CHAPTER 1

THE PALAEO-ECOLOGY OF THE AFRICAN CONTINENT –

The Physical Environment of Africa from Earliest Geological to Later Stone Age Times

THE EVOLUTION OF THE CONTINENT

Geological structure and Precambrian history

The continent of Africa, second only to Asia in size, has an unusual combination of features and environments, including many extreme contrasts. It lies astride the Equator but, unlike South America, has northern and southern limits at almost identical latitudes (37° N and 35° S). However, this symmetry does not apply to area, for the northern portion is twice as large as the southern. Much of the interior of Africa, especially in the south, is an elevated plateau, capped in the east by the great piles of volcanic material that form the highlands of Ethiopia and East Africa. Cutting through these highlands are the trenches of the Great Rift Valley, occupied in part by important lakes, both deep and shallow. Volcanic cones form spectacular mountains with peaks rising almost to 6000 m above sea level and snow-clad despite their equatorial situation. In contrast there are areas in Egypt and Ethiopia that are as much as 120 m below sea level – Afar in the Rift system and the wind-scooped Qattara and other depressions in Egypt. In addition to the volcanic cones, there are other mountainous areas, but they are largely uplifted erosional remnants; true mountain chains are confined to the northern extremity (Atlas Mountains) and to the southernmost margin (Cape Ranges). The largest dry, hot desert in the world, the Sahara, stretches from the Atlantic to the Red Sea, forming a significant continent-wide barrier between the narrow Mediterranean littoral belt and the rest of the continent, often conveniently termed 'sub-Saharan Africa'. In contrast to this arid belt are the tropical forests of western equatorial Africa, with rainfall well over 2500 mm per year in Liberia and Cameroun, reaching a top figure four times as high in the mountains of the latter region.

Geologically speaking, almost the whole of the continent has

TABLE 1.1 *The international geological time scale and selected African events*

Million years BP	*Eons*	*Eras*	*Periods*	*Epochs*	
0	PHANEROZOIC	CENOZOIC	QUATERNARY	PLEISTOCENE	
2			TERTIARY	PLIOCENE	(see Fig. 1.7)
5				MIOCENE	East African volcanism
23				OLIGOCENE	(see Table 1.2)
38				EOCENE	
54				PALAEOCENE	
65		MESOZOIC	CRETACEOUS	Numerous epochs	'Continental Intercalaire' ↓; Nubian Sandstone ↓
145			JURASSIC		
210			TRIASSIC		KARROO deposition
255		PALAEOZOIC	PERMIAN		
280			CARBONIFEROUS		
360			DEVONIAN		CAPE deposition
415			SILURIAN		
460			ORDOVICIAN		
520			CAMBRIAN		
580	PRECAMBRIAN		No international subdivision		
1000					
2000					
3000					

Orogenic/metamorphic episodes

N.W. Africa	*N.E. and sub-Saharan*
'PAN-AFRICAN' DAHOMEYAN	DAMARAN–KATANGAN
PHARUSIAN	KIBARAN–IRUMIAN
EBURNIAN	MAYOMBIAN
ZAGORIAN	SHAMVAIAN

Note: Figures are estimated ages in millions of years; not to scale.

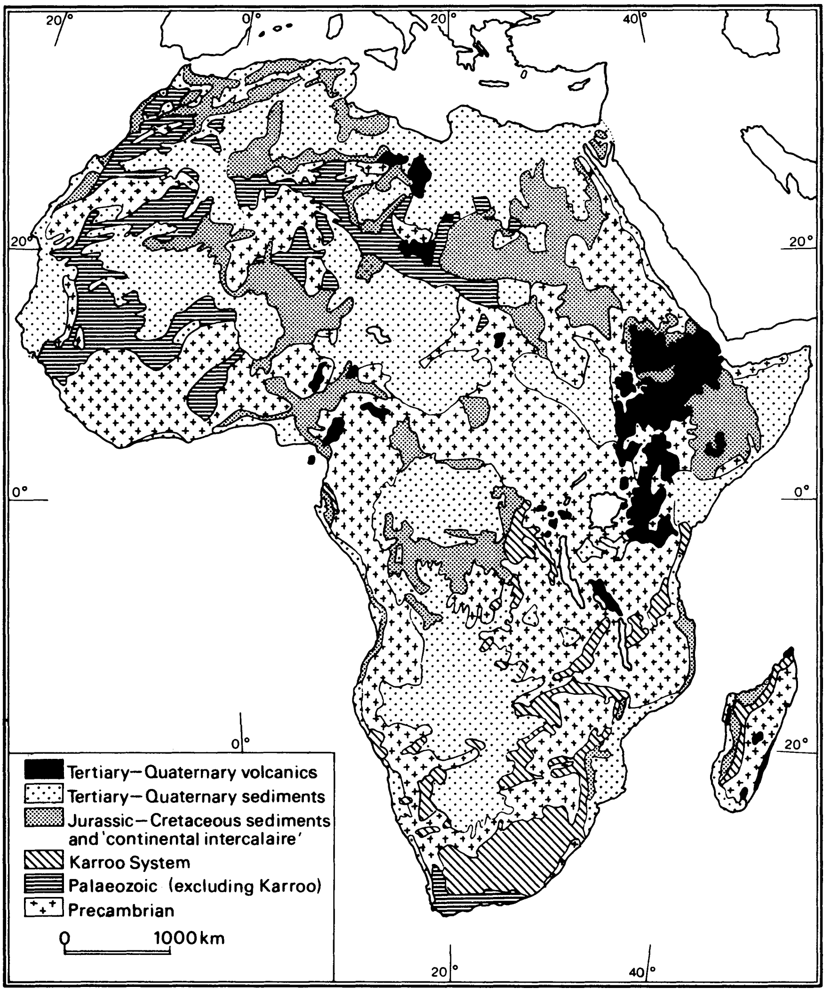

Fig. 1.1 Simplified geological map of Africa, based on the UNESCO (1963) *Geological map of Africa.*

assumed its present form as a result of progressive uplift, gentle warping, erosion and deposition during the past 500 million years, without the strong mountain-building episodes of folding and dislocation that are so familiar in most other continents; the Atlas and Cape ranges, and part of the Mauritania coast, are the exception. The Atlas folding is the youngest, being essentially contemporary with the Alpine orogeny (mountain-building) of the late Mesozoic and early Cenozoic (see table 1.1), whereas the Cape Ranges and the Mauritania fold belt are middle Palaeozoic to early Mesozoic in age. As these fold belts are marginal and involve so small an area, the greater part of the continent consists of a veneer of Phanerozoic sediments resting on eroded remnants of Precambrian rocks, often collectively grouped as the 'Basement'. Since the end of the Precambrian, most of Africa has behaved as a rather rigid block. Fig. 1.1 is a generalized geological map showing the distribution of the main sedimentary units, some of which will be considered separately below.

The Precambrian basement itself is complex in structure and consists of extensive areas of granitic rocks, gneisses and schists, but also includes thick sequences of sedimentary rocks that have been relatively little altered by metamorphism and often only gently folded. It is startling for American or European geologists to see in Africa rock formations more than 1000 million years old that are still almost horizontal and with little significant alteration despite their antiquity. However, this does not mean that all the Precambrian rocks are little changed or disturbed, for the basement geology is complex and has involved several periods of strong deformation, orogenesis and denudation, still recognizable as belts with distinctive trends and with characteristic radiometric ages imprinted on their minerals in the metamorphic process. The UNESCO *International tectonic map of Africa* (1968a) distinguishes Precambrian orogenic belts belonging to six age groups, to some of which names have been attached by various workers (see table 1.1). Stabilization of the basement has been a progressive process and it is possible to recognize certain core areas as having become rigid much earlier than others. The oldest nuclei still preserved contain rocks more than 2500 million years old, some as old as 3600 million. These nuclei are surrounded by younger orogenic belts which, together with the nuclei, build portions of crust that have remained stable for at least the past 900 million years; these stable areas are referred to in the literature as 'cratons' and are shown in fig. 1.2. The remainder of the basement area was widely affected by metamorphic episodes in the very late Precambrian or early Cambrian (600 to 500 million years ago), sometimes called the pan-African orogenesis. The Precambrian basement is the source of most of the mineral wealth of the African continent and the important ore deposits seem to be related genetically to the major cratons and orogenic belts (Clifford 1966, Clifford and Gass 1970). These mineral resources have played an important role in the history of exploration and the development of the continent.

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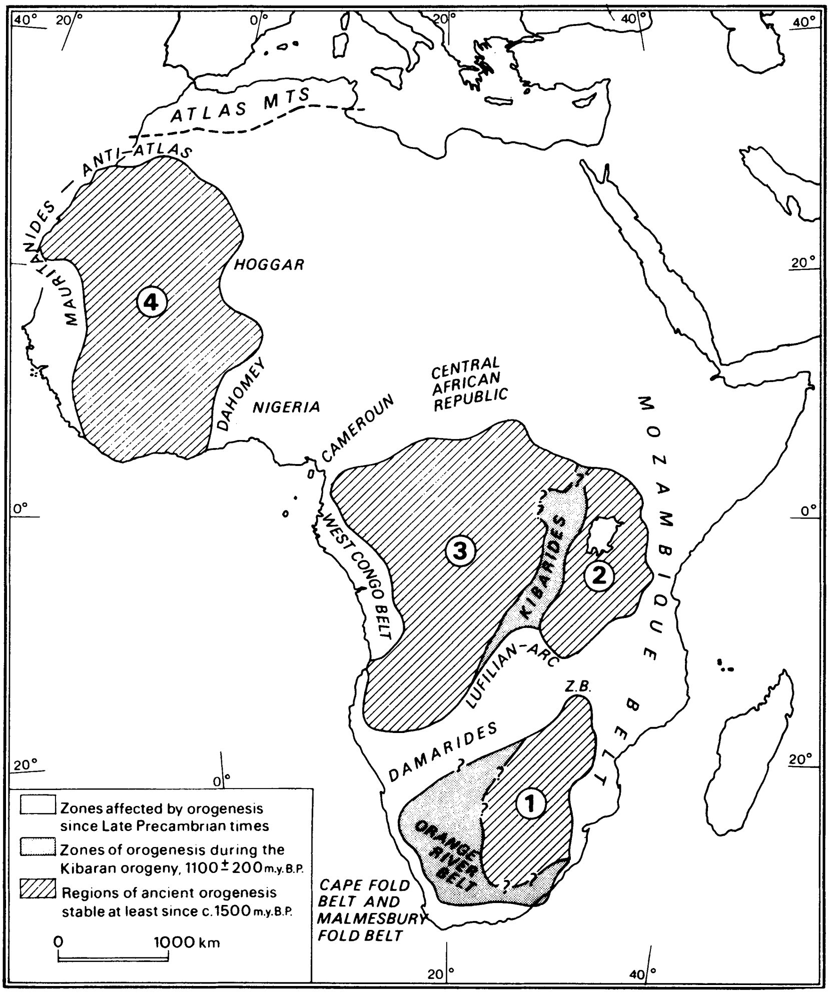


Fig. 1.2 Generalized map of the major orogenic structural units of Africa (excluding the rift valley system). The four older cratons are: (1) the Rhodesia–Transvaal craton, (2) the Tanzania craton, (3) the Angola–Kasia craton, (4) the West African craton. After the Kibaran orogeny, the consolidated Kibarides united (2) and (3) to form the *Congo craton* and the Orange River belt was added to (1) to form the *Kalahari craton*, which were stable during the late Precambrian–early Palaeozoic orogenesis. The Cape folded belt and the Mauritanide-Anti-Atlas belt are mid-Palaeozoic to early Mesozoic in age. The Atlas Mountains represent Alpine (Tertiary) orogenesis. (From Clifford 1966.)

Palaeozoic–Mesozoic history

By the late Precambrian, almost the whole of Africa had become effectively a large stable craton and most of the central area was never invaded by the sea. However, Palaeozoic marine sediments do occur in various parts of North Africa, bounded roughly by a line from Ghana to the Sinai peninsula, and also in the Cape folded belt at the extreme southern end of the continent. Between these two areas the deposits are continental and, in many instances, devoid of fossil material by means of which their age may be fixed exactly. The Lower Palaeozoic marine beds in part of north-west Africa rest on a tillite of considerable lateral extent that marks a major glacial event quite out of keeping with the present environment. The Palaeozoic rocks of this area are mainly limestones and sandstones, with some shales, and the fossils have broad affinities with those of Europe. In the Cape Supergroup[1] at the southern end of the continent, however, the only significant fossils are in Devonian strata and have their closest affinity with the faunas of the Falkland Islands and Brazil. On the other hand, the fossil plants in the upper part of the Cape Supergroup, of Upper Devonian to Lower Carboniferous age, are very similar to the flora from corresponding beds in the Sahara region.

At the end of the cycle of deposition of the Cape Supergroup, southern Africa was affected by an intense glaciation that ushered in the long period of sedimentation of the Karroo Supergroup. This unit has its maximum development in South Africa, where accumulation of upwards of 7000 m of sediment took place in a subsiding basin in the geographical area known as the Karoo. Although it is only in this type area that the succession is complete, the Supergroup is very extensive and reaches as far north as the equator; there are equivalent beds in Madagascar as well (fig. 1.1). The Karroo Supergroup spans the period from later Carboniferous to early Jurassic, ignoring the usual break between the Palaeozoic and Mesozoic eras (see table 1.1). In South Africa, the Karroo is divided into four Groups known from below upwards as the Dwyka, Ecca, Beaufort and Stormberg. The Dwyka is largely glacial tillite and the Ecca mainly dark-coloured shales and grey sandstones, up to 3000 m thick. The Ecca Beds contain fossil plant remains typical of the southern hemisphere *Glossopteris* flora, and some specimens prove that well-protected fleshy fructifications had developed

[1] The term Supergroup is now officially replacing System with Group for the subordinate Series, though the well-known, traditional nomenclature may still continue in use for some time.

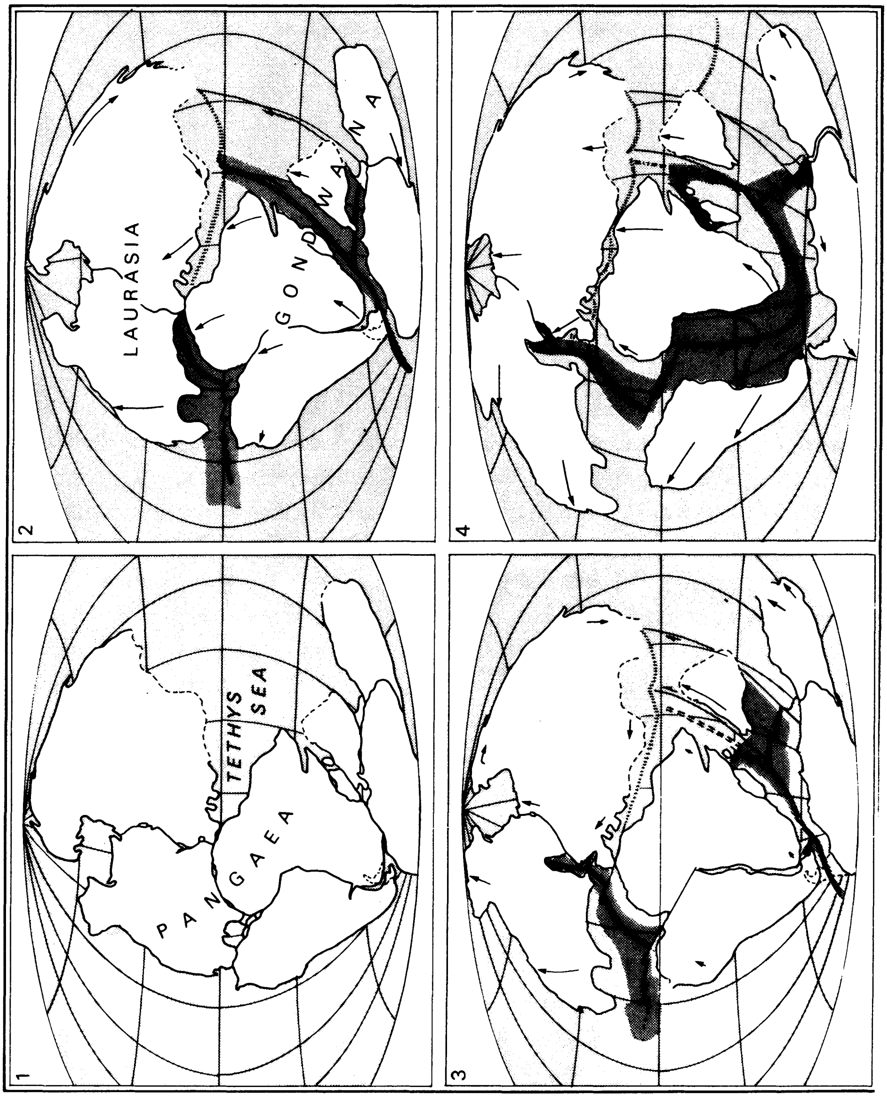
on the leaves, perhaps suggesting a proto-angiosperm stage of plant evolution (Plumstead 1969). The Ecca Beds also contain extensive and valuable coal deposits, mainly in South Africa and Zimbabwe. The Beaufort Group comprises a thick succession of yellowish sandstones alternating with colourful shales and mudstones indicative of deposition in a swampy environment subject to desiccation and flooding. This unit is remarkable for the abundance of vertebrate fossil remains, including some amphibians but principally reptiles that become increasingly mammal-like in the higher horizons of the Group. It is probable that some of these mammal-like reptiles were already warm-blooded and may even have had hair. Two of the earliest 'true' mammals so far known come from the Stormberg Group in Lesotho and are uppermost Triassic in age (Crompton 1974). The Stormberg Group shows a progressive development of desertic conditions and ends with the outpouring of up to 1000 m of basaltic lavas – the Stormberg or Drakensberg volcanics – now forming a protective cap on the highlands of Lesotho. The Karroo Supergroup thus demonstrates progressive climatic change from glaciation, through warm swamps, to near desert conditions.

In West Africa the continental rocks are commonly grouped under the term used by French geologists, *Continental Intercalaire*, and in the Sudan and Egypt their extension is part of the *Nubian Sandstone*. Although the name Continental Intercalaire should strictly be applied only to rocks of upper Jurassic to mid-Cretaceous age, it has been used broadly to include rocks as old as the late Carboniferous. The same is true of the Nubian Sandstone, which is strictly a unit of unfossiliferous brownish sandstones of Cretaceous age in Egypt, but beds of strikingly similar lithology occur to the south and to the west, some as old as Devonian, and they have been included under the catch-all term of 'Nubian Sandstone'. The Nubian Sandstone and the Continental Intercalaire, both *sensu lato*, thus represent in North Africa the time-equivalent of the southern Karroo Supergroup, but they also include strata that are considerably younger. Jurassic continental deposits are unknown south of the Sahara and those of Cretaceous age are of very limited extent and occur only in localized troughs or basins. It is believed that during most of these two periods erosion was active and there are, indeed, surviving remnants of erosion surfaces ascribed to this interval.

It is notable that during the lengthy period from the Cambrian to the end of the Triassic, marine beds are virtually confined to north-western Africa. There the marine Permian is restricted to a small area in Tunisia, expanding a little into Algeria in the Triassic and also occurring in northern Sinai. These marine beds were laid down on the southern margin of an ancient sea known as the Tethys, of which the present Mediterranean is a shrunken remnant; the faunas have European affinities. The short Devonian marine invasion of the southern tip of the continent has already been mentioned. During the late stages of the Dwyka, a shallow sea also extended over the south-west Cape and southern Namibia but the Devonian and the Permian fossils clearly belong to a southern faunal assemblage and have no link with the Tethys sea. There is thus no sign of any Atlantic or Indian Ocean shorelines in Africa during the Palaeozoic. In Madagascar the Karoo Beds contain occasional marine intercalations of mid-Permian to mid-Jurassic age, but these episodes are followed by well-developed Upper Jurassic marine beds on the west side of Madagascar. There are also two localities in East Africa that have furnished marine fossils – a patch of Lower Triassic near Mombasa and outcrops of Mid-Permian near Kidodi 250 km west of Dar es Salaam. Marine Jurassic beds also occur on the Tanzania coast and extend up through eastern Kenya, Somalia and Ethiopia into Arabia. In north-eastern Zaïre, just south of Kisangani, there is a thin marine limestone of Upper Jurassic age with fossil fish suggestive of a temporary link with the marine area in Ethiopia. There is no marine Jurassic south of Tanzania but such deposits do occur buried on the continental shelf off the southern tip of the continent. On the Atlantic side, mid-Triassic marine deposits occur along the coastal belt of the Spanish Sahara, but not farther south, and Jurassic marine beds just reach Senegal. Early in the Cretaceous the Atlantic coastline was reasonably well defined and by the end of that period the southern Atlantic coast extended along the present shelf area, but offshore, as far north as Walvis Bay. The Upper Cretaceous also saw an extensive marine invasion from the Tethys of a two-branched belt through the western Sahara to the Gulf of Guinea; the West African craton lay as a landmass to the west of it, the Ahaggar massif formed an island in the middle, and the Tibesti massif to the east. From the Gulf of Guinea, marine Cretaceous beds extended down the Atlantic coast, inland of the present shoreline, as far as Moçamedes. Thus by the end of Cretaceous times the African block was established with an approximation of its present shoreline. The extensive Cretaceous seas withdrew from much of the Sahara, leaving a marine embayment in Nigeria during the Palaeocene and Eocene, separated by dry land from the fluctuating Tethys shoreline in the north. Eocene marine beds extend far inland in Algeria, Tunisia, parts of Libya and northern Egypt, but in the Oligocene and Miocene only a limited area of the northern margin of the continent was still inundated. Until the Miocene, Arabia was effectively an integral part of the African continent, from which it became separated by invasion of the sea after faulting had created the Red Sea trough as a major rift system. The Miocene is also the main period for the commencement of volcanicity in East Africa, associated with the massive crustal stresses that formed the Great Rift Valley.

Continental drift

Ever since the continents were adequately mapped, the parallelism of the opposite shores of the Atlantic has led to comment and speculation. Although Antonio Snider published a reassembly of the continents in 1858 in an endeavour to account for the close similarity between the fossil plants of the Carboniferous in North America and Europe, it was not until the beginning of the present century that serious scientific attention was paid to the matter, largely through almost simultaneous, but independent, publications by Taylor (1910), Baker (1911) and Wegener (1912). Wegener's book of 1915, *Die Entstehung der Kontinente und Ozeane*, established his name as the main protagonist of the hypothesis of continental drift, and his concept of a hypothetical single supercontinent that he called 'Pangaea'. This is now regarded as comprising two major units, 'Laurasia' in the north, made up of North America and Greenland ('Laurentia') plus 'Eurasia', and a southern 'Gondwanaland' embracing South America, Africa, India, Australia and Antarctica. The latter name is derived from the Gondwana Supergroup in India, of Carboniferous to Jurassic age, very similar to the African Karroo Supergroup and to geological units of corresponding age in other parts of the supercontinent. Wegener's ideas were supported strongly by du Toit, who made careful geological comparisons between South America and South Africa, based on his own observations, and demonstrated a host of geological matches. In 1937 du Toit published *Our Wandering Continents*, which stands with Wegener's work as the major pioneer documentation of the hypothesis. However, continental drift was rejected by most geologists until studies of the great mid-oceanic ridges, on the one hand, and of the magnetism preserved in rocks, on the other, produced compelling evidence that drift was a reality. The concept that new oceanic crust is being formed continually


1
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LAURASIA
GONDWANA
TETHYS SEA
PANGAEA