Overberg Geoscientists Group (OGG)

Harold Porter Gardens and Betty's Bay Beach Field Trip

(Meeting Point: 14.00 at Harold Porter Gardens Parking area at 2.00pm)

Introduction

The exceptional Harold Porter Gardens (HPG) are a 200ha botanical gardens, owned and administered by SANBI (South African National Biodiversity Institute), set between mountain and sea, in the heart of the Cape Fynbos region within the Kogelberg Biosphere Reserve. It consists of 10 hectares of cultivated fynbos garden and 190.5 hectares of pristine natural fynbos. The Garden Estate is the natural part of the garden with several kilometres of nature trails providing scenic views of forests, mountains and coastline.

It encompasses steep mountain slopes, two fascinating deep fault-controlled gorges with relict forests, wind-clipped heathlands, flats and marshes with restios, sedges and bulbs, as well as dunes adjacent to the beach with specialised salt-adapted plants. The Garden is renowned for its waterfalls and amber pools.

The main fynbos families (proteas, ericas and restios) are present as well as other important families such as irises, daisies and orchids. The Garden boasts red disa (*Disa uniflora*) in its natural habitat as well as South Africa's national flower, the king protea (*Protea cynaroides*).

Field Excursion Summary

The Overberg Geoscientists Group (OGG) field-trip on 7 April 2022 will involve the following activities:

1. An initial visit to the HPG and the excellent 'Rock-Garden', and 'Soil-Plant' Gardens, and 'Earth-Age Display' which is currently under construction by the OGG. The surrounding geology of the impressive Kogelberg Mountains which rise sharply above HPG to the north, north-west, and north-east comprising massive successions of highly jointed Table Mountain Sandstones (TMS) will be discussed. The TMS successions immediately above the HPG mostly comprise rocks of the Ordovician Peninsula Formation, the basal sandstone unit of the Table Mountain Group (TMG).

   There are two distinct sharply incised gorges running north-west and north-east away from the HPG Rock-Garden which are follow distinct fault-lines in the TMS rocks. Various excellent geological features including cross-bedding structures and shear hosted silica filled veins from the later 280-230 Ma Cape orogeny are apparent in exposures along trails and in the gorges above the HPG. These localities will be incorporated in future Geological Guidebooks of the HPG and adjacent Kogel Mountains.

2. The visit to HPG will be followed by a short drive and excursion on the western-part of Betty's Bay beach, to examine modern sand dune formation, which represents an example of how some of the extensive sandstone units of the 500 – 400 Ma Table Mountain Sandstones (TMS) within the Table Mountain Group (TMG) of the Cape Fold Belt (CFB) Mountains formed.

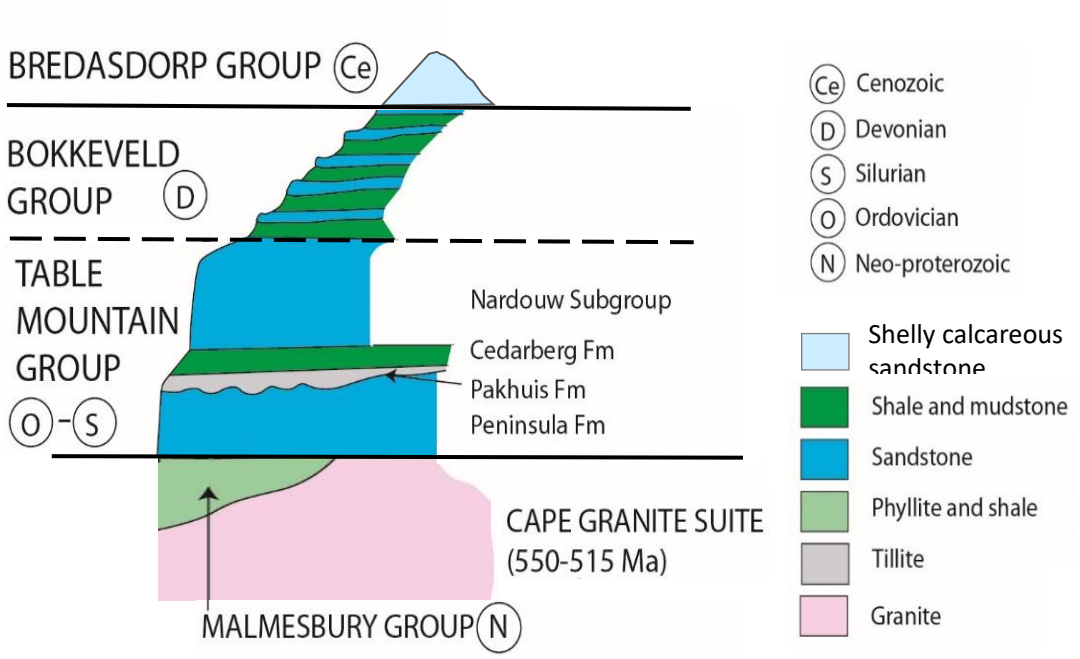
3. Thereafter the participants will proceed along the beach to the south-west to examine excellent exposures of glacial deposits (diamictites or tillites) (444 Ma) of the Pakhuis Formation (TMG) and related sandstone 'dykes'. This locality is to the south-west of the old Radar Station which was one of three built along the Overstrand coastline in the Second World War.

Summary of the Overberg Geology

Group/Formation	Age-period/Time-lines	Group Formation	Rock-types	Comments
Coastal shallow marine and shoreline deposits	Peistocene 1.8 Ma - Recent	Bredasdorp Group	Coastal aeolinites (dune sands), shallow marine deposits	Raised and drowned beaches due to cyclical Climate Change events
Duricrusts (Koffieklip)	Variable ages - Ancient landsurfaces		Hardepan, ferricretes, koffieklip, silicretes, calcretes	Hemel+Aarde Valley; Extensive across RSA
Bokkeveld Formations	Devonian 390 – 375 Ma *Age of the Fish*	Table Mountain Group	Alternating shale (5) and sandstone (4) units	Shallow marine deposits
Table Mountain Sandstones (TMS)	Ordovician-Silurian 500 – 400 Ma	Table Mountain Group	Massive accumulations of high silica sandstones, minor shales, diamictites (Pakhuis Formation) and the 30-50 m Cederberg shale marker	Deposited in an extensive linear Agulhas Sea streching nortwards up the west coast, and up the east coast of RSA
Cape Granites	Proterozoic 550 – 515 Ma	Intrusive plutons that intruded Basement-rocks of the Saldanian Orogeny	Coarse biotite granites comprising abundant coarse intergrowth of quartz and feldspar	Hemel + Aarde Valley; Paarl Granites
Malmesbury Supergroup	Proterozoic 1 200 Ma – 510 Ma	Basement-rocks formed in the Saldanian Orogeny	Mudstones, shales, ignimbrites	Highly metamorphosed and altered; Clarence Drive Blousteen

Summarized stratigraphic profile of the Kogelberg Biosphere Reserve (adjacent to HPG)

The Kogelberg Bioshphere Reserve abuts the HPG at their northern end, with the geological sequence of this spectacular moutainous area summarised in the diagram below. The spectacular cliffs and gorges rising above HPG shw sections of Peninsula, Pakhuis (indistinct) and Cedarburg Formations



Schematic stratigraphic profile of the rock units of the Kogelberg Biosphere reserve.

The Table Mountain Sandstone (Table Mountain Group, Cape Fold Belt)

The **Table Mountain Sandstone** (TMS) is a group of quartz or silica-rich rock formations within the Table Mountain Group (TMG) sequence of rocks. Although the term 'Table Mountain Sandstone' is still widely used in common parlance, the term TMS is no longer formally recognized, and the correct name for the most extensive and common sandstone sequences within the TMS is the Ordovician 'Peninsula Formation Sandstone' and the Silurian Nardouw Sandstones, which is a key part of the TMG.

The designation "Table Mountain Sandstone" will, however, in deference to the title, continue to be used in the rest of this article. The name is derived from the famous and iconic **Table Mountain** landmark in Cape Town.

The TMS are made up predominantly of quartzitic sandstone laid down between 500 Ma (the Ordovician Period) and 400 Ma (the Silurian Period). It is the hardest, and most erosion resistant layer of the Table Mountain Group. These rocks form most of the highest and most conspicuous peaks in the Western Cape, as well as the steepest cliffs of the *Cape Fold Mountains*, despite being the oldest, and lowermost units of the TMG.

The folding, thrusting, duplexing and deformation by the Cape orogeny of the TMS sequence into the coast-parallel mountain ranges of the Western Cape started about 280 Ma ago and ending around 230 Ma. The Cape Fold Belt event tectonically deformed the Cape Supergroup from about Clanwilliam, approximately 200 km north of Cape Town, to Port Elizabeth, approximately 650 km east of Cape Town.

Table Mountain Group sediments extend beyond these points but are not folded into mountain ranges, though form steep cliffs or gorges, where the surrounding sediments have been eroded away, as for instance in Oribi Gorge in KwaZulu Natal.

Trace Fossils in the TMS

The dominant rock types along the Overstrand coastline are sandstones of the Table Mountain Group (TMG) and Cape Fold Mountains. It forms all the mountains and high cliffs with which we are all familiar. As its name implies it was formed by the solidification of sands into rocks. A process called Lithification.

The sands were very similar to what we see on all the local beaches – naturally enough as they are derived from the erosion older granites, gneisses, and other quartz rich rocks (including older sandstone sequences) of the original hinterland. They were primarily deposited in a shallow marine basin created not long after the super-continent Gondwana had formed by the docking of what is now South America at around 510 million years ago.

The dominant sequence of the Peninsula Formation (of the Table Mountain Group), were laid down by Deltas into offshore sandbanks by strong currents. These currents were sufficient to scour any traces of hard shells and so on from the sands thus we have no actual fossil hard parts in these sandstone rocks.

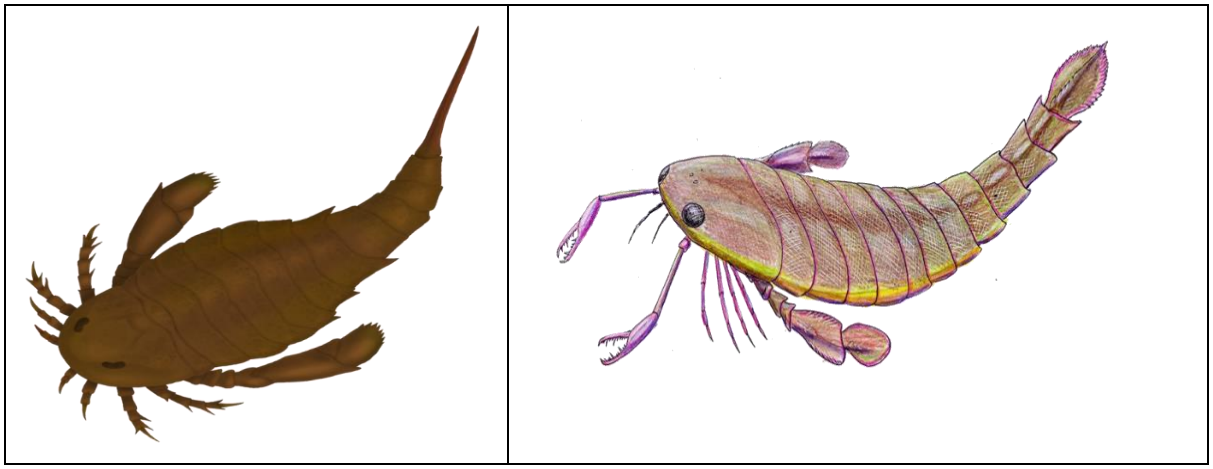
However, this does not imply that there were no animals in the seas here at that time. Local Betty's Bay resident Mike Burns was taking a walk in the hills on the eastern side of the R44 when he came upon some unusual marks on a slab of the sandstone. Images of these features were sent to local geologist Dave Mourant who was extremely excited about this 'find' given the likelihood of them possibly being the tracks of an animal living about 450 million years ago!

Once carefully examined by Dave Mourant (Betty's Bay resident and geologist) it became obvious that the images, and piece of sandstone rock photographed and collected by Mike Burns was a well preserved TMS 'Trace Fossil'.

The remnants of the tracks clearly obvious in the image below, were made by an animal walking across the sand at the bottom of the shallow sea.

With additional follow-up and research, and assistance from colleagues and paleontologists in Academia, it was found that the tracks had been created by the species **EURYPTERID**. These are sometimes known as Sea Scorpions, but they are not closely related to scorpions at all, they just resemble them somewhat.

Below are examples of Eurypterids, though it is not known what species made the tracks, of course. They vary greatly in size as we shall see, but the one that made the tracks we have was around 30cm long.



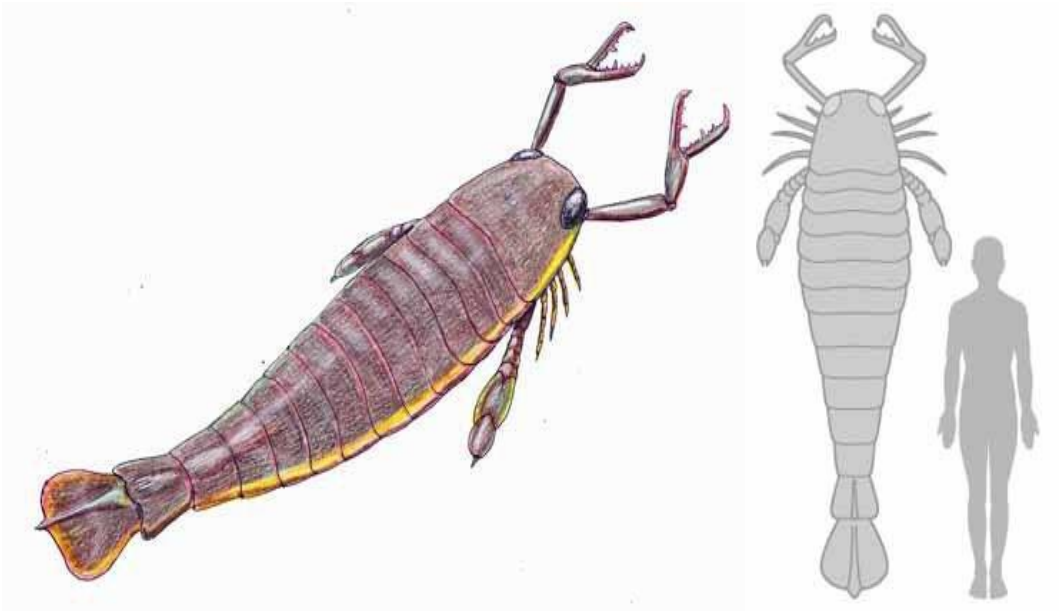
They were predators and mostly lived in shallow waters feeding off other small fish and even other Eurypterids. They lived very widely near shore around the continents, and their fossils have been found worldwide.

Below are images that that show tracks that were found in Antarctica in rocks of a similar age. At the time of course Antarctica was part of Gondwana, so conditions were very similar.

They were, obviously, Arthropods, a group which includes insects, spiders crabs etc. Arthropod means 'jointed foot'. They all have external skeletons and jointed appendages. Eurypterids are related to Horse shoe crabs but most closely to spiders!

However, they grew much larger than any spider, and they are the largest known Arthropod that has ever been found, with one species reaching up to 2 metres in length as depicted in the images below.

Fortunately (or unfortunately), they died out about 250 Ma ago! These tracks were also readily identifiable as having been made by an animal with legs and feet.



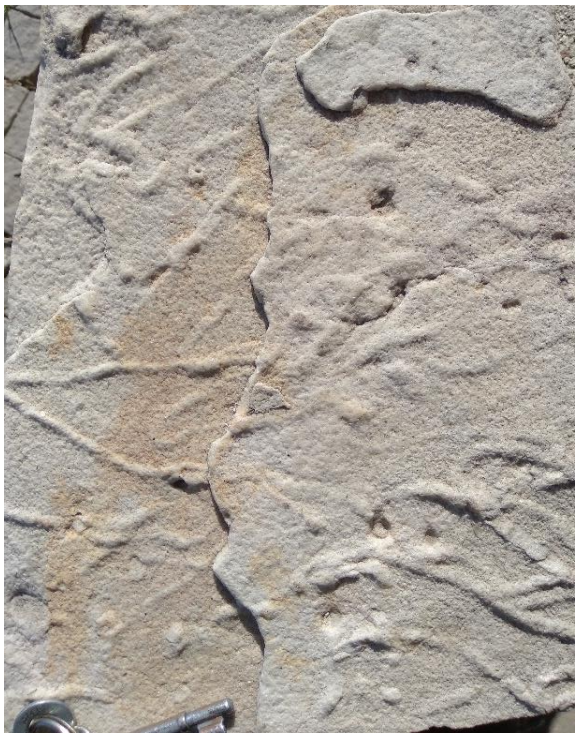
There is, however, another type of trace fossil that is far less identifiable. These are termed 'Cruziana' which represent the tracks and burrows of ancient soft-bodied "worms" and similar creatures. They are more common than the Eurypterid tracks, but perhaps don't stand out immediately as traces. Examples of these trace fossils in the TMS rocks are shown in the images below

U-shaped Burrow of small sea creature

Indentations and tracks

Numerous Cruziana tracks and trace imprints within the middle Peninsula Formation can also be accessed and examined easily at the west side of Kleinmond. On entering the village from the Betty's Bay side, turn right into the very first road DF Malherbe Street. Drive towards the coastline and stop at the parking spot at the end of the road before it turns left into Albertyn Street. Join the Palmiet coastal pathway heading away from Kleimond and walk towards the rocky shore.

After some 200 m, where the path turns to follow the coastline, leave the path and head for the Peninsula outcrop where the low angle bedding planes with the Cruziana indentations and tracks can be found. Importantly these exposures of unique trace fossils should also be respected and protected for posterity, future, and next generations to also experience.



In effect the rocks of the TMS sequences , predominantly sandstones, do not contain fossils. The same cannot be said, however, for the younger rocks of the fascinating and much more colourful Bokkeveld

rocks which are characterised by greater abundances of siltstones, mudstones, and fine sands with considerably more clay content than the older rocks of the TMS.

From around 390 Ma this area was under deeper and quieter conditions with less sand being brought down by the deltas. The sandy muds that were forming the bottom of the sea were much more likely to be inhabited and, more importantly, much quieter conditions led to the fossilization of some of the animal life there. These rocks, called the Bokkeveld Group can be found mainly to the north and east of HPG. They form the lower lying valleys with very nutritious soils, and have been largely taken over by agriculture. However, they contain many fossils of Trilobites, and shellfish especially in the Cedarberg area.

Trilobite Fossil

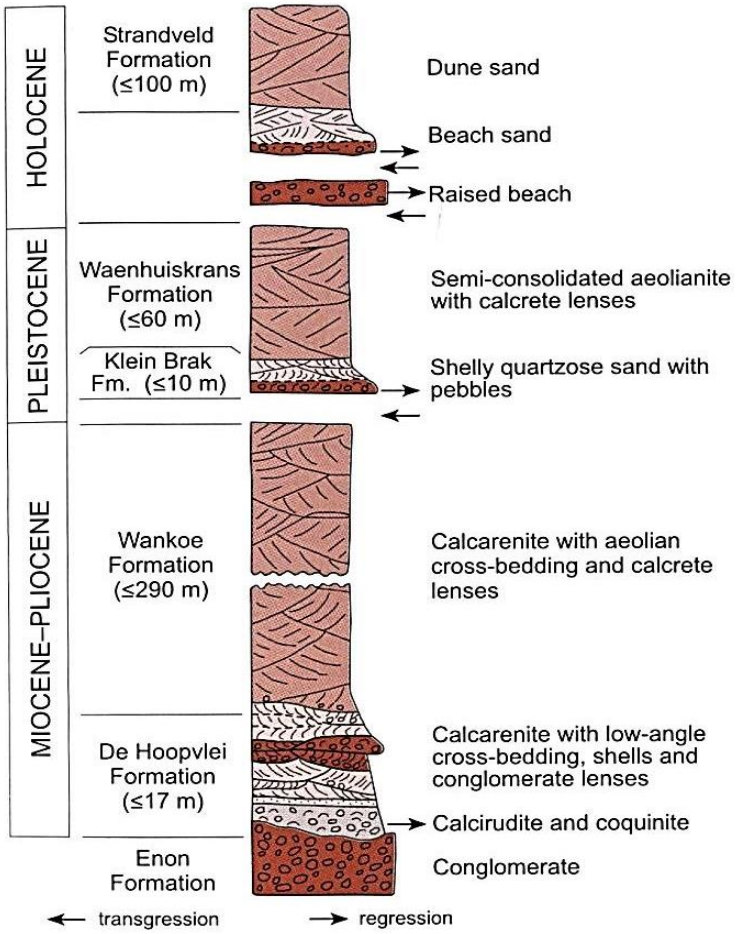
The same conditions as the Bokkeveld Formation occurred again much later when the Karoo sediments were being laid down in a huge inland sea starting some 290 Ma ago. Once again muds and quiet conditions led to the preservation of many animals. The younger Karoo rocks hold some of the rarest and earliest specimens of many animal types.

The image below shows an example of what it might have been like to be diving in clear water some 450 Ma ago at the time that the TMS sequences were being deposited.

The Bredasdorp Group

Sediments of the Cenozoic Bredasdorp Group overlie older bedrock over large areas on the coastal plain between Hermanus and Mossel Bay. It consists of a succession of limestone, sandy limestone, sandstone, shelly material and conglomerate. These occur in a narrow belt that in places extends inland up to a maximum distance of approximately 25 km.

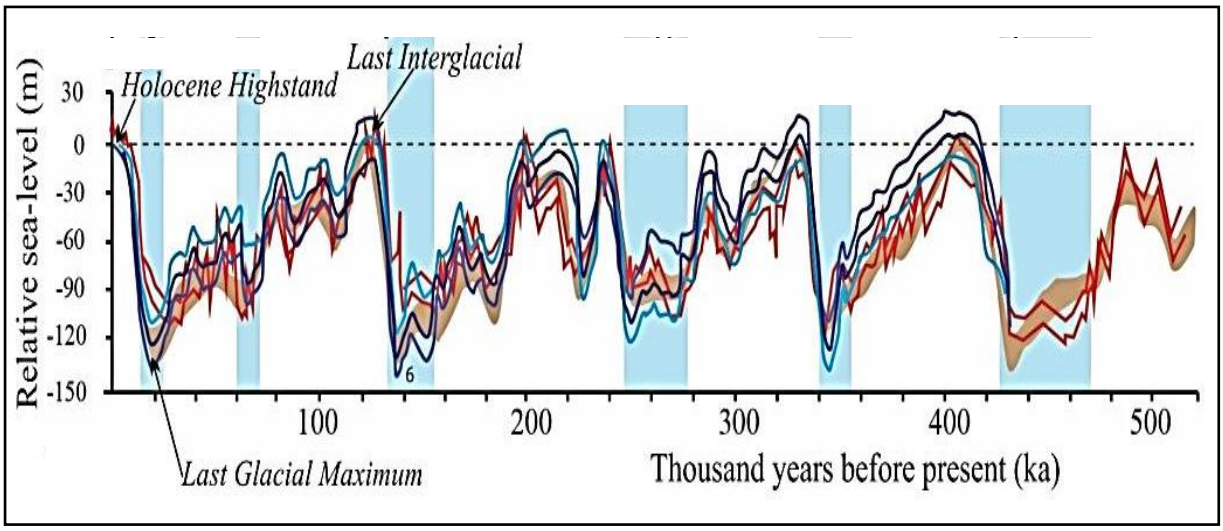
To the west of Hermanus, specifically the Betty's Bay to Cape Hangklip area, the absence of older elevated wave cut surfaces and coastal platforms prevented any deposition and preservation of the older Pliocene Bredasdorp units. The Bredasdorp Group has been divided into five formations. Only the upper aeolianite and dune sand units, the Pleistocene Waenhuiskrans and the Recent Strandveld Formations occur in the Betty's Bay, and Pringle Bay area.



During the Quaternary Period (2.6 Ma to present), and in particular during the past 1 Ma (one million years) glacial-interglacial climate cycle created shifting shorelines with and semi-consolidated cross-bedded dunes (aeolinitites) and conglomerates depicted in the cross-section above. These shorelines varied between a maximum depth of 130 m below and a maximum elevation of 13 m above present-day sea level and happened approximately every 120 000 years (hundred and twenty thousand years), for the past nine hundred thousand years.

During most of this time (namely the past 900 thousand years) the sea level has been significantly lower than it is at present. This previously exposed the now submerged terrestrial ecosystem of the

current continental shelf, including the now ‘drowned’ Agulhas Banks off the southern-end of the African continent.



Along the coast to the east of Betty’s Bay, particularly on the left (east) bank of the Palmiet River Estuary, immediately west of Kleinmond +15 to +18 m wave-planed terrace form the last Interglacial 120 000 year ago can be seen.

At Kleinmond an older upper terrace of +30m can also be seen. A younger lower +6 to +8m narrow wave-planed terrace can be followed along the coast in Betty’s Bay.

On the wider section of the Betty’s Bay coastal terrace a couple of lakes Grootvlei and Rondevlei and the back-dune lagune of Bass Lake can be seen. The longitudinal vegetated coastal dunes of the

Waenhuiskrans Formation form a 300m wide barrier preventing Bass Lake having a direct outlet to the ocean. The three water bodies are located on the +8 to +12m marine terrace.

An article in the Betty' Bay Ratepayers Association (BBRA) newsletter (20 March, 2016) discussed the fascinating Malkopsvlei or Brass Lake and its water outlet. Water flows through a deep trough between two old and stable backshore dune systems to enter the sea some 1.5km to the east near Dawidskraal. The channel banks and upper edges consist of very steep sandy slopes consolidated by typical dune vegetation. In the lower, damper sections of the outlet channel, this scrub merges into swamp vegetation, dominated by various species of reeds. Milkwood trees are common along the damper parts of the channel.

Scree slopes of the Betty's Bay Mountains

On the mountain side of the road through Betty's Bay plenty large angular boulders of Table Mountain Group sandstone litter the scree slopes below the vertical cliffs of the coastal mountains.

It can be presumed that they mainly fell during the Pleistocene glacial periods and that, therefore the homeowners of Betty's Bay are relatively safe during the present interglacial!

Summary

Harold Porter Gardens with its fascinating fynbos gardens, imposing gorges and Kogelberg Mountains at the north-end of the gardens, the raised-beaches to the south, and adjacent Atlantic Ocean provides a very real 'sense of place', which John Compton has eloquently described on the Cape West Coast (Compton, 2021).

The HPG with its imposing setting on the foot-slopes of the Kogelberg Mountains with imposing highly jointed TMS cliffs, gorges that have developed along major fault lines provide a fascinating vista of the ancient underlying solid Earth, with rock formations whose origins extend back over hundreds of millions of years of geological time. It is out of these bedrock foundations that the mountains, hills, valleys, and other landforms of the southern Cape have emerged by tectonic uplift and weathering over tens of millions of years.

This ancient bedrock foundation is the slowest to change, such that the landscape seen today, with its many shapes and forms, is more or less what our earliest ancestors witnessed over the last hundreds of thousands of years.

Thriving on the bedrock foundation is the far more dynamic thin veneer of life adapted to the climate and rock types exposed at the surface. Individual life forms came and went in rapid (in geological age parlance) succession. Some evolved into new species while other became extinct. The living ensemble of plants and animals generally turns over on much shorter timescales than changes in the landscape.

The third and final layer of the HPG area and surrounds is now occupied by human species, just one of numerous coexisting species embedded in the living landscape. However, the intensity of these very recently arrived supposedly intelligent beings and aggressive human activities constitute a new global force. Although probably not insignificant before, human impacts have exploded over the last two centuries, so much so that they define a new geological epoch, the Anthropocene (age of humans) (Compton, 2021).

The three interwoven layers indicated above are increasingly being researched and understood, providing progressively better understanding of our planet, including previous increasingly well documented extinctions of species, and prior sea level impacts due to cyclical Climate change. Anthropological studies, for example at the Kelders Caves between Stanford and Gansbaai, also provide an increasingly important role in the understanding of future Climate change, and its likely impact of human beings and their habitation of the earth, particularly in respect of the impact of people prior to the Industrial Revolution.

Over the last 200 years, humans have significantly modified both the physical and living landscape of the southern Cape (and West) Coast, and globally, in ways that are leading us into a new world and uncertain future (Compton, 2021).

The HPG and adjacent 'natural' environment provides a wonderful setting to observe and better understanding recent and obvious Anthropocene impacts on our local environment, including plant and animal species (for example human impact on local baboon troops), the impact of invasive aliens, uncontrolled fires, illegal construction, wetland shrinkage and unmanaged water usage, and other facets.

Taking time to visit this exceptional Botanical garden and its Rock-garden, Earth-Age and Soil Type-Plant displays should be a priority for each and every citizen passing through Betty's Bay, and the adjacent Kogelberg Biosphere, and local Coastal strip.

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Contacts and Further Information

For more details of the geology, and related facets of the Overberg's remarkable +600 Ma geology, rocks deposits, structural history, ancient landsurfaces and duricrusts, modern coastal deposits (including aeolinites), climate change record, and anthropology (eg. The Kelders Caves, please contact one of the following for more information

Dave Mourant (082 923 5366; amourant@iafrica.com)

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Linear sand trails and troughs created by the South-easter - Betty's Bay west-beach (view looking east)

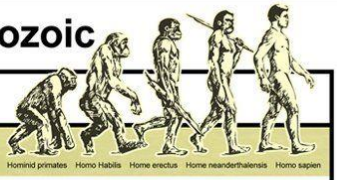
Modern sand dune formation (dominantly silica with fine shell material) of the Strandveld Formation on Betty's Bay west-beach.

Ancient cross-bedded TMS surrounded by silica sand forming modern dunes (dominantly silica with fine shell material) on Betty's Bay west beach

Diamictites of the Pakhuis Formation on Betty's Bay west beach

Sandstone 'dykes' in the Pakhuis diamictites on Betty's Bay west beach

Geological time scale, Late Proterozoic to Cenozoic



millions of years ago

era	period	events
Cenozoic (0 – 2.6)	Quaternary	**Evolution of Humans** Humans evolve from Hominid primates to Homo sapiens.
Cenozoic (2.6 – 50)	Neogene Palegene	**Mammals Diversify** Mammals and birds continued to evolve into roughly modern forms, while other groups of life remained relatively unchanged.
Mesozoic (50 – 100)	Cretaceous	**Extinction of Dinosaurs** It is thought that a comet, asteroid or meteor impact event may have caused the extinction of the dinosaurs. **First Primates** **First Flowering Plants** A plant that had no petals and lived underwater more than 125 million years ago could be the oldest known 'flower', according to scientists.
Mesozoic (150 – 200)	Jurassic	**First Birds** The earliest known is Archaeopteryx lithographica, from the Late Jurassic period, though Archaeopteryx is not commonly considered to have been a true bird. **Dinosaurs Diversify**
Paleozoic (200 – 250)	Triassic	**First Mammals** The first placental mammals appeared at the beginning of the Cretaceous period. The earliest mammals were tiny, shrew-like mammals. **First Dinosaurs** Eoraptor (pronounced EE-oh-RAP-tor) is one of the earliest known dinosaurs.
Paleozoic (250 – 300)	Permian	**Major Extinctions** This occurred about 252 Ma (million years) ago, forming the boundary between the Permian and Triassic geologic periods, as well as the Paleozoic and Mesozoic eras. **Reptiles Diversify**
Paleozoic (300 – 350)	Carbon-iferous: Pennsylvanian	**First Reptiles** The first reptiles evolved from advanced reptiliomorph labyrinthodonts.
Paleozoic (300 – 350)	Carbon-iferous: Mississippian	**Scale Trees** **Seed Ferns**
Paleozoic (350 – 400)	Devonian	**First Amphibians** These ancient lobe-finned fish had evolved multi-jointed leg-like fins with digits that enabled them to crawl along the sea bottom. **Jawed Fishes Diversify**
Paleozoic (400 – 450)	Silurian	**First Vascular Land Plants** The earliest known representatives of this group (mostly from the northern hemisphere) are placed in the genus Cooksonia.
Paleozoic (450 – 500)	Ordovician	**Sudden Diversification of Metazoan Families**
Paleozoic (500 – 550)	Cambrian	**First Fishes** Early fish from the fossil record are represented by a group of small, jawless, armoured fish known as ostracoderms. **First Chordates**
Late Proterozoic (550 – 650)		**First Skeletal Elements** **First Soft-bodied Metazoans** **First Animal Traces**