

Economic behaviors and cognitive capacities of early hominins between 2.34 Ma and 0.70 Ma in West Turkana, Kenya

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Abstract: *In the past few years, an increasing number of discoveries of Early Stone Age sites in East Africa revealed a more complex picture of early hominins behaviors than had been documented before. However, evidence of technological elaboration and abilities among our early ancestors remains limited, and the nature of the technical change during African Lower Paleolithic is still poorly documented. This paper presents the results of a comparative techno-economic study of four rich and well-preserved Early Oldowan, Oldowan, Early Acheulean, and Acheulean lithic assemblages from a recently investigated region of East Africa, the Nachukui Formation west of Lake Turkana, Kenya. This study, spanning a wide chronological period ranging from 2.34 to 0.70 Ma, documents the antiquity of raw material provisioning strategies in very early chronological contexts in highlighting the existence for raw material selectivity and technological planning as early as 2.34 Ma. The comparative analysis demonstrates diachronic differences in patterns of resource use between the sites from the Late Pliocene, the Early Pleistocene, and the very beginning of the Middle Pleistocene. These differences are related to an improvement in technical skills throughout the Plio-Pleistocene rather than to variations in resource availability.*

Keywords: *Early hominins, West Turkana, Kenya, Plio-Pleistocene, Raw material procurement and management, Selectivity, Technical changes*

Ökonomieverhalten und kognitive Fähigkeiten früher Homininen zwischen 2,34 und 0,70 Millionen Jahren vor heute in West Turkana, Kenia

Zusammenfassung: In den vergangenen Jahren hat eine wachsende Zahl an Fundplätzen des Early Stone Age in Ostafrika gezeigt, dass das Bild vom Verhalten früher Homininen wesentlich komplexer ist als bisher angenommen. Nach wie vor sind jedoch die Hinweise auf die technischen Fähigkeiten unserer frühen Vorfahren überhaupt sowie auf Verbesserungen im Bereich der Technologie begrenzt, und das Ausmaß und die Art des Technologiewandels während des afrikanischen Altpaläolithikums sind immer noch unzureichend erfasst. Der Beitrag präsentiert die Ergebnisse einer vergleichenden techno-ökonomischen Untersuchung am Fundmaterial aus vier reichen und gut erhaltenen Steinartefaktkomplexen des frühen Oldowan mit einem Alter von etwa 2,34 Millionen Jahren (Lokalalei 2C), des Oldowan mit einem Alter von ca. 1,70 Millionen Jahren (Kokiselei 5), des frühen Acheuléen mit einem Alter von ca. 1,65 Millionen Jahren (Kokiselei 4) und des Acheuléen mit einem Alter von ca. 0,70 Millionen Jahren (Nadung'a 4). Alle genannten Fundplätze befinden sich in einer in den vergangenen Jahren untersuchten Region in Ostafrika, der Nachukui-Formation westlich des Turkana-Sees in Kenia. Mit den genannten Alterseinstufungen umfasst das analysierte Fundmaterial einen großen zeitlichen Rahmen. Als Rohmaterialien dienten vor allem vier Haupttypen vulkanischer Gesteine, nämlich Phonolith, Basalt, Trachyt und Rhyolith, dazu kommen einige Silkatgesteine und Syenit. Durch die Untersuchungen kann gezeigt werden, wie weit in der Menschheitsentwicklung bewusste Rohmaterialbeschaffungsstrategien zurückreichen, da schon für den ältesten hier behandelten Fundkomplex von Lokalalei 2C mit einem Alter von 2,34 Millionen Jahren eine absichtliche Selektion von Steinrohmaterialien und eine Vorausplanung bei der Artefaktproduktion nachgewiesen werden können. Die vergleichende Analyse der vier Fundkomplexe offenbart diachrone Unterschiede in der Ressourcennutzung vom späten Pliozän (Lokalalei 2C) über das Altpleistozän (Kokiselei 5 und 4) bis an den Beginn des Mittelpleistozäns (Nadung'a 4). Diese Unterschiede hängen eher mit einer Verbesserung der technischen Fertigkeiten im Verlaufe des Plio-Pleistozäns als mit Unterschieden in der Rohmaterialzugänglichkeit zusammen.

Schlagwörter: Frühe Homininen, West Turkana, Kenia, Plio-Pleistozän, Rohmaterialversorgung und -behandlung, Vorauswahl, Technikänderungen

Introduction

Issues related to raw material procurement patterns in the African Lower Paleolithic have been treated by several authors over the past four decades particularly at Olduvai Gorge, in Tanzania, and in the region of Koobi Fora, east of Lake Turkana, Kenya (e.g. Leakey 1971, 1975, 1994; Hay 1976; Isaac 1977; Isaac and Harris 1978; Jones 1979; Clark 1980; Toth 1982, 1987). Undertaken at a regional scale, these raw material studies have shown evidence of stone transport involving distances of several kilometers (up to 13 km at Olduvai: Hay, 1976; overview in Féblot-Augustins 1997) and evidence for the management of lithic resources during the Early Pleistocene (Toth 1985; Schick 1987; Isaac et al. 1997). However, the preferential use of a specific raw material from 1.9 Ma onwards is generally interpreted as a result of local abundance rather than choice on the part of the toolmakers (e.g. Merrick and Merrick 1976; Toth 1985; Schick 1987; Isaac et al. 1997). Furthermore, examples of selection patterns remain limited for the Early Stone Age (Plummer et al. 1999; Semaw 2000; Hovers et al. 2002; Stout et al. 2005; Braun et al. 2006; Goldman et al. 2006; Harmand in press a, b).

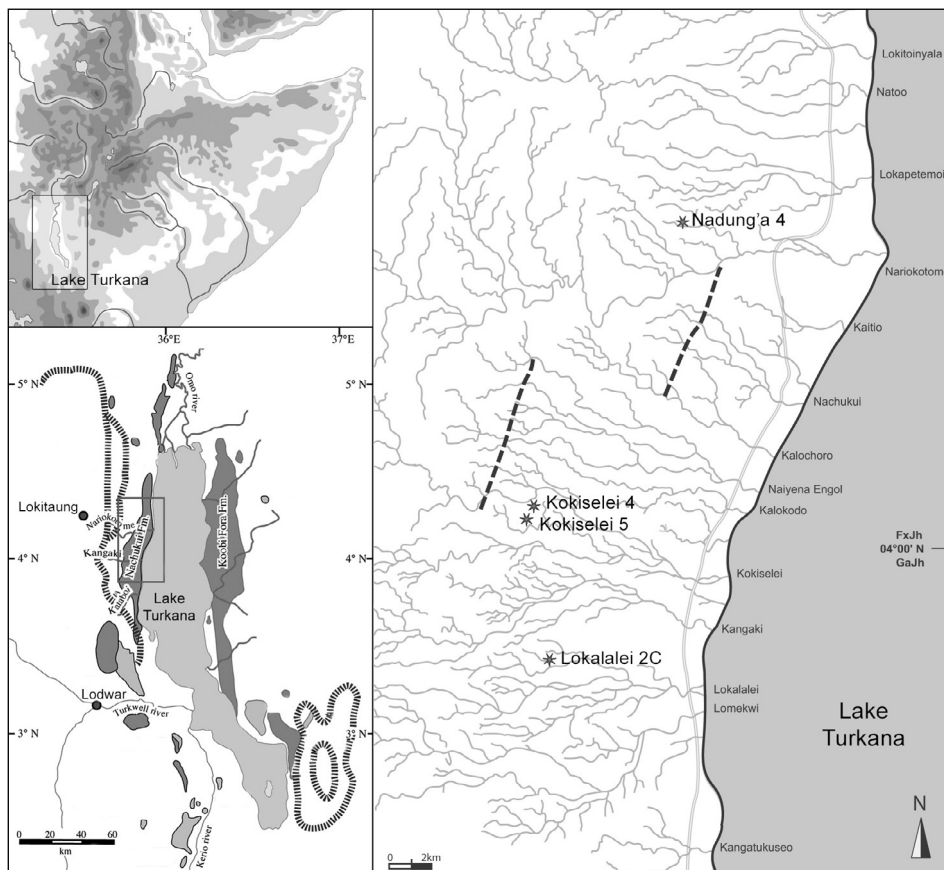


Fig. 1: Map of the Lake Turkana Basin with the location of the sites mentioned in the text, modified after Roche et al. 2003.

Here, the comparative study addresses the lithic procurement and exploitation patterns brought into play by hominins in four sites from the Early Oldowan, Oldowan, Early Acheulean, and Acheulean located in the recently investigated Nachukui Formation, in the West Turkana region, Kenya (Fig. 1). Owing to their chronological position, these sites offer the opportunity to provide, at a regional scale, new data on the nature of the economic organisation from 2.34 Ma onwards, and its evolution throughout the Plio-Pleistocene time-period, up to 0.70 Ma. The diachronic comparison between the four lithic assemblages and samples of cobbles available near the sites displays evidence of raw material selectivity and technological planning on the part of the toolmakers as early as 2.34 Ma, and contradicts the assumption generally made for the Early Stone Age of an opportunistic gathering of rocks. It demonstrates diachronic changes in the exploitation of rocks between the Late Pliocene and the very beginning of the Middle Pleistocene, which do not correspond to variations in raw material availability. Rather, these changes are related to an improvement in hominins technical skills throughout the Plio-Pleistocene.

The Nachukui Formation

The Nachukui Formation is a Plio-Pleistocene sedimentary Formation located in the northern part of Kenya, between the western shores of the lake Turkana and two volcanic escarpments, the Labur and Murua Rith. It is one of the longer and more complete geological sequences in East Africa, and it offers a set of Oldowan and Acheulean sites, aged between 2.34 and 0.70 Ma (Brown and Feibel 1988; Harris et al. 1988; Feibel et al. 1989; 1991). These sites are attributed to three Early Stone Age chronological groups and related to four cultural periods (Roche et al. 1999).

So far one of the oldest sites known in Kenya, the Late Pliocene site of Lokalalei 2C (Early Oldowan), is located in the south of the Nachukui Formation (Fig. 1), and is dated at 2.34 Ma (Roche et al. 1999; Delagnes and Roche 2005; Tiercelin et al. in prep.). The Early Pleistocene site of Kokiselei 5 (Oldowan) is located in the middle of the sequence, more in the north of the Formation (Fig. 1) and dates to ca. 1.70 Ma (Harris et al. 1988). The Early Pleistocene site of Kokiselei 4 (Early Acheulean, Fig. 1) is one of the oldest Early Acheulean sites in Africa, ca. 1.65 Ma. The Acheulean site of Nadung'a 4 is located in the northern part of the Nachukui Formation (Fig. 1) and correlates to the end of the Early Pleistocene or to the very beginning of the Middle Pleistocene, ca. 0.70 Ma (Delagnes et al. 2006).

In this study, the pattern of raw material procurement and management for each of these sites was examined using the techno-economic approach to lithic analysis to reconstruct long-term trends of raw material provisioning during the Plio-Pleistocene period. The implemented methodology combined the systematic sourcing of raw materials, based on the reconstruction of the geological and geomorphological contexts of the region, and the study of the distribution and characteristics of the different types of raw materials by petrographical analysis and stone knapping tests.

Raw material characteristics in the Nachukui Formation

The most common raw materials in the Nachukui Formation are fine to coarser-grained volcanic rocks, from aphyric to porphyritic textures, formed in the Labur and Murua Rith volcanic escarpments. They can be found in river deposits and debris-flow outcrops in secondary position on the alluvial deposits on the west bank of Lake Turkana, at an average distance of between ten to a hundred meters from the archaeological sites (Harmand in press a). Throughout the Plio-Pleistocene in the Nachukui Formation, raw material procurement consisted of collecting and carrying volcanic rocks from these local debris-flow outcrops or dry riverbeds available in the immediate vicinity of the sites.

Four major volcanic rock types were identified in the study area based on classical petrologic classification (MacKenzie and Adams 1996): phonolite, basalt, trachyte, rhyolite, and a few siliceous rocks and syenites (Fig. 2). Each of these rock types can be divided according to groundmass features (micro- to cryptocrystalline), grain-sizes (fine- to coarse-grained fabrics), and textures (aphyric to porphyritic), resulting in distinct knapping and functional properties and varying initial morphologies and sizes.

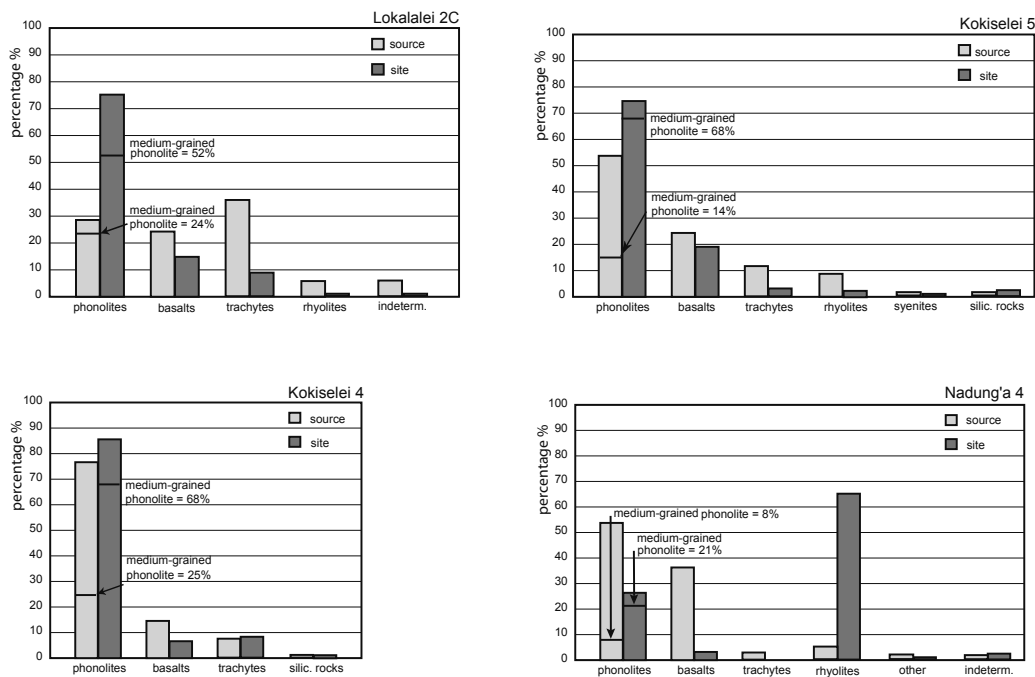


Fig. 2: Raw material composition at geological sources and at archaeological sites in the Nachukui Formation. Lokalalei 2C: Early Oldowan (ca. 2.34 Ma); Kokiselei 5: Oldowan (ca. 1.70 Ma); Kokiselei 4: Early Acheulean (ca. 1.65 Ma); Nadung'a 4: Acheulean (ca. 0.70 Ma).

Among phonolites, the homogeneous and medium-grained type is a high-grade rock most suitable in terms of flaking quality. This raw material displays a parallel mineral orientation that gives the rock a natural foliation and has the mechanical advantage of breaking easily along the foliation plane when direct hard hammer percussion is used. It therefore offers a measure of predictability in terms of fracture orientation (Harmand 2004, 2005). The medium-grained phonolite is also very suitable for obtaining potentially functional active edges (sharp cutting edges). The presence of numerous phenocrystals within the dark black porphyric basalts (phenocrystals of olivine and pyroxene) and the dark gray porphyric phonolites significantly lessens the predictability of flake sizes and morphologies. Poorer quality cobbles of light brown medium-grained trachytes and dark black fine-grained aphyric basalts are usually hard and difficult to break and also display low fracture predictability. The resistance and the roundness of these rocks appear to be appropriate for percussion. Fine-grained red and green rhyolites are very suitable rocks for obtaining hard-wearing and potentially functional active edges despite the fact that these rocks frequently occur as small diclastic and angular blocks, less compact and less homogeneous than phonolites and basalts owing to frequent internal fissures.

Behavioral continuity in raw material procurement patterns in the Nachukui Formation during Plio-Pleistocene

With regard to petrography from the Early Oldowan (ca. 2.34 Ma) to the Acheulean (ca. 0.70 Ma), hominins selected good quality rocks (medium grained phonolites, rhyolites) over coarse-grained or porphyric basalts and trachytes for knapping (Harmand in press a). Rock type frequency distributions show differences between the lithic assemblages and samples of cobbles from the area of the sites (Fig. 2). The frequencies underline the preferential selection of cobbles of a medium grained phonolite until the Early Acheulean (the frequency of medium-grained phonolite is higher in the assemblages than in the local conglomerates, Fig. 2), and of angular blocks of red and green rhyolite at the Acheulean site of Nadung'a 4, a rock quite uncommon in the conglomerates sampled in the vicinity of the site (Fig. 2). At Nadung'a 4, the medium-grained phonolite was also used although it is very rare at the sources (Fig. 2). From the Early Oldowan to the Acheulean, the selectivity towards raw material quality can also be inferred from the avoidance of poorer quality rocks including trachytes and basalts, which are higher in the local conglomerates than in the assemblages (Fig. 2).

Diachronic changes in raw material procurement patterns during Plio-Pleistocene

While the same good quality raw material was predominantly used during the Early Oldowan, the Oldowan, and the Early Acheulean, substantial diachronic changes in patterns of raw material procurement and management can be seen during Plio-Pleistocene in the Nachukui Formation, related to the selection for raw material sizes and morphologies, as well as to the way raw material was processed.

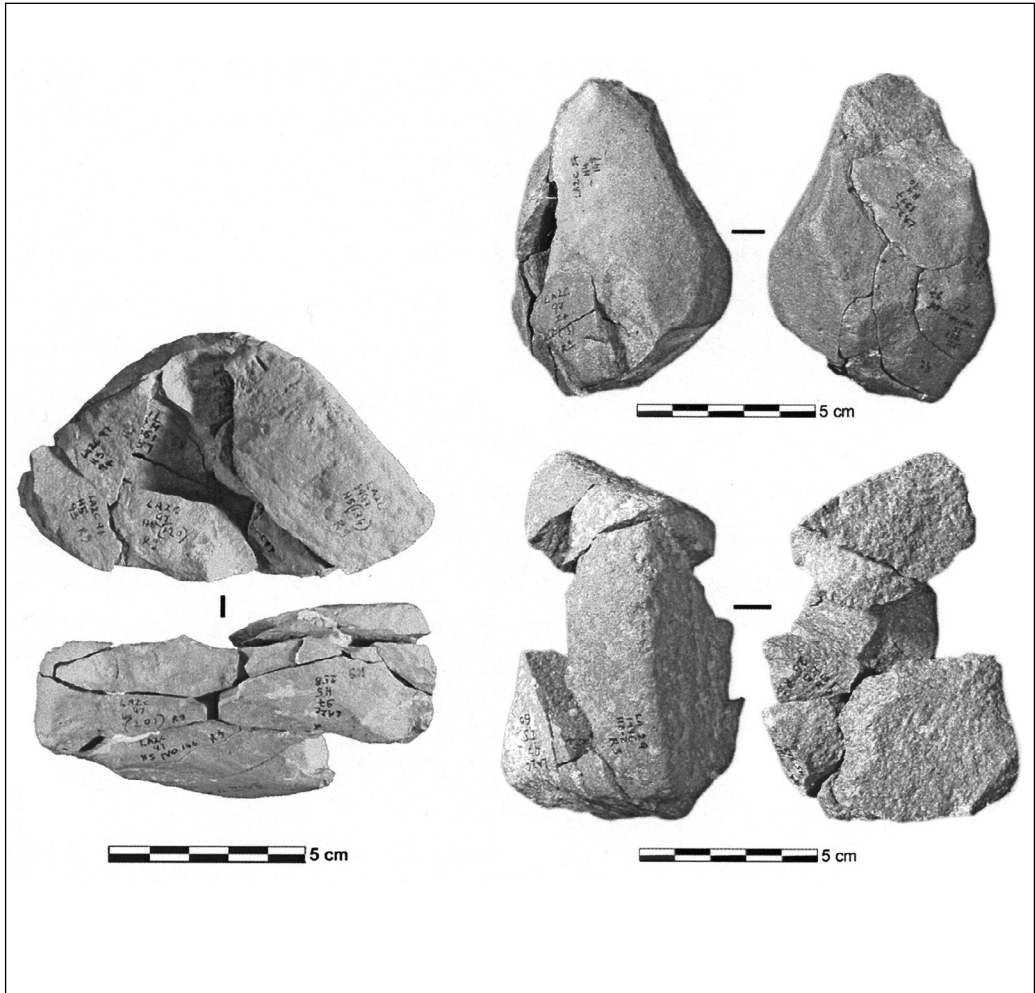


Fig. 3: Lokalelei 2C, Early Oldowan (ca. 2.34 Ma). Three refitted complexes showing organized reduction of deliberately selected cobbles. Modified after Harmand 2005.

The study of the relationship between raw materials at sites and raw materials at sources highlights a high degree of planning and foresight as early as 2.34 Ma. This is testified to by the careful selection of good quality rocks with naturally serviceable striking platforms, for the purpose of carrying out long reduction processes according to the level of skill the Lokalelei 2C (Fig. 3 and 4) knappers have mastered (see Delagnes and Roche 2005; Harmand in press b). To a lesser extent, debitage was struck from poorer quality cobbles or fragments of cobbles of aphyritic or porphyritic basalts (Fig. 2). A series of heavy and medium-sized rounded cobbles of a resistant medium-grained trachyte were selected for use as hammerstones and few unmodified cobbles of medium-grained trachyte or fine-grained basalt were also brought to the site and probably stockpiled as manuports.

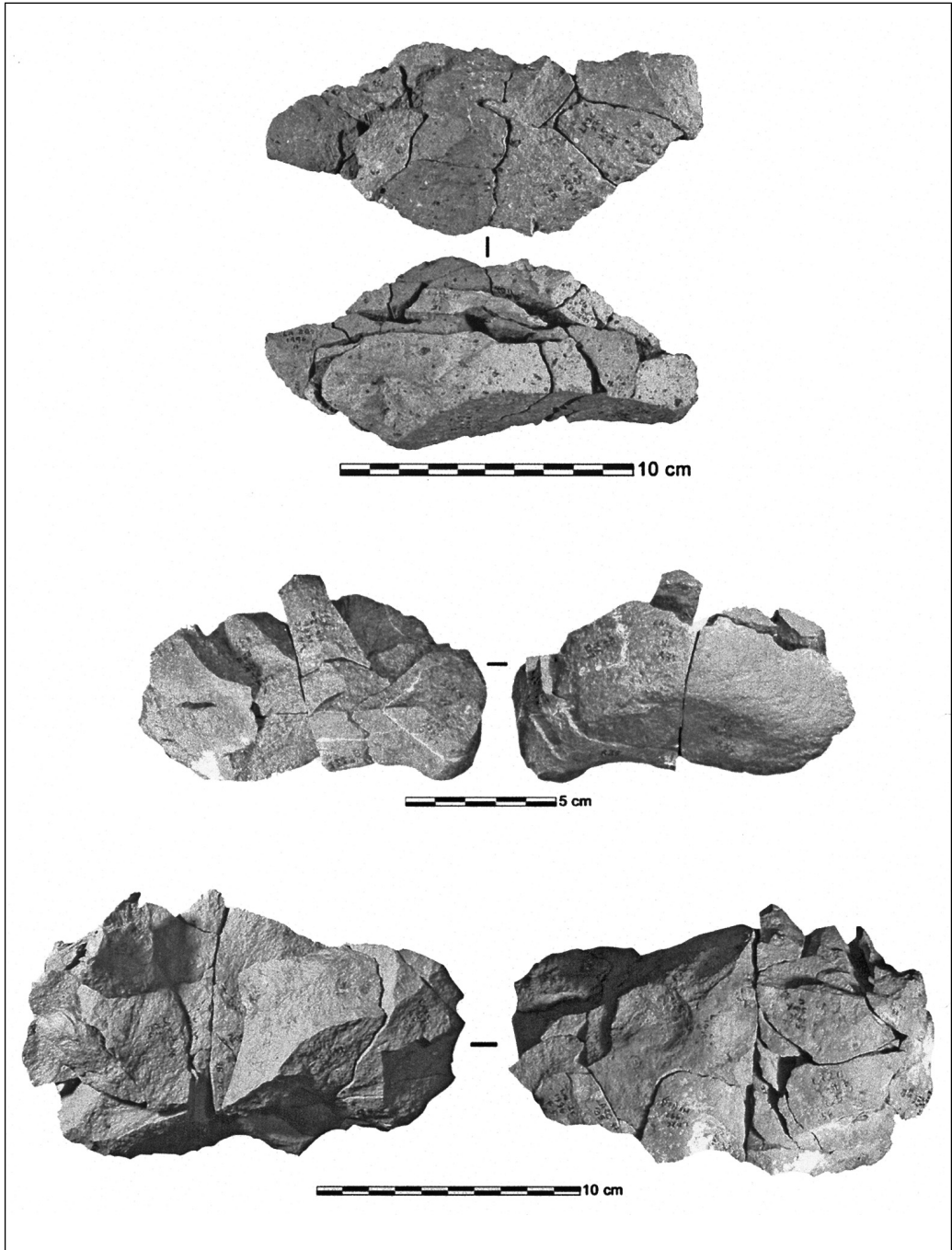


Fig. 4: Lokalelei 2C, Early Oldowan (ca. 2.34 Ma). Three refitted complexes showing organized reduction of cobbles. Modified after Harmand 2005.

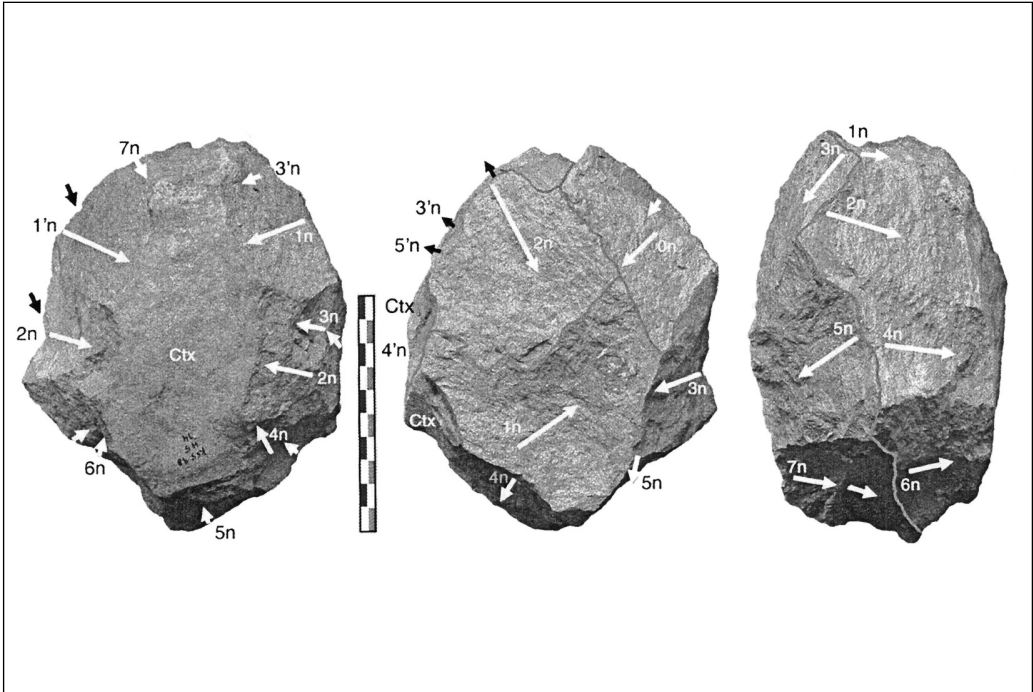


Fig. 5: Kokiselei 5, Oldowan (ca. 1.70 Ma). Phonolite core showing alternating production of blanks. Ctx = cortex, n = negative; the numbers indicate the sequence of reduction, arrows indicate the striking direction. Modified after Harmand 2005.

While evidence of selectivity at Lokalalei 2C was largely determined by the knappers' technological limitations, the procurement and exploitation strategies at Early Pleistocene underscore a higher degree of selectivity. At the site of Kokiselei 5, ca. 1.70 Ma, and later on, at the site of Kokiselei 4, ca. 1.65 Ma, the medium-grained phonolite accounts for a higher proportion of the on-site raw materials than at Lokalalei 2C (Fig. 2). Moreover, selection at the sources within the phonolite group was more important at Kokiselei 5 and Kokiselei 4, since the medium-grained type of phonolite is rare in both cases (Fig. 2). Furthermore, at the Oldowan site of Kokiselei 5 (Fig. 5), the debitage systems appear less constrained by the initial morphology of the raw materials available at the sources, and the knappers display for the first time the ability to modify the initial morphology of the raw material by creating new striking platforms (Texier et al. 2004, 2006). Finally, the study of the relationship between raw materials and artifacts at Kokiselei 5 highlights evidence for distinct provisioning patterns in relation with distinct morphological and functional goals. Two types of production, flakes and "heavy-duty tools" (sensu M. Leakey 1971), are identified, each of them involving the selection of specific sizes of clasts at the nearby raw material sources. Small to medium-sized cobbles of the medium-grained phonolite were preferably exploited for debitage reduction sequences to obtain flakes, while larger blocks of medium-grained phonolite were selected for the manufacture of heavy-duty tools (Harmand in press a). To a lesser extent, debitage was also conducted on lower quality cobbles of basalts, trachytes and syenites (Fig. 2).

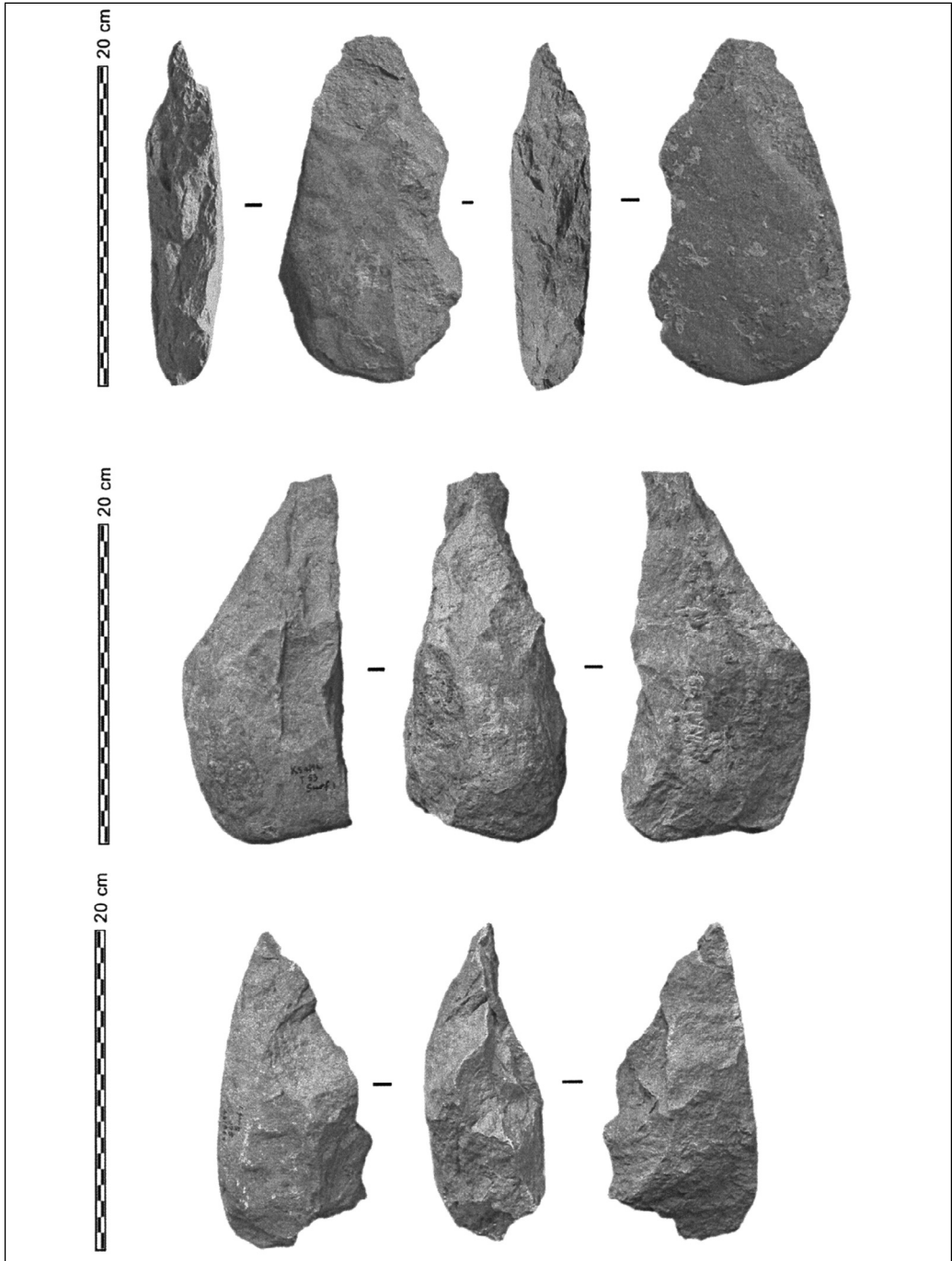


Fig. 6: Kokiselei 4, Early Acheulean (ca. 1.65 Ma). Proto-handaxes made of phonolite. Modified after Harmand 2005.

At the Early Acheulean site of Kokiselei 4, new volumes are exploited to create specific tools, large handaxes, proto-handaxes (Fig. 6) and picks, through a shaping reduction system (Texier et al. 2006; Fig. 2). This reduction system involves a measure of anticipation in the selection of large flat and elongated slabs of a medium-grained phonolite poorly represented in the nearby conglomerates (Fig. 2) but suitable for maximizing tool sizes and producing large handaxes and picks with long sharp cutting edges.

The patterns of raw material procurement and management become more sophisticated at the Acheulean site of Nadung'a 4, ca. 0.70 Ma. A wider range of raw materials has been exploited, without an increase in procurement possibilities. Along with the medium-grained phonolites, rhyolites were also preferentially exploited (Fig. 2), although they were rarely exploited in the preceding time-periods (Late Pliocene and Early Pleistocene). Furthermore, the selection of different types of rocks appears very closely linked to specific types of products, for the purpose of carrying out various processing tasks, probably partly connected with the presence of an elephant carcass in the site (Delagnes et al. 2006; Harmand in press a). Red or green rhyolite was exclusively used to produce sharp flakes and obtain cutting edges (Fig. 7). The medium-grained phonolite was used for flake production according to the same principles of debitage documented for rhyolite, as well as for manufacturing some heavy-duty tools by simple shaping (Fig. 2). The remaining rocks at the site are large and compact cobbles of fine-grained phonolite, basalt or trachyte used as heavy-duty tools.

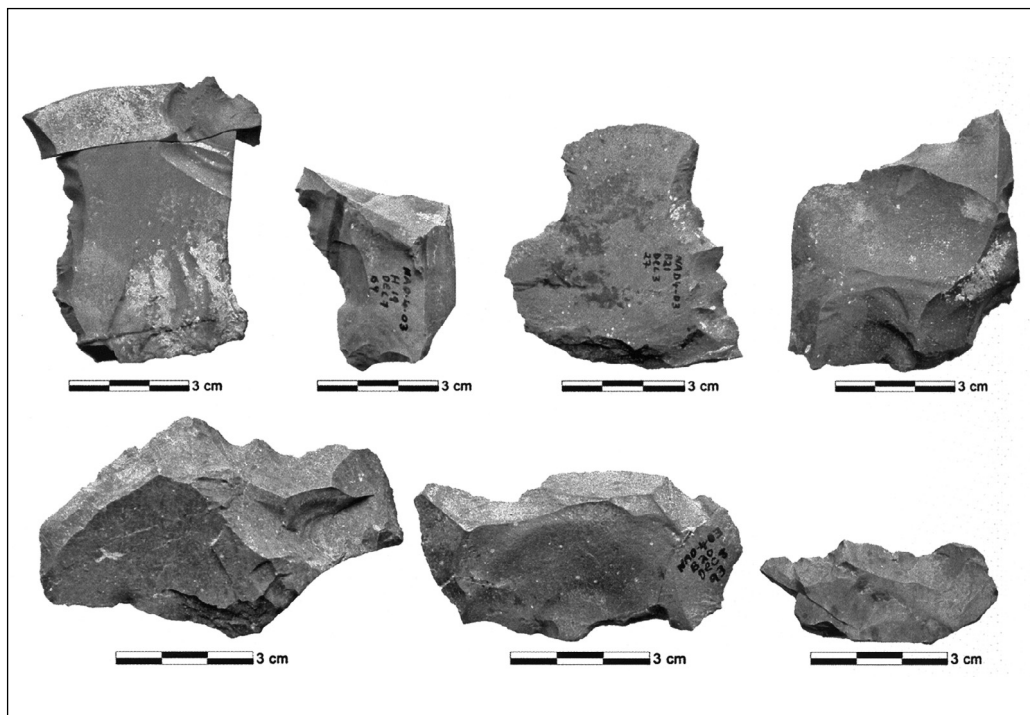


Fig. 7: Nadung'a 4, Acheulean (ca. 0.70 Ma). Notched and denticulate tools made of red and green rhyolite. Modified after Harmand 2005.

Conclusion

The archaeological record in the Nachukui Formation reveals evidence of raw material selectivity and technological planning on the part of the toolmakers as early as 2.34 Ma. It contradicts the assumption generally made for the Oldowan of an opportunistic gathering of rocks and the notion of artifacts being made in an immediate and rudimentary way. These patterns lend strong support to recent investigations on plio-pleistocene lithic productions which reveal a much more complex panorama of the first technical systems and their related behaviors (Plummer et al. 1999; Roche 2000; de la Torre et al. 2003; de la Torre 2004; Plummer 2004; Stout et al. 2005; Delagnes and Roche 2005; Goldman et al. 2006).

The present study also demonstrates that the observed behavioral changes in raw material procurement and exploitation patterns from Early Oldowan to Acheulean are related to the qualities and morphologies of the raw materials selected as well as to the way they were processed, rather than to variations in raw material availability. These temporal changes could reflect a gradual improvement in technical skills throughout the Plio-Pleistocene, and could possibly be related to distinct hominin species or genera (*Paranthropus*, *Homo* aff. *habilis*, *Homo erectus*).

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