appeared anomalous. Terrestrial richterite, however, is a well-known skarn mineral (*2*) indicative of formation at a high temperature (300° to 800°C) and low total pressure (100 to 3000 bars) (*4*). As such it is precluded as a weathering product of, for example, a pyroxene. Furthermore, in this particular case, half the hydroxyl position is filled with fluoride, a situation which precludes a weathering phenomenon. In addition, the amphibole grains are optically clear and almost colorless, and in transmitted light they are bright and clear with good cleavages and sharp extinctions and interference figures. The x-ray pattern is extremely sharp, which indicates good crystallization. Finally, adjacent olivine, albite, and roedderite grains are completely fresh. Both optical examination and x-ray patterns of olivine show no signs of weathering or other types of alteration products. The excavations were performed on a cut surface in the interior of the iron, and all specimens came from within the graphite. Thus, although the meteorite from Wichita County is a find (*5*), the amphibole is definitely preterrestrial. Preterrestrial hydroxylated and hydrated phases are, of course, well known from the carbonaceous chondrites.

Regarding the water content, it is possible to make some semi-quantitative estimates of the conditions implied at some time in the past thermal history of this meteorite. We may, for example, write a reaction for the hydroxyl-tremolite component of the amphibole,

$$Ca_2Mg_5Si_8O_{22}(OH)_2 + Mg_2SiO_4 = 2\,CaMgSi_2O_6 + 5\,MgSiO_3 + H_2O$$

From this we may calculate the water pressure at each temperature (*6*). Since no pyroxenes are present in the graphite nodules with the amphibole, these pressures represent the minimal ones required to stabilize it. Over the range of temperatures 300° to 800°C, these calculated pressures range from only 10^{-2} atm to a little less than 100 atm. However, since the amphibole is not pure hydroxyl-tremolite, but contains Na and F, the activity terms of these act to reduce these water pressure requirements. Thus, qualitatively, we can say that over this temperature range $P(H_2O) \ll 1$ atm. Since the magnetite-iron boundary only requires that $P(H_2O)/P(H_2)$ be $\lessapprox 1$ in this temperature range (*7*), no unusual H_2 pressures are required. Thus, the amphibole can stably form with metallic iron without serious contradictions arising. Also, at least a dozen other iron meteorites show degrees of oxidation only a few orders of magnitude of $P(O_2)$ within the metallic iron field (*8*), commensurate with the most oxidized L and LL group chondritic meteorites.

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Table 1. X-ray powder-diffraction data for richterite from the Wichita County iron meteorite compared with richterite from skarn rock, Langban, Sweden. *I*, intensity; *d*, spacing.

Meteorite richterite		Langban richterite	
I/I_0 (visual)	*d* (Å)	*d* (Å)	I/I_0 (visual)
70	8.605	8.572	80
70	8.393	8.330	80
30	4.864	4.842	40
50	4.493	4.470	50
70	4.160	4.150	30
30	4.004	3.994	30
50	3.850	3.857	50
100	3.376	3.373	90
80	3.267	3.271	80
100	3.125	3.140	100
80	2.944	2.948	90
40	2.800	2.814	40
100	2.709	2.694	100
70	2.581	2.584	70
90	2.522	2.524	90
20	2.382	2.392	20
50	2.320	2.332	50
50	2.286	2.281	40
40	2.258		
20	2.203	2.201	10
70	2.160	2.161	60
40	2.048	2.051	40
10	2.020	2.020	30
10	1.952	1.962	10
20	1.893	1.906	20
10	1.857	1.860	20
10	1.794	1.798	10
30	1.676	1.679	20
60	1.650*	1.656	40

* Plus 27 additional spacings to 0.7882 Å.

Table 2. Electron microprobe analysis of richterite from the Wichita County meteorite. The calculated empirical formula is:

$$(Na_{2.02}K_{.10}Ca_{.85})_{2.97}\,(Mg_{4.63}Fe_{.05}Al_{.07}Ti_{.16}Cr_{.08})_{4.99}\,Si_8O_{22}(F_{1.00}OH_{1.00})_{2.00}.$$

Subscripts outside parentheses give totals of subscripts within parentheses.
The ideal empirical formula is:

$$(Na, K, Ca)_3\,(Mg, Fe, Al, Ti, Cr, Mn)_5\,Si_8O_{22}(F, OH)_2.$$

Compound	Percent by weight
SiO_2	57.8
TiO_2	1.5
Al_2O_3	0.4
Cr_2O_3	.7
FeO	.5
MgO	22.4
CaO	5.8
Na_2O	7.5
K_2O	0.6
H_2O	1.1
F	2.3
	100.6
F = 0	1.0
Total	99.6

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16 January 1967

Middle and Late Eocene Mammal Communities: A Major Discrepancy

Abstract. *The multituberculate* Parectypodus lovei *has been found in late Eocene rocks in Montana, together with 11 other mammal species similar to those found in the late Eocene Tepee Trail Formation in Wyoming. The multituberculate and six other species are unknown in rocks of equivalent age or of middle Eocene age elsewhere. It is suggested that the known middle Eocene faunas are all taken from a similar ecological situation and do not reflect the true diversity of middle Eocene life. Middle Eocene faunas of different ecological aspect may be recovered from sediments along, and in, the mountain fronts of northwestern Wyoming.*

The unexpected discovery in central Wyoming (*1*) in a fauna of late Eocene age of several groups of archaic mammals, previously thought to have become extinct in earliest Eocene time, stimulated efforts to recover a comparable faunal assemblage from rocks of late Eocene age in other areas. During the summer of 1966 such a fauna was recovered from the Climbing Arrow Formation (*2*) near Three Forks, Montana.

Previous work in this area (*2, 3*) had indicated that some part of the Climbing Arrow Formation was of late Eocene age, but no attempt had been made to collect a representative fauna. With the use of washing techniques (*4*), 12 species of mammals have now been collected. Although the Montana fauna, called here the Shoddy Springs local fauna, has fewer species represented than the Badwater fauna from the northeastern part of the Wind River Basin, Wyoming (*5*), 10 of the 12 species so far recorded from Montana are the same as those found in the Badwater fauna. The following species are present in the Shoddy Springs local fauna (species marked with asterisk are also found at Badwater): *Hyopsodus* sp., **Domnina* sp., **Scenophagus* sp., *dermopteran sp., **Mytonolagus wyomingensis, *Parectypodus lovei, *Peratherium* sp., *eomyid sp., cylindrodontid sp., *paramyid sp., **Protoreodon pumilus*, and **Dilophodon leotanus*. Listing of species as *Hyopsodus* sp., *Domnina* sp., and so forth, is not meant to imply that these materials are insufficient for specific identification but rather that new and distinctive taxa are found in these two faunas and are now under study.

Of particular interest is the discovery of a multituberculate and a dermopteran which are identical to those found at Badwater. This second occurrence of two groups otherwise unknown in Tertiary faunas after the early Eocene, coupled with the closely comparable species composition of the Montana and Wyoming faunas, strongly suggests that a similar paleoecological setting of rather narrow limits is being sampled. Well-known faunas of late Eocene age from the Uinta Basin in northeastern Utah, from the Sespe Formation and Poway Conglomerate in California, and from the Washakie Basin in Wyoming, as well as faunas of similar age now under study from the Big Bend area of Texas, have produced no record of either multituberculates or dermopterans (*6*). The Badwater fauna, and to a lesser extent the Shoddy Springs fauna, also differ from other late Eocene faunas in the number of small rodents and insectivores present. This suggests that these two assemblages, while taken from similar ecological situations, represent sampling of an environment or environments previously unknown for this period and also evidently unknown for the middle Eocene, since there is no middle Eocene record for multituberculates or dermopterans.

How representative of middle Eocene life are the mammal faunas which we now know? Are we missing not only such relatively rare groups as multituberculates and dermopterans but also possibly a variety of other small mammals that are associated with them in the late Eocene and whose ancestors might very likely have shared a similar ecological situation in the middle Eocene? Mammals in this category might include the ancestral stocks for shrews (Soricidae) and moles (Talpidae), both of which have their earliest records in the Badwater fauna. Several rodent phyla, such as ancestral cricetids, eomyids, and some cylindrodonts might also be included.

Many groups that made their first appearances in the late Eocene may represent immigrants from other areas and thus were not present in earlier North American faunas. This is probably true of the lagomorphs, and possibly of the talpids and soricids as well. Until an adequate record for the Eocene in Asia is forthcoming such questions cannot be solved. For many of the rodents, however, such a solution is less likely. Eomyids and a variety of cylindrodonts are rather common in late Eocene faunas in North America and one genus of cylindrodont is known from the middle Eocene, but these groups are unknown elsewhere until the Oligocene. There are also a variety of small paramyids and sciuravids in the Badwater faunas which undoubtedly have their forebears in still unknown middle Eocene species. All of this suggests that there is considerably more to be learned about middle Eocene mammal communities; it also raises a question about the diversity of possible habitats sampled in the North American record at present.

Continental deposits that produce mammals of middle Eocene age in North America are almost exclusively confined to the intermontane areas of Wyoming, Utah, and Colorado. These sediments are either lacustrine or fluviatile, representing channel and floodplain deposits associated with and spreading back from the lake margins. Generally, the areas of deposition are described (*7*) as being areas of low relief, dissected by many rather broad sluggish streams emptying into large lakes. The lake margins and perhaps extensive areas back from these margins were one large swamp covered with subtropical vegetation. In a situation of this sort it seems highly unlikely that the upland communities would be represented to any extent, if at all, in the accumulating sediments. Most of our knowledge of middle Eocene mammals has come from the lowland, a limited area of uniform vegetation, low relief, and probably little annual climatic fluctuation. These areas, where many vertebrate paleontologists have collected mammals for nearly a century, have produced closely similar faunas in all cases. In contrast, late Eocene faunas are widely distributed geographically, and many are quite dissimilar in faunal composition. While some, such as the Uinta Basin faunas and those from the Washakie Basin and Texas, have been recovered from sediments that represent fluviatile depositional environments, probably similar to those of the middle Eocene, other assemblages, such as those in California, at Badwater, and in Montana, include elements that are very distinct and suggest different ecological situations. California faunas are, of course, quite distant from those of the Rocky Mountain area, and their geologic and geographic setting suggest a certain endemism which the fossil record bears out. Texas faunas are more similar to those of Utah and Wyoming, although Texas and California are about the same distance from these states.

The Badwater and Shoddy Springs assemblages, although having the same provenience as the Uinta and Washakie Basin faunas, share a number of species unknown in areas to the south. The larger mammals, horses, tapiroids, and artiodactyls are similar in the four faunas. It is in the small mammals, insectivores, primates, and rodents that the northern faunas differ from those to the south. The difference may be due to a latitudinal effect, but this does not appear to be likely. Climatic conditions in the late Eocene were still subtropical in this region, and the localities are separated by only about 3° latitude—hardly enough to permit any significant climatic zonation. Also, during the late Eocene there was no appreciable mountain barrier between the Uinta Basin and the Badwater area. The same species of larger herbivores, such as *Epihippus, Dilophodon, Amynodon, Protoreodon*, and various dichobunid artiodactyls, are found in Utah, the Washakie Basin, and at Badwater, which indicates open migration routes. It is, therefore, quite probable that the many mammal species found at Badwater and in Montana occupied ecological niches that were either nonexistent to the south or, more probably, were distant from the drainage systems contributing sediments to southern basins.

If such niches were present in the middle Eocene of the Rocky Mountain region, is there any possibility of finding 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

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 struc-