Dates for the Middle Stone Age of East Africa

Abstract. *Three potassium-argon age determinations on sanidine from crystal-rich pantellerite and volcanic ash in the Main Rift Valley of central Ethiopia indicate that the Middle Stone Age of East Africa began prior to 180,000 years ago. This suggests that the technological developments which characterize the Middle Stone Age have a far greater antiquity than previously estimated.*

A sequence of Middle Stone Age living floors in the Main Rift Valley of Ethiopia have been radiometrically dated. These dates suggest a far greater antiquity for the Middle Stone Age of East Africa than has heretofore been estimated. By extension, these dates also suggest a greater antiquity for the Middle Stone Age and middle Paleolithic of North Africa, the Near East, and Europe.

The dated living floors from Ethiopia occur in a thick series of late Pleistocene terrigenous clastic sediments which mantle a prominent volcanic ridge located west of the town of Ziway in the Galla Lakes region of central Ethiopia (Fig. 1). Three dates have thus far been obtained, two of which refer to the Middle Stone Age sequence. All were determined by K-Ar analyses of sanidine crystals. [The alkali feldspar is untwinned, but the K content (Table 1) suggests that it could be either sanidine or low-Ca anorthoclase.] Two of the samples are from airfall ashes, the third from a pantellerite (Table 1).

The greatest age, 1.048 ± 0.025 million years, was obtained for a sample from the oldest exposed member of the Kulkuletti volcanic sequence (Table 1, sample UAKA 73-130). The Kulkuletti Volcanics (pantellerites and pumiceous tuffs) constitute a remnant of the western rim of what appears to be an incomplete caldera. Capping the Kulkuletti Volcanics is the late Pleistocene Gademotta Formation, which contains the Middle Stone Age sites. The Gademotta Formation consists of reworked volcaniclastic sediments—interbedded tuffaceous laharic mudstones, thick paleosols, and thin-bedded sandstones—the formation aggregating a maximum thickness in the type area of 40 m. In addition, three thin, but distinctive ash beds form widespread stratigraphic markers within the Gademotta Formation. Two of the dates come from these sanidine-rich ashes (Table 1, samples UAKA 73-131 and 73-132).

Two adjacent localities were investigated. The first, known as the Gademotta area (Fig. 1), has been specified as the type locality for the Gademotta Formation (*1*); the second, located approximately 2 km northeast, is known as Kulkuletti. The geology of both areas has been described by Laury and Albritton (*2*) (see Fig. 2). The dated samples were collected in the Kulkuletti area from units 10 and D of the Gademotta Formation (Table 1). Unit 10 is the most distinctive and widespread stratigraphic marker in the formation, and is confidently correlated into the Gademotta area. Unit D occurs within Unit 13, which is equally well recognized in both areas.

Traces of Middle Stone Age occupation are abundant in both the Gademotta and Kulkuletti areas. People were doubtless attracted to this vicinity by the outcrops of obsidian which occur here, and by proximity to Lake Ziway, which apparently stood at much higher levels at intervals during the period of occupation. Four living floors have been excavated in the Gademotta area, and three at Kulkuletti.

The cultural sequence begins with a possible final Acheulean occupation, traces of which were noted at the base of Unit 9. No living floor of this period could be identified. This is followed, in the upper part of the same unit, by the earliest Middle Stone Age occupation, which is covered by the crystal-rich pyroclastic ashfall of Unit 10 (Fig. 2). The age obtained for this unit, 181,000 ± 6,000 years, is a minimum age for the Middle Stone Age at the Gademotta area. Unit 13, dated at approximately 149,000 years, also occurs with a Middle Stone Age living floor, and is in turn overlain by still younger Middle Stone Age occupations.

The Middle Stone Age sites and their associated lithic assemblages have been described by Wendorf and Schild (*3*). All these are similar in that they might be classified as Stillbay, or as generally similar to Typical Mousterian of Levallois Facies. Although both the K-Ar dates and the complex sequence of paleosols preserved within the Gademotta sediments suggest a considerable time span for the Middle Stone Age occupation, there are few consistent trends in cultural change evident in the sequence. Two such trends are a reduction in the frequency of bifacial tools through time, and an increase in the percentages of upper Paleolithic type tools in the most recent site. Neither the frequency of use of the Levallois technique nor tool size showed consistent change within the sequence.

Faunal remains were not preserved with the living floors, but a typical late Pleistocene fauna (*4*), consisting of hippopotamus (*Hippopotamus am-*

Table 1. Potassium-argon data for Ethiopian samples. Abbreviation: UAKA, University of Arizona potassium-argon. Potassium is given as percentage by weight.

UAKA sample number	Description	K (%)	Radiogenic ^{40}Ar ($\times 10^{-12}$ mole/g)	Atmospheric ^{40}Ar (%)	Age (million years)
73-130	Sanidine, pantellerite with sanidine phenocrysts. Older exposed unit of the Kulkuletti volcanic sequence underlying the Gademotta Formation, a terrigenous sedimentary sequence; quarry at end of the gravel road, west of Ziway, Shoa Province, 7°51′30″N, 38°43′E, central Ethiopia (sample EL-3A).	4.55	8.44 8.60	45.7 44.9	1.048 ± 0.025
73-131	Sanidine, unconsolidated crystal ash bed, most widespread and easily recognizable stratigraphic unit in the Gademotta Formation, of Middle Stone Age time (Unit 10), Kulkuletti area, Shoa Province, 7°52′N, 38°42′30″E (sample EL-36D-1).	5.07	1.63 1.73	60.8 58.4	0.181 ± 0.006
73-132	Sanidine, unconsolidated vitric ash, one of the youngest ashes within the Middle Stone Age sequence of the Gademotta Formation (Unit D), Kulkuletti area, Shoa Province, 7°52′N, 38°42′30″E (sample EL-36J).	4.84	1.32 1.32	71.5 71.3	0.149 ± 0.013

phibius Linne), equid (*Dolichohippus grevyi*?), wildebeest (*Connochaetes taurinus*?), hartebeest (*Alcelaphus buselaphus*?), and an unidentified, medium-sized antelope, was recovered from a channel fill within the Gademotta Formation and tentatively correlated with the earliest Middle Stone Age occupation.

The dates from the Gademotta Formation are clearly at variance with several older carbon-14 dates for Middle Stone Age assemblages from southern Africa (*5*). Until recently, it was generally believed that the Middle Stone Age of Africa was roughly contemporary with the upper Paleolithic of Europe, and perhaps began around 40,000 years ago (*6*). However, this estimate and many of the dates on which it was based have recently been challenged by a large series of new South African dates obtained from specimens with firm stratigraphic contexts and based on sample processing with refined cleaning methods (*7*). These new dates have not provided an absolute age for the South African Middle Stone Age, but they indicate an antiquity of greater than 50,000 years ago and beyond the range of carbon-14. In addition, faunal analysis indicates that the South African Middle Stone Age began contemporaneously with the last Interglacial (Eem), or at approximately the same time the earliest complexes with evident technological characteristics of the middle Paleolithic (pre-Mousterian) occur in Europe (*8*).

There is no adequate basis for correlating the Lake Ziway Middle Stone Age sites with comparable complexes in either South Africa or the Near East, beyond that suggested by the close similarity resulting from shared technological developments which characterize the middle Paleolithic throughout this entire area. The faunal evidence is inadequate to relate the Ziway sequence to the climatic events of the Northern Hemisphere or to fluctuations in sea level, except for the statement that the recovered fauna is of typical late Pleistocene character. On the other hand, there is no basis for assuming the Lake Ziway Middle Stone Age sites are older than similar materials elsewhere in Africa, the Near East, or Europe. For this reason, it is suggested that the sites are no older than Eem, or possibly younger.

The K-Ar ages of the Lake Ziway sites are in substantial agreement with the K-Ar age of 230,000 years for an

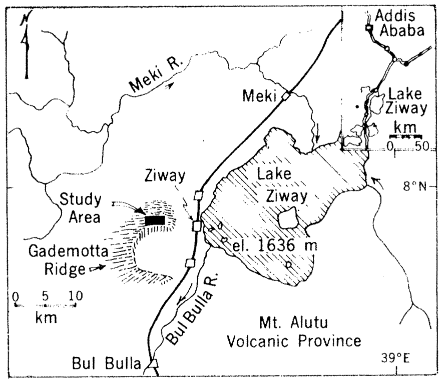

Fig. 1. Map of the Lake Ziway district, Galla Lake region, Ethiopia. Study area includes the Gademotta and Kulkuletti areas.

upper Acheulean site from the Lake Baringo area of Kenya (*9*) and strongly support the K-Ar age of 240,000 years for Kenya Stillbay from Malawa Gorge (*10*). They are also in agreement with a uranium disequilibrium age of 260,000 (+70,000 −40,000) years for an upper Acheulean site from Isimila in Tanzania (*11*). However, they conflict with a series of K-Ar dates for Laacher See Volcanics (West Germany), which are incorporated in Rhine terraces and believed to be synchronous with some "classical" European glaciations. Four of these, thought to be the most reliable, place the period between late and early Saale (Riss) at about 145,000 years ago, late Elster (Mindel) at 220,000 years, Cromer Interglacial at 350,000 years, and Gunz at about 400,000 years (*9, 12*).

The most serious conflict, however, is between the Lake Ziway K-Ar determinations and the dates obtained by analyses of ^{230}Th and ^{234}U in shells from Atlantic and Mediterranean beaches and raised coral reefs regarded as of Eem age. Until now, these ^{230}Th-^{234}U analyses provided the best estimate for the age of this event, and suggested a time range between 80,000 and 140,000 years ago (*13*). It is perhaps premature to suggest that the Lake Ziway dates may provide a means for independent evaluation of the relative precision of these two dating techniques, but it is useful to note that the K-Ar dates from Lake Ziway are in correct sequence with reference to their stratigraphic order, and, in addition, the precision is excellent for such young samples. There is always a possibility

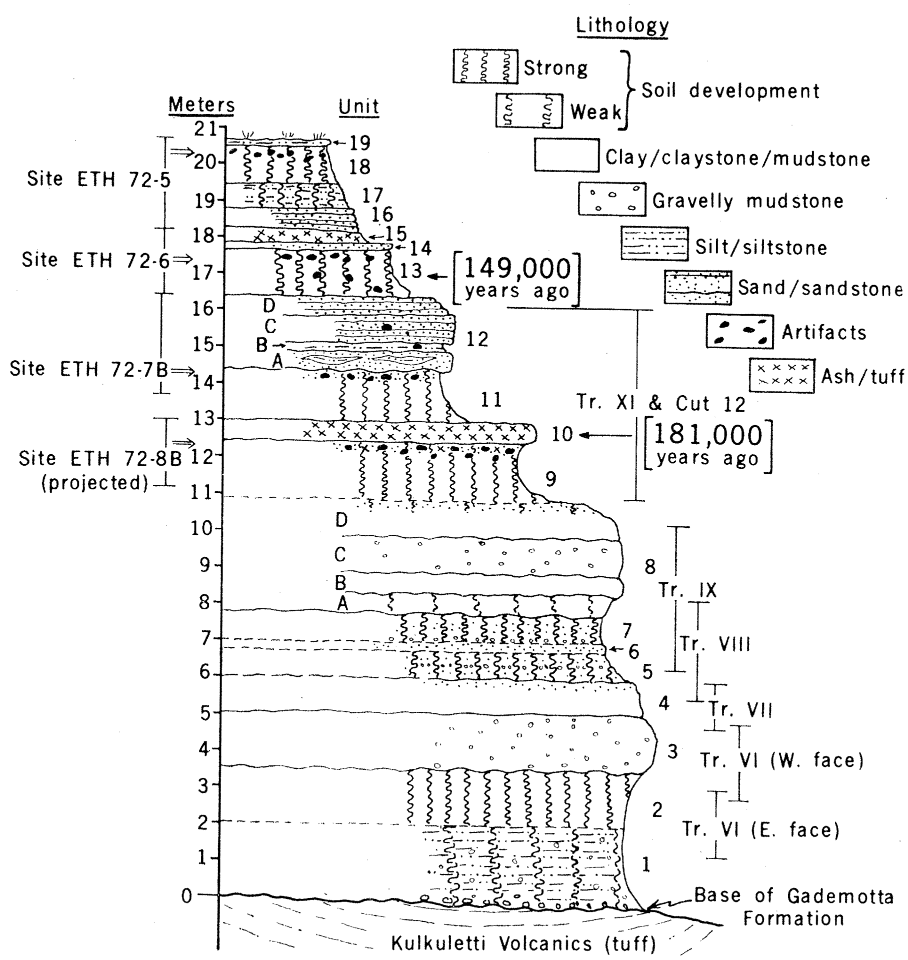

Fig. 2. Sequence of sediments from the type section of the Gademotta Formation. Abbreviation: *Tr.*, excavated trench. [After Laury and Albritton (*2*)]

of excess argon (dissolved in the mineral from the magma before eruption); however, sanidine has been found to be remarkably free from this problem. Furthermore, the abundant sanidine in all the samples permitted the use of this mineral exclusively for the dating process.

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Extreme Toxicity from Combustion Products of a Fire-Retarded Polyurethane Foam

Abstract. The products from nonflaming combustion of wood and a trimethylolpropane-based rigid-urethane foam that was not fire-retarded produced elevated carboxyhemoglobin levels but no abnormal neurological effects. However, when this type of foam contained a reactive phosphate fire retardant, the combustion products caused grand mal seizures and death in rats. The toxic combustion product responsible for the seizures has been identified as 4-ethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2.]octane-1-oxide.

The utilization of plastics and polymeric materials in our man-made environment is increasing yearly along with the likelihood that they will become involved in industrial or domestic fires. The fire hazard of a plastic material was demonstrated by the Cleveland Clinic fire in 1929. A highly combustible nitrocellulose material, in the form of x-ray films, caught fire, and 125 persons died. Most of the deaths were due to smoke inhalation rather than flame contact (*1*).

Depending upon anticipated use, some polymeric materials are now required by law to pass various flammability tests (*2*) of ignition, surface flame propagation rate, fire endurance, and heat contribution (*3*). In order to pass these tests, many materials require the addition of a fire retardant. However, the relative toxicity of the combustion products of fire-retarded materials compared to those which are not fire-retarded has not been widely investigated. A meaningful risk analysis that takes into account the reduced ignition probability and flame spread characteristics, as opposed to the possible increase in smoke-induced toxicity, cannot be conducted until such studies are completed. We report that in the case of a laboratory-formulated fire-retarded rigid-polyurethane foam, the physiological and toxicological effects of its combustion products proved fatal in a matter of minutes. The same rigid-polyurethane foam, without fire retardant, produced nondebilitating carboxyhemoglobin (COHb) levels but no other observed signs of toxicity.

Animals were exposed in an Aminco chamber developed at the National Bureau of Standards for smoke density research. The chamber was equipped with a heater modified to give a radiant-energy flux of 5 watt cm^{-2} (*4*). For each smoke exposure, four male pigmented Long-Evans rats were held radially nose-to-nose in slings that permitted free movement of legs and head. Thus, all four animals inhaled smoke from the same breathing zone. One of the animals had an intra-arterial cannula for removal of blood. These samples were analyzed for hemoglobin (Hb) concentration and percentages of COHb and oxyhemoglobin (O_2Hb) with an Instrumentation Laboratories model 182 CO-oximeter by a spectrophotometric technique (*5*). Hemoglobin concentration and percentages of COHb and O_2Hb were determined from samples drawn before and periodically after exposure. The rate of return to a baseline percent COHb level was used to indicate efficiency of pulmonary function.

Eight animals were exposed to smoke from samples of Douglas fir (two trials); 12 were exposed to smoke from polyurethane foam that was not fire-retarded (three trials); and 8 and 12 animals were exposed to smoke from the same foam after fire-retarding with *O,O*-diethyl-*N,N*-bis-(2-hydroxyethyl)-

Table 1. Formulations of rigid-polyurethane foam; FR, fire retardant (percentage by weight); MW, molecular weight.

Substance	Parts by weight		
	0% FR	4% FR	8% FR
Polymethylene polyphenyl isocyanate	100.5	100.5	100.5
Propoxylated trimethylolpropane (MW 340)	75.0	68.7	62.25
Silicone surfactant	0.9	0.9	0.9
Trichlorofluoromethane	21	21	21
Triethylene diamine	2.65	2.65	2.65
O,O-Diethyl-*N,N*-bis(2-hydroxyethyl)-aminomethyl phosphonate	0	8.0	16.25
Phosphorus (% by weight)	0	0.48	0.97