Setting the scene: the first part of a series of articles that examines why a remarkably high number of new species seem to originate where the Cape Floristic Region meets the Karoo

The Cederberg-Tanqua tension zone

tension stretching, being stretched, stress by which bar, cord, etc. (*read ecosystem*) is pulled when it is part of a system in equilibrium or motion.
(Concise Oxford Dictionary)

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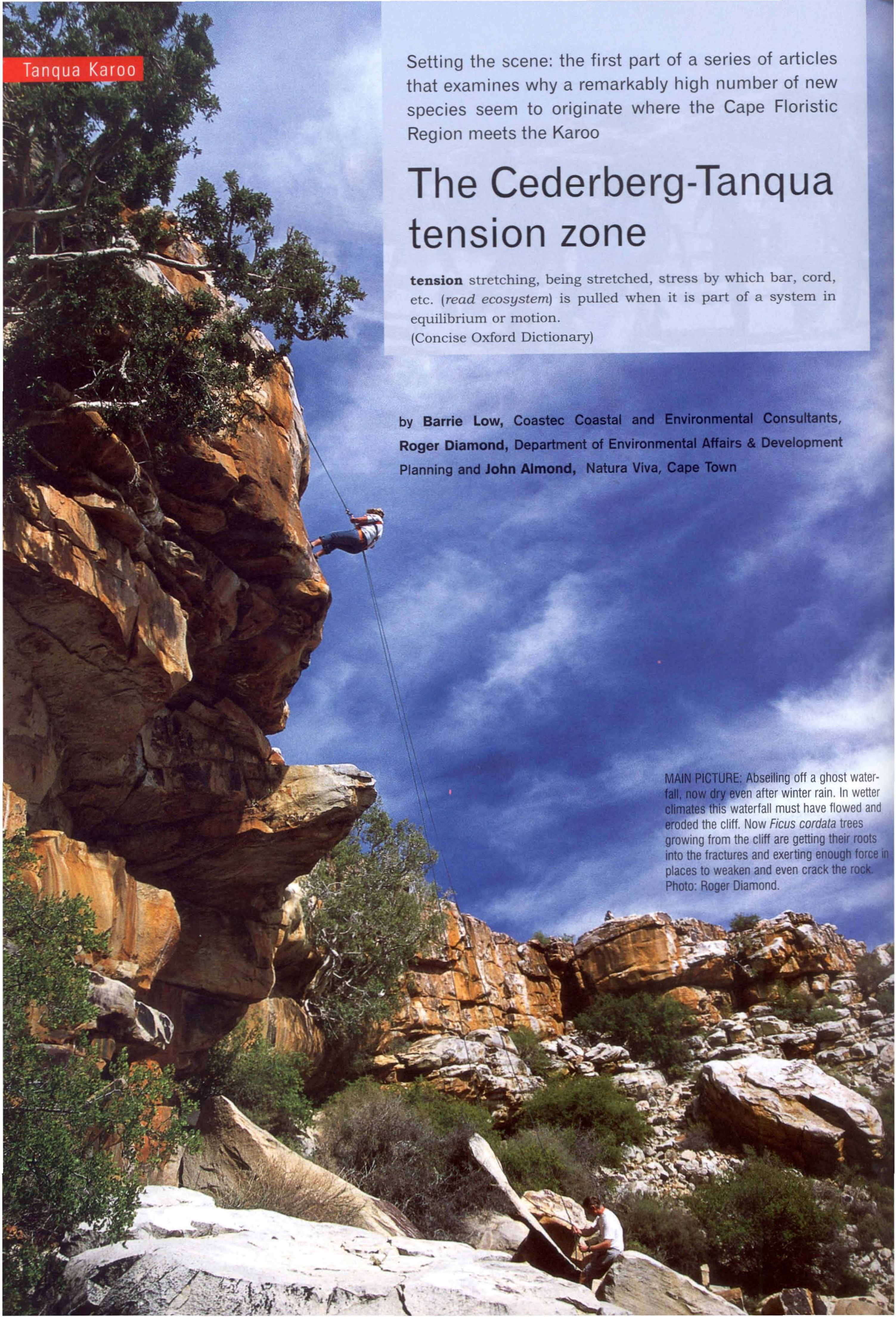

MAIN PICTURE: Abseiling off a ghost waterfall, now dry even after winter rain. In wetter climates this waterfall must have flowed and eroded the cliff. Now *Ficus cordata* trees growing from the cliff are getting their roots into the fractures and exerting enough force in places to weaken and even crack the rock. Photo: Roger Diamond.

TOP: Blinkberg - some time around 370 to 400 million years ago clay, silt and sand was washed off an ancient coastline and deposited in a shallow marine environment to form the Bokkeveld Group. Layers of clay rich rocks that form the gentle slopes you see, were deposited in deeper water, while sandy layers that form small cliffs today, were once ancient sand bars or channels in a delta. The capping quartzite band is the base of the later geological succession, the Witteberg Group, and probably represents ancient beaches or shallow sand bars, formed in storm events. Photo: Roger Diamond.
ABOVE: Doring River Canyon - the tranquil water of the Doring River here belies the turbulence that comes with winter floods. The desert slopes in the background, almost totally devoid of any vegetation, contrast with the thick riverine flora. Photo: Roger Diamond.

One of the driving forces behind plant speciation (the creation of new species) in the Cape Floristic Region is the juxtaposition of contrasting habitats over short distances. Simply put, it is the shifts in rainfall - amount and seasonality - and variation in geology, that have prepared the Cape Floristic Region for commanding global centre stage as a biodiversity 'hotspot'. The speciation process is more evident where the Cape Floristic Region abuts the Karoo: where the roughly L-shaped form of the Cape Fold Belt forms a wedge between the coastal lowlands of the western and southern Cape, and the vast interior expanse of the Tanqua and Great Karoo.

The Cederberg-Tanqua Karoo transition is our area of focus. This is the domain of the seasonal river - here the Groot, Riet, Matjies, Tra-Tra and Biedouw all conspire to join the Doring which becomes the conduit for the water flowing from the eastern Cederberg and much of the Swartruggens.

The building blocks

But let us first examine the underlying geological building blocks of this magnificent system. The Cape Fold Belt is the erosional remnant of a mountain range that was formed some 215 million years or more ago, when Gondwanaland underwent a final compression, leading to the building and folding of the progenitors of the mountain ranges one sees today. Our area lies on the very edge of these folded mountains and geologically comprises Palaeozoic sediments of the Bokkeveld and Witteberg Groups.

The Bokkeveld succession is dominated by clay-rich mudrock that weathers relatively easily, forming valleys or gentle slopes. Examples are the mudrock-floored valleys of the Ceres, Agter Witzenberg (Visgat) and Kouebokkeveld regions. By contrast, the Witteberg Group is dominated by quartzites that are highly resistant to weathering and therefore often form steep scarps or small mountains; for example, the Blinkberg (1456 m) and Tierhoksberg (1410 m). The 'classic' Table Mountain-Bokkeveld-Witteberg Group sequence, outcropping successively from west to east, characterizes the drive northwards from the turn-off to Katbakkies Pass (Swartrug Road) to Matjies River, and onwards to near Wuppertal. The Swartruggens Range is an excellent example of the rugged mountainous terrain that the Witteberg Group can create.

To complete the sequence, the Witteberg Group in turn dips eastwards under the Karoo Supergroup. Here glacial Dwyka and marine Ecca sediments form the geological base for the Tanqua Karoo and Roggeveld escarpment on its eastern border.

Apart from folding, another feature of importance in moulding the landscape here is the presence of major fractures or faults in the hard quartzites. These have arisen mainly through the process of crustal compression during mountain building and crustal stretching during the break up of Gondwana. Faults occur in three main orientations throughout the south-western Cape: NW-SE, NE-SW and E-W. A typical example of a NW-SE fracture is the Algeria valley. These fractures constitute weak zones along which rivers carve their paths. The Doring is a good example of a fracture-controlled river, even undergoing a 90° bend upstream of Elandsvlei.

Another interesting feature of this area is its dry valleys and 'waterfalls'.

LEFT: Dead River Valley - the Matjiesfontein River Kloof is dry and erosionally dead, having been carved out in times of wetter climates when rainfall was high and fynbos and even forest covered vast parts of what today is Karoo. There is not even a scrap of riverine scrub to indicate groundwater flowing under the channel. Photo: Roger Diamond.

RIGHT: Fractures to valleys - the blocky nature of this outcrop of Witteberg Group is caused by the fractures that can be seen clearly in the wall of the gully leading down to the Doring River. This gully would itself have started as a fracture hundreds of thousands to millions of years ago and one day will widen to a ravine or valley. Photo: Roger Diamond.

The deeply incised canyons of the Riet (Kagga Kamma) and Doring rivers are evidence of a much wetter era (the Tertiary) when rainfall was high and fynbos and even forest covered vast parts of what today is Karoo.

Past climates, together with sporadic crustal uplift of the whole region, saw immense erosion that produced the deep valleys (excavated to depths of over 350 m) we see today. Thus the deeply incised canyons of the Riet (Kagga Kamma) and Doring rivers are evidence of a much wetter era (the Tertiary) when rainfall was high and fynbos and even forest covered vast parts of what today is Karoo. Dry cliffs and canyons with cliffs at their lips have developed where there is a particularly thick or hard layer of quartzite overlying relatively softer layers. This hard layer can act as a barrier to erosion of the landscape, but eventually, given enough water and time, the hard layer is undermined and breaks so that a gully or valley can work its way into the landscape. This process of upstream 'eating' into the landscape by a watercourse is called headward erosion.

Prehistoric life

Embedded within the alternating mudrock and sandstone formations of the lower Bokkeveld Group is a rich variety of marine fossils, predominantly the shells of invertebrates such as trilobites, brachiopods (lamp shells), crinoids (sea lilies) and molluscs. This fauna inhabited the shallow seas along the margins of the supercontinent Gondwana (Africa plus the other southern continents of today) some 400 million years ago in the early Devonian Period. The presence of other animals is indicated by a wealth of trace fossils in the northern Bokkeveld outcrops. Many Mid Devonian (c. 375 million years ago) fossil fish, land plants, molluscs and trace fossils have recently been collected from the upper Bokkeveld rocks of the eastern Cederberg.

The fossil record of the Witteberg Group is much sparser. It is dominated by a limited range of trace fossils and locally-abundant fragments of primitive vascular plants, mainly lycopods or club mosses, that lined the banks of rivers in Devonian times and were washed offshore into coastal seas during floods. Unusually, these fossils are frequently found in quartzites rather than the finer-grained siltstones and mudrocks associated with quiet-water

Further reading

MacRae, C. 1999. *Life etched in stone. Fossils of South Africa*. Geological Society of South Africa, Johannesburg.

Slingsby, P. & Coombe, E. 2002. *Cederberg: The map.* Baardskeerder, Muizenberg.

White, M. E. 1986. *The greening of Gondwana.* Reed, Frenchs Forest (NSW).

deposition, which generally favours fossil preservation. The most striking and abundant Witteberg fossils are the intersecting, downward-spiralling traces called *Spirophyton* (because they were initially thought to be the remains of fossil algae). When an organism is not itself preserved but rather leaves a trace of its activity, it is called a trace fossil, and such an example is found in these intersecting *Spirophyton* burrows. These were generated at some depth below the sediment/water interface and probably over a considerable period of time. It seems they were constructed in a fairly pure sandstone or quartzite (metamorphosed sandstone) which in itself would not have represented a rich food source for a deposit-feeding organism. They probably represent the intricate faecal depository of an animal which was 'gardening' mutualistic microbes on its own dungheap (like termites do).

The uppermost beds of the Witteberg (Waaipoort Formation), which crop out along the western margins of the southern Tanqua Karoo, have yielded the well-preserved remains of freshwater bony fish and vascular plant remains (mainly lycopods) of Early Carboniferous age (345 million years ago). The fish corpses are sometimes found packed densely together on bedding planes suggesting mass mortality - caused perhaps by sudden overturning of the water body, an influx of freezing water, or poisoning by plankton blooms.

The glacial sediments of the Dwyka Group are – not surprisingly – poorly fossiliferous, although concretions containing plant and fish fragments are known from the Tanqua region. The immediately overlying, post-glacial mudrocks of the lower Ecca Group beds in the western Tanqua are of palaeontological interest mainly for their well-preserved fossil fish, crustaceans and mesosaurid reptiles (the oldest known sea-going reptiles) of Mid Permian age (270 million years ago).

In a forthcoming article, we will focus on the plants, animals and human colonists of this special transition area.

If you are interested in finding out more abut this fascinating area, and would like to join the Rivers Dancers on an expedition, please contact Barrie or Ushchi at 021-685 5445, 082 579 7040 or email us at coastec@mweb.co.za.

LEFT: Faecal cesspits? Two samples of *Spirophyton* trace fossils, perhaps faecal storage burrows made by sediment dwellers around 370 million years ago. Photo: Roger Diamond.

BELOW: Giant or club mosses living 400 million years ago were amongst the first vascular plants (as opposed to algae and fungi) on land and have left remains in the form of a spiky stem (lower mould in the pic) and a tough, needle-like leaf (below lens filter). The left mould, also of a spiky stem, still has some of the internal cast material, showing how some fossils, after decomposition of the soft pith, are 'in-filled' with the same material that surrounds them. Photo: Roger Diamond.

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LEFT: These leafy looking, fern-like things are indeed growths, but of minerals, not plants. The yellow is iron oxide and the black edge is manganese oxide. Formed in fractures by precipitation from high temperature fluids, these dendrites grow relatively fast, a refreshing change from the millions of years of many other geological processes. Photo: Roger Diamond.