Part I

REGIONAL LANDSCAPE PERSPECTIVES

Chapter 1

RAW MATERIALS AND TECHNO-ECONOMIC BEHAVIORS AT OLDOWAN AND ACHEULEAN SITES IN THE WEST TURKANA REGION, KENYA

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ABSTRACT

In East Africa, the significant increase in lithic studies on newly discovered Plio-Pleistocene sites provides renewed data on the emergence of early technological developments. The current techno-economic study of several rich and well-preserved Oldowan and Acheulean lithic assemblages from the West Turkana region in North Kenya opens new perspectives on how raw material procurement activities are economically structured in the Early Stone Age and documents their transformations during the Plio-Pleistocene time period. This study, carried out in combination with geological surveys, petrographic analyses, and lithic assemblage analyses, reveals distinctive characteristics in raw material procurement and exploitation patterns between 2.34 and 0.70 myrs in the West Turkana region. It demonstrates the antiquity of decision-making in ancient contexts and highlights substantial diachronic changes in the management of raw materials during the Plio-Pleistocene, which 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 resource availability.

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INTRODUCTION

Raw materials, considered from the viewpoint of their provenance and use, have been the object of a long-standing interest in the African Lower Paleolithic. Over the past three decades, research addressing hominin behavior in relation to lithic procurement has been particularly active at Olduvai Gorge, 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). Carried out on a regional scale and focusing mainly on hominin ranging and foraging behavior, raw material studies indicating that from 1.9 myr onwards site provisioning involved distances of several kilometers (overview in Féblot-Augustins 1997a) have furthered the construction of Early Pleistocene hominin activity models (e.g., "home base hypothesis", Leakey 1971; "routed foraging model", Binford 1980; "favored places model", Schick 1987; Schick and Toth 1993). The preferential use of a raw material during the Pliocene and the Early Pleistocene is generally interpreted as a result of local abundance (e.g., Merrick and Merrick 1976; Toth 1985; Schick 1987; Isaac *et al.* 1997). However, provenance studies based on bibliographical data and conducted from a techno-economic perspective have shown that distinct rock types from variously distant sources were introduced into sites under different forms (rough blocks/finished tools) and used for specific productions in the Acheulean, a pattern heralded in the Oldowan (Féblot-Augustins 1990, 1997b). More recently, lithic studies based on raw material characterization from new sites dated to the Late Pliocene have provided unexpected evidence for selection patterns as early as 2.6 myrs (Braun and Harris 2003; Plummer 2004; Stout *et al.* 2005). These involve a certain level of anticipation in the effects of raw material properties and further contradict the assumption generally made for the Early Stone Age of an opportunistic gathering of rocks.

In this chapter, we report the results of a techno-economic study that addresses the lithic procurement and exploitation patterns brought into play by the Plio-Pleistocene hominins of a recently investigated region of East Africa, the Nachukui Formation west of Lake Turkana, Kenya, and spans a wide chronological period ranging from 2.34 to 0.70 myrs (Harmand 2004, 2005).

One of the most noteworthy results ensuing from the study of several Nachukui Formation sites is new evidence of planning and foresight in raw material procurement and management from 2.34 myrs onwards, testified to by the selection of specific raw materials and cobble morphologies, and their stockpiling for future use. The in-depth techno-economic study has also highlighted significant diachronic changes and successive stages in the exploitation of raw materials between 2.34 and 0.70 myrs, related to an improvement in technical skills throughout the Plio-Pleistocene rather than to variations in resource availability (Harmand 2004, 2005).

PHYSICAL SETTING: THE NACHUKUI FORMATION, WEST TURKANA, KENYA

The Nachukui Formation lies on the western shore of Lake Turkana in the north of Kenya (Figure 1.1). The basin margin is bounded at the northwest by the Labur and Murua Rith ranges. The Plio-Pleistocene sedimentary deposits of West Turkana are aerially exposed in an area of about 700 km^2 and reach a thickness of about 730 m. The Nachukui Formation is divided into eight members (from 4 to 0.7 myrs) using widespread volcanic tuffs as bed markers (Harris *et al.* 1988; Feibel *et al.* 1989, 1991) (Figure 1.2). It is known as a source of significant paleontological finds, which have extended much of what is known about early hominin phylogeny and morphology in the Plio-Pleistocene (Brown *et al.* 1985; Walker *et al.* 1986; Feibel *et al.* 1989). Furthermore, this sequence is one of the longer and more complete in East Africa, and happens to be very rich in archeological sites of great antiquity. These sites were revealed by the West Turkana Archaeological Project, a project co-leaded by H. Roche and M. Kibunjia, and associating the National Museums of Kenya (Nairobi) and the *Mission Préhistorique au Kenya* (France). Since 1996, the Nachukui Formation has yielded a large number of rich and well-preserved archeological sites, geographically close and occupied by hominins between 2.34 and 0.70 myrs (Roche and Kibunjia 1994, 1996; Roche *et al.* 1999, 2003; Prat *et al.* 2003). Compared to the two other Plio-Pleistocene sedimentary formations from the Omo Group (Shungura Formation in the north of the Turkana Basin and Koobi Fora Formation in the west, dated from 4.5 to 0.7 myrs: Brown and Feibel 1988; Harris *et al.* 1988; Feibel *et al.* 1989, 1991), the Nachukui Formation is the only sedimentary formation that offers, on a regional scale, the opportunity

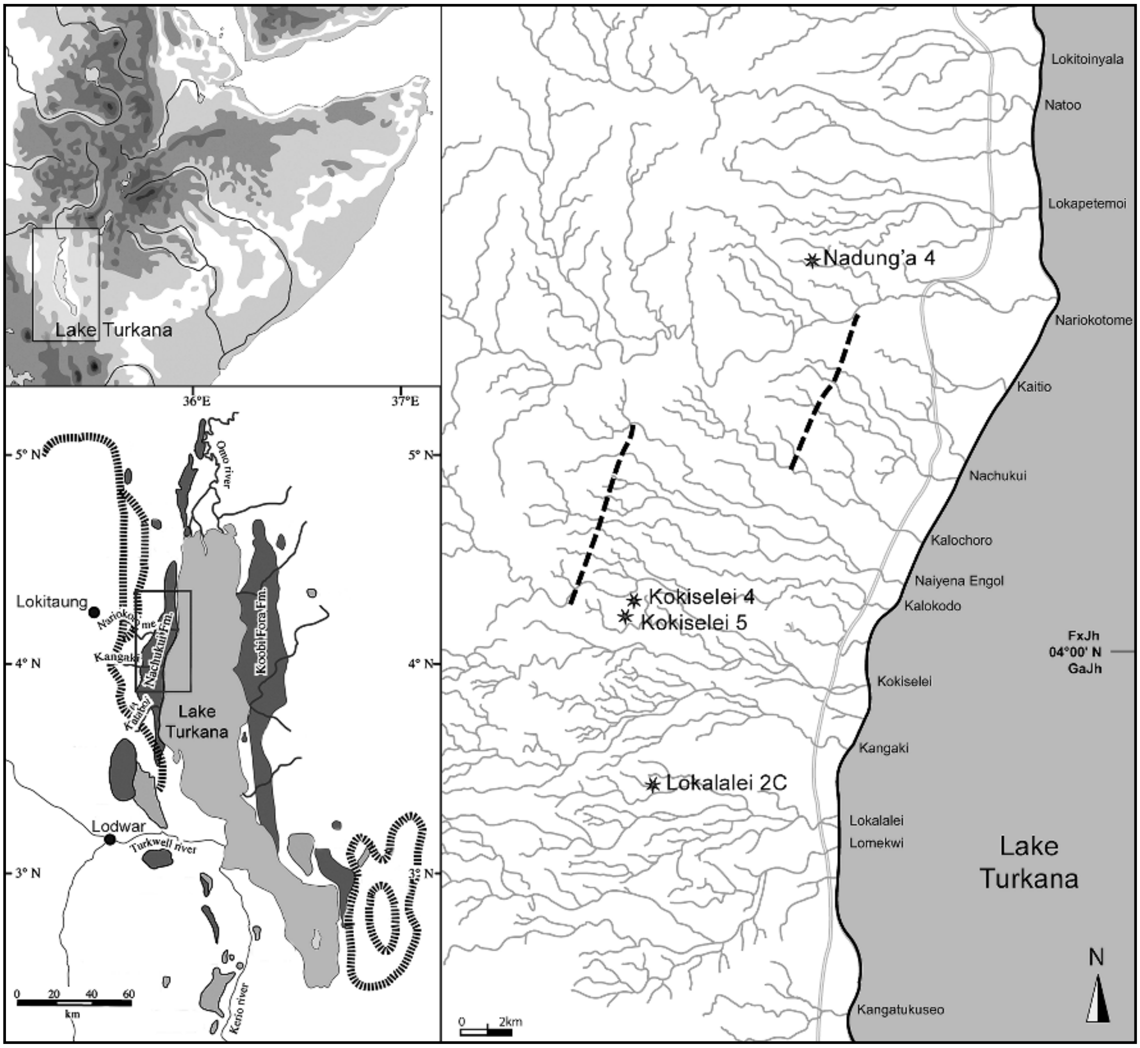

Figure 1.1 Counter-clockwise from upper left: East Africa; lake Turkana; archaeological sites discussed in the text. Modified after Roche *et al.* 2003.

to compare Early Stone Age lithic-oriented behaviors across a wide chronological time span, ranging from 2.34 to 0.70 myrs.

The assemblages under study in this chapter issue from four well-preserved archeological sites recently excavated in the Nachukui Formation, and dated through tuff-to-tuff correlations (Brown and Feibel 1988; Harris *et al.* 1988; Feibel *et al.* 1989). These sites, attributed to three Early Stone Age chronological groups and related to four cultural periods, are the Late Pliocene site of Lokalalei 2C (Early Oldowan), the Early Pleistocene sites of Kokiselei 5 (Oldowan) and Kokiselei 4 (Early Acheulean), and the Early/Middle Pleistocene site of Nadung'a 4 (Acheulean) (Roche *et al.* 2003).

The Early Oldowan site of Lokalalei 2C (Figure 1.1) is one of the very few African Pliocene sites (Kibunjia *et al.* 1992; Delagnes and Roche 2005). It is located in the south of the Nachukui Formation (Figure 1.1), at the base of the Kalochoro Member, and dated at 2.34 myrs (Figure 1.2) (Roche *et al.* 1999; Brown and

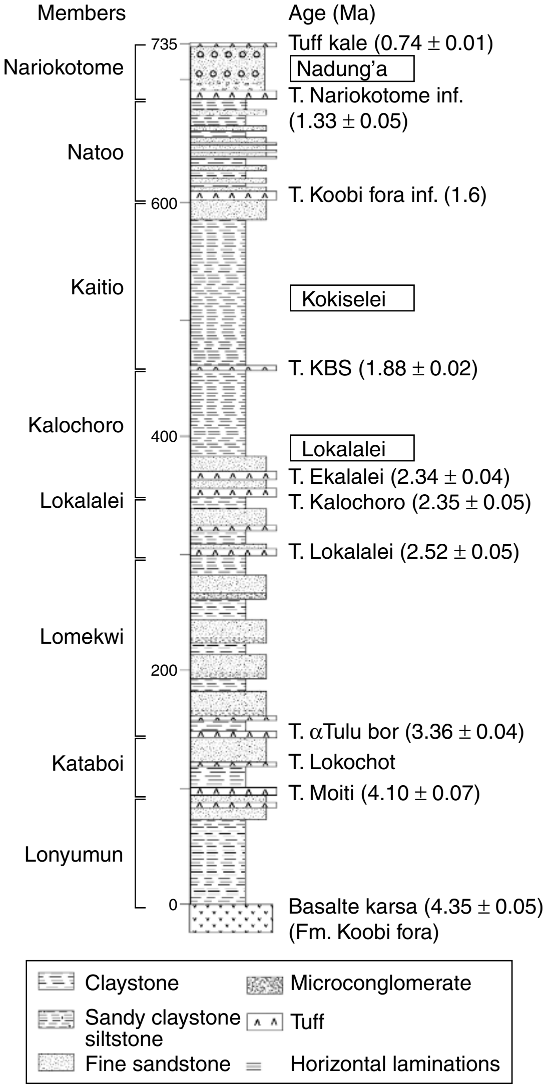

Figure 1.2 Lithostratigraphical and chronological correlations of the Lokalalei, Kokiselei and Nadung'a archaeological sites within the Nachukui Formation. Modified from Harris *et al.* 1988.

Gathogo 2002; Delagnes and Roche 2005; Tiercelin *et al.* in prep.). A total of 17 m² was exhaustively excavated yielding 2629 lithic artifacts, cores, whole or broken flakes, a very few possibly retouched pieces, unmodified split cobbles and hammerstones. Despite the fact that the archaeological deposit is partly truncated by erosion, the preserved part of the site shows clear evidence of good preservation, as indicated by a high ratio of very small elements and the freshness of the artifacts (Delagnes and Roche 2005). The Early Oldowan lithic material at Lokalalei 2C reflects organized and highly productive debitage[1] sequences, which result in a large production of relatively well standardized flakes (Delagnes and Roche 2005).

The Oldowan site of Kokiselei 5 (Figure 1.1) belongs to the upper part of the Kaitio Member (Harris *et al.* 1988) *ca.* 1.70 myr (Figure 1.2). It is situated in a low-energy setting, and its comprehensive excavation has revealed well-preserved features of the spatial organization (Roche *et al.* 2003). An area of 65 m² was excavated, yielding over 1600 Oldowan lithic artifacts including cores, flakes and fragments, unworked or roughly flaked pebbles and cobbles, and one trihedral tool (Texier *et al.* 2004; Texier *et al.* 2006). Owing to its chronological position, halfway between the Early Oldowan site of Lokalalei 2C and the Early Acheulean site of Kokiselei 4, it is a key site for understanding the transition between the Early Oldowan and the Early Acheulean.

Kokiselei 4 (Figure 1.1) is one of the oldest Early Acheulean sites in Africa, *ca.* 1.65 myr. It is a relatively eroded site where several trenches (19 m²) have been dug and material collected over a surface of 100 m². The lithic assemblage is quite small in number ($n = 191$) but yields large proto-handaxes, handaxes, picks, flakes (some of them very large), and cores.

Nadung'a 4 is located in the northern part of the Nachukui Formation (Figure 1.1) and is related to the end of the Early Pleistocene or to the very beginning of the Middle Pleistocene, *ca.* 0.70 myr (Figure 1.2) (Delagnes *et al.* 2006). The excavation covered an area of 53 m² from which an abundant lithic assemblage ($n = 6797$) *in situ* has been recovered in close association with the partial carcass of an elephant.

METHOD OF ANALYSIS: VOLCANIC PETROGRAPHY AND *CHAÎNE OPÉRATOIRE*

The lithic procurement and exploitation patterns brought into play by Plio-Pleistocene hominins are inferred from the techno-economic analysis of the aforementioned assemblages. The author drew upon the major publications concerning these assemblages (Roche *et al.* 1999; Delagnes and Roche 2005; Delagnes *et al.* 2006; Texier *et al.* 2006), and her own in-depth technological observations, which aimed more particularly to highlight the relationship between raw materials and tool production processes (Harmand 2005). This approach is based on the notion of *chaîne opératoire*, whereby each and every technical sequence and their mutual organization are identified (e.g., Leroi-Gourhan 1964, 1971; Geneste 1989, 1991). Artifacts are analyzed as the outcome of a process, that is to say the strategies of reduction and the technical skills involved in tool production.

The techno-economic analysis implemented here included as a prerequisite: (i) the systematic sourcing and sampling of raw materials by field surveys in order to assess the opportunities for procurement and the possibilities of natural transport, (ii) petrographic analyses, and (iii) rock mechanics tests through knapping experiments in order to evaluate the range of raw materials available in the conglomerates, and also to assess the relative abundance in these secondary deposits of each type of rock in relation to their characteristics (rock qualities and properties). This involved locating and mapping secondary sources, computing the distance from each archaeological site, and characterizing the types of outcrops and the nature of secondary deposits. As a result, the rocks were grouped into several categories, differing in terms of petrographic, structural, and granular patterns. In addition to the petrographic determination, the initial morphologies and sizes of all the collected cobbles were recorded and taken into consideration. Ultimately, building on the results of the technological study of the reduction sequences, the relationship between raw materials and desired end products has been determined and analyzed for each lithic assemblage.

AN ENDURINGLY LOCAL SITE PROVISIONING

The Nachukui Formation is located along the western shore of the Turkana Basin between the left bank of Lake Turkana and the Murua Rith and Labur Ranges, which border the basin to the west (Figure 1.1). The systematic sourcing of the poorly sorted debris-flow outcrops available in the vicinity of the archeological sites indicates the predominance of rounded boulders or cobbles of igneous and extrusive rocks all originating from flows of lava from these Miocene volcanic ranges. Paleogeographic reconstructions of the Turkana Basin indicate that during the last 4 myrs it was dominated by two hydrographic systems: a series of lakes acknowledged for different time periods, and a river system interpreted as the Paleo-Omo.

Prior to 2 myrs, the Turkana Basin was dominated by the Paleo-Omo, which flowed through the basin from the north and exited east into the Indian Ocean (Brown and Feibel 1988; Feibel *et al.* 1991; Rogers *et al.* 1994). After 2 myrs the basin was dominated by a lake system, which waxed and waned at different time periods represented in the basin. Even then the river continued to flow into the lake system and exited the basin to the east until the damming of the exit by the uplifting of Mt Kulal to the southeast. In the Nachukui Formation, the archeological sites are all located in close proximity to small and ephemeral east-flowing streams, joining the main axial river system that flows from north to south (Lokalalei 2C site), or the paleo-lake Turkana (Kokiselei 5, Kokiselei 4 and Nadung'a 4 sites) (Brown and Feibel 1988). From the development of these east-flowing streams, debris-flow outcrops were accumulated near the archeological sites, between ten to a few hundred meters, and stratigraphically a few meters below the archeological layers or within the same layers, providing the only ready sources of boulders, cobbles, and pebbles for the knappers[2].

These secondary deposits yielding the available rocks result from the filling of small channels flowing from west to east according to the paleogeographic reconstructions of the hydrographic systems that dominated the Turkana basin between 4.5 and 0.7 myrs (Brown and Feibel 1988, 1991; Feibel *et al.* 1991). Throughout the Plio-Pleistocene in the studied area, raw material procurement consisted of collecting and carrying volcanic rocks from exclusively local debris-flow outcrops or dry riverbeds available in the immediate vicinity of the sites, at an average distance comprising between ten to a hundred meters. As a result, the cost of search, acquisition, and transport of raw materials was minimal, and this local provisioning seems to have undergone no changes between 2.34 and 0.70 myrs.

VARIABLE ROCK COMPOSITION OF LOCAL SOURCES

The volcanic rocks carried by the network of rivers, nowadays dry most of the time, display distinctive physical features in terms of color, grain, texture, homogeneity, and veining. These are indicative of micro- to cryptocristalline groundmasses, fine- to coarse-grained fabrics, and aphyritic to porphyritic textures, resulting in distinct knapping and functional properties and varying initial morphologies and sizes.

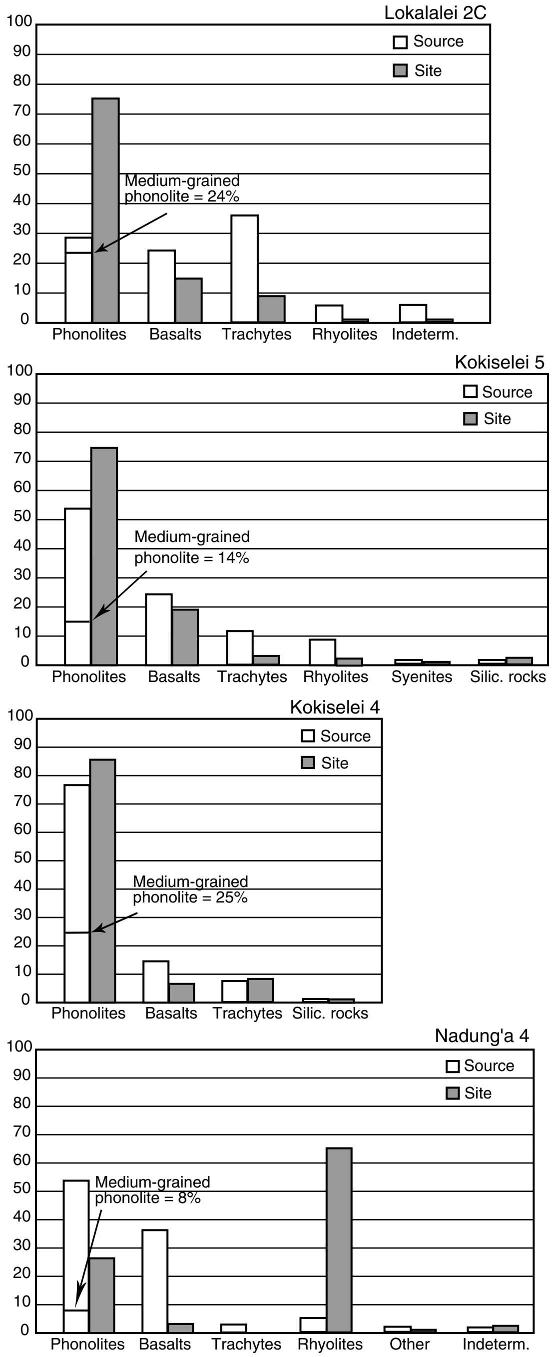

Figure 1.3 Raw material composition at geological sources and at archaeological sites in the Nachukui Formation.

For instance, medium-grained phonolite is an excellent raw material in terms of its flaking qualities.

In addition, the detailed petrographic and morphometric characterization of the secondary deposits through sampling of the conglomerates revealed variations in the proportions of the several types of lavas available in the vicinity of the different archeological localities (Figure 1.3). The randomly sampled outcrops in the Kokiselei 5, Kokiselei 4, and Nadung'a 4 areas are dominated by a dark gray aphyritic phonolite (54%, 77%, and 54%, respectively) (Figure 1.3), which accounts for only 28% of the raw materials at the randomly sampled outcrops around Lokalalei 2C. Among the phonolites, the medium-grained type is predominant in the randomly sampled outcrops at Lokalalei 2C (24% of the raw materials), while it is a minority at Kokiselei 5 (14% of the raw materials), at Kokiselei 4 (25% of the raw materials), and at Nadung'a 4 (8% of the raw materials). Dark black porphyric or aphyric basalts account for 15–36% of the rocks sampled on the outcrops. Various other rocks occur in smaller proportions: light brown trachytes (1.6–37%), red and green rhyolites (between 0 and 8%), siliceous rocks (0–1.5%), and large-grained rocks such as syenites (0–1%) (Figure 1.3).

RAW MATERIAL SELECTION AND EXPLOITATION PATTERNS: DIACHRONIC CHANGES THROUGHOUT THE PLIO-PLEISTOCENE

Selective raw material provisioning as early as 2.34 myrs

At the Late Pliocene Early Oldowan site of Lokalalei 2C, the relative proportions of the different categories of artifacts suggest that the site was a knapping spot where large quantities of raw materials were brought from a nearby channel (no further than 50 m away) for on-site subsistence-related activities (Delagnes and Roche 2005). 190 cobbles or fragments of cobbles were carried to the site along with a few unmodified split cobbles. The knappers favored medium-grained phonolite (52% of the on-site raw materials, Figure 1.4), a type of raw material that was most suitable in terms of flaking quality and morphology for the production of large amounts of flakes, considering the technical skills they had developed (60% of the flakes and flake fragments, $n = 745$). At the sources, this involved selecting

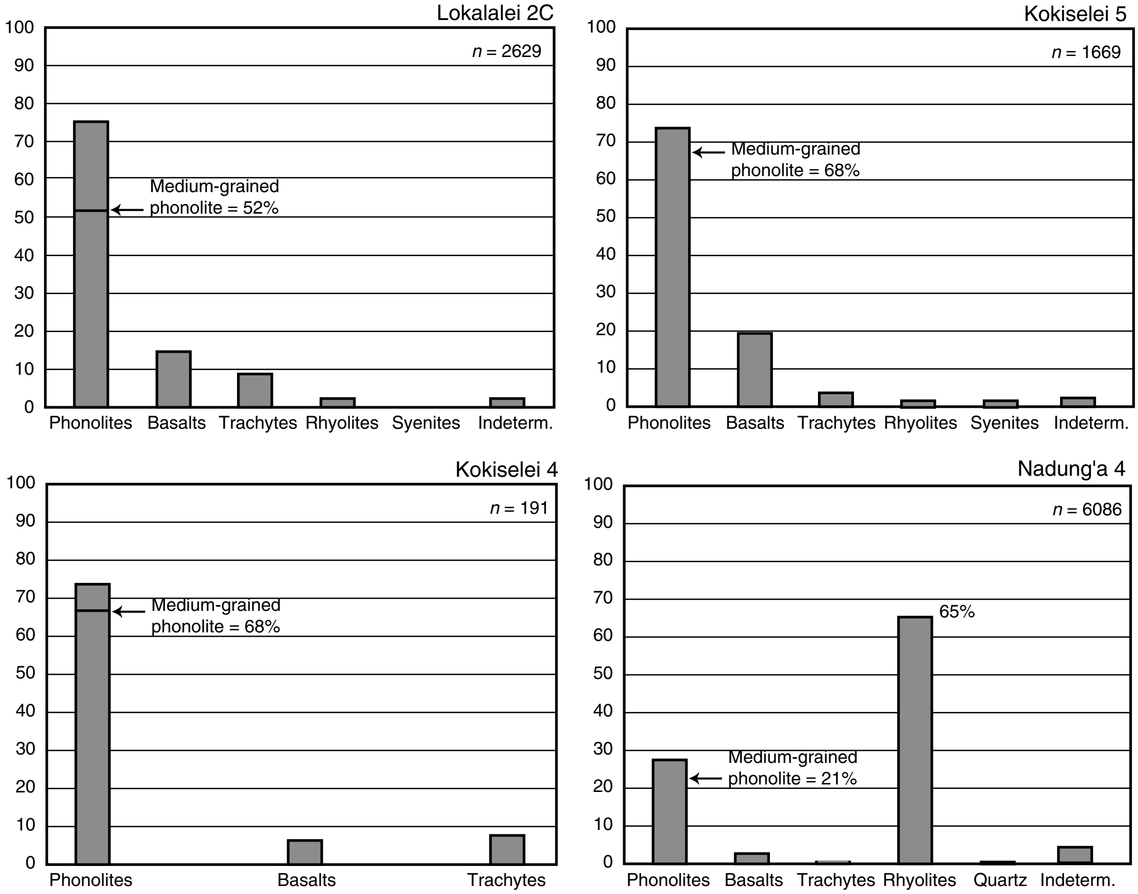

Figure 1.4 Raw material composition at archaeological sites in the Nachukui Formation.

phonolites in general over basalts and trachytes, but within the phonolite group itself there was little selection since the medium-grained type is predominant (see Figure 1.3).

Medium-grained phonolite is a rock with good flaking qualities, because it displays a parallel mineral orientation that gives the rock a natural foliation. It has the mechanical advantage of breaking easily along the foliation plane when using direct hard hammer percussion, and therefore offers a measure of predictability in terms of fracture orientation (Harmand 2004, 2005). At the sources, this type of phonolite occurs mainly as rounded to sub-rounded cobbles, and more rarely as angular cobbles.

Because lithic technical skills at 2.3 myrs remained strongly constrained[3] by the original shape of the available raw materials (Delagnes and Roche 2005), the initial morphology of the blocks had significant repercussions on the condition in which raw materials were introduced onto the site (whole or split cobbles, Harmand 2005). Medium-sized *angular* cobbles or fragments of cobbles (12 cm maximum dimension[4]) of the medium-grained phonolite with *naturally* serviceable striking surfaces (n = 95) were preferentially exploited for their suitability to be knapped without any preparation (Delagnes and Roche 2005). Flakes, cores, and fragments are mainly made on these angular specimens of medium-grained phonolite. The low representation of such specimens at the sources is probably one of the reasons for the deliberate breakage of large-sized (>15 cm) to medium-sized (8–15 cm) rounded cobbles of medium-grained phonolite into several pieces to obtain suitable blanks, probably prior to transport and perhaps at the source, where the raw material was collected.

To a lesser extent, debitage was also conducted on poorer quality cobbles or fragments of cobbles of aphyritic or porphyritic basalts (14%, Figure 1.4). The presence of numerous phenocrystals of olivine and pyroxene within the porphyritic basalts significantly lessens the predictability of flake sizes and morphologies. A series of unmodified cobbles (*n* = 54), mostly rounded cobbles (tested or not) of medium-grained trachyte or fine-grained basalt, were also brought to the site and probably stockpiled as resistant, massive, and difficult to break "manuports". Eighteen heavy and medium-sized rounded cobbles of a resistant medium-grained trachyte bear signs of percussion damage and are interpreted as hammerstones used for knapping most of the cores flaked at the site (Delagnes and Roche 2005). These hammerstones were selected among the cobbles most appropriate for percussion in terms of mass, size, and shape, within the supply of raw materials brought to the site (Harmand 2004).

The differential selection and management of raw materials at the Late Pliocene site of Lokalalei 2C suggests sensitivity to the quality of raw materials and an empirical knowledge of the mechanics of rock fracture from 2.3 myrs onwards. This is in keeping with the new and unexpected results obtained at the Early Oldowan localities of Gona in Ethiopia and Kanjera in Kenya (Plummer *et al.* 1999; Semaw 2000; Semaw *et al.* 2003; Plummer 2004; Stout *et al.* 2005). On the other hand, the selection of particular morphologies (angular clasts) at Lokalalei 2C is tied to the level of skill mastered by the knappers.

MORE ABOUT SELECTION IN THE PLEISTOCENE

Oldowan

The selective attitude towards raw materials highlighted for the Early Oldowan of Lokalalei 2C is documented to an even higher degree for the Oldowan of Kokiselei 5, *ca.* 1.70 myr, where the same medium-grained phonolite accounts for a higher proportion of the on-site raw materials (68% against 52%, Figure 1.4). Moreover, selection at the sources within the phonolite group was more important, since the medium-grained type of phonolite is a minority (see Figure 1.3). In addition, two types of productions, 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, from where an estimate of 170 cobbles or fragments of cobbles were brought to the site.

Small to medium-sized cobbles (angular and rounded) or fragments of cobbles[5] of the medium-grained phonolite were used for debitage reduction sequences to obtain flakes (74% of the flakes and flake fragments, *n* = 998). To a lesser extent, debitage was also conducted on lower quality cobbles or fragments of cobbles of aphyritic or porphyritic basalts (20% of the on-site raw materials, Figure 1.4), as well as on the poorly represented trachytes, rhyolites, syenites, and siliceous rocks (a total of 6.5%, Figure 1.4).

Larger blocks of medium-grained phonolite, fragmented prior to their transport to the site, were selected for the manufacture of heavy-duty tools (22 cm maximum dimension, 2.5 kg) (only 1% of the lithic assemblage). In addition, the lithic assemblage includes 138 cobbles consisting mostly of rounded cobbles (tested or not) of fine-grained aphyric or porphyric basalts, possibly stockpiled to serve as resistant and massive "manuports" and/or hammerstones (Harmand 2005).

Thus, around 1.7 myr in the Nachukui Formation, there is some evidence that distinct provisioning patterns came into play for distinct morpho-(functional?) ends. Furthermore, the debitage systems appear less constrained by the initial morphology of the raw materials available at the sources. Indeed, at Kokiselei 5, the knappers display for the first time the ability to modify the initial morphology of the raw material by creating new striking platforms, rather than always using **naturally** serviceable ones (Texier *et al.* 2006). This is probably why they did not find it necessary to select only angular cobbles at the sources, or to conduct debitage on the deliberately fragmented larger blocks of medium-grained phonolite, as at Lokalalei 2C: these fragments were transformed into heavy-duty tools. Finally, the Kokiselei 5 knappers had the ability to tackle small volumes, as testified to by the flaking of a chert block – a very unusual raw material in this assemblage.

EARLY ACHEULEAN

The Early Acheulean assemblage of Kokiselei 4, *ca.* 1.65 myr, is characterized by the appearance of large handaxes or proto-handaxes and picks, alongside a flake production (Texier *et al.* 2006). New volumes are exploited to create specific tools through bifacial shaping,[6] involving a measure of anticipation in the selection of raw materials suitable for such a purpose in terms of quality, size, and morphology.

Accordingly, the site was provisioned mainly with large flat slabs (length >20 cm) of a medium-grained phonolite (68% of the on-site raw materials, Figure 1.4). Selection at the sources was high since such rocks and such dimensions are poorly represented in the nearby conglomerates (see Figure 1.3). The initial selection of a hard-wearing high-grade raw material from which blanks with a specific morphology (large flat elongated flakes) could be easily obtained, enabled the knappers to maximize tool sizes and to produce large handaxes and picks (n = 35) through a shaping reduction system. As a result, the flakes produced have relatively high dimensions (20 cm maximum length) and display long sharp cutting edges, serviceable without any transformation by retouch.

Because of the disturbed archaeological context and the small amount of material recovered (191 pieces), it is difficult to assess the relative importance of the shaping and debitage systems in the assemblage. Firm evidence of the latter is however provided by 11 cores, made from small cobbles of medium-grained phonolite.

ACHEULEAN

In the assemblage of Nadung'a 4 the large cutting-tools characteristic of the Acheulean, handaxes and cleavers, are lacking, and the heavy-duty component is small (10 "worked pebbles"). However, the assemblage is remarkable in many respects, among which is the use of raw materials hitherto barely represented – rhyolites – for the exclusive manufacture of a new toolkit of "light-duty tools" (*sensu* M. Leakey 1971).

The high proportion of small elements (length <2 cm), the significant quantity of cores, and the presence of hammerstones are consistent with knapping activities carried out on the spot. An estimate of 170 blocks and cobbles were introduced into the site from the nearby sources.

Raw material type frequencies show a marked increase in the amount of rhyolites (65% of the on-site raw materials (Figure 1.4), which were rarely exploited during Late Pliocene and Early Pleistocene time period. This involves a high degree of selection at the sources, since rhyolites are quite uncommon (see Figure 1.3). The medium-grained phonolite was also used, to a lesser degree (21%, Figure 1.4), and this also testifies to selection at the sources, where this raw material is a very small minority (see Figure 1.3).

At Nadung'a 4, the knappers judiciously exploited the rocks according to their petrographic properties, for the purpose of carrying out various processing tasks, probably partly connected with the presence of an elephant carcass (Delagnes *et al.* 2006). The study of the relationship between raw materials and artifacts highlights different behaviors depending on the type of raw material used.

On the one hand, rhyolite was exclusively used to produce flakes and obtain cutting edges. Mostly red, sometimes green, and more seldom gray, brown, or yellow, rhyolite is a fine-grained raw material. Despite the fact that this rock frequently occurs as small diaclasic angular blocks, less compact and less homogeneous than phonolites and basalts owing to frequent internal fissures (Harmand 2005), it is very suitable for obtaining hard-wearing and potentially functional active edges (sharp cutting edges resistant to abrasion), using direct hard hammer percussion. At Nadung'a 4, a better controlled production of flakes (Delagnes *et al.* 2006) accounts for the choice of this fine-grained but less homogenous raw material, from which numerous sharp flakes were produced (61% of the flakes and flake fragments >2 cm, n = 2196), serviceable without any transformation by retouch. In addition, notches and denticulates are numerous in the lithic assemblage (n = 410) (Delagnes *et al.* 2006), and these light-duty tools were probably also partly devoted to tasks related to meat processing and consumption activities such as cutting and scraping.

On the other hand, the medium-grained phonolite was equally used for flake production according to the same principles of debitage documented for rhyolite (Delagnes *et al.* 2006), and for manufacturing some heavy-duty tools by simple shaping.

The remaining rocks are those usually found in the region. Represented by large and compact cobbles of phonolite, basalt, or trachyte (maximum length: 24 cm; maximum width: 12 cm), they were used for heavy-duty tools, suitable for activities such as breaking an elephant carcass. The few hammerstones found in the site are medium-size cobbles of quartz, basalt, or phonolite, appropriate for hammering hard rocks.

Around 0.7 myr in the Nachukui Formation, the procurement and exploitation patterns point to more highly selective raw material provisioning. Furthermore, the selection of different types of rocks appears very closely linked to specific types of products. This is interpreted as the result of higher requirements in terms of technical efficiency, as indicated by the presence of notches and denticulates, requirements that could best be met by the use of rhyolite (Delagnes *et al.* 2006).

CONCLUSION

Usually focusing on more recent periods of Prehistory, the present techno-economic study applied to rich and well-preserved Early Oldowan, Oldowan, Early Acheulean, and Acheulean lithic assemblages from the West Turkana region has proved relevant for investigating how raw material procurement activities are economically structured in the Early Stone Age, and for monitoring behavioral differences between complexes from the Late Pliocene, the Early Pleistocene, and the very beginning of the Middle Pleistocene. Early hominin provisioning behaviors in the Nachukui Formation show the antiquity of decision-making in ancient contexts (selection of raw materials for their flaking quality, size, and/or morphology as early as 2.3 myrs), and the existence of a higher degree of technological planning than previously acknowledged for the Early Oldowan. Furthermore, the techno-economic analysis has highlighted significant changes in raw material procurement and exploitation during the Plio-Pleistocene. In the Pliocene, selection is largely determined by the knappers' technological limitations. During the Pleistocene, selection bears increasingly on rocks best suited in terms of quality and morphologies to more varied templates (light-duty/heavy-duty tools). These could take shape as a result of the development of higher technical skills, and possibly higher cognitive capacities. The results of this study are consistent with the idea of a gradual improvement in technical efficiency throughout the Plio-Pleistocene related to distinct hominin species or genera with different levels of technical capabilities (*Paranthropus*, *H. aff. habilis*, *H. erectus*). They lend strong support to recent investigations on early hominin lithic production, which reveal a much more complex picture of the first technological manifestations, suggestive of temporal variability in the technical systems documented for the African Oldowan (Roche 2000; Martinez-Moreno *et al.* 2003; Roche *et al.* 2003; de la Torre *et al.* 2003; de la Torre 2004; Delagnes and Roche 2005).

At present, evidence of temporal changes in techno-economic patterns for African Oldowan and Acheulean productions remains limited. More studies based on detailed and comparable techno-economic analyses from a larger number of sites are needed to sketch an overview of potentially different responses to resource availability by Oldowan and Acheulean hominins in terms of raw material selection and management, to make regional assessments and ultimately to generate a clearer picture of the nature and significance of technical changes in the Early Stone Age.

ACKNOWLEDGMENTS

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ENDNOTES

1 The word debitage is used throughout this chapter in its original French meaning as a reflection of a specific reduction process, not as the residue of production.
2 The size, morphology, and cortex of the lavas sampled in primary contexts are very different from those of the cobbles in derived sources. There is no indication in the archaeological assemblages that any raw material was collected in primary context.
3 As evidenced by knapping accidents, which reflect technical deadlocks due to the lack of extensive edges with appropriate striking angles (Delagnes and Roche 2005: 443).
4 Dimensions inferred from refittings (see Delagnes and Roche 2005).
5 Dimensions inferred from refittings (see Texier *et al.* 2006).
6 Shaping refers to a "knapping operation carried out for the purpose of manufacturing a single artifact by sculpting the raw material in accordance with the desired form" (Inizan *et al.* 1999: 138).

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