TECTONIC DEVELOPMENT OF THE NORTHERN EARS

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EARS is a classic example of continental rifting where Africa is splitting into two plates, the Somali and Nubian. EARS extends from the Red Sea/Gulf of Aden to Malawi and is seismically active beyond.

It is characterized by extensive extensional magmatism from Tertiary to Recent.

Several volcanic complex have developed along the rift, many with associated geothermal systems where the heat source is magmatic. Studies indicate that the geothermal potential of EARS is in the excess of mostly confined to the Eastern branch.
Idealized diagrams comparing the active and passive hypotheses for initiation of continental rifting. (1) shows the initial stage for both hypotheses, and (2) shows a subsequent stage of development. (a) The ascent and emplacement of a hot, low-density body in the sublithospheric mantle (hot spot) is a primary cause for extension in the active mechanism. This mechanism accounts for prerift uplift and volcanism (V). (b) In the passive mechanism, extension is driven by a tensional regional stress field, usually assumed to originate from remote plate boundary forces.
Different modes of continental extensional tectonics. (a) Narrow rift mode; (b) wide rift mode; (c) core complex mode (after Buck, 1991).
Sequential changes of the mantle through the time according to the Wilson cycle or supercontinental cycle

- Lithospheric extension accompanied by upwelling of the underlying asthenospheric mantle followed by melt formation due to decompression of the asthenosphere.

- Asthenospheric upwelling of the African superplume formed (Ethiopian dome) and the (Kenya dome).

- Further brittle extension of the crust results in down faulting and formation of the graben.
EVOLUTION OF EARS


• The EARS preferentially follows the ANS

• Which was amalgamated 800 Ma and continued to about 620 Ma
Schematic map which shows locations of mantle plumes and mantle flow directions along with fast axes of shear-wave splitting.
Landsat imagery (onshore) and Seasat-derived bathymetry (offshore) of the Red Sea–Gulf of Aden rift system and environs.
Schematic diagram illustrating the volcanic and tectonic evolution of the Ethiopian Rift during the last 40 million years.
Geology of the Afar region  Generalized stratigraphy of the Afar Depression and correlations with western Yemen (after Canuti et al., 1972; Davison et al., 1994; Sagri et al., 1998)—1, crystalline basement; 2, pebbly mudstone; 3, sandstone and conglomerate; 4, shale; 5, limestone; 6, dolostone; 7, volcanic rocks; 8 granitic intrusives; 9, evaporite;
THE EVOLUTION OF THE MAIN ETHIOPIAN RIFT (MER)

The first tectonomagmatic event related to the Tertiary rifting was the eruption of voluminous flood basalts.
• Activation of large boundary faults (11–2 Ma), giving rise to major fault-escarpments and rift-floor subsidence.
Progressive extension led to the second (Pleistocene) rifting stage characterised by a riftward narrowing of the volcanotectonic activity.
• The volcano-tectonic activity is localised within the rift segments, a strong feedback between deformation and magmatism develops:
With further thinning, heating and magma intrusion, the tectonically and magmatically thinned lithosphere may rupture in the heavily intruded zones, and new oceanic lithosphere created.
Volcanism in Afar Depression

Syn-rift Miocene volcanism
A dramatic decrease in volcanism occurred in the Ethiopian Plateau from 25 to 20 Ma, Within the Afar Depression, Miocene volcanic rocks are assigned to the Adolei, Mabla, and Dalha series.

Pliocene–Pleistocene volcanism
Pliocene–Pleistocene volcanic rocks cover most of the Afar Depression, and these units are mostly assigned to the Afar Stratoid series. The oldest exposed flows of the Afar Stratoid series are 4.4 Ma or 7.4 Ma and may therefore extend down into the Late Miocene.

Quaternary geology and neotectonics
Basaltic flows, scoria cones, and alkaline to peralkaline silicic rocks were erupted locally in the Afar Depression over the past 1 My
a) 30-20 Ma
Nubian Plate

b) 20-11 Ma
Nubian Plate

Arabian Plate

Gulf of Aden

Kenya Rift-related deformation

Somalian Plate

Southern MER

End of (Kenya Rift-related) deformation in the southern MER

C) 11 Ma
Nubian Plate

Afar

Gap in the future MER

Configuration of the Afar triple junction

Somalian Plate

d) 11-6 Ma
Nubian Plate

Afar

Somalian Plate

Gobsa-Bonga

Possible diversion of deformation along the YTWL

Incipient CMER

Counter-clockwise rotation of the Somalian Plate

Tectonic pause in SMER

Somalian Plate

e) 5-3 Ma
Nubian Plate

Afar

Somalian Plate

Red Sea

Arabian Plate

Borun Toru structural high

Transfer of deformation at the Borun Toru structural high

Somalian Plate

f) 3-0 Ma
Nubian Plate

Afar

Somalian Plate

Red Sea

Arabian Plate

MER

SMER (former Kenya Rift-related basins)

Somalian Plate

Keny Rift

Lineament

Somalian Plate
Tectonic development of the Afar triple junction, illustrated with snapshots of representative stages

a) Between 35 and 27 Ma, continental rifting commences in Red Sea and Gulf of Aden.

b) Rifting continues in the Red Sea, and seafloor spreading has commenced in the eastern Aden rift. Extension between Nubia and Danakil microplate may have initiated.

c) After 11 Ma, extension in the Main Ethiopian rift initiates to form a triple junction for the first time. Greatest stretching has occurred in southern Afar, where some oceanic crust may have been created by 8 Ma. d) Then the triple junction migrated north-eastwards to the present-day Tendaho-Goba'ad Discontinuity (TDG;
Motion of crustal segments from continuous GPS reading showing different displacement rating.
THANK YOU