Supplementary Online Material (SOM):

New Oldowan locality Sare-Abururu (ca. 1.7 Ma) provides evidence of diverse hominin behaviors on the Homa Peninsula, Kenya

Emma M. Finestone [a,b,*], Thomas W. Plummer[c,d,e], Thomas H. Vincent[f], Scott A. Blumenthal[e,g,h], Peter W. Ditchfield[i], Laura C. Bishop[f], James S. Oliver[j], Andy I.R. Herries[k,l], Christopher Vere Palfery[k], Timothy P. Lane[m], Elizabeth McGuire[g], Jonathan S. Reeves[n,o], Angel Rodés[p,q], Elizabeth Whitfield[f], David R. Braun[n,o], Simion K. Bartilol[r], Nelson Kiprono Rotich[r,s], Jennifer A. Parkinson[e,t], Cristina Lemorini[u], Isabella Caricola[u,v] Rahab N. Kinyanjui[b,e,w], Richard Potts[e,w]

[a] *Department of Anthropology, Cleveland Museum of Natural History, 1 Wade Oval Dr, Cleveland, OH 44113, USA*

[b] *Department of Archaeology, Max Planck Institute for Geoanthropology, Kahlaische Str. 10, 07745 Jena, Germany*

[c] *Department of Anthropology, Queens College, 314 Powdermaker Hall 65-30 Kissena Boulevard Flushing, Flushing, NY 11367, USA*

[d] *The CUNY Graduate Center, 365 5th Ave, New York, NY 10016, USA*

[e] *Human Origins Program, National Museum of Natural History, Smithsonian Institution, P.O. Box 37012, Washington, DC 20560, USA*

[f] *Research Centre in Evolutionary Anthropology and Palaeoecology, School of Biological and Environmental Sciences, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF, UK*

[g] *Department of Anthropology, University of Oregon, 1585 East 13th Avenue, Eugene, OR 97403, United States*

[h] *Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, 2020 – 2207 Main Mall, Vancouver, BC V6T 1Z4, Canada*

[i] *School of Archaeology, University of Oxford, 1 S Parks Rd, Oxford OX1 3TG, United Kingdom*

[j] *Anthropology Section, Illinois State Museum, 502 S Spring St, Springfield, IL 62706, USA*

[k] *The Australian Archaeomagnetism Laboratory, Department Archaeology and History, La Trobe University, Melbourne Victoria 3086, Australia*

[l] *Paleo-Research Institute, University of Johannesburg, 42 Bunting Rd, Cottesloe, Johannesburg, 2092, , South Africa*

[m] *Geography and Environmental Science Research Group, School of Biological and Environmental Sciences, Liverpool John Moores University Byrom Street, Liverpool L3 3AF, UK*

[n] *Technological Origins Research Group, Max Planck Institute for Evolutionary Anthropology, Deutscher Pl. 6, 04103 Leipzig, Germany*

[o] *Center for the Advanced Study of Human Paleobiology, George Washington University, 800 22nd Street NW, Washington, DC 20052, USA*

[p] *Departamento de Xeografía, Universidade de Santiago de Compostela, Praza da Universidade,1, 15703 Santiago de Compostela, Spain*

[q] *Scottish Universities Environmental Research Centre, University of Glasgow, Rankine Ave, Scottish Enterprise Technology Park, East Kilbride G75 0QF, UK*

[r] *Institute of Nuclear Science and Technology, University of Nairobi, P.O. Box 30197, Nairobi, Kenya*

[s] *Institute of Nuclear Chemistry and Technology, Dorodna 16, 03-195 Warsaw, Poland*

[t] *Department of Anthropology, University of San Diego, 5998 Alcala Park Way, San Diego, CA 92110, USA*

[u] *LTFAPA Laboratory, Department of Science of Antiquities, Sapienza University of Rome, Piazzale Aldo Moro, 5, 00185 Rome, Italy*

[v] *Zinman Institute of Archaeology, Haifa University, 199 Aba Hushi Avenue, Mount Carmel, Haifa 3498838, Israel*

[w] *Department of Earth Sciences, National Museums of Kenya, Kipande Rd, Nairobi, Kenya*

[*]Corresponding author.

E-mail address: efinestone@cmnh.org (E. Finestone)

SOM S1 Methods

Cosmogenic nuclide dating

Samples were crushed and sieved to the size fraction 250–500 µm. These were then separated magnetically to remove magnetically charged particles from non-magnetic particles in order to isolate the non-magnetic quartz grains. Isolated quartz grains were then placed in 1 liter of HNO3 8.8% and HCl 4.6% (acqua regia) and heated on a hot plate overnight. Samples were then subject to froth flotation to remove feldspars, before being repeatedly etched in dilute hydrofluoric acid (HF). Samples were spiked with ca. 240 µg of ^{9}Be from the in-house CIAF-PH9 solution before dissolution. Al and Be were extracted from quartz core separates using standard methods of HF dissolution and column chromatography (Stone, 2004). Inductively Coupled Plasma Optical Emission spectrophotometry was used to calculate Al concentrations on aliquots of the dissolved sample. ^{26}Al/^{27}Al and ^{10}Be/^{9}Be isotope ratios were then calculated through accelerator mass spectrometry (AMS) at SUERC (Xu et al., 2010). ^{10}Be and 2^{6}Al concentrations are based on $2.79 \cdot 10^{-11}$ ^{10}Be/Be and $4.11 \cdot 10^{-11}$ ^{26}Al/Al ratios for NIST SRM4325 and Purdue Z92-0222 standards, respectively. ^{10}Be and ^{26}Al concentrations include blank corrections between 0.1 and 5.3%, and between 0.03 and 0.77% respectively. The uncertainties of AMS measurements of blanks and samples are included in the ^{10}Be and ^{26}Al concentrations. ^{26}Al concentration uncertainties also include between 1.9% and 2.6% for the uncertainty of stable Al determination.

Isochron burial method

Burial dating uses the differential decay rates of cosmogenic nuclides where samples have become shielded (burial) from cosmic rays (high energy charged particles that penetrate the earth's atmosphere and collide with the surface from outer space) (Dunai, 2010). Commonly, and in this study, the ratio of the different half-lives of cosmogenic radionuclides ^{26}Al and ^{10}Be are utilized, due to their simultaneous occurrence in quartz, as well as the accurate knowledge of their decay constants and half-lives[3]. Because the surface ^{26}Al/^{10}Be production rate ratio and the ^{26}Al and ^{10}Be decay rates are known, a burial age can be calculated from ^{26}Al and ^{10}Be concentrations from a single sample. This method assumes that the sample has been completely shielded from cosmic radiation since its burial. The isochron burial method is similar but uses the slope of the concentrations from several samples instead of from a single sample. This method is applied to a set of samples with a common burial age but differing in other aspects of their exposure history (Balco and Rovey, 2008). The data from the Sare-Abururu sites show an inverse relationship between the ^{10}Be concentration and the ^{26}Al/^{10}Be concentration ratio, indicating post-burial exposure to cosmic radiation, probably due to the recent incision of the river. This post-burial lateral irradiation increases all ^{26}Al and ^{10}Be concentrations equally, increasing faster the ^{26}Al/^{10}Be concentration ratios in samples with lower initial concentrations, and keeping the ^{26}Al and ^{10}Be concentrations aligned with the same slope in the ^{26}Al-^{10}Be space as with no post-burial irradiation. Therefore, the isochron burial method was considered the most appropriate burial method to calculate the burial age of the Sare-Abururu samples.

SOM S2 Methods

Sedimentology

Particle size analysis

Particle size analysis is a long-established approach for reconstructing the environment, transport behavior and depositional mechanisms of sediments. Particle size trends appear to be the result of sedimentary processes (Hassan, 1978; Friedman, 1979; Le Roux and Rojas, 2007; Clarke et al., 2014; Liu et al., 2014; Amireh, 2015) and due to the ubiquitous nature of sediments, its application spans an array of environmental settings (Bement et al., 2007; Dill and Ludwig, 2008; Dinakaran and Krishnayya, 2011; de Haas et al., 2014; Guan et al., 2016) and time periods (Gillies et al., 1996; Lekach et al., 1998; Houben, 2007; Yin et al., 2011; Wang et al., 2015; Schillereff et al., 2016).

Samples were first subject to chemical pre-treatment similar to that outlined by Konert and Vandenberghe (1997) to isolate the discrete particles and provide evenly dispersed suspension (Liu et al., 2014). Ten milliliters of 30% H_2O_2 were added to oxidize samples and remove unwanted organic material that may otherwise reduce repeatability of results or skew particle size distributions (Blott et al., 2004; Gray et al., 2010). Subsequently, samples were heated for further oxidation until all reaction ceased. Carbonates were not removed by the use of hydrochloric acid, as these were suspected to make up a large proportion of the samples and to be part of the original deposition. Deionized water was added to neutralize samples. The samples were then placed in a 400 °C oven until almost all the water had evaporated. Calgon was then added to ensure the even dispersal of particles.

Particle size was measured using laser diffraction, which offers the advantage of rapid analysis, higher resolution and small sample requirement (Konert and Vandenberghe, 1997; Beuselinck et al., 1998; Eshel et al., 2004; Di Stefano et al., 2010; Wang et al., 2013). In this study, a Beckman Coulter LS11320 laser granulometer was used to measure particle size using the Fraunhofer model, as samples contained coarser material >63μm and a refractive index could not be obtained. Analyses of samples were repeated five times to ensure reproducibility. The computer program GRADISTAT Version 8.0 (Blott and Pye, 2001), developed to rapidly calculate textural parameters from particle size datasets, was used to calculate textural parameters and size classes in the phi unit using the Folk and Ward (1957) method.

SOM S3 Methods

Lithic Analysis Methods

Technological Flake Categories

Flakes were classified into Technological Flake Categories based on Toth's (Toth, 1982) classification system. Flakes were divided into six categories based on the presence or absence of cortex on the dorsal surface and platform. Toth Type I contains cortical platforms and completely cortical dorsal surfaces. Toth Type II flakes have cortical platforms and partial cortex on the dorsal surface. Toth Type III flakes have cortical platforms but lack cortex on the dorsal surface. Toth Type IV flakes contain noncortical platforms but complete cortex on the dorsal surface. Toth Type V flakes have partial dorsal cortex and no platform cortex. Finally, Toth Type VI flakes have no cortex on any surface.

SOM Table S1

Facies classification model from (Miall, 2013).

Facies code	Facies	Sedimentary structures	Interpretation
Gmm	Matrix-supported, massive gravel	Weak grading	Plastic debris flow (high strength, viscous)
Gmg	Matrix-supported gravel	Inverse to normal grading	Pseudoplastic debris flow (low strength, viscous)
Gci	Clast-supported gravel	Inverse grading	Clast-rich debris flow (high strength), or pseudoplastic debris flow (low strength)
Gcm	Clast-supported massive gravel	-	Pseudoplastic debris flow (inertial bedload, turbulent flow)
Gh	Clast-supported, crudely bedded gravel	Horizontal bedding, imbrication	Longitudinal bedforms, lag deposits, sieve deposits
Gt	Gravel, stratified	Trough cross-beds	Minor channel fills
Gp	Gravel, stratified	Planar cross-beds	Transverse bedforms, deltaic growths from older bar remnants
St	Sand, fine to very coarse, may be pebbly	Solitary or grouped trough cross-beds	Sinuous-crested and linguoid (3D) dunes
Sp	Sand, fine to very coarse, may be pebbly	Solitary or grouped trough cross-beds	Transverse and linguoid bedforms (2D dunes)
Sr	Sand, very fine to coarse	Ripple cross-lamination	Ripples (lower flow regime)
Sh	Sand, very fine to coarse, may be pebbly	Horizontal lamination parting or streaming lineation	Plane-bed flow (critical flow)
Sl	Sand, very fine to coarse, may be pebbly	Low-angle (<15°) cross-beds	Scour fills, humpback or washed-out dunes, antidunes
Ss	Sand, fine to coarse, may be pebbly	Broad, shallow scours	Scour fill
Sm	Sand, fine to coarse	Massive, or faint lamination	Sediment-gravity flow deposits
Fl	Sand, silt, mud	Fine lamination, very small ripples	Overbank, abandoned channel, or washed-out dunes, antidunes
Fsm	Silt, mud	Massive	Backswamp or abandoned channel, or waning flood deposits
Fm	Mud, silt	Massive, desiccation cracks	Overbank, abandoned channel, or drape deposits
Fr	Mud, silt	Massive, roots, bioturbation	Root bed, incipient soil
C	Coal, carbonaceous mud	Plant, mud films	Vegetated swamp deposits
P	Paleosol carbonate (calcite, siderite)	Pedogenic features: nodules, filaments	Soil with chemical precipitation

SOM Table S2

Mean directions of declination and inclination (degrees), K, paleolatitude (degrees) and polarity for the various block samples from the Sare-Abururu section.

Sample	Unit	Declination	Inclination	K	Paleolatitude	Polarity
NP08	SR-2	174.9	-11.7	28.4	-81.9	R
NP07	phonolitic tuff	148.9	-35.8	14.5	-53.5	IR
NP06	phonolitic tuff	201.6	2.4	52.7	-68.4	R
NP05	phonolitic tuff	156.9	-1.9	551	-66.9	R
NP04 upper	SR-1	56.6	5.4	187.8	33.3	I
NP04 lower	SR-1	357.1	-3	105.5	86.9	N
NP03	SR-1	356	-0.9	35.9	86	N

Abbreviations: R = reversed; IR = intermediate reversed; I = intermediate; N = normal.

SOM Table S3

Accelerator mass spectrometry measurements of samples taken from Sare-Abururu. ^{10}Be concentrations are based on a 2.79 x 10^{-11} ^{10}Be/Be ratio for NIST SRM4325. ^{26}Al concentrations are based on a 4.11 x 10^{-11} 26Al/Al ratio for the Purdue Z92-0222 standard.

Sample	**^{10}Be (x10^{6} atoms per gram)**	**^{26}Al (x10^{6} atoms per gram)**	**26Al/^{10}Be (x10^{6})**
SR1	0.920 ± 0.026	5.120 ± 0.164	5.56 ± 0.24
SR2	0.157 ± 0.006	1.061 ± 0.053	6.74 ± 0.43
SR3	1.01 ± 0.036	5.143 ± 0.316	4.68 ± 0.32
SR4	1.808 ± 0.05	7.853 ± 0.246	4.34 ± 0.18
SR5	1.139 ± 0.032	5.969 ± 0.215	5.24 ± 0.24
SR6	0.916 ± 0.031	4.61 ± 0.242	5.03 ± 0.31
SR8	2.527 ± 0.067	8.743 ± 0.261	3.46 ± 0.14
SR9	0.445 ± 0.012	2.796 ± 0.133	6.29 ± 0.34
SR10	0.451 ± 0.014	2.63 ± 0.088	5.83 ± 0.26

SOM Table S4

Technological attributes compiled from various archaeological sites published in Braun et al. (2019). Nyayanga (Plummer et al., 2023), HWK-EE (de la Torre et al., 2018) and Ewass Oldupa (Mercader et al., 2021) lithic characteristics are added in addition to Sare-Abururu.

Site	Industry	Frequency of cores in assemblage (%)	Frequency of angular fragments out of DP (%)	Average core size (mm)	Ratio mean flake size to mean core size	Average flake scar count	Ratio of flake scar count to $\log_{10}$ (mean core size)	Average flake max dimension (mm)	Average flake thickness (mm)	Percussion in assemblage (%)
EFHR	Acheulean	22.6	39.5	94.9	0.6	10.2	5.2	58.0	16.0	0.9
FxJj63	Acheulean	6.7	37.9	108.9	0.6	7.0	3.4	60.0	10.2	0.3
FxJj37	Acheulean	8.9	26.7	84.6	0.8	7.1	3.7	66.0	15.2	4.4
Peninj_ST	Acheulean	7.1	24.2	62.2	0.5	9.4	5.2	40.5	12.3	3.1
FxJj20Main	Oldowan	2.0	63.7	50.5	0.5	7.1	4.2	26.0	6.5	0.1
FxJj18IHS	Oldowan	3.5	55.1	52.9	0.7	9.1	5.3	37.0	8.3	0.2
DK	Oldowan	16.1	40.1	67.9	0.6	7.2	3.9	40.2	11.9	3.0
FLKZinj	Oldowan	3.4	56.5	76.4	0.5	5.8	3.1	36.8	11.5	1.2
FxJj1	Oldowan	13.8	46.7	54.4	0.7	5.4	3.1	39.0	11.3	0.6
FxJj10	Oldowan	6.3	48.4	58.6	0.7	5.3	3.0	40.4	11.9	0.2
Omo57	Oldowan	1.4	35.9	37.4	0.7	3.2	2.0	24.7	7.7	0.6
Omo123	Oldowan	1.2	41.4	30.5	0.6	3.2	2.2	17.7	6.4	0.2
KJS	Oldowan	11.2	50.4	56.3	0.6	5.4	3.1	32.6	9.9	0.1
EO	Oldowan	10.3	18.8	70.9	10.4	6.3	3.4	30.4	12.5	2.8
Fejej	Oldowan	3.5	35.9	58.3	0.6	5.1	2.9	36.9	10.7	7.0
AL894	Oldowan	0.8	16.9	75.0	0.5	6.9	3.7	35.9	10.5	0.0

OGS7	Oldowan	3.8	44.9	44.1	0.9	5.4	3.3	39.1	11.8	1.1
EG10	Oldowan	5.6	57.2	83.3	0.4	7.3	3.8	36.1	13.6	0.0
EG12	Oldowan	1.5	41.3	74.5	0.5	5.4	2.9	34.6	12.8	0.0
BD1	Oldowan	13.0	23.4	58.0	0.6	2.9	1.6	32.4	9.4	1.3
NYA	Oldowan	20.6	51.2	72.7	0.6	5.1	2.7	43.1	13.9	7.0
Sare	Oldowan	0.5	93.0	47.9	0.7	5.2	3.1	34.6	8.0	0.0
HWK_EE	Oldowan	5.5	71.5	70.2	0.4	4.3	2.3	31.0	11.8	4.2

SOM Table S5

The loading of variables on principal components (PC) 1, 2, 3 and 4.

	PC 1	PC 2	PC 3	PC 4
Frequency of cores in assemblage (%)	-0.33	-0.29	0.13	0.28
Frequency of angular fragments out of DP (%)	0.17	0.31	0.50	0.50
Average core size (mm)	-0.42	-0.02	0.11	-0.39
Ratio mean flake size to mean core size	-0.05	-0.28	-0.72	0.22
Average flake scar count	-0.40	0.44	-0.20	0.20
Ratio of flake scar count to $\log_{10}$ (mean core size)	-0.33	0.50	-0.24	0.31
Average flake max dimension (mm)	-0.45	0.02	0.25	-0.26
Average flake thickness (mm)	-0.44	-0.22	0.12	-0.01
Percussion in assemblage (%)	-0.16	-0.49	0.19	0.52

PC = Principal Component.

DP = Detached pieces.

SOM Table S6

Eigenvalues and percent of variance on principal components 1–6.

	Eigenvalue	Percentage of variance
Principal component 1	3.66	40.71
Principal component 2	1.71	19.04
Principal component 3	1.20	13.38
Principal component 4	0.77	8.53
Principal component 5	0.64	7.09
Principal component 6	0.56	6.19

SOM Table S7

Compilation of d^{13}C from pedogenic carbonates associated with Early Stone Age sites in eastern Africa from ca. 2.6 Ma to 1.5 Ma.

Area	Country	Formation	Stratigraphic unit	Site	Sample ID	$\delta^{13}C_{VPDB}$ (‰)	Data source
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	SBK-16C-1	-0.3	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	SBK-16C-2	-2.6	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	SBK-16C-3	0.5	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	SBK-16C-4	-1.0	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	HOM19-01	-2.4	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	HOM19-02	-1.3	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX1-50	-1.0	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX1-80	-1.0	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX2-TOP	-0.8	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX2-Base	-1.8	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX5-0	-0.9	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX5-60	-1.6	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX5-100	-1.1	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX5-160	0.2	this study
Homa Peninsula	Kenya		SAR-2	Sare-Abururu	EX5-170	1.0	this study
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	HP-95-46	-0.5	Plummer et al. (1999)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58	-1.2	Plummer et al. (1999)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	KJS.96-6b	0.2	Plummer et al. (1999)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	HP-95-46/2	-1.4	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/7	-2.3	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/6	-2.0	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	HP-95-46/4	-0.3	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	KJS-96-17/1	-1.7	Plummer et al. (2009)

Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/8	-1.2	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/10	-2.6	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	HP-95-46/3	0.0	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	1481G	1.1	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/4	-0.9	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/3	1.6	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	HP-95-46/1	-0.4	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	KJS-96-6b/1	0.0	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	KJS-96-6b/2	0.5	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/9	-2.4	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-1	Kanjera South	1481F	-2.6	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/2	-1.8	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	HP-95-58/1	0.3	Plummer et al. (2009)
Homa Peninsula	Kenya	Kanjera	KS-2	Kanjera South	KJS-96-2/1	-0.7	Plummer et al. (2009)
Homa Peninsula	Kenya		NY-1	Nyayanga	PWD 070608/2	-3.2	Plummer et al. (2023)
Homa Peninsula	Kenya		NY-1	Nyayanga	PWD 070608/1	-2.1	Plummer et al. (2023)
Turkana	Kenya	Koobi Fora	KBS	FxJj 1	FxJj1-20	-8.1	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 1	FxJj1-42	-6.3	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 1	FxJj1-047A	-6.5	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 1	FxJj1-047B	-6.0	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 1	105NL-06a	-6.6	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj 3	FxJj3-045A	-5.3	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 3	FxJj3-045B	-5.5	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 3	FxJj3-047C	-4.8	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 3	FxJj3-48	-5.8	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj 10	105NL-02A	-3.4	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj 10	105NL-02B	-3.4	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj 10	105NL-04A	-5.8	Levin et al. (2011)

Turkana	Kenya	Koobi Fora	KBS	FxJj 10	105NL-04B	-4.6	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj 10	105NL-04C	-2.7	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj 10	118NL-04a	-4.7	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj 10	FxJj10a	-5.7	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj82	130NL-16A	-6.4	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj82	130NL-16B	-6.3	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj82	130NL-22A	-5.6	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj82	130NL-22B	-3.9	Levin et al. (2011)
Turkana	Kenya	Koobi Fora	KBS	FxJj81	FxJj81-0	-4.4	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj81	FxJj81-25	-5.8	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj83	FxJj83-2HILLS	-7.0	Quinn et al. (2013)
Turkana	Kenya	Koobi Fora	KBS	FxJj83	FxJj83-56	-6.6	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-061	-9.6	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-062	-7.2	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-063	-6.2	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-055	-7.7	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-056	-8.5	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-058	-7.4	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-059	-7.2	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Upper Lomekwi	Lokalalei LA1A,2C	K07-060	-7.4	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-025	-8.9	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-029	-3.2	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-030	-6.9	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-041	-7.0	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-042	-6.8	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-043	-6.5	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-044	-6.6	Quinn et al. (2013)

Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-048	-3.5	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-049	-7.4	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-050	-6.8	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-4	K07-051	-6.7	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-031	-7.0	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-033	-6.8	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-034	-4.5	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-036	-5.0	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-037	-6.0	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-038	-5.3	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-046	-5.9	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-047	-5.6	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-052	-5.6	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-053	-5.5	Quinn et al. (2013)
Turkana	Kenya	Nachukui	Kaitio	Kokiselei KS-6	K07-054	-5.8	Quinn et al. (2013)
Olduvai	Tanzania		Basal Bed II Paleosol	HWK-E	10	-4.3	Sikes (1994)
Olduvai	Tanzania		Basal Bed II Paleosol	HWK-W	11	-5.7	Sikes (1994)
Olduvai	Tanzania		Basal Bed II Paleosol	HWK-W	13	-3.9	Sikes (1994)
Olduvai	Tanzania		Upper Bed I	Trench 57	GA-104-96	-4.8	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 57	NS-286-96 (avg)	-6.6	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 62	NS-239-96	-4.3	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 62	NS-229-96	-4.3	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 62	NS-230-96	-4.3	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 62	NS-226-96	-4.6	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 63	NS-246-96	-5.7	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 63	NS-247-96	-4.8	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 63	NS-243-96	-4.4	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 64	NS-271-96	-5.8	Sikes and Ashley (2007)

Olduvai	Tanzania		Upper Bed I	Trench 64	NS-266-96	-5.7	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 64	NS-269-96	-6.4	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 64	NS-265-96	-5.2	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 66	NS-303-96	-4.2	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 66	NS-305-96	-4.9	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 66	NS-301-96	-4.0	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 66	NS-304-96	-4.6	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 67	NS-295-96	-4.3	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 67	NS-297-96 (avg)	-5.6	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 67	NS-294-96	-4.7	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 68	NS-307-96	-4.0	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 68	NS-309-96	-5.1	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 68	NS-308-96	-4.7	Sikes and Ashley (2007)
Olduvai	Tanzania		Upper Bed I	Trench 68	NS-306-96	-5.7	Sikes and Ashley (2007)
Afar—Gona	Ethiopia	Busidima		DAN-5	DAN5-CRN1	-7.7	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-5	DANL-097	-5.3	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-5	DANL-098	-5.1	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-5	DANL-100	-6.4	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-5	DANL-128	-7.3	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-5	GONJQ-156	-6.5	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-5	GONJQ-157	-6.0	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-1	DANL-122	-3.7	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-1	DANL-121	-5.8	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		OGS-7	GONJQ-160	-3.8	Cerling et al. (2011)
Afar—Gona	Ethiopia	Busidima		OGS-7	GONJQ-159	-5.5	Cerling et al. (2011)
Afar—Gona	Ethiopia	Busidima		OGS-6	GONJQ-173	-5.6	Cerling et al. (2011)
Afar—Gona	Ethiopia	Busidima		OGS-6	GONJQ-174	-5.2	Cerling et al. (2011)
Afar—Gona	Ethiopia	Busidima		OGS-6	GONJQ-175	-5.6	Cerling et al. (2011)

Afar—Gona	Ethiopia	Busidima		DAN-1	DANL-120	-5.7	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-1	DANL-119	-5.9	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-1	DANL-118	-6.3	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-2	DANL-162	-6.1	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-2	DANL-160	-4.7	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-2	DANL-161	-6.0	Levin et al. (2004)
Afar—Gona	Ethiopia	Busidima		DAN-2	DANL-008	-6.4	Levin et al. (2004)
Afar—Hadar	Ethiopia	Busidima	Kada Hadar	AL 666	76	-3.7	Aronson et al. (2008)
Afar—Hadar	Ethiopia	Busidima	Kada Hadar	AL 666	93	-5.1	Aronson et al. (2008)
Afar—Hadar	Ethiopia	Busidima	Kada Hadar	AL 666	75	-4.8	Aronson et al. (2008)
Afar—Hadar	Ethiopia	Busidima	Kada Hadar	AL 666	112	-5.1	Aronson et al. (2008)

SOM References

Amireh, B.S., 2015. Grain size analysis of the Lower Cambrian–Lower Cretaceous clastic sequence of Jordan: Sedimentological and paleo-hydrodynamical implications. J. Asian Earth Sci. 97, 67–88.

Aronson, J.L., Hailemichael, M., Savin, S.M., 2008. Hominid environments at Hadar from paleosol studies in a framework of Ethiopian climate change. J. Hum. Evol. 55, 532-550.

Balco, G., Rovey, C.W., 2008. An isochron method for cosmogenic-nuclide dating of buried soils and sediments. Am. J. Sci. 308, 1083–1114.

Bement, L.C., Carter, B.J., Varney, R.A., Cummings, L.S., Sudbury, J.B., 2007. Paleo-environmental reconstruction and bio-stratigraphy, Oklahoma Panhandle, USA. Quat. Int. 169, 39–50.

Beuselinck, L., Govers, G., Poesen, J., Degraer, G., Froyen, L., 1998. Grain-size analysis by laser diffractometry: Comparison with the sieve-pipette method. Catena 32, 193–208.

Blott, S.J., Pye, K., 2001. Gradistat: A grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surf. Process. Landf. 26, 1237–1248.

Blott, S.J., Croft, D.J., Pye, K., Saye, S.E., Wilson, H.E., 2004. Particle size analysis by laser diffraction. Geol. Soc. Lond. Spec. Publ. 232, 63–73.

Braun, D.R., Aldeias, V., Archer, W., Arrowsmith, J.R., Baraki, N., Campisano, C.J., Deino, A.L., DiMaggio, E.N., Dupont-Nivet, G., Engda, B., 2019. Earliest known Oldowan artifacts at >2.58 Ma from Ledi-Geraru, Ethiopia, highlight early technological diversity. Proc. Natl. Acad. Sci. USA 116, 11712–11717.

Cerling, T.E., Wynn, J.G., Andanje, S.A., Bird, M.I., Korir, D.K., Levin, N.E., Mace, W., Macharia, A.N., Quade, J., Remien, C.H., 2011. Woody cover and hominin environments in the past 6 million years. Nature 476, 51–56.

Clarke, D.W., Boyle, J.F., Chiverrell, R.C., Lario, J., Plater, A.J., 2014. A sediment record of barrier estuary behaviour at the mesoscale: Interpreting high-resolution particle size analysis. Geomorphology 221, 51–68.

de Haas, T., Ventra, D., Carbonneau, P.E., Kleinhans, M.G., 2014. Debris-flow dominance of alluvial fans masked by runoff reworking and weathering. Geomorphology 217, 165–181.

de la Torre, I., Mora, R., 2018. Oldowan technological behaviour at HWK EE (Olduvai Gorge, Tanzania). J. Hum. Evol. 120, 236–273.

Di Stefano, C., Ferro, V., Mirabile, S., 2010. Comparison between grain-size analyses using laser diffraction and sedimentation methods. Biosyst. Eng. 106, 205–215.

Dill, H.G., Ludwig, R.-R., 2008. Geomorphological-sedimentological studies of landform types and modern placer deposits in the savanna (Southern Malawi). Ore Geol. Rev. 33, 411–434.

Dinakaran, J., Krishnayya, N.S.R., 2011. Variations in total organic carbon and grain size distribution in ephemeral river sediments in western India. Int. J. Sediment Res. 26, 239–246.

Dunai, T.J., 2010. Cosmogenic Nuclides: Principles, Concepts and Applications in the Earth Surface Sciences. Cambridge University Press, Cambridge.

Eshel, G., Levy, G.J., Mingelgrin, U., Singer, M.J., 2004. Critical evaluation of the use of laser diffraction for particle-size distribution analysis. Soil Sci. Soc. Am. J. 68, 736–743.

Folk, R.L., Ward, W.C., 1957. Brazos River bar [Texas]; a study in the significance of grain size parameters. J. Sediment. Res. 27, 3–26.

Friedman, G.M., 1979. Address of the retiring President of the International Association of Sedimentologists: Differences in size distributions of populations of particles among sands of various origins. Sedimentology 26, 3–32.

Gillies, J.A., Nickling, W.G., McTainsh, G.H., 1996. Dust concentrations and particle-size characteristics of an intense dust haze event: Inland delta region, Mali, West Africa. Atmos. Environ. 30, 1081–1090.

Gray, A.B., Pasternack, G.B., Watson, E.B., 2010. Hydrogen peroxide treatment effects on the particle size distribution of alluvial and marsh sediments. The Holocene 20, 293–301.

Guan, H., Zhu, C., Zhu, T., Wu, L., Li, Y., 2016. Grain size, magnetic susceptibility and geochemical characteristics of the loess in the Chaohu lake basin: Implications for the origin, palaeoclimatic change and provenance. J. Asian Earth Sci. 117, 170–183.

Hassan, F.A., 1978. Sediments in archaeology: Methods and implications for palaeoenvironmental and cultural analysis. J. Field Archaeol. 5, 197–213.

Houben, P., 2007. Geomorphological facies reconstruction of Late Quaternary alluvia by the application of fluvial architecture concepts. Geomorphology 86, 94–114.

Konert, M., Vandenberghe, J.E.F., 1997. Comparison of laser grain size analysis with pipette and sieve analysis: A solution for the underestimation of the clay fraction. Sedimentology 44, 523–535.

Le Roux, J.P., Rojas, E.M., 2007. Sediment transport patterns determined from grain size parameters: Overview and state of the art. Sediment. Geol. 202, 473–488.

Lekach, J., Amit, R., Grodek, T., Schick, A.P., 1998. Fluvio-pedogenic processes in an ephemeral stream channel, Nahal Yael, Southern Negev, Israel. Geomorphology 23, 353–369.

Levin, N.E., Quade, J., Simpson, S.W., Semaw, S., Rogers, M., 2004. Isotopic evidence for Plio–Pleistocene environmental change at Gona, Ethiopia. Earth Planet. Sci. Lett. 219, 93–110.

Levin, N.E., Brown, F.H., Behrensmeyer, A.K., Bobe, R., Cerling, T.E., 2011. Paleosol carbonates from the Omo Group: Isotopic records of local and regional environmental change in East Africa. Palaeogeogr. Palaeoclimatol. Palaeoecol. 307, 75–89.

Liu, B., Qu, J., Ning, D., Gao, Y., Zu, R., An, Z., 2014. Grain-size study of aeolian sediments found east of Kumtagh Desert. Aeolian Res. 13, 1–6.

Mercader, J., Akuku, P., Boivin, N., Bugumba, R., Bushozi, P., Camacho, A., Carter, T., Clarke, S., Cueva-Temprana, A., Durkin, P. and Favreau, J., 2021. Earliest Olduvai hominins exploited unstable environments ~ 2 million years ago. Nat. Commun. 12, 1–15.

Miall, A.D., 2013. The Geology of Fluvial Deposits: Sedimentary Facies, Basin Analysis, and Petroleum Geology. Springer, New York.

Plummer, T., Bishop, L.C., Ditchfield, P., Hicks, J., 1999. Research on Late Pliocene Oldowan sites at Kanjera South, Kenya. J. Hum. Evol. 36, 151–170.

Plummer, T.W., Ditchfield, P.W., Bishop, L.C., Kingston, J.D., Ferraro, J.V., Braun, D.R., Hertel, F., Potts, R., 2009. Oldest evidence of toolmaking hominins in a grassland-dominated ecosystem. PLoS One 4, e7199.

Plummer, T.W., Oliver, J.S., Finestone, E.M., Ditchfield, P.W., Bishop, L.C., Blumenthal, S.A., Lemorini, C., Caricola, I., Bailey, S.E., Herries, A.I.R., Parkinson, J.A., Whitfield, E., Hertel, F., Kinyanjui, R.N., Vincent, T.H., Li, Y., Louys, J., Frost, S.R., Braun, D.R., Reeves, J.S., Early, E.D.G., Onyango, B., Lamela-Lopez, R., Forrest, F.L., He, H., Lane, T.P., Frouin, M., Nomade, S., Wilson, E.P., Bartilol, S.K., Rotich, N.K., Potts, R., 2023. Expanded geographic distribution and dietary strategies of the earliest Oldowan hominins and *Paranthropus.* Science 379, 561–566.

Quinn, R.L., Lepre, C.J., Feibel, C.S., Wright, J.D., Mortlock, R.A., Harmand, S., Brugal, J.-P., Roche, H., 2013. Pedogenic carbonate stable isotopic evidence for wooded habitat preference of early Pleistocene tool makers in the Turkana Basin. J. Hum. Evol. 65, 65–78.

Schillereff, D.N., Chiverrell, R.C., Macdonald, N., Hooke, J.M., 2016. Hydrological thresholds and basin control over paleoflood records in lakes. Geology 44, 43–46.

Sikes, N.E., 1994. Early hominid habitat preferences in East Africa: Paleosol caron isotopic evidence. J. Hum. Evol. 27, 25–45.

Sikes, N.E., Ashley, G.M., 2007. Stable isotopes of pedogenic carbonates as indicators of paleoecology in the Plio-Pleistocene (upper Bed I), western margin of the Olduvai Basin, Tanzania. J. Hum. Evol. 53, 574–594.

Stone, J., 2004. Extraction of Al and Be from quartz for isotopic analysis. UW Cosmogenic Nuclide Lab Methods and Procedures. http://depts.washington.edu/cosmolab/chem.html.

Toth, N.P., 1982. The stone technologies of early hominids at Koobi Fora, Kenya: An experimental approach. Ph.D. Dissertation, University of California, Berkeley.

Wang, J., Li, A., Xu, K., Zheng, X., Huang, J., 2015. Clay mineral and grain size studies of sediment provenances and paleoenvironment evolution in the middle Okinawa Trough since 17 ka. Marine Geol. 366, 49–61.

Wang, W.-P., Liu, J.-L., Zhang, J.-B., Li, X.-P., Cheng, Y.-N., Xin, W.-W., Yan, Y.-F., 2013. Evaluation of laser diffraction analysis of particle size distribution of typical soils in China and comparison with the Sieve-Pipette method. Soil Sci. 178, 194–204.

Xu, S., Dougans, A.B., Freeman, S.P.H.T., Schnabel, C., Wilcken, K.M., 2010. Improved ^{10}Be and ^{26}A1-AMS with a 5 MV spectrometer. Nucl. Instrum. Methods Phys. Res. B 268 (7–8), 736–738.

Yin, Y., Liu, H., He, S., Zhao, F., Zhu, J., Wang, H., Liu, G., Wu, X., 2011. Patterns of local and regional grain size distribution and their application to Holocene climate reconstruction in semi-arid Inner Mongolia, China. Palaeogeogr. Palaeoclimatol. Palaeoecol. 307, 168–176.