

Geoheritage of Kangaroo Island, with an emphasis on caves and karst

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Introduction

There are currently 21 sites on the South Australian geoheritage register for Kangaroo Island (Table 1). These can broadly be grouped into:

- a limited outcrop of Proterozoic rocks;
- Cambrian granites, sandstones and metasediments, with some fossil sites;
- Permian glacial deposits and striations;
- Jurassic basalt; and
- Holocene dune fields.

There are only two cave sites currently on the register: the Ravine des Casoar cave, near Cape Borda, and Admiral's Arch (as a part of Cape de Couedic). There is clearly scope to identify some cave and karst sites on the island to complement those already on the heritage register.

Table 1: Existing SA Heritage Sites on Kangaroo Island. Grid references UTM zone 53S

Site	Easting	Northing	Feature
Big Gully	733500	6060700	Cambrian White Point conglomerate and Boxing Bay formation; richly fossiliferous
Cape de Couedic	653600	6007700	Cambrian metasandstones, dune limestones
Cape D'Estaing	725100	6059400	Cambrian sediments and fossils well exposed
Cape Gantheaume	713600	6014700	Mobile Holocene dunefield
Cape Willoughby granite	781800	6031500	Cambrian granite overlying Early Cambrian Middleton sandstone
Christmas Cove	765500	6043300	Cambrian rocks overlain by Permian glacial deposits, excellent glaciated pavement
D'Estrees Bay	736100	6024000	Pleistocene dune limestone of Last Interglacial age
Emu Bay	727000	6058700	Cambrian Emu Bay shale fossils; trilobites
Harveys Return	648200	6042700	Metamorphosed Cambrian sediments with zebra rock (contorted bedding)
Kingscote foreshore	738600	6050600	Eocene bryozoal Kingscote Limestone in cliffs
Little Sahara	702500	6018800	Mobile Holocene dunefield
Old Government Quarry	739200	6051800	Jurassic Wisanger basalt overlying Permian sediments in quarry
Point Ellen	697100	6014100	Cambrian igneous migmatites with granite melts, overlain by Pliocene shell beds
Ravine des Casoars	642900	6038000	Pleistocene limestone; flank margin caves
Remarkable Rocks	658300	6009300	Cambrian granite weathering, xenoliths
Smith Bay	722300	6058200	Permian shales and glaciated pavements
Snapper Point	773800	6041000	Neo-Proterozoic metamorphic rocks of Adelaide geosyncline
Stokes Bay	699800	6055600	Pleistocene dune limestone overlying Early Cambrian rocks
West Bay	639800	6027300	Cambrian Middleton sandstone with sedimentary structures
Wilson River dune	765200	6028600	Holocene dune overlying floodplain deposits, bedding very clear

Geological Overview

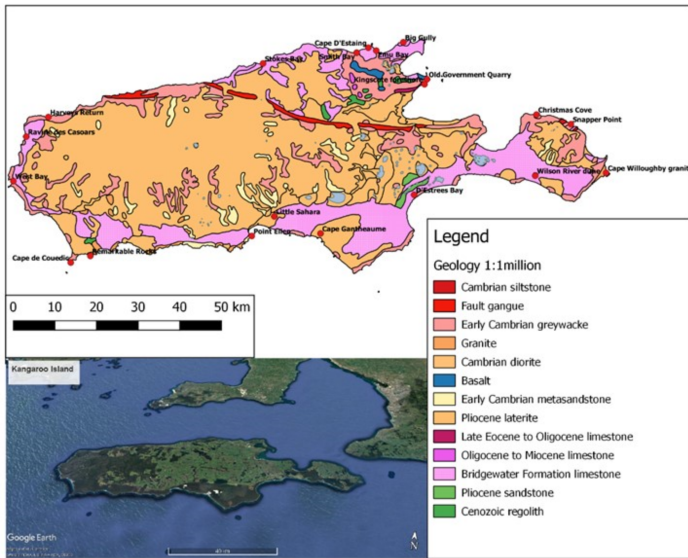
The broad geology of Kangaroo Island is made up of a central plateau capped with late Neogene laterites, probably of Pliocene age, with deep weathering profiles and ferricrete nodules. On the north coast, the underlying Cambrian sandstones and metasediments are exposed at the coast. These are part of the widespread Kanmantoo group of South Australia. There are similarities with the geology of the Fleurieu Peninsula and the Mount Lofty Ranges. The sandstones are steeply dipping and are unconformably overlain by phyllites and other metamorphic rocks formed in a shear zone associated with the Cygnet-Snelling fault. That feature is dominant in the topography of Kangaroo Island and extends from near Kingscote to Snelling Beach on the north-west coast. The Cambrian sandstones and siltstones were deposited in a deep oceanic trench and, as sediments accumulated, the depression of the crust initiated igneous intrusions around 400 million years ago. These are today represented by a number of granite outcrops along the south coast and on the Dudley Peninsula, most noticeably at Cape Willoughby. The best-known example of this granite is the Remarkable Rocks.

During the Permian, much of Australia was covered with ice sheets, as the landmass was much closer to the South Pole. Ice flowed north north-westwards in a trough be-

tween the present-day Dudley Peninsula and the main mass of Kangaroo Island. Glacial striations can be seen at Christmas Cove near Penneshaw and at Smith Bay, while glacial tillites and some erratics are found at Boxing Bay on the northern extremity of the island. During the Jurassic, extensive lava flows were extruded to the west of Kingscote in the Wisanger area. There was extensive uplift and folding of the landmass of Kangaroo Island during the Neogene and this is best seen on the extreme west coast of the island to the north and south of West Bay. During the Pleistocene, high sea levels facilitated movement of carbonate-rich shelly sand on to the landmass forming a series of coastal dunes.

There are at least four phases of dune building and consolidation of that material to form the dune limestone or aeolian calcarenite. Soils formed on each dune deposit and these can be seen today in section on the coastal cliffs.

These dune limestones are widespread on the southern and western coasts of Kangaroo Island and are broadly contemporaneous with the Bridgewater Formation in western Victoria and south-eastern South Australia. Karst features are widespread on the dune limestone; in excess of one hundred caves and karst features have been recorded.



Generalised geology of Kangaroo Island. Based on Kingscote Special sheet S153-16, Geological Survey of South Australia.

Heritage sites

Admiral's Arch

This iconic site is a sea cave in Pleistocene dune limestone overlying Cambrian metasandstone. There are numerous outside stalactites in the roof of the Arch. There are also extensive shore platforms on the gently dipping sandstone and a raised beach in the Arch has been dated to 122,000 years ago. This beach deposit has analogues elsewhere on the island, where raised conglomerate beach deposits form benches 5-6m above present sea level. The site and neighbouring Weirs Cove show flank margin caves at several levels related to Pleistocene uplift. This is an important site for tourism and a Long-nosed fur seal colony is usually present in the Arch.



Admiral's Arch: Pleistocene dune limestone overlying Cambrian sandstone

Remarkable Rocks

These residual tors or inselbergs on the south coast are formed in the Remarkable Granite, which is circa 500 million years old and is thus of Cambrian age. Some deformation of the granite occurred about 400 million years ago, and xenoliths (foreign stones) of metasandstone occur in the mass of the granite. Isolated blocks of granite or koppies lie on a rounded dome of granite with well-

developed sheeting joints due to exfoliation (pressure release). There are particularly fine examples of cavernous weathering, tafoni and solution runnels on the outcrops. Salt weathering due to spray and subsequent wetting-drying cycles aid the granular disintegration of the bedrock. There has been a great deal of spalling of the lower rock surfaces due to the extreme heat from the recent bushfires.



Remarkable Rocks in February 2020 after the bushfires

Some additional heritage sites?

Kelly Hill caves

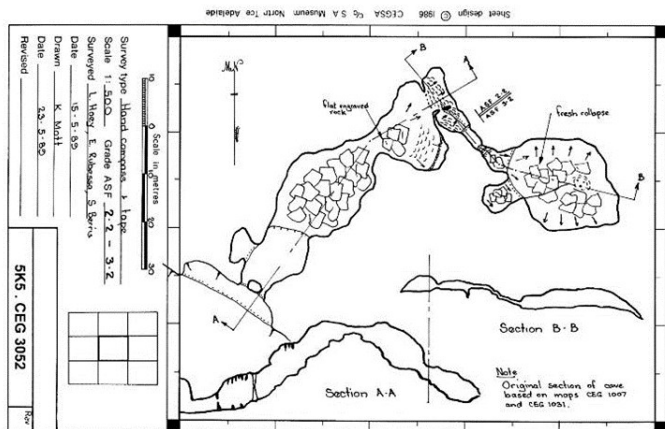
These caves in Pleistocene dune limestone are probably the best-known on Kangaroo Island and a section of the main cave, KH11, is open to the public. The original entrance, K1, consists of two solution pipes which enter the show cave. There is a series of collapse domes, linked by short rift passages. Originally, there was a shallow lagoon just to the north the cave with multiple water entry points into the karst. Progressive lowering of the water table led to a loss of stability of the cavities with roof breakdown forming a series of tensional arches. This mode of cave formation, first described here by Alan Hill of CEGSA, appears to be quite widespread in dune limestones. The cave has abundant speleothems derived from percolation water from the surface. Large collapse blocks are also covered in flowstone and stalagmites, whose orientation suggest ongoing movement of the blocks. The cave is also important for fossils and palaeoclimate studies carried out by scientists from Adelaide and Flinders Universities.



Typical speleothems and evidence of collapse at Kelly Hill

Ravine des Casoars

This is a deep valley running inland from the coast south of Cape Borda, with several flank margin caves. First named by the French explorer Nicholas Baudin in 1803, who thought the now extinct dwarf emus there were casowaries. It was also home to a group of shipwrecked French sailors in 1815, who left an engraving on a flat rock well within the cave. The present entrance is at sea level and the cave is best visited at low tide. The cave has two collapse domes linked by a short passage, with abundant speleothems. There are several other flank margin caves in the north wall of the valley near this cave, and some large dolines to the north and south.



Map of K5 cave at Ravine des Casoars, courtesy of Kevin Mott and CEGSA

Cape Dutton sea cave

This site is located on the north coast of the island, to the west of Stokes Bay. A thick sequence of Bridgewater Formation dune limestone overlies Cambrian sandstones, and is exposed in cliffs 50m high. The cave is located at the contact of the sandstone and limestone and its horizontal tunnel 80m long has a floor of sand and rounded boulders. Its entrance is 5-6m above present sea level, which would suggest that it relates to the Last Interglacial sea level some 125,000 years ago. There are several marine terraces, gravel and cobble deposits at this level at Admirals Arch and at Kingscote along the coast of Kangaroo Island. Below the entrance, windblown sand forms a ramp leading to the entrance.



Sea cliff in dune limestone overlying Cambrian sandstone at Cape Dutton. Sea cave at contact of sandstone and dune limestone with a ceiling height 3m. The cave extends 80m into the cliff

The cave is located on private property and is reached by climbing down a steep ridge to the sea. A large sea eagles' nest above the cave has been occupied by a breeding pair for the last 30 years.

Vennachar Point and West Bay

At the extreme western end of the island, West Bay is a deep harbour regularly used by yachts. To the north of the bay is Vennachar Point, the site of the 1905 wreck of the Loch Vennachar wool clipper. Wreckage from this ship was spread along the southwest and south coasts of the island; there were no survivors. In the days of sail, ships frequently came to grief on this cliffed coast, fully exposed to westerly winds and the Southern Ocean. To the north of the point are deep gulches or geos cut into the Cambrian sandstone, and capped with Pleistocene dune limestone. The massive sandstone dips gently to the northwest and forms tall cliffs and shore platforms.



Aerial image of geos and a deep shaft north of Vennachar Point. Image sourced from Location SA viewer <http://location.sa.gov.au/viewer/>

This site is on a very high energy coast with many deep embayments and geos. Further north, towards Ravine des Casoars, are several large dolines formed in the dune limestone—these are, as yet, unexplored.

Boar Beach trace fossils

This site is located on private property on the southern shore of the Dudley Peninsula. It has been studied in detail by Camens et al. (2017). A series of trace fossils or animal tracks occur within cross-bedded dune limestone (calcarenite) of the Bridgewater Formation. The tracks are exposed in gently dipping laminae of the calcarenite, within the tidal zone, and are periodically covered by sand.

There are several trackways as well as individual footprints of reptiles, shorebirds, extant species such as possums, kangaroos and the Tasmanian Devil.

Of particular interest are the tracks of large extinct marsupials such as diprotodons, short-faced (sthenurine) kangaroos, and thylacines. Possible contenders for the diprotodontid tracks include the giant wombat *Phascolonus gigas*, the "marsupial tapir" *Palorchestes azael* and a juvenile diprotodontid (*Diprotodon optatum* or *Zygomaturus trilobus*).

The deposits have been dated using Optically Stimulated Luminescence (OSL), which dates the last time the sediment was exposed to sunlight. Samples taken above and below the trace fossil layer are indistinguishable at their uncertainty ranges and suggest that the fossilized dune sequence accumulated relatively rapidly. The consistency of the dating results provides a mean age of 135,000 years for the trace fossils at Boar Beach. This puts them in the middle of the Last Interglacial when sea level was higher, and the climate warmer and wetter. A concentration and overprinting of tracks at one point suggest animals were congregating to drink at a shallow freshwater lagoon at the back of the beach.

side stalactites up to 35m above present sea level. About 1km west of the access track, fulgurites are well exposed on a cliff-top dune. These are formed in sand when lightning hits the ground, fusing and vitrifying the grains into hollow tubes about 20cm long, with some minor branching.



Sea stacks in early Pleistocene limestone



Tracks of an extinct juvenile *Diprotodontid*

Effects of 2019-2020 bushfires

In December 2019 and early January 2020, most of the western half of Kangaroo Island burnt in catastrophic bushfires. Strong northerly winds and high fuel loads in native vegetation areas created conditions well beyond the best efforts of firefighters. A total of 165,000ha was burnt, with fire intensity only patchy at the eastern extremity of the fireground. Most of Flinders Chase NP was burnt, although there were unburnt patches along deep gullies on the west coast of the island. Losses of wildlife were very high, despite a concerted effort by several agencies to treat injured marsupials and eradicate cats preying on endangered species such as dunnarts. As a result of the fires, 80 houses were burnt. A large number of sheds and many hundreds of kilometres of fences were destroyed. The Kangaroo Island community is resilient and people have worked together to rehabilitate land and livelihoods in the ensuing ten months. The island economy is slowly recovering and visitors are now very welcome. Flinders Chase NP is progressively re-opening to visitors as facilities are rebuilt and burnt areas rendered safe from falling trees and branches.

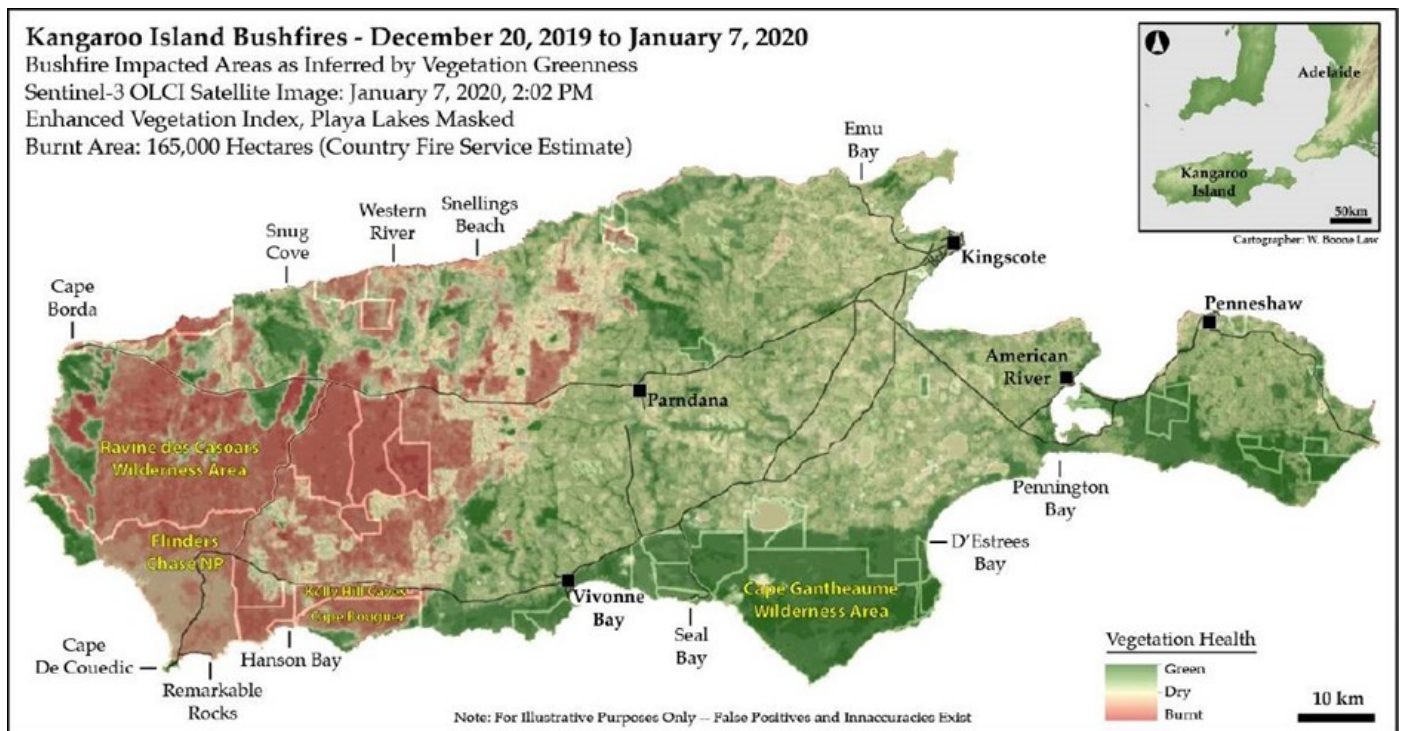
Many karst areas on the western half of the island were burnt. At Kelly Hill Conservation Park, almost the entire area was burnt, including all above-ground infrastructure. Fire intensities were high resulting in widespread spalling of limestone outcrops; baking of soil; and washing of soil and charcoal into closed depressions and cave entrances following intense rainfall of 60mm in late January. Prompt and effective action by Parks SA staff limited washing of fine sediment into the show cave. Sediment and charcoal washing downslope across the main road diverted water flows and partially blocked the three main water sink points along the northern side of Kelly Hill. Within two months of the fires, resprouting of yaccas (grass trees or *Xanthorrhoea semiplana*) and mallee eucalypts was evident and widespread. Subsequently, other native genera such as *Isopogon*, *Petrophile*, *Acacia paradoxa* and *Banksia* have resprouted, while a ground cover of native grasses and *Scaevola sp.* has established.



Tracks of a large short-faced (*Sthenurine*) kangaroo

Flour Cask Bay

This site is located on the exposed south coast of the island, at the eastern end of D'Estrees Bay. The name derives from cask markers mounted on poles to guide sailors into a whaling station established there in the early 19th century. There are sea cliffs 40-50m high, formed in mid-Pleistocene Bridgewater Formation dune limestone overlying early-Pleistocene Cape Hart limestone. At the base of the cliffs are well developed shore platforms and small sea stacks, with solutional potholes and tafoni in the dense limestone. Several pedogenic calcrete layers are visible in the cliffs, with flank margin caves and out-



Further reading:

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