i12 The Karroo system < Southern Pangea, Gondwana >

> [in] A landscape of aloes and thorns,
> ... you, in minimalist Xhosa
> struggle to express a response / to waterlilies, a bridge, a stream. —Chris Zithulele Mann.[1]

The present deep oceans between Africa, Antarctica, Australia, South America, and India have been opening (beginning in the Late Jurassic). All these continental areas are fragments of *Gondwanaland* a continent during the Jurassic and formerly a realm of Pangea. In Pangea, the Gondwanaland realm was physically isolated to the south of Southern Laurasia and Northern Laurasia realms by a deep-ocean embayment called the *Paleotethys* that opened eastward and, from it, running west, a high mountain chain, south of which was a wide desert.

The Late Jurassic that saw the separation of Gondwandland (minus Florida that was part of the Gondwandland realm in Pangea) as a continent, was accompanied by vast outpourings of fissure-erupted plateau basalts. These capped off layers of platform continental sediments that had accumulated on the gondwanide craton (of mid-Cambrian inception). The uppermost of these sediments are loess underlain by sandstone and shales. These contain dinosaur fossils of Upper Triassic age. Conformable below and accumulated in greatest abundance, are sandstone and shales that famously contain mammallike reptiles and stem reptiles of Early Triassic and Late Permian age. Below these are coal-bearing sandstones of Permo-Carboniferous (Early Permian and Late Carboniferous) age with intercalations of cold freshwater and cold-marine shales. The lithology of this succession of sediments that collected in the vast gondwanide basin, give little hint of its area being a realm of Pangea during the Triassic, a realm of the Pangea-to-be during the Permian and Pennsylvanian, or of its existence before as the paleocontinent Gondwana. However, physical isolation is recorded by their contained fossils of land animals and plants. These are so different from those of the combined Southern Laurasia and Northern Laurasia realms of Pangea, and the earlier Southern Laurasia realm of Pangea-to-be, that back and forth correlations of species is not possible. Also, the usual way of establishing correlations using warm-sea index fossils is not available as the gondwanide shales contain only cold-water fossils. The succession at its base has a great thickness of tillites of Carboniferous age. The whole is called the *Gondwana System*.[2]

The theory of continental drift is supported by the observation that today the Gondwana System on each of the southern continents and India, from its basalt cap down to its tillite base, terminates abruptly at (reconstructable) full thickness at coasts facing the Atlantic, Indian, and Antarctic oceans. The part of the Gondwana System in South Africa is called the *Karroo* (also spelled *Karoo*) *System*.

Karroo strata are conformable on each other (***Figure i12.1***). They thin to the north, and furthest there, where some are also missing, the total thickness is about one kilometer. In the south, in the Cape, where the succession is at its most complete, the Karroo System has a thickness of seven and a half kilometers. A description of the succession shows that the final layers were deposited when the climate was arid. The accumulation of the system had begun when the climate was frigid and wet. Between these two extremes, the recorded climate change through moist temperate, was gradual. This is consistent with northward continental drift. Triassic aridity was also from the rain shadow effect of high mountains, to the north, that had come into being at the beginning of the Pennsylvanian when becoming the Gondwanaland and Southern Laurasia realms of Pangea-to-be, paleocontinents Gondwana and Southern Laurasia (*see* Topic *i15*) sutured. Fold mountains that were in existence along the southern margin of the Gondwanaland realm in Pangea were the source of freshwater clastic sediments that, after Early Permian, were transported in huge volumes into Gondwanaland's basined interior.[3] There, during the Early Permian, a freshwater interior sea collected shale. Gondwanaland, during the Late Carboniferous, and Gondwana, during the Early Carboniferous, contained the south pole about which ice sheets waxed and waned.[4]

Four main divisions of the Karroo System are recognized (***Table i12.1***). Described (data mostly from George Nairne Gordon Hamilton, 1954)[5] from the top down they are:

Stormberg Series

Drakensberg Volcanics (Jurassic) are plateau tholeiitic-basalts that piled to a thickness of 1500 meters and capped over the Karroo sediments at the onset of Pangea's fragmentation. Occasional andesite flows are included. Duration of magmatism was 8 My, with an apparent south-to-north migration of outpouring-locations, with 6 My for the main volume.[6] The successive flows are without intervening soils (speaks to aridity). Each flow ranges up to 100-150 feet in thickness and some have been traced laterally for 35 kilometers. The lowest flows are interbedded with layers of Cave Sandstone.

During the outpouring of the Drakensberg Volcanics, the whole of what is now southern Africa, but not the Cape Folded Belt, was invaded by innumerable sills and feeder dikes of dolerite. The sills, some of which are almost of laccolithic dimensions, are mainly confined to the horizontal or gently inclined Karroo sediments. The dikes cut Karroo sediments and basement rocks equally.

Cave Sandstone or Bushveld Sandstone (Upper Triassic) is extraordinarily uniform and consists of unbedded, massive, fine-grained white, cream-colored or pinkish sandstones made up of rounded or sub-rounded quartz grains and fresh felspar grains set in a dusty matrix. It is predominantly a loess.

Red Beds or Bushveld Marls (Upper Triassic) are red-weathering brilliant purple and red shales and mudstones with some red, yellow and white bands of felspathic sandstones. Plant remains are rare in the Red Beds, but fossils of large dinosaurs occur.

Moteno Beds (Upper Triassic) consist mainly of coarse glittering sandstones with some mudstones and shales and occasional conglomerates. Coal seams and oil shales also occur. The fossil remains of plants, particularly *Thinnfeldia* (a seed fern) are abundant, but no animal remains have yet been recorded.

Beaufort Series is famous for is its abundance of land-vertebrate fossils. Its beds are mostly felspathic, yellow weathering sandstones with interlayered thin bands of bright colored (red, purple and greenish) mudstones and shales. The higher horizons have amphibians *Capitosaurus* and some beds have yielded fish remains. Reptiles of various genera occur throughout the thickness (3,000 meters in the south-east) of the series. *Glossopteris* species (seed ferns) are found fossilized sparingly throughout. The commonest reptile fossils are of the two genera *Dicynodon* (advanced mammallike reptiles) and *Pareiasaurus* (a cotylosaur, the most primitive of reptiles).

Beaufort Series is divided into six zones, each characterized by the presence of a particular "zone fossil:"

Upper Beaufort (Lower Triassic with living-fossils of the day)
Cynognathus Zone (primitive mammallike reptiles)
Procolophon Zone (primitive reptiles)

Middle Beaufort (Lower Triassic)
Lystrosaurus Zone (advanced mammallike reptiles)

Lower Beaufort Beds (Upper Permian)
Cistecephalus Zone (Dicynodont advanced mammallike reptiles)
Endothiodon Zone (Dicynodont advanced mammallike reptiles)
Tapinocephalus Zone (Dinocephalia "giant heads," primitive mammallike reptiles)

Ecca Series (Lower Permian) are freshwater sediments that record a foredeep to the Gonwanide folding of the southern margin of Gondwana. Upper and lower strata are soft dark-blue, deepwater, unfossiliferous shales and flagstones. But of great economic importance, is a median succession of grits, sandstones, and carbonaceous shales that contain many thick and extensive seams of semi-bituminous coals. The "Glossopteris flora," seed fern genera *Glossopteris* and *Gangamopteris*, are the distinctive plants of the coals. In addition occur *Lepidodendron, Sigillaria*, and *Cordaites.*

The absence of limestones in the coal measures is indicative of these being cold-climate coals.

Dwyka Series

Upper Dwyka shales (Lower Permian) record brackish marine incursion of restricted extent in the south western area of the Karroo. They are thinly bedded greenish-gray and black shales and thin flagstones with phosphatic concretions and occasional fish scales and *Eurydesma* (a clam). In outcrop, the black shales

weather white and form the White Band famous for the fossils in it of *Mesosaurus* (a small, highly specialized, aquatic reptile).

Lower Dwyka tillites (Upper Carboniferous), the basal formation of the Karroo Series, are very extensive, thick, unbedded, layers of tillite. Fluviatile sediments with *Gangamopteris* and *Glossopteris* fossils are occasional layers in its upper part. The morainal tillites rest unconformably on older formations. Where exposed, the unconformity is a glacially striated pavement. However, in the Cape (southernmost area), the tillites are massive shales (600 meters thick) with drop stones. Here, the tillites are conformable on the deepwater bottomset beds of a delta (Witteberg series) that had its source further to the south. ❑

Figure i12.1 [4] Diagrammatic cross section of the Karroo system along a 700 kilometer traverse NW from the coast, at Port Shepstone, Natal.

The Karroo system is a succession of conformable strata (Drakensberg Volcanics of Jurassic age uppermost and Dwyka Series of Carboniferous age lowermost) that rest on an unconformtiy that cuts across Ventersdorp Lavas (gray with 'v's), Table Mountain Sandstone (stippled), and basement complex (pale gray with '+'s).

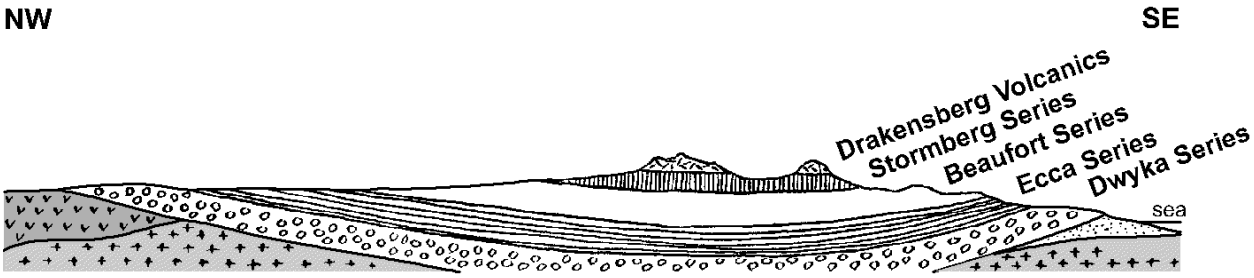

Table i12.1 **Correlation of the Karroo System with the standard geological column**

Southern continents and India				
Gondwanaland continent	U & M Jurassic	KARROO SYSTEM	Stormberg Series	Drakensberg (volcanics)
Gondwanaland realm of Pangea	Lower Jurassic			Cave Sandstone
	U & M Triassic			Red beds **dinosaurs**
				Molteno Beds
	Lower Triassic		Beaufort Series	Upper Middle **mammallike reptiles**
Gondwanaland realm of Pangea-to-be	U & M Permian			Lower **stem reptiles**
	Lower Permian		Ecca Series	Upper Middle (Coal Measures) **seed-ferns** Lower
	Upper Carboniferous (Pennsylvanian)		Dwyka Series	Upper (White Band) ***Mesosaurus*** Lower (**Tillite**)
Gondwana paleocontinent				