CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

PART I

Introduction

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

1 Introduction to the biogeography and ecology of the rain forests of eastern Africa

SAMUEL K. WASSER and JON C. LOVETT

The tropical rain forests of Africa are divided by a corridor of arid land that runs from the Horn of Africa, through Kenya, Tanzania, Zambia, Zimbabwe and Botswana to the Namib Desert of Namibia (Werger, 1978). The arid corridor reaches the sea on the east coast of Africa in Mozambique, where Madagascar casts a rain shadow, and in the north where the corridor covers much of Somalia. A narrow strip of relatively high rainfall lies between the deserts of the Somalia coast in the north, the Madagascar rain shadow in the south and the woodland of the central African plateau to the west. It is this humid area of eastern Tanzania, Kenya and southern Somalia that we define here as eastern Africa (Figures 1.1 and 1.2).

The area of tropical rain forest in eastern Africa is not large; it is approximately 10 000 km^2, a mere 0.1% of the estimated 10 million km^2 of tropical rain forest in the world (Mabberley, 1983). Unlike the vast west and central African forests, the forests of eastern Africa are highly fragmented – discrete islands associated with localised areas of high rainfall, surrounded by a sea of comparatively arid woodland. Contrasts between these wet and dry areas are pronounced. For example, on the eastern slopes of the Uluguru Mountains of Tanzania there is a per-humid climate where more than 100 mm of rain falls each month of the year and the annual rainfall exceeds 3000 mm. A high diversity of slender boled, narrow crowned trees reach heights greater than 60 m in a closed, epiphyte-rich canopy. Streams cascade down steep slopes with banks of ferns, begonias and *Impatiens*. A few kilometres to the south is the highly seasonal climate of the Selous Game Reserve, where large populations of game animals roam wooded grasslands. In the mountain's rain shadow to the west, there are sisal estates in semi-arid land that receive less than 600 mm of rain per year.

As described by Griffiths (Chapter 2) and Lovett (Chapter 3), it is the geological and climatological histories of eastern Africa that make its forests unique. Climatic vicissitudes throughout the Pleistocene are thought to have caused major extinctions by substantially reducing the total area of African rain forest. However, the forest patches of eastern Africa appear to have escaped these changes owing to the remarkable stability of the Indian Ocean currents that bring moisture to the tropical East African coast (Figure 1.2; Hamilton, 1982). There probably has been tropical rain forest in eastern Africa since approximately 30 million years ago, when Africa drifted to its present position at the end of the Oligocene (Axelrod & Raven, 1978). The continental divide between East and West Africa was accentuated by the Miocene uplift of the central African plateau (Griffiths, Chapter 2). The great age, isolation and fragmented nature of the eastern African forests have combined to produce remarkably high levels of endemism and diversity. About one third of the more than 2000 moist forest plant species are endemic (found nowhere else; Lovett, 1988) with over 20 endemic genera (Iversen, 1991). The

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

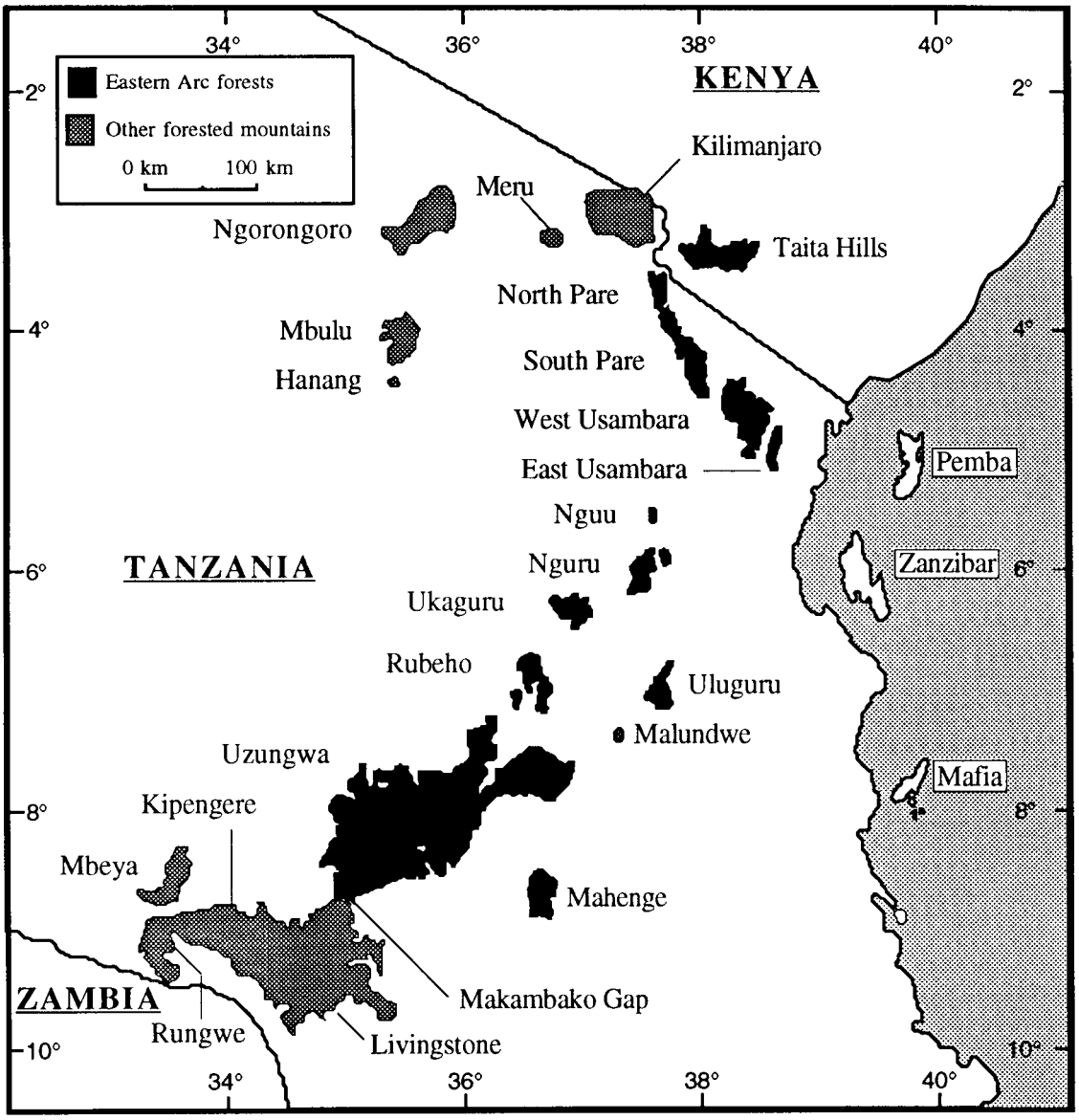


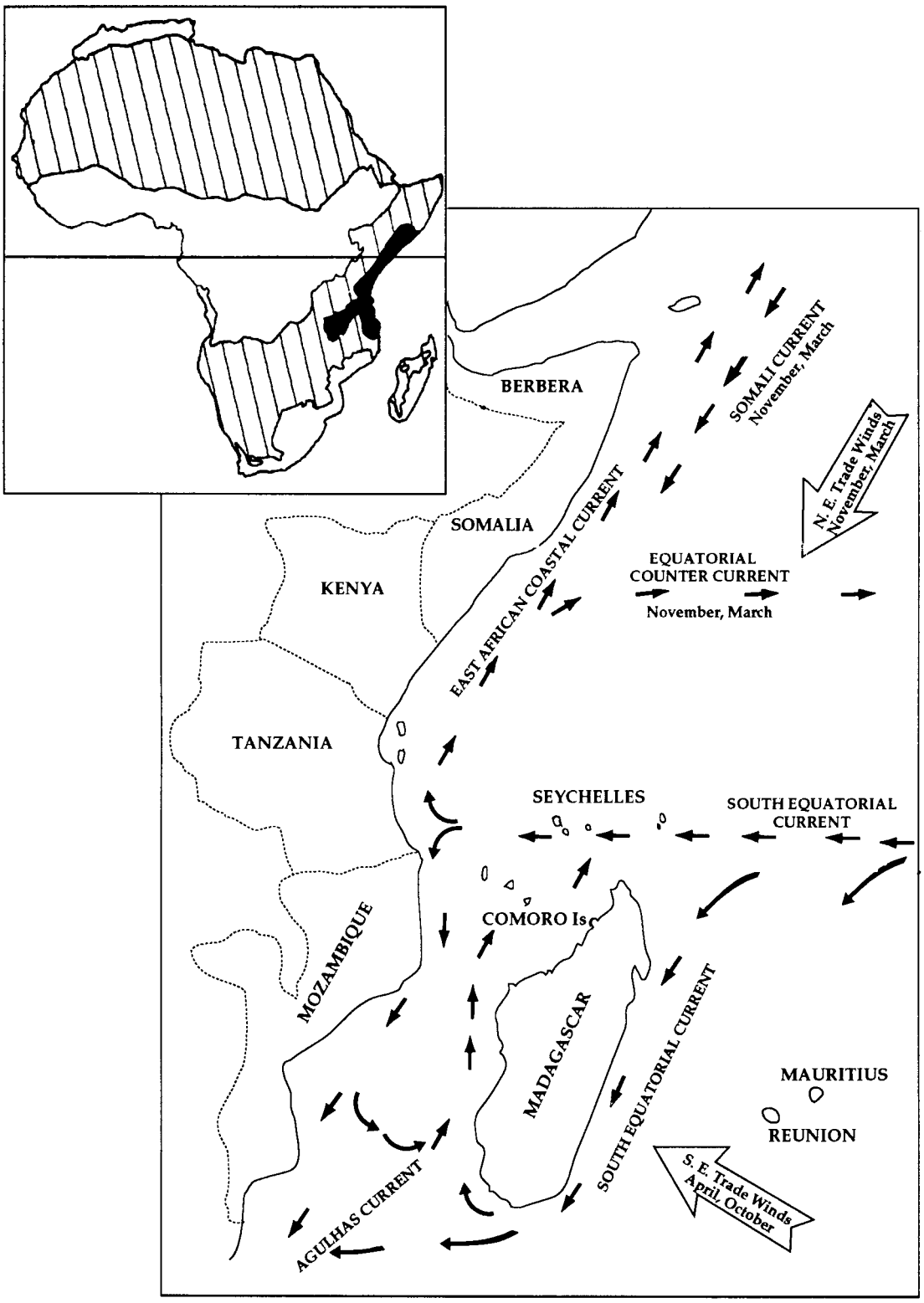
Figure 1.1. Mountains of eastern Tanzania and southeastern Kenya supporting moist forest. Eastern Arc mountain forests are shown in black.

Figure 1.2. Map of eastern Africa showing oceanic currents and trade winds (from IUCN/UNEP, 1982). Inset is a map of the arid corridor along with other arid regions throughout Africa (hatched areas, from Werger, 1978), with the wetter part of eastern Africa marked in black.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information



© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

percentage of endemism is even greater in slow-moving, forest-dependent invertebrates such as millipedes (Hoffman, Chapter 6) or moisture-dependent amphibians (Howell, Chapter 9).

The eastern African forests have an altitudinal range from near sea level on the coast to almost 3000 m on Mount Kilimanjaro. A continuous altitudinal range from 400 to 2000 m is found on the Uzungwa and Nguru mountains. The eastern African forests are of three general geographical types: the Eastern Arc forests on ancient crystalline mountains; the forests of more recent origin on volcanic mountains; and coastal forests on overlying sedimentary rocks between the Eastern Arc mountains and the coast, and on the offshore islands of Pemba, Zanzibar and Mafia. Each of these forests is an effective island, whether surrounded by arid land or sea. This book is about the results of physical and biogeographical events, including isolation and speciation, that have occurred at each of these localities.

The book begins with the geological and climatological history (Griffiths, Chapter 2; Lovett, Chapter 3). The remaining chapters describe how these physical events have affected the biogeography, ecology and conservation biology of the eastern Africa forest fauna and flora. The vegetation chapters (Lovett, Chapter 4; Hawthorne, Chapter 9) describe ways in which climatological and vegetational changes reinforce one another. This sets the stage for the section describing biogeography and patterns of endemism throughout the animal kingdom, including millipedes (Hoffman, Chapter 6), spiders (Scharff, Chapter 7) butterflies (de Jong & Congdon, Chapter 8), amphibians and reptiles (Howell, Chapter 9), birds (Stuart *et al.*, Chapter 10) and mammals (Kingdon & Howell, Chapter 11). What is remarkable about these chapters is the degree of consistency in biogeographical patterns found across taxonomic groups, despite phylogenetic constraints in mobility or resistance to desiccation.

The montane forests of eastern Africa have been isolated and comparatively stable for a relatively long period of evolutionary time. This isolation has created both palaeoendemics (relicts of the formerly widespread distribution of the pan-African rain forest) and neoendemics (more recent immigrants from other habitats that were able to survive and radiate in areas of high rainfall). These patterns are compared with those in the more recent forests of the eastern African volcanoes where considerably fewer endemics are found, most of which are neoendemics. Compared with the more continuously distributed western African forests, the highly fragmented forests of eastern Africa appear to have fewer species overall but a relatively high proportion of endemics.

Movement of forest species into, and out of, the forests of eastern Africa is demonstrated throughout the book, using both northwestern and southwestern routes from the Guineo–Congolian Forest to the Eastern Arc. Most important among the northwestern routes were those through the Kenyan highlands and down the easterly, riverine drainages to the more northerly mountains of the Arc. Most important among the southwestern routes were the riverine forests passing through the Tanganyika Rift, along mountains and valleys of the Rukwa rifts and continuing into the climatic system created by Lake Nyasa. Several chapters provide evidence of these routes, based on north–south differences in species composition within the Eastern Arc montane forests. But exceptional patterns also are apparent, owing in part to interactions between phylogeny, mobility and ecology; most notable are mobility and ecological constraints on the distribution of invertebrates (see Chapters 6, 7 and 8 by Hoffman, Scharff, and de Jong & Congdon). Some species also appear to have adapted to the forest from the surrounding open woodland, and vice versa (Chapters 11 and 8 by Kingdon & Howell, and de Jong & Congdon).

The remaining chapters of the book focus on behavioural ecology and conservation biology. Two chapters (12 and 13) on forest primates, by Mturi, and Wasser, illustrate the impact that biogeographical events described throughout the book can have on the behavioural ecology of a species. Wasser's chapter suggests ways in which such behavioural and ecological changes might have facilitated processes that led to speciation (e.g. niche shifts, character displacement and

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

hybridisation). The concluding chapter 14, by Rodgers, focuses on the conservation of the forests of eastern Africa, both historically and into the future. This chapter and others emphasise that the highly fragmented, relatively small forest patches of eastern Africa place them at considerably greater conservation risk than the larger forest blocks of western Africa (see also Newmark, 1991). Rodgers argues that forests were once much more extensive in Tanzania and Kenya (20% and 10%, respectively) but were destroyed by clearing and burning for cultivation. He draws upon biogeographical theory to develop management strategies for forest conservation in eastern Africa.

The unique nature and conservation importance of the rain forests of eastern Africa have been recognised for many years (Polhill, 1968; Lucas, 1968; Rodgers & Homewood, 1982). These points are highlighted throughout this book. Collectively, the chapters provide the readers with a comprehensive view of how evolutionary events have shaped the biogeography and ecology of these forests. It is our hope that these studies will contribute to the development and implementation of effective conservation strategies for the eastern African forests into the future.

References

AXELROD, D. I. & RAVEN, P. H. (1978). Late Cretaceous and Tertiary vegetation history of Africa. In *Biogeography and Ecology of Southern Africa*, ed. M. J. A. Werger, pp. 77–130, The Hague: Junk.

HAMILTON, A. C. (1982). *Environmental History of Africa: A Study of the Quarternary*. London: Academic Press.

IUCN/UNEP (1982). Conservation of coastal and marine ecosystems and living resources of the East African Region. *United Nations Environment Programme Regional Seas Reports and Studies* No. 11.

IVERSEN, S. T. (1991). The Usambara mountains, NE Tanzania: Phytogeography of the vascular plant flora. *Symbolae Botanicae Upsaliensis* **24**, 1–234.

LOVETT, J. C. (1988). Endemism and affinities of the Tanzanian montane forest flora. In *Systematic Studies in African Botany*, ed. P. Goldblatt and P. P. Lowry, pp. 591–8. St Louis: Missouri Botanical Garden.

LUCAS, G. L. (1968). Kenya. In *Conservation of Vegetation in Africa South of the Sahara*, ed. I. Hedberg and O. Hedberg, pp. 152–63. Acta Phytogeographica Suecica, Vol. 54.

MABBERLEY, D. (1983). *Tropical Rain Forest Ecology*. London: Blackie.

NEWMARK, W. D. (1991). Tropical forest fragmentation and the local extinction of understory birds in the Eastern Usambara Mountains, Tanzania. *Conservation Biology* **5**, 67–78.

POLHILL, R. M. (1968). Tanzania. In *Conservation of Vegetation in Africa South of the Sahara*, ed. I. Hedberg and O. Hedberg, pp. 166–78. Acta Phytogeographica Suecica, vol. 54.

RODGERS, W. A. & HOMEWOOD, K. M. (1982). Species richness and endemism in the Usumbara mountain forests, Tanzania. *Biological Journal of the Linnean Society* **18**, 197–242.

WERGER, M. J. A. (1978). The Karoo–Namib Region. In *Biogeography and Ecology of Southern Africa*, ed. M. J. A. Werger, pp. 231–99. The Hague: Junk.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

2 The geological evolution of East Africa

C. JANE GRIFFITHS

Abstract

This chapter examines the geological and geomorphological processes that have shaped the present-day landscape of the eastern part of East Africa. The underlying rock types, their age, environment of formation and interrelationships are described. The structural evolution of the landscape is traced from the Karroo *c.* 300 million years before present (myr BP), encompassing the Karroo Rifting, the breakup of Gondwanaland, the relative ages of the block mountains, volcanic mountains, plains and plateau, the East African Rift Valley system, and the vertical movements affecting the continental margin of East Africa. Reference is made to the general geology and topography of West Africa for comparison and the debate about the pre-drift position of Madagascar is briefly reviewed. Variations in soil types in relation to parent rock, age, climate, organic material and relief are considered.

Introduction

A wide variety of rock types are found in East Africa representing all three of the major groups: igneous, metamorphic, and sedimentary. They range in age from over 2000 myr BP to unconsolidated sediments accumulating at present, but represent two geological time spans: the Precambrian (>2000–570 myr BP) and the Karroo–Recent (290–0.01 myr BP) (Figure 2.1 and Table 2.1), separated by a major break in the geological record. These two groups of rocks were formed under entirely different geological conditions, resulting in distinct properties.

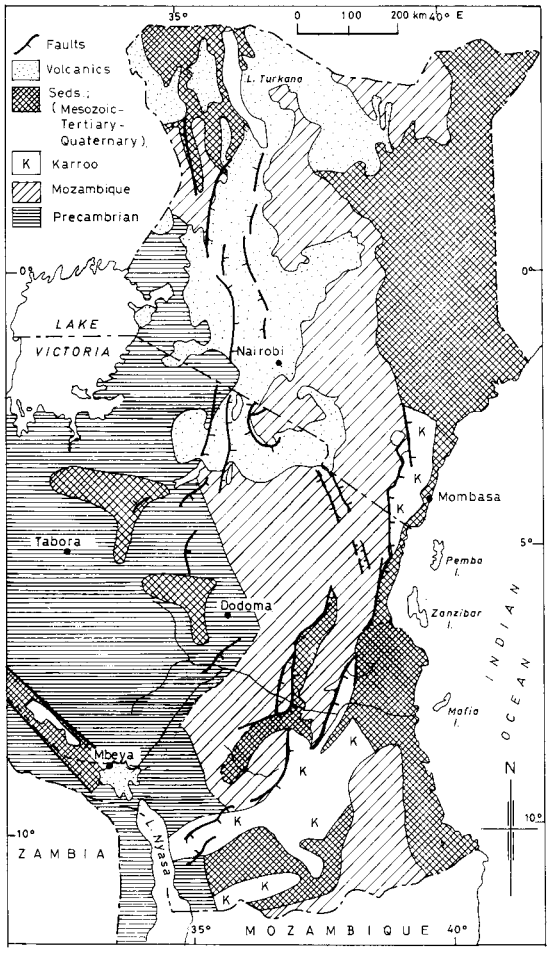


Figure 2.1. Geological map of the eastern part of East Africa.

The Precambrian rocks are highly deformed, high grade metasedimentary, with minor meta-igneous, crystalline rocks, including granulites,

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

Table 2.1. *Geological record for East Africa*

Era	Period/Tectonic unit (epoch)		Absolute age (myr BP)	Brief description of rock types and environment of formation
Quaternary	Recent		0.01	Volcanics associated with rifting in Arusha–Kilimanjaro and Mbeya regions
	Pleistocene		2.5	Continued marine sedimentation along the coast with non-marine inland
Tertiary	Neogene	Pliocene	7	Rifting and volcanism in northern and southern areas
		Miocene	26	Dominantly marine sediments including limestones and marls in coastal areas with non-marine alluvium and eluvial soils inland throughout Tertiary
		Oligocene	38	
	Palaeogene	Eocene	54	
		Palaeocene	65	
Mesozoic	Cretaceous		135	Marine sediments along part of the coastal belt with non-marine inland
	Jurassic		180	Dominantly marine sediments east of the faulted Mozambique Belt accumulated in the East African sedimentary basin
	Karroo		290	Continental sediments including sandstones, shales, coal measures, lagoonal evaporites and minor marine incursions near top of sequence
Palaeozoic				Major break in sequence without geological record
Precambrian	Mozambique Belt		438	Highly deformed N–S trending metamorphic belt consisting of largely reworked older rocks with less deformed cover including marbles
			2100	

gneisses and schists. The Karroo–Recent sediments include conglomerates, sandstones, limestones, shales, marls and evaporites. Volcanic rocks, which occur in association with the East African Rift Valley were formed in the Plio–Pleistocene–present day during the last 7 myr, and consist of alkaline basalts.

Following their uplift in the early Palaeozoic (438 myr BP), the Precambrian rocks have been land areas subjected to the effects of sub-aerial weathering and erosion, which has reduced large areas to plains. However, since Karroo time the region has been intermittently affected by periods of vertical movements which have formed rift valleys (grabens) and fault block mountains (horsts) on the otherwise monotonous plains. These two opposing processes of levelling and dislocation, together with volcanic activity, are responsible for the often spectacular landscape found in East Africa today. Block faulting and volcanicity produced most of the mountain ranges where the moist forests are found. These vertical movements contrast with the lateral movements which affected other parts of the ancient supercontinent of Gondwanaland comprising Africa, South America, Madagascar, India, Antarctica and Australia (Figure 2.2). The lateral movements also began with rifting but continued with a widening of the rift by basaltic intrusions followed by invasion by seawater. The continents then drifted apart by sea-floor spreading, taking them to their present-day locations. The coastal forests are found on the Mesozoic–Quaternary marine, fluviatile and lacustrine sediments (Figure 2.1).

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

Figure 2.2. Reconstruction of Gondwanaland in Karroo times (from Windley, 1977).

The Precambrian rocks

The Precambrian rocks of eastern Africa belong to the Mozambique Belt which runs north–south and can be traced from Ethiopia to Mozambique. West to east, it occurs from the Gregory Rift in the eastern arm of the Rift Valley to where it is faulted beneath the younger sediments of Karroo–Recent age (Figure 2.3). Rocks of the Mozambique Belt also occur in the Seychelles and over a large area of central and eastern Madagascar.

Granitoid gneisses (metamorphosed granites), hornblende–pyroxene granulites (high grade metamorphosed rocks probably derived from sediments of sandstone and shale), marbles (metamorphosed limestones) and graphite schists (metamorphosed shales) are all found.

Radiometric dating of rocks from the Mozambique Belt has produced a range of ages extending from *c.* 2000 to 450 myr BP with the highest frequency occurring in the 650–450 myr BP range (Cahen & Snelling, 1966; Cahen *et al.*, 1984). This latter span is thought to coincide with the Mozambiquian orogeny (a period of mountain building involving sedimentation, deformation, metamorphism and uplift), which led to the creation of a north–south mountain chain. Now only the deeper root zones remain, the upper layers having been removed by the processes of weathering and erosion.

Since the marbles and schists are less deformed and metamorphosed than the granulites it is believed by some authors (Sampson & Wright, 1964; Cahen *et al.*, 1984) that they represent the sedimentary cover sequence of Mozambiquian age. These sediments were deposited on an older (granulite) basement which suffered further reworking by deformation and metamorphism during the Mozambiquian orogeny. The reheating of older rocks resets their radiometric clocks, giving a wide range of ages dependent on the degree of reworking. This relationship would account for the spread of absolute ages generated by the rocks of this belt.

The Mozambique Belt is only a part of a much more extensive orogenic belt, known as the Pan-African Belt, which affected and reworked older rocks over large areas of Africa. Figure 2.4 shows the continental extent of the Pan-African Belt. The underlying rocks of much of East and West Africa are rather uniform and consist of ancient Precambrian rocks. As will be seen in later sections, younger sedimentary or volcanic rocks overlie the ancient crystalline rocks in some places.

Karroo–Recent sediments

In Tanzania, Karroo sediments are exposed principally in the southeast, together with a block near Tanga which broadens northwards in Kenya (Figure 2.1). In addition to these surface deposits, great thicknesses of Karroo sediments lie buried beneath younger ones in the coastal zone, both onshore and offshore (Figure 2.5). Most of the Karroo sediments, consisting of sandstones, shales, conglomerates, red and grey mudstones, occasional limestones and coal measures, were deposited in a terrestrial environment under riverine or lake conditions in down-faulted basins. The Tanga beds include some brackish water sediments. These, together with great thicknesses (3000 m) of evaporites that accumulated in a graben at Mandawa in the Triassic (Kent *et al.*, 1971), herald the initiation of the true marine conditions of the future Indian Ocean and the breakup of Gondwanaland.

The onset of marine conditions during the mid-Jurassic coincided with renewed faulting of the Mozambique Belt along the inland edge of the Somali–Kenya–Tanzania sedimentary basin

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-06898-7 - Biogeography and Ecology of the Rain Forests of Eastern Africa
Edited by Jon C. Lovett and Samuel K. Wasser
Excerpt
More information

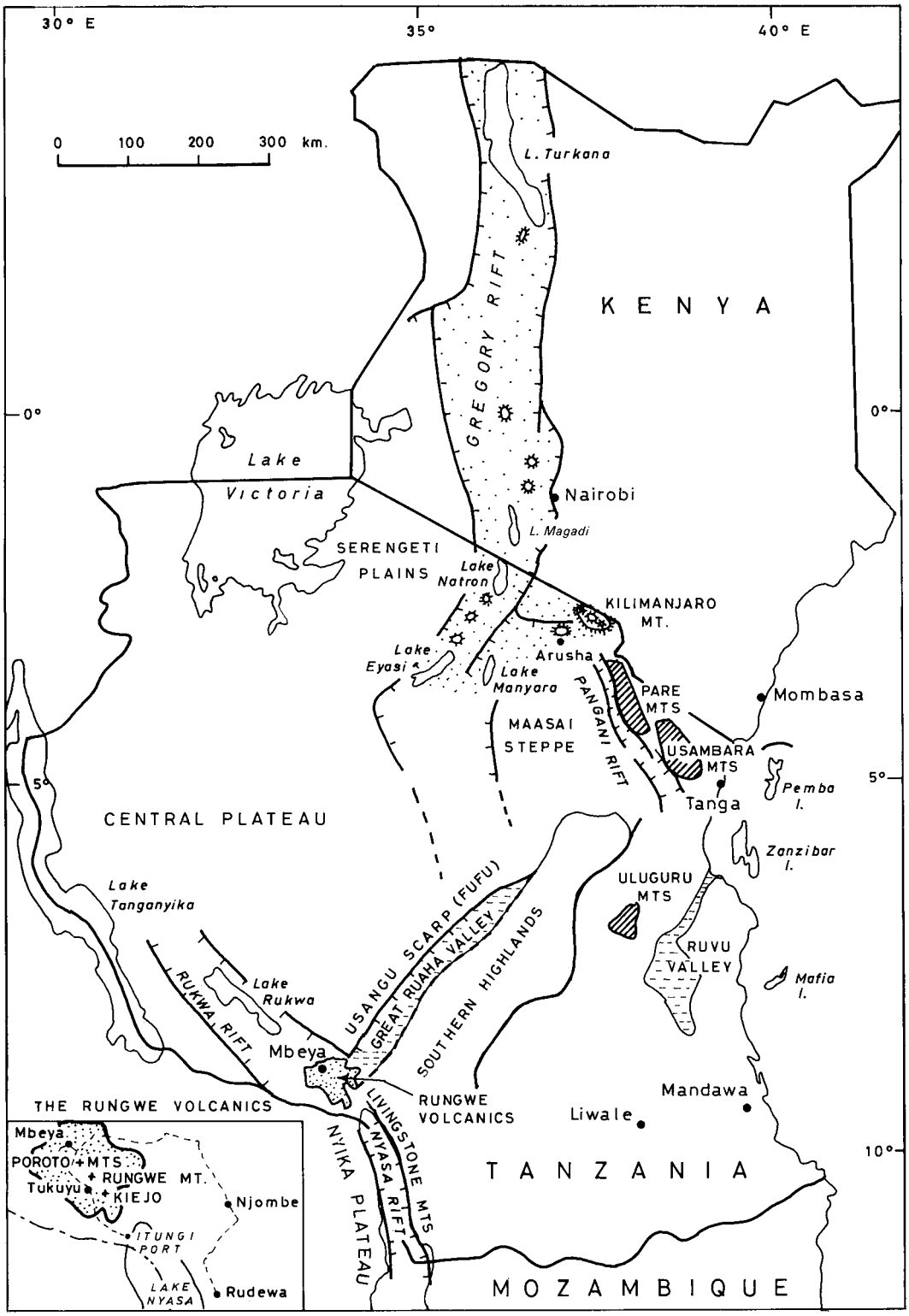


Figure 2.3. Location map.

© Cambridge University Press www.cambridge.org