ing sediments that might yield small mammals that are ancestral to those found at Badwater and in Montana? There is a considerable thickness of rocks of middle Eocene age in the Absaroka, Washakie, and Owl Creek mountains and possibly along the northern end of the Wind River Mountains. These rocks, the Aycross Formation (*8*), have been prospected only in a limited area (*9*); their fauna is poorly known and no micromammals have been reported from them. They occur at high elevations, close to what were the mountain fronts during the middle Eocene. Sediments of the Aycross Formation were deposited in the upland areas as valley fills, burying much of the Owl Creek and Washakie ranges and also spreading out into the Wind River Basin (*8*). If one assumes rather narrow ecologic niches for some of the late Eocene species, particularly the multituberculate and dermopteran, and if one also assumes that these niches were in upland areas, then it is probable that the drainage systems that deposited the Aycross Formation might have sampled these environments—environments that were beyond the reach of the depositional regime of the Green River and Bridger formations. It is in these areas, close to and in the mountain fronts, that the small mammals ancestral to the Badwater and Montana species may be found and where mammalian communities quite different from those presently known for the middle Eocene may have existed.

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27 January 1967

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Hominid Humeral Fragment from Early Pleistocene of Northwestern Kenya

Abstract. *The distal end of a hominoid humerus was recovered from early Pleistocene sediments in the Kanapoi drainage near the southern end of Lake Rudolf. Lava capping the sediments yielded a potassium/argon date of 2.5 million years. The fragment can be distinguished on inspection from gorilla and orangutan; discriminate analysis of humeri of* Homo *and* Pan *assigns it as hominid. From other evidence we consider it more likely to represent* Australopithecus s.s. *than* Paranthropus.

A new locality for early Pleistocene fossils, among them a hominoid fragment, was discovered in southeastern Turkana in 1965 (*1*). The fossil-bearing sediments, which are capped by a thin basaltic lava, are largely lacustrine, and the fauna they contain appears to be earlier than that of Olduvai Bed 1. The sediments have so far been traced from the discovery area in the Kanapoi drainage southward into the valley of the Kerio River, northward to a point near the junction of the Kerio and the Kalabatha and northwestward across the Kalabatha valley to an area south of Kachau cone. The sediments were involved in diastrophic movements, mostly rather gentle warping with some minor faulting. The exposures along the juncture of the Kerio and Kalabatha rivers occur in a low, east-west trending anticline. On the north limb of the anticline some sediments, mainly conglomeratic, rest on the capping lava and, like it, dip northward. Apart from superficial accumulations, these are the only sediments later than the lava flow that have so far been encountered in the region. Lava and sediments here dip toward Lake Rudolf, which is only 48 km away following the line of the Loriu Hills (a barrier between the southern extremity of Rudolf and the Kerio-Kalabatha valley), and it seems certain that they were related to an early stage in the history of the lake.

There is no indication of any appreciable difference in age between the capping lava and the underlying, predominantly lacustrine sediments. Many exposures of the lava show pillow structure, indicating that the lava advanced into standing water. The lava has reversed polarity, and a potassium/argon date obtained from it gave an age of 2.9 ± 0.3 million years (*1*). Taking the earliest date within the limits of the error, this was a fair approximation to the beginning of the Matuyama reversed polarity epoch, now regarded as 2.5 million years old (*2*). Geochron Laboratories have recently done further work on the samples and obtained an age of 2.5 ± 0.2 million years. This result is believed to be the more reliable of the two because of the much smaller atmospheric argon correction; the new analysis is 12 percent radiogenic as compared with 5 percent for the earlier one. In terms of the new date, there is now very good agreement with polarity, and the fauna, taken as a whole, is also in accord. This date suggests that the lava is approximately contemporaneous with Roccaneyra in the early (but not the earliest) part of the European Villafranchian sequence (*3*), which has been dated by the potassium/argon method at about 2.6 million years (*4*). No artifacts of any sort have been found *in situ* in the sediments (*1, 5*).

The hominoid fragment found in 1965 is a well-preserved distal end of a left humerus (Fig. 1). No additional specimens of hominoids were discovered during the 1966 field season, and, despite extensive excavation and sifting, no further parts of this humerus were recovered. The fragment was found on the surface of exposures at the base of the west side of Naringangoro Hill (*1*). Color, hardness, and degree of mineralization agree with those of numerous specimens collected *in situ* in the sediments. The excellent state of preservation—the fragment shows no significant postmortem damage other than the break that separated it from the remainder of the original bone—rules out the possibility of derivation from later deposits that may once have been present in the vicinity above the capping lava. The specimen has been catalogued as Kanapoi Hominoid 1 by the National Museum Centre for Prehistory and Palaeontology, Nairobi.

As Straus has pointed out (*6*), it is difficult to identify family from only the distal end of the hominoid humerus. Chimpanzee and man in particular resemble each other closely in the structure of this part of the skeleton. Kanapoi Hominoid 1 can at once be recognized as a hominoid on its gross morphology, and it is readily distinguished on this basis from gorilla and orangutan. Detailed morphological and metrical comparisons have been made with chimpanzee, modern man, and a cast of *Paranthropus robustus*, the only early hominoid for which this part of the humerus is known (*6*, *7*).

Table 1. Measurements of humeri of four different species. Measurements are in millimeters.

Measurement	*Pan* $\bar{X}$	*Paranthropus*	Kanapoi Hominoid 1	*Homo* $\bar{X}$
Biepicondylar width	64.07	53.6	60.2	58.02
Trochlear ridge to apex, medial epicondyle	44.76	33.6	41.7	40.72
Trochlear ridge to medial border of shaft	41.31	32.1	39.4	38.82
Capitulum groove to post-trochlear margin	26.35	19.9	22.2	22.14
Length, medial epicondyle	24.71	15.5	20.8	20.34
Width, medial epicondyle	12.80	10.4	13.9	12.63
Capitulum to lateral epicondyle, maximum height	31.52	24.9	27.6	26.71

For the metrical comparison, samples of 40 human and 40 chimpanzee humeri were used, without regard to sex (*8*). We took seven measurements designed to register certain morphological differences among species (Table 1).

In these diagnostic measurements Kanapoi Hominoid 1 is strikingly close to the means of the human sample. It is larger than the individual of *Paranthropus robustus* represented by the corresponding humeral fragment from Kromdraai in each measurement; the latter fossil is difficult to place relative to *Pan* and *Homo* from these figures alone, since it is smaller than the means of both species throughout.

Certain morphological characters in this part of the humerus distinguish a large majority of men from a large majority of chimpanzees. Some of them are reflected in the measurements in Table 1; however, these show considerable species overlap. (i) In man the posterolateral margin of the trochlea extends only slightly more posteriorly than the posteromedial margin, and it projects only a little beyond the adjacent bone surface; in chimpanzee it is usually much more salient. (Compare the means in measurement 4, Table 1.) (ii) The medial border of the shaft in man usually flares out to a lesser extent than in chimpanzee, forming less of an angle with the medial epicondyle. (See the relations between measurements 2 and 3, Table 1: the excess of the distance from the most distal point on the trochlear ridge to the apex of the medial epicondyle over the distance from the same point to the medial shaft border is 3.45 in our chimpanzee sample but only 1.90 in the human sample.) (iii) The distal margin of the capitulum is usually inclined anterolaterally and forms an angle of about 45° with the transverse axis in man, whereas in chimpanzee the margin generally curves out laterally before turning anteriorly. (iv) Most men differ from most chimpanzees in that comparatively little of the capitulum is situated on the distal face of the bone. (v) The area between the capitulum and the posterolateral margin of the trochlea in man usually exhibits a more "squared-up" outline when viewed from below. (vi) In most chimpanzees the distal projection of the trochlear ridge forms a sharper and higher crest between the furrows on either side than is the case in man, in whom it is usually more smoothly rounded and lower. (vii) The line of the greatest anteroposterior diameter of the distal portion of the shaft is situated near the center in man and nearer the medial border in chimpanzee; therefore, the medial side above the epicondyle is more tapering in the former and more rounded in the latter. Of these various distinctions (vii) is rather constant. In (i) no men of our sample approach the chimpanzee condition, although approximately 25 percent of the chimpanzees approach the human condition (*9*). In characters (ii) through (vi) a minority of each sample, approximately 10 to 25 percent, approaches the condition seen in the majority of the other.

Kanapoi Hominoid 1 agrees with chimpanzee in (vii), with man in (i), and with the majorities of our human sample in the rest. It is peculiar, although by no means unique, in one character. The medial epicondyle is stout, rather rugose, and deep, and maintains a nearly constant anteroposterior diameter almost to its distal extremity; minorities of men and of chimpanzees, approximately 15 and 20 percent respectively, approach it.

Paranthropus emerges from these morphological comparisons as rather less man-like than Kanapoi Hominoid 1. It agrees with man or majorities of men and with Kanapoi Hominoid 1 in traits (i), (ii), and (vi), with majorities of chimpanzees in (iii), (iv), and (v), and with chimpanzee and Kanapoi Hominoid 1 in (vii). *Paranthropus* is unique among hominoids in the flatness of the capitulum and peculiar in the rather pointed and slender medial epicondyle (*6*). In both these traits it differs decidedly from Kanapoi Hominoid 1.

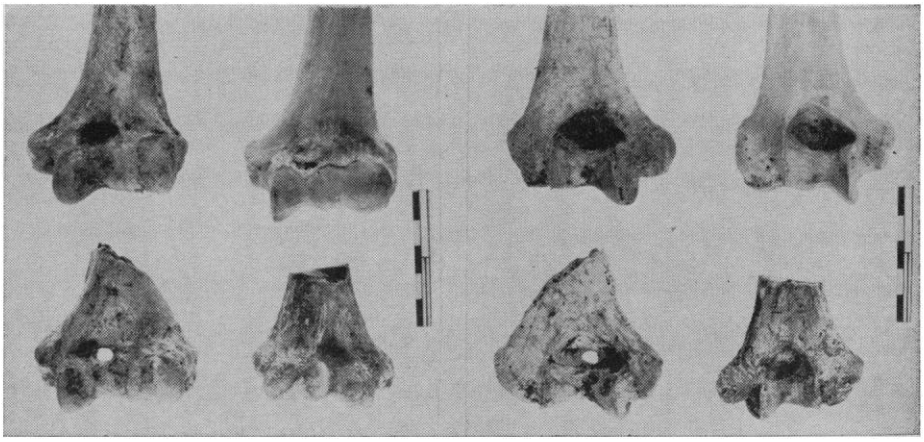

Fig. 1. Distal ends of hominoid humeri. Set on left are anterior views, those on right are posterior views. Upper left, modern man; upper right, chimpanzee; lower left, Kanapoi Hominoid 1; lower right, *Paranthropus robustus* (cast). The *Paranthropus* specimen is from the right side, the others from the left. The perforation of the fossa olecrani in Kanapoi Hominoid 1 is natural; this perforation is not uncommon in hominoids.

In cases such as this, where there is much similarity and overlap between the populations in question, a discriminant function is valuable. The seven measurements listed in Table 1 were used in such a function, which assigned all but 3 of the 80 human and chimpanzee specimens of our two samples to the correct population, producing little overlap in scores. To indicate the degree of discrimination, the means and standard deviation of the individual scores were: chimpanzee, $\bar{X}$ 99.77, s.d. 13.19; *Homo*, $\bar{X}$ 61.42, s.d. 9.23.

Kanapoi Hominoid 1, with a discriminant score of 59.4, falls very close to the human mean and at a point where the probability of its occurrence in the chimpanzee population approximates .001. The *Paranthropus* specimen has a score of 63.9, which also falls beyond the observed range of the sample of 40 chimpanzees. However, aspects of the data suggest that, while statistically excluded from a chimpanzee population, the *Paranthropus* specimen is distinctly less like a hominine than is the specimen of Kanapoi Hominoid 1. Metrical and morphological data appear to be in agreement for both fossils.

On the basis of our interpretation of the geological and faunal data, Kanapoi Hominoid 1 is the earliest Pleistocene representative of the Hominidae yet found. To us the most interesting fact is the difference of form and size of the new fossil from the Kromdraai fragment identified as *Paranthropus robustus*. If the latter assignment is correct—and there is at present no reason to doubt it—then it is quite unlikely that Kanapoi Hominoid 1 was a member of the same lineage; although earlier in time it is more hominine. Napier (*10*) has presented evidence that *Australopithecus s.s.* and *Paranthropus* were widely different in the structure of the pelvic bones and the proximal ends of the femora, to a degree indicating a difference in gait, with *Australopithecus* being much closer to modern man. This evidence supports the view of Robinson (*11*) and others that *Australopithecus* was a hominine. Kanapoi Hominoid 1 suggests that corresponding differences in the arm may have existed within the Hominidae during the earlier Pleistocene. All this points to the possibility that Kanapoi Hominoid 1 may prove to be *Australopithecus*, and the comparatively large size of Kanapoi Hominoid 1 is compatible with this possibility. The dimensions of the proximal end of the humerus of *Australopithecus* from Sterkfontein (*12*) are within the observed range of modern man; in fact there are individuals in our sample of man on whom measurements of this specimen and of Kanapoi Hominoid 1 can be duplicated almost exactly.

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6 February 1967

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Radiocarbon Dating of Biogenetic Opal

Abstract. *Approximately 75 grams of biogenetic opal were isolated from 45 kilograms of soil by employing gross particle-size and sink-float specific gravity fractionation procedures. After pretreatment of the sample to remove extraneous organic and inorganic carbon contaminants, the carbon occluded within opal phytoliths was dated at 13,300 ± 450 years before the present. Therefore, biogenetic opal is stable for relatively long periods.*

The feasibility of utilizing opal phytoliths isolated from soils as a C^{14} source when other materials are unavailable or undesirable for dating purposes has been proposed (*1, 2*). This report describes a procedure for dating carbon occluded within opal phytoliths without apparent contamination from extraneous forms of soil carbon.

Opaline constituents were isolated from the surface horizon (0 to 18 cm) of a well-drained Brunizem soil (Warsaw silt loam, site CH-34, Lab. No. 10539) which was sampled on a nearly level terrace along the Mad River Valley in west-central Ohio. The age of the valley train sediments from which the soil developed is 14,000 to 18,000 years before the present (*3*). Based on the vegetative history of the area (*4*), the physical and chemical properties of Warsaw soil, and its opaline constituents, it is concluded that this soil developed under a prairie vegetation.

From opaline analysis of this profile, it was observed that the distribution of opal phytoliths (20 to 50 μ) (expressed on a total soil basis) decreases with depth as follows: 0.56 percent, 0 to 18 cm; 0.23 percent, 18 to 33 cm; 0.15 percent, 33 to 48 cm; and 0.04 percent, 48 to 63 cm. This amounts to a total accumulation of 22,430 kg of opal per hectare for the 0- to 63-cm portion of soil profile [20,466 lb/acre (25-inch depth) based on a weight of 2 million pounds of soil per acre (6-inch depth)]. If one assumes an annual deposition of 16.4 kg of opal per hectare (15 lb/acre) as previously estimated (*5*), it would require about 1350 years to accumulate the quantity of opal found at this site. Similar calculations for a Brunizem soil in Illinois suggests that approximately 5000 years of grass vegetation, presumably since the Climatic Optimum, would be required to accumulate the opal found at that site (*5*). Based on this evidence, it was anticipated that the radiocarbon age of opal isolated from Warsaw soil would be between 1000 and 1500 years before the present.

The following laborious and time-consuming procedures were employed to fractionate and purify approximately 75 g of opal from 45 kg of soil. The bulk sample was crushed to < 2 mm in a mechanical crusher (Hasco-Asplin), dispersed with 1 g of Calgon