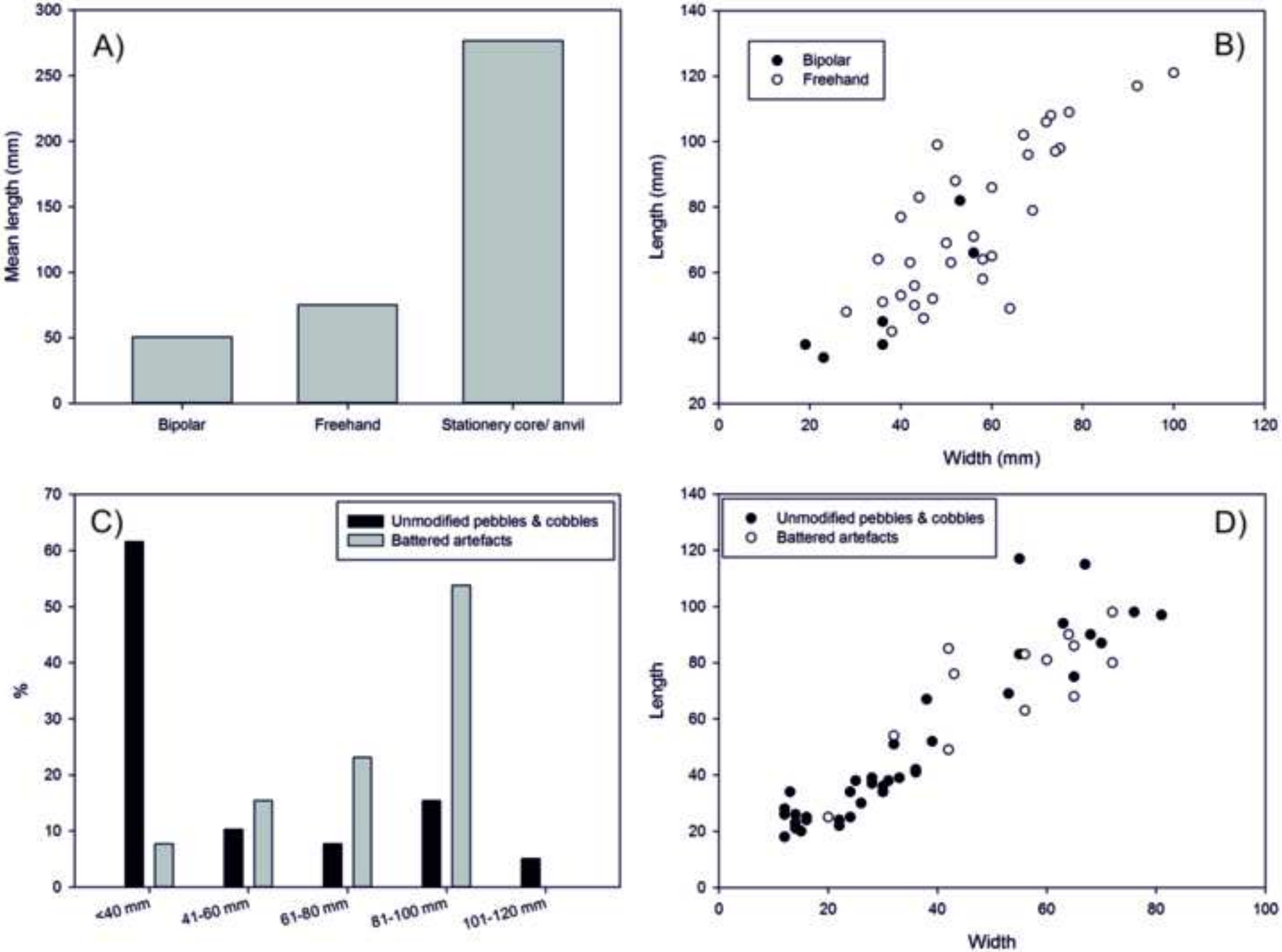

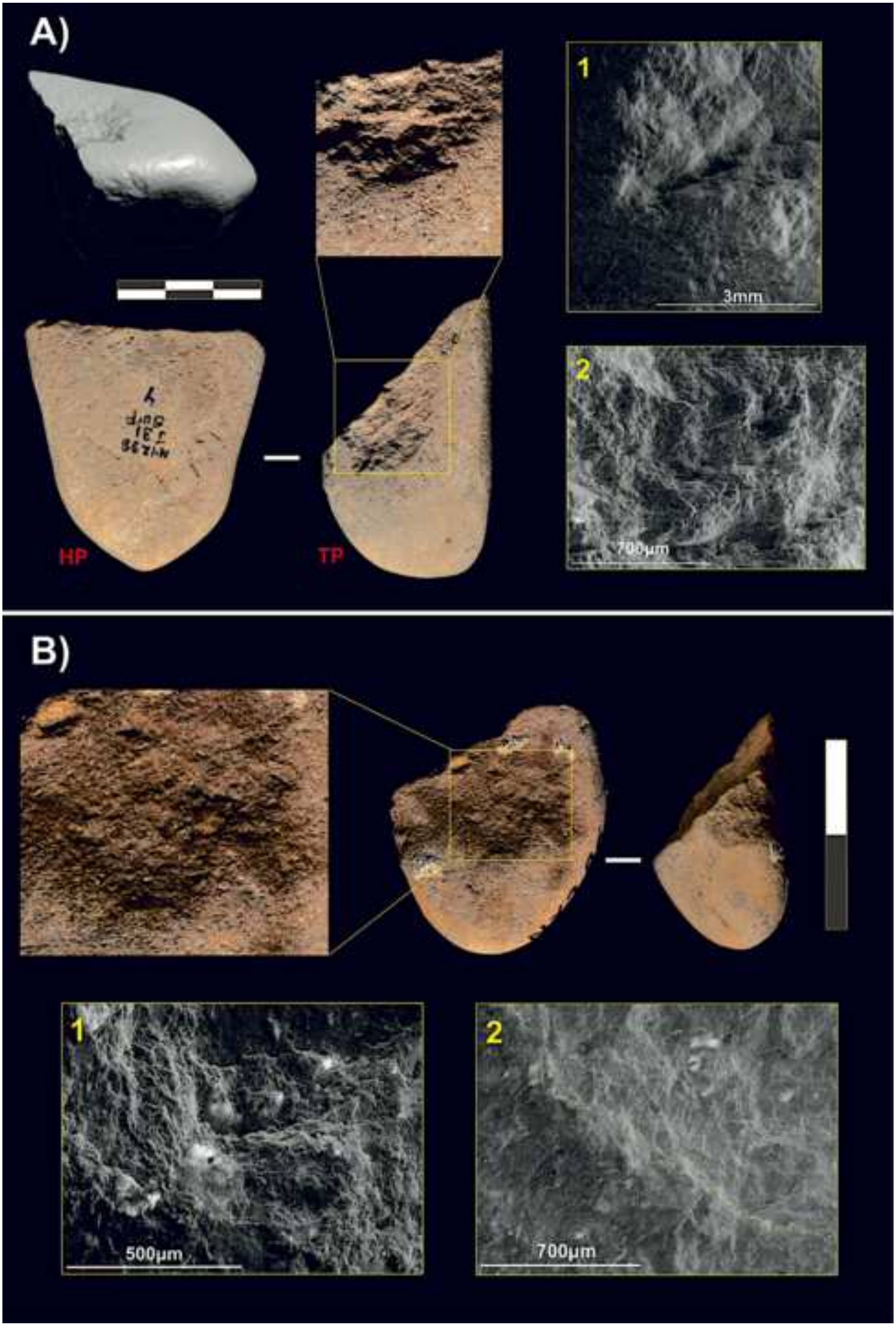
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B)
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700µm

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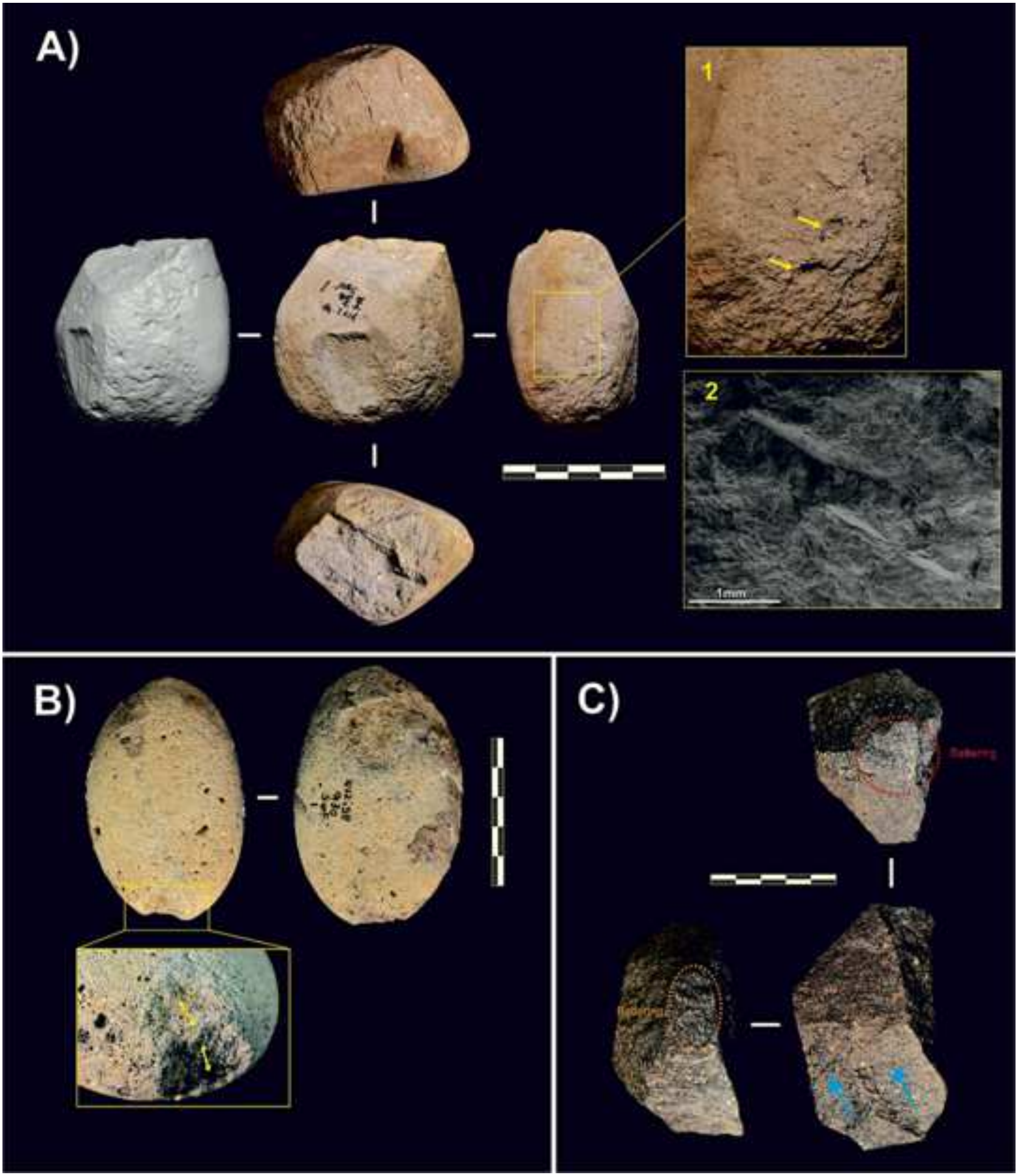

	1 *In situ*	2 Surface site	3 Sieving site	4 Around site surface	TOTAL	% Total excluded col.3	
Pisces		1	37		38*	0,33	*Clarias,* sp. Indet.
Geochelonid			3		3	0,00	
Crocodyle	2	3	2	3	10	2,66	cf. *R.lloydi*
Rodentia	1			1	2	0,66	*Thryonomys*
Primate	2				2	0,66	*Cercopithecus* nov.sp.
Carnivore				2	2	0,66	Hyenid & canid size
Antilopini + cf. Ant	2	8+2		1	13	4,32	*Gazella* sp.
Alcelaphini	1	1			2	0,66	aff.*Damaliscus*
Reduncini+ cf. Red	7	2+2		4	15	4,98	*Kobus*sp. (size 3)
Tragelaphini	1	7		3	11	3,65	*Tragelaphus* sp. (size 2 & 3)
Bovini		1		7	8	2,66	(small size)
Bovid 2	6	14		2	22	7,31	
Bovid 3	8	9		4	21	6,98	
Bovid indet	3	12	98	2	115	5,65	
Giraffid		2			2	0,66	aff *G.stillei*
Equid	1	5	4	5	15	3,65	*Hipparion* (n=8) & *Equus* (n=1)
Suid		13	10	7	30	6,64	*Kolpochoerus* sp. & *Metridiochoerus* sp.
Hippopotamid	2	18	17	3	40	7,64	*H.gorgops*
Rhinocerotid	16	5	36	2	59	7,64	*Ceratotherium* sp.
Proboscid		11	131		142	3,65	*Elephas* sp.
Mam 4-5	4		356		360	1,33	
Mam indet	69	11	2498	3	2581	27,57	
TOTAL	**125**	**127**	**3192**	**49**	**3455**	**100,00**	** probably underestimated*

Table 1.

	In situ		Surface		Total	
	n	**%**	**n**	**%**	**n**	**%**
Cores	10	3.9	31	13.1	41	8.3
Core fragments	1	0.4	5	2.1	6	1.2
Small retouched pieces	1	0.4	3	1.3	4	0.8
Hammerstones and anvils	6	2.3	7	3.0	13	2.6
Flakes	54	20.9	60	25.4	114	23.1
Flake fragments	66	25.6	74	31.4	140	28.3
Debris <25mm	60	23.3	21	8.9	81	16.4
Angular fragments	11	4.3	13	5.5	24	4.9
Split pebbles	3	1.2	5	2.1	8	1.6
Unmodified material	46	17.8	17	7.2	63	12.8
TOTAL	**258**	**100.0**	**236**	**100.0**	**494**	**100.0**

Table 2.

		Mean	St.D.
Cores	Length	81.5	50.648
n=41	Width	60.2	35.679
	Thickness	36.5	27.265
	Weight	588.5	1911.8
Flakes	Length	38.4	15.19
n=114	Width	27.9	11.031
	Thickness	11.6	5.93
	Weight	16.8	24.9553
Small retouched pieces	Length	74.3	31.383
n=4	Width	49.3	18.518
	Thickness	24.3	7.632
	Weight	124.9	113.4286
Anvils	Length	37.0	16.971
n=2	Width	31	15.556
	Thickness	22	12.728
	Weight	33.85	38.9616
Regular hammerstones	Length	78.89	13.365
n=9	Width	55.22	13.818
	Thickness	41.56	14.51
	Weight	254.567	193.8632
Hammerstones with fracture angles	Length	77	12.728
n=2	Width	65	0
	Thickness	45	7.071
	Weight	308.1	57.9828
Unmodified cobbles	Length	47.82	29.245
n=39	Width	34.13	20.522
	Thickness	19.56	14.482
	Weight	92.079	143.3992
Split pebbles	Length	44.88	8.149
n=8	Width	33.63	9.62
	Thickness	15.5	3.071
	Weight	24.887	8.9937

Table 3.

Flaking technique	Core Type		Mean	Std. Deviation
Freehand	TEST CORE n=13	Length	72.9	22.4
		Width	53.5	17.7
		Thickness	30.0	11.4
		Weight	161.6	138.3
	UNIFACIAL (UAP, UP) n=3	Length	54.3	8.4
		Width	55.0	10.8
		Thickness	27.0	8.5
		Weight	67.3	32.9
	CHOPPER (USP and BSP) n=7	Length	82.0	26.0
		Width	55.6	23.3
		Thickness	32.4	17.5
		Weight	238.5	271.1
	BIFACIAL (BALP, BP, BAP) n=8	Length	87.9	19.9
		Width	64.6	9.8
		Thickness	49.9	13.3
		Weight	364.9	175.5
	FREEHAND Average n=33	Length	74.9	23.8
		Width	55.9	17.0
		Thickness	34.2	15.7
		Weight	210.1	197.6
Bipolar	BIPOLAR (pebbles and regular cores) n=6	Length	50.5	19.2
		Width	37.2	15.1
		Thickness	20.5	10.5
		Weight	46.9	46.5
Stationery core or hammer	PASSIVE n=2	Length	276.5	13.4
		Width	196.0	12.7
		Thickness	123.0	67.9
		Weight	8458.3	3820.9

Table 4.

		Mean	Std. Deviation
Anvil n=2	Length	37.0	17.0
	Width	31.0	15.6
	Thickness	22.0	12.7
	Weight	33.8	38.9
Regular hammerstones n=9	Length	78.9	13.4
	Width	55.2	13.8
	Thickness	41.6	14.5
	Weight	254.5	193.8
Hammerstones with fracture angles n=2	Length	77.0	12.7
	Width	65.0	0.0
	Thickness	45.0	7.1
	Weight	308.1	57.9

Table 5.