Title
Potassium/Argon Dating at Olduvai Gorge: A Preliminary Report

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Potassium-Argon Dating At Olduvai Gorge

A Progress Report by F. Clark Howell

Nature (July 29, 1961) published Leakey-Evernden-Curtis on new dating which indicated that the usual million years for the evolution of man and culture might be extended to 1,750,000 years or more. Knowing our readers are interested in the significance of the new dating for theories of human evolution, we asked 26 scholars to suppose that these dates are correct and to write a comment for CA. A few responded, but others refused to do so until the dates can be verified.

Meanwhile, von Koenigswald-Gentner-Lippolt published an article (*Nature* November 25, 1961) indicating a difference in K/A dates of material from the same site. At this point the *New Scientist* (November 30, 1961) published a short report on this controversy concluding that we should have to await new dates.

F. Clark Howell has kindly prepared for CA this progress report on the dating, which both Leakey and von Koenigswald have approved. When the dates are settled, we shall proceed with the symposium now held in abeyance.—EDITOR.

Many Associates of CURRENT ANTHROPOLOGY have doubtless read or heard of the effort being made by geochemists to apply the potassium-argon (K/A) method of absolute dating to volcanic-derived sediments of Pleistocene age. The method, when sufficiently refined and capable of consistent and accurately duplicable results, promises to be a major advance toward dating the biological and cultural evolution of the Hominidae.

Within the past year the method has been employed to determine the absolute ages of the sediments comprising the two lower beds (I, II) at Olduvai Gorge, northern Tanganyika, a locality renowned for its splendid succession of Pleistocene mammals and early human occupation sites, and most recently for the important discoveries by Dr. and Mrs. L. S. B. Leakey of early hominid skeletal remains (CA 1:76–77). Two series of determinations have been made on volcanic products within or underlying the Olduvai series of deposits. The results of these determinations are summarized in the accompanying table. While there is a certain internal consistency in each series of determinations, the results from one laboratory (Max-Planck Institute für Kernphysik, Heidelberg) (von Koenigswald *et al.* 1961) contradict those from another laboratory (Department of Geology, University of California, Berkeley) (Leakey *et al.* 1961). The following points may be made with reference to these series of dates:

(1) A single determination is available for a sample taken from Bed II, at a level *below* that known to yield an East African Chellean 3 stone industry. The determination was 360,000 years (Leakey *et al.* 1961). Now the Chellean 3 stone industry is known at the LLK 2 site, in the FLK locality, and this site has recently yielded a well preserved hominid cranium (Leakey 1960) which, while exhibiting some ("pithecanthropine") characters typical of early *Homo,* is also very significantly larger and in some respects, especially in the occipital region, is quite unlike the East (Choukoutien) and Southeast Asiatic (Java) human populations. This K/A determination is quite comparable with two K/A determinations on phonolite tuffs from the Laacher See, Rhineland. These samples were from the upper half of the lower Main terrace, a feature generally assigned to the early Middle Pleistocene (or Lower Pleistocene of German workers), and probably of late Elster (Mindel or perhaps even inter-Mindel interstadial age according to A. Frechen; but of Günz age according to P. Woldstedt). The corrected ages of the determinations are 353,000 and 388,000 years, with an average age of 370,000 years (Evernden *et al.* 1957).

Another K/A determination from volcanic deposits representing the initial eruptions of the Sabatino (Bracciano) volcanic group, and which the late A. C. Blanc (1957) referred to as the Flaminian stage, is the third of five successive cold stages in the Pleistocene succession of the Latium. He regarded the Flaminian as pre-Tyrrhenian (I) in age and as most probably broadly equivalent to the later phases of the Elster (Mindel) Glaciation. The determination is approximately 450,000 years (Evernden 1959). (These several determinations should be compared with Emiliani's [1955, 1956, 1958*a, b,* 1961] very tentative estimation, on the basis of the deep-sea core evidence and of assumed continental equivalence, of ca. 175,000 to 205,000 years as an age for the Antepenultimate Glaciation.)

Another single K/A determination is available for the Capranica tuffs in the Rome region. These were regarded by A. C. Blanc as most probably of early Tyrrhenian (I) age, that is, corresponding to the Great Interglacial (Holsteinian-Hoxnian) stage. The determination is approximately 230,000 years. (This determination should be compared with Emiliani's [1955, 1958*b*] tentative estimation of the age of the Great Interglacial as 130,000 to 175,000 years.)

(2) Three K/A determinations are from samples taken from deposits in Olduvai Gorge which are recognized to be *near the top* of Bed I, and certainly to postdate those sites in Bed I which have thus far yielded hominid skeletal remains. The determinations would hence provide an approximate age for the site of the FLK N. I, a clay bed with (advanced) Oldowan industry and a rich fauna, especially many desertic rodents, but as yet no hominid remains, and which underlies the hard "Marker Bed" at the top of Bed I (Leakey 1961*a*). The results of these determinations were: 1.02×10^6 years (1,020,000 years) (Sample #664), 1.13×10^6 years (#664R), and 1.38×10^6 years (#861), with an average age of 1.23×10^6 years (Leakey *et al.* 1961).

(3) Two determinations are from samples in close relation to the level in Bed I at the site of FLK I (or FLK Main) which has yielded the australopithecine skeletal remains referred to *Zinjanthropus boisei* Leakey, found on an extensive occupation horizon in association with Oldowan industry and a rich fauna (Leakey 1959). The results of these determinations were: 1.89×10^6 years (#849: tuff overlying the "Zinj" horizon, with 20% fresh shards), and 1.64×10^6 years (#851: tuff immediately below the "Zinj" horizon, containing numerous bone fragments, a possible contaminant).

Another determination is from a sample collected from the upper of two thin (2.5–5.1 cm. thick) bands of ash which overlie the ("pre-Zinj") horizon at the adjacent site of FLK NN. 1. This site has recently yielded skeletal remains of another, and distinct hominid (Leakey 1961*a, b*), and lies some .6 m. to 1.2 m. *below* the FLK Main ("Zinj") horizon. The result of this determination was: 1.78×10^6 (#850: most glass shards altered to clay).

Two other (unidentified) localities, situated west of the third fault on the south side of the gorge, and several miles from the FLK locality, have provided samples for age determination from a tuff series comparable with that which yielded the aforementioned skeletal remains at FLK. The results of these determinations were: 1.63×10^6 years (#412: most glass shards altered to clay) and 1.74×10^6 years (#437:

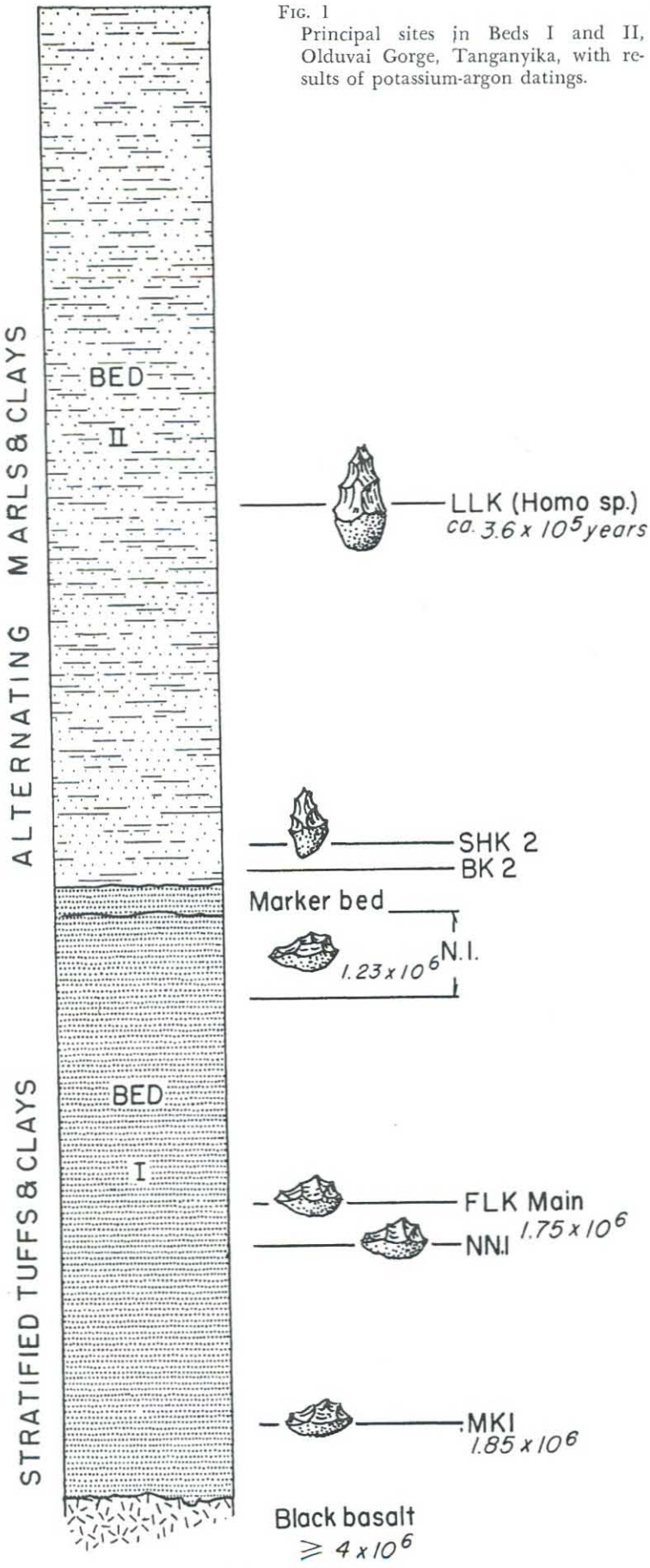

FIG. 1
Principal sites in Beds I and II, Olduvai Gorge, Tanganyika, with results of potassium-argon datings.

most glass shards altered to clay) (Leakey *et al.* 1961). The authors concluded, on the basis of these several determinations, that the best average "absolute" age for the FLK hominid-bearing horizons in Bed I is approximately 1.75×10^6 years.

(4) Two additional determinations are from samples from another locality, MK, in Bed I and situated several miles to the east of the FLK locality. This site has also yielded hominid skeletal remains (teeth), and is considered to represent most likely a lower level in Bed I than the hominid-bearing horizons at FLK. (Thus, the hominid-bearing horizons at FLK lie at ca. 4.6–4.9 m. above the underlying basalt lava flow, whereas the horizon at MK lies 2.7 m. above the underlying basalt; however, the basalt is markedly undulating and shows pronounced ridges and hollows in its extent through the eastern sectors of the Gorge.) The results of these determinations were: 1.57×10^6 years (#846: from a tuff 45.7 cm. *below* the hominid-bearing horizon; most glass shards altered to clay) and 1.85×10^6 years (#847: tuff just *above* the hominid-bearing horizon; most glass shards fresh).

Thus, these K/A determinations would indicate that all sediments comprising Bed I have an age in excess of a million years. They also indicate an *approximate* age difference of five hundred thousand years between the uppermost levels of Bed I (just below the "Marker Bed") and those hominid-bearing horizons some twenty feet lower in the FLK locality. Moreover, they would suggest an approximate age difference of nearly 750,000 years between the uppermost deposits of Bed I and the lowermost deposits of Bed II (assuming an age of approximately 500,000 years for the latter, where several occupation sites have yielded rich assemblages of early East African Chellean and abundant mammalian fossils, as well as two hominid teeth [Leakey 1958]). An age-difference approximating a million and a half years would separate the early "Zinj" and "pre-Zinj" hominids from an evolved hominid, doubtless referable to *Homo* sp. and associated with an evolved East African Chellean stone industry.

In the FLK locality there are some 25–30 individual tuffs and tuffaceous beds, with intercalated silty and/or clayey deposits, which total around forty feet (11.9–13.1 m.) in thickness. The authors state that "most beds . . . appear to be primary ash falls," whereas some others are clearly reworked materials deposited under fluviatile conditions. The matter of sedimentation and source of volcanic products is especially important since the possibility of min-

eral contaminants from older, reworked and redeposited volcanic products must be eliminated. The authors believe this has been done, calling attention to "no visible contaminants" in the samples reported on and stating specifically that "there seems to be no chance of their being contaminated by older eroded debris" (Leakey *et al.* 1961).

(5) The second series of determinations has been aimed at providing an age for the basalt lava flow which underlies the sedimentary series exposed in Olduvai Gorge (von Koenigswald *et al.* 1961). A single direct determination of a sample of the basalt provided an age of 1.3 (± 0.1) $\times$ 10^6 years. This would thus afford a *terminus non ante quem* for the succeeding sedimentary series. This is (in part) the basis for the recent statement by Oakley (1961) that the K/A determinations "so far obtained indicate that the oldest hominids, the Australopithecinae in Bed I, Olduvai, are approximately a million years old, whereas the oldest hominines, in Asia and Africa, are about half a million years old." (See also Oakley 1962.) Such a determination conflicts with the aforementioned determinations (3) and (4) which are substantially older than the basalt flow which they overlie! Two other determinations are on Oldowan chopping-tools ("pebble-tools") of basalt from Bed I: one provides a date, 1.4 (± 0.1) $\times$ 10^6 years, substantially in agreement with that from the basalt flow sample, whereas the other is substantially older, 2.25 (± 0.16) $\times$ 10^6 years.

These latter specimens of basalt were collected from Olduvai Gorge under less than ideal conditions and their appropriateness for dating is indeed open to question. Curtis and Evernden (1962) have recently published dates for the basalt on two samples (probably representing different lava flows judging from the types of minerals and their proportions) collected specifically for this purpose. One sample (KA 927, collected by Leakey at the FLK I site), an olivine basalt, yielded the following ages from three K/A determinations: 4.1 ± 0.5, 4.0 ± 1.0, and $4.4 \pm 0.2 \times 10^6$ years. The results clearly demonstrate that the underlying basalt is *at least* four million years old. The second sample (KA 933, collected by Curtis at the 3rd fault), an olivine basalt or olivine trachyte converted to iddingsite, yielded the same results from two K/A determinations: $1.7 \pm 0.2 \times 10^6$ years. In fact, however, the basalt is not reliable for dating purposes since it has been extensively weathered and such alteration affects the constituent mineral products and releases argon. Hence any age determinations are sure to be too young. Nonetheless the dating of sample KA 927 demonstrates that the original K/A age determinations for the Berkeley laboratory for Bed I are correct; and, as Curtis and Evernden (1962) state, the Heidelberg estimation of the age of the basalt is "the result of using unreliable material and is to be ignored."

The question of the rate of sedimentation at Olduvai was raised by von Koenigswald *et al.* (1961) who thought it extraordinarily slow considering the long time range involved if the Berkeley K/A dates for Bed I were correct. However, Curtis and Evernden (1962; also L. S. B. Leakey, personal communication) point out that most of the Bed I sediments represent primary ash falls which instantly buried hitherto exposed surfaces; this would of course account for the essentially unweathered and excellently preserved bone on the various surfaces of hominid occupation. Moreover there are numerous soil profiles, some quite deep, developed into the various falls of tuffs, and requiring substantial periods for their development. Hence, the sedimentation was sporadic and frequently interrupted, sometimes for protracted periods, and these disconformities represented by fossil soils have yet to be taken into consideration.

The significance of Olduvai Gorge dates can in part only be seen in terms of other determinations for the late Cenozoic (cf. Kulp 1961). Elsewhere, Curtis, Savage, and Evernden (1961) have presented the results of K/A determinations for the Neogene (Mio-Pliocene) of North America. Of particular interest are those from certain intermontane basins in the western United States which yield paleobotanical and mammalian assemblages from several stages of the Pliocene. The Clarendonian stage (Lower Pliocene) has been dated by four determinations, the oldest of which is 12.0 $\times$ 10^6 years (regarded as the approximate base of the Pliocene) and the youngest of which is 10.6 $\times$ 10^6 years. One determination is available for the Hemphillian stage (Upper Pliocene), 9.1 $\times$ 10^6 years (regarded as probably representing the very base of this stage). One determination, with a 10% error, is available for the Blancan stage (latest Pliocene to basal Pleistocene), 2 $\times$ 10^6 years.

However, as Kulp (1961) lamented, in his recent review of the geologic time scale, "the date of the Pleistocene-Pliocene boundary is probably the most poorly known of the dates for boundaries between geologic periods, at least if expressed as a percentage of the correct age." (He did hesitantly suggest that the boundary might be placed at a date of 1.0 million years before present, but "with the understanding that this figure is subject to considerable revision.")

The question of the age of the Pliocene-Pleistocene boundary and the broader significance of the results of K/A age determinations as these bear on mammal evolution, and especially the evolution of the higher primates and man, will be duly considered in the aforementioned symposium planned by the Editor of CURRENT ANTHROPOLOGY.

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