

**Title:** The Middle Awash region structural transition zone: Age constraints on volcanotectonic and sedimentation processes and paleontological resources

**University Campus:** Department of Integrative Biology  
UC Berkeley, University of California at Berkeley

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**I. Title:** The Middle Awash region structural transition zone: Age constraints on volcanotectonic and sedimentation processes and paleontological resources

**Abstract**

The Middle Awash research project is an international, multidisciplinary effort whose objectives include gathering accurate geological information for elucidating the impacts of tectonic and volcanic processes on climate and biota in a rift environment during the last 6 Ma. The volcanic and fossiliferous sedimentary deposits along rift escarpments and within the rift floor are investigated, using satellite and Shuttle imageries and subsequently explored using aerial photographs and foot traverses. The geological research is conducted in parallel with paleontological investigation, which explores the evolutionary history of biotic communities and their parts, and relating this evolution to local, regional, and global paleoclimatic and ecological changes driven by tectonic and associated volcanic activities. Changes in paleoclimatic records indicate wet and wooded habitat in late Miocene and early Pliocene periods and dry, more open grasslands during the late Pliocene and Pleistocene times.

Current research is focused more on late Miocene (>6 Ma) sediments to accurately document when rifting started in the Middle Awash region. Moreover, the field study is investigating why the width of the rift floor and the orientations of the western and eastern rift escarpments changed within the active tectonic transition zone between the continental Main Ethiopian Rift and the proto-oceanic Afar Depression in northeastern Ethiopia. The younger (<6 Ma) volcanic and sedimentary deposits exposed within the rift floor and the adjacent western margin provided information about the intensity and episodic nature of the tectonic and volcanic activities.

The proposed field studies are geared to identifying and mapping older (>6 Ma) volcanic and sedimentary deposits along the broad (>30 km) western rift margin to delineate the volcanic record and rift-related tectonic processes. Similar studies have been carried out within the rift floor. The ultimate goal of the research is to establish precise temporal and spatial placement of the dynamic interactions of tectonic and volcanic processes and determine their impact on landform evolution and paleoclimate and biota conditions during the earliest time of rifting from geobiostratigraphic records.

**II. Principal investigators and team, including all contact information**

- i. **University PI:** Tim D. White, Department of Integrative Biology, UC Berkeley, University of California at Berkeley, Berkeley, CA 94720-3140, Tel. 510-642-2889, Fax 510-642-3281, e-mail [timwhite@socrates.berkeley.edu](mailto:timwhite@socrates.berkeley.edu)
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- iii. **Graduate Students:** Kyle Brudvik, Department of Integrative Biology, Leah Morgan, Department of Earth and Planetary Sciences, University of California at Berkeley, Berkeley, CA 94720-3140

### **3. STATEMENT OF PROGRESS DURING PREVIOUS YEAR**

#### **1. Fieldwork (October 2004 to January 2005)**

All of the field season's geological investigations were carried out in the northern part of the western side of the Middle Awash study area. During the previous field season (2003-2004), more than 30 volcanic ash units interbedded within the sedimentary sequence were sampled to determine the stratigraphic relations of the complexly faulted deposits. Thick Quaternary sediments dominate the rift floor, whereas late Miocene volcanic and sedimentary rocks are common within the broad rift margin. Most of the volcanic ash units exposed along fault scarps and along stream cuts throughout the study area were correlated using the new geochemical results generated in the summer of 2004. Geochemical correlations were noted within the younger tuff units exposed throughout the study area. Although most of the geological survey was conducted within the rift floor, the adjacent rift margin was briefly explored at the beginning and at the end of the field season.

##### **A. Halibee**

The Quaternary sedimentary deposits of the Halibee area are located between the western rift margin and the Awash River at the northern part of the Middle Awash study area. The area is extremely dissected and complexly faulted. About 10 volcanic ash layers were identified within the sedimentary sequence and these stratigraphic markers were used to establish preliminary temporal and spatial relations of several stratigraphic sections. Although dominated by fluvial sedimentary deposits, the youngest sediments were deposited in a lacustrine environment. The fluvial deposits beneath the lacustrine sediments contain abundant Middle Stone Age archaeological records. Moreover, diverse vertebrate fauna, including several hominid remains were collected from these fluvial deposits.

Preliminary paleogeographic reconstruction during the 2004-2005 field investigation suggests that intense faulting during the late Pleistocene led to the formation of broad basins adjacent to the western rift margin. Thick sedimentary deposits accumulated in these basins because of widespread erosion from the adjacent uplifted rift margin. The volcanic ash stratigraphic markers facilitated the reconstruction of the tectonic, sedimentation, and erosional processes that shaped the Halibee area of the rift floor during the late Pleistocene.

##### **B. Aramis**

The Pliocene (4-5 Ma) Aramis area of the Central Awash Complex was repeatedly investigated during the 1990s. The most important localities within the Aramis area were surveyed for two days in January 2005. Several carbonate samples were collected to determine the origin of the widespread deposits interbedded within the fossiliferous sedimentary rocks.

##### **C. Asa Issie**

The Pliocene (~4.0 Ma) Asa Issie sedimentary deposits and interbedded basaltic and silicic ash to the west of the Central Awash Complex were also visited in early January 2005. Paleomagnetic studies, volcanic ash chemistry,

and dating of the basaltic tuff resolved the temporal and spatial relations of the stratigraphic sequence of the fossiliferous sedimentary deposits. Additional hominid fossil remains were recovered during the brief survey.

#### **D. Bouri**

The late Pleistocene Herto Member of the Bouri Formation was also briefly surveyed to collect obsidian samples for a Ph.D. research by one of the UC Berkeley graduate students. An effort is being made to determine the provenance of obsidian stone tools, and to provide chronometric control for their distribution and use.

#### **E. Western Margin**

The northern half of the western margin was extensively surveyed for the first time in late November and early December 2004. The terrain is rugged, very steep and covered by dense and thorny vegetation. The geology is dominated by partially altered basaltic lava flows and basaltic tephra. A number of localities, containing sedimentary rocks with interbedded silicic ash were identified along the strike of the rift escarpment. Several silicic and basaltic ash layers were sampled for geochemical analysis and age determination.

### **2. Laboratory Analysis**

- a. Electron microprobe analysis of 30 volcanic ash samples are in progress
- b.  $^{40}\text{Ar}/^{39}\text{Ar}$  dating of the Asa Issie basaltic tuff yielded a Pliocene age (4.1 Ma) that is consistent with paleomagnetic results of the volcanic layer and underlying sediments.
- c.  $^{40}\text{Ar}/^{39}\text{Ar}$  dating of Halibee silicic volcanic ash samples yielded late Pleistocene age. A basaltic ash was too young to be dated and yielded large errors, whereas charcoal below the basaltic ash is too old to be dated by the Carbon method.

### **2. Publications**

#### **1. Refereed journal articles published (2003-2003)**

- WoldeGabriel, G., P. R. Renne, W. K. Hart, S. Ambrose, B. Asfaw, and T. D. White, Geoscience methods lead to paleo-anthropological discoveries in Ethiopia, EOS, 85, # 29, 273, 276-277, 2004.
- Haile-Selassie, Y., G. WoldeGabriel, G., T. D. White, R. L. Bernor, D. Degusta, P. R. Renne, W. K. Hart, E. Vrba, A. Stanley, and F. C. Howell, Mio-Pliocene mammals from the Middle Awash, Ethiopia, GeoBios, 37/4, 536-552, 2004.
- Haile-Selassie, Y., G. Suwa, and T. D. White, Late Miocene teeth from the Middle Awash, Ethiopia, and early hominid dental evolution, Science, 303, 1503-1505, 2004.
- WoldeGabriel, G., W. K. Hart, S. Katoh, Y. Beyene, and G. Suwa, Correlation of Plio-Pleistocene tephra in Ethiopian and Kenyan rift basins: temporal calibration of geological features and hominid fossil records, J. of Volcanology and Geothermal Research, 147, 81-108, 2005.

WoldeGabriel, G., W. K. Hart, and G. Heiken, Innovative tephra studies in the East African Rift System, EOS Transactions, 86, No. 27, 255-256, 2005.

## **2. Invited Technical Presentations (Abstracts)**

WoldeGabriel, G., Scientific Research And Cultural Heritage:  
Prospects For Innovative Conservation In Eastern Africa, Meeting  
for Society of Applied Anthropology, April 5-10, 2005, La Fonda  
Hotel, Santa Fe, NM.

Our outreach activities resulted in the placement of Middle Awash  
fossil discoveries in Nature (a three-page feature), and the San  
Francisco Chronicle (a front-page story).

- a) Rex Dalton, Awash with Fossils, Nature 439, no. 7072, 14-16, 5 January 2006.
- b) David Perlman, Parched Ethiopian region is ground zero for fossils Researchers focus on evolution of human ancestors, San Francisco Chronicle Science Editor, Tuesday, February 21, 2006.

## **Graduate Students (Participated in the 2004 fieldwork)**

Kyle Brudvik, Department of Integrative Biology, UC Berkeley  
Leah Morgan, Department of Earth and Planetary Science, UC Berkeley

## **4. REVISED WORK PLAN FOR FY07**

The detailed surveys conducted in the southern part of the Middle Awash study area during the 2005-2006 fieldwork led to the discovery of several new sections in the Atuteli, Burka, Hamuquili, and Baranlaudi drainage basins. These localities will be investigated again during FY07 using new chemical and age data from the 2005-2006 samples.

The field survey during the 2005-2006-field season has yielded very important data on Plio-Pleistocene paleontology and archaeology of the study area. The new and apparently ancient archaeological occurrences are particularly important in this regard, and fruitful work on these sites is projected for the future, once we have made progress in the laboratory chemical analysis and dating efforts now underway at Berkeley, Los Alamos, and Miami Ohio. We collected about 40 volcanic and sedimentary samples for chemical analysis,  $^{40}\text{Ar}/^{39}\text{Ar}$  dating, and paleomagnetic determination. Results from the FY06 field and laboratory studies will be used to refine the temporal and spatial relations of the stratigraphy of the various sections and localities and the tectonic history of the area.

### **a. Burka Drainage**

Multiple sections and localities were designated on both sides of the east-west-trending Burka drainage over a distance of several kilometers. The side basins contain sedimentary layers of silty clays, sandstone, and conglomerate units and interbedded tephra units and bentonite units.

#### **b. Guneta (Baranlaudi) Basin**

The Burka drainage is located to the north of the Guneta stream. A pumice fallout deposit and several vitric ash layers, showing different degrees of alteration occur at the base, middle and upper levels of the stratigraphic sequence. Seven tephra samples were collected from the basin.

#### **c. Atuteli Drainage**

The Atuteli is a major east-trending drainage system that occurs directly north of the Burka stream. Several traverses were carried out across the Atuteli drainage. Like the Burka basin, the geology is dominated by fluvial deposits of silty clays, sandstone, and conglomerate deposits. Multiple ash layers and bentonite interbedded within these fossiliferous sedimentary rocks were sampled. A major north-south-trending horst capped by basaltic lava flows runs across the Atuteli drainage.

#### **d. Meskid Dululu**

The Meskid Dululu stream is located directly north of the Atuteli drainage system. A traverse upstream to the Meskid Dululu water holes revealed thick basaltic outcrops. The moderately altered and strongly jointed basaltic flow is capped by conglomerate and silty clays.

We are fast-tracking the geological samples for Ar/Ar dating, tephrochemistry analysis, and paleomagnetism associated with the Burka hominid and archaeology sites. Biochronological evidence suggests that this may be one of the oldest Oldowan sites in the world, and probably the oldest in the Middle Awash study area.

### **5. Updated declaration of other ongoing research projects related to the IGPP funded project**

The 2005-2006 field research was entirely funded by a grant from the U. S. National Science Foundation (NSF). This award was for the fifth of five years funded by the NSF. Because of the abbreviated 2005-2006 field season, we plan to stretch this fifth year of funding to cover both this year, and next year's (2006-7) field seasons. The NSF is also funding a UC Berkeley-based research, which is coordinating an international endeavor known as "Revealing Human Origins Initiative (RHOI)." Several international working groups have been established to facilitate collaborations and coordination of analytical studies among different field-based research organizations in order to achieve better results with greater efficiency.