Chapter 1: High Africa: Eroding Surfaces

The formation of High Africa began in the Afar region of north-east Ethiopia around 30 Ma, brought about by the billowing mantle plume. By ~20 Ma, the continental uplift had propagated into South Africa, where the land surface was raised by about 250 m in the east and 150 m in the west. The elevated surface was subjected to a renewed phase of erosion, which produced the Post-African I (or Miocene) landscape. More substantial uplift took place starting around 10 Ma and accelerating after 5 Ma, especially along the eastern side of the continent. The land surface rose by as much as 1500 m in eastern Africa and by up to 900 m in eastern parts of South Africa.[1] This generated the Post-African II (or Pliocene) cycle of erosion, not readily distinguished from the preceding phase I. The product is the high interior plateau extending from Ethiopia through eastern Africa and broadening westward across southern Africa (Figure 1.1; Box 1.1 explains the continental divisions used throughout the book). The elevated continental interior profoundly influenced climates, exposed bedrock, altered river courses, shifted lakes and affected soil formation, as will be outlined in the chapters that follow.

Land Surfaces

Remnants of the African erosion surface persist in South Africa's Highveld region, Manica region of central Zimbabwe, above the Muchinga escarpment in Zambia and over parts of eastern Africa despite blanketing there under lava flows (Figure 1.2).[2] Distinctions between the African and Post-African surfaces are particularly striking in the southern Highveld and Karoo regions of South Africa, where flat-topped hills capped by resistant bedrock retain remnants of the African surface on their crests (Figure 1.2D). Further north in parts of Zimbabwe, Angola and northern Mozambique, erosion has exposed inselbergs composed of basement granite (Figure 1.2E). While erosion lowered the interior surface, it pushed back coastal escarpments. Sandy sediments accumulated in the Kalahari and Congo basins in the west and extended the eastern coastline outward (Figure 1.2F).

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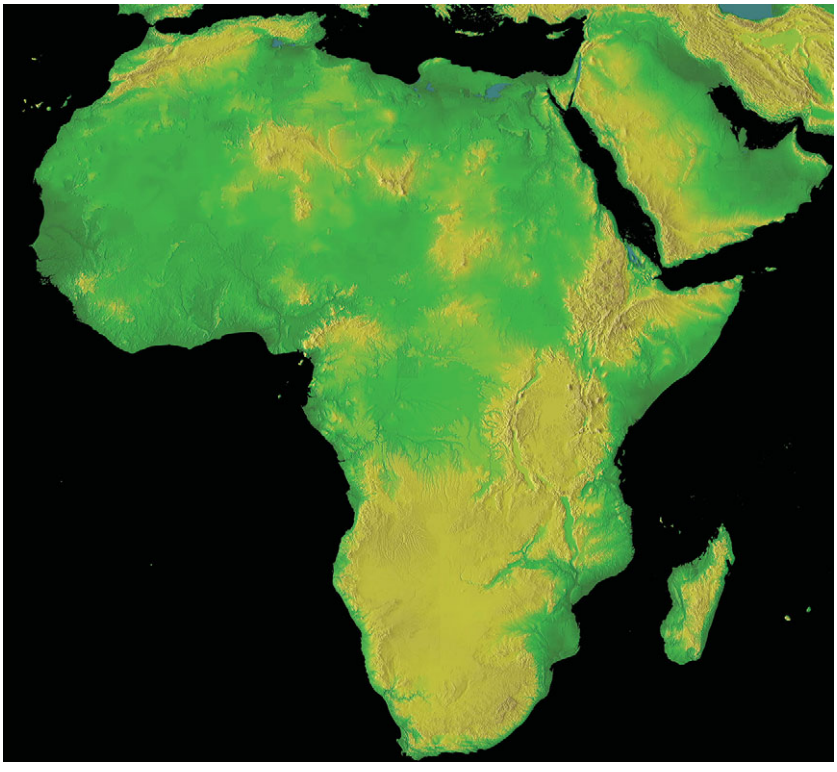

Figure 1.1 Topographic map showing the extent of High Africa stretching continuously from Ethiopia through southern Africa, shown in yellow.

Box 1.1 Geographical Subdivisions of Africa Distinguished in the Text

1. Eastern Africa – the equatorial region encompassing Kenya, Tanzania and Uganda
2. South-Central Africa – the tropical region extending through Zambia, Zimbabwe, Malawi, northern Mozambique and Angola
3. Southern Africa – the region extending into the subtropics encompassing South Africa, Botswana, Namibia and southern Mozambique
4. North-eastern Africa – southern parts of Sudan, Ethiopia and Somalia
5. Western Africa – the region extending from Cameroon to Senegal
6. Northern Africa – the Mediterranean region extending from Egypt to Morocco

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Figure 1.2 Land surfaces. (A) The gently undulating Africa surface generated by the early Miocene, represented in Athi-Kaputiei Plains in Kenya; (B) eroding eastern edge of South Africa's Highveld plateau; (C) elevated highlands in eastern Zimbabwe, representing marginal uplift following the breakup of Gondwana; (D) flat-topped hill retaining the Africa surface above the Post-African or Pliocene erosion surface in South Africa's Karoo region; (E) granite inselbergs exposed by erosion into the basement shield in south-eastern Zimbabwe; (F) depositional surface of Kalahari sand in north-western South Africa.

South Africa's Highveld plateau attains its maximum elevation of 2332 m near Dullstroom ~200 km from Johannesburg above the eastern (or Transvaal) escarpment, while the Lesotho highlands above the Drakensberg escarpment rise to 3482 m and retain remnants of the Gondwana surface on hilltops. In

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the south-west, highlands near the Namibian capital Windhoek reach 2606 m, while Angola's western escarpment rises ~2500 m above the coastal plain, counteracting the general lowering westward. Serengeti National Park (NP) in Tanzania ranges in elevation from 1200 to 2000 m, while the Ngong Hills near Nairobi reach 2460 m. Plateau regions of Ethiopia exceed 3000 m in elevation.

In contrast, western Africa is mostly low-lying, with only localised high country. The Jos Plateau in central Nigeria forms a tableland at a mean elevation of 1280 m, with its highest point 1829 m above sea level. Further west, the Guinean highland reaches a maximum altitude of merely 1538 m. Other highland regions exist deep within the Sahara. The plateau region of Cameroon and adjoining Nigeria connects with the eastern African highlands via the Ubangi-Shari region of the Central African Republic. Every major city in Africa within the eastern and southern interior lies more than 1000 m above sea level, while no city in the west approaches this elevation (Table 1.1). Higher eminences are all volcanic cones associated with rift valley formation, except for the Ruwenzori range, which is an upthrust block within the Western Rift.

Rift Valley Formation

The rifting that began in Ethiopia eventually spread through northern Mozambique, spanning a distance of ~6000 km (Figure 1.3). The downward subsidence in the trough was counterbalanced by raised rift shoulders due to the local pressure release. In some regions there was only a single fault, generating a 'half-graben' rather than a two-sided full graben. The rift valleys accumulated sedimentary deposits, and thus played a crucial role in preserving fossils of past faunas. They trace much of our knowledge of the course of human evolution. Volcanic cones rose beside the rifts and fissure eruptions spread volcanic deposits more widely. Minerals contained in the lava deposits can be used to date the time line of evolution.

In Ethiopia, the rift depression dividing the Simien Mountains in the north-west from the Bale Mountains in the south-east forms a valley 50-km wide. On its margin, Ras Dashen in the Simien range reaches an altitude of 4624 m, while the floor of the Danakil depression in neighbouring Eritrea lies 125 m below sea level. The Eastern (or Gregory) Rift extended through northern Kenya after 12 Ma and reached northern Tanzania by 5 Ma, where it fades out. The Western or Albertine Rift branched off along the border of the Congo DRC with Uganda, Rwanda, Burundi and western Tanzania. Incipient signs of rifting appeared in the Semliki region of Uganda around 8 Ma, but its current configuration was attained only after 3 Ma. The Western Rift continued propagating through southern Tanzania and Malawi to reach the Mozambican coast

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Table 1.1 Altitudes of major African cities situated away from coastal regions and their mean annual and dry season rainfall totals (source: Wikipedia and climate-data.org)

City	Country	Altitude (m)	Mean annual rainfall (mm)	Dry season rainfall (mm)
Johannesburg	South Africa	1753	790	67
Windhoek	Namibia	1728	359	12
Gaborone	Botswana	1014	457	28
Lilongwe	Malawi	1050	860	13
Harare	Zimbabwe	1490	831	23
Lusaka	Zambia	1277	831	3
Huambo	Angola	1721	1366	39
Dodoma	Tanzania	1120	564	2
Nairobi	Kenya	1795	869	139
Kampala	Uganda	1190	1293	457
Goma	Congo DRC	1460	1192	381
Kigali	Rwanda	1567	1000	226
Addis Ababa	Ethiopia	2200	1143	111
Juba	South Sudan	550	941	101
Abuja	Nigeria	840	1389	49
Yaoundé	Cameroon	726	1643	355
Bangui	Central African Republic	369	1535	290
Ndjamena	Chad	298	481	0
Niamey	Niger	218	505	2
Bamako	Mali	350	953	5

Note: Dry season rainfall is averaged over the five driest months.

near Beira. A minor south-western offshoot extended through Zambia's Luangwa Valley into northern Botswana, ending in the faults blocking drainage from the Okavango Delta. Most rift activity took place between 9 and 5 Ma in the north-east, then again 1–2 Ma extending through the south, associated with the two phases of tectonic uplift.

Lake Naivasha in the rift floor lies at an elevation of 1884 m, higher than the elevation of the city of Nairobi to the east (Figure 1.4A). The lowest region of the rift near Lake Turkana in northern Kenya is only 375 m above sea level. The rift margins in the Turkana Basin are separated by ~300 km, but become narrowed to under 60 km near Nairobi.[3] Approaching its terminus in northern

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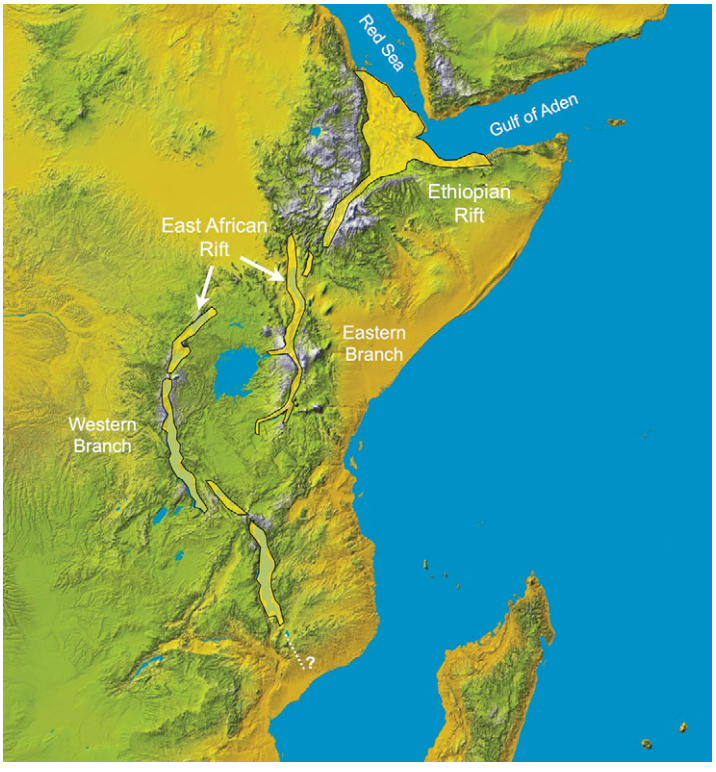

Figure 1.3 Map of the African Rift Valley System extending through eastern Africa from Ethiopia in the north to Mozambique in the south (from Wood & Guth, www.geology.com/articles/east-africa-rift).

Tanzania, the Eastern Rift splits into three arms. The western arm extends through Lake Eyasi, the central one reaches south of Lake Manyara, and the eastern one goes past the town of Moshi near Kilimanjaro. The road heading towards Serengeti ascends the margin of the Eastern Rift while passing Lake Manyara (Figure 1.4B).

The Western Rift is somewhat narrower than the Eastern Rift and includes several deep basins filled by large lakes. The Ruwenzori Mountains were formed as an upthrust block within the rift subsidence, with Mount Stanley reaching 5120 m above sea level. Lake Kivu's surface lies at 1460 m, while the surface elevation of Lake Tanganyika to the south is much lower at 773 m. Lake Tanganyika attains a maximum depth of 1470 m, meaning that its floor lies well below sea level. The Western Rift is still widening at a rate of a few millimetres per year, portending a split of the Somali plate including much of eastern Africa from the rest of the continent in some distant future. The Virunga volcanoes lie to the east of this rift, with Mount Karisimbi attaining

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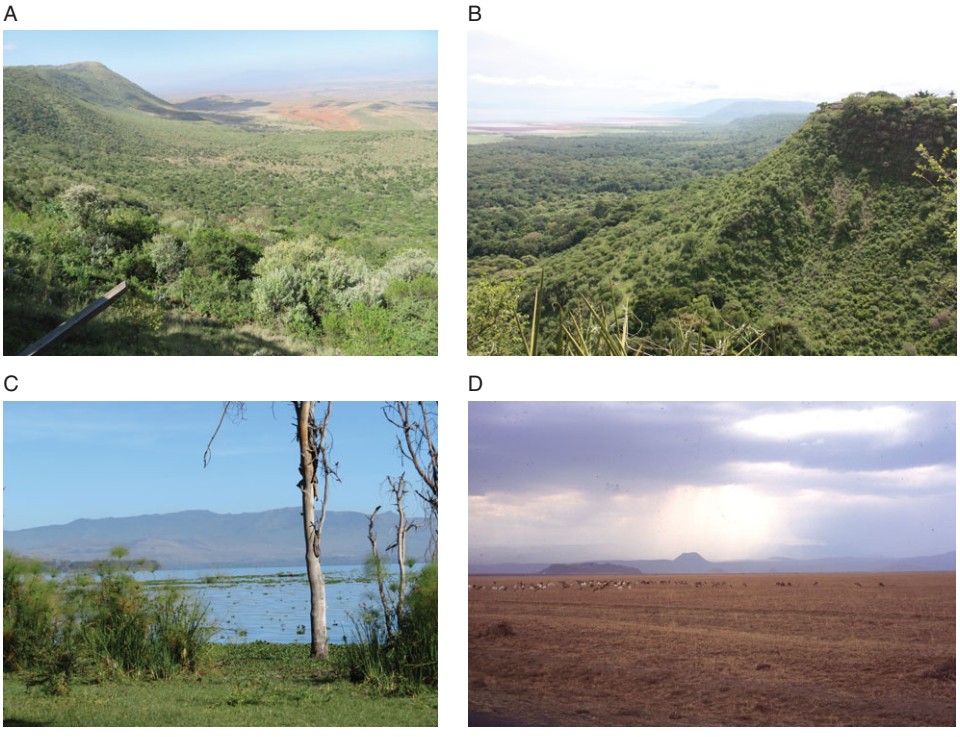

Figure 1.4 African Rift Valley views. (A) Eastern Rift Valley descending from the Ngong Hills in Kenya; (B) Eastern Rift shoulder above Lake Manyara in Tanzania; (C) rift wall rising beyond Lake Naivasha; (D) arid floor of the Eastern Rift near the equator in Kenya.

an elevation of 5109 m. Mounts Nyamulagira and Nyiragongo are still active. The low volcanic cones and associated crater lakes in Queen Elizabeth National Park in Uganda were generated quite recently.

Numerous volcanoes are allied with the Eastern Rift, most of them on adjoining platforms rather than within the rift subsidence. Mount Elgon (4321 m), situated on the border between Kenya and Uganda, was formed around 22 Ma before local rifting began. Mount Kilimanjaro (5895 m) rose to its full height between 2.5 and 1 Ma. Mount Kenya (5199 m) formed earlier around 2.6 Ma and was initially much higher than it is today. Ngorongoro Crater, with its rim rising to 2380 m, is the remnant of a volcano blasted open by a tremendous explosion around 2 Ma, producing the world's largest caldera. Oldoinyo Lengai, situated in the Ngorongoro highlands, still spews carbonatite tuffs over earlier lava flows.

Volcanic cones occur also in the Cameroon highlands, with Mount Cameroon rising to an altitude of 4040 m. Other volcanoes formed the islands of Sao Tome and Principe in the Gulf of Guinea. Southern Africa's land surface

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has remained much more stable. There have been no volcanic eruptions more recent than the early Jurassic period when Gondwana broke up.

Overview

Africa was predominantly high-lying following its separation from Gondwana, with its surface becoming eroded to a gently undulating plain rimmed by retreating scarps. Its interior elevation was raised further by tectonic uplift during the Miocene and Pliocene, especially through the east and south, while western Africa remained mostly low-lying. The eastern region became disrupted by ramifying rift valleys, with volcanic cones emerging on their margins. These troughs accumulated the sediments that preserve most of the fossil record of evolution since the Miocene. The Kalahari basin in the west accumulated predominantly loose sands that do not retain fossils, while in the east sediments carried by rivers extended coastlines.

In contrast, most of South America east of the Andes mountain ranges is low-lying. The plateau region of southern Brazil is divided from the highlands of Venezuela and Colombia by the vast Amazon basin. A transect strip at 30°S through southern Brazil and adjoining Argentina, excluding the Andes, averages under 200 m in elevation, compared with 1200 m for a corresponding strip across southern Africa. Within North America, a distance of 3000 km must be traversed from the east coast to the Rocky Mountains before elevations exceeding 1000 m are encountered. Most of Europe and northern Asia is low-lying, except where the Alps and other fold mountains intrude. Much of the Indian peninsula exists as an undulating plateau under 1000 m in elevation, although hills in the Western Ghats approach 3000 m above sea level. To the north of India, the Tibetan plateau reaches 4500 m, while several peaks in the Himalaya and adjoining mountain ranges rise above 8000 m. Australia remains mostly the low-lying plain developed by the end of the Cretaceous. Only a narrow region of the Great Dividing Range in the east exceeds 1000 m, while the highest peak, Mount Koskiusko in the Snowy Mountains, attains merely 2440 m. Western Africa resembles South America and other continents in its mostly low-lying terrain. The extent of the East African Rift System is unrivalled in any other continent.

Africa's disrupted topography affects local rainfall patterns, as will be described in the following chapter. Its eroding land surface exposes soils to bedrock influences below as well as above escarpment rims. In these ways 'High Africa' constitutes a foundation for Africa's distinctive ecology, as will be outlined in subsequent chapters.

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Suggested Further Reading

Burke, K; Gunnell, Y. (2008) The African erosion surface: a continental-scale synthesis of geomorphology, tectonics, and environmental change over the past 180 million years. *Geological Society of America Memoirs* 201:1–66.

Macgregor, D. (2015) History of the development of the East African Rift System: a series of interpreted maps through time. *Journal of African Earth Sciences* 101:232–252.

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