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Provenience, Age and Associations of Archaic *Homo sapiens* Crania from Lake Eyasi, Tanzania

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Fifty years ago, an ethnographic expedition found primitive human fossils at Lake Eyasi, Tanzania. Subsequent emphasis has centered almost exclusively on cranial morphology, neglecting the discovery site and associated finds. Fauna has been deemed "essentially modern" and racemization dates suggest a late Pleistocene age for the hominid remains; these assessments have been advanced as consistent with a "terminal Middle Stone Age" antiquity. Based on recent observations at the site and new sediment analyses, a provisional sequence is now proposed: an earlier formation, the Eyasi Beds, is distinguished from later Pleistocene deposits, the Mumba Beds, the latter being partially calibrated by uranium series and radiocarbon dates. This evidence indicates that the Eyasi Beds, the probable source of the human fossils, are older than 130,000 years, and the fauna may include seven extinct large mammal species. Documented Eyasi Beds artifacts are mostly unspecialized Middle Stone Age types; no typological or technical features suggest later MSA specializations or innovations foreshadowing Later Stone Age industries. A series of core tools from the lakeshore suggests an industry of Sangoan aspect. All lines of evidence from the locality contradict the young amino acid racemization dates; artifacts and fauna, including archaic *Homo sapiens* remains, are of probable Middle Pleistocene age.

Keywords: TANZANIA, LAKE EYASI, *HOMO SAPIENS*, HUMAN EVOLUTION, PLEISTOCENE LAKES, FAUNAL EXTINCTIONS, SANGOAN, MIDDLE STONE AGE.

Introduction

In sub-Saharan Africa, few localities have yielded diagnostic fossils of early *Homo sapiens*: Elandsfontein, Florisbad, Cave of Hearths (South Africa); Kabwe (Zambia); Eyasi, Laetoli-Ngaloba (Tanzania); Omo-Kibish, Bodo (Ethiopia); and Singa (Sudan). The individuals represented at these sites are not anatomically modern (see Bräuer, 1984; Rightmire, 1984), but they all share a closer morphological resemblance to modern *Homo sapiens sapiens* than to *Homo erectus* (for a dissenting opinion about Bodo see Howell, 1984). In contrast to Eyasi, other archaic *Homo sapiens* are assigned an antiquity which is at least earliest Upper Pleistocene and usually later Middle Pleistocene (Butzer *et al.*, 1969; Klein, 1973, 1983; Rightmire, 1978, 1984; Stringer, 1979; Day *et al.*, 1980; Kalb *et al.*, 1980, 1982; Adamson *et al.*, 1982); their associations are Acheulean, Sangoan or broadly

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MSA artifacts, and a pre-modern (Florisbad-Vlakkraal or Vaal-Cornelia) faunal span with at least 20% extinct large mammal species.

The Eyasi crania are frequently cited for their morphology. Archaic features of the one well preserved skull, Eyasi I, have been debated (cf. Leakey, 1936*a*, 1952; Weinert *et al.*, 1940), but current consensus (Wells, 1957; Tobias, 1962; Protsch, 1975, 1976, 1981; Rightmire, 1975; Howell, 1978, 1982; Bräuer, 1984) indicates their close resemblance to remains from Kabwe (Broken Hill) and Elandsfontein (Hopefield). Eyasi I, racemization dated to ≈35,000 years bp, is being cited as the most recent African archaic *Homo sapiens* example (Protsch, 1981; Howell, 1982); by this reckoning, Eyasi evidence affords the last remaining hook upon which to hang the concept (cf. Butzer, 1971:464; 1977) of Africa as a cultural and evolutionary backwater in the later Pleistocene.

While interest has focused on cranial morphology, site context at Eyasi has been neglected. This situation results from a combination of factors. The discoverer, L. Kohl-Larsen, was not a prehistorian. Professionals assisting in the preliminary publication of the find—Hans Reck in Germany and L. S. B. Leakey in England—had no first-hand knowledge of the locality; initial accounts (Reck & Kohl-Larsen, 1936; Leakey, 1936*a*) are accordingly inaccurate and incomplete. Kohl-Larsen's (1943) fullest report is woven through a verbose account of his African travels. A 1937 reconnaissance at Eyasi by Leakey and the geologist W. H. Reeve was limited, by Kohl-Larsen's absence, to superficial observations; publication of their impressions was delayed to 1946 (Reeve, 1946). Another 30 years passed before a detailed site description (Rafalski *et al.*, 1978) appeared; by then, some faunal remains and artifacts had been lost. Amplified and distorted through time, Leakey's preliminary assessments continue to prevail, particularly in Anglo-American archaeological literature.

Eyasi Basin Geomorphology

The Eyasi Basin is situated at the southern end of the Gregory Rift (Figure 1). The escarpment which dominates the northwestern side of the basin results from trap door faulting (Orr & Granthan, 1931:10–11, 16–17); local base level lies between 600 and 1000 m below the adjacent Serengeti Plains. Volcanic highlands, including Oldeani Mountain and Ngorongoro Crater, rise to the northeast. East and southeast of the lake, broken country tilts upwards towards the Precambrian highlands of Mbulu or towards the Kidero escarpment and another trap door system. Minor faults occur in the area drained by the Mbarai River east of the lakeshore along the flanks of Oldeani (Pickering, 1961).

Some Tanganyika Survey geologists maintained that the Eyasi fault, much less the lake basin, is no older than end Middle Pleistocene (Williams & Eades, 1939; Grantham, 1952). With that understanding, Reeve (1946) simply affirmed a late Pleistocene, but pre-Recent, age for Skull Site strata situated at the modern surface and overlying lacustrine deposits. Other research (Kent, 1941; Pickering, 1961) advocates existence of the escarpment when the Laetolil Beds of Pliocene age were deposited. Recent studies (Hay, 1981) reject these previous views and conclude that the fault has been intermittently active from the onset of the Pleistocene. No deep natural exposures into Eyasi basin sediments exist, nor have they been sounded by coring; thus, the depth of lacustrine accumulations and the time of their inception are unknown.

Natural springs are a common feature of the northeastern lakeshore (Orr & Grantham, 1931:18–19; Tanaka, 1969); they vary from saline to fresh water. Gisimangheda, in the eastern corner of the lake, forms a pond which sustains hippopotamus; three similar springs lie within a 10 km radius. Most seepages are vegetated, slightly raised mires on otherwise barren lake flats; one of these, 5 m across, occurs 1 km east of the Skull Site.

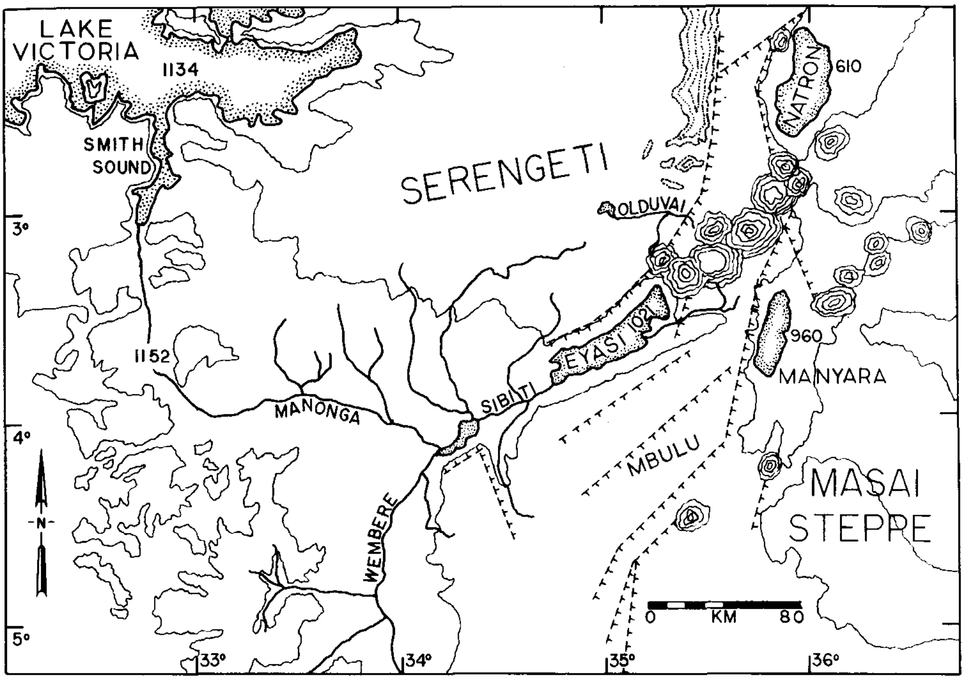

Figure 1. The Eyasi lake basin in regional context; major faults indicated by broken lines; the single contour line indicates 1220 m; volcanic centers represented by irregular concentric circles; altitudes in meters.

The Quaternary history of Eyasi may have been intricate; Lake Victoria overflow possibly reached this basin via Smith Sound and the Manonga/Sibiti river drainages (Hurst, 1957:157–158; Temple, 1964, 1967). Lacustrine deposits to the southwest, the Manonga–Wembere lake beds (Teale, 1931:3,5,33; Williams, 1939:9; Williams & Eades, 1939:6,8–9; Grantham *et al.*, 1945:4,16), appear to be Pleistocene on the basis of terrestrial deposits with vertebrate remains at Tinde (Grace & Stockley, 1930; Hopwood, 1931); their extent and age, as well as their relationship to either Eyasi or Victoria (Stockley, 1929:22–23; Grantham, 1952), have yet to be seriously explored. Given modern relief, a rising Lake Eyasi would back up via the Sibiti into the Wembere Swamp and along the Manonga River; a controlling location for overflow from such an expanded lake has not been determined.

Lakeshore Localities

Kohl-Larsen discovered fossilized hominid remains in an area which he called the "fossile Bank in der Westbucht" ("Western Embayment"); the Eyasi I cranium fragments were collected there at a point near the shoreline (Skull Site) in 1935. The site lies about 3 km west of a large rockshelter called Mumba (Figure 2). A second surface scatter, the Nordostbucht ("Northeastern Embayment") situated 5+ km northeast of the Skull Site, was also extensively collected that year. Kohl-Larsen returned to the Westbucht in 1938, finding other surface hominid remains (Eyasi II and III) and undertaking test excavations in order to augment collections and clarify stratigraphy.

Kohl-Larsen, Leakey and Reeve believed the surface accumulations originated from recent deflation of a reddened, partially consolidated sand—Kohl-Larsen's "upper

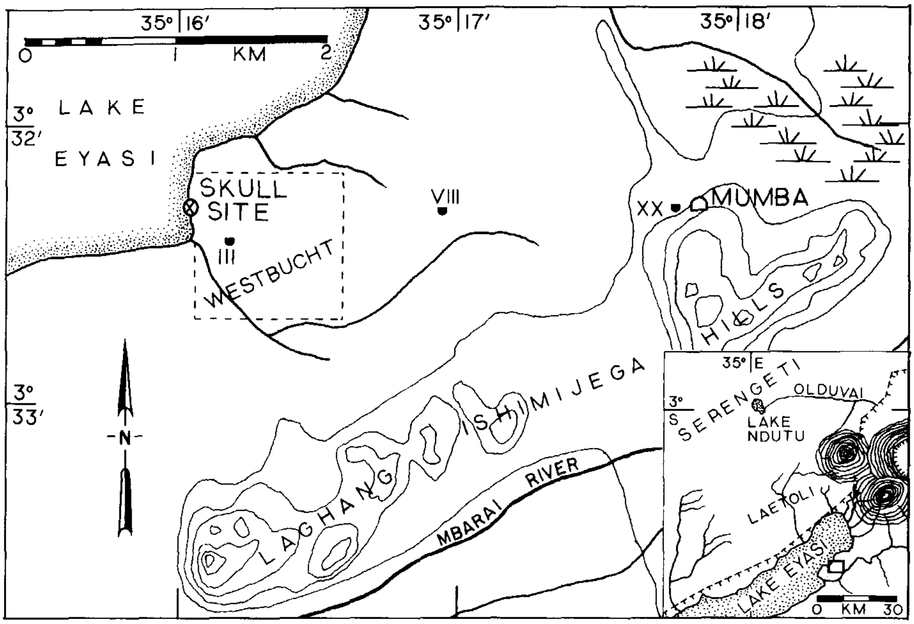

Figure 2. Location of Eyasi Skull Site in the Westbucht and relationship to Kohl-Larsen's Excavations III, VIII, XX and Mumba Shelter. Inset relates site (in box) to Laetoli.

sandstone" ("oberer Sandstein")—thereby leaving bones and tools exposed on a gray-green clay surface. Ikeda (1967, no date) cites a similar context for two hominid mandible fragments at a locality called Banghani, 7 km northeast of the Skull Site; this approximates to Kohl-Larsen's Nordostbucht area.

All Westbucht hominid fossils were recovered on the surface (Reck & Kohl-Larsen, 1936:434). [See Mehlman (1984) for a fuller discussion in view of contrary assertions by Protsch (1981).] However, adhering matrix on most Eyasi I fragments was thought to refer them to the "Upper sandstone", and Kohl-Larsen (1943: Vol. II, 154) observed that several pieces of the cranium appeared to be embedded in the exposed surface of the deposit. Protsch (1981:37) relates cleaning "fine red sand" from 80% of these bone fragments.

In conjunction with later Quaternary archaeological research (Mehlman, 1977, 1979), I inspected the lake flats west of Mumba. Kohl-Larsen did not specify location of the Skull Site, but Reeve (1946) took compass bearings on nearby landmarks from the site during his 1937 visit; those bearings led me to the locality in 1977. Kohl-Larsen's photographs were consulted in the field in 1981 as a visual triangulation on the background hills; they verify that the 1977 scatter coincides with the Eyasi I discovery site. I found artifacts and fossils resting on lacustrine clays, adjacent to remnant patches of reddish-brown, zeolite-cemented, clay-pellet aggregate; several clasts of altered trachytic vitric tuff were also present on this surface.

Stratigraphic Relationships at Eyasi

Reck & Kohl-Larsen (1936:406–8,415) originally identified a terrestrial sandstone, locally reddened and interbedded with lacustrine marls containing fish bones, as the source of the mammalian fauna and artifacts. Reeve's (1946) observations were in agreement, designating the deposit a "reddish, ill-consolidated sandstone" containing mammalian fauna; he described the upper part of this unit as darker red and cemented by "lateritic material". Reeve also sampled a brown or brownish-red "clayey sand with abundant flakes of white mica" as the lowest exposed stratum in each of his sections; believing that the mica in the deposit originated from decomposed bedrock, he interpreted the stratum as an "old land surface on the primitive rock foundation...of gneissose granite".

Kohl-Larsen (1943: Vol. II, 276–9) later proposed a five-fold lithological division of lakeshore strata—"capping horizon" (Deckschicht), "upper sandstone", "lower sandstone", "shale unit" (Lettenschicht) and "sandy shale unit"; he noted that the "upper sandstone", source of fossils and artifacts, was predominantly "medium-fine to coarse-grained sandstone", locally friable and elsewhere hard-cemented by "clayey material" [throughout, translations from original German are my own]. S. Giering-Rafalski joined Kohl-Larsen's 1938 expedition to elucidate stratigraphic matters. She undertook 18 soundings—Excavations (Grabungen) I–VII, IIa–IIg, VIa–VIc, Main Excavation (Hauptgrabung)—in the Westbucht area, 15 of them within 200 m of the Skull Site. Excavation VIII, 10 m deep, was situated roughly equidistant between the Skull Site and Mumba; an 8·5 m pit, Excavation XX, was sunk at the foot of the Mumba talus slope. Spatial relationships of several of these sections to Mumba and to Reeve's Section "A" are indicated in Figures 2 and 3.

Rafalski's sediment data (Rafalski *et al.*, 1978:13–18) are limited. Most sections were sampled in the field, but only Excavation VIII samples underwent subsequent laboratory analyses; other lakeshore sediment descriptions represent field approximations to standard texture and color designations. In formal analyses, Bleich (in Rafalski *et al.*, 1978:20–21) appreciates that cemented, reddened VIII deposits are not laterites as Reeve had thought; however, zeolites, clay-pellets, and tuff in that column are overlooked. Pelletoid clay (Price, 1963; Bowler, 1973; Hay, 1976:21) is a key indicator of saline mud flats desiccation; its association with zeolites in specific East African depositional environments (Hay, 1966, 1970, 1976:22–23; 1978) suggests aridity and extreme chemical environments.

These deficiencies and lack of any attempt to relate deposits in the Mumba Shelter to those at the lakeshore prompted my examination of 146 sediment samples: 88 from Kohl-Larsen's Excavations XX, VIII and VIa; 43 from Mumba (34 from my 1977/1981 seasons and 9 made by Kohl-Larsen); and 15 collected at the Skull Site in 1977. Bleich (in Rafalski *et al.*, 1978:16) presents granulometric data for the 38 samples from VIII (his sample "380 cm" should read "280 cm" according to original bag label). My Mumba and lakeshore samples were likewise disaggregated. Another 59 samples from XX, VIa, and Mumba were processed less rigorously: after noting sample color, clay/silt fractions were decanted; sand and gravel sizes were HCl treated to remove $CaCO_3$. All 146 samples were compared at 30 × magnification for their content of claystone-pellets, quartz grains, biotite, zeolitized ash and fish bones. A result of this study is the designation of two formations (detailed below and in Figure 3) in a provisional stratigraphic sequence for this part of the Eyasi basin.

Excavation VIII is proposed as type section for a formation called the Eyasi Beds. Where Rafalski *et al.* (1978:19) subdivided it into four parts ("capping horizon", "upper sandstone", "lower sandstone" and "clay bed") the present study recognizes six divisions. Their "clay bed" (Tonschicht) includes Members E and F of the Eyasi Beds. Member F has very pure lacustrine clays and a basal layer (thickness unknown) of biotite-rich trachytic vitric tuff altered to the zeolite phillipsite (Hay, pers. comm.); in the absence of deeper exposures, this tuff is the lowest known stratum of the Eyasi Beds. Member E is composed of lacustrine clays with fish bones, and three weakly developed clay-pellet

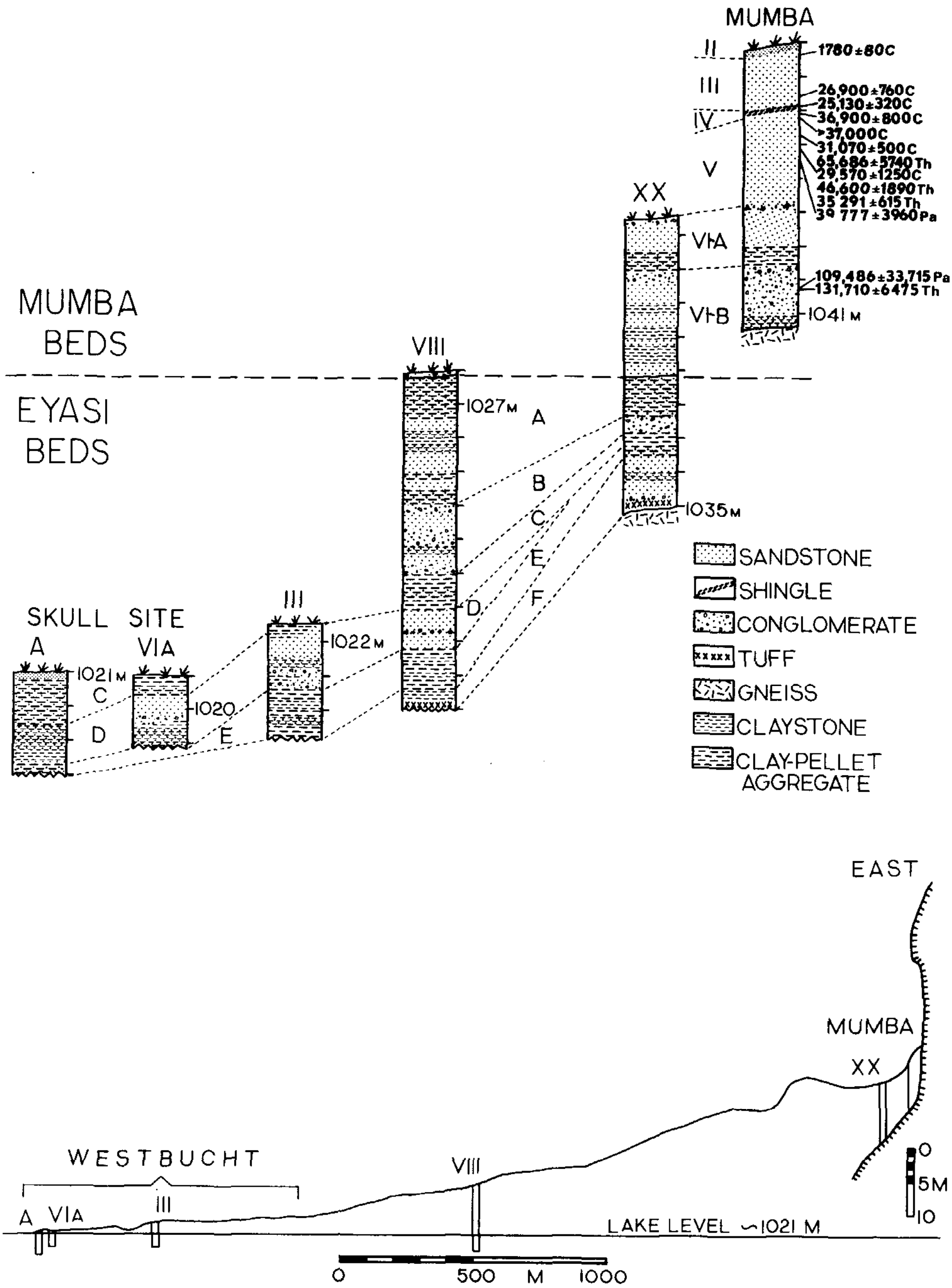

Figure 3. Correlation of sections between Eyasi Skull Site and Mumba Rockshelter; absolute elevation estimates in meters based on data in Rafalski *et al.* (1978). Levelled profile, measured in 1981, has a vertical exaggeration × 20.

horizons (see Figure 3 and Table 1) containing abundant biotite; the clay-pellet levels suggest brief retreats of the lake from VIII levels. Biotite in the sediments (cf. Reeve, 1946) originates from reworked volcanic ash rather than from proximity to bedrock.

Table 1. Westbucht and Excavation VIII section correlations

	Eyasi I Skull Site			
Reeve "A" + "B"	Kohl-Larsen VIa	Mehlman 1977 shore	Kohl-Larsen III	Kohl-Larsen VIII
Eyasi Beds Member C				
Reddish, ill-consolidated sandstone 120+ cm total	5YR 5/6 clay-pellet aggregate 80+ cm total	2·5YR 4/4 clay-pellet aggregate remnant patch	Reddish sandstone remnant patch	5YR 5/6 clay-pellet aggregate 120 cm total
Eyasi Beds Member D				
Concreted limestone Gray-green sandy marl + fish Green-brown sandy marl	10YR 7/3 coarse sand + fish + ash 10YR 6/4 gravelly sand + ash	10YR 5/3 clayey sand + fish + ash + limey concretions	2·5Y 6/2 clayey sand + fish + $CaCO_3$ 10YR 5/3 gravelly sand + ash	10YR 5/4 clayey sand to gravelly clayey sand
Gray-green clayey marl + limey concretions Greenish sandy marl Green clay Greenish sandy clay Beach sand 117 cm total	5Y 7/1 clay + fish 2·5Y 6/2 sandy clay + fish + $CaCO_3$ 2·5Y 6/2 clayey sand + $CaCO_3$ 120+ cm total base not seen	5Y 4/1 clay + fish + ash + $CaCO_3$ 70+ cm total base not seen	5Y 7/1 clay lens + $CaCO_3$ 10YR 6/3 gravelly sand + $CaCO_3$ coarse sand + ash + $CaCO_3$ 190 cm total	10YR 6/4 gravelly clayey sand + $CaCO_3$ 10YR 5/3 clayey sand to sandy clay + $CaCO_3$ 120 cm total
Eyasi Beds Member E				
Brown sand to brownish-red clayey sand + abundant flakes of white mica 120+ cm total base not seen			10YR 5/4 clay-pellet aggregate + biotite 10YR 6/3 sandy clay + ash + $CaCO_3$ 10YR 6/4 clay-pellet aggregate + biotite 5YR 6/4 clay + $CaCO_3$ 5YR 5/6 clay-pellet aggregate + biotite + ash 140+ cm total base not seen	5YR 6/3 pelletoid clay + fish + ash + $CaCO_3$ 7·5Y 6/2 gravelly clay + fish + ash 5YR 5/4 pelletoid clay + fish + biotite 2·5Y 6/2 clay + fish + ash 5YR 5/4 pelletoid clay + fish + biotite + ash 120 cm total
Eyasi Beds Member F				
		[lumps of 5Y 8/2 to 2·5Y 8/2 trachytic vitric tuff]		5Y 6/2 clay + fish + ash 10YR 8/2 to 2·5Y 8/2 trachytic vitric tuff 50+ cm total base not seen

Member D of the Eyasi Beds corresponds to Rafalski's "lower sandstone"; in VIII it is a sandy deposit containing variable quantities of gravel and clay-pellets. The sediments suggest lacustrine near-shore or beach deposition, rather than fluvial agency as proposed by Rafalski. Member C is approximately the same as Rafalski's "upper sandstone". In section VIII it is a clay-pellet aggregate, cemented by analcime. Member C sediments do not represent "variable terrestrial, lacustrine and fluvial properties" as Rafalski claims; they are aeolian, cemented by zeolites.

Rafalski's "capping horizon" includes Members A and B of the new formation. These units contain the same kinds of sediments as described above for Members C and D. Contrary to Rafalski's estimate, these deposits do not represent "latest Pleistocene and Holocene pluvial episodes". They are indicative of a much older, extended interval of fluctuating low lake levels and extreme chemical environments.

At the 1977 lakeshore, bones, artifacts and clasts of trachytic tuff coated with carbonate-cemented conglomerate were lying on the surface of a dark gray (5Y 4/1) clay containing fish bones. Trenching revealed up to 30 cm brown (10YR 5/3) clayey sand overlying at least 40 cm clay. The clayey sands best compare (Table 1) with the top 1 m in Kohl-Larsen's Excavation III; underlying clay compares to deposits 1·6 m deep in Excavation VIa. Derived tuff fragments occur at the sand/clay contact in the 1977 sections, also in coarse sands below 1·3 m depth in VIa, and at 1·2–1·4 m depth in Excavation III. A surface patch of cemented, reddish-brown to weak red, claystone-pellet aggregate sampled in 1977 resembles deposits of the top 80 cm of Excavation II and VIa in color, texture and content; it is a remnant of the "upper sandstone". Sediments exposed at the 1977 locality are therefore judged to represent Members C ("upper sandstone") and D ("lower sandstone") of the Eyasi Beds.

The Eyasi Beds are defined as a formation at least 11·5 m thick. Reddened (2·5YR to 5YR), zeolite-cemented, clay-pellet aggregates (Members A, C, E) alternate with lacustrine clays, sands and gravels (Members B, D and F) of different hue (brown 10YR to dark gray 5Y). Age is estimated as later Middle Pleistocene, in part on the basis of demonstrably Upper Pleistocene deposits stratigraphically overlying them (the Mumba Beds, see below). Eyasi Beds strata indicate fluctuating low (Members A, C, E) to moderate (Members B, D, F) lake levels in the basin during a prolonged interval of strong alkaline chemical environments under the influence of an arid climate. Deposits of the formation are exposed in all lakeshore sections, in the VIII type section and in Excavation XX.

A contact between the Eyasi Beds and younger sediments occurred in Excavation XX at a depth of 4·7 m (Figure 3). Reddened deposits of the earlier formation clearly contrast with overlying pale brown to light brownish-gray gravels, clayey sands and sandy clays containing fish bones. These younger strata compare to those of Bed VI in the Mumba Shelter at approximately the same absolute level. In particular, brown/pale brown gravelly clayey sand at 8·4 m deep in Mumba deposits is the equivalent of gray/pale brown clays 2·2–2·8 m deep in XX; overlying clayey sands and gravels in XX (light yellowish-brown/pale brown) compare to clayey sandy gravels (brown/pale brown) in Mumba unit VI-B. Pale brown clay-pellet aggregate at the base of Mumba VI-A correlates to light yellowish-brown/pale brown clayey sand with abundant clay-pellets at 0·8–1·5 m depth in the XX section.

The Eyasi Beds are therefore stratigraphically lower than either the deposits in the Mumba Shelter or the upper part of Excavation XX. These more recent sediments are hereafter termed the Mumba Beds. Mumba deposits were briefly described by Kohl-Larsen (1943: Vol. II, 310–313), and formal analyses of some soil samples were undertaken by Lais & Schmid (1952); I have retained (Mehlman, 1979) and augmented (Bräuer & Mehlman, in press) their nomenclature to indicate informal members in the Mumba Beds proposed here. This younger formation is > 10 m thick. Except for Bed VI-B described above, and Bed IV as outlined below, deposits in the shelter consist primarily of light yellowish-brown to pale brown aeolian sediments mixed with grus from weathering of the quartzo-feldspathic gneiss walls. In a preliminary report on the Mumba Shelter (Mehlman, 1979: figure 5), I described various deposits as "red", "reddish" or "reddish-gray"; subsequent reference to a Munsell Soil Color Chart has determined that the only reddened Mumba deposit is Bed II at the top of the sequence.

Chronometric dates and associated artifacts support an Upper Pleistocene and Holocene assignment for the Mumba Beds. The informal members are listed from older to youngest.

Bed VI-B: Fluctuating high lake, at least 20 m above present level; concordant uranium series dates on bone from 7·1 to 7·4 m depth in the Mumba Shelter: 230-Th at 131, 710 ± 6475 years bp and 231-Pa at 109,486 ± 33, 715 years bp (No. 82–19, USGS laboratory of J. L. Bischoff); associated with MSA artifacts and "anatomically modern" human teeth (Bräuer & Mehlman, in press).

Bed VI-A: Lake flats desiccation indicated by claystone-pellet aggregate and other aeolian deposits associated with MSA artifacts.

Bed V: Aeolian deposits containing an MSA/LSA intermediate industry; age unresolved, but radiocarbon and uranium series dates suggest antiquity beyond the range of conventional C-14, or > 30,000 and perhaps ≈ 65,000 years bp.

Bed IV: Shingle beach and sands containing fish bones, indicating lake level ± 26 m above present; tufa radiocarbon date 25, 130 ± 320 years bp (USGS-1505, courtesy of S. W. Robinson and K. Lajoie).

Bed III: Lower clayey sands containing a Nasera-like MSA/LSA intermediate industry radiocarbon-dated to 26,900 ± 760 years bp (ISGS-566); upper clayey sands with quartz LSA industry and Kansyore pottery sherds dating to ≈ 5000 years bp; charcoal date of 1780 ± 80 years bp (ISGS-565) near top of deposit probably associated with artifacts and human burials intrusive from above.

Bed II: Reddish-brown silty sand containing Pastoral Neolithic and Iron Age pottery and a microlithic obsidian industry.

Geochronology of the Eyasi Beds

Two amino acid racemization dates are the only absolute age assessments on items of Eyasi Beds origin. A fragment of Eyasi II calibrates to 34,000 years bp (Bada & Protsch, 1973; Protsch, 1981:128) and a piece of Eyasi I to 35,600 years bp (Protsch, 1976, 1981: 128). Protsch defends these dates by uncritical and distorted references to the preliminary reports of Leakey, Reck and Kohl-Larsen (Mehlman, 1984). He claims the dated Eyasi I fragment was an "expedient" choice because microanalyses indicated the piece had a "much higher" amount of nitrogen than most of the other hominid fragments (Protsch, 1981:72); this nitrogen content, "a direct indication of higher organic content", signals the suitability of the specimen for amino-acid dating. However, Protsch's own data reveal that nitrogen amounts in Eyasi I fragments range between 0 and 0·02%; he variously lists the dated piece at 0·01% (Protsch, 1981:83) and 0·02% (Protsch, 1981:165). These trace amounts indicate insufficient organic content for dating purposes.

Bones low in organic nitrogen yield inaccurately young aspartic acid ages (Bada, 1981). Moreover, bones exposed to damp conditions or periodic inundation experience particularly complicated racemization reactions (Hare, 1980; Zurer, 1983); in an aquatic environment, amino acids in bone become significantly leached, so that surviving amino acids are the least racemized and calibrate younger than true age. Thus, the Eyasi I fossils meet several criteria for achieving spuriously young racemization dates. The amino acid content in a bone sample from the 1977 surface proved too low to obtain an allo-isoleucine/isoleucine date (J. L. Bada, pers. comm.).

Dating of Skull Site bone by uranium series analyses has not been successful. Two different specimens, a mammalian longbone shaft collected in 1977 and an Eyasi I cranium fragment, yielded unreliable results; J. L. Bischoff (pers. comm.) attributes the error to "gross contamination of Th as indicated by high 232-Th activity" and an excess of daughter elements indicated by dpm/g 232-Th/234-U in excess of unity. The Eyasi I fragment (Biscoff in Protsch, 1981:128–132) had Th 1500·0 ppm and U 230·0 ppm; the 1977 bone shaft (sample No. 82–17 in the USGS laboratory of J. L. Bischoff) registered 232-Th at 1533·8 ppm and 238–U at 308·4 ppm.

Current prospects for direct dating of Eyasi Beds strata are poor, but a minimum age for the top of the formation is indicated by dates from the overlying Mumba Beds. The most reliably calibrated sector in the Mumba sequence is the base of Bed III and the shingle beach deposit IV, situated approximately 2 m deep in the section (Figure 2). Assuming an average deposition rate of 1 m in 13,000 $\pm$ 500 years, then the base of Mumba Beds deposits would be 130,000 $\pm$ 5000 years bp; this estimate compares well to the 131,000 bp uranium series date from deposits of Bed VI-B at 7·1–7·4 m depth. Using the same rate of deposition, deposits at 7 m deep should register $\approx$ 91,000 $\pm$ 3500 years bp. According to these calculations, the uranium series date for VI-B seems too old; however, some allowance must be made for compaction of earlier sediments, and an estimated rate of 1 m per 13,000 years is probably most accurate in calibrating deposits of Members II–V in which substantial human refuse contributed to a more rapid accumulation of strata than had previously prevailed. Additionally, the Bed IV shingle beach truncates underlying Bed V deposits so that some sediments of the earlier unit are missing from the stratigraphic column.

Applying the radiocarbon-based rate to the 11·5 m thickness of the Eyasi Beds gives a duration of about 150,000 years for that unit and an age of 275,000 years bp for the trachytic tuff in Member F. If the uranium series date from VI-B is used to infer a sedimentation rate of 1 m per 17,300 years, then the top of the Eyasi Beds calculates at $\approx$ 173,000 years bp, and the ash at its base to $\approx$ 372,000 years bp. These extrapolations to Eyasi Beds deposits are purely speculative, since deposition would have varied according to lake level fluctuations and tectonic trends; nevertheless, they consistently indicate a later Middle Pleistocene age for the formation.

Tectonics and Tephra at Eyasi

Previous studies claim an absence of volcanic material in lakeshore deposits and assert their undisturbed horizontal orientation. By implying that the Eyasi Beds were laid down after regional faulting and volcanism had ceased, these allegations contribute to a false impression that the strata have no great antiquity. All such misconceptions need to be jettisoned.

Reck & Kohl-Larsen (1936:416) had the qualitative impression that deposits at the shore were approximately undeformed and horizontal. Reeve (1946:46) levelled the top of a single horizon between his two sections, concluding that they were at exactly the same height as the top of that deposit in Kohl-Larsen's Skull Site pit (Main Excavation); he therefore concluded that the beds show "*no suggestion of dip*" (his emphasis). However, the alignment of Reeve's A and B sections is southwest to northeast, or parallel to strike of the Eyasi Fault; this is the least likely direction in which to measure for dip in this basin, particularly between points less than 100 m apart.

Some of the individual sections of Rafalski *et al.* (1978:104–109) show horizontal contacts between sedimentary layers, but the lateral extent of each pit is too limited to document regional tilting. Although each section was measured in the field, neither vertical nor horizontal relationships between sections were calibrated by surveying equipment; without these spatial controls, it is impossible to judge whether deposits are tilted or not. In this area of obvious tectonic instability, matters of tilting and deformation will require careful attention to levelled features and strata exposed over a distance of kilometers, not meters.

The trachytic tuff in Eyasi Beds Member F has a regional significance. Similar tuff occurs in the upper Ngaloba Beds at Laetoli and in the lower Ndutu Beds at Olduvai Gorge. Biotite-rich trachytic tuff is a unique deposit in each of the three sequences. No other ash has been recognized in Eyasi sediments, whereas Ngaloba and Ndutu deposits are dominated by tuffs and ash of phonolitic, melilitic and nephelinitic composition originating from Kerimasi and Oldonyo Lengai situated northeast of Olduvai (Leakey *et al.*, 1972; Hay, 1976). A possible source of trachytic ash is Oldonyo Dili, about 50 km east-northeast of the Skull Site (Pickering, 1965); otherwise, the fine-grained texture of the trachytic ash at each of the three sites suggests a distant northeastern source or atypical wind direction over the eastern Serengeti at the time(s) of deposition (Hay, pers. comm.).

The lower Ndutu marker tuff at Olduvai appears to correlate to the upper Ngaloba trachytic tuff at Laetoli (Day *et al.*, 1980). A uranium series date of $\approx 129{,}000 \pm 4000$ bp associated with early *Homo sapiens* remains (L. H. 18) immediately postdates the trachytic tuff at Laetoli (Hay, in press); this date agrees with an earlier estimate of $\approx 120{,}000 \pm 30{,}000$ years bp for the marker tuff in the Olduvai lower Ndutu Beds. If these figures are of the right order of magnitude, then the trachytic tuff at Eyasi must represent a separate, earlier eruptive event.

Samples of biotite-rich trachytic tuff from Eyasi and Olduvai were submitted to the U.S. Geological Survey in the hope that their equivalence or dissimilarity might be established; however, they proved too fine-grained and too altered to yield unambiguous microprobe analyses of biotites or any other constituents (André Sarna-Wojcicki, pers. comm.).

Lake Flats Taphonomic Considerations

The Westbucht lakeshore area (Figure 3) is one of low relief. I surveyed a transect from Mumba to the Skull Site at the end of the dry season in March of 1981; the vertical difference between the top of Mumba Shelter deposits and modern lake level proved to be about 28 m. This is 8 m less than the 36 m difference between "lake floor and Mumba Cave" reported by Kohl-Larsen (1943: Vol. I, 76). Since the distance between shelter and shore is 3·25 km, slope averages 9 m/km. Across the Westbucht, however, slope is only 2·5 m/km; over most of this area, deposits of Eyasi Beds Members B, C and D lie adjacent to the modern surface. All sections exposed within 30 m of the skull find–Kohl-Larsen's Excavations VII, VIa and V, Reeve's Pits Nos 1 and 2 (his "A" and "B" sections, respectively)–revealed Member C deposits at the surface (Table 1) or just beneath drifted sand. Given extremely low relief in this area and reddened matrix on Eyasi I fragments, the only reasonable conclusion is that the skull had recently been eroded from Member C when discovered by Kohl-Larsen.

Stratigraphic origin of surface fauna and artifacts at the lakeshore is less certain since they were collected over a much wider area than the Skull Site. Kohl-Larsen and his successors have thought that the bulk of these finds are broadly contemporary with the cranium. This assumption of recent derivation from Eyasi Beds deposits requires further consideration.

On a deflation surface such as the Westbucht, a range of bone preservation types from recent through those in various stages of mineralization and abrasion might be expected, but that is not the case at Eyasi. Only extremes of mineralized fossil bones—either whole and presumably freshly exposed, or highly fragmented splinters with varying degrees of abrasion—and recent, unmineralized, incipiently weathering bone are present. My observations suggest, therefore, that even mineralized bone of the type collected in the Westbucht can suffer fairly rapid destruction after surface exposure; this appears particularly true of cancellous parts and fragile cranial elements.

Any bone on these lake flats is exposed to the usual array of destructive forces including periodic wetting and drying, diurnal temperature extremes, abrasion by wind and water and trampling by animals. Chemical processes, particularly development of salt and alkaline crusts as water retreats with the onset of the dry season, may be the most potent factors in breaking down heavily mineralized bone. This kind of attrition was clearly observable on bone, and even on stone artifacts, which had eroded from deposits between my 1977 and 1981 visits to the Skull Site. Surface bones and stones are periodically saturated by saline, alkaline waters; as these waters evaporate, crystals grow in crevices and incipient cracks of an object, tending to shatter it, much in the manner noted for frost spalling and ice wedging in temperate latitudes. Fossil bone is unlikely to survive in identifiable form very long after surface exposure in this environment.

Stone artifacts are likewise vulnerable to the effects of saline, alkaline waters. Rafalski *et al.* (1978:6, 61) noted that some quartz artifacts encountered in excavation of stratigraphic pits literally came to pieces upon removal; these artifacts may have undergone brine penetration and crystalline growth along plane faces in the raw material. Rafalski believes that this phenomenon accounts for some of the discrepancy in quartz frequency between surface and excavated collections. Some nephelinite artifacts from the 1977/1981 Skull Site surface display encrusted, uneven fracture and spall faces, several of which could be conjoined.

From these various observations—low relief at the lakeshore, presence of Eyasi Beds members B, C and D at the surface, destructive chemical and mechanical forces at work there—Kohl-Larsen's surface collections of identifiable faunal remains may be granted a certain integrity in age. These collections must derive from the middle part of the Eyasi Beds. The foregoing conclusion does not apply consistently to durable stone artifacts; obvious heterogeneity exists in surface artifact samples, as will be considered in a following section.

Finally, a distinction between rolled and unabraded artifacts and fossils does not have the significance that Leakey (1936*a*, 1946, 1952) claimed; an appreciable augmentation of the surface accumulation by pre-Eyasi Beds artifacts or bones transported into the Westbucht from elsewhere is most unlikely given such low relief and the fact that the oldest and lowest natural exposures anywhere between Mumba and the shore are Eyasi Beds deposits. In fact, Schröter (in Rafalski *et al.*, 1978:67) has logically argued that in the process of deflation of overlying strata down to "upper sandstone" levels, items of least antiquity should be most rolled; in other words, the younger the item, the earlier it is deflated, the longer it will remain on the surface, and the more abraded it is likely to become.

Lakeshore Fauna

An impressive fauna, including 32 large mammal species (Table 2), has been identified with the Eyasi hominid crania, although the assemblage combines finds from Nordostbucht and Westbucht. Leakey (1936*a*, 1946) offered a preliminary assessment of the sample based on his brief visit to Berlin in 1936. Detailed identifications were made by W. O. Dietrich (in Reck & Kohl-Larsen, 1936:421–2; Dietrich, 1939, 1942, 1943, 1950; see also Schröter in Rafalski *et al.*, 1978:86–90). Cooke (1963) curiously lists only 24 large mammal species under Eyasi, including *Caracal caracal*, remains of which were not recognized by Dietrich; each of Cooke's omissions, except for "*Alcelaphus*(?) sp.", is a species

Table 2. Eyasi lakeshore mammalian fauna

Common name	Leakey (1936*a*, 1946)	Dietrich (1943)	Cooke (1963)
Giant baboon	*Simopithecus* sp.	*	
Baboon	Baboon	*Papio* cf. *neumanni*	
Mangabey	Small monkey	*Cercocebus* sp.	
Lion		*Panthera leo*	*P. leo*
Leopard		*Panthera pardus*	*P. pardus*
Caracal			*Caracal caracal*
Spotted hyena	Large carnivore	*Crocuta crocuta*	*C. crocuta*
Jackal		*Thos* sp.	
Slender mongoose		*Mungos* cf. *sanguineus*	*Herpestes sanguineus*
Aardvark		*Orycteropus* cf. *aethiopicus*	*O.* cf. *aethiopicus*
Porcupine	Porcupine	*Hystrix* sp.	
Cane rat			*Thryonomys swinderianus*
Spring hare		*Pedetes* cf. *surdaster*	*P. surdaster*
Elephant		*Loxodonta* cf. *africana*	
Zebra	Zebra	*Equus quagga*	*E. burchelli*
Three-toed horse	*Hipparion* sp.	*Hipparion* sp.	
White rhinoceros	White rhinoceros	*Ceratotherium simum*	
Black rhinoceros	Black rhinoceros	*Diceros bicornis*	*D. bicornis*
Hippopotamus	Hippopotamus	*Hippopotamus amphibius*†	*H. amphibius*
Wart hog	Wart hog	*Phacochoerus aethiopicus*	*P. aethiopicus*
Bush pig	Pig	*Koiropotamus* sp.	*P. koiropotamus*
Forest hog	Forest hog	*Sus* sp.‡	
Giant giraffe	Large giraffid	*Giraffa* sp.	
Giraffe	Giraffe	*Giraffa camelopardalis*	*G. camelopardalis*
Giant buffalo	*Bubalus*-type bovoid	§	*Homoioceras nilssoni*
Cape buffalo		*Bubalus* cf. *caffer*	*Syncerus caffer*
Eland		*Taurotragus oryx*	*T. oryx*
Kudu		*Tragelaphus strepsiceros*	*S. strepsiceros*
Grant's gazelle		*Gazella* cf. *granti*	*G. granti*
Thomson's gazelle			*G. thomsoni*
Waterbuck		*Kobus ellipsiprymnus*	*K. ellipsiprymnus*
Kob	Several antelopes	cf. *Adenota kob*	*A. kob*
Reedbuck		*Redunca redunca*	*R. redunca*
Duiker		*Cephalophus* sp.	
Roan antelope		*Hippotragus equinus*	*H. equinus*
Oryx		*Oryx beisa*	*O. beisa*
Impala		*Aepyceros suara*	*A. melampus*
Blue wildebeest		*Gorgon taurinus*	*G. taurinus*
Hartebeest?		*Alcelaphus*(?) sp.	
Hirola or impala?	Extinct antelope?	*Beatragus* (*Damaliscus*) or *Aepyceros* sp.	

*Listed as cf. *Simopithecus oswaldi* by Dietrich in Reck & Kohl-Larsen (1936) and as *Theropithecus* cf. *oswaldi* by Howell (1982).
†At least some of the *H. amphibius* material is *H.* cf. *gorgops* (cf. text of this paper).
‡Listed as *Hylochoerus* sp. in Reck & Kohl-Larsen (1936).
§Described as *Buffelus palaeoindicus* with reference to *Bubalus antiquus* by Dietrich (1950); listed as *Pelorovis* cf. *antiquus* by Howell (1978) and *P.* cf. *bainii/nilssoni* in Howell (1982).

identified by Dietrich on the basis of teeth and often including postcranial remains. The Eyasi collection might well benefit from restudy in light of much larger comparative samples of extant and extinct forms available today than were available to Dietrich in the 1940s; however, most of the fossils are thought to be lost or misplaced in East Berlin.

Leakey (1936*a*) assigned the fauna to the Upper Pleistocene period (his "Gamblian Pluvial"), although he noted a few extinct species. Reck & Kohl-Larsen (1936:423) judged it as "basically recent". Howell (1978:207; 1982:135) cites Dietrich (1939) and Cooke (1963) in designating the collection as "essentially modern in aspect"; he notes only two extinct species, *Theropithecus* cf. *oswaldi* and *Pelorovis* cf. *bainii/nilssoni*, as being represented in a total of 29 larger mammal species.

There are more than two extinct species represented in Westbucht and Nordostbucht collections. Several teeth are attributed to *Hipparion* sp., although Leakey, Dietrich, Reck and Kohl-Larsen have dismissed them as "derived"; however, Dietrich also identified unabraded postcranial remains of a three-toed horse of "Caballus size". *Theropithecus* remains (later attributed by Dietrich to *Papio neumanni*) are not listed as rolled by Dietrich, although Leakey (1946:41) claimed that the "*Hipparion* and *Simopithecus*... in the Eyasi deposits...occur *only as very rolled and derived fossils*" (his emphasis). As noted in the previous section, whatever bones may be abraded, they do not necessarily constitute evidence of derivation from earlier deposits.

Leakey and Dietrich are in agreement that teeth of a large giraffid (*Sivatherium* or *Giraffa jumae*?) are present in addition to anatomically modern *Giraffa camelopardalis*. Leakey thought that a large extinct carnivore was represented in the sample by a half-mandible which Dietrich has apparently attributed to *Crocuta crocuta*. Leakey also included an antelope among the extinct fauna; this may be based on remains including horn cores, teeth and limb bones which Dietrich has described as "*Alcelaphus*(?) sp." and/or "*Aepyceros* oder *Beatragus* (*Damaliscus*) sp."

Collections made in 1977, although small, indicate another extinct species; hippopotamus elements are most conspicuous, not only by their size, but also by frequency. The 1977 sample includes articulating cuneiform, magnus, unciform and metacarpal III–V of a right manus, completely mineralized and black in color. According to both M. D. Leakey and J. M. Harris (pers. comm.), morphology of these bones, particularly the way in which they articulate, is clearly not modern; the pattern most closely resembles that seen in hippopotami of Olduvai and Lake Turkana Middle Pleistocene localities—that is, they are *H. gorgops*-like as opposed to *H. amphibius*. These observations call into question Dietrich's (1939) assertion that *H. gorgops* is not present. In any event, hippopotamus remains are particularly abundant in Eyasi surface collections, Dietrich having estimated a minimum number of 20 individuals.

In sum, at least seven extinct forms probably occur in fauna from the Eyasi Beds: *Theropithecus*, *Pelorovis*, *Hipparion*, a giraffid, a large carnivore, a hippopotamus and an antelope. Counting larger mammals at 32 species then gives a 22% rate of extinctions. This figure compares closely to the 25% (Howell, 1982:133) and 21·7% (Clark, 1982*a*:293) frequencies of extinct forms claimed for Kabwe. Leaving aside more problematic *Crocuta* and antelope identifications, the remaining five extinct species appear also in the Bodo d'Ar fauna (Kalb *et al.*, 1980:114–7; 1982:26); two or three are shared with Kabwe and Elandsfontein, and three are shared with Cornelia (based on lists in Cooke, 1963). *Pelorovis* is the only extinct form which Eyasi seems to have in common with Florisbad.

Man–Land Relationships: A Speculation

When Eyasi Beds Members C was deposited, the lake (if extant) must have been at least as low as at present, and sedimentary evidence indicates a prevailing arid climate. Yet hippopotamus and wildebeest dominate a diverse fauna from these sediments including a number of indicators (bush pig, forest hog, waterbuck, reedbuck and impala) of nearby water and foliage. The simplest hypothesis encompassing this diversity of evidence is that the Skull Site was situated near a major spring in Eyasi Beds times.

Fossils and artifacts may be horizontally clustered in Eyasi Beds Member C; if so, sediments are aeolian and, in any case, generally too fine grained to invoke aggregation of stones and bones by water. An accumulating agent for bones and stones probably was early *Homo sapiens*. However, these localities are unlikely camp sites; modern lakeshore conditions at the Skull Site are harsh, with strong northeasterly winds, flying sand and intense insolation by day. Currently, this bleak locality is unattractive to terrestrial mammals. Locally mitigating factors on these lake flats today are the natural springs.

In an otherwise arid setting, a large spring is a magnet for animals. Archaic *Homo sapiens* would therefore have been attracted in pursuit of food resources, if not water. The vicinity of a water hole is not a likely hominid camp site; at night, with hippopotami and carnivores about, it would be a particularly dangerous locale. Moreover, sustained human presence discourages potential game. However, given sufficient foliage in which to hide, people might have occasional hunting success in this otherwise open environment. Prospects for locating and scavenging kills made by other predators are also enhanced around a spring.

Kohl-Larsen's and Leakey's Artifact Collections

Preliminary assessment of Westbucht and Nordostbucht artifacts was based on collections made during the same season in which the Eyasi I skull was discovered. Leakey and Reck spent a week in Berlin in 1936 sorting through a sample (Reck & Kohl-Larsen, 1936:426). Leakey (1936*a*:1083) concluded that the assemblage was "Levalloisian", containing "tortoise cores" and "characteristic Levallois flakes", only a few of which "showed any signs of retouch", associated with "a very few broken Acheulean hand-axes". Over the years, "Acheulean" hand-axes seen by Leakey in Berlin became "one or two broken and probably derived hand-axes" (Leakey, 1946:42) and were finally described as "rolled and derived" (Leakey, 1952). This dismissal seems inconsistent with Leakey's (1936*b*:61; Leakey & Owen, 1945:50, 54–55) belief that assemblages like Eyasi ("pure Levalloisian") were closely related to Sangoan assemblages having core tools.

Rafalski *et al.* (1978) have now provided details of the 1935/1938 lakeshore assemblages; these are here summarized in Table 3. There are two large surface collections, one each from Westbucht and Nordostbucht. A third, Westbucht *in situ* collection includes several hundred artifacts from Rafalki's stratigraphic pits. Artifacts were recovered in only five of them, but those from the two pits nearest to the Skull Site were lost before they could be analyzed; thus, all that remains from Excavations VI and VIa are three quartz cores and one basalt flake. Other excavated artifacts total 77 from Excavation II at 190 m south of the Skull Site; another 120 items come from Excavation III at 325 m southeast, and 91 are from Excavation IV at 765 m to the southeast.

The sample collected *in situ* is size-biased and typologically limited. Quartz artifacts are about four times more frequent than in surface collections; this abundance is at the expense of both basalt and quartzite, although the latter is particularly rare in excavated samples. A single retouched tool illustrated by Rafalski *et al.* (1978:197, figure 261) appears to be a rolled, unifacial quartz point from the top of Excavation IV; by Rafalski's data (see Rafalski *et al.*, 1978: 14, 233), this piece was recovered from deposits overlying Eyasi Beds Member C. Schröter (in Rafalski *et al.*, 1978:66–68) claims that the *in situ* assemblage is Middle Stone Age (MSA) by definition (see below), as much for its contents as for the absence of heavy-duty tools.

In surface samples as analyzed by Rafalski, heavy-duty tools (Figures 4 & 5) comprise 28% of Nordostbucht tools, but amount to only 5% of shaped tools in the Westbucht. Retouched points are 24% of Westbucht shaped tools, and about 15% of those in the Nordostbucht. Rafalski's small tool categories are only two, retouched points and retouched flakes; most of these small tools are made on fine-grained quartzite, which is

Table 3. Kohl-Larsen's Eyasi lakeshore artifact collections: data reworked from Rafalski et al. (1978)

	Westbucht *in situ*		Westbucht surface		Nordostbucht surface	
	N	%	*N*	%	*N*	%
Core-axes*	—	—	1	0·7	13	13·5
Chopping tools*	—	—	5	3·3	12	12·5
Core scrapers	—	—	2	1·3	2	2·1
Points—unifacial	1	25·0	11	7·2	8	8·3
Points—bifacial	—	—	14	9·1	3	3·1
Points—divers†	—	—	12	7·8	4	4·2
Bifacially modified pieces	—	—	3	2·0	1	1·1
Scrapers	—	—	9	5·9	5	5·2
Backed blades	—	—	2	1·3	—	—
Sundry retouched flakes	3	75·0	94	61·4	48	50·0
Total tools	4	100	153	100	96	100
Sundry cores	105	96·3	374	97·9	242	97·2
Levallois cores‡	4	3·7	6	1·6	7	2·8
Bipolar cores	—	—	2	0·5	—	—
Total cores	109	100	382	100	249	100
Sundry flakes	172	96·1	1050	98·2	809	98·8
Levallois flakes‡	7	3·9	19	1·8	10	1·2
Total flakes	179	100	1069	100	819	100
Total tools	4	1·4	153	9·5	96	8·2
Total cores	109	37·3	382	23·8	249	21·4
Total flakes	179	61·3	1069	66·7	819	70·4
Artifact total	292	100	1604	100	1164	100
Quartz	185	63·3	257	16·0	175	15·0
Quartzite	21	7·2	676	42·2	387	33·2
Basalt	77	26·4	647	40·3	570	49·0
Other	9	3·1	24	1·5	32	2·8

*Rafalski's distinction between core-axes and "chopping tools" is not defined; nine illustrated "chopping tools" from the Nordostbucht (Rafalski *et al.*, 1978: Tafel 42, 44–51) are best classed as core-axes for consistency with African terminology. An illustrated "core-axe" from the Westbucht (Tafel 54,#141) is cited as a "chopping tool" in the list of plates (1978:111) and appears to be a rolled radial core.

†Rafalski's flake tool typology consists of the two categories retouched flakes and retouched points; by reference to the illustrations, I have made some finer distinctions.

‡Neither Levallois flakes nor Levallois cores are distinguished from the bulk of the debitage by Rafalski or Wagner; numbers in the table are minima based on illustrated artifacts.

five to six times more frequent in surface collections than *in situ*. Frequency of basalt artifacts on the surface is about twice that of the *in situ* sample. Heavy-duty tools are made almost exclusively on lavas and quartz. Obvious Later Stone Age (LSA) and Neolithic artifacts, including backed blades, a fresh obsidian bipolar core, ceramics and a polished axe fragment, are also present in the surface samples.

Heavy-duty tools, particularly core-axes, are more frequent in the surface collections than Leakey had realized and they are not rolled. Core-axes have been distinguished from

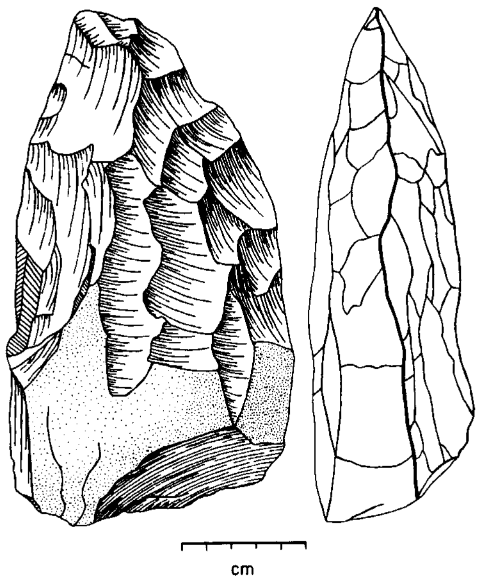

Figure 4. Eyasi lakeshore, Nordostbucht surface: core-axe, diorite, collected by Kohl-Larsen (redrawn from Rafalski *et al.*, 1978: Tafel 43).

hand-axes by their untrimmed butt ends, low flake-scar counts and thick cross-sections (Clark, 1964:317; Cole, 1967:501); these characteristics are evident in the Eyasi core-axe sample (Table 4, Figures 4 & 5), giving some examples the appearance of being unfinished or broken. By emphasizing this component as an integral part of lakeshore collections, Müller-Beck (in Grahmann & Müller-Beck, 1967:133) has argued that the Eyasi industry is Sangoan or Late Acheulean. The combination of core-axes, choppers and core scrapers in some Eyasi samples is in harmony with that described elsewhere as Sangoan.

When Leakey visited Eyasi in 1937, he found two artifacts in "upper sandstone" back-dirt from Kohl-Larsen's pit at the Skull Site. He also picked up others (Leakey, 1946:42) "lying on the... eroded slopes associated with fragments of fossil bone, and clearly being washed out of the bone-bearing sand". Seven of these pieces are now in collections of the National Museums of Kenya, five others being casts of specimens forwarded to the British Museum. They include a small quartz core-axe, a discoidal basalt core, and nine flakes, eight of which are basalt or nephelinite, one with a scraper edge and one with a bifacially modified edge; three unretouched flakes are Levallois.

Ceasing to acknowledge even a qualified presence of hand-axes, Leakey (1974:93) accepted the designation "Middle Stone Age" for Eyasi aggregates. This term was initially applied to South African assemblages of flake tools (especially retouched points) and prepared cores in which core tools, particularly bifaces, were absent (Goodwin, 1928, 1929:98; Malan, 1957). Thus, Leakey's "Levalloisian" concept may be said to convey the sense of early Middle Stone Age; it certainly does not imply terminal MSA features, either technical or typological. In this context, Protsch (1975:316) has confounded time and typological nomenclature by claiming that the Eyasi cranium "belongs to the terminal phase of the Middle Stone Age", basing his conclusion on amino acid dates, not on characteristics of the lithic assemblage.

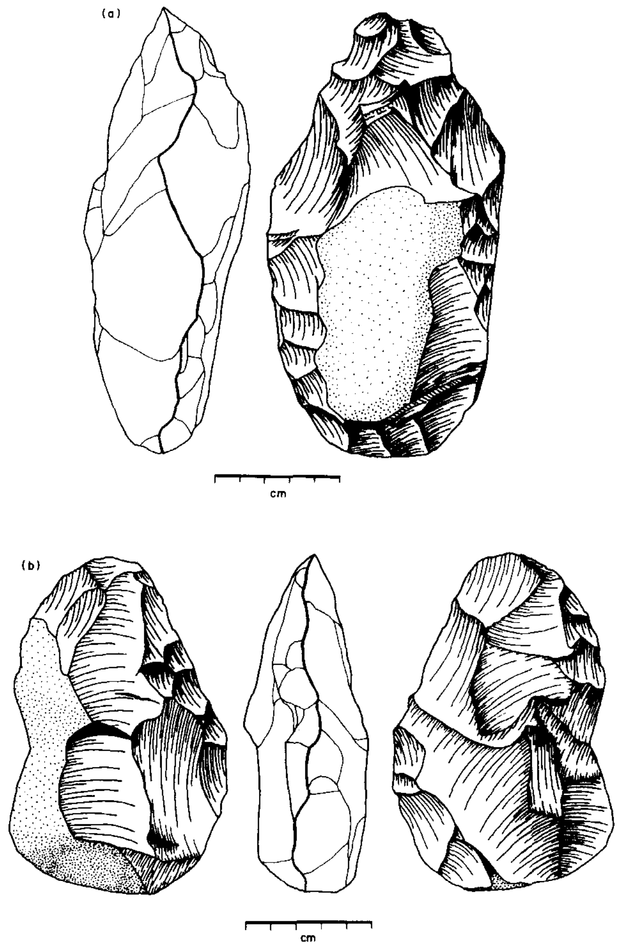

Figure 5. Eyasi lakeshore, Nordostbucht surface: core-axes collected by Kohl-Larsen. (a) diabase; (b) basalt (redrawn from Rafalski *et al.*, 1978: Tafel 44, 51).

Table 4. Core-axe dimensions and standard deviations for East African sites

	Sango Hills Uganda surface*	Gayaza Uganda surface*	Lake Eyasi Tanzania surface†
Mean length (mm)	134	158	169 ± 23·1
Range length (mm)	—	—	210–131
Breadth: length	0·55	0·51	0·63 ± 0·08
Thickness: breadth	0·72	0·66	0·67 ± 0·11
Sample size	4	12	13

*Data from Cole (1967:501).
†Core-axes collected by Kohl-Larsen from Eyasi Nordostbucht.

Table 5. Eyasi lakeshore 1977/1981 artifact assemblage

	Quartz/quartzite	Basalt/nephelinite	Other	Totals *N*	Totals %
Core scraper	3	3	—	6	24·0
Side scraper	1	3	—	4	16·0
Concave scraper	—	—	1	1	4·0
End scraper	1	—	—	1	4·0
Convergent scraper	—	1	—	1	4·0
Scraper fragment	—	2	—	2	8·0
Bec	2	—	—	2	8·0
Bifacially modified pieces	—	3	—	3	12·0
Sundry modified	2	3	—	5	20·0
Total tools	9	15	1	25	100·0
Levallois core	—	2	—	2	8·7
Radial/disc core	2	12	—	14	60·9
Part-peripheral core	—	3	—	3	13·0
Amorphous core	—	4	—	4	17·4
Total cores	2	21	—	23	100·0
Chip/chunk	19	217	—	236	48·5
Flake/fragment	16	211	—	227	46·6
Levallois flake	—	8	—	8	1·6
Core fragment	—	16	—	16	3·3
Total debitage	35	452	—	487	100·0
Total tools	9	15	1	25	4·7
Total cores	2	21	—	23	4·3
Total debitage	35	452	—	487	91·0
Artifact total	46	488	1	535	100·0
Raw material %	8·6	91·2	0·2		100·0

The 1977/1981 Lithic Aggregate

I collected unabraded artifacts from a 4000 m^2 surface at the Skull Site. No other cluster of fossils or artifacts occurred within a kilometer of the locality. The sample (Tables 5 & 6) documents radial flaking of nephelinite and basalt cores to yield large, plain and simple faceted, rarely Levallois, flakes. Neither core-axes nor retouched points were recovered. Heavy-duty core scrapers and bifacially modified flakes (Figures 6–8) are the most distinctive retouched implements, aside from flake scrapers. This assemblage is consistent with Leakey's "Levalloisian" concept as proposed in 1936 and reinforced by his 1937 sample from the site.

Separate outcrops of nephelinite and basalt occur 10 km northeast of the Skull Site, at a point about 2 km east of the Nordostbucht area (Pickering, 1961:6; 1964). Kohl-Larsen (1943: Vol. II, 193–194) mentions one of them as a quarry site; lava there was "of the same material as that from which the core-axes [literally, Faustkeile = hand-axes] were made" and "thousands of individual boulders were observed" at the foot of the hill.

Wagner (in Rafalski *et al.*, 1978) describes lakeshore lithic technology as Levallois. However, he neither specifies dorsal scar patterns or talon facets on flakes nor quantifies the frequencies of the core types he has defined; he provides nothing of comparative potential. My data and the set of Kohl-Larsen's illustrated artifacts indicate that the predominant core form in each lakeshore sample has a pattern of negative scars converging from the periphery on both faces to give a radial effect. The continuum of these cores,

Table 6(a). Mean dimensions in millimeters, standard deviations (range in parentheses) and form ratios of measurable volcanic stone artifacts in the 1977/1981 Eyasi lakeshore collection

	N	Length(mm)	Breadth(mm)	Thickness(mm)	Breadth/length	Thickness/breadth
Levallois flakes	8 (65–32)	44·5±11·0 (72–24)	44·4±14·2 (18–5)	12·5±4·1	0·99±0·16	0·29±0·06
Other flakes	95 (109–8)	44·8±17·7 (79–16)	43·0±14·2 (44–5)	13·7±6·0	1·01±0·27	0·36±0·14
Total flakes	103	44·8±17·2	43·1±14·2	13·6±5·9	1·01±0·26	0·35±0·14
Tools on flakes	6 (73–46)	58·8±9·6 (51–38)	44·7±4·2 (23–15)	17·7±2·8	0·78±0·13	0·40±0·04
Tools on chunks	4 (89–53)	64·3±14·8 (48–38)	42·5±4·2 (32–23)	26·5±3·4	0·68±0·07	0·63±0·04
Radial/disc/Levallois cores	7 (88–38)	51·7±17·2 (59–34)	42·6±8·5 (31–18)	24·3±4·5	0·85±0·09	0·58±0·10
Part-peripheral cores	3 (73–43)	57·7±15·0 (53–42)	46·0±6·1 (44–28)	34·7±8·3	0·82±0·14	0·75±0·08
Amorphous cores	4 (64–36)	54·0±12·4 (54–34)	45·0±8·3 (44–18)	33·5±4·0	0·85±0·12	0·76±0·11
Total cores	14	53·6±14·6	44·0±7·5	29·1±7·0	0·84±0·10	0·66±0·13

Table 6(b). Talon position on 103 whole flakes of volcanic stone

	End-struck	Equidimensional	Side-struck
Number	47	6	50
Frequency(%)	45·6	5·8	48·6

Table 6(c). Talon state on 211 flakes and broken flakes of volcanic stone

	Plain/cortex	Two-facet	Three-facet	Four-facet
Number	118	58	25	10
Frequency(%)	55·9	27·5	11·8	4·7

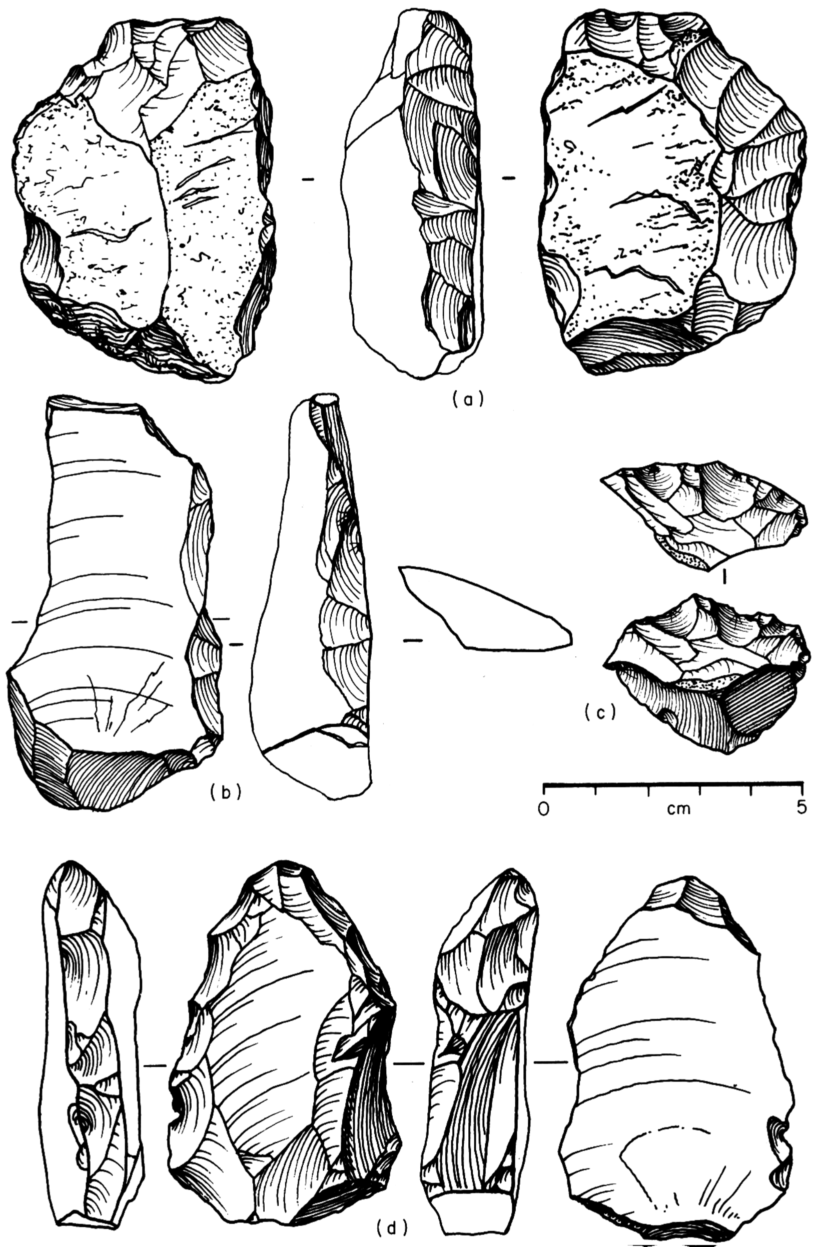

Figure 6. Eyasi lakeshore, 1977 surface: combination core scraper and chopper on a quartz cobble (a); inverse side scraper, nephelinite (b); bec or irregular scraper, fine-grained quartzite (c); side scraper with knife-like cross-section and a bifacial tip, *nephelinite (d).*

from biconic through high-backed radial to discoidal forms, is sometimes lumped with Levallois types as "prepared cores"; but this array is usually divided into various kinds of "specialized" or "regular" cores which are non-Levallois. If Levallois preparation refers specifically to shaping a core with the aim of removing a single flake (several at most), the

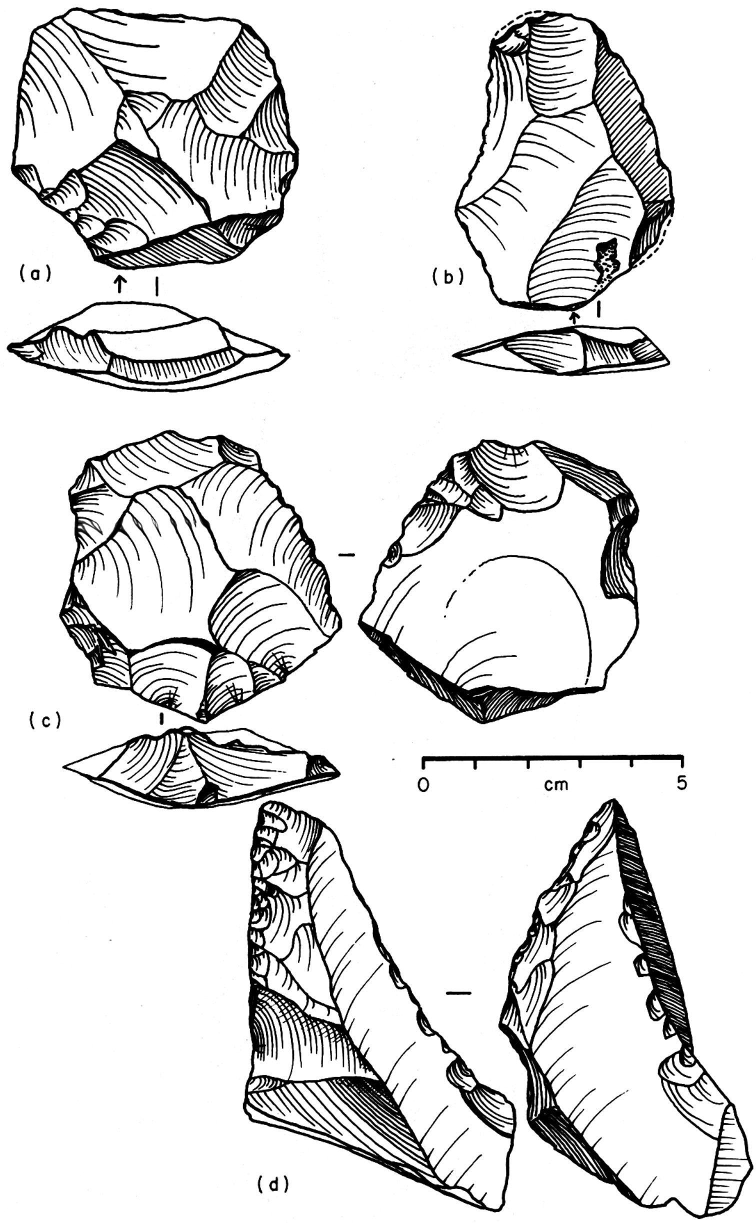

Figure 7. Eyasi lakeshore, 1977 surface: Levallois flakes (a–b); bifacially modified flake (c); core scraper on a chunk (d). All pieces are nephelinite.

plan form of which has thus been predetermined, then examples of such technology are infrequent in the 1977/1981 sample.

Leakey and I recovered artifacts immediately at the Skull Site, and after Kohl-Larsen cleared the surface of the lithic mélange which had accumulated before his first visit.

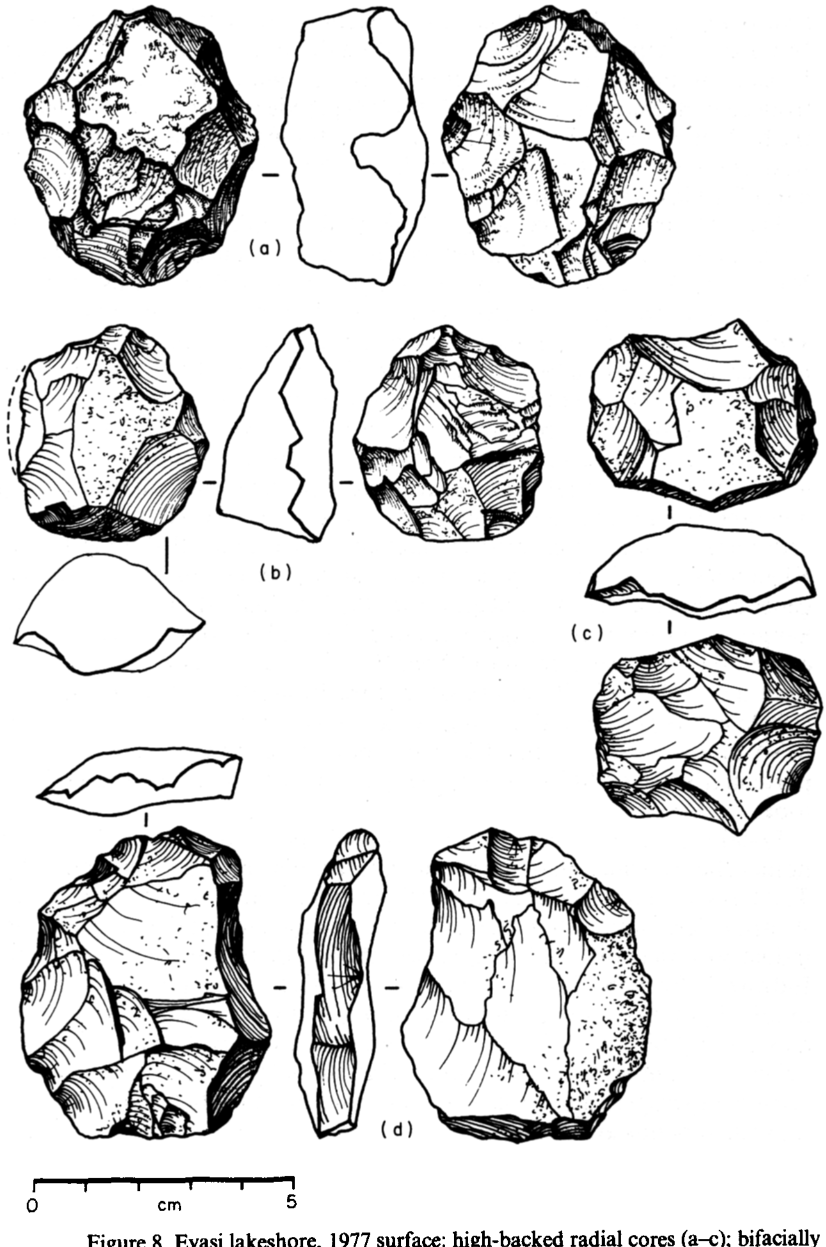

Figure 8. Eyasi lakeshore, 1977 surface: high-backed radial cores (a–c); bifacially modified knife-like piece or disc core (d). All pieces are nephelinite.

These considerations and lack of surface relief at the site are reasons to regard 1937 and 1977/1981 tools and debitage as representing an uncontaminated middle Eyasi Beds sample.

The 1977/1981 assemblage is not obviously Sangoan, since core-axes are lacking. However, a single quartz biface is part of the 1937 sample. Except for three quartz examples, core-axes, picks and bifaces are absent from MSA and LSA assemblages at Mumba. Thus, lava core-axes in the 1935 surface collections are unique. Between the lakeshore and Mumba, no deposits which could yield unabraded core-axes are exposed other than the Eyasi Beds; unrolled core-axes are inconsistent with any argument for their redeposition from distant exposures. Also, these tools are made on raw materials that were favoured for the bulk of verifiable Eyasi Beds artifacts. Although the issue is murky without a detailed stratigraphic correlation of Westbucht and Nordostbucht localities, core-axes are a likely part of the lakeshore industry.

The 1937 and 1977/1981 assemblages have a marked MSA aspect, but they differ from unquestionable MSA industries which I have studied from the Mumba Shelter and Nasera Rock (Table 7). Quartz dominates each rockshelter assemblage from the base of deposits through LSA. At these sites MSA artifacts are markedly smaller in size, and scrapers seem typologically more diverse than verifiable Eyasi Beds counterparts; retouched points occur in all Mumba and Nasera MSA levels, but heavy-duty tools of any sort are rare. The range of core technology differs between Mumba and the lakeshore, and radial/Levallois core types are less frequent in the Mumba MSA.

For the past 20 years in eastern Africa, generic terminology has been used informally to avoid the industrial nomenclature (e.g. Stillbay, Levalloisian, Magosian, Wilton) inherited from a previous generation of research. "MSA" and "Sangoan" are second-order abstractions from primary archaeological data (Bishop & Clark, 1967:861–875; Kleindienst, 1967 and appended discussion); neither of them is a clearly appropriate generic label for the assemblages from the Eyasi lakeshore. A current problem with the Sangoan concept is that aggregates so called, at least those thus far published, are either contaminated or selected (see Cahen, 1978:22); surface collections from the Uganda type localities (Cole, 1967; Posnansky, 1967) are the products of both kinds of distortion. Clark (1982*a*,*b*) has proposed that Sangoan tool sets simply be regarded as components of some MSA industries. I am unenthusiastic about redefining "Sangoan" as an MSA tool kit, particularly since "MSA" was initially formulated to apply to assemblages lacking core tools.

Local units having integrity in time and space must be the foundation for a precise nomenclature which may ultimately allow a new regional synthesis of prehistoric data. The Eyasi assemblages are sufficiently distinct from any at Mumba or Nasera to merit a separate designation, but "Levalloisian" is an unacceptable name for any African lithic industry (Tixier, 1967:813; Clark *et al.*, 1966). I therefore prefer the neutral label "Njarasa Industry", from the Sukuma name for Lake Eyasi, to apply to artifact assemblages of the middle Eyasi Beds. In this industry, primary raw materials are lavas and perhaps quartz; cobbles and blocks of these stones have been radially flaked to produce relatively large flakes and simple flake tools; other angular chunks and cobbles have been trimmed to form core scrapers and choppers. Core-axes are a probable component of this industry; retouched points are doubtful.

The Njarasa Industry occurs in the middle part of the Eyasi Beds, specifically in Members C and D, but is neither necessarily limited to those strata, nor confined to the Eyasi Basin. Parallels have been noted between this industry and that from the Ndutu Beds at Olduvai (Leakey *et al.*, 1972:334–335); resemblances in typology, technology and raw materials are striking (Table 7). The Olduvai Ndutu collections have been described as "a Middle Stone Age industry of somewhat indeterminate character". A similar array of artifacts is also present in the upper Ngaloba Beds at Laetoli (my observations and Leakey, 1979:108).

Conclusions

The foregoing sections clarify matters of stratigraphy, fauna and artifacts at the Eyasi lakeshore. The stratigraphic sequence and taphonomic considerations indicate a middle

Table 7. Comparison of Njarasa Industry and northern Tanzania MSA assemblages; (L = mean length in mm)

	Eyasi 1977/81 Lakeshore			Olduvai Ndutu Beds*			Mumba VI-B	Mumba lower VI-A	Nasera levels 18–25			Mumba upper VI-A
	%	*L*	Range	%	*L*	Range	(%)	(%)	%	*L*	Range	(%)
Biface/other	—	—	—	4·8	72	—	1·6	—	—	—	—	0·5
Core scraper	24·0	61	89–41	—	—	—	1·6	2·0	0·5	100		1·0
Core chopper	—	—	—	9·5	60	71–50	7·4	3·5	—	—	—	1·0
Total heavy duty	(24·0)	—	—	(14·3)	—	—	(10·6)	(5·5)	(0·5)	—	—	(2·5)
Point/percoir	—	—	—	—	—	—	3·3	13·4	13.3	42	73–30	10·3
Small scraper	36·0	52	73–31	19·0	52	62–32	38·1	42·6	35·1	36	65–16	42·9
Other tool	40·0	46	60–36	66·7	—	—	48·0	38·5	51·1	—	—	44·3
Total light duty	(76·0)	—	—	(85·7)	—	—	(89·4)	(94·5)	(99·5)	—	—	(97·5)
Total tools (*N*)	25			21			123	202	188			399
Radial/Levallois	69·6	52	88–34	85·7	59	83–42	18·2	19·8	41·4	40	83–25	21·6
Part-peripheral	13·0	58	73–43	—	—	—	44·1	47·2	23·4	40	76–26	39·6
Platform	—	—	—	—	—	—	5·0	8·5	3·6	27	37–21	12·4
Bipolar	—	—	—	—	—	—	1·8	2·5	9·9	26	37–16	2·8
Amorphous/other	17·4	54	64–36	14·3	57	60–55	30·9	22·0	21·6	37	72–21	23·6
Total cores (*N*)	23			14			220	354	111			777
Levallois flake	1·6	45	65–32	20·0	46	69–34	1·5	2·0	0·2	39	65–25	2·0
Flake/fragment	46·6	45	109–8	38·8	47	80–19	51·6	57·4	24·4	24	72–7	63·8
Chip/chunk	51·8	—	—	41·2	—	—	46·9	40·6	75·3	—	—	34·2
Total debitage (*N*)	487			85			825	911	3290			1692
Total tools	4·7			17·5			10·6	13·8	5·2			13·9
Total cores	4·3			11·7			18·8	24·1	3·1			27·1
Total debitage	91·0			70·8			70·6	62·1	91·7			59·0
Total artifacts (*N*)	**535**			**120**			**1168**	**1467**	**3589**			**2868**
Quartz	5·4			0·8			78·1	74·7	82·9			79·5
Quartzite	3·2			—			10·2	10·0	0·1			10·0
Lava	91·2			99·2			4·2	4·9	0·0			4·4
Other	0·2			—			7·5	10·4	17·0			6·1

*Data from Leakey *et al.* (1972).

Eyasi Beds provenience for the Eyasi I cranium and other Westbucht fossils. Kohl-Larsen's "Westbucht *in situ*" artifacts, Leakey's 1937 series and my 1977/1981 sample are all reasonable correlates of middle Eyasi Beds deposits. Kohl-Larsen's surface lithic samples are an amalgam of items having different antiquities; core-axes, usually considered diagnostic Sangoan implements, comprise the most archaic artifact type in these surface collections.

Eyasi I is an early *Homo sapiens* specimen. A number of extinct genera occur in the Eyasi Beds fauna. The Njarasa Industry from these deposits has a combination of Middle Stone Age and Sangoan features. Youngest Eyasi Beds strata are reasonably assayed at > 130,000 years bp; the middle of the formation could easily be 200,000 years old. These age estimates are provisional assessments based on agreement of as many factors as are presently available for consideration.

Local observations at the Eyasi lakeshore and at Mumba are consistent; they mutually accord with regional evidence including the long archaeological sequences established on the Serengeti Plains at Nasera Rock and Olduvai Gorge. Moreover, the interpretation offered here is compatible with our limited knowledge of other early *Homo sapiens* localities in Africa.

This assessment of Eyasi data is substantially different from previous syntheses. When long-standing distortions and misconceptions are dismissed, we find that Eyasi has not deserved its obscurity. In contrast to comparable hominid remains from Kabwe and Singa, if not Elandsfontein, the Eyasi human fossils have a relationship to other fauna and artifacts in a relatively unambiguous context; moreover, relevant localities and strata remain at Eyasi and will repay further study. Eyasi sites could contribute exceptionally to our understanding of early *Homo sapiens* lifeways.

A number of questions about Eyasi are unanswered; foremost is the nature of association of artifacts and fauna in Eyasi Beds sites. Do Nordostbucht and Westbucht localities represent discrete short-term occupation clusters? Are they long-term accumulations adjacent to spring deposits or on stable land surfaces? New efforts in the field are required to resolve these uncertainties. Future work at Eyasi can also refine the stratigraphic framework proposed here and should yield unselected artifact and faunal samples from sealed contexts. In the meantime, extant evidence demands a considerable antiquity for the Eyasi archaic *Homo sapiens* crania. These remains surely are not late Upper Pleistocene fossils; they most likely represent later Middle Pleistocene hominid populations.

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