

*June 12, 2023*

## News and notes



**Kilauea summit eruption in Halema'uma'u – June 7, 2023**  
**Source: [United State Geological Survey \(USGS\)](#), public domain**

Before going on to discuss how geology has affected the fate of [Australia](#), here are some news items I thought were interesting.

## Research

- [Geochronology of the Daitari Greenstone Belt, Singhbhum Craton, India](#); behind a paywall, Phys.org summary [here](#).
- More geochronology: [Older than they look: Cryptic recycled xenotime on detrital zircon](#).
- Geophysics: [Filtering of Magnetosonic Waves by Mesoscale Plasmaspheric Density Interfaces](#).
- Glacial geology: [Rapid Basal Channel Growth Beneath Greenland's Longest Floating Ice Shelf](#).
- Sedimentology research: [Important Contribution of Bacterial Carbon and Nitrogen to Sinking Particle Export](#).
- [Thermal architecture of the Salmon River suture zone, Idaho, USA: Implications for the structural evolution of a ductile accretionary complex during arc-continent collision](#)

- [Seismically imaged lithospheric delamination and its controls on the Mesozoic Magmatic Province in South China](#); Phys.org summary [here](#).
- [Plate bending earthquakes and the strength distribution of the lithosphere](#).
- [How transform fault shear influences where detachment faults form near mid-ocean ridges](#).

## Paleontology

- Australian fossils from the [Tonian](#) Period of the [Neoproterozoic](#): [Remains of an extinct world of organisms discovered](#). Three papers are referenced: [here](#), [here](#) and [here](#).
- [Visualized: The 4 Billion Year Path of Human Evolution](#).
- Dinosaurs: [An early-diverging iguanodontian \(Dinosauria: Rhabdodontomorpha\) from the Late Cretaceous of North America](#); Phys.org summary [here](#).
- [Unique dentition of rhynchosaurs and their two-phase success as herbivores in the Triassic](#), Eureka Alert summary [here](#).
- Mass extinction research: [Enhanced Continental Weathering as a Trigger for the End-Devonian Hangenberg Crisis](#).

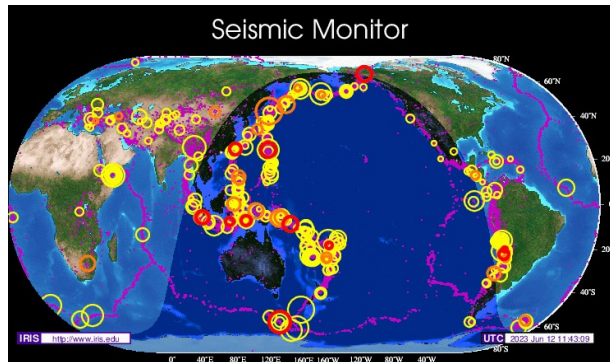
## Hydrogeology

- Groundwater research in the United Kingdom: [The enhanced future Flows and Groundwater dataset: development and evaluation of nationally consistent hydrological projections based on UKCP18](#).
- Groundwater research, Arizona: [A Spatiotemporal Characterization of Water Resource Conditions and Demands as Influenced by the Hydrogeologic Framework of the Willcox Groundwater Basin, Southeastern Arizona, USA](#).

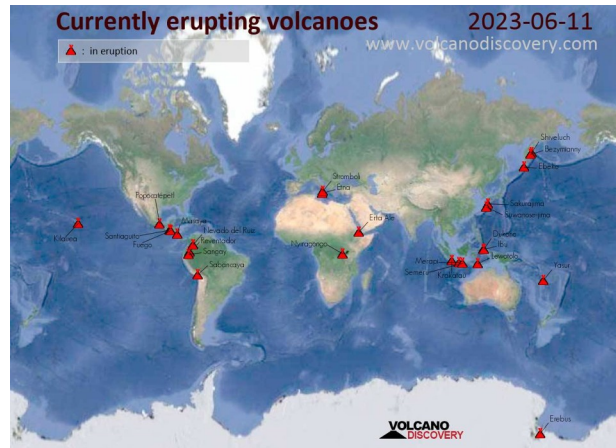
## Mining and Energy

- [Norway opens vast ocean area to deep-sea mining](#).
- Gold and uranium deposits: [Multiscale \(microscopic to remote sensing\) preliminary exploration of auriferous-uraniferous marbles: A case study from the Egyptian Nubian Shield](#).
- Ore deposit research in Australia: [Stratiform Host-Rock Replacement via Self-Sustaining Reactions in a Clastic-Dominated \(CD-type\) Zn Deposit](#).
- Whoopee: [A Copper Buying Spree Is Set To Commence](#).
- Exploration activity: [U.S. Drillers Cut Oil and Gas Rigs for Sixth Week in a Row – Baker Hughes](#).
- From the United States Energy Information Administration (USEIA): [Oil and natural gas resource categories reflect varying degrees of certainty](#).

## Volcanoes, Earthquakes and Geohazards



[Seismic Monitor](#)



[Active Volcano Map](#)

- From the USGS: [Volcano Watch — Reflections of recent eruptions.](#)
- Do you like spending time stuck in traffic? [Tweet from the USGS, lots of visitors at Kīlauea.](#)
- [Thousands evacuated as Philippine volcano spews ash, rocks.](#)
- [Potential for rupture before eruption at Campi Flegrei caldera, Southern Italy](#); Phys.org summary [here](#).
- Alaska volcano research: [Double Reservoirs Imaged Below Great Sitkin Volcano, Alaska, Explain the Migration of Volcanic Seismicity.](#)
- Not because of [St. Patrick](#) and the snakes: [Seismicity of Ireland, and why it is so low](#); Phys.org summary [here](#).
- [Strong earthquake rattles northern Japan; no damage reported.](#); USGS summary [here](#).
- Earthquake hazard research: [Unified approach for evaluation of horizontal site amplification factors with special reference to history of studies on the effects of surface geology on seismic motion.](#)
- More earthquake research: [Velocity structure above seismological bedrock estimated from earthquake recordings: an application of diffuse wave-field concept to strong motions in Iran.](#)
- Ancient volcanoes, earthquakes and tsunami: [Formation of undulating seafloor bedforms during the Minoan eruption and their implications for eruption dynamics and slope stability at Santorini](#); behind a paywall, Phys.org summary [here](#).
- More on tsunami: [Rapid shallow megathrust afterslip from the 2021 M8.2 Chignik, Alaska earthquake revealed by seafloor geodesy](#); Phys.org summary [here](#).
- Landslide research: [A Stochastic Dynamical Model of Slope Creep and Failure.](#)

June 12, 2023

## Geology and the Fate of Societies – Australia



Figure 1 – Map of Australia from Encyclopedia Britannica 1911

Credit: Justus Perthes Company, [public domain](#)

[Australia](#) is a very interesting country. It is the only nation-state that encompasses an entire continent with fascinating geology, history and geopolitical situation. So, let's go!

According to the United States [Central Intelligence Agency](#) (CIA) [World Factbook](#), about 26,461,166 people currently live in Australia. The country has a total area of 7,741,220 square kilometres (km<sup>2</sup>) including [Lord Howe](#) and [Macquarie](#) Islands. Of the total area, 7,682,300 km<sup>2</sup> is land and 58,920 km<sup>2</sup> is water.

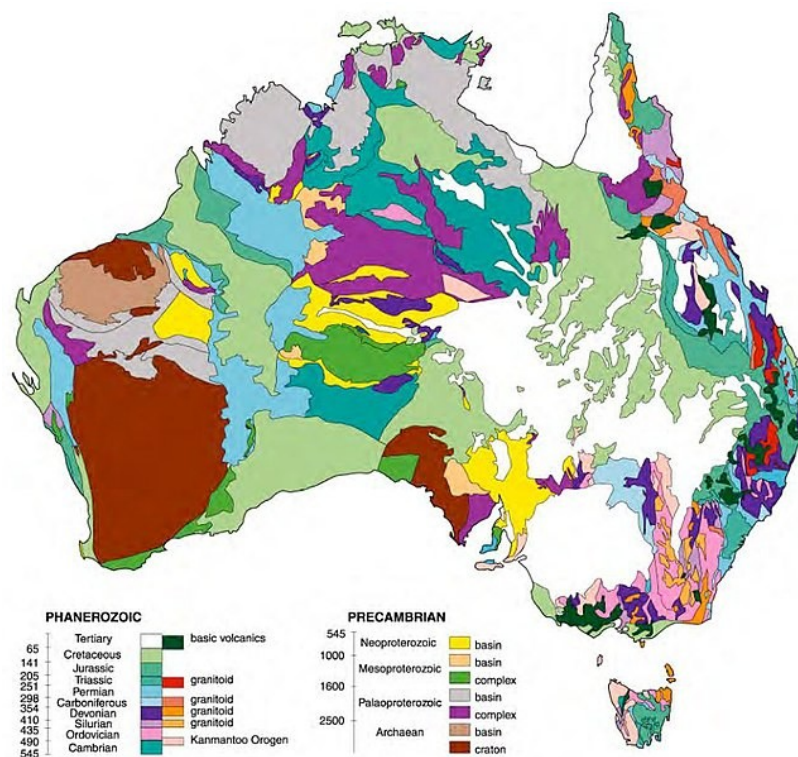
Australia is surrounded by water. To the north of Australia are [New Guinea](#) and [Indonesia](#). To the southeast is [New Zealand](#).

Most of the inhabitants of Australia are descendants of European immigrants, mostly from the British Isles. About 2.9% of the population are descendants of the original inhabitants of the country. Australia is a predominantly (72%) [English](#) speaking country. Languages spoken at home include: English 72%, Mandarin 2.7%, Arabic 1.4%, Vietnamese 1.3%, Cantonese 1.2%, other 15.7%, unspecified 5.7% (2021 est.)

Australia is a [parliamentary democracy on the British model](#) with [King Charles III](#) as the official [Head of State](#). It is a member of the British [Commonwealth of Nations](#). Australia is allied with the [United States](#) and the [United Kingdom](#) through the [AUKUS Agreement](#) and is also a member of the [Five Eyes](#) intelligence gathering organization with [Canada](#), New Zealand, the United Kingdom and the United States.

Australia is a [federal](#) polity with its capital in [Canberra](#). The states and territories of Australia are: the [Australian Capital Territory](#), [New South Wales](#), the [Northern Territory](#), [Queensland](#), [South Australia](#), [Tasmania](#), [Victoria](#), and [Western Australia](#). Australia is also responsible for the [governance](#) of: the [Ashmore and Cartier Islands](#); [Christmas Island](#); the [Cocos \(Keeling\) Islands](#); the [Coral Sea Islands](#); the [Australian Antarctic Territory](#); the [Territory of the Heard and McDonald Islands](#); and [Norfolk Island](#).

## Geology



**Figure 2 – Basic Geological Regions of Australia, By Age**  
 Credit: [Rolinator](#) after [Addario et al, 1976](#),  
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[Australia's geology](#) can be divided into several main sections:

- [Archaean cratonic](#) cores;
- [Proterozoic fold belts](#) and [sedimentary basins](#);
- [Phanerozoic](#) sedimentary basins, [metamorphic](#) and [igneous](#) rocks; and
- The [Paleozoic](#) formation of the [Great Dividing Range](#).

Australia is on the [Indo-Australian tectonic plate](#) and separated from the rest of the [Gondwana Supercontinent](#) over a prolonged period lasting from the [Permian](#) until the [Cretaceous](#) periods. Prior to its association with Gondwana, the Australian cratons have been part of the formation of, and dispersal of, the [Nuna](#), [Rodinia](#) and [Pangea](#) supercontinents.

### *Quaternary, Neogene and Paleogene*

The youngest bedrock in Australia is the [Quaternary](#) aged [Newer Volcanics Province](#) that is made up of [maar volcanic](#) deposits such as [basalt](#), and [tuff](#).

The [tectonic rifting](#) that began with the breakup of of Gondwana split Australia and [Antarctica](#) during the [Eocene](#).

### *Cretaceous*

[Cretaceous](#) aged rock in Australia include the [volcanic arc](#) deposits of the [Whitsunday Islands](#) off the shore of Queensland and the Cretaceous sedimentary deposits in the [Perth Basin](#).

The tectonic rifting of Australia and Antarctica that began during the [Jurassic](#) continued through the Cretaceous, with offshore development of a [mid ocean ridge seafloor spreading](#) centre. A rift developed that separated Tasmania from the rest of the continent during the Cretaceous.

### *Jurassic*

Jurassic deposits in Australia include:

- Sedimentary deposits of the [Surat Basin](#) in Queensland and New South Wales, a basin that includes the [Great Artesian Basin](#);
- The Perth Basin in Western Australia, which includes of the [Cattamarra Coal Measures](#);
- The [Gippsland](#), [Bass](#) and [Otway](#) Basins in Victoria; and
- [Offshore shelf basins of South Australia and Western Australia](#), all of which host significant oil and gas deposits; and
- The [Sidney Basin](#), including the [Prospect Dolerite Intrusion](#).

During the Jurassic, Australia began rifting away from Antarctica, a process that formed the offshore basins noted above. Another result of this tectonic movement was an intrusion of [dolerite](#) in the Sidney Basin.

An interesting Jurassic aged deposit is a [regolith](#) on top of the [Yilgarn Craton](#). One of the facts teased from [study of the regolith](#) is that the west of Australia had a tropical savanna and jungle environment during the Jurassic.

### *Permian and Triassic*

Important deposits during the [Permian](#) and [Triassic](#) periods in Australia include:

- Glacial deposits, [tillites](#) and fossiliferous [limestone](#) deposits formed during the erosion of the [Petermann Ranges](#);

- The beginnings of sedimentary deposition in the Perth Basin and the Sydney Basin;
- Sedimentary rocks of the [Gunnedah–Bowen Basin](#), including [coal deposits](#); and
- [Clarence Moreton Basin](#), sedimentary deposits that include [oil and gas reservoirs](#).

The major tectonic event of these two periods in Australia was the [Hunter-Bowen Orogeny](#) which began during the [Carboniferous](#) and lasted till the middle of the Triassic. The orogeny [created](#) major arc-accretion, subduction and back-arc sedimentary basins on the eastern part of the continent.

### ***Carboniferous***

The Great Dividing Range and other parts of the [Eastern Highlands of Australia](#) formed during the Carboniferous Period by the collision of the Australian craton with [New Zealand](#) and parts of South America. The [Northern New England Fold Belt](#) was complete by the Carboniferous.

A [major ice age](#) occurred during the Carboniferous Period in Australia, leaving behind [glacial features](#) and depositing fossil [gelisols](#).

### ***Devonian***

Conditions in Australia during the [Devonian Period](#) were warm. Where the [Great Sandy Desert](#) now exists was a tropical reef depositing limestones. Other deposits included sandstones, that formed the [Bungle Bungle Range](#), and [granite](#) from mountain building during the [Tabberabberan Orogeny](#) which affected the eastern part of the country.

The first Australian land plant, [Baragwanathia longifolia](#) appeared during the Devonian.

### ***Silurian***

A fluvial sedimentary basin deposited clastic sediments along the far Western Australian coast from [Geraldton](#) to [Exmouth Gulf](#). There was also a sea where the Great Sandy Desert now exists. Deep water sediments formed in the [Cowra](#), [Tumut](#) and [Hillend](#) Troughs. [Volcanic deposits](#) from the Silurian are found along the eastern side of the country. The [Bega Batholith](#) was intruded during this time.

Fossil footprints of a [giant water scorpion](#) were found near [Kalbarri](#) on the [Murchison River](#). These footprints are the earliest evidence of an animal to walk on the Australian continent.

### ***Ordovician***

The major geological event of the Ordovician in Australia was the [Lachlan Orogeny](#) creating the [Lachlan Fold Belt](#). [Serpentinite](#) deposits associated with this orogeny are found in New South Wales. Deep water [molasse](#) and [flysch](#) deposits associated with the orogeny are found in Victoria and New South Wales. Other deep water deposits include [turbidites](#) of the [St. Arnaud and Castlemain Group](#). Other depositions include the [Sunbury Group](#), the [Bendoc Group](#) and the [Molong Arc](#), a calc-alkaline volcanic arc which is associated with the [Kiandra Group](#) turbidites.

### ***Cambrian***

During the [Cambrian Period](#), basalts of the [mid-ocean-ridge basalt terrane](#) were [deposited in Victoria](#). The Victorian basalt terrane appear to be connected to a similar terrane at [Mount Reade](#) in Tasmania. The [Antrim Plateau flood basalts](#) also formed during the Cambrian.

Deep water sediments of the [Adaminaby Beds](#) were deposited in Victoria and New South Wales. [Ophiolite](#) sequences are also found in the Lachlan Fold Belt. Other sedimentary basins from the Cambrian include the [Stansbury Basin](#), the [Gascoyne Sub-basin](#) and the [Bonaparte Gulf Basin](#).

The major orogeny of the Cambrian in Australia was the [Petermann Orogeny](#) in Central Australia. The Petermann Orogeny, [which began](#) in the [Neoproterozoic](#), resulted in the deposition of a thick intracontinental sequence of fluvial sediments in the centre of Australia. Another orogeny, the [Delamerian](#) occurred, forming [marginal carbonate platforms](#) and [passive margin basins](#) in eastern Australia.

### *Neoproterozoic*

Widespread deposition occurred in the [Centralian Superbasin](#) and [Adelaide Geosyncline](#) (Adelaide Rift Complex) during the Neoproterozoic. The Petermann Orogeny began during this time, and caused extensive uplift, mountain building and basin fragmentation in central Australia at the close of the Neoproterozoic.

### *Mesoproterozoic*

During the [Mesoproterozoic](#), the oldest rocks in Tasmania formed in on King Island and in the [Tyennan Block](#).

Other Mesoproterozoic igneous events include the:

- mafic-ultramafic intrusions in the [Musgrave Block](#);
- [Volcanic sills](#) in the [Bangemall Basin](#) and the [Glenayle](#) area; and
- The [Warukurna Large Igneous Province](#) including the [Giles Complex](#).

### *Paleoproterozoic*

In Australia during the [Paleoproterozoic](#), the [Archean Yilgarn](#) and [Pilbara](#) cratons were brought together in the during the first phases of the [Capricorn Orogeny](#). The rocks of this age all highly deformed and metamorphosed.

### *Archean*

Three cratonic shields the Yilgarn, the Pilbara and the [Gawler](#) cratons formed during the Archean. There are several other Archean-Proterozoic orogenic belts, usually sandwiched around the edges of these major cratonic shields.

Some of the oldest examples of geological features deposited by living things, [stromatolites](#) are found in the Archean [Dresser Formation](#) in Western Australia.

## Resources

Australia is rich in natural resources and a [major exporter of food](#).

### *Agricultural Resources*

[Australia produces](#) a large variety of [primary products](#) for export and domestic consumption. Table 1 shows the top ten agricultural products by value are listed for the years 2001 to 2007.

Commodity (in millions of AUD\$)	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
<a href="#">Cattle</a> and calves	6,617	5,849	6,345	7,331	7,082	6,517
<a href="#">Wheat</a>	6,356	2,692	5,636	4,320	5,905	6,026
<a href="#">Milk</a>	3,717	2,795	2,828	3,808	3,268	3,245
<a href="#">Fruit</a> and <a href="#">nuts</a>	2,333	2,408	2,350	2,640	2,795	2,915
<a href="#">Vegetables</a>	2,269	2,126	2,356	2,490	2,601	2,715
<a href="#">Wool</a>	2,713	3,318	2,397	2,196	2,187	2,138
<a href="#">Barley</a>	1,725	984	1,750	1,240	1,744	1,624
<a href="#">Poultry</a>	1,175	1,273	1,264	1,358	1,416	1,461
<a href="#">Lamb</a>	1,181	1,161	1,318	1,327	1,425	1,348
<a href="#">Sugar cane</a>	989	1,019	854	968	1,037	1,208

**Table 1 – Top 10 Agricultural Products by Value, 2001 to 2007**

**Credit: [Food and Agriculture Organization](#)**

Not included in Table 1 is an important Australian agricultural product, [wine](#). In the 2021-2022 season, [Australia produced approximately 1.3 billion litres of all types of wine](#). Contrary to [Monty Python](#)'s humorous review, Australian wines often have an [excellent reputation](#).

### ***Mineral Resources***

[Australia has large quantities of minerals and resources](#), here is a summary:

- Iron ore – Australia was the world's largest producer in 2019, supplying 580 million tonnes, 37% of the world's output (39% of the world's contained metal production).
- Nickel – Australia was the world's fifth largest producer in 2019, producing 6.7% of world output.
- Aluminum – Australia was the world's largest producer of bauxite in 2019 (27% of world production), and the second largest producer of alumina (15%), after [China](#).
- Copper – Australia was the world's 6th largest producer in 2019 (5% of world's production).
- Gold – Australia was the second largest producer after China in 2019, producing 330 tonnes (11,000,000 ozt), 10% of the world's output.
- Silver – In 2019 Australia was the sixth largest producer, producing 1,400 tonnes (45,000,000 ozt), 5% of the world's output.
- Uranium – Australia is responsible for 12% of the world's production and was the world's third largest producer in 2018, after Kazakhstan and Canada.

- Diamond – Australia has the third largest commercially viable deposits after Russia and Botswana.[citation needed] Australia also boasts the richest diamantiferous pipe with production reaching peak levels of 42 metric tons (41 LT/46 ST) per year in the 1990s.
- Opal – Australia is the world's largest producer of opal, being responsible for 95% of production.
- Zinc – Australia was third to China and Peru in zinc production in 2019, producing 1.3 million tonnes, 10% of world production.
- Coal – Australia is the world's largest exporter of coal and fourth largest producer of coal behind China, USA and India.
- Oil shale – Australia has the sixth largest defined oil shale resources.
- Petroleum – In 2019 Australia was the thirty-third largest producer of petroleum.
- Natural gas – Australia is world's largest exporter of LNG with 77.5 million tonnes in 2019.
- Rare earth elements – In 2019 Australia was the third largest producer after China and USA, with 10% of the world's output.

[Australia exports much of the mined raw material](#) to countries such as China for processing into refined product. Energy and minerals constitute two-thirds of Australia's total exports to China and more than half of Australia's iron ore exports are to China.

## Climate

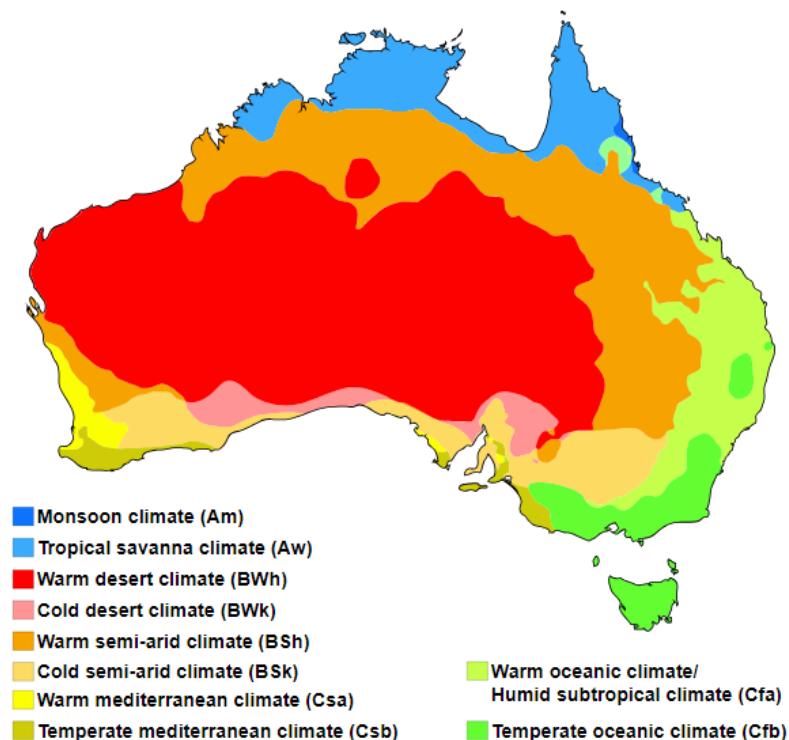


Figure 3 - Australia Map of Köppen Climate Classification

Credit: [World Köppen Classification](#), [Creative Commons Attribution-Share Alike 4.0 International](#) license

[Australian climate](#) varies greatly, as is shown on Figure 3. Much of the centre of the country is desert. The east, south and west coasts have the most habitable areas, with moderate, temperate, climates and the north coast has a tropical climate.

## History and Geopolitics

Human settlement began in Australia about [65,000 years ago](#). However, [while they developed sophisticated cultures](#) and means to survive in the various parts of the country, they never developed state level organizations. This left them at a great disadvantage when people from Europe began to arrive after the Dutch sailor, [Abel Tasman](#), first encountered the continent.

In 1699, the English explorer [William Dampier](#) visited the northwest coast of Australia and in 1770 [James Cook](#) reached the east coast of the continent. British colonization of the continent began in 1778, with many of the immigrants [being convicts exiled to Australia](#) in lieu of capital punishment.

The European population of Australia grew through both immigration and natural growth. Eventually they took over the whole of the continent, [displacing and / or exterminating the native population](#). In 1901, the Australian gained self-governing status within the British Empire. During [many colonial wars](#), Australian troops distinguished themselves as some of the most effective troops within the British Empire.

The geopolitics of Australia is that of an island in the outer orbit of [Mackinder's World Island](#). They have the role of providing commodities to larger nations and providing a place to send surplus population, such as England's unwanted convicts but also any number of ambitious people. Australians have the opportunity to make money from the export of commodities excess to their local needs. For this they need to keep friendly trade relations with larger states, such as China.

But not too friendly. To preserve their freedom of action, and avoid the fate of the original inhabitants of the country, Australians need to make strong alliances with friendly powers and take their own defence seriously. In the past, Australia was bound by the British Empire, and the British provided some measure of protection. In more recent times, the United States has taken on the role of senior partner in military alliance with Australia. Even relationships with friendly powers [need to be watched closely](#).

## Current Condition

Australia has become a commodities export economy, largely downsizing their domestic manufacturing capacity in [favour of globalization](#). They are [closely tied economically to China](#) but are also uneasy with China's potential for becoming a regional, or world, power. Having secured effective independence from the British Empire, they have no wish to become a Chinese colony. To this end, they have secured a close alliance with the United States, and the United Kingdom, in the aforementioned AUKUS pact. If there are disputes between the United States and China, Australia will be drawn into them.

The Australian geopolitical situation shows interesting, and troubling, features. I have noted in previous posts, such as the one on [Argentina](#), that economics are downstream of politics, which, in turn, are downstream of culture. Until more recent times, Australia's off-shore economic ties were with Great Britain and the United States. This aligns with Australia's predominately English-speaking culture. However, during the 21<sup>st</sup> Century, Australian trade with [China has grown](#) significantly. This growth has not been without [trouble](#). In fact, we should expect future trouble between Australia and China because

of the conflicting interests and cultures. It must grind on proud [Australian patriots](#) to be so dependent on a foreign country like China that is so different from Australia in culture and values.

China is not the only worry for Australia. Indonesia, with a population of about 280 million people greatly outnumbers Australia's 26,461,166 people. Indonesia is also much smaller than Australia. Ambitious politicians, and desperately poor people, could easily make a great deal of trouble for Australia should they attempt a mass migration in Australia's direction.

And not just the Indonesians, [many people are anxious to escape poverty](#) and enjoy the good life in Australia. Many [refugees continue to seek entry to Australia](#), but many [do not get a warm welcome](#). It is unlikely that this problem will go away and is very likely to be a major political headache for Australia for years to come.

That winds up this short look at Australia. If this interests you, follow up on the links for more information.

### **Standard Caveat**

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.