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Editorial

Recent discoveries on the evolution of early human behavior at Olduvai Gorge (Tanzania)

For almost a century now, researchers have turned to northern Tanzania's Olduvai Basin as a key testing ground for models of early Pleistocene hominin behavior. The basin is dominated by Olduvai Gorge, a forty-kilometer-long gash at the eastern edge of the Serengeti that preserves, on the one hand, some of the world's earliest anthropogenic sites and, on the other, archaeo-paleontological palimpsests with only marginal input from hominins. The most well-known of these anthropogenic sites is, of course, Level 22 at the FLK locality (aka the "*Zinjanthropus* Floor" or "FLK *Zinj*"), which, a full sixty years after its discovery by Mary Leakey in 1959, remains a primary datum for reconstructions of early Pleistocene hominins and the landscapes they inhabited. Mary Leakey's other excavations in the gorge's lowest depositional units, Beds I and II, uncovered a nearly continuous record of hominin bio-behavioral evolution stretching from approximately two to one million years ago. Working with or inspired by data from Olduvai Gorge, researchers from around the world have built on Leakey's legacy through decades of innovative studies in zooarchaeology, taphonomy, lithic analysis, geology, and paleoecology.

Among those indebted to Leakey's pioneering work is The Olduvai Paleoanthropology and Paleoecology Project (TOPPP), which, since 2006, has organized nearly a dozen full-scale excavations throughout Beds I and II. Over the last decade, TOPPP has made several contributions that, we think, have important implications for our understanding of hominin evolution at Olduvai specifically and during the early Pleistocene of Africa more generally. Perhaps the most exciting is the discovery in Bed I of at least three large anthropogenic sites within the same stratigraphic unit as FLK *Zinj*—an extraordinary opportunity to track behavioral variation across a single paleolandscape at a time when humanity was developing many of its foundational elements (Domínguez-Rodrigo and Cobo-Sánchez, 2017). TOPPP has also uncovered at FLK West in middle Bed II what is among the earliest manifestations, at 1.7 million years ago, of Acheulean technology (Díez-Martín et al., 2015), and evidence for megafaunal exploitation throughout Bed II, expressed most clearly at BK in upper Bed II ca. 1.3 million years ago (Domínguez-Rodrigo et al., 2014). Extensive geoarchaeologial and geomorphological work has documented in great detail the stratigraphic relationships of Olduvai's sites (Uribelarrea et al., 2017), and multiproxy paleoecological analyses have produced precise reconstructions of Olduvai's ancient environments (Arráiz et al., 2017). Lithic analyses, too, have produced significant insights, including the co-existence of Oldowan and Acheulean technologies (Díez-Martín et al., 2015) and the association, through image analysis and predictive modeling, of taphonomic traces on bones to the lithic raw materials that created them (Yravedra et al., 2017). Several hominin remains have been recovered as well, the most spectacular of which is a partial skeleton of a robust australopithecine from BK (Domínguez-Rodrigo et al., 2013).

This special issue of Quaternary International highlights TOPPP's continuing work in the Olduvai Basin. In the first contribution, Domínguez-Rodrigo et al. (2019a) provide micro- and meso-wear data for ungulate dentitions from FLK *Zinj*, DS, FLK North, and BK. The microwear data from FLK *Zinj*, DS, and BK, all of which are anthropogenic, are similar and reflect short-term occupations, while those from FLK North, largely the result of carnivore activity, suggest a more prolonged period of accumulation. The similarities in microwear signal between the penecontemporaneous FLK *Zinj* and DS sites are particularly intriguing. The microwear signal at BK, however, contradicts previous interpretations of the diachronic nature of that site's occupation. While Domínguez-Rodrigo and his colleagues caution that poor enamel preservation and small sample size preclude definitive conclusions, these preliminary results are encouraging. Indeed, given how difficult it is to estimate the accumulation times of early Pleistocene sites, this methodology should complement other approaches.

The autochthony of the Bed I and II sites at Olduvai has long been debated. Many researchers argue that these sites experienced post-depositional disturbance by hydraulic processes and were, in some cases, even transported far from their original depositional loci. Two of the papers address this issue. Martín-Perea et al. (2019) provide compelling sedimentological evidence that the *Zinj* clay—which contains four large anthropogenic Bed I assemblages—formed under very low energy geological processes. They also identify two separate episodes of clay formation, which coincides nicely with the recognition of at least two distinct archaeological levels within the clay. The upshot is that the original configuration of lithic and faunal materials has probably not been significantly modified. Domínguez-Rodrigo et al. (2019b) reach a similar conclusion, as they find that the occurrence of bones from several Bed I and II sites within size, shape, and texture classes closely resembles experimental assemblages in minimally transported or, in some cases, semi-lag, contexts. Both of these contributions highlight the importance of biotic agents to the accumulation of bones and lithic artifacts at many sites.

The co-existence of Acheulean and Oldowan industries at Olduvai Gorge hinges largely on the stratigraphic position of FLK West relative to other Bed II sites. Detailed geoarchaeological work by Uribelarrea et al. (2019) now confirms unequivocally the location of FLK West and its Acheulean artifacts within the Lower Augitic Sandstone of lower middle Bed II and, by implication, their contemporaneity with the Oldowan artifacts at HWK. As Uribelarrea and colleagues point out, this is inconsistent with the idea of slow, anagenetic development of the Acheulean from within the Oldowan tradition. This dovetails nicely with Díez-Martín et al.'s (2019) painstaking analysis of a large basalt handaxe from FLK West. The symmetry, flaking organization, and sheer size (over 30 cm in length and weighing in at just over 3,660 g) of this artifact suggest that the tool-maker may, in their words, have "relied on

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a level of cognitive control not evident for Oldowan knappers." This indicates that many of the sophisticated technological strategies associated with the later Acheulean were in place ca. 1.7 million years ago—at least within one community of hominins in the Olduvai Basin.

Sánchez-Yustos et al. (2019) examine the evolution and diversification of Acheulean technology at SHK, a site in middle Bed II and one of the very few that Mary Leakey used to define and characterize the Developed Oldowan B (DOB) tradition. Their techno-economic analyses identify highly structured reduction sequences, and the assemblage's Acheulean affinities validate the growing consensus that the DOB is not, in fact, a distinct cultural entity. Explanations of technological variability in the Acheulean also need to account for site function. Unfortunately, as Panera et al. (2019) point out, interpretations of Acheulean site functionality are often unsatisfactory because of poor faunal preservation and significant post-depositional alteration. The *Sivatherium* Floor at the site of TK (TKSF) in upper Bed II is, without a doubt, one of the most impressive archaeological accumulations in the gorge. In this issue Panera and colleagues present an in-depth analysis of the Acheulean lithics and megafaunal remains (highlighted, of course, by several complete *Sivatherium* bones) from TKSF. Despite poor cortical surface preservation, three cutmarked bones are present, which suggests that the lithics were used for carcass butchery. This interpretation is strengthened by sophisticated spatial statistics that show the lithic and faunal remains are largely *in situ* and, in several areas of the site, spatially co-dependent. They contrast this with an underlying archaeological level, the TK Lower Floor (TKLF), where a techno-economically distinct lithic assemblage is preserved with, but is functionally unrelated to, an assemblage of faunal remains. Panera et al. stress that without functional context, these two lithic assemblages may be erroneously assigned to different cultural stages rather than functionally discrete components of the same technological system.

The lithic assemblages from TK and many other archaeological sites in the gorge are dominated by quartz-rich metamorphic artifacts. These rocks come from Archean-aged inselbergs that rise above the basin's grasslands. The most conspicuous of these is Naibor Soit, whose southern extension lies within just a few hundred meters of TK and less than 2 km from FLK *Zinj* and the other junction sites. Bello-Alonso et al. (2019) present micro- and macrowear data on experimentally produced Naibor Soit flakes used to cut, peel, and saw various plants and to butcher carcasses. They identify a number of modifications, including the continuity and morphology of macro-scars and micro-traces like striations, pits, rounding, and polish, that can distinguish used from unused edges and hard or abrasive materials from soft materials. Bello-Alonso and colleagues are careful to note, however, that analysts must be familiar with the pre-use morphology of flake edges, since brittle material like Naibor Soit can potentially mimic use-wear traces. Nevertheless, this study lays the groundwork for detailed functional interpretations of Early Stone Age quartz artifacts from Olduvai Gorge.

Mary Leakey argued long ago that hominins in the Olduvai Basin selected stone raw materials based on their suitability for particular tasks and their availability. Egeland et al. (2019) evaluate Leakey's propositions through physical and geochemical studies of several sources of igneous and metamorphic rocks. Using Schmidt rebound hardness tests as a proxy for fracture predictability, they find that the basin's basalts and phonolites are well-suited to the consistent production of complete flakes, while the softer and more friable metamorphic rocks are less so. It appears that hominins in many cases eschewed harder, predictably fractured rocks in favor of more friable ones, perhaps because the latter were more easily procured, produced more durable cutting edges, and/or did not require as much skill or strength to flake. Egeland and colleagues also report that macroscopically similar metamorphic outcrops are geochemically distinct enough for multivariate predictive models to correctly assign specimens to the correct source with 75–80% accuracy.

As noted above, megafaunal butchery is well attested throughout the upper Bed II sequence at BK. In their taphonomic analysis of a previously unreported faunal assemblage from BK Level 3b, Organista et al. (2019) identify nearly 100 cutmarked bones, a number that, in proportion to the area excavated, exceeds even the extensively butchered FLK *Zinj* collection. Patterns of skeletal part frequencies, bone surface modifications, and spatial configuration all suggest that the area represented by the Level 3b paleosurface was deliberately selected by hominins in order to carry out the systematic butchery of over twenty small- and medium-sized animals. Courtenay et al. (2019) use 3D geometric morphometrics to compare cutmarks from BK to those produced with experimental flakes knapped from Naibor Soit quartz. Most of the BK cutmarks appear to have been produced with relatively fine-grained varieties of quartz, which suggests that hominins preferentially selected specific rocks among raw material types for butchery activities.

One contribution, that of Maíllo-Fernández et al. (2019), ventures outside the Early Stone Age of Beds I and II and into the Middle Stone Age of the Ndutu Beds. They provide chronometric, geological, taphonomic, and technological data from the Victoria Cabrera Site (VCS), which is the first Middle Stone Age site in the gorge that links secure chronometric dates with lithic and faunal remains. Infrared Stimulated Luminescence places the site's discoid and Levallois-based lithic assemblage between 90,000 and 70,000 years ago, while the fauna reflects a dry, open paleoecological context.

We hope that the studies in this issue build usefully on the work of previous researchers and help to break new ground in our quest to reconstruct the last two million years of human evolution.

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