

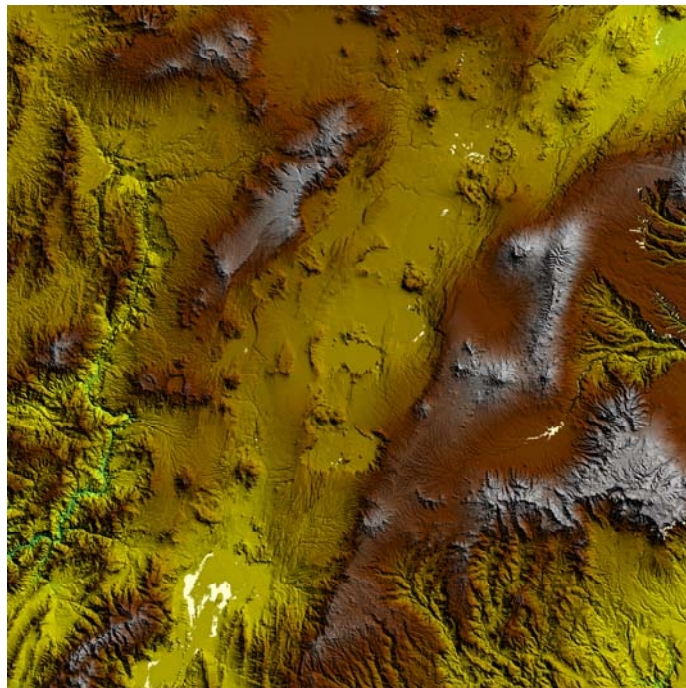


*International Association of Geomorphologists
Association Internationale de Géomorphologues*

IAG/AIG REGIONAL CONFERENCE 2011

**GEOMORPHOLOGY FOR HUMAN ADAPTATION TO
CHANGING TROPICAL ENVIRONMENTS**

ADDIS ABABA, ETHIOPIA FEBRUARY 18-22, 2011



**PRE-CONFERENCE EXCURSION GUIDE
TO
THE MAIN ETHIOPIAN RIFT (MER)
(15 – 17 February 2011)**

**Editors:
Asfawossen Asrat & Mohammed Umer**

Day 1 (February 15/2011)

Departure from Ghion Hotel at 8:00 a.m. We will take lunch packs and lunch will be outdoors on the way.

Major Themes: Geoarchaeology, tectonic and volcanic geomorphology, land degradation and resilience, Environmental Change and Human Impact

The itinerary will follow the Western Margin of the Main Ethiopian Rift along the road that goes through Butajira, Werabe and Hossaina diverting through Durame towards the east into the rift valley floor to reach Shashemene (see figure 1). Final destination will be at Hawassa where we spend the night.

A. The Melka Kunture Archaeological site (STOP 2a)

Melka Kunture is a renowned Palaeolithic archaeological site located some 50 km SW of Addis Ababa. There will be a guided tour to the site. Discussion on the site's archaeological significance.

Facilitator: Dr. Mohammed Umer

B. The Tiya Stelae Site (STOP 2b)

Tiya is a stelae site and a UNESCO world heritage site located some 90 Km NW of Addis along the same road. Description by local guide as well as by scientists in the group.

C. Land degradation between Werabe and Hosaina including views into the rift valley (STOP 3)

Discussion on land prone to degradation due to land use-land-cover change as well as geological and tectonic features; and on efforts to rehabilitate such a land.

Facilitator: Dr. Asfawossen Asrat

D. General explanation about the rift floor and rift escarpment at Hosaina (STOP 4)

Discussion on the rift evolution and its implications on palaeoenvironmental processes. Concluding remarks on the first day's visits.

Facilitators: Dr. Asfawossen Asrat and Dr. Mohammed Umer

We will leave the main Addis Ababa – Sodo road at Durame (No. 5, Fig. 1) and we will drive east into the rift through Alaba (No. 6) then to Shashemene (No. 7) where we will join the main Addis Ababa – Hawasa road. Evening at Hawasa (STOP 8): Check-in at Tadesse Enjory Hotel and Dinner at Lewi Resort and Spa.

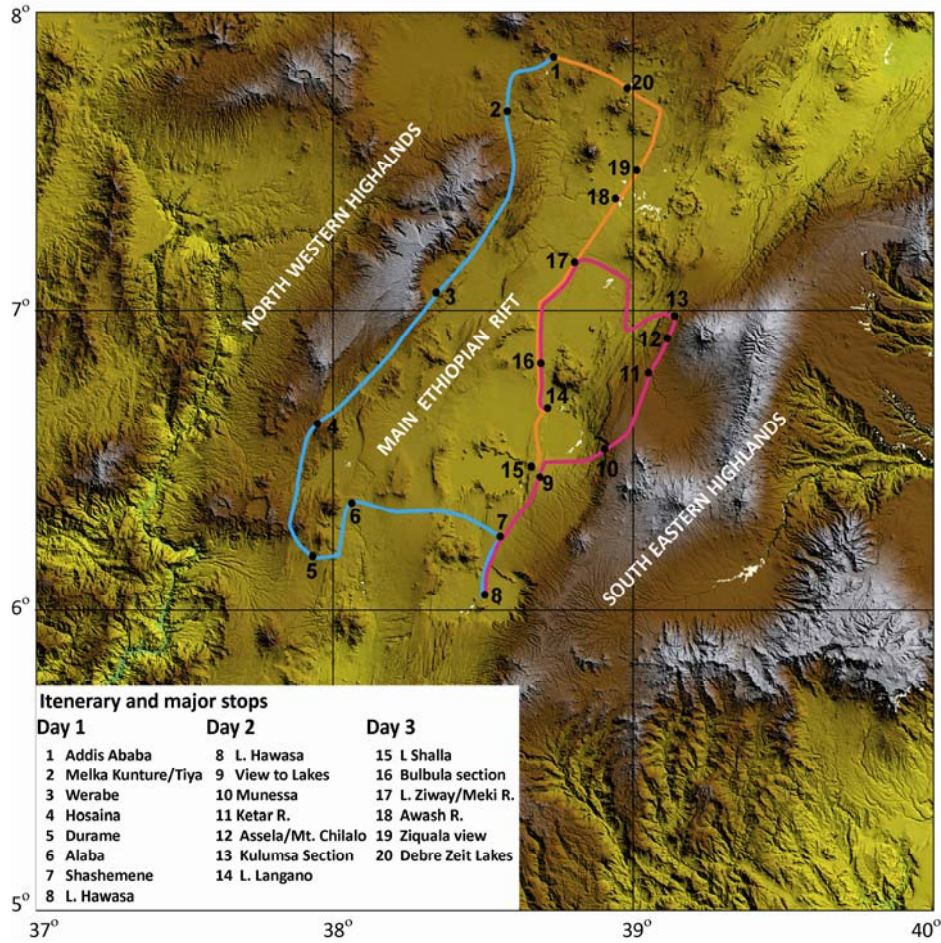


Fig. 1. DEM map of the central sector of Ethiopia showing the geomorphological setting. The itinerary of the excursion and the major stops are marked.

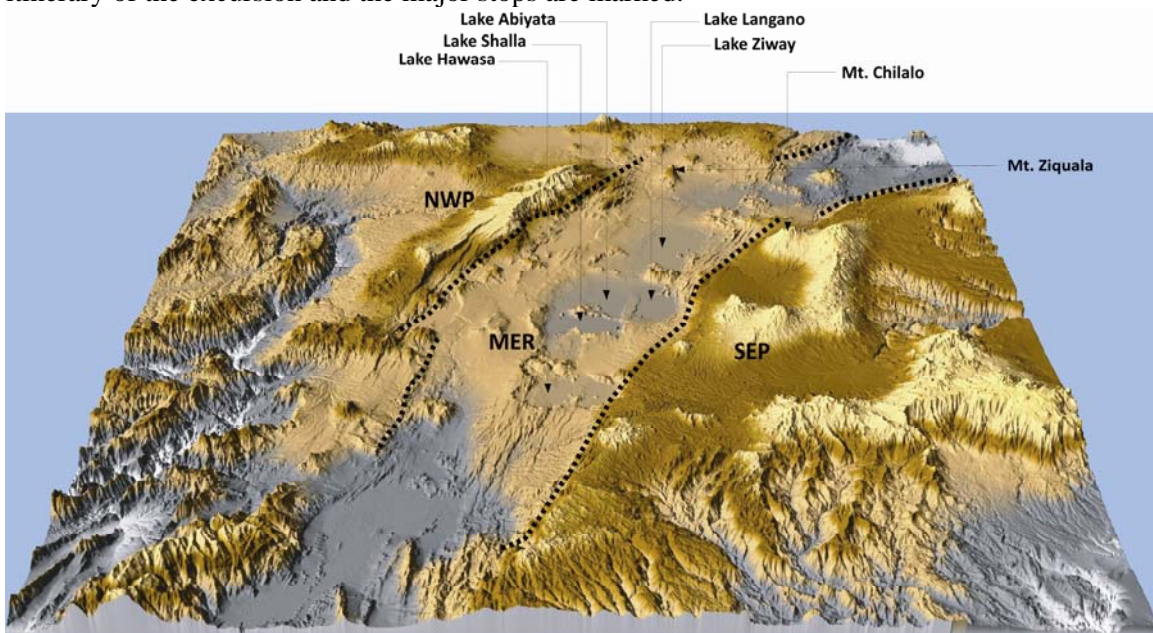


Fig. 2. 3D Map of the central sector of Ethiopia (same area of Fig. 1) where the rift margins and the rift lakes are highlighted.

Day 2 (February 16, 2011)

Breakfast: at 7.00 - 8.00 a.m. at Tadesse Enjory Hotel; Departure at 8.00 a.m. We will take lunch packs and lunch will be outdoors on the way.

Major Themes: Quaternary stratigraphy and palaeoclimate, Environmental Change and Human Impact, fluvial geomorphology, tectonic and volcanic geomorphology, land degradation and resilience, Glacial-Post Glacial History, fluvial geomorphology.

The itinerary will follow the road from Hawasa to Lake Shalla on the main Addis Ababa – Hawasa road, and then branches from this road to the east across the rift and climbing up the Southeastern Ethiopian Plateau until Assela (a gravel road). We will then follow the Assela – Meki road (gravel road) along the northern shore of Lake Ziway. We will then follow the Meki – Langanano road, and the final destination will be at Wabe Shebele Hotel at the western shore of Lake Langanano.

E. Lake Hawassa Hydrology and Palaeoenvironment (STOP 8)

Discussion on the hydrology and palaeoenvironmental context of Lake Awassa.

Facilitators: Dr. Mohammed Umer and Dr. Asfawossen Asrat

F. The Lakes Region (STOP 9)

We will look from a vantage point along the road the three lakes (Shalla to the west, Abiyata to the northwest and Langanano to the NNE). A short description followed by brief discussion on the Holocene history of the lakes.

Facilitators: Dr. Mohammed Umer and Dr. Asfawossen Asrat

G. The Eastern Rift Margin Vegetation History (STOP 10)

Discussion about the once extensive Munessa/Shashemane *Podocarpus/Juniperus* forest, an important site where the effects of human-environment interaction can be witnessed.

Facilitator: Dr. Mohammed Umer

H. Ketar River hydrology and geomorphology (STOP 11)

The main tributary of Lake Ziway.

Facilitator: Prof. Paolo Billi

I. Assela and Mount Chilalo (STOP 12)

Mount Chilalo is a silicic volcanic centre at the plateau margin. A stop at the margin of the rift to observe (from distance) the Chilalo volcanic centre. Discussion on the Glacial-Postglacial History.

Facilitator: Dr. Mohammed Umer and Dr. Asfawossen Asrat

J. The Kulumsa section and other faults (STOP 13)

The plateau-rift margin is best exposed at the Kulumsa section where an echelon faults and active tectonic features are observed.

Facilitator: Dr. Asfawossen Asrat

Check-in and dinner at Langanano Wabishebele Hotel (No. 14).

Day 3 (February 17, 2011)

Breakfast: at 7.00 - 8.00 a.m. at Wabishebelle Hotel; Departure at 8.00 a.m. We will take lunch packs and lunch will be outdoors on the way.

Major Themes: Tectonic topography, tectonic and volcanic geomorphology, fluvial geomorphology, Environmental Change and Human Impact, land degradation and resilience, Geomorphology of tropical mountains

The itinerary will be along the main Hawasa- Adiss Ababa road.

K. The Shalla –Abiyata National Park (STOP 15)

The Shalla and Abiyata lakes form part of the Ziway-Shalla basin of four lakes (fig. 2): Ziway-Langano-Abiyata and Shalla, united during the early Holocene at about 1700m altitude when water was overflowing into the adjacent Awash Valley. We will see Lake Shalla (160m maximum depth) and the surrounding hot springs. We will also look at Lake Abiyata (< 9m maximum depth) from a distance. There is a soda-ash factory that abstracts water from this lake. The lake underwent several fluctuations in recent years and had receded substantially over the last decades.

Facilitators: Dr. Mohammed Umer and Prof. Paolo Billi

L. The Bulbula Section (STOP 16)

This is a section with sediments of fluvial, marginal, lacustrine and volcanic origin. It also contains paleosols. It holds evidences of Holocene and pre-Holocene high stands.

Facilitator: Dr. Mohammed Umer

M. Lake Ziway-Meki River (STOP 17)

A few short stops between Lakes Ziway and Meki river to see the new developments (floriculture, horticulture, etc.) in the area.

Facilitator: Prof. Paolo Billi

N. Awash river at Koka (STOP 18)

Combined Late Quaternary Paleohydrology of Awah, Ziway-Shalla and Lake Abhe. The location of Awash and Paleoanthropological sites in its middle part (Afar).

Facilitators: Prof. Paolo Billi and Dr. Mohammed Umer

O. View of Mt. Ziquala (STOP 19)

Mt. Ziquala is a huge central silicic volcanic centre with a caldera lake on its top. It is located along the Siliti Debre Zeit Fault Zone.

Facilitator: Dr. Asfawossen Asrat

P. Debre Zeit Crater Lakes (STOP 19)

A brief visit to one of the five crater lakes in the Debre Zeit area (Lake Bishoftu)

Facilitators: Dr. Mohammed Umer and Dr. Asfawossen Asrat.

Back to Addis Ababa by about 7.00 p.m. (projected time!)

The Palaeolithic Site of Melka Kunture

(Source: *Melka Kuntue: the Guide*, 2001)

The Site: Melka Kuntre contains a sequence of Palaeolithic sites with lithic industries, faunal and Hominid remains, distributed over in situ living floors, with structures that can still be recognized, together with economic and social activity areas. Melka Kunture was discovered in 1963 by G. Decker. Since then Bailloud in 1963, Chavaillon in 1965 -1981 and 1992-1995 carried out surveys and extensive excavations in the area, with the help of local workers and the Ethiopian Authorities (Berthelet et al., 2001). Melka Kunture is located in the Upper Awash valley some 50 km southwest of Addis Ababa (Fig. 1). Melka Kunture is the name of a ford of the Awash, and the site extends for 5km on both banks of the river.

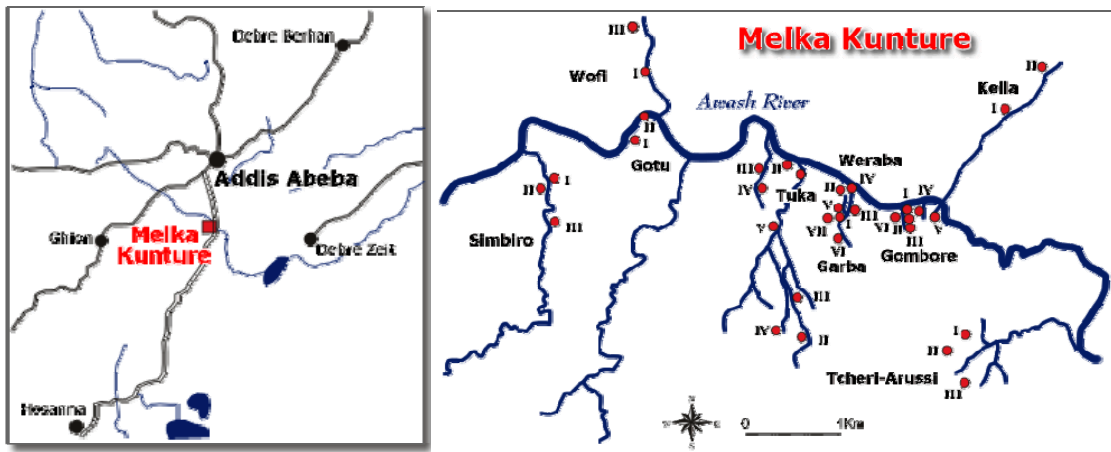


Fig. 1. Location of Melka Kunture (left) and the various archaeological localities in Melka Kunture (right).

Geology and Stratigraphy: The main sites are related to fluvio-lacustrine and volcanic formations and they are often on old terraces. The fluvial sediments consist of pebbles (which were used to make tools), gravel and clay. The volcanoclastic sediments are represented by tuffs. The Pleistocene formations represent a thickness of several tens of meters and their age starts from around 1.7 Ma, and are presumably preserved under the present level of the Awash. The geological history of the site is characterized by alternating sedimentary or volcanic phases and erosive phases. Tectonic influences cannot be ruled out. The repetition of the fluvio-lacustrine cycles is due to the presence of numerous faults (Taieb, 1971), although climatic factors might have also played a role. Six main cycles of erosion-sedimentation represent the geological history of the site and the alternating phases of human presence at Melka Kunture (see Fig. 2).

Cycle 1: the lowest deposits of Melk Kunture, the top of which represented by Oldowan sites with remains of *Homo erectus*.

Cycle 2: erosion of the preceding deposits was followed by clayey sediments forming a fossil beach.

Cycle 3: following the erosion phase, the base of the first cycle deposits are exposed over the fluviolacustrine deposits and capped by 1.3 -1.1 Ma old volcanic tuff layer, which in turn is overlain by archaeological levels referable to the ancient Acheulean.

Cycle 4: Erosive phases of variable extent followed by deposits of different origin (0.9 – 0.4 Ma) envelop the levels of Middle Acheulean with remains of a skull of *Homo erectus* and Upper Acheulean remains.

Cycle 5: An extreme erosion phase, followed by deposits of sand, gravel and ferruginous deposits incised and destroyed the top of the preceding cycle. Here there are levels dating to the late Acheulean with remains of a skull of *Homo sapiens* (about 200,000 years).

Cycle 6: This incision phase was apparently caused by reactivation of older faults, followed by an accumulation of slope deposits and sedimentation of clay and sand, which have preserved remains of Middle Stone Age. The entire Melka Kunture formation was covered by brownish black alluvial clays which were contemporaneous with human frequentation during the Late Stone Age.

A strong erosive phase (20 m or more) followed the arrival of the first productive societies, and exposed the deposits of the preceding periods, creating a landscape similar to that of the present day.

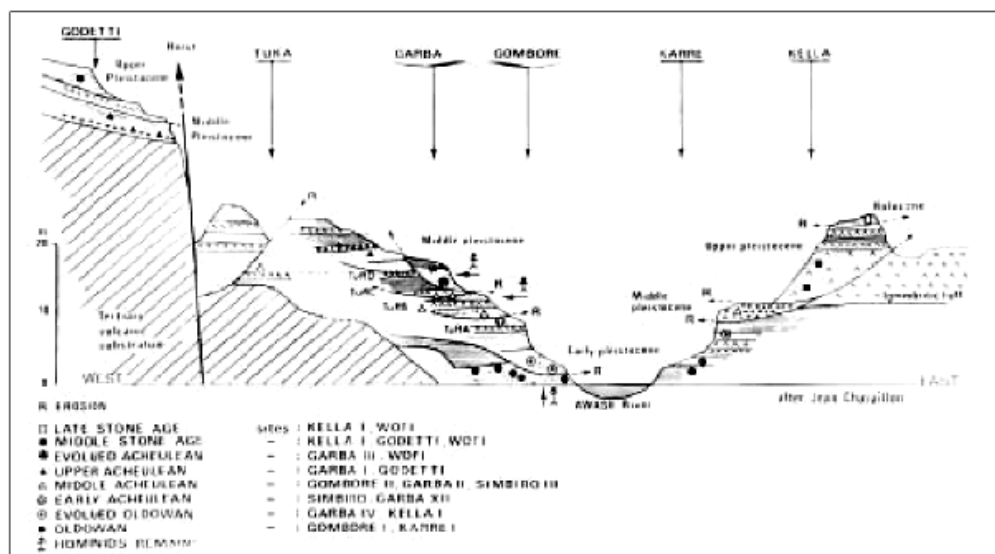


Fig. 2. Schematic cross section of the Melka Kunture showing the excavated archaeological sites and their stratigraphic relationships (from Chavaillon, 1979).

Archaeology: Excavations and researches were carried out especially in the following sites (See figure 1 for stratigraphic section):

- 1.7 – 1.4 Ma: Karre, Oldowan/Developed Oldowan
- 1.7 Ma: Gombore I, Oldowan
- 1.6 – 1.4 Ma: Garba IV, Developed Oldowan
- 1.2 Ma: Gombore I γ , Developed Oldowan
- 1.0 – 0.8 Ma: Garba XII, Lower/Middle Acheulean
- 0.9 – 0.8 Ma: Simbiro III, Middle Acheulean
- 0.8 – 0.7 Ma: Gombore II: Middle Acheulean
- 0.6 – 0.4 Ma: Garba I: Upper Acheulean
- 0.3 – 0.2 Ma: Garba III, Late Acheulean/Middle Stone Age
- 20,000 – 4,000 B.P.: Kella, Late Stone Age
- 20,000 B. P. – 2,000 AD: Balchit, Late Stone Age – Present day.

In all these sites, the lithic tool kit was associated to animal remains and some Hominid remains: *Homo erectus* and later *Homo sapiens* periodically frequented the Awash River banks at Melka Kunture. They made their camps on the pebble beaches or inside sandy channels excavated by small tributaries of the Awash. It has been possible to investigate the organization of these camps: constructed shelters, areas for stone working, animal butchering and meat cutting. In the most recent periods the use of fire has also been documented.

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Geological and Tectonic Setting of the Main Ethiopian Rift

(Compiled by: Asfawossen Asrat & Mohammed Umer)

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Introduction: The Main Ethiopian Rift (MER) constitutes the northernmost part of the East African Rift System (EARS). It runs approximately NNE–SSW through Ethiopia, and opens at latitude of about 10°N into the Afar Triangle (Fig. 1). The MER has been tectonically and volcanically active throughout the Late Holocene and Quaternary. It is believed to represent an incipient stage of continental break-up (Fairhead, 1986). Although the MER is some 80 km wide, tectonic and volcanic activity are concentrated within a 10–20 km wide sub-axial zone (Fig. 1) known as the Wonji Fault Belt (Mohr, 1960, 1967; Mohr et al., 1978).

The onset of the rifting process probably occurred during early Miocene time to the north of the EARS and during the late Miocene time to the south (Ebinger 1989 and references therein). The Red Sea probably commenced opening about 25 Ma ago and the Gulf of Aden somewhat earlier. Recent work has shown that the Red Sea is currently widening at a rate (from north to south) of 0.8–1.7 cm per year (Chu and Gordon, 1998; Jestin et al., 1994) and the Gulf of Aden at 1.5–2.5 cm per year (Jestin et al., 1994) as a result of sea floor spreading. Rifting in the MER commenced about 10 Ma ago, preceded by initial downwarping at about 15 Ma and has continued in several stages until the present (Kazmin et al., 1980; Mohr, 1983; Woldegabriel et al., 1990; Chernet et al., 1998). The Wonji Fault Belt was probably initiated about 1.6 Ma ago (Meyer et al., 1975) and a major impulse in volcanic and tectonic activity occurred within it at 0.25 Ma (Berhe, 1986).

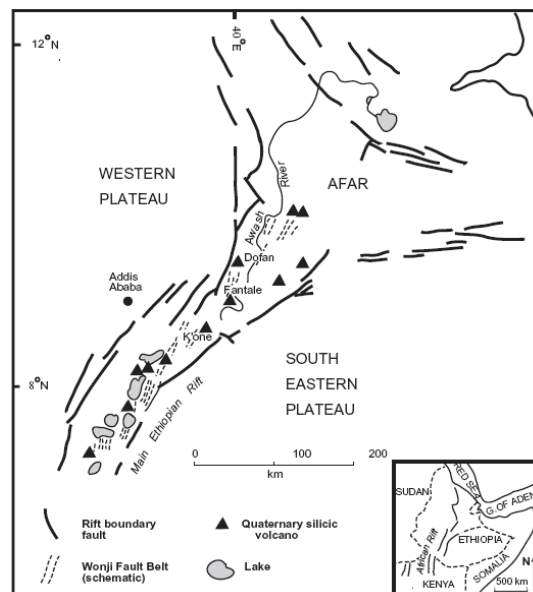


Fig. 1. The Main Ethiopian Rift and Afar (from Williams et al., 2004).

Geological make up: The central sector of the MER and its shoulders are made of volcanites and pyroclastic rocks, whereas large areas of the rift floor are covered by volcano-lacustrine and fluvio-lacustrine deposits (fig. 2). Limited outcrops of Precambrian biotite gneiss, covered by Early Mesozoic fluvial sandstones, marine shales and limestones, occur in a complex horst structure on the western margin (Kela horst, Woldegabriel et al., 1990; Di Paola et al., 1993).

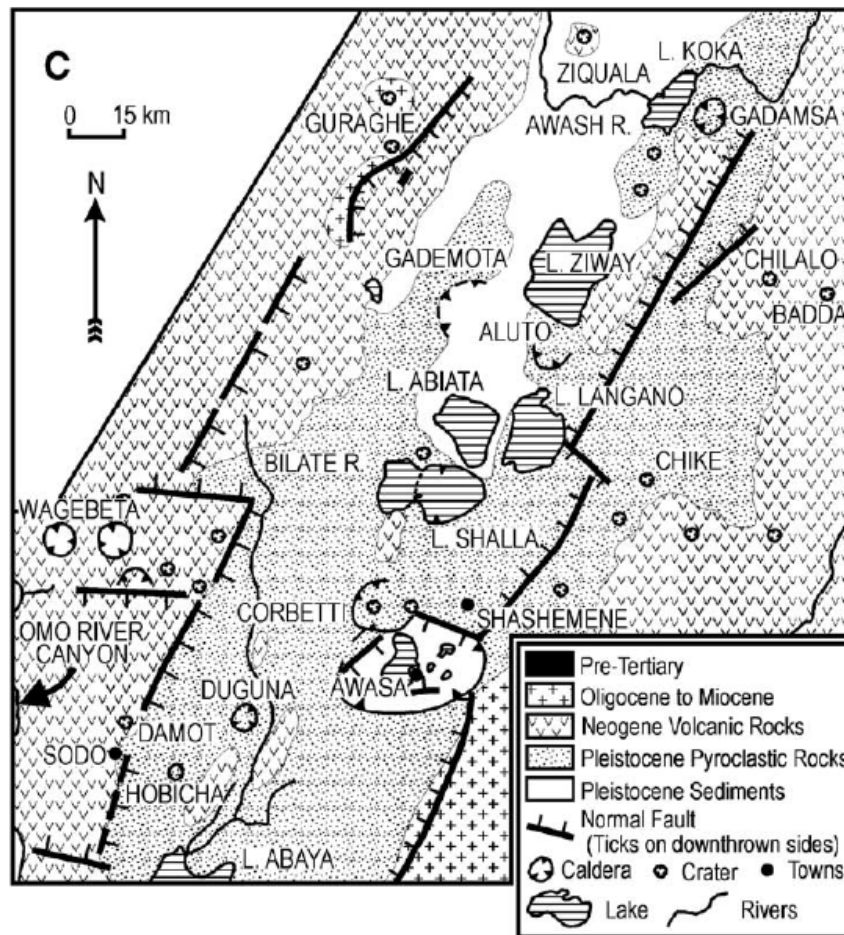


Fig. 2. Geological make up of the central sector of the Main Ethiopian Rift (from WoldeGabriel et al. 1999).

The oldest volcanic rocks (Plateau Trap Series) are exposed in the western escarpment and consist of about 1000 m of basaltic lava flows, with interbedded ignimbritic beds, topped by massive rhyolites and intervening tuffs and basalts (Di Paola, 1972; Merla et al., 1979; Woldegabriel et al., 1990; Di Paola et al., 1993). Radiometric ages range from 40 to 25 Ma in the basalts and from 37 to 27 Ma in the rhyolites (Merla et al., 1979; Woldegabriel et al., 1990). Middle Miocene to Pliocene (15–3 Ma) basalt flows, rhyolites and tuffs unconformably cap the early Tertiary volcanic units (Merla et al., 1979; Woldegabriel et al., 1990).

The eastern plateau is covered by Pliocene to early Pleistocene (4.6–1.6 Ma) shield volcanoes (Chilalo, 4005 m, Kecha, 4245 m Badda, 4170 m). These consist of trachytes with subordinate basalts and mugearites (Di Paola, 1972; Merla et al., 1979; Woldegabriel et al., 1990; Bigazzi et al., 1993), and of Miocene phonolites (Chike Mt).

Silicic pyroclastic materials cover most of the MER floor (Mohr, 1962; Di Paola, 1972; Woldegabriel et al., 1990); they are Early to Middle Pliocene (4.2–3 Ma, Woldegabriel et al., 1990), mainly peralkaline rhyolitic ignimbrites, interlayered with basalts and tuffs and associated with layered, unwelded pumices. The thickness of the ignimbrites is not known, but outcrops (Di Paola, 1972; Woldegabriel et al., 1990) and well data (Gianelli and Teklemariam, 1993) suggest it exceeds 500–600 m.

Alkaline and peralkaline rhyolitic lava flows and domes, associated with pumice and ash represent the late silicic volcanic events (Di Paola, 1972). These lavas were erupted from Late Pliocene to Middle Pleistocene and, in some places, crop out as remnants of large calderas. The Gademota Ridge, dated 1.30–1.27 Ma (Laury and Albritton, 1975; Mohr et al., 1980; Woldegabriel et al., 1990) is one such remnant. It rises in an arc structure, 25–30 km in diameter, up to 400 m above the plain west of Lake Ziway.

A more recent volcanic unit, crops out along the Silti Debre Zeit Fault Zone (SDZfz; fig. 3) and the WFB (Di Paola, 1972; Kazmin et al., 1980); it is made up of basaltic lava flows, associated with hyaloclastites and scoria cones. The thickness of this unit is only a few dozen meters; it is very recent, as testified by a radiometric age of 0.13 Ma (Woldegabriel et al., 1990) and by sub-historical lava flows (Di Paola, 1972; Di Paola et al., 1993).

Young volcanoes and calderas, such as the Bora–Bericcio complex, the Alutu volcano, the Ficke, O’ a and Corbetti calderas, are made up of rhyolitic lava flows, unwelded pumice flows, pumice falls and ashes. Obsidian flows represent the final product of the volcanic activity (Di Paola, 1972; Mohr et al., 1980). These recent volcanoes started to be active from the Middle Pleistocene (about 0.25 Ma, Di Paola, 1972; Mohr et al., 1980; Woldegabriel et al., 1990) with intermittent Late Holocene activity; obsidian flows and pumices were dated 2000 yBP (Gianelli and Teklemariam, 1993) and very recent ash deposits 1500 and 230 y BP (Haynes and Haas, 1974). Many of these volcanoes are presently in a fumarolic stage (Di Paola, 1972).

Within the volcanic and volcanoclastic succession of the O’ a caldera, Middle Pleistocene fluviolacustrine sands and clays occur (Mohr et al., 1980; Le Turdu et al., 1999). Late Quaternary fluvio-lacustrine sediments cover a large area of the central sector of the MER (Merla et al., 1979). They were laid down in a very wide lake which, in the past,

occupied most of the rift floor. The four present-day lakes (Ziway, Langano, Abiyata, Shala) are the remnants of that ancient lacustrine basin (Fig. 4).

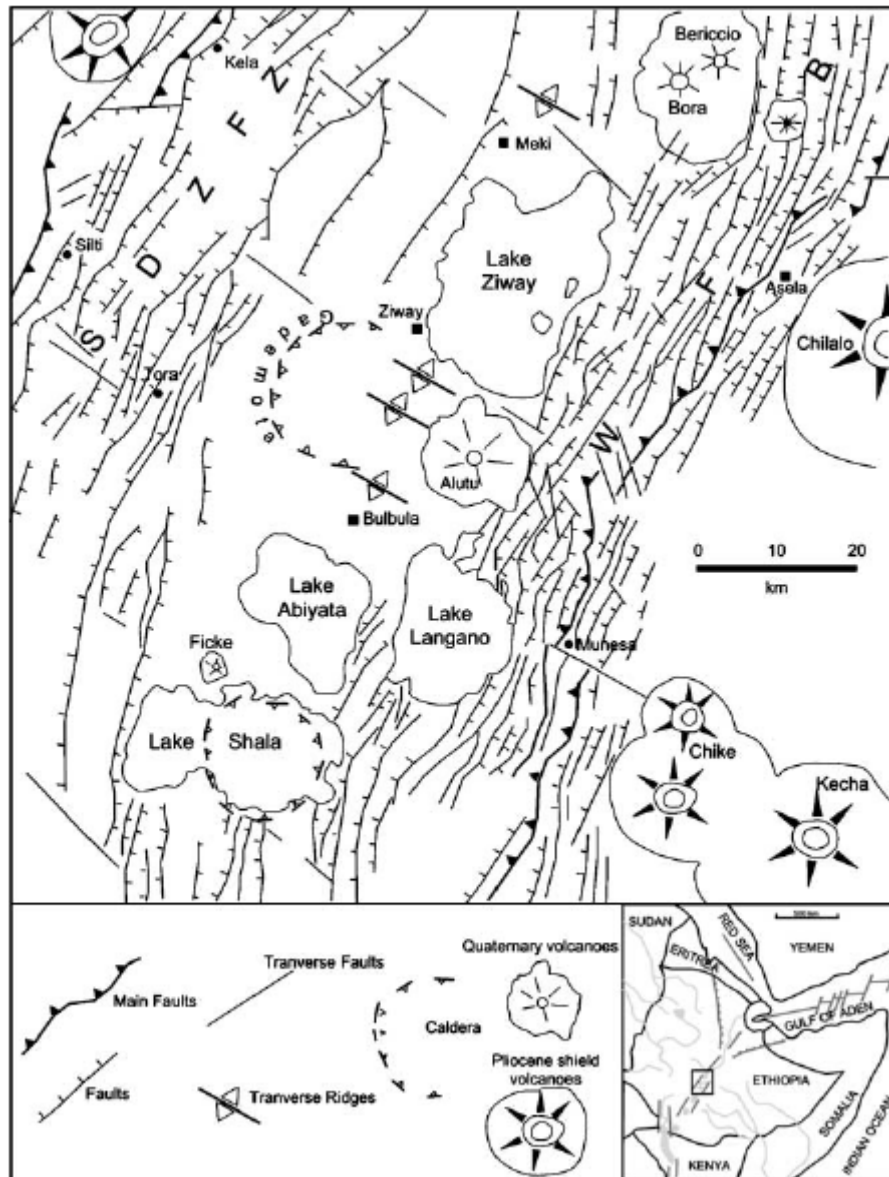


Fig. 3. Volcano–tectonic features of the Lake Region in the MER. WFB: Wonji Fault Belt; SDZFFZ: Silti-Debre Zeit Fault Zone (from Benvenuti et al., 2002).

Tectonics and rift development: Eruption of huge volumes of volcanites started in the MER and the adjacent plateaux in Late Eocene–Early Oligocene (Merla et al., 1979; Kazmin et al., 1980; Woldegabriel et al., 1990; Ebinger et al., 1993; Zanettin, 1993), preceding rift formation.

The early rifting phase (Late Oligocene–Early Miocene) was characterized by formation of a series of alternating half-grabens (Woldegabriel et al., 1990) and/or by downwarping

(Merla et al., 1979; Abbate and Sagri, 1980; Kazmin et al., 1980). This was followed by the development of full symmetrical grabens and rift-in-rift structures (Di Paola, 1972; Woldegabriel et al., 1990; Le Turdu et al., 1999).

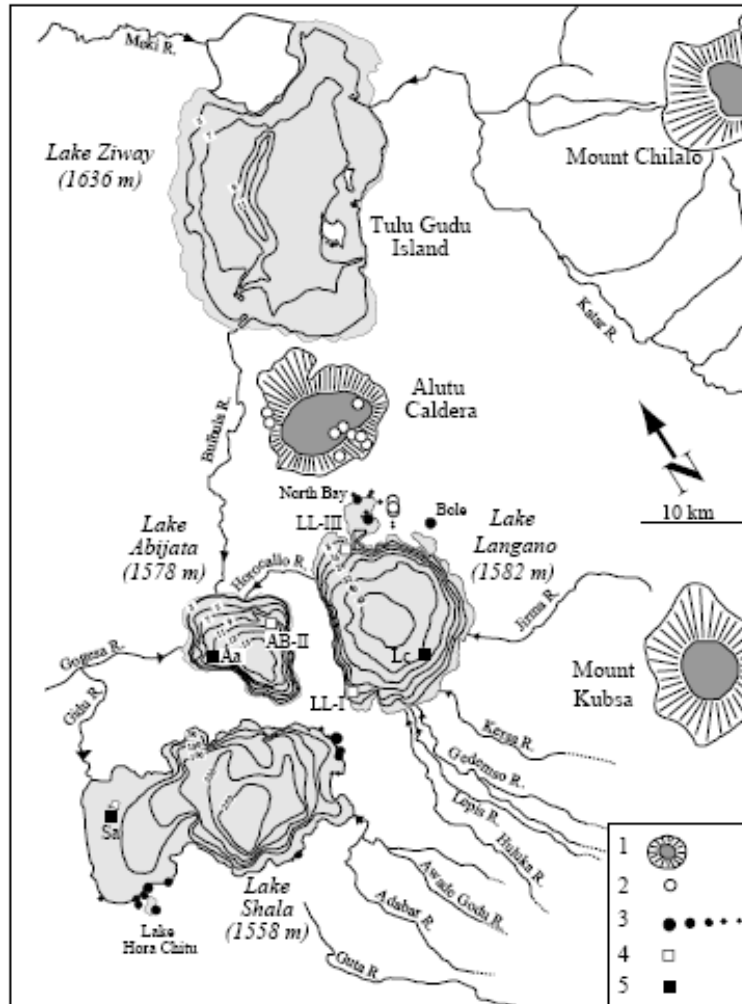


Fig. 4. Hydrological network, lake bathymetry, core location and distribution of hydrothermal activity and fumaroles within the Ziway–Shala lake basin system. 1: volcanoes and calderas; 2: fumaroles; 3: hydrothermal springs; the diameter of the black dots indicates the spring discharge in $l\ s^{-1}$, from $>10\ l\ s^{-1}$ (large dot) to $<0.25\ l\ s^{-1}$ (small dot) (after UNDP, 1973; Baumann et al., 1975; Street, 1979; Chernet, 1982); 4: Equarift and Livingstone cores; 5: Mackereth cores. (From Le Turdu et al., 1999)

The most important volcano–tectonic event in the central sector of the MER occurred in Early Pliocene, with the eruption of voluminous flows of rhyolitic ignimbrites and the collapse of very large calderas (Di Paola, 1972; Woldegabriel et al., 1990). The full symmetrical Rift configuration was achieved during this paroxysmic event (Woldegabriel et al., 1990).

From early Pleistocene to the present, tectonic and volcanic activity was concentrated along the WFB, and successively along the SDZFFZ (Mohr, 1962; Di Paola, 1972; Bigazzi

et al., 1993). Since Middle Pleistocene (or earlier?) fluvio-lacustrine basins developed along the WFB, under a tectonic–volcanic control (Le Turdu et al., 1999). Successively (late Pleistocene–Holocene) a fluvio-lacustrine basin occupied large areas of the MER floor (Di Paola, 1972; Laury and Albritton, 1975; Bigazzi et al., 1993) extending, in late Pleistocene, up to Mojo, 50 km north of Lake Ziway.

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