# STORIES IN STONE

# FURTHER AFIELD: THE CAPE FOLD BELT

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Parts of the text have been reworked from the following articles published previously:

Miller, D. 2005. The Sutherland and Robertson olivine melilitites. *South African Lapidary Magazine* 37(3): 21–25.
Miller, D. 2006. The history of the mountains that shape the Cape. *Village Life* 19: 38–41.
Miller, D. 2007. A brief history of the Malmesbury Group and the intrusive Cape Granite Suite. *South African Lapidary Magazine* 39(3): 24–30.
Miller, D. 2008. Granite – signature rock of the Cape. *Village Life* 30: 42–47.



**Safety**

Some locations can be dangerous because of opportunistic criminals. Preferably travel in a group with at least two vehicles. When inspecting a road-cut, park well off the road, your vehicle clearly visible, with hazard lights switched on. Be aware of passing traffic, particularly if you step back towards the road to photograph a cutting. Keep children under control and out of the road.

**Fossils**

It is illegal to collect fossils in South Africa without a permit from the South African Heritage Resources Agency. Descriptions of fossil occurrences do not encourage illegal collection.

Previous page: Hermitage Kloof in the Langeberg, Swellendam, Western Cape

## THE CAPE FOLD BELT

The Western Cape owes its scenic splendour to its mountains. From the Cedarberg to the Langeberg, from Du Toits Kloof to Devil's Peak, sandstone cliffs tower over the intervening valleys, trapping moisture to form the rivers that irrigate the picturesque Cape farmlands. Without our mountains there would be no winelands, no snowy peaks in winter, no mountain fynbos, and no spectacular gorges. We take our mountains for granted, assuming they were always there, and always will be. We couldn't be more wrong. The lifetimes of humans are measured in tens of years, so we think of mountains as eternal. But the lifetimes of mountains are measured in tens of millions of years. They emerge, wear away, and disappear in majestic cycles that geologists have begun to understand only recently. We have only a tiny glimpse of the complex and incomprehensibly long history of the rocks that we see on the surface of the Earth today.

Anyone with a passing interest in rocks can recognise that the mountain peaks of the Cape are all made up of the same yellowish gritty sandstone, and that the fertile valleys tend to have low hills of very different rocks – fine-grained dark shales and coarse grey granite. For a long time, geologists have known that sandstones such as these originally were laid down as sandy sediments on beaches which flanked a shallow sea; that the dark shales were originally mud; and that granite is the frozen relic of once molten rock that cooled very slowly at great depths in the Earth. But how did all three of them land up together in the Western Cape?

The lush valleys below the sandstone mountains of the Cape receive their water from the numerous gorges carved by erosion. This is the southern side of the Langeberg, near Swellendam.

Why are some of the sandstone layers neatly horizontal, like on Cape Town's Table Mountain, and others are shockingly distorted, like in Montagu's Cogman's Kloof? What cataclysm could have caused the seabed to turn to stone, vault onto land, and perch end-up like an open book lying on its spine?

Originally flat-lying sandstones of the Table Mountain Group tilted vertically in Kogman's Kloof, cut through the Cape Fold Belt near Montagu

If you know what to look for, you can read the silent history written in these pages of stone. The story is written in three dimensions, on pages jumbled by time, so it takes great persistence and even greater imagination to piece together the remnants. The story is incomplete, necessarily so, because many of the pages are missing.

Indeed, whole chapters may be missing, but generations of geologists have worked at piecing together a story that is consistent with what remains there are, and how we currently understand the subterranean workings of the Earth. The Earth is not static or immutable, as those who live near volcanoes or who suffer earthquakes and tsunamis are well aware. Powerful internal forces tear away at the continents, heave up mountains, and shunt huge slabs of Earth's crust around like toffee.

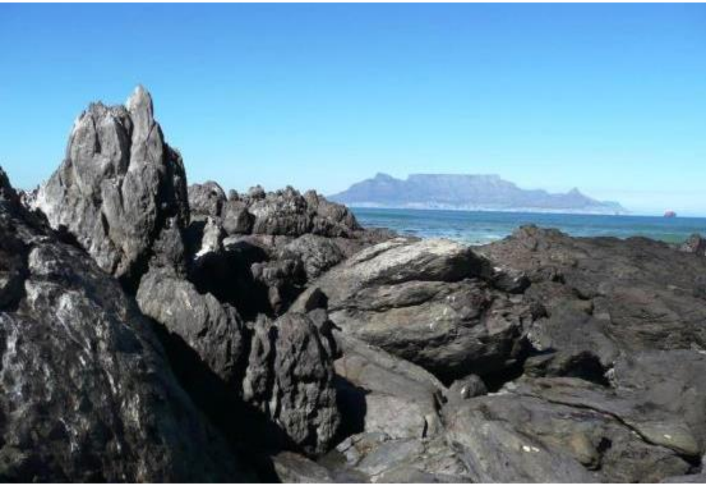
In cross-section the Earth is like an apple cut in half. The thin skin is the crust on which we live, on which the oceans lie, and on which mountain ranges sit like wrinkles. Beneath, the flesh of the apple is represented by Earth's mantle, which over time can creep like tar, responding slowly to the Earth's internal heat. In the centre is the nickel-iron core, part molten, part solid. Like a very slowly simmering pot of porridge, the mantle carries heat from the core to the crust, causing the cold and rigid crust to crumple, tear, and slide about, colliding with itself, keeping the surface of the Earth in a stately dance in which crustal 'plates' grow and shrink, causing the continental masses on them to join up, rotate, separate, and move off to join other partners. These collisions and ruptures form and destroy the ocean floors, endlessly changing the surface of the Earth over hundreds of millions of years.

It is probably impossible to comprehend a time span of a million years - even geologists just get used to bandying about huge numbers without really thinking about them – but to get some idea imagine shaving just a millimetre off the top of Table Mountain each year. At that rate, it would take a million years to erode it down to sea-level. And forty thousand human generations would have passed during that time! So a lot can happen in a million years; but geology works in tens, hundreds and thousands of millions of years. To understand the origin of the Cape mountains we have to travel back in time over a thousand million years, to a time when a huge mountain chain, similar to the modern South American Andes, straddled southern Africa. Its deeply eroded roots stretch from Namaqualand to KwaZulu-Natal but a thousand million years ago it formed the southern margin of the now vanished supercontinent known to geologists as Rodinia.

Around 1000 million years ago, Rodinia started to crack up, undermined by hot material welling up through the mantle. An ocean (known as the Adamastor Ocean by us time travellers) formed more or less where the present Atlantic Ocean is. Sediments brought down by rivers poured into this ocean, joining the lavas erupted by undersea volcanoes to form the new floor of this widening ocean basin.

Fossil current ripples in the Van Riebeeck's Quarry on Robben Island, formed in sediments on the floor of the former Adamastor Ocean.

About 100 million years later, the Earth's internal engine shunted the continents in the opposite direction again, and the Adamastor Ocean was forced to close up, squashing and baking the ocean sediments and lavas, finally plastering some of this stew onto the southern and western margins of what would become the African continent. Fragments of these rocks now underlie some of the Western Cape valleys, forming fertile dark soils derived from these so-called Malmesbury Group rocks.



The rocks in the foreground belong to the Malmesbury Group. They originally were deposited on the floor of the Adamastor Ocean, which closed up during the formation of the Gondwana supercontinent.

They once formed the roots of yet another mountain chain stretching around the coast of southern Africa, caused by the continental collision that closed the Adamastor Ocean. Buried to a depth of over 10 kilometres in this crumpled heap, some of the Malmesbury Group rocks were intruded by molten rock that cooled slowly to form granite, now exposed by erosion as the grey granite of Paarl Mountain and the familiar rounded boulders seen on many of the beaches of the Atlantic seaboard of the southern Cape Peninsula.

The granite domes of Paarl mountain in the middle distance are remnants of the erosional surface of Gondwana, before the deposition of the Table Mountain Group sandstones.

These granites are about 540 million years old, but very quickly were exposed by erosion of the mountain chain to result in a nearly flat, only slightly undulating landscape forming part of the supercontinent called Gondwana.

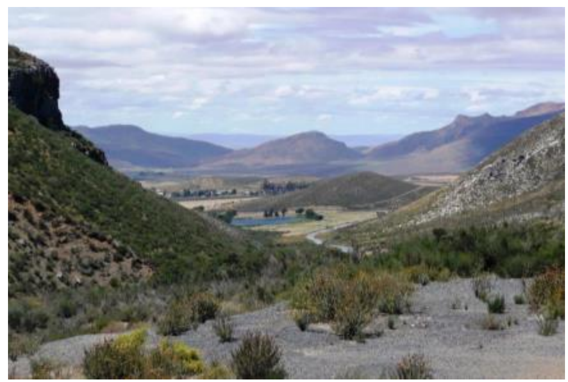
At this time, southern Africa and South America were joined, with the now submerged Falkland Plateau wrapped around the southern tip of Africa, and the present Falkland Islands just off Port Elizabeth. This didn't last long, in geological terms.

The Table Mountain Group sandstones were laid down in the Agulhas Sea, on top of the eroded surface of Malmesbury Group rocks and the intrusive Cape Granite Suite.

The area occupied now by the Western Cape started to sag and an ocean called the Agulhas Sea invaded, depositing coarse sandy sediments on the exposed granite and Malmesbury Group rocks basement. The new ocean sediments were laid down horizontally on the bottom of this shallow sea, and were followed by more muddy sediments above them, and in turn another layer of sandy ones.

This three-fold package, the yellowish lower sandstones of the Table Mountain Group, the dark blue shales of the Bokkeveld Group, and the white sandstones of the Witteberg Group can be recognised throughout the Western Cape, except of course where they have been removed by erosion.

The shales and sandstones of the Graafwater Formation at the base of the Cape Supergroup on the Cape Peninsula, on Chapman's Peak

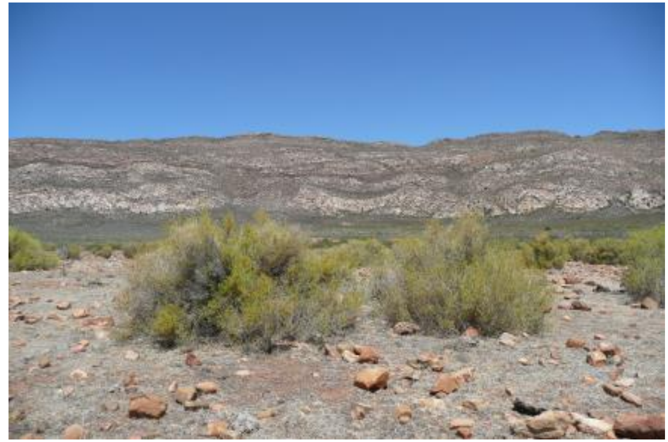


Typical scenery in the Bokkeveld shales near Ceres

On the Cape Peninsula only the lowermost sandstones are preserved, resting on the granite/Malmesbury basement. Further north and east, the Cedarberg and Langeberg ranges consist of the Table Mountain Group, and their intervening valleys tend to be filled with the blue shales of the Bokkeveld Group.

Characteristic brachiopod fossils in shales of the Bokkeveld Group, near Ceres

The Witteberg Group sandstones form the southern edge of the Karoo, and are well exposed on the inland side of the Langeberg and their continuations into the southern Cape.



The Witteberg, consisting of Witteberg Group sandstone, south of Laingsburg on the edge of the Great Karoo Basin

A characteristic trace fossil in the Witteberg sandstone, perhaps caused by a feeding trilobite

So why do these rocks not form a uniform layered cake, with neatly horizontal layers, perhaps just cut by a few river valleys? Instead, they form spectacular, contorted mountains, with narrow gorges cut through rocks crumpled like soft cloth thrown into huge folds by some enormous force. Well, they have been thrown into huge folds by some enormous force.

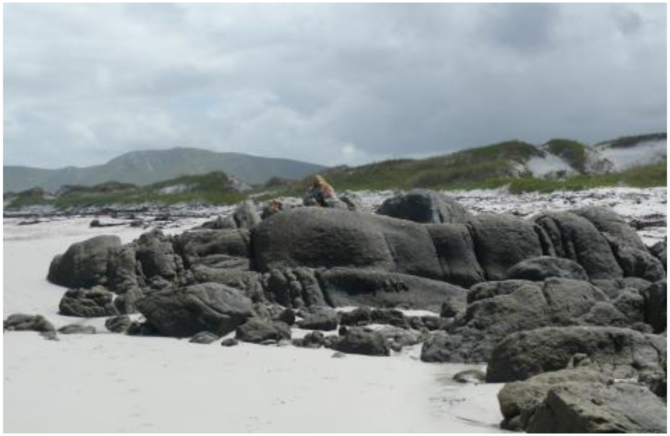
Far to the south, at the outer margin of what now is the Falkland Plateau, compression was taking place, due to the sea floor plunging back into the mantle by the inexorable power of Earth's heat engine. This compression was transmitted to the area of weakness where sagging of the crust had formed the Agulhas Sea, and the sediments there were wedged up against the cold, hard, edge of the former supercontinent of Rodinia. (Remember Rodinia?) The so-called Cape Fold Belt mountains were formed during this period of compression about 400 million years ago, much like a thick cloth being rumpled up as you push it from one side of a table to a heavy pot in the middle. This accounts for the vertical folding in gorges like Cogman's Kloof.

Geologists have identified four episodes, or ‘paroxysms’ of compression and folding in the Cape Fold Belt. The sandstones on Table Mountain were spared this fate, probably because they rest on a particularly resistant block of granite.

The contorted sandstones in Kogman’s Kloof near Montagu, due to compressive forces from far to the south

On the southern Cape coast a beautiful granite is exposed on the beach at Haelkraal, just east of Pearly Beach. This granite contains rounded crystals of blue quartz, which glint in the sun like little fish eyes.

This rock has also been deformed by Earth movements, but in this case the deformation was associated with the north-south squeezing that took place with the formation of the Cape Fold Belt mountains. This was also the result of compression due to the continental collision that took place around 400 million years ago about 1 000 kilometres south of present South Africa.



The sheared and jointed Haelkraal granite near Pearly Beach

The black tourmaline-rich nodules in the Haelkraal granite are up to the size of tennis balls.

The Haelkraal granite, itself originating in a previous mountain building episode, was squeezed towards the north, and now has a layered and fractured look due to shearing. It also has an unusual concentration of tourmaline, which originally crystallised in spherical lumps up to tennis ball size. These black nodules add to the visual appeal of this rock.

The story doesn't stop there though, because on the inland side of the Cape Fold Belt mountains another crustal sag developed, onto which a huge thickness of Karoo rocks was deposited, capped by the Drakensberg lavas which were erupted as Gondwana itself started to crack up, as supercontinents do. The Falkland Plateau tore away, sliding south and west as the present Atlantic Ocean started to open up from the south, and the coastline of southern Africa took on more of its familiar shape.

With this tearing way, huge cracks developed in the rocks of the western and southern Cape, the Worcester Fault being the most famous of these. Subsequent erosion has exposed the Table Mountain Group rocks in long linear mountains with their steepest faces just on the northern side of these cracks. Rivers draining the Karoo cut through them to form spectacular gorges like Cogman's Kloof, Seweweekspoort, and Meiringspoort.

Seweweekspoort follows a river valley that cut through the Langeberg Mountains of the Cape Fold Belt.

This erosion also exposed an interesting and geologically relatively recent phase of igneous intrusion in the Western Cape. As you leave Robertson you can take the turnoff to the right to Bonnievale and visit Van Loveren Private Cellar. The Goedemoed olivine melilitite pipe is exposed on the hillside on the southern side of the Breede River on the wine farm. It forms a dark triangle of rocks on the yellow quartzite hill. This outcrop was a failed volcano. The molten rock tunnelled its way up through the crust of the Earth, until at a fairly high and cool level, it hit a thick layer of sandstone, and ran out of steam.

Where roads cross over the crests of the Cape Fold Belt mountains, like the Swartberg Pass between Prince Albert and Oudtshoorn, they are among the most spectacular in the country.

The Goedemoed intrusive pipe crops out as the dark patch on the hillside, below the sandstone capping.

Here it solidified, waiting until erosion of the sandstone by the waters of the Breede River cut through the hillside, exposing the dense, dark rock on its slopes. In places, this dark rock cracked while cooling to form hexagonal columns, reminiscent of the famous ones at Giant's Causeway in Northern Ireland.

The Goedemoed outcrop has columnar jointing, due to contraction of the cooling magma as it crystallised.

This intrusion has been dated to 63,7 ± 1,3 million years (Duncan et al. 1978). It is part of an arc of co-called olivine melilitite intrusions located at Heidelberg, Robertson, Lambert's Bay, Sutherland, and in Bushmanland and Namaqualand. They are all arranged around the margin of the Kalahari Craton, which is a very ancient and relatively stable piece of Earth's crust.

These rocks are the result of partial melting of upper mantle peridotite, and have their origins below the base of the crust. Because of their similarity to kimberlite, they have been prospected quite intensively, but no diamonds have been found. These intrusions all have Late Cretaceous to Early Tertiary ages, spanning about 26 million years, and postdating the intrusion of the 80 to 90 million year old diamond-bearing kimberlites further to the north east (Verwoerd et al. 1990).

The Goedemoed intrusion did not reach the palaeo-surface to erupt as lava. This small intrusion literally ran out of steam before reaching the surface. Having lost heat by contact with the relatively cold country rocks, it was stopped in its ascent by layers of Witteberg sandstone. It has been exposed by erosion by the Breede River, that runs between Van Loveren Private Cellar and the hillside.

The erosion of the Cape Fold Belt mountains will continue unabated for several millions of years. Eventually they will have been eroded down to a coastal plain, probably invaded by the sea, to form a new sequence of sedimentary rocks. These in turn will be welded onto the resistant core of southern Africa, in the next round of supercontinent formation. Enjoy the mountains while you can!

A view of the snow-capped Matroosberg in the Cape Fold Belt mountains between DeDoorns and Ceres, seen from the N1 travelling south

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