
Supplementary information

**New finds shed light on diet and locomotion
in *Australopithecus deyiremeda***

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Supplementary Information

New finds shed light on diet and locomotion in *Australopithecus deyiremeda*

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Supplementary Text

S1. $^{40}\text{Ar}/^{39}\text{Ar}$ detrital dating at BRT-VP-3

The BRT-VP-3 locality is separated from other Burtele vertebrate localities by a northwest-southeast trending normal fault (down to the northeast), hence it's chronostratigraphic relationship to the well-dated Burtele Tuff is not directly observed. No tuffs have been observed in this fault block. We address age considerations through paleomagnetic polarity analysis of sedimentary strata, and detrital $^{40}\text{Ar}/^{39}\text{Ar}$ dating of K-feldspars in a sandstone near the top of the local section. The youngest component of the sandstone represents the maximum age of the deposit.

S1.1. Methodology

All preparation and analyses were performed at the Berkeley Geochronology Center (BGC). Fresh, unaltered K-feldspar was obtained from the ~300-600 micron size fraction of a medium grained, well-sorted brown sandstone. The sandstone, a 3-5 cm bed intercalated with gravels, lies about 4 m beneath the capping basalt at the sampled locality (sample WM23-BRT-3; 11.460352°N, 40.536693°E). The feldspar was washed with distilled water in an ultrasonic bath and hand-picked to minimize inclusions and alteration. The resulting separate of ~100 grains was irradiated for three hours in the Cd-lined in-core CLICIT facility of the Oregon State University TRIGA reactor (BGC irradiation #506). Sanidine phenocrysts from the Alder Creek Rhyolite of California was used as the monitor mineral (age = 1.1848 ± 0.006 Ma)¹. Reactor-induced isotopic production ratios for this irradiation were: $(^{36}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 2.65 \pm 0.02 \times 10^{-4}$, $(^{38}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 1.96 \pm 0.08 \times 10^{-5}$, $(^{39}\text{Ar}/^{37}\text{Ar})_{\text{Ca}} = 6.95 \pm 0.09 \times 10^{-4}$, $(^{37}\text{Ar}/^{39}\text{Ar})_{\text{K}} = 2.24 \pm 0.16 \times 10^{-4}$, $(^{38}\text{Ar}/^{39}\text{Ar})_{\text{K}} = 1.220 \pm 0.003 \times 10^{-2}$, $(^{40}\text{Ar}/^{39}\text{Ar})_{\text{K}} = 2.5 \pm 0.9 \times 10^{-4}$. Atmospheric $^{40}\text{Ar}/^{36}\text{Ar} = 298.56 \pm 0.31$ (ref. 2) and decay constants were according to Min et al (ref. 3).

After radiological cooling of one month, the grains were analyzed by the single-crystal total-fusion (SCTF) method, wherein individual grains were rapidly fused (< 6 s) using a focused CO₂ laser under ultra-high vacuum and analyzed after several minutes of cleanup with a 5-detector Nu Instruments *Noblesse* mass spectrometer operating in ion-counting, simultaneous collection mode. Further details of the applicable analytical procedure are provided in ref. 4.

S1.2. Results

A total of 104 grains were analyzed by the SCTF method (Supplementary Data 1). Five yielded a ³⁹Ar abundance several orders of magnitude less than the typical grain, and either represent low-K plagioclase, non-feldspar, or poor fusion; these grains were omitted from further consideration. The remaining analyses are plotted as an age probability-density curve in Supplementary Fig. S1. The age distribution contains a preponderance of Oligocene feldspars, a common feature of WORMIL tuffs⁴, as well as a late Miocene peak that is also commonly present. The focus of the detrital dating here is on the youngest populations, represented by a single grain at ~ 4.6 Myr, and two nearly identical SCTF analyses at a weighted mean age of 3.55 ± 0.05 Myr (highlighted in bold in Supplementary Data 1). These latter two grains are the youngest component of the age distribution and represent the maximum age of deposition of the sandstone. Given their age and low Ca/K ratio (~ 0.002), It is likely that these grains were eroded from the Kilaytoli Tuff (3.566 ± 0.017 Myr; ref. 55) exposed widely 4 km northwest of the BRT-VP-3 locality. The detrital mean age is in agreement with a normal paleomagnetic determination for the BRT-VP-3 strata, which we attribute to the lower part of the Gauss normal chron (C2An.3n; 3.596–3.330 Myr; ref. 5) and precludes attribution of these strata to a yet-older normal chron (e.g., C3n.1n; 4.300–4.187 Myr).

S2. Mandibular dental development of BRT-VP-2/135

In total, the BRT-VP-2/135 mandible preserves 11 permanent teeth: the right and left I_1 and I_2 , the right canine, both right and left P_3 and P_4 , and the M_1 on both sides. Below are listed the fractional stages of crown (C) and root (R) development for each incisor (I), canine (C), premolar (P), and molar (M). The subscripts “i” and “c” are used to denote ‘initiation’ and ‘completion’, respectively.

<u>Left side:</u>		<u>Right side:</u>	
Tooth	Stage	Tooth	Stage
I_1	$R_{1/2}$	I_1	$R_{1/2}$
I_2	$R_{1/4}$	I_2	$R_{1/4}$
-	-	C	Cr_c
P_3	R_i	P_3	R_i
P_4	R_i	P_4	R_i
M_1	$R_{3/4} - R_c$	M_1	$R_{3/4} - R_c$

S2.1 Dental score assessment

Often in studies of early hominin dental maturation, the progress of dental calcification is measured using a standard scoring scale (n=8 crown and root stages) and assessed via conventional radiographs⁶. These crown and root scores, however, likely underestimate crown and root formation as the incompletely mineralized state of enamel and/or the thinned dentinal extensions of a developing root are difficult to resolve in standard radiographs⁷. As a result, we used a revised dental scoring scale⁸ for both single- and multi-cusped/rooted teeth that leverages the advanced resolution of crown/root growth available from microCT imaging to provide a set of more refined dental stages (n=15). This is equivalent to the total number of stages of crown and root formation (n=14) detailed in other recent revisions in dental stage assessments of great apes and hominins⁹.

S2.2 Age at death determination in BRT-VP-2/135

To estimate the age at death of BRT-VP-2/135, we rely on a regression model that relates dental developmental scores assessed from radiographs to absolute (i.e., calendar) age utilizing a sample of known-age chimpanzees⁶, allowing us to derive what has been appropriately termed a “chimpanzee-equivalent age”⁸ (see below). Recently, such estimates have been shown to be accurate when compared to actual (i.e., virtual histological via synchrotron microtomography) ages at death⁸.

Crown and root scores for I₁-M₂ (right side only) using the revised scale⁸ were assessed by one of us (GTS). BRT-VP-2/135 does not preserve the developing M₂, though one would have certainly been present in life. From previous work, it is clear that the pace of M₂ development roughly tracks that of P₄ development⁹ and so the score for the BRT-VP-2/135 P₄ was used for the M₂ in the age at death estimation (orange shaded cells in Supplementary Table 1). Because the revised scale differs from the original scale used to create the regression model, Gunz et al. (ref. 8) created a conversion protocol to adjust revised scores to match the original radiographic scale used in Kuykendall (ref. 6). Adjusted scores for I₁-M₂ were summed to create an overall dental maturity score (DMS), which could then be inserted into Kuykendall’s regression equation relating chimpanzee DMS to age (in years):

$$\text{Age} = 0.002(\text{DMS}^2) + 0.078(\text{DMS}) - 0.073 (\pm 0.99) (1)$$

The preserved mandibular teeth of BRT-VP-2/135 yield a DMS of 33.5 which converts to an adjusted radiographic-equivalent DMS of 32. From the above formula, this generates a “chimpanzee equivalent age” estimate of 4.47 years (range: 3.48-5.46; light blue shaded cells in Supplementary Table S1). It is important to note that this is only an estimated age at death assuming that this specimen developed its dentition at the same pace as do modern chimpanzees.

A more accurate age at death estimate is only possible from accessing the incremental growth record of dental hard tissues using standard or synchrotron virtual histology (e.g., ref. 10).

S3. Brief description of craniodental specimens from BRT-VP-1 and BRT-VP-2

BRT-VP-1/13 is a R. LC₁ crown worn almost all the way to the cervicoenamel junction (Extended Data Fig. 1g). The root is preserved with only a small chip at its apex. The buccal face of the crown is also missing. Although it is poorly preserved and more description of its morphology cannot be provided, the preserved occlusal outline is a mesiobulley to distolingually oriented oval with a maximum dimension of 10.3 mm. The preserved length of the root on the distal side is 20.7 mm.

BRT-VP-1/256 is a L. M₃ crown lacking its roots (Extended Data Fig. 1b). Measurements are provided in Table 1. It is relatively unworn although most of its cusps are polished but without any dentine exposure. The cusps appear to be low crowned. The occlusal outline is a mesiodistally elongated distally tapering rectangle. The metaconid is the largest cusp followed by the protoconid. The hypoconid and entoconid are of comparable size. Most of the hypoconulid, located on the distobuccal corner of the crown, is broken. A prominent and well-defined c6 occupies the distolingual corner and separated from the entoconid by a groove on the occlusal rim. The protoconid and hypoconid are also separated by a groove on the buccal wall. A small buccal groove also separates the hypoconulid from the hypoconid. Both the protoconid and hypoconid slope slightly occlusally. Most of the cusps are slightly crenulated. The mesial IPF is concave and measures 4.7 mm buccolingually and 3.5 mm superoinferiorly. The mesial marginal ridge bounds a slit-like mesial fovea and the longitudinal groove emanates from here

and zigzags posteriorly ending in a small distal fovea bound be the entoconid, hypoconulid, and c6.

BRT-VP-1/271 is fragment of an edentulous mandibular corpus anteriorly broken at the distal M₂ root and posteriorly immediately behind the distal root of the M₃ (Extended Data Fig. 2h–k). The posterior root of the M₂ and most of the M₃ root are visible. The maximum preserved anteroposterior and superoinferior dimensions of the corpus are 36.3 mm and 34.5 mm, respectively. The preserved corpus cross-section at M₂ is 29.4 mm superoinferiorly and 20.4 mm buccolingually. Numerous hairline cracks traverse the lingual and buccal walls. However, on the buccal side, the origin of the anterior boarder of the ascending ramus is preserved and positioned very high only a few mm below the alveolar margin of the M₂. On the lingual side at the M₂ level, the superior and inferior tori appear to have been separated by a shallow transverse groove (see Extended Data Fig. 1k). The preserved anteroinferior part of the medial pterygoid muscle insertion is deep and extends to below the distal root of the M₃.

BRT-VP-1/345 is fragment of a left edentulous mandible whose edges are abraded across all preserved parts (Extended Data Fig. e–g). It is broken lateral to midline at the lateral wall of the I₁ root. The I₂ root, canine root socket, and roots of P₃–M₁ are preserved. Posteriorly, it is broken right behind the M₁ at the origin of the anterior boarder of the ascending ramus. The corpus base is missing along its entire preserved length exposing the internal structure lingually. Anteriorly, there is a slight depression at the I₂ root level which makes the C₁–P₃ lateral surface more raised. The corpus surface posterior to the C₁–P₃ is slightly depressed and extending past the mental foramen toward the base but not posteriorly bounded by a raised surface to form a lateral corpus

hollow. A large, superiorly facing mental foramen is present at P₃ level ca. 23.8 mm below the preserved alveolar margin of the P₃. The foramen is 3.6 mm superoinferiorly and 2.7 mm anteroposteriorly. Lingually, only some portion of the superior transverse torus is preserved at C₁-M₁. Based on the preserved roots of the premolars, the P₃ was more likely two-rooted and the P₄ three-rooted.

BRT-VP-1/363 is a R. P₄ attached to a small fragment of the mandibular bone (Extended Data Fig. 1c). Most of the enamel cap on the lingual and mesial sides, and inferior half of the buccal face is missing although the dentine is intact. A few cracks transect the entire crown mesiodistally. The smaller mesial fovea is positioned higher than the larger distal fovea. It is difficult to infer the occlusal outline of the crown since it is lacking the entire enamel cap on the lingual side. The distal marginal ridge is thick, and it is separated from the protoconid by a prominent distobuccal groove close to the occlusal rim. The preserved mesiodistal and buccolingual dimensions are 10.5 mm and 12.1 mm, respectively. These dimensions are without any correction and should not be used for size comparisons.

BRT-VP-1/365 is a complete unworn L. M¹ crown broken at the cervicoenamel junction (Extended Data Fig. 1d). Measurements are provided in Table 1. A small enamel is missing on the lingual base of the protocone and no parts of the root are preserved. It has a square, slightly rhomboidal, occlusal outline. The protocone is the largest cusp, followed by the paracone. The metacone and hypocone are about the same size. The protocone contacts the metacone, only separated by a faint groove. All four cusps have pointy apex suggesting that it was at an early stage of occlusion. However, the presence of faint mesial and distal IPFs suggests that it was in

contact with the P⁴ and M² along the tooth row. A deep central lingual groove separates the protocone from the hypocone. The paracone and metacone are also separated by a groove starting at the central fovea and extending to the occlusal rim which continues to the buccal wall. A small groove, reminiscent of a carabelli's feature is present on the mesiolingual face of the protocone. A thin MMR mesially bounds a small slit-like mesial fovea. The distal fovea is distally bound by a thick, slanted buccally positioned DMR. The lingual wall of the crown slopes slightly occlusally while the buccal wall is vertical.

BRT-VP-1/380 is a L. C¹ crown with a complete root (Extended Data Fig. 11). It is a heavily worn canine but has no sign of weathering. The buccal face of the crown is sheared off. The sheared surface of the crown is polished and the preserved mesial and distal enamel edges of are rounded suggesting that it was more likely a premortem fracture. The crown has small contact facets on both of its mesial and distal faces suggesting that it was in contact with the I² and P³. The occlusal surface had dentine exposure that extends from the occlusal edge of the mesial crown shoulder to the distal tubercle measuring 6.6 mm mesiodistally. Another dentine exposure (2.9 mm mesiodistally) is also present positioned centrally on the lingual side immediately above the lingual basal tubercle. There is a shallow mesial marginal groove on the lingual side distal to the mesial crown shoulder. The distal marginal groove separating the distal tubercle from the crown on the lingual side is obliterated by wear. The lingual face of the crown between the mesial and distal marginal grooves on the lingual side seems to have been flat because the lingual enamel rim on the worn occlusal surface is straight. In lingual and buccal views, the crown flares from the cervicoenamel junction toward the mesial crown shoulder and distal tubercle. The mesial cervicoenamel line is deeply concave rootward while the distal line is also

concave but shallower. The root has a vertical groove on its mesial face while it is convex on the distal side. Its length measured on the mesial side is 22.2 mm while its mesiodistal and buccolingual dimensions immediately below the cervicoenamel junction are 7.1 mm and 9.2 mm, respectively.

BRT-VP-2/10-150 is a frontal fragment preserving the posterior portion at midline (Extended Data Fig. 2a–d). A small fragment recovered from the same area (previously BRT-VP-2/150) joined BRT-VP-2/10 and hence the specimen number BRT-VP-2/10-150. Anteriorly, it is broken at the posterior end of the frontal crest and posteriorly extends to the coronal suture. Its preserved anteroposterior (at midline) and bilateral breadth are 33.1 mm and 53.9 mm, respectively. Most of the preserved part is to the left of the midline. The external surface is smooth and concave bilaterally. On the endocranial surface, a shallow sagittal sulcus is present. Intermittent depressions are apparent on this surface. Faint temporal lines are palpable on both sides and appear to run perpendicular to midline suggesting that they may not have formed a sagittal crest. The overall thickness and size of the frontal also suggests that it may have belonged to a subadult individual.

BRT-VP-2/89 is a R. P⁴ germ lacking most of the inferior half of its buccal crown face (Extended Data Fig. 1j). The occlusal outline is a rounded rectangle with its long axis running buccolingually. Both cusps show no sign of wear and are set slightly mesially. They are about the same height and same size even though the protocone appears to be slightly larger. Both cusps have multiple vertical grooves descending from their apices to the longitudinal groove which divides the two cusps. This groove emanates from a slit-like mesial fovea distally

extending to the distal fovea which is also slit-like but buccolungually longer. The well-defined mesial marginal ridge bounds the mesial fovea mesially and the distal marginal ridge is thicker. There is no sign of interproximal facet on either the mesial or distal face of the crown. The paracone slopes occlusally more so than the preserved buccal face.

BRT-VP-2/200 is a small cranial fragment from the asterionic region on the left side (Extended Data Fig. 2o–r). The specimen is too fragmented to provide detailed description. However, a small depression on the ectocranial surface marks an asterionic notch. Internally, a small portion of the medial end of the transverse sulcus is preserved. Small fissures and tiny but numerous foramina are also present on the preserved endocranial surface. The preserved dimensions of the fragment are 29 mm anteroposteriorly and 42 mm superoinferiorly.

S4. Description of BRT-VP-2/87 (Right Ischium)

BRT-VP-2/87 (Extended Data Fig. 7) is a right ischium of a juvenile individual found from the same locality and horizon as the BRT foot. The specimen is relatively complete and belongs to a subadult individual. The ischial body is preserved intact although there are some cracks on its medial face. The acetabular margin along the posterior lunate surface, the ischial spine and tuberosity are abraded and part of the acetabulum medial to the acetabular fossa is missing. The ischiopubic ramus is also broken right at its base at the inferior end of the ischial tuberosity. The preserved superoinferior length is 41.7 mm and the ischial length, measured from the approximate center of the acetabulum to the preserved inferior end of the tuberosity, is 33.6 mm. Its preserved mediolateral breadth at the inferior edge of the lunate surface perpendicular to the ischium's vertical axis is 16.4 mm.

Based on modern human acetabular lunate surface morphology, BRT-VP-2/87 would be older than 6 years. The epiphyseal surface of the preserved posterior part of the lunate surface is developed and does not show any porosity like modern humans that are younger than 6 years (see Extended Data Fig. 8). While in modern human terms its size falls close to the 3-4 year range (Extended Data Fig. 8), the epiphyseal surface of the preserved posterior part of the lunate surface is developed and does not show any porosity like modern humans that are younger than 6 years (see Extended Data Fig. 7a). This is not surprising because based on dental, cranial, and facial developmental studies, early hominins are thought to have had a short developmental period compared to modern humans (e.g., refs. 11–13). However, whether the same developmental trajectory characterized postcranial elements of early hominins is poorly understood. Therefore, it is difficult to accurately estimate the ontogenetic age of BRT-VP-2/87 other than to say that morphologically, it is more developed than six-year-old modern humans though its size indicates a much younger age.

Unfortunately, there are no similarly aged ischia of *Au. anamensis* or *Au. afarensis* for comparison, but BRT-VP-2/87 is morphologically similar to MLD 8, a subadult ischium of *Au. africanus* from Makapansgat, South Africa¹⁴. The similarities include the tuberoacetabular sulcus being relatively wide and shallow. It also appears that in standard anatomical orientation, the superior edge of the ischial tuberosity is lower than the inferior end of the lunate surface of the acetabulum in almost all *Paranthropus* and *Australopithecus* ischia. These morphological traits are probably related to the elongated ischial body and characterize almost all known fully adult (e.g., A.L. 288-1, KSD-VP-1/1, Sts 14) and non-adult (e.g., MLD 7; MLD 25) *Australopithecus* ischia regardless of their ontogenetic stage^{14,15}. *Ardipithecus ramidus* is also characterized by similar ischial morphology¹⁶, indicating that it is probably a primitive retention from an ancient

ape-like quadrupedal ancestor. In species of *Homo*, such as *H. erectus*, the ischium is generally shortened, the tuberoacetabular sulcus is deep and narrow, and the superior terminus of the ischial tuberosity is positioned more superiorly relative to the inferior edge of the posterior lunate surface of the acetabulum¹⁷. In these aspects, the ischial morphology of *H. erectus* is similar to that of modern humans. Whether the ischial morphological features shared by *H. erectus* and *H. sapiens* characterize all members of the genus *Homo*, however, is currently unknown due to lack of pelvic specimens of earlier *Homo* species such as *H. habilis* and *H. rudolfensis*¹⁷.

In summary, fossils of early hominin subadult individuals provide significant information to reconstruct the evolutionary history of growth and development in early hominin fossil taxa¹⁸. However, fossil subadult individuals are mostly represented by craniodental elements and postcranial remains are extremely rare. As a result, most of the studies related to early hominin growth and development are based on dental remains. Studies of tooth crown formation and eruption have shown that early hominins had different patterns of dental growth and development compared to modern humans. However, the evolutionary history of the growth and development of fossil hominin postcranial elements has always been elusive largely due to lack of adequate juvenile and subadult postcranial fossil remains. What BRT-VP-2/87 and other postcranial elements of juvenile australopiths (e.g., ref. 19) indicate is that functionally significant aspects of early hominin skeleton related to locomotion and/or diet develop early in ontogeny. For example, the developmental stage of the lunate surface in BRT-VP-2/87 is far advanced relative to its size compared to the lunate surfaces of modern human acetabula of similar size. This might support the hypothesis that australopiths had accelerated but short infantile and pre-adulthood growth in their postcranial skeleton.

S5. Additional notes on taxonomy and phylogenetic relationships

A parsimony analysis to assess the phylogenetic position of *Au. deyiremeda* has previously shown that it is a sister to a clade containing *Au. africanus*, *Paranthropus*, and *Homo*¹ with some dentognathic homoplasy. The inclusion of BRT-VP-2/73 in the *Au. deyiremeda* hypodigm and its morphological similarity in some aspects of its morphology to *Au. africanus* further highlights close relationship between these two taxa.

It should also be noted that Haile-Selassie et al. (ref. 20) suggested a null hypothesis that BRT-VP-2/73 belongs to *Au. deyiremeda* because its morphology is inconsistent with what is currently known for *Au. afarensis*. This scenario indicates that some members of the genus *Australopithecus*, except *Au. afarensis*, did not have *Homo*-like bipedal locomotor adaptation and retained some degree of opposability in their big toe. While the foot morphology of the earliest australopith, *Au. anamensis*, is unknown, it now seems plausible that it may have had a foot morphology similar to *Au. deyiremeda* and *Au. africanus*, particularly if it descended from *Ar. ramidus* which had opposable big toe. Based on current evidence, it is possible to hypothesize that the pedal morphology of *Au. deyiremeda* and *Au. africanus* might be an intermediate morph between *Ar. ramidus* and *Au. afarensis*/later hominins. This could only be tested with the recovery of pedal remains of *Au. anamensis* and other mid-Pliocene hominins such as *Kenyanthropus platyops*.

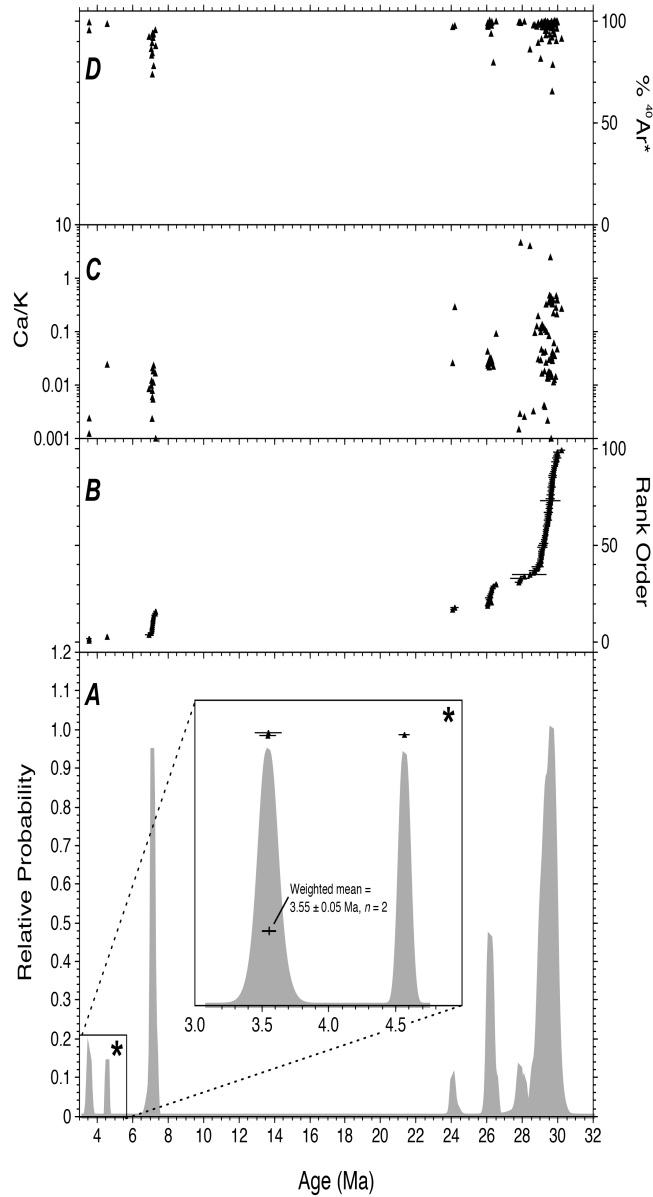
It now appears that there was radiation following the last appearance of *Au. anamensis* ca. 3.7 Ma²¹. The fossil record shows that at least *Au. afarensis*, *Au. deyiremeda*, and *K. platyops* overlapped more likely as early as 3.5 Ma suggesting that there was significant hominin radiation at that time possibly triggered by climate change. While it is possible that these taxa trace their origins to *Au. anamensis*, it is also possible that other earlier taxa such as *Ar. ramidus* may have given rise to species such as *Au. deyiremeda* while *Au. afarensis* descended from *Au. anamensis*.

This would be a more likely scenario if it could be incontrovertibly demonstrated that *Au. anamensis* lacked ape-like pedal morphology or opposable big toe. In fact, *Au. africanus* and *Au. deyiremeda* appear to be more related to each other than either is to *Au. afarensis*. At this point, it appears that *Au. deyiremeda* could be a better candidate to be the ancestor of *Au. africanus*. These two taxa share facial and pedal morphological features to the exclusion of *Au. afarensis* making it less likely that *Au. afarensis* gave rise to *Au. africanus* as previously thought. Rather, these taxa might all be sister taxa that descended from a common ancestor such as *Au. anamensis* or *Ar. ramidus* and adapted to different habitats and locomotor adaptations. This is the most plausible hypothesis given the currently available fossil evidence.

S6. Locomotor diversity in australopiths

The assignment of the BRT partial foot (BRT-VP-2/73) to *Au. deyiremeda* is based on its temporal and spatial proximity to dentognathic specimens that can be securely allocated to *Au. deyiremeda*. Its assignment to this species, however, has broader implications for the foot morphology and locomotor adaptations of early australopiths. *Australopithecus anamensis*, the first australopith that appeared ca. 4.2 Myr, has been characterized as a species with a suite of adaptations for habitual bipedalism²² while its predecessor, *Ar. ramidus* had a unique adaptation for both arboreal and terrestrial modes of locomotion. Habitual bipedality in *Au. anamensis* is inferred based mainly on proximal and distal parts of a tibia (KNM-KP 29285) that shows a morphology similar to later hominins that are habitual bipeds²². The foot morphology of *Au. anamensis*, however, is currently unknown. The evidence for human-like gait and foot morphology in *Au. afarensis* is derived from bony morphology of pedal remains as well as the 3.6 Myr footprints at Laetoli²³. It has been argued recently, however, that some of the footprints

(Site A) provide evidence for bipedal locomotor diversity. Other australopiths such as *Au. africanus* and *Au. sediba* retained more primitive, ape-like, foot morphology suggesting that not all australopiths were bipedal in the same way. For example, while *Au. sediba* possessed a tibia that is morphologically human-like, most aspects of its foot morphology, and thus inferred locomotor kinematics, were not human-like. BRT-VP-2/73 is morphologically mosaic in its retention of pedal grasping traits combined with features that are more derived toward later hominins. Taken together, there is increased fossil evidence suggesting diversity and variability in pedal morphology and function²⁴, and implied bipedal locomotor adaptations among australopiths²⁵. However, it seems increasingly likely that most or all australopiths lacked the full suite of morphological traits that characterizes modern human-like bipedal gait, which appears to be only evident in the fossil record after the appearance of the genus *Homo*.



Supplementary Figure S1. SCTF age-probability spectrum and related parameters. A) Age-probability density spectra of $^{40}\text{Ar}/^{39}\text{Ar}$ ages obtained for individual grains of K-feldspar from sandstone sample WM23-BRT-3. The inset (‘*’) highlights the youngest part of the age distribution. A weighted-mean age of the two youngest grains is shown. B) Rank order plot of the individual analyses. Uncertainties in age are given at 1s standard error. C) Ca/K atomic ratio derived as a by-product of the $^{40}\text{Ar}/^{39}\text{Ar}$ analysis. D) Percent radiogenic ^{40}Ar of the total ^{40}Ar released.

Supplementary Table S1. Dental scores and DMS tabulation.

Kuykendall (1996) score:		Gunz et al. (2020) microCT score:		Adj. Gunz et al. (2020) score:	
I1	6	I1	5	I1	5
I2	5	I2	4.5	I2	4
C	4	C	4	C	4
P3	4	P3	4	P3	4
P4	4	P4	4.5	P4	4
M1	7	M1	7	M1	7
M2	4	M2	4.5	M2	4
DMS= 34		DMS= 33.5		DMS= 32	
Est. from Regression:	4.89		4.78		4.47
Lower range	3.90		3.79		3.48
Upper range	5.88		5.77		5.46

Supplementary Table S2. Statistical summary of early australopith lower deciduous teeth.

Species		dc ₁		dm ₂	
		MD	LaL	MD	BL
<i>Au. deyiremeda</i> *	BRT-VP-2/135	5.3	5.1	9.7	8.7
<i>Au. anamensis</i> ^a	n	2	2	3	3
	median	6.75	5.55	10.0	7.9
	range	6.7–6.8	5.5–5.6	9.9–11.0	7.9–9.3
	s.d.	-	-	0.68	0.81
<i>Au. afarensis</i> ^a	n	2	2	5	5
	median	6.55	5.8	11.9	10.6
	range	6.5–6.6	-	10.8–12.6	9.4–12.6
	s.d.	-	-	0.71	1.25
<i>Au. africanus</i> ^a	n	1	1	7	6
	median	6.0	5.8	12.2	10.0
	range	-	-	10.6–12.8	9.4–10.5
	s.d.	-	-	0.89	0.46

* Measurements of *Au. deyiremeda* were taken by the authors.

^a Measurements were compiled from refs. 26, 27 (*Au. anamensis*), refs. 28–31 (*Au. afarensis*), and ref. 32 (*Au. africanus*). MD = mesiodistal. LaL = labiolingual.

Supplementary Table S3. Statistical summary of early australopith upper dentition measurements used in the comparative analysis.

Species		C ¹		M ¹		M ²	
		MD	BL	MD	BL	MD	BL
<i>Au. deyiremeda</i> *							
	BRT-VP-1/365	-	-	11.2	11.8	-	-
	BRT-VP-1/380	9.4	9.6	-	-	-	-
	BRT-VP-3/1	8.3	9.4	10.6	11.0	11.8	13.2
<i>Ar. ramidus</i> ^a							
n		5	5	8	8	8	9
median		11.2	11.7	10.45	11.8	12.0	14.2
range		11.2–11.9	10.6–12.2	9.8–10.8	11.2–13.0	11.0–12.8	13.3–15.3
s.d.		0.33	0.62	0.35	0.55	0.50	0.60
<i>Au. anamensis</i> ^a							
n		8	8	9	9	10	10
median		10.5	11.25	11.6	13.0	13.0	14.7
range		9.1–11.8	9.9–12.5	10.3–12.1	11.8–14.2	11.4–14.2	12.9–16.3
s.d.		0.97	0.97	0.83	0.96	0.80	1.1
<i>Au. afarensis</i> ^a							
n		13	13	14	12	8	9
median		10.0	10.9	12.05	13.35	13.1	14.9
range		8.9–11.6	9.3–12.5	10.5–13.5	12.0–14.6	12.1–14.1	13.4–15.8
s.d.		0.68	1.02	1.07	0.92	0.6	0.6
<i>Au. africanus</i> ^a							
n		13	14	35	22	33	31
median		9.9	10.3	12.8	14	14.4	15.7
range		8.8–10.9	8.7–12.0	11.4–13.8	12.7–15.3	12.8–16.4	13.7–18.3
s.d.		0.58	0.91	0.64	0.82	1.05	1.23

* Measurements of *Au. deyiremeda* were compiled from ref. 1 and additional measurements were taken by the authors.

^a Measurements were compiled from refs. 33, 34 (*Ar. ramidus*), refs. 26, 27 (*Au. anamensis*), refs. refs. 28–31 (*Au. afarensis*), and ref. 32 (*Au. africanus*). MD = mesiodistal; BL = buccolingual.

Supplementary Data S1. $^{40}\text{Ar}/^{39}\text{Ar}$ analytical data of geological samples from Burtele (BRT)

locality.

Supplementary Data S2. Statistical summary of early hominin lower dentition measurements used in the comparative analysis.

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