

The geodiversity of Australia



An introduction to The geodiversity of Australia

This is a pdf of an online presentation given on 26 November 2022. The original PowerPoint file contained 33 embedded video clips that have had to be removed. Talking head clips have been replaced with blue boxes like this, while Google Earth zoom-ins have had to be deleted entirely. Video scripts follow each slide, with voiceovers for the zoom-ins highlighted in grey.

The original presentation also contained several animations, like fading a satellite image to a geological map, then back to the image again. For those you'll just have to use your imagination 😊



Opening

Hello and welcome to my take on the geodiversity of Australia.

Firstly, I'd like to acknowledge and pay my honest respects to the traditional custodians of this land, the various Aboriginal peoples who have a deep understanding of country, having lived here for more than 40 000 years. In many Aboriginal languages around the coast there are stories of hills that, over time, became islands in an event that today we call the Post Glacial Marine Transgression. Knowledge of that sea level rise has been preserved across hundreds of generations by word-of-mouth oral history. Respect.

Geodiversity is everywhere you look, making the geodiversity of Australia a rather ambitious topic, so this is going to be nothing more than an introduction. Over the next 25 minutes I'll be cherry picking just a few examples, but let's start with an overview.

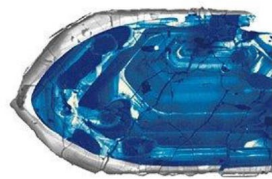
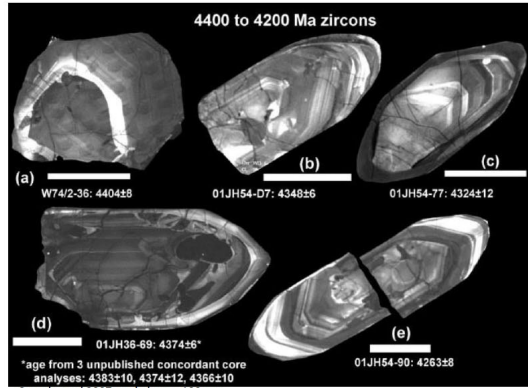
Google Earth start

Continental Australia is currently located a safe distance from tectonic plate boundaries and has been largely spared the landscape rejuvenating effects of Quaternary glaciation. Australia could be considered an old continent.

It has a rusty red, interior with some green margins. It's been worn down to the flattest continent on Earth. Ancient. So old in fact that rocks of the Jack Hills in Western Australia contain the oldest known minerals on Earth



Jack Hills: Earth's oldest known minerals – up to 4.4 Ga



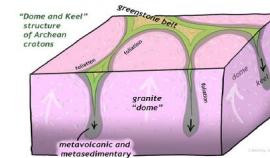
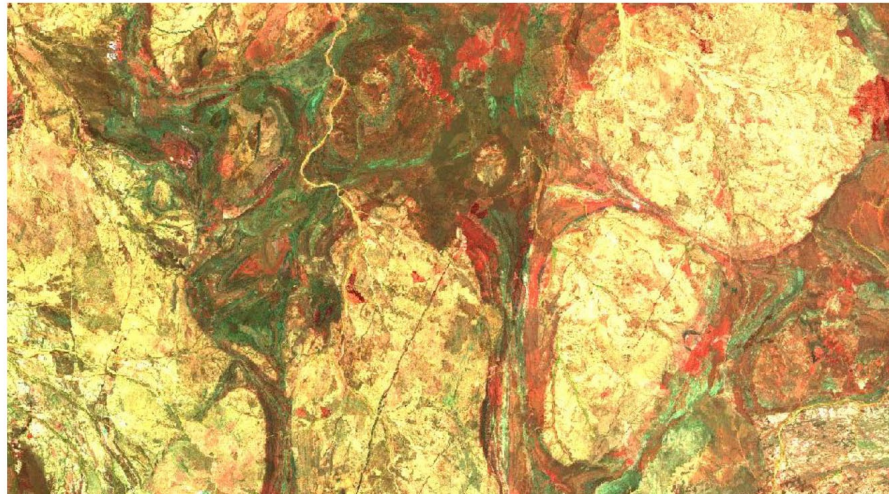
Jack Hills

These are detrital zircons contained in an Archean conglomerate. Of those that have been uranium – lead dated, about 10% have returned ages of more than four billion years, with the oldest clocking in at a staggering 4.4 billion years. Which means that little crystal grew a mere 150 million years after the initial formation of the Earth itself.

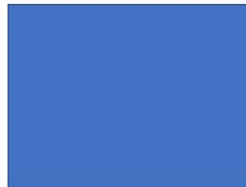
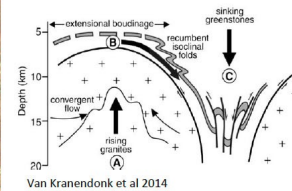
For what they can tell us about that Hadean crust, these zircons have been the subject of more than 50 scientific papers over the past 30 years. Also, just last month IUGS – the International Union of Geological Sciences – recognised their significance by including the Jack Hills in their list of the first 100 IUGS global geoheritage sites.

A long day's drive to the north – or just a short hop on Google Earth - Western Australia also contains some of the oldest stable crust on Earth - the Pilbara granite-greenstone terrain.

Ancient crust: Pilbara granite – greenstone terrain



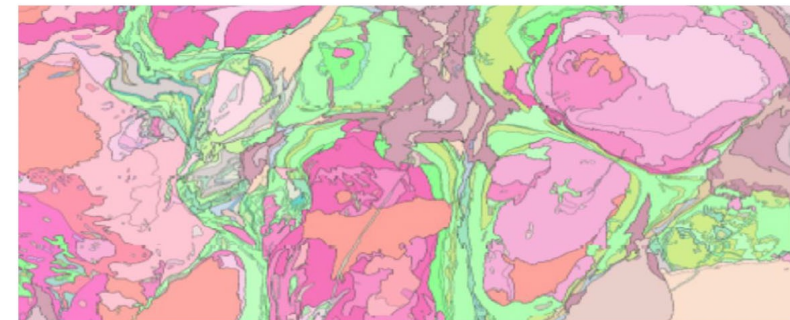
Opengeology.org



Pilbara granite-greenstone terrain

This began forming more than 3.6 billion years ago – in other words only shortly after the Late Heavy Bombardment had finished annihilating any earlier proto-crust. It represents a tectonic style unique to the Archean. Back then the planet was hotter than now, and that early crust was little more than a thick pile of dense basaltic lava, although intercalated sediments do indicate the presence of surface water. As the basaltic crust thickened with further volcanic activity, it started melting at its base. That initial partial melt was dominated by the product of minerals with the lowest melting temperatures. That enriched the melt in silica and aluminium – making it granitic in composition and less dense than the overlying basalt. So, the granite rose in balloon-like plumes, while the denser basalt folded and sank around them in a process called gravitational inversion. Looking at the satellite image, I find it astounding just how little imagination it takes to visualise what happened so long ago. There's also enough on-ground evidence to prompt calls for a Pilbara geopark.

... And while still on the subject of old things, Australia is the place where fossils of the earliest multicellular animals were first discovered - in the Flinders Ranges



Flinders Ranges, South Australia



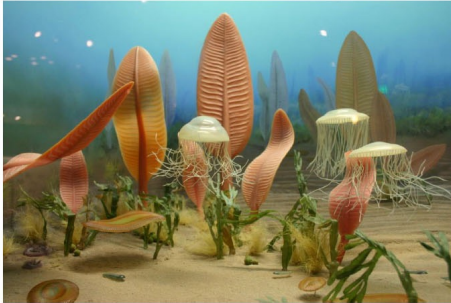
Peter Neaum



Merikanto



ABC.net.au



Ryan Somma



Flinders Ranges

Geologist Reg Sprigg initially had a hard time convincing his peers, including Douglas Mawson, that these were true Precambrian fossils. But now they are recognised as the Ediacaran fauna, which forms the basis of the first 'new' geological period identified in 120 years. The base of the Ediacaran is marked by an IUGS golden spike in Brachina Gorge – the only one in the southern hemisphere.

The events of the Cryogenian 'snowball Earth' episodes through the Ediacaran to the Cambrian explosion represent a critical period in Earth history and there is no other place on Earth where these are recorded in a near-continuous succession of highly accessible strata. For that reason, the Ediacara Hills are second of the three Australian sites recognised in the IUGS list of its first 100 geoheritage sites. Furthermore, parts of the Flinders Ranges were officially nominated for World Heritage listing in April last year...

World Heritage

Selection criterion (viii):

... to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.



Grant Dixon

Theme 1: History of planet Earth and the evolution of life

Theme 2: Tectonic systems

Theme 3: Erosional systems

Theme 4: Volcanic systems

Theme 5: River, lake and delta systems

Theme 6: Cave and karst systems

Theme 7: Coastal systems

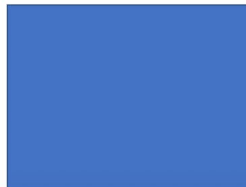
Theme 8: Marine systems

Theme 9: Glacial and periglacial systems

Theme 10: Desert and semi-desert systems

Theme 11: Meteorite impacts

McKeever and Narbonne 2021



World Heritage sites

... And for the remainder of this talk I'll be focusing on Australian World Heritage sites listed for their outstanding universal geodiversity values. Aspects of geodiversity are relevant to several of UNESCO's World Heritage criteria, including number 7 (aesthetics) and number 9 (ecosystems). This is shown in this spectacular image of New River Lagoon in the Tasmanian Wilderness World Heritage Area. Its entire 290 km² catchment is undisturbed by post palaeolithic technology and hosts an endemic palaeobiota of Gondwanan affinity.

However, the key World Heritage criterion for geodiversity is number 8, which looks at:

*major stages of Earth's history,
the record of life,
on-going geological processes
or significant geomorphic or physiographic features.*

Criterion 8 has been subdivided into 11 major themes and there are Australian World Heritage sites recognised for nine of those.

So, let's look at each of those Aussie World Heritage sites. Theme one is the history of Earth and the evolution of life. The first site is again in Western Australia – Shark Bay

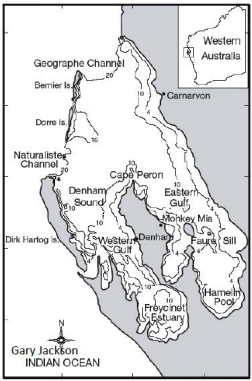
Theme 1: History of planet Earth and the evolution of life

Shark Bay



SharkBay.org

Living stromatolites flourish in Hamelin Pool because its salinity is twice that of seawater, which limits grazing herbivores



Gary Jackson



SharkBay.org



Shark Bay

For the best part of two billion years the fossil record of life on earth was largely limited to microbial mats and stromatolites. They thrived simply because there was no other life form around that was advanced enough to eat them. Then they all but disappeared as soon as the simplest of animals first evolved.

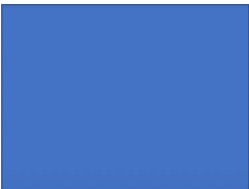
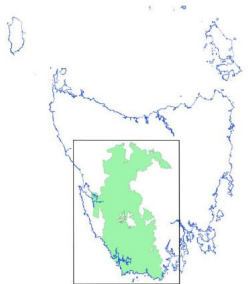
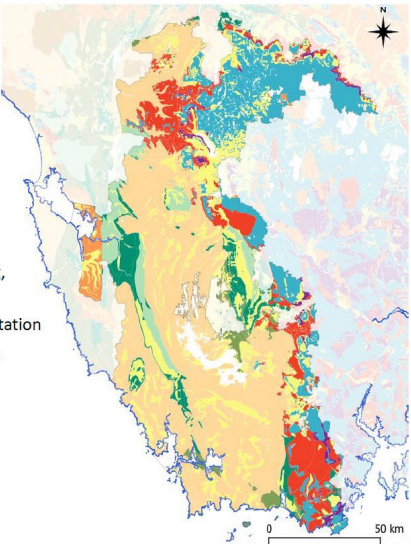
However, in a few places with exceptional environmental conditions that no herbivore can tolerate, living stromatolites persist to this day. One of those places is Shark Bay, which was World Heritage listed in 1991 especially for its stromatolites. Here the shallow Faure Sill limits water circulation into Hamelin Pool which, due to the high evaporation rate, is hypersaline - about twice as salty as seawater. The microbes can live with that, but their predators can't.

Tiny living stromatolites have also recently been discovered in the Tasmanian Wilderness, but that's another story, because the Tasmanian Wilderness was World Heritage listed for, amongst six other criteria, the preserved record of its geological history...

Theme 1: History of planet Earth and the evolution of life

Tasmanian Wilderness

Cenozoic	Quaternary	Quaternary: periodic glaciation
	Neogene	Paleogene – Neogene: rifting and drifting
	Paleogene	
Mesozoic	Cretaceous	Cretaceous: erosion, basal graben sediments?
	Jurassic	Jurassic: Dolerite intrusion correlated with Karoo-Ferrar LIP
	Triassic	Triassic: - semi-arid fluvial basin
Paleozoic	Permian	Late Carboniferous – Permian: basin sag, Paleozoic glaciation
	Carboniferous	
	Devonian	Devonian: Gondwana accretion, folding, thrusting, granite emplacement: Tabberabberan Orogeny
	Silurian	Silurian: predominantly siliceous marine sedimentation
	Ordovician	Ordovician: post orogenic flysch followed by thick marine limestone
	Cambrian	Cambrian: volcanics, and clastics, ophiolite obduction, Tyennan (aka Delamerian) Orogeny
Neoproterozoic		Late Mesoproterozoic – Neoproterozoic: shelf sedimentation
Mesoproterozoic		



Tasmanian Wilderness

... Which I'll summarised by progressively adding layers to the geological map. It starts with the idea that Tasmania has not always been part of Australia.

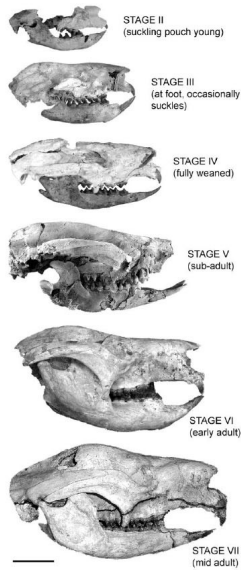
- Some of the Mesoproterozoic basement rocks have been correlated with formations exposed in the Grand Canyon, which if correct would make early Tasmania quite the traveller.
- The Cambrian Tyennan Orogeny (known as the Delamerian on mainland Australia) saw volcanism and ophiolite obduction *as part of Gondwana accretion*.
- That was followed by a post orogenic flysch sequence and then thick marine limestone through the Ordovician.
- The Silurian saw predominantly siliceous marine sedimentation as the basin deepened.
- The next big event was further accretion of this part of Gondwana in the Devonian Tabberabberan Orogeny.
- The Late Carboniferous to Permian saw basin sag and the Late Paleozoic glaciation in a predominantly shallow marine environment.
- While a changing climate and relative uplift meant mostly semi-arid fluvial deposition through the Triassic.
- The Jurassic saw the onset of Gondwana breakup, with huge dolerite intrusions that are part of the Karoo-Ferrar large igneous province.
- The Cretaceous was a period of erosion and planation, leaving extensive remnant erosion surfaces...
- ... Which have been offset by block faulting associated with the separation of Australia from Antarctica. The grabens then filled with terrestrial sediment.
- And finally, the Quaternary record is one of periodic glaciation and sea level oscillation.

With this rich and varied geological history there can be little doubt that the Tasmanian Wilderness World Heritage Area – and Tasmania in general – is a global geodiversity hotspot.

Also within the theme of Earth history and the evolution of life are two key fossil mammal sites separated by 2000 km and almost ten million years.

Theme 1: History of planet Earth and the evolution of life

Australian fossil mammal sites



Nimbadoron ontogeny
Karen Black



D Dunphy



Karen Black



Australian fossil Mammal Sites

Their importance lies in the fact that after 35 million years of isolation the Australian mammal fauna is the world's most distinctive (some might even say weirdest).

The older site is at **Riversleigh**, where freshwater limestone spanning the Oligocene – Miocene epochs hosts a 20 million year record of mammal evolution as the habitat changed from humid lowland rainforest to dry eucalypt forest and woodland. Fossils include the first records for many distinctive groups of living mammals and some of the most unusual animals in the [Australian fossil](#) record, like Thylacynodont and Fangaroo. Fossils of some species, like the arboreal diprotodont *Nimbadoron lavarackorum*, are so abundant that a complete sequence of development, from pouch young to mature adult, can be reconstructed. Wow!

Later, at Naracoorte, limestone caves started forming at least 1.34 million years ago in the Eocene to Miocene Gambier Limestone. These opened to the surface around 600 thousand years ago, forming pitfall traps and owl roosting sites that collected animals for at least half a million years, spanning several ice ages, the arrival of humans and the extinction of the Pleistocene megafauna. Almost 100 vertebrate species have been discovered here and many are exceptionally well preserved, with some, like this thylacoleo, on display.

And lastly within the history and evolution theme, I've grouped together two separate World Heritage areas with a rainforest focus. The Wet tropics in the north and Gondwana rainforests in the south.



Steven Bourne



Julian Hume



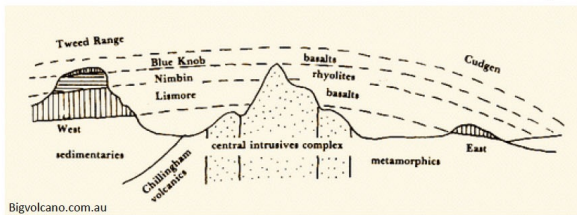
Karora

Theme 1: History of planet Earth and the evolution of life

Gondwana Rainforests and Wet Tropics



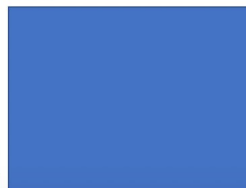
Wollumbin Mount Warning, NSW AUSTRALIA



Bigvolcano.com.au



BriMiDra



Tweed Regional Museum

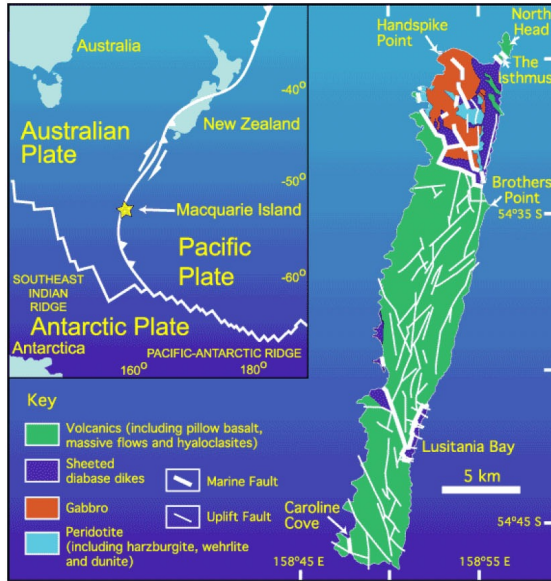
Rainforests and Wet Tropics

The first is **The Wet Tropics**, which is the largest area of the entire Australasian region in which rainforests have persisted continuously since Gondwanan times. It contains one of the most complete and diverse living records of the evolution of land plants, from Mesozoic pteridophytes through early southern gymnosperms and on to the angiosperms. All Australian marsupials originated in rainforest ecosystems and the Wet Tropics still contains many of their closest surviving relatives.

The second of the pair is the **Gondwana Rainforests**. Apart from the vegetation, this contains a north to south sequence of Cenozoic shield volcanoes that erupted as the Australian continental plate moved northwards over a mantle hot spot. One of those volcanoes is the Tweed Shield, where the "erosion caldera" is regarded the best-preserved example in the world. Without denying outstanding universal value under other criteria, that does strike me as a somewhat contrived accolade for criterion viii: the best-preserved example of what ... a state of degradation?

But moving on, the second theme under criterion eight is tectonic systems, and for that we look at Macquarie Island which is located in the Southern Ocean some 15 hundred kilometres southeast of Tasmania.

Theme 2: Tectonic systems – Macquarie Island



ABC.net.au

A unique exposure of typical oceanic crust *in situ*

Macquarie Island

It's the exposed summit of the Macquarie Ridge Complex, which forms the active oceanic transform boundary between the Australian and Pacific tectonic plates. The island exposes the eastern side of the otherwise submarine ridge and lies about 4.5 km east of the major boundary fault zone itself. Macquarie Island is globally unique in that it is the only exposed piece of typical oceanic crust still lying within the basin in which it formed. And by typical, I mean that unlike Iceland or Hawaii, it's unrelated to any hot spot plume. Although disrupted by later faulting, the island exposes a complete cross-section through normal oceanic crust, from pillow lavas and sediment through sheeted dolerite dykes, coarse gabbro and right on down to the basal ultramafics.

The third theme under criterion eight is erosional systems, and for that we travel back to Western Australia, to Purnululu, also known as the Bungle Bungle Range.

Theme 3: Erosional systems – Purnululu



Macleaite



David Nicholson

Purnululu

This is an exceptional cone karst developed in Devonian sandstone. Chemical weathering has leached much of the intergranular cement from the sandstone, leaving the rock with little shear strength, but retaining its high compressive strength. That combination has allowed erosion to cut the steep gorges separating the many domes. The striking grey bands on the orange rock are not an intrinsic feature, but are due to cyanobacteria, which grow on slightly damper layers of the sandstone.

The only other entry under the theme of erosional systems is * this well-known icon, which is the third of the three Australian sites recognised in the IUGS list of its first 100 geoheritage sites.

Next up, the fourth theme under criterion eight is volcanic systems and here we must again look to oceanic islands to find the only active Australian volcanoes in one of the remotest places on Earth, more than 4000 kilometres southwest of Perth.

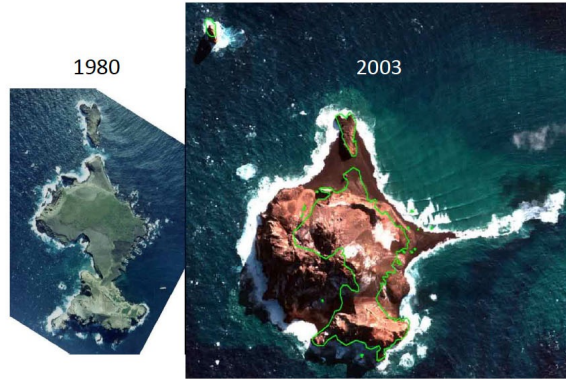


Corey Leopold

Theme 4: Volcanic systems – Heard and McDonald Islands



A.J. Graff



Geoscience Australia



Wikivoyage



Heard and McDonald Islands

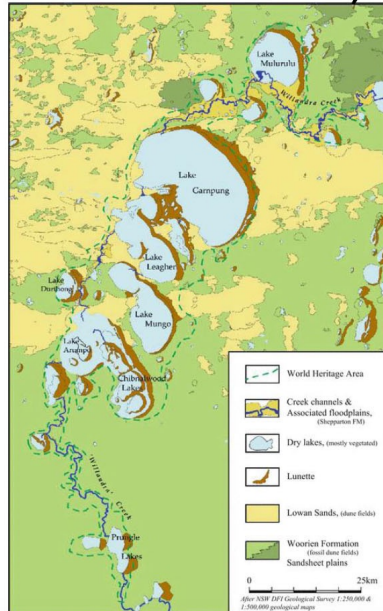
Heard and McDonald Islands are distinctive among oceanic islands in that their foundation is a major submarine plateau. In contrast to Macquarie Island, the Kerguelen Plateau owes its existence to a hotspot that formed during Gondwana breakup about 130 million years ago. It existed for a while as a microcontinent but sank 20 million years ago and now lies a kilometre or two beneath the waves. The continuation of volcanic activity at Heard and McDonald Islands means it is the world's longest known operational plume system.

A notable feature of Heard is the presence of Australia's only active glaciers outside Antarctica.

Both islands are also remarkable for their undisturbed ecosystems, which is perhaps not surprising, since they're pretty difficult places to visit.

And now back on the mainland, we'll look at the one Australian example listed under theme five – river, lake and delta systems – the Willandra Lakes

Theme 5: River, lake and delta systems – Willandra Lakes



Stern 2014



The Pale Ridah



Eleanor Hilton



Willandra Lakes

These are a relict system in semi-arid southwestern New South Wales. The area's main claim to fame is an archaeological record that dates back perhaps as far as 60 000 years includes the skeletons of Mungo Man and Mungo Woman.

However, the sediments, landforms and soils contain an outstanding record of Pleistocene climatic oscillations within a low-altitude, non-glaciated landscape. This not only places the archaeological record in context but satisfies criterion eight in its own right. Of particular interest are the clay lunettes on the lakes' eastern shores. These formed over 140 000 years as the lakes intermittently dried out, leaving behind salts that helped liberate the clay bed, allowing the wind to blow clay pellets to the lee shore. The lakes last dried out about 18 500 years ago, and without further input the lunettes have been subject to erosion ever since.

Theme 6: Cave and karst systems



All photos: Rolan Eberhard



Cave and karst systems

And on to theme six - Cave and karst systems. Purnululu is listed under the karst theme, while Naracoorte is of course also a karst system. The Tasmanian Wilderness also has some well-developed karst, including Australia's deepest cave, which is measured at 401 vertical metres from the Delta Variant entrance to the bottom of Growing Swallet. And there are many other well-known cave systems in the country, including Jenolan, Buchan, Yarrangobilly and Margaret River, to name a few.

However, the hottest contender for the next Australian World Heritage listing under the karst theme must be the Nullarbor karst. This is recognised as the world's largest exposed karst terrain and is formed in the monotonously flat lying Eocene to Miocene Eucla Group Limestone. Karst forms when water dissolves susceptible rocks, mostly carbonates. So how could that happen in a semi-desert terrain? It didn't. The Nullarbor karst formed during the wetter climate of the Pliocene, with the peak of karst activity around 4.2 million years ago. Amazingly, even the most delicate formations, like straws, date from around that time. It's a fossil underground landscape of unparalleled antiquity.

Toward the younger end of the age scale, coastal systems are for the most part Holocene landscapes. We've already looked at Shark Bay and glimpsed the wild coast of southwest Tasmania, but the headline act under the coastal theme is K'Gari.

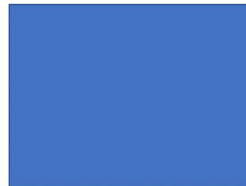


Woodhead et al 2019



Woodhead et al 2019

Theme 7: Coastal systems – K'Gari



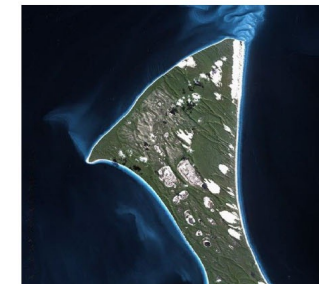
K'Gari

Briefly known as Fraser Island, K'Gari is the largest sand island in the world and has long been recognised as representing an outstanding demonstration of the process of longshore drift. Inland from the beach, Holocene parabolic dunes are superimposed on one of the longest and most complete age sequences of coastal dune systems anywhere, with the earliest sands dating back 1.2 million years. Deeply leached podsol soils on the older dunes are up to 25 m thick, far exceeding known depths of podsoles anywhere else. And nestled among the dunes are an exceptional variety of wetlands, including parts of the largest subtropical patterned fen complex in the world and what's said to be half the world's perched freshwater dune lakes. K'Gari is certainly an exceptional island in many ways. But that's not all.

A paper published in Nature Geoscience earlier this month put the case that by blocking the northward drift of sediment along the coast and leaving clear water in its wake, the presence of K'Gari has allowed development of the Great Barrier Reef.



Genet



CNES SPOT image



Korkut Tas

Theme 8: Marine systems – Great Barrier Reef



Ayanadak123

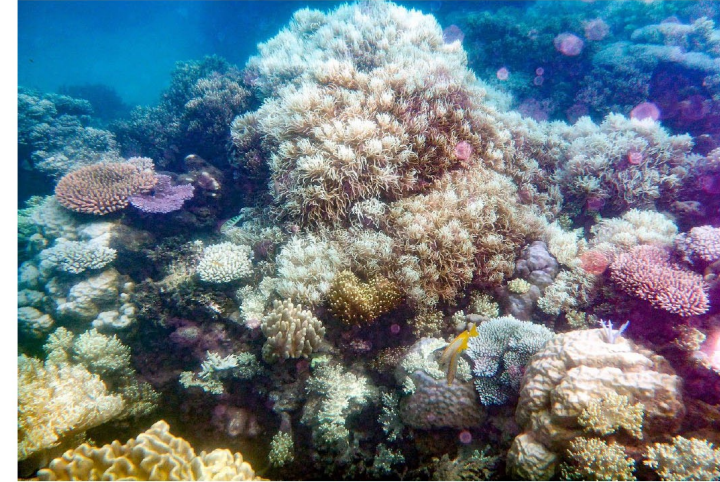


GBRMPA



Great Barrier Reef

This is a carbonate platform and massive bioherm stretching 2300 km along the edge of the continental shelf. It consists of thousands of individual coralline reefs and keys. Its sheer size led to early conjecture that it must be at least millions of years old. However current consensus has its age at about half a million years. Nonetheless, that means its development has seen at least five big oscillations in sea level, between glacial and interglacial phases, * with the coral growing upwards again with each sea level rise. Truly amazing. But moving back to more familiar territory.



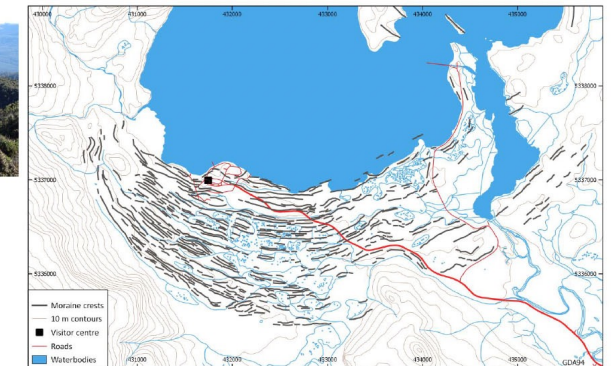
Gökhan Tolun

Theme 9: Glacial and periglacial systems – Tasmanian Wilderness

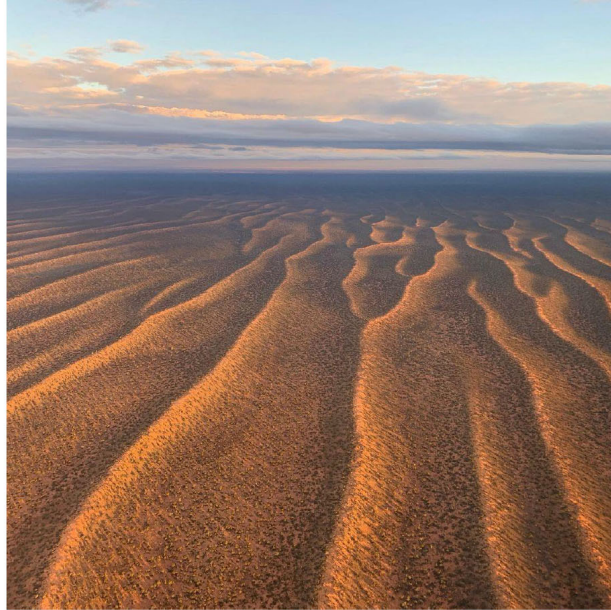


Tasmanian Wilderness glacial systems

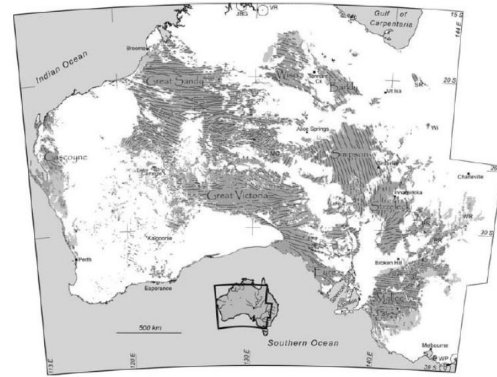
Theme 9 is glacial and periglacial systems and Tasmania has a record of three of the major global glacial events: the Cryogenian, Late Paleozoic and the Pleistocene. Here landforms and deposits from the last glacial stage – MIS2 – are for the most part exceptionally well preserved. They range from simple erosional landforms, like this cirque and rock basin at Haven Lake * to the complexly eroded terrain of the Western Arthur Range. Similarly, depositional features range from isolated moraines, like the one damming Hartz Lake to the complex barrage of dozens of moraines that formed during final retreat of the 27 km long valley glacier that carved Australia's deepest natural lake - Lake St Clair. Absolute and relative dating of the glacial debris has established that there was at least three, probably four and perhaps six or more separate glacial stages affecting Tasmania during the Pleistocene. However, there's still much to be learnt.



Theme 10: Desert and semi-desert systems



Chintair



Hesse 2010



Mark Marathon



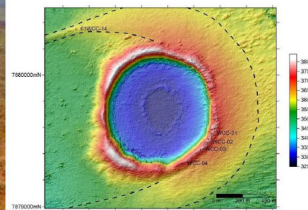
Desert and semi-desert systems

Jumping climate zones again, Australia is perhaps over endowed with desert and semi-desert landform systems. Purnululu, Uluru and the Willandra Lakes all have values under this theme but are inscribed on the World Heritage list for other themes. Strangely there are no Australian World Heritage listings specifically for arid zone landforms or processes. Perhaps some gibber plains or Pleistocene linear dune systems should be considered for World Heritage listing, but they're so extensive that it might be hard to pick the truly outstanding examples.

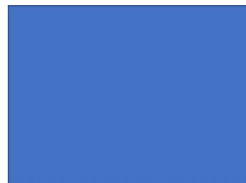
Theme 11: Meteorite impacts



Dainis Dravins - Lund Observatory, Sweden

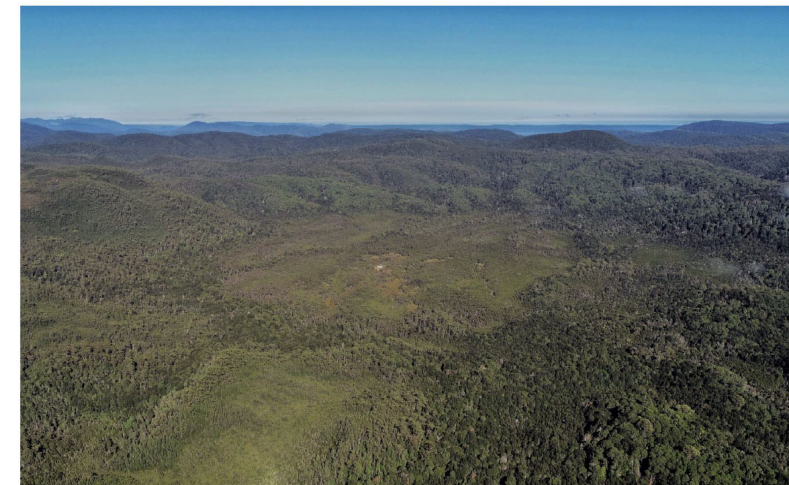


University of Wollongong



Meteorite impacts

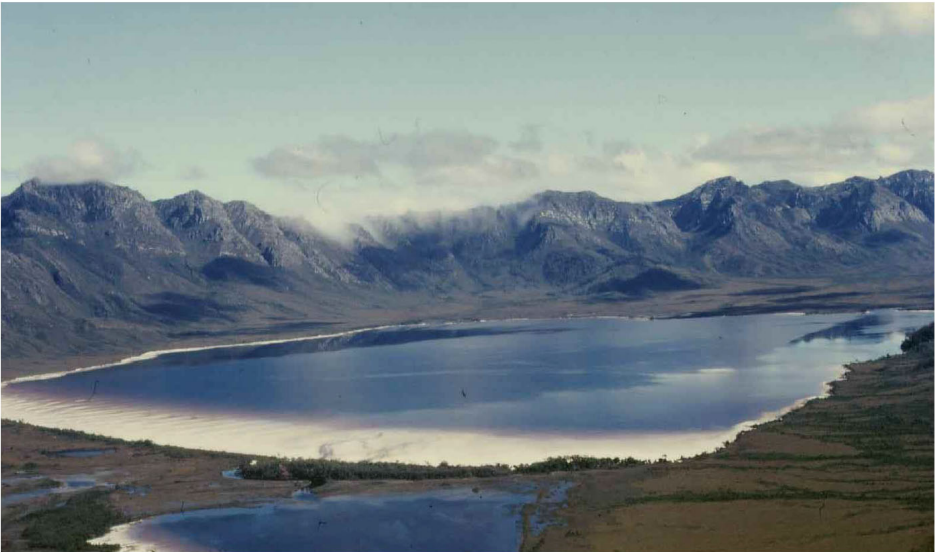
The final theme is meteorite impacts and Australia has had its fair share of those, although again there are no World Heritage listings specifically for this theme. Impact sites include the 90 km wide, Ediacaran-aged Acraman structure in South Australia, and this 300 000 year old crater at Wolfe Creek in the Tanami. * Back in the Tasmanian Wilderness once more, the 1.2 km wide and 816 thousand year old Darwin Crater is associated with a scattering of impact glass across some 400 square kilometres. Despite the entire known strewn field being predominantly within reserves and partly within the World Heritage Area, Darwin glass is frequently subject to theft and sale on international markets.



Michael Fletcher



Concluding remarks



Kevin Kiernan

Unfortunately, the overall outlook for geoheritage is poor, and the current lack of protection for geoheritage nationally is unlikely to improve without a specific focus on, and resourcing for, this area of heritage. State of the Environment Australia 2021



Concluding remarks

From small scale pilfering to large infrastructure projects, like the one that drowned the original Lake Pedder, we're constantly losing geodiversity. Which should be alarming, since geodiversity is the provider of essential ecosystem services like water, soil and habitat diversity. That last makes geodiversity the very foundation of biodiversity, which is being lost so quickly that there's little doubt we're in the middle of a mass extinction.

For all the conservation effort that's directed at pandas or pretty birds, every time we lose a known species, we lose ten more that science hasn't even named yet. The most recent Australian State of the Environment Report was released in July. It refers to geodiversity only within the narrow constraints of geoheritage but nonetheless delivers a poor prognosis.

Part of the problem would appear to be a lack of public engagement. Perhaps even disengagement – university enrolments in geology courses are plummeting in favour of 'greener' subjects. But what could be greener than learning to understand the Earth? How the atmosphere, hydrosphere, biosphere and geosphere all interact to keep us safe and comfortable?

To finish off, I'd like to suggest that those of us who understand geodiversity, who can read a landscape or the rock record, we need to be more active in telling the story of planet Earth. Because the ABC of effective conservation involves the Abiotic, the Biotic and the Cultural. That means we're the A team.

Credits

While compiling this talk, I read that atmospheric CO₂ had climbed above 420 ppm – more than 50% higher than pre-industrial levels. Outside Australia, much of the coal responsible for that was deposited in the aptly named Carboniferous period, when rampant growth led to the sequestration of so much atmospheric carbon that it precipitated the Late Paleozoic ice age. Now we're burning that coal millions of times faster than it was laid down. What could possibly go wrong?

Thanks for watching. And thanks too to everyone who's made their excellent photos available under a Creative Commons licence.

Image credits

<p>Jack Hills Jack Hills conglomerate: James St John, https://commons.wikimedia.org/wiki/File:Quartz-pebble_mosaicconglomerate_(Jack_Hills_Quartzite_Archean_2_65_to_3_05_Ga_Jack_Hills_Western_Australia)_2.jpg Jack Hills: Shire of Murchison https://www.murchison.wa.gov.au/murchison-geo-region/jack-hills.aspx Zircon: https://www.abc.net.au/science/articles/2014/02/24/3950076.htm Dated zircons: Cavosie AJ, Valley JW, Wilde SA 2007. The oldest terrestrial mineral record: a review of 4400 to 4000 ma detrital zircons from Jack Hills, Western Australia. DOI: 10.1016/S0166-2635(07)15025-8.</p> <p>Pilbara granite-greenstone terrain Pilbara geological map: https://geoview.dmp.wa.gov.au/geoview/ Block diagram: https://opengeology.org/historicalgeology/case-studies/greenstone-belts/primordial/tectonic/ Cross section: Van Kranendonk, Martin & Smithies, R. & Griffin, W. & Huston, David & Hickman, Arthur & Champion, D. & Anhaeusser, Carl & Pirajno, Franco. (2014). 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