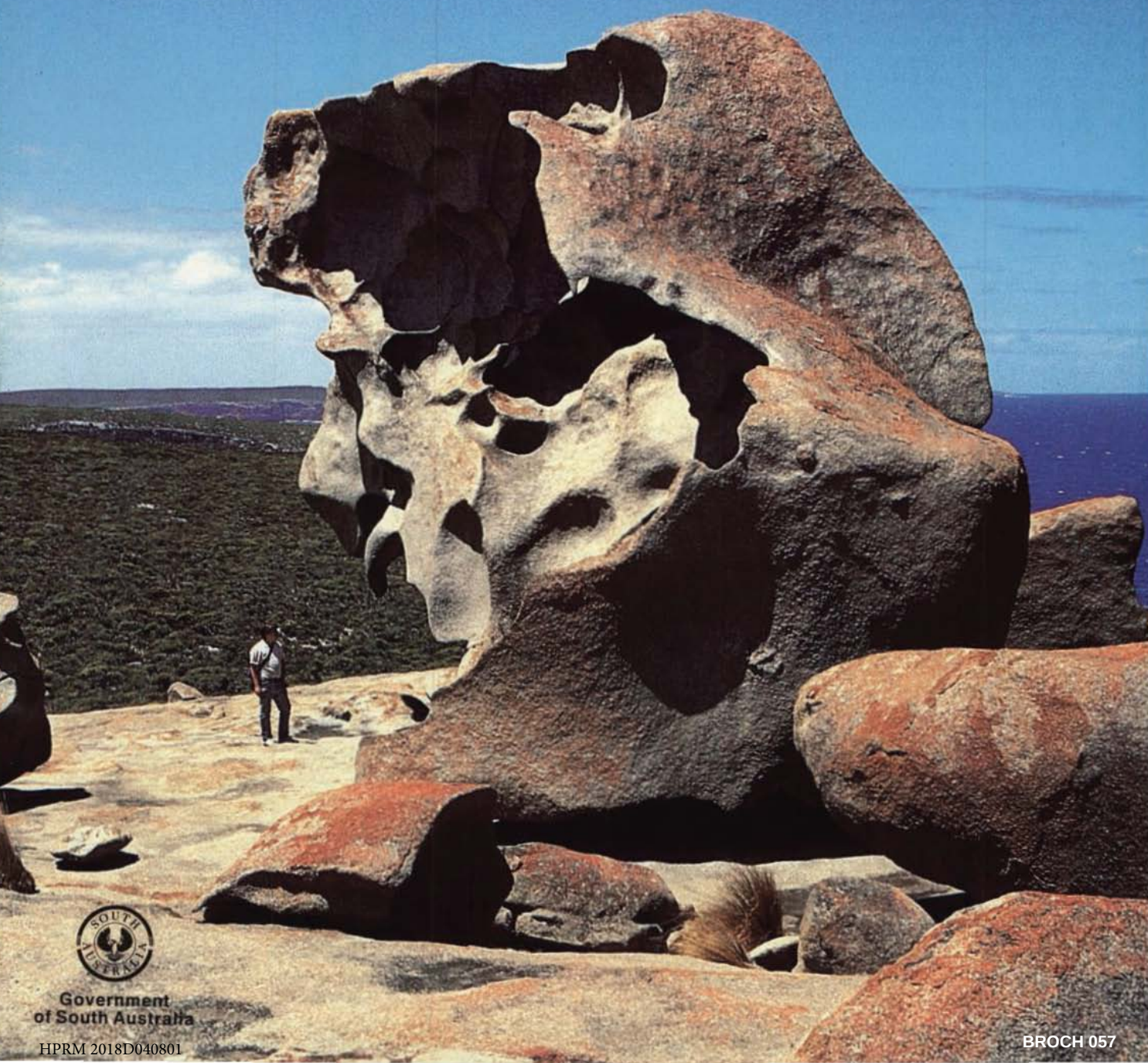
PRIMARY INDUSTRIES AND RESOURCES SA

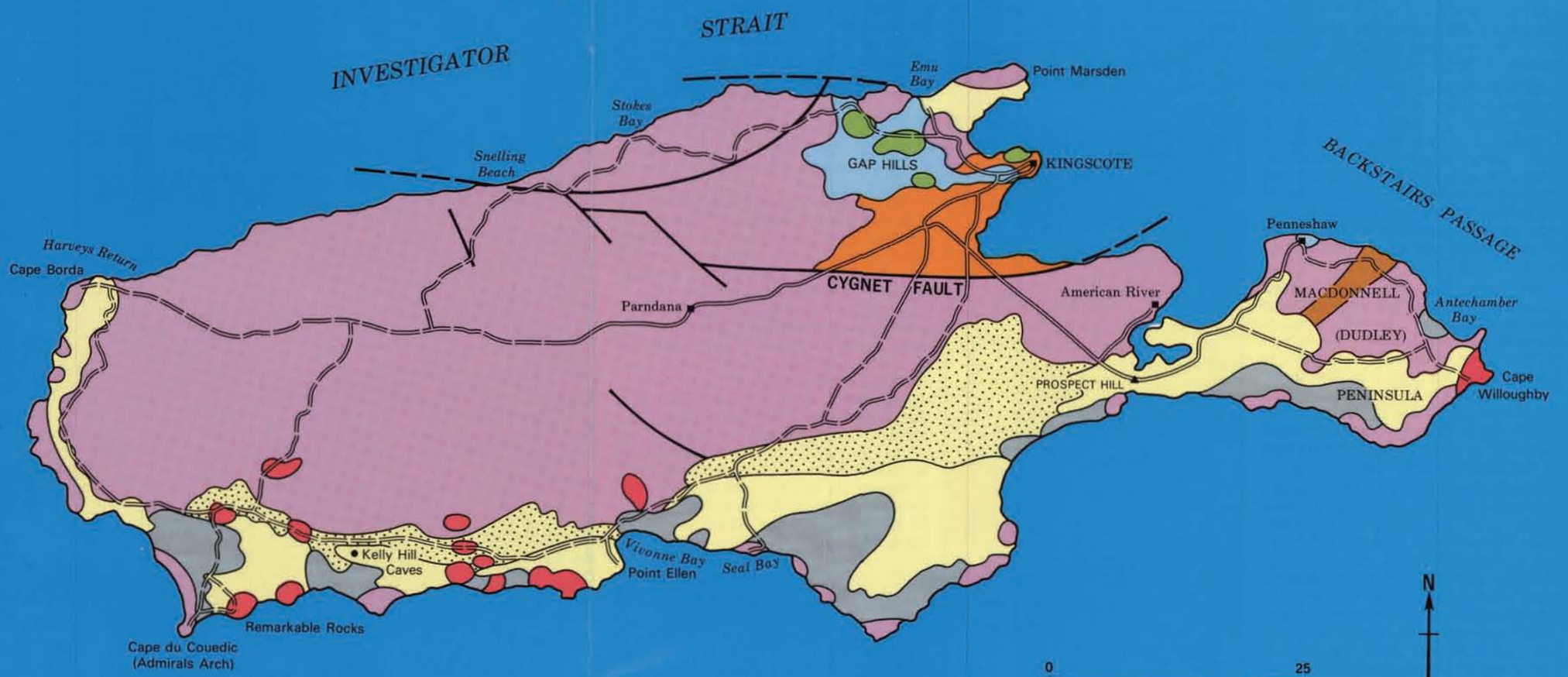
Geology of Kangaroo Island



Government of South Australia

BROCH 057

Geological Map
of Kangaroo Island



CAINOZOIC ERA

QUATERNARY
- Recent sand dunes
- Raised beach and river deposits
- Older sand dunes (aeolianite)

TERTIARY
- Limestone

MESOZOIC ERA

JURASSIC
- Basalt lava

PALAEOZOIC ERA

PERMIAN
- Glacial deposits

ORDOVICIAN
- Granite

CAMBRIAN
- Sandstone, shale and schist

PRECAMBRIAN ERA

PROTEROZOIC
- Shale, sandstone and limestone

Fault zone

Major sealed road

Major unsealed road

Note: The sites described in this brochure have been classified as Geological Monuments by the Geological Society of Australia.

Please do not damage them by the unnecessary collection of rock specimens.

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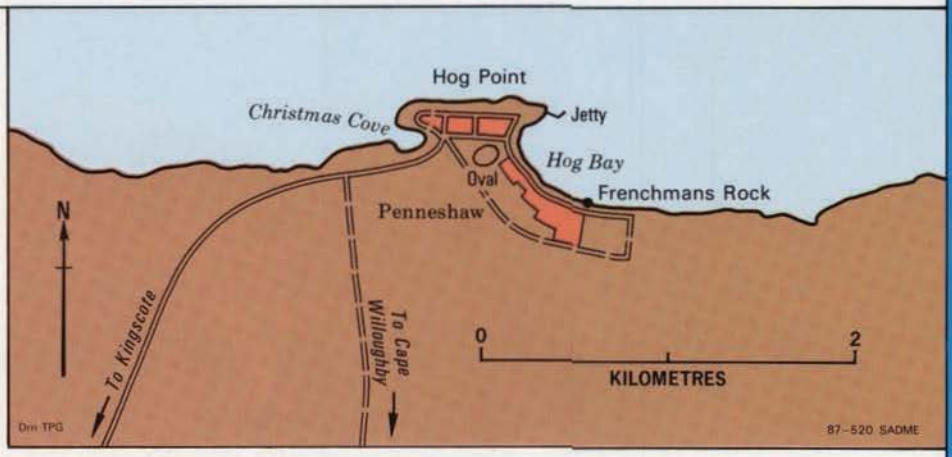
Penneshaw

The cliffs and beaches of Penneshaw provide evidence of geological conditions during the Palaeozoic era. At first the area was covered by the Cambrian sea and later by snow and ice as the supercontinent of Gondwana drifted towards the South Pole. All of the sites can be covered in half a day.



Hog Point

Rocks which form these low cliffs were originally deposited as layers of mud, sand, and pebbles on the floor of the Cambrian sea. During the subsequent mountain building period they were changed by heat and pressure into schist, and some of the pebbles in the rock have been slightly flattened by these forces.

Frenchmans Rock

Here outcrops of Cambrian schist stick out of the beach like tombstones. They contain minute glittering flakes of mica and occasional veins of white quartz.

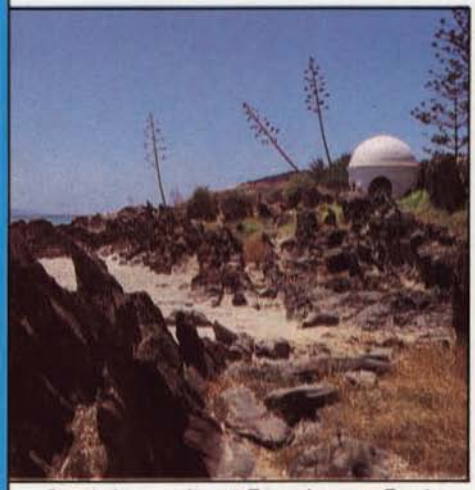
Christmas Cove

Lying immediately west of Penneshaw, this small cove shows some of the best evidence of Palaeozoic glaciation on the island. The cove was scoured out by ice action and has been filled with glacial sediments.

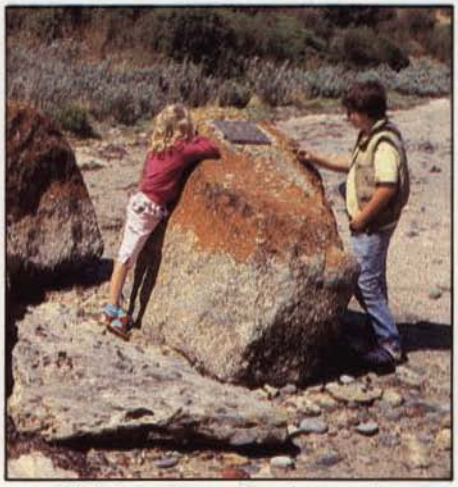
In the middle of the beach are several large granite boulders, one with a plaque commemorating the landing of Matthew Flinders in 1802. Granite does not occur naturally near Penneshaw and these 'erratics' were carried in by a glacier, possibly from Cape Willoughby over 30 km to the south-east.

Greenish clay which crops out at high tide level near the erratics is also of glacial origin. At the northeast end of the cove the cliffs show horizontal scratches caused by ice movement.

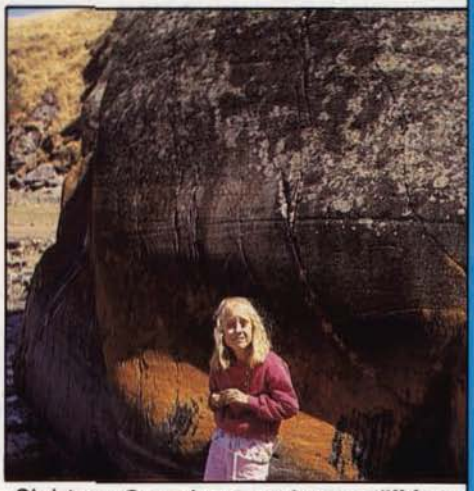
Features of this type are common in present day glaciated areas in other parts of the world and show that about 250 million years ago this region was covered by snow and ice.



Cambrian rocks at Frenchmans Rock.



Christmas Cove: Granite erratics



Christmas Cove: Ice scratches on cliff face.

South Coast

Granite, injected about 500 million years ago during the Palaeozoic mountain building period, is exposed at several localities along the southern coast. Caves occur in limestone deposited in the Tertiary sea.

Half a day can be spent on the MacDonnell Peninsula and visiting Prospect Hill. A full day is needed to travel along the south coast to Cape du Couedic and return.

Cape Willoughby

Cliffs on which the lighthouse stands are of granite which was injected in molten form into Cambrian rocks about 500 million years ago.

The granite consists of three minerals: blueish opalescent quartz, black mica, and pinkish feldspar. Darker patches within the rock mass are the remains of Cambrian rocks partly absorbed by the molten granite.

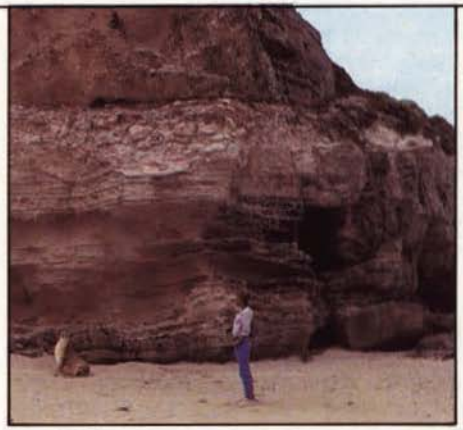
Cape Willoughby granite resembles granites found at Remarkable Rocks and Victor Harbor. All of these may form part of one great intrusion at depth.

Prospect Hill

Rising about 100 metres above the surrounding countryside, this was climbed and named by Matthew Flinders in 1802. The hill is a geologically recent sand dune consisting of loose beach sand piled up by wind action. The summit presents a good view of MacDonnell Peninsula which was an island during much of the Tertiary period.

Seal Bay

An important breeding ground for the Australian sea lion, the bay contains cliffs of aeolianite - a rock composed of windblown quartz grains and shell fragments cemented by lime. The main cliff at the eastern edge of the beach shows a layer of cobbles a few metres above beach level; this marks a previous beach level, thousands of years old.



Aeolianite cliffs at Seal Bay with line of cobbles marking earlier beach level.

Kelly Hill caves

Caves occur within Tertiary limestone and have been formed by the dissolving action of percolating groundwater. The caves display stalactites, stalagmites and helictites and a brochure describing these features is available from the Conservation Park headquarters.

Admirals Arch

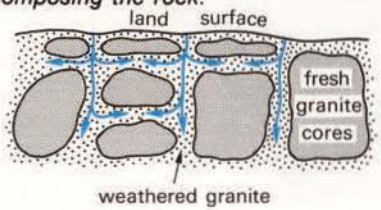
This spectacular cave has been caused by erosion along a zone of weakness between two contrasting rock types. Aeolianite, which forms the roof of the cave, is a soft rock. Below it at sea level, hard Cambrian rocks occur as large slabs dipping out to sea. Wave action has eroded the softer aeolianite more quickly and caused it to collapse by undercutting to form the arch.

Stalactites and petrified roots of plants which once grew in the dunes can be seen hanging from the roof.

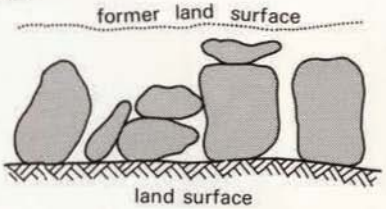
Remarkable Rocks

One of South Australia's most famous geological features, Remarkable Rocks consist of granite of the same age as the Cape Willoughby granite. The way in which these curious shapes have been produced by the weathering action of rain and wind over thousands of years is shown in the following sketches.

1. Rain penetrates cracks in the granite, decomposing the rock.



2. Land Surface is lowered by erosion, leaving corestones of unweathered granite.



3. Corestones become shaped by wind and rain forming caves, overhangs and gullies.

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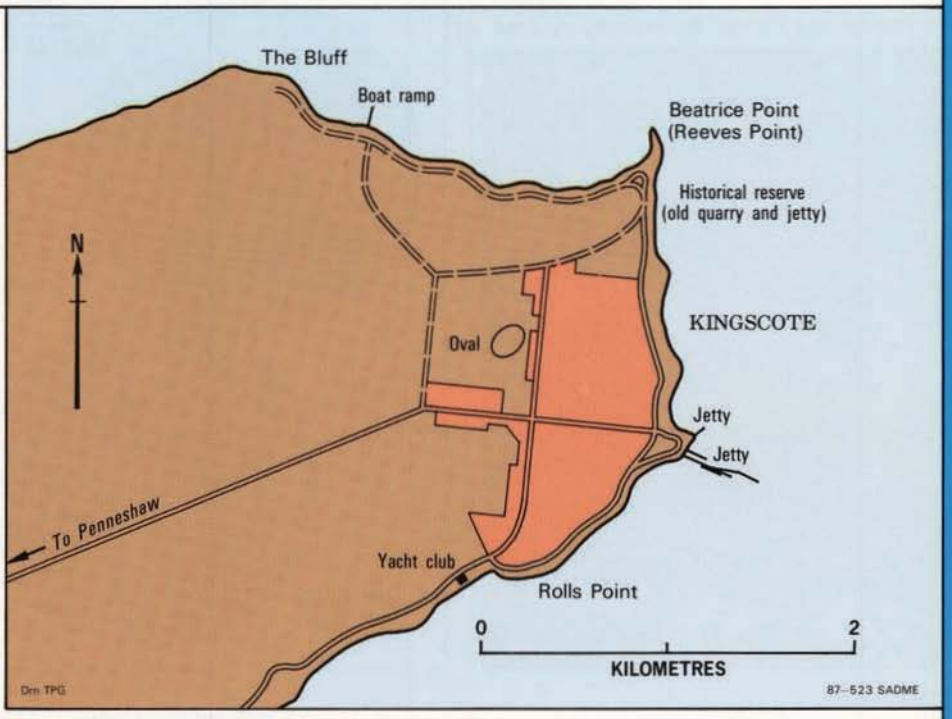
Kingscote

Basalt lava, fossiliferous limestone, and evidence of an ancient raised beach may be seen on the coastal cliffs around Kingscote. These sites can all be visited within a few hours.



Beatrice (Reeves) Point Quarry

Basalt was first quarried here in 1840 and shipped to Port Adelaide for the construction of Port Road. Parts of the old jetty still exist.

The basalt was extruded as lava about 150 million years ago as the supercontinent of Gondwana began to break up.

Access to the quarry is gained from the beach by following back along the line of the jetty. On exposed quarry faces the lava is seen as dark greenish rock overlying lighter coloured sediments. Columnar joints, formed during cooling, have developed in the basalt giving it a blocky appearance and making it easy to quarry. Sediments underneath the lava were probably laid down during the Palaeozoic ice age.

Basalt lava (top) at Reeves Point Quarry.

The Bluff

Basalt cobbles and boulders are scattered over the beach around the boat ramp. This area may be compared with the fossil raised beach at Rolls Point, described later.

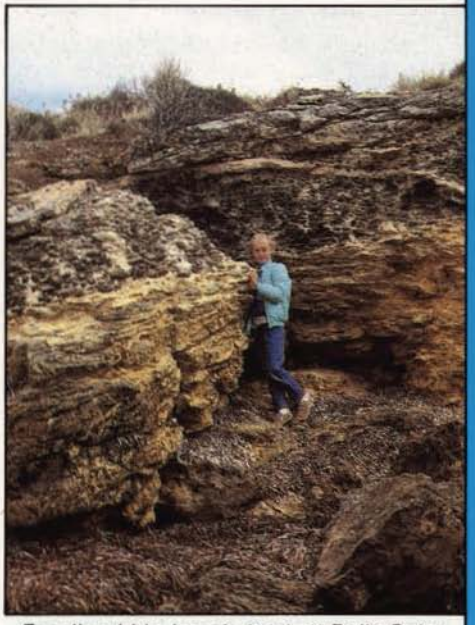
Coastal Cliffs

Near Kingscote jetty the cliffs are formed of limestone which contains abundant fragments of fossil shells and sea urchins.

The limestone was deposited between about 40 and 25 million years ago when a shallow sea covered parts of the island. Rocks of a similar type and age have been intersected by boreholes further inland.

Rolls Point

Above the fossiliferous limestone, at the top of the cliffs, is a layer of black basalt cobbles, cemented by lime, resembling those found on the beach at The Bluff boat ramp. This cobble layer marks an earlier high sea level dating back many thousands of years.



Fossil cobble beach (top) at Rolls Point.

North Coast

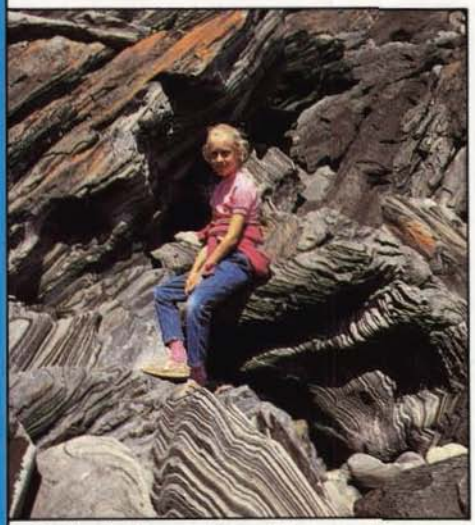
Cambrian rocks are exposed along the picturesque northern coast of the island. Unusual zebra-like banded rocks may be seen at Harvey's Return.

This part of the island can be covered in a day trip from Kingscote by proceeding directly to Cape Borda via Parndana and calling in at the various bays on the way back.

Cambrian rocks exposed along the North Coast near Harveys Return.

Harveys Return

Located a few kilometres east of Cape Borda, this bay was once used as a supply route for the lighthouse. Access to the bay is by steep footpath and the round journey takes about an hour. Cambrian rocks form cliffs surrounding the bay and occur as large boulders along the shore. Spectacular zebra-like banding on some of the rocks in the western corner is caused by layers of dark mica and lighter quartz. These represent layers of clay and sand deposited as the original sediments which have since been folded and converted to schist and quartzite by the heat and pressure of mountain building forces.



Folded zebra schist at Harveys Return.

Snelling Beach

Cambrian rocks are exposed along the north coast from Snelling Beach to Point Marsden. The rocks were deposited as sediments in a warm shallow sea and consist mainly of sandstone and shale. Mud cracks and ripple marks have been found in these rocks together with fossil trilobites and their tracks.

Stokes Bay

The cliffs consist of aeolianite crowded with shell fragments. A natural tunnel, caused by the collapse and separation of large aeolianite blocks from the cliffs, leads to a secluded beach where boulders of Cambrian sandstone are exposed at low tide.

Gap Hills

The road from Stokes Bay to Kingscote passes the flat topped Gap Hills. These are the remains of basalt lava flows extruded when the supercontinent of Gondwana began to break up during the Mesozoic era, about 150 million years ago.

Emu Bay

On the foreshore north of the jetty, Cambrian rocks are exposed as reddish brown sandstones and darker grey shale.

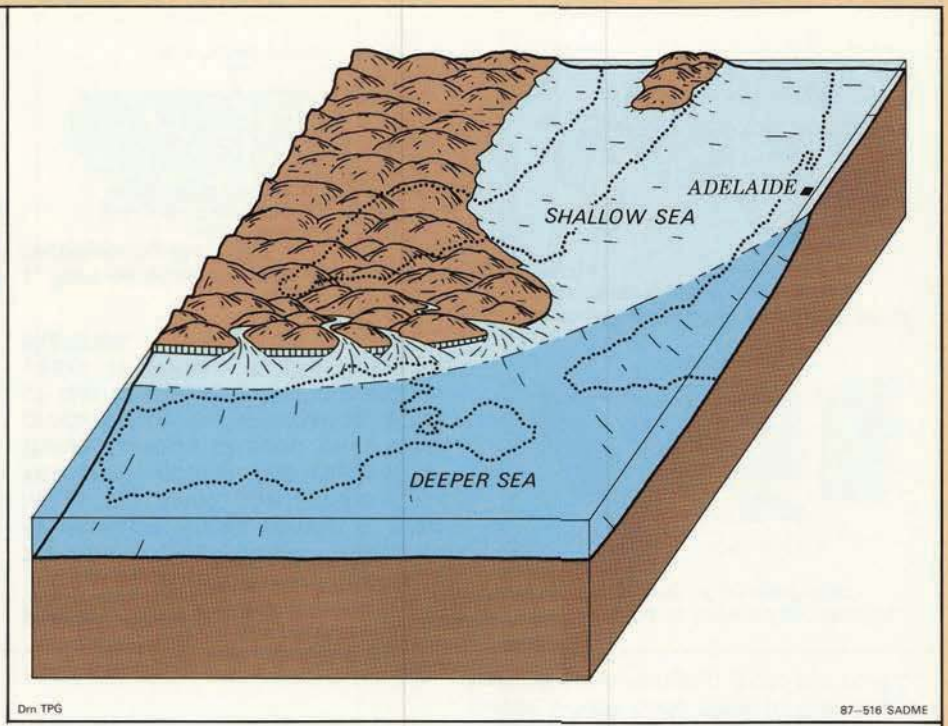
Fossil trilobites.

Geological Evolution of Kangaroo Island

PRECAMBRIAN ERA

Little is known of the Earth's geography at this distant time in the past, but it appears that Australia and Antarctica were joined, probably forming part of a greater landmass.

The oldest rocks known on Kangaroo Island were deposited about 750 million years ago. They were originally sediments deposited on older crystalline rocks in a long narrow basin which stretched across part of both continents. At the end of the Precambrian era, a sea which occupied the basin withdrew and the compacted sediments were locally uplifted.



Geography of part of the Cambrian period.

PALAEOZOIC ERA

Cambrian time

Around the beginning of the Cambrian period a shallow sea once again flooded this region. Limestone containing extinct coral-like organisms was deposited on the sea floor.

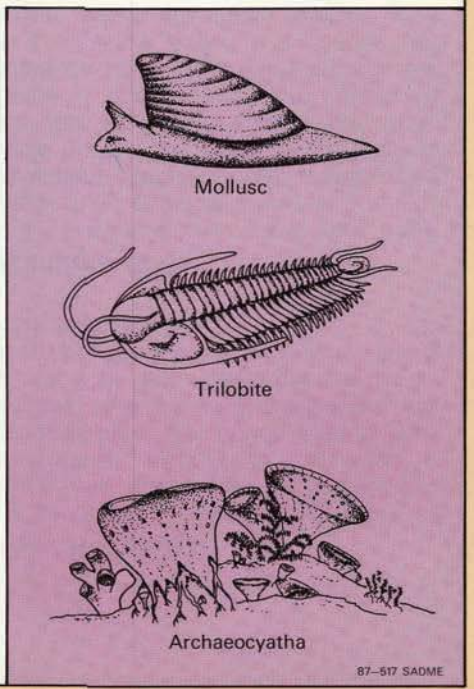
Later, the area north of Kangaroo Island was uplifted above sea level as a result of faulting. These highlands were eroded by streams which carried sand, silt, and limestone pebbles southwards to the sea where they were deposited as sediments up to a thickness of several kilometres.

Along the coast were stagnant pools, rich in hydrogen sulphide, which killed passing organisms. Some of these animals have been preserved almost intact by rapid burial in sea floor sediments.

Life in the Cambrian Sea

At this time in the earth's history life existed only in the seas. It included unique coral-like creatures called archaeocyaths which lived in reef communities attached to the sea floor in clear water. Primitive tiny snail-like molluscs crawled on the sea floor while worms burrowed in the sand.

The best known Palaeozoic organisms are the trilobites, ancient relatives of crabs, insects and woodlice. These had a hard but flexible external skeleton which allowed them to roll up for protection. They had gills, walking and swimming appendages, and jaws. Some had well developed eyes giving them a distinct advantage over competitors. Well adapted to the warm shallow clear Cambrian sea, they have been found in rocks of similar age all over the world.



Mountain Building

About 500 million years ago, the Precambrian and Cambrian sedimentary rocks of the Flinders and Mount Lofty Ranges, and Kangaroo Island, were heated and folded by compressive forces during a period of deep burial and mountain building. Changes to the rocks caused by heat and pressure increased in intensity southwards across Kangaroo Island, but were mild enough along the north coast to preserve delicate fossils.

Granite, formed from the melting of rocks deep in the earth's crust, was injected up into the sedimentary rocks and crystallised several kilometres below the earth's surface.

Erosion

During the next 200 million years the mountain belt, which extended northwards at least as far as Oodnadatta, was deeply eroded. A thickness of several kilometres of rock was removed, unroofing the granites.

At this time Australia formed part of a supercontinent called Gondwana which was drifting slowly around the southern hemisphere.

Glaciation

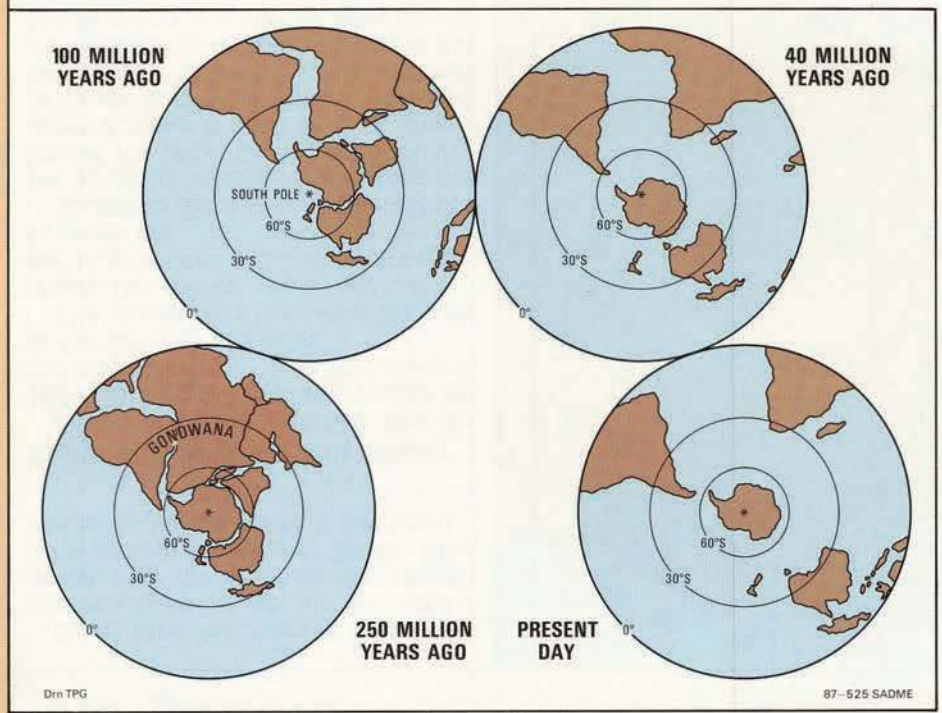
The supercontinent slowly drifted southwards eventually coming under the influence of a much colder climate at the beginning of the Permian period about 250 million years ago. An ice sheet formed and spread northwestwards across South Australia. As the ice moved over the land surface, it grooved and scratched rock faces and gouged out Backstairs Passage to over 300 metres below present sea level. Later in the Permian a warmer climate caused glaciers to melt and dump their load of boulders (called erratics), pebbles, sand, and clay far from their original source.

MESOZOIC ERA

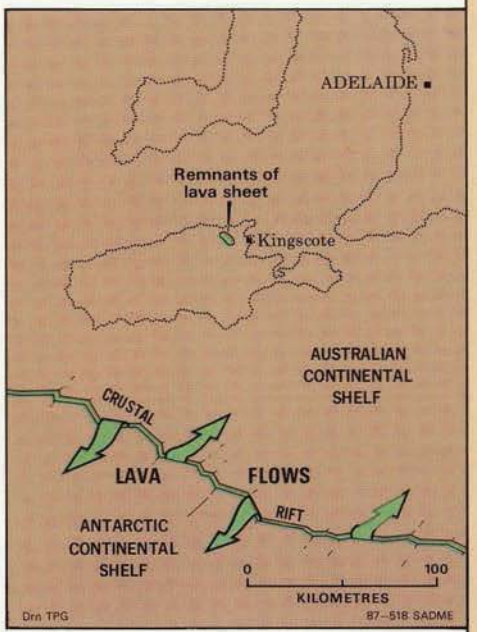
Jurassic lava flows

About 150 million years ago, during the Jurassic period, Gondwana became unstable and a deep rift developed in the crust along what is now the continental shelf south of Kangaroo Island. Lava extruded along this opening formed sheets of basalt which covered part of the island, infilling valleys and hollows in the land surface. Similar basalts are found in Tasmania and Antarctica. Erosion has since removed most of the lava sheet leaving only a small area left on the island forming the Gap Hills.

Gondwana had now begun to break up into fragments and eventually Australia separated from Antarctica and began to drift northwards.



During the Mesozoic era the supercontinent of Gondwana began to break up, eventually forming Australia, South America, Africa, India and Antarctica.



Part of Gondwana during the Jurassic period

CAINOZOIC ERA

The Tertiary Sea

Sea began to flood the gap between Australia and Antarctica, spreading into Gulf St Vincent. Australia's northward drift set up stresses in the crust and these were relieved by fault movements which lifted and lowered parts of the land surface.

Part of Kangaroo Island was lifted and tilted and an arm of the sea flooded the southern and central parts, isolating the MacDonnell Peninsula; at this time the rest of Kangaroo Island may have been joined to Yorke Peninsula. The warm shallow Tertiary sea which ebbed and flooded over parts of the island contained a rich variety of marine life some of which have been preserved as fossils. Many of these closely resemble shells found on modern beaches.

Another ice age

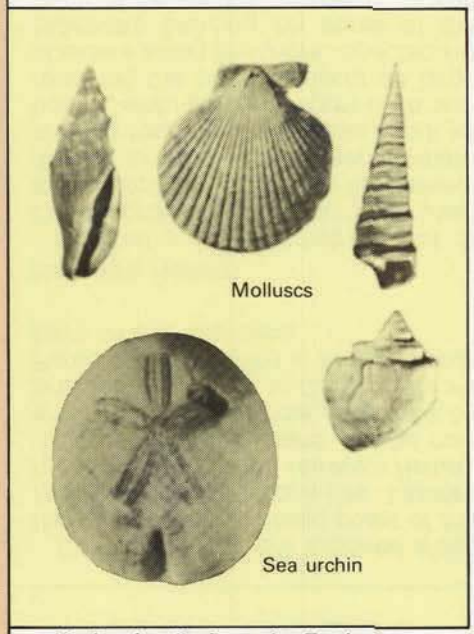
About 2 million years ago the climate began to change and become cooler. Large ice masses were formed in the Northern Hemisphere and the Antarctic ice cap began to expand. There is no evidence that ice extended to Kangaroo Island, but the region was affected by the many cycles of changing climates and sea levels that characterised the Quaternary Period. As the ice masses expanded, water was removed from the oceans, climates became colder and drier and sea levels fell. As the areas of ice contracted, climates became warmer and wetter and sea levels rose.

During periods of low sea level Kangaroo Island formed part of the mainland when a great alluvial plain extended southwards to the edge of the continental shelf. Across this plain flowed the extended Murray River and its tributary, the River Vincent. Evidence of submarine canyons carved by the Murray on the edge of the continental shelf has been found on the present sea floor.

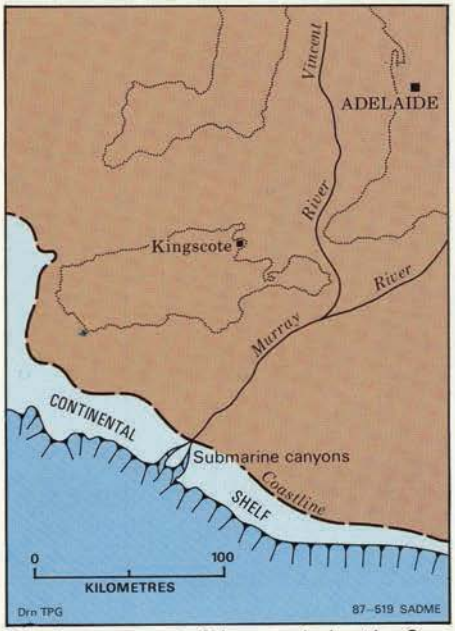
Thick coastal sand dunes were deposited as the shoreline migrated across the alluvial plain. These have since been hardened to aeolianite rock by the action of percolating rainwater and have been eroded to form steep cliffs along parts of the island's southern coast.

Aboriginal occupation

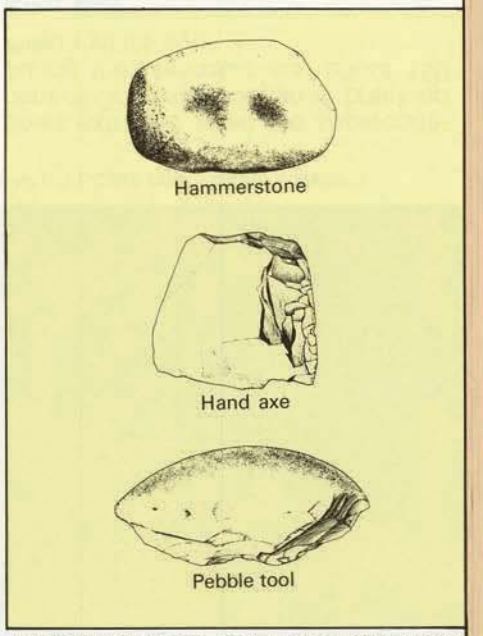
It is believed that Aborigines were living on the island before rising sea level isolated it from the mainland about 10 000 years ago. Stone tools, broken animal bones, and shells have been found at several localities providing evidence of ancient aboriginal occupation. At the time of discovery by Europeans in 1802, the island was uninhabited by Aborigines but the cause of their disappearance is unknown.



Marine fossils from the Tertiary sea.



Maximum retreat of the sea during the Quaternary ice age.



Aboriginal stone tools from Kangaroo Island.

Further reading

A Guide to the Geology and Mineral Resources of South Australia. S.A. Department of Mines and Energy.
Natural History of Kangaroo Island. Royal Society of S.A.

Geology and the Earth's History

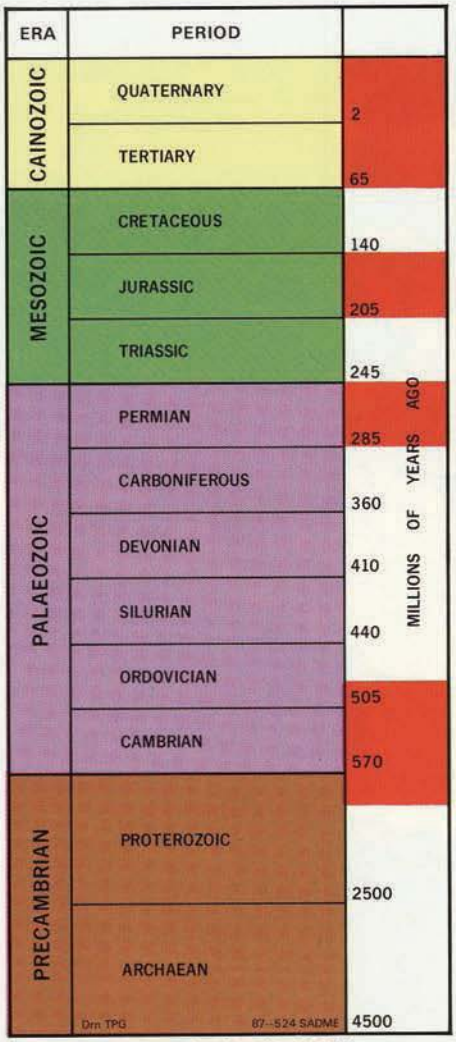
Geology is the study of planet Earth and the materials of which it is made. Geologists also study the processes which act on these materials and the history of the planet and its life forms.

Early geologists, working in the 19th century, relied almost entirely on information obtained from rocks exposed at or near the surface. Since then, many indirect methods such as deep drilling, geophysics, and satellite imagery have been developed. All of these techniques can be used to provide us with a picture of the history of our planet and of the time scale involved.

We know that the Earth formed around 4500 million years ago at about the same time as the solar system. Earth is believed to have condensed from a cloud of gas and dust, and to have passed through a molten stage from which the first rocks crystallised. Since then, a variety of natural processes have moulded and changed these early rocks to form the surface of the Earth as we know it today.

Rocks are divided into three classes according to their origins. *Igneous rocks,* such as basalt, have crystallised from molten material either on the surface or below ground. *Sedimentary rocks,* such as sandstone, have been formed from the weathering of existing rock into small grains which are carried by water, wind and ice and then laid down on land or under water. *Metamorphic rocks,* such as slate or schist, are formed by recrystallisation of any rock by heat and pressure, generally deep beneath the Earth's surface.

GEOLOGICAL TIME SCALE



The first rocks studied by geologists were mainly sedimentary in origin and their relationships were used to set up a geological time scale. By comparing their position with respect to each other and the fossils within them, the rocks were ranked in order of increasing age. This process has been refined so that nowadays most rocks can be assigned to the time scale, which has a universal application.

Until recently it was not possible to date rocks accurately and the geological time scale was based on relative ages and indirect estimates only. However, during the last fifty years, radioactive elements have been used as geological clocks. These elements emit radiation at constant rates to form more stable elements and the extent to which this has occurred gives a measure of the ages of rocks containing them. It is now possible to date certain rocks fairly accurately and express geological time in years.

The geological time scale forms the basis of this brochure, and the history of the rocks, together with the fossils found in them, is presented in order of the geological periods shown on the table.

Primary Industries and Resources
101 Grenfell Street, Adelaide SA 5000
May 2000

Front Cover: Remarkable Rocks

Back Cover: Looking across Cape Willoughby and Antechamber Bay (Department of Lands)

The geological history recorded by rocks exposed on Kangaroo Island spans about 750 million years.

Structures and fossils in the rocks show how this small area of the earth's crust has been inundated by ancient seas, heated and compressed by mountain building forces, deeply eroded and then covered by glaciers, lava flows, and shallow seas under changing climatic conditions.

For much of its history Australia formed part of Gondwana, a supercontinent in the southern hemisphere, together with what is now South America, Africa, India and Antarctica. About 150 million years ago Gondwana began to break up and, later, the piece that became Australia drifted northwards. At this time Kangaroo Island was part of the southern edge of this continental fragment. Later the island became an extension of Fleurieu Peninsula, and was finally separated from the mainland about ten thousand years ago by a global rise in sea level.

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