

Past and Future Climate – Present Weather

Week 3

Changing Geography – and its impact on climate

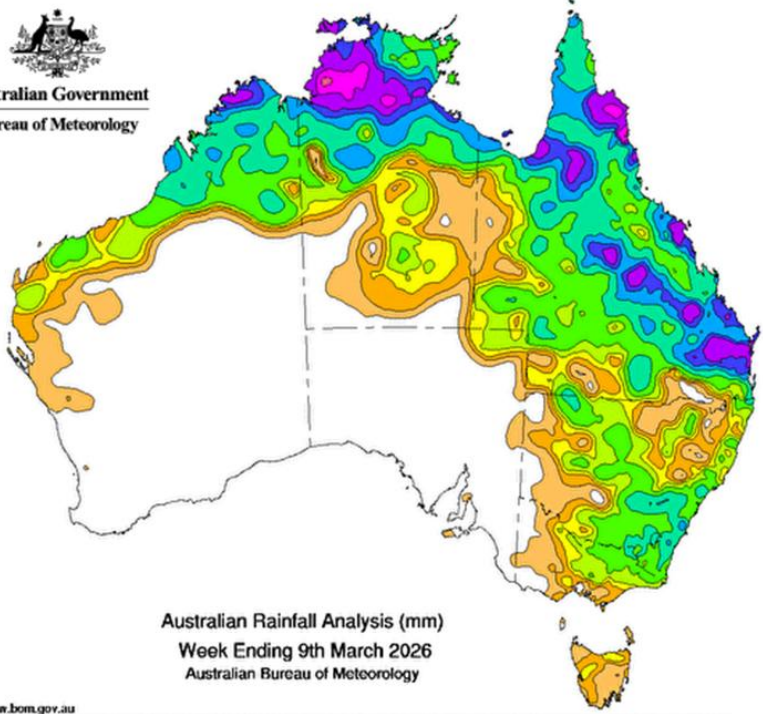
Terry Hart

Katherine experiences worst flooding in 28 years as remote NT communities evacuated





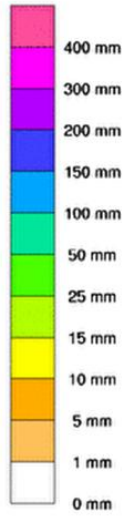
Australian Government
Bureau of Meteorology



Australian Rainfall Analysis (mm)
Week Ending 9th March 2026
Australian Bureau of Meteorology

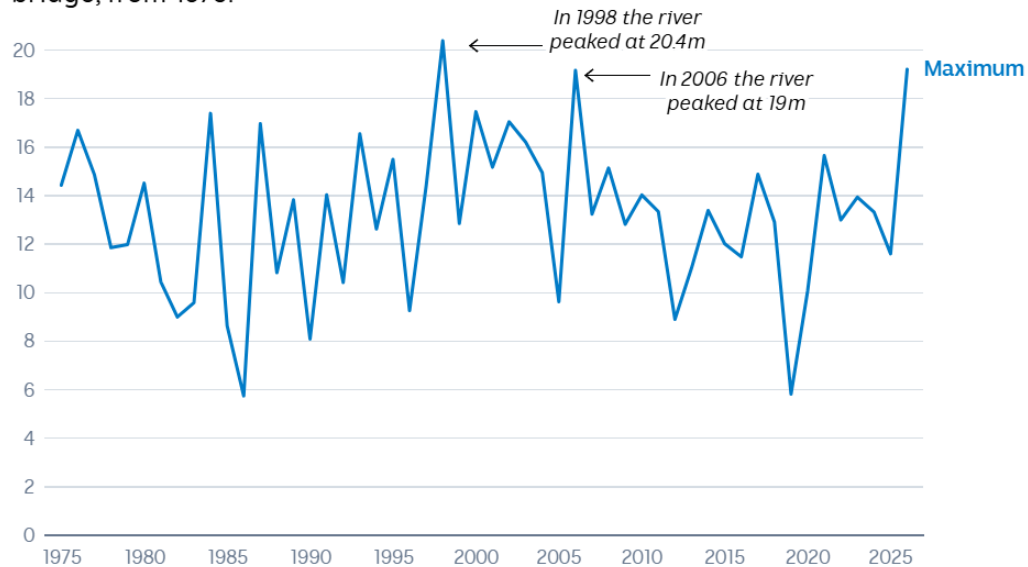
<http://www.bom.gov.au>
© Commonwealth of Australia 2026, Bureau of Meteorology

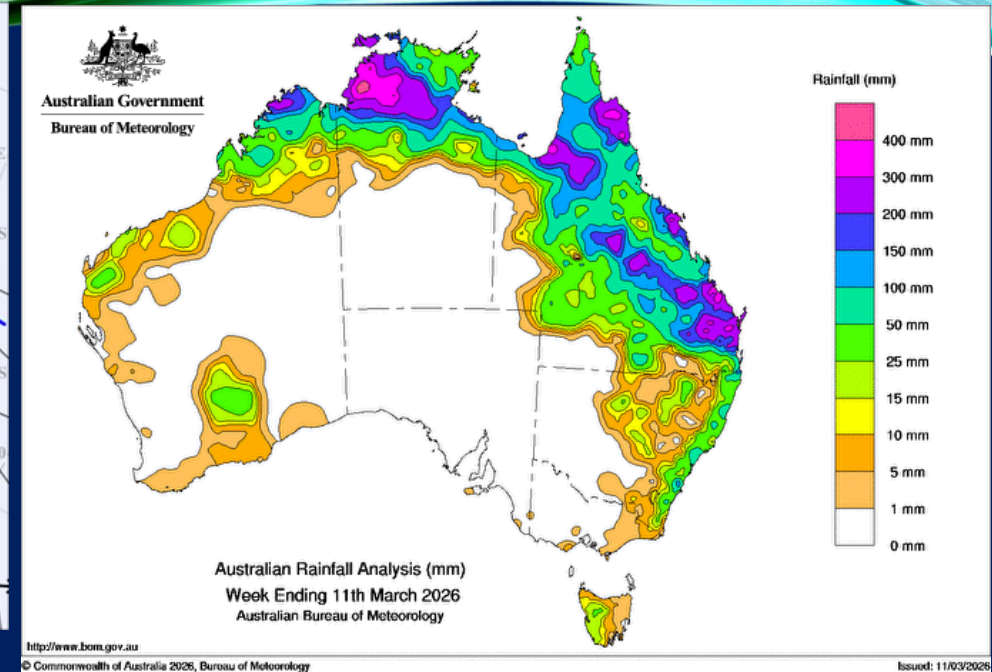
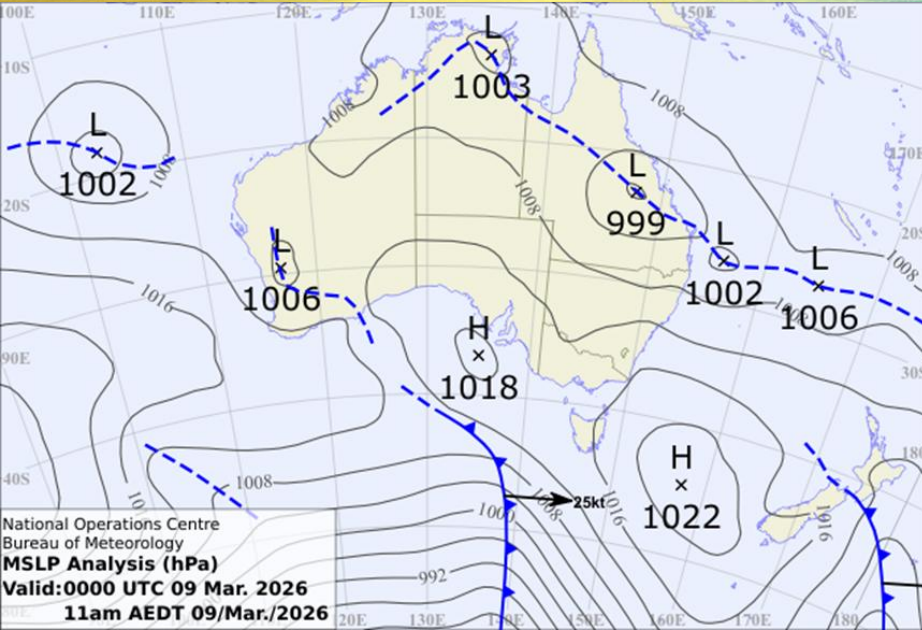
Rainfall (mm)



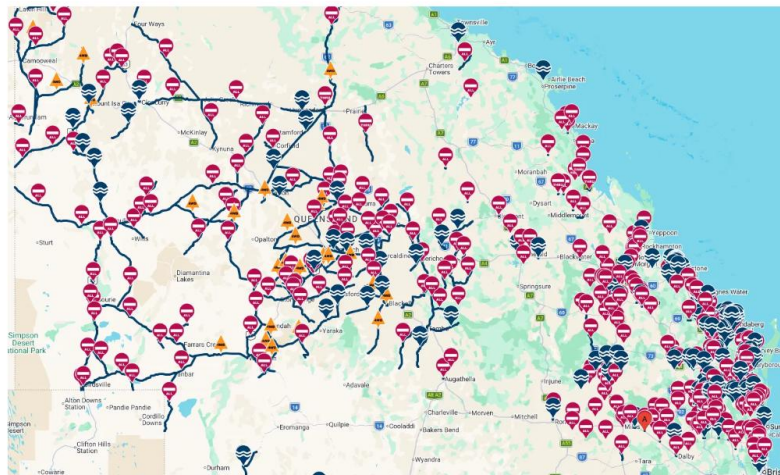
Maximum levels of Katherine River

The yearly data summary of the Katherine River, as measured at the railway bridge, from 1975.





Earlier the premier said 760 roads had been affected by floodwaters across the state.



Floodwaters have closed roads across the state (QLD Traffic)

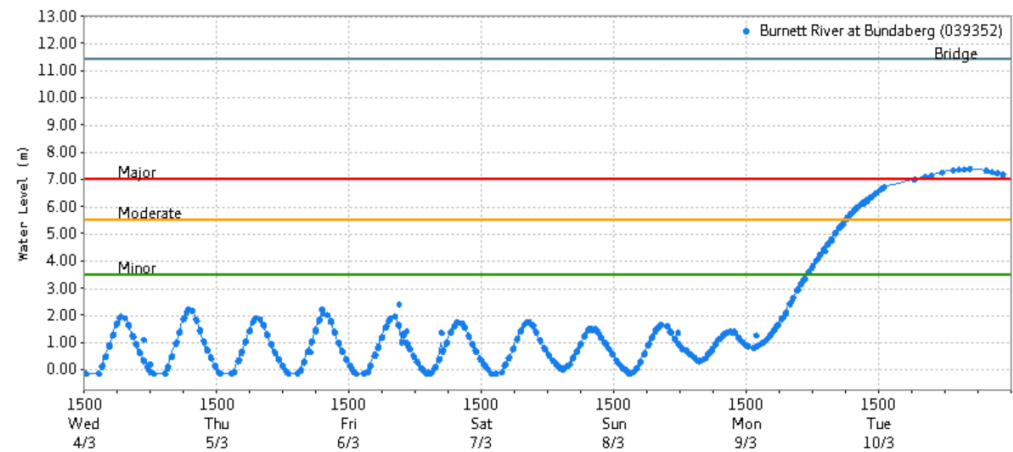
Latest River Heights for Burnett River at Bundaberg

Issued at 03:08 PM AEST Wednesday 11 March 2026

[About river heights plots](#) | [About this Plot](#)

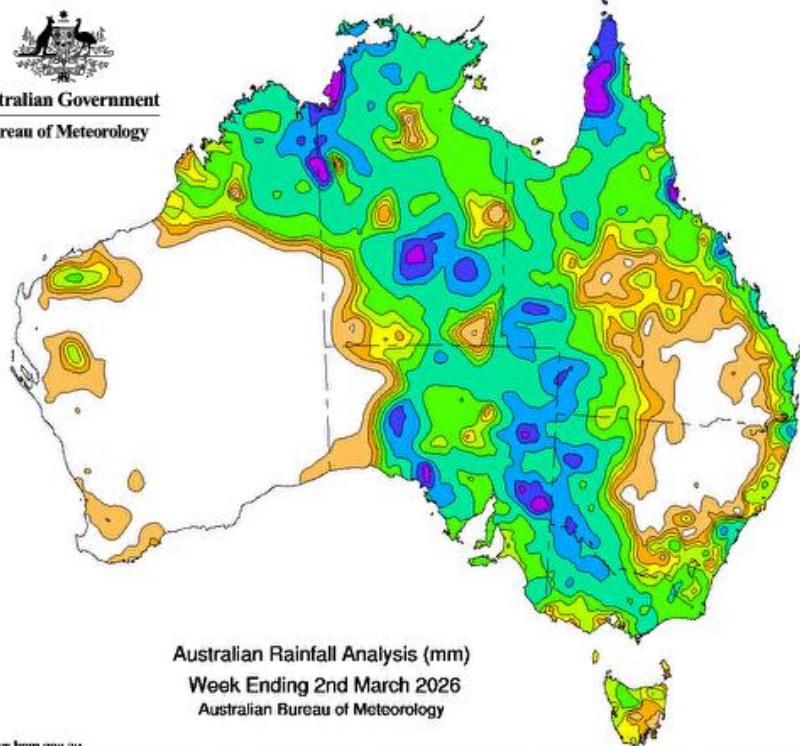
Station details: Station Number: 039352 Name: Burnett River at Bundaberg
Flood Classification Levels: Minor: 3.50 m Moderate: 5.50 m Major: 7.00 m
Crossing Levels: Bridge: 11.40 m

Data from the previous 7 days.

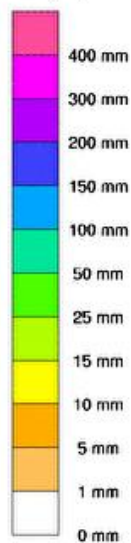




Australian Government
Bureau of Meteorology



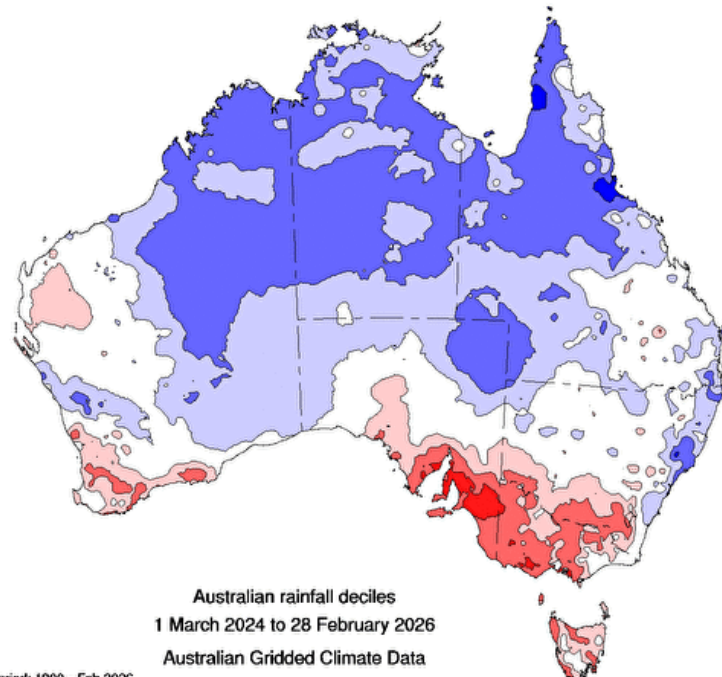
Rainfall (mm)



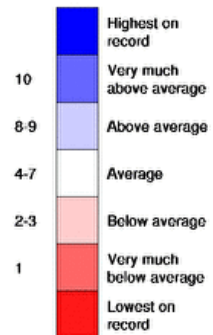
Australian Rainfall Analysis (mm)
Week Ending 2nd March 2026
Australian Bureau of Meteorology

<http://www.bom.gov.au>

© Commonwealth of Australia 2026, Bureau of Meteorology



Rainfall decile ranges



Australian rainfall deciles
1 March 2024 to 28 February 2026
Australian Gridded Climate Data

Base period: 1900—Feb 2026

© Commonwealth of Australia 2026, Bureau of Meteorology

Dataset: AGCD v2

Issued: 28/02/2026

At least eight dead as 'Godzilla tornadoes' rip devastating trail through the US



HALLIE GOLDEN & KATHY MCCORMACK AND JEFF MARTIN & REANNA SMITH

Sun, March 8, 2026 at 1:02 AM GMT+11

Michigan and
Iowa

The convergence of a weather system drawing moisture from the Gulf of Mexico and a warm front pushing northward established the perfect conditions for a tornado in a state where they're uncommon, explained David Roth, a meteorologist at the weather service's Weather Prediction Center in College Park, Maryland. The system collided with significantly colder air in the Great Lakes region.

“The spring storms arrive near the beginning of what many refer to as tornado season, which typically starts at different times across various parts of the US.”

<https://www.bbc.com/news/articles/crxpwzvd5vo>





REG SPRIGG'S DIVING CHAMBER

Reginald Claude Sprigg (1/3/19 – 2/12/94) a pioneering South Australian geologist and adventurer. His enquiring mind and willingness to challenge the scientific viewpoint of the day led to many great discoveries. Reg found the oldest animal fossils in the world the Ediacaran fossils (on display at the South Australian Museum) and the deepest undersea canyons in Australia, one of which is now named Sprigg Canyon in his honour. He also discovered the Cooper Basin oil and gas fields and helped establish the companies SANTOS and Beach Energy. In his early days, Reg studied under Sir Douglas Mawson at The University of Adelaide. A conservationist ahead of his time, Reg created the Arkaroola Wilderness Sanctuary to preserve the flora, fauna and geology of the northern Flinders Ranges.

Reg and his family lived on Baker Street, Somerton Park and then in a home they built and affectionally named 'Arkaroola' at number 30 Esplanade Somerton Park:



Reg Sprigg



Chamber at workshop in Woodville



Chamber on stern of SAORI



Chamber on stern of SAORI

Reg's geological interests extended under the sea. He was an early adopter of scuba diving in the 1960s and built his own underwater diving chamber from a disused boiler. He commissioned a research vessel, SAORI built at Searles boatyard, Port Adelaide to confirm his discovery of massive undersea canyons south of Kangaroo Island. He and his team of scuba divers completed the first benthic survey of Gulf St Vincent, establishing a valuable baseline for the plants, animals and sub-surface terrain in existence at the time. These results are still referenced today.



Chamber at Arkaroola



Restoration Team



The diving chamber, built by Reg's company Geosurveys, finished its days 600km from the sea at Arkaroola. In 2012, a group of South Australian divers launched an effort to restore the chamber and preserve its history. The chamber was brought to Adelaide and restored over a period of four years by a dedicated team of volunteers led by Dr Richard Harris from the Diving and Hyperbaric Medicine unit, Royal Adelaide Hospital.

It stands now as a monument to the early days of underwater exploration in South Australia and to Reg Sprigg's tenacity, achievements and spirit of adventure.

CITY OF
HOLDFAST BAY



P 8229 9999
HOLDFAST.SA.GOV.AU

REG SPRIGG'S DIVING CHAMBER

Reginald Claude Sprigg (1/3/19 – 2/12/94) a pioneering South Australian geologist and adventurer. His enquiring mind and willingness to challenge the scientific viewpoint of the day led to many great discoveries. Reg found the oldest animal fossils in the world the Ediacaran fossils (on display at the South Australian Museum) and the deepest undersea canyons in Australia, one of which is now named Sprigg Canyon in his honour. He also discovered the Cooper Basin oil and gas fields and helped establish the companies SANTOS and Beach Energy. In his early days, Reg studied under Sir Douglas Mawson at The University of Adelaide. A conservationist ahead of his time, Reg created the Arkaroola Wilderness Sanctuary to preserve the flora, fauna and geology of the northern Flinders Ranges.

Reg's geological interests extended under the sea. He was an early adopter of scuba diving in the 1960s and built his own underwater diving chamber from a disused boiler. He commissioned a research vessel, SAORI built at Searles boatyard, Port Adelaide to confirm his discovery of massive undersea canyons south of Kangaroo Island. He and his team of scuba divers completed the first benthic survey of Gulf St Vincent, establishing a valuable baseline for the plants, animals and sub-surface terrain in existence at the time. These results are still referenced today.

Chamber at Arkaroola

The diving chamber, built by Reg's company Geosurveys, finished its days 600km from the sea at Arkaroola. In 2012, a group of South Australian divers launched an effort to restore the chamber and preserve its history. The chamber was brought to Adelaide and restored over a period of four years by a dedicated team of volunteers led by Dr Richard Harris from the Diving and Hyperbaric Medicine unit, Royal Adelaide Hospital.

It stands now as a monument to the early days of underwater exploration in South Australia and to Reg Sprigg's tenacity, achievements and spirit of adventure.

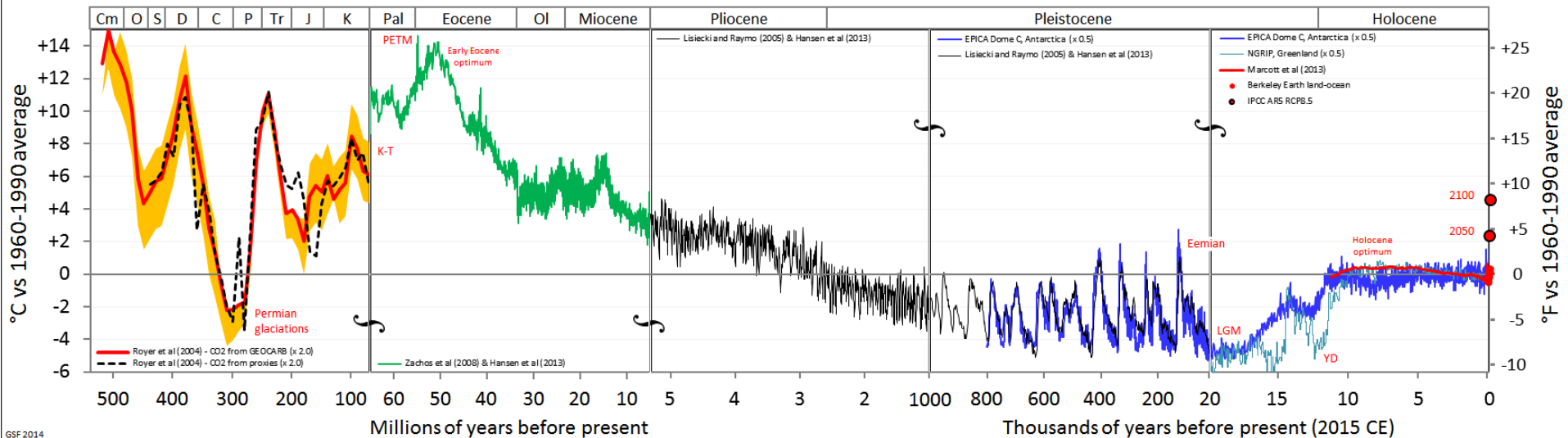
Ediacran Period

635-539 million years ago.

Named after the Ediacra hills in SA.

First multicellular fauna.

Temperature of Planet Earth



Time is plotted forward to the present, taken as 2015 CE.

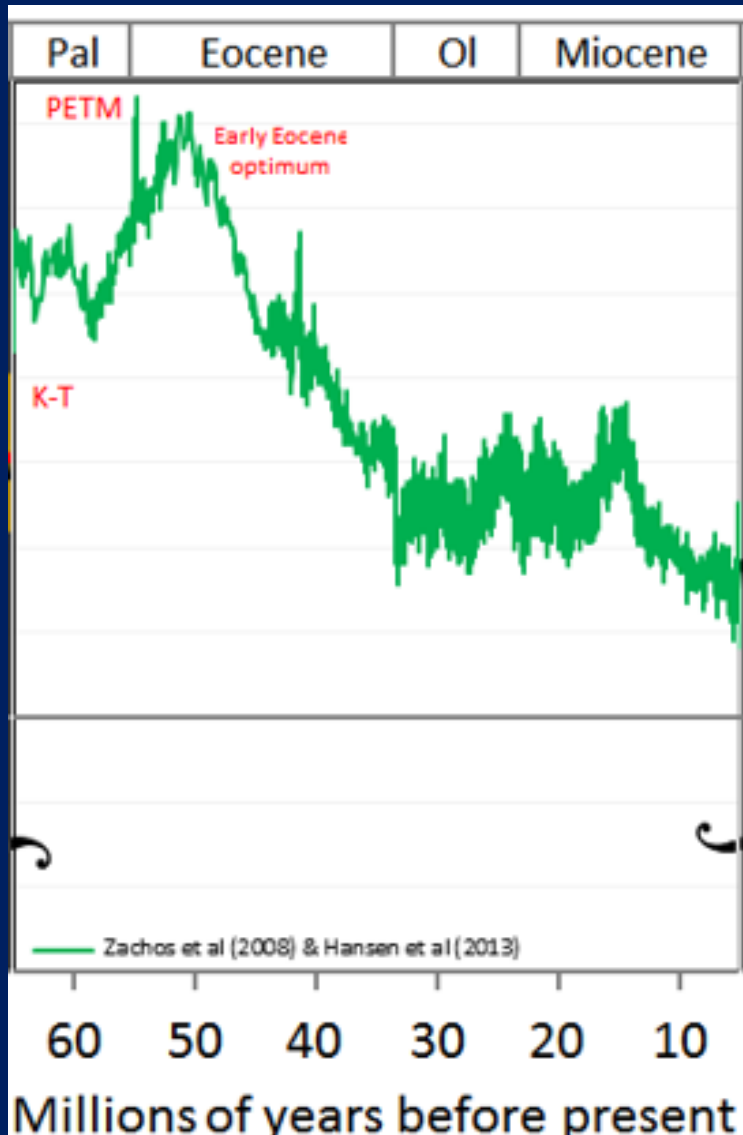
Note that the scale expands towards the present. There are five separate linearly scaled segments, expanding by about an order of magnitude at each vertical break.

Surface air temperature is plotted as anomalies (differences) from the average over the reference interval 1960–1990 (which is about 14°C)

https://commons.wikimedia.org/wiki/File:All_palaeotemps.png#Data

Figure prepared by Glen Fergus.

Changing Geography – and its impact on climate



Focus on the period 30 Ma – 10 Ma

There were some very important changes in geography that have set up the Southern Ocean and Pacific Oceans as we have them today.

These changes were due to the movement of the continents through plate tectonics.

It introduces some basic themes and concepts:

- Effect of movement of continents on climate and ocean
- Formation of mountains and the associated impact on the carbon dioxide levels due to weathering – **the slow carbon cycle**.
- another fundamental concept along with **greenhouse gases**.

CONTINENTAL DRIFT

Pangaea



Laurasia and Gondwana



Modern world



200-300 mya

Plate Tectonics, Paleogeography, & Ice Ages (540 million years ago - Present-day)

by

Christopher R. Scotese

Play K June 1, 2019

0:02 / 1:39

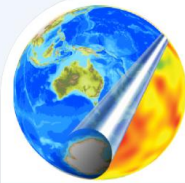
Scotese Plate Tectonics Paleogeography & Ice ages

Christopher Scotese
48.9k subscribers

6.3k Share Save Download

<https://youtu.be/UevnAq1MTVA>

"Scotese, C.R., 2019. Plate Tectonics, Paleogeography, and Ice Ages, YouTube video: • Scotese Plate Tectonics Paleogeography & I... ."



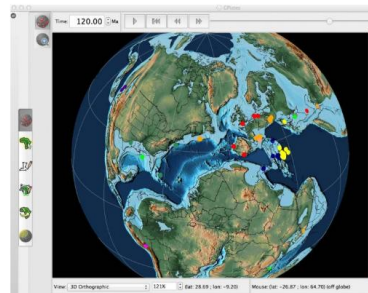
EarthBYTE

Building a Virtual Earth

Home Research People Publications Resources Training & Outreach News Multimedia Opportunities Links

PALEOMAP PaleoAtlas for GPlates

19 April, 2016 by Carmen Braz



The PALEOMAP PaleoAtlas for GPlates consists of 91 paleogeographic maps spanning the Phanerozoic and late Neoproterozoic. The PaleoAtlas can be directly loaded into GPlates as a *Time Dependent Raster* file. The paleogeographic maps in the PaleoAtlas illustrate the ancient configuration of the ocean basins and continents, as well as important topographic and bathymetric features such as mountains, lowlands, shallow sea, continental shelves, and deep oceans. This tutorial also describes how the maps in the PaleoAtlas were made, documents the sources of information used

to make the paleogeographic maps, and provides instructions how to plot user-defined paleodata on the paleogeographic maps using the program *PaleoDataPlotter*.

Search ...

THE UNIVERSITY OF SYDNEY School of Geosciences

GPlates 2.5

GPlates 2.3

GPlates 2.4

GPlates Legacy

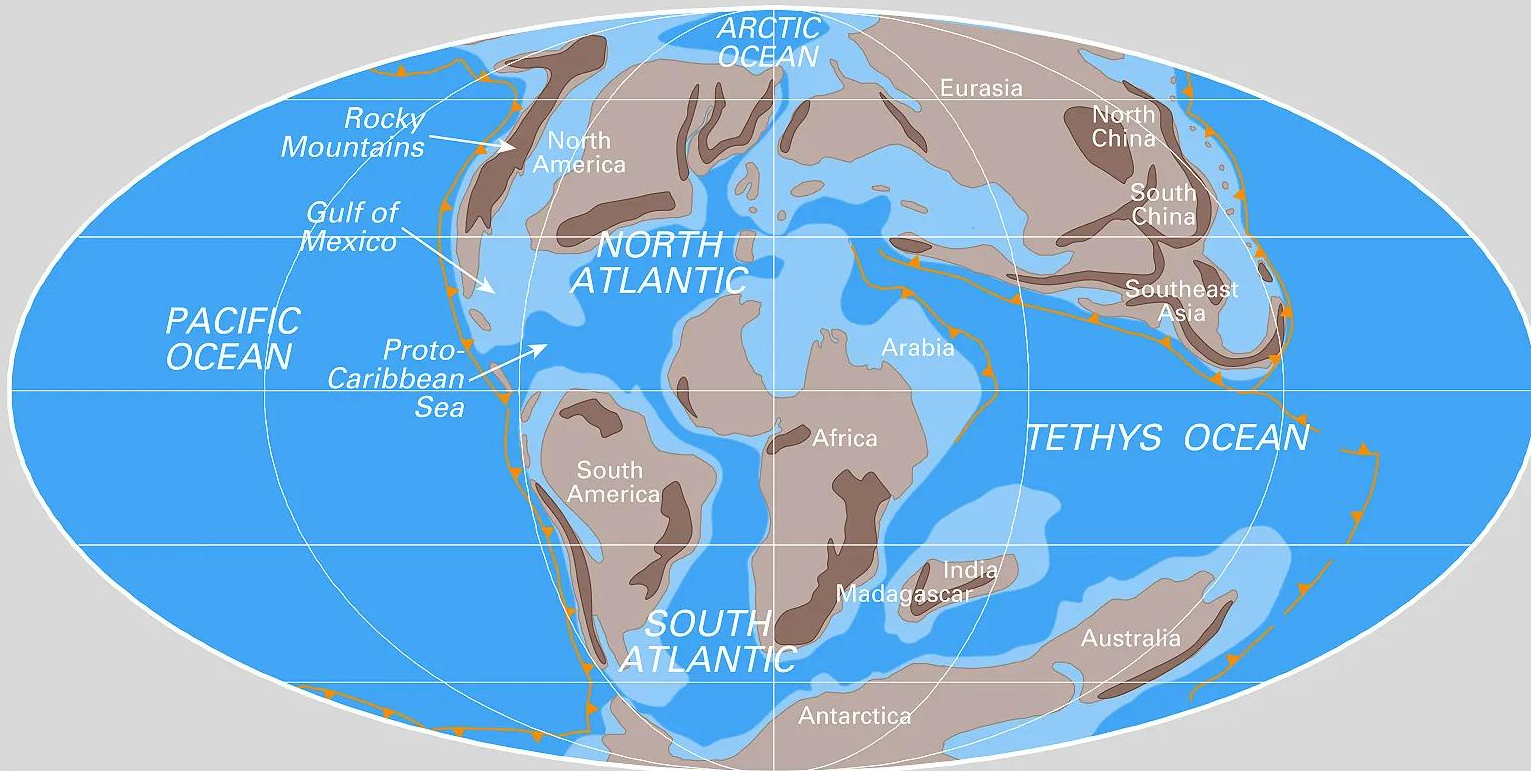
How changing geography affects climate




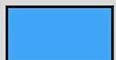

- New surfaces at different latitudes – effect on land cover, rainfall, reflectivity (albedo)
- Land at the poles can be colder than sea at the poles
- Mountain building
- New seaways change ocean currents
- Changes in ocean circulation affect the direction and rates of water flow and heat transfer across latitudes.
- Snow and ice on land can change reflectivity (albedo) and sea level
- Can affect the evolution of life forms (plants and animals).

References: Chapter 4 Climate Change – Geoscience Perspective p 269 -

Two regions of our planet that experienced dramatic change over the past 70 million years are Antarctica and the Arctic.

- 50 Million years ago - no ice sheets in either of the polar regions.
- 34 million years ago - onset of widespread glaciation of Antarctica.
- Only 2.75 million years ago - development of large-scale ice sheets in the Arctic.

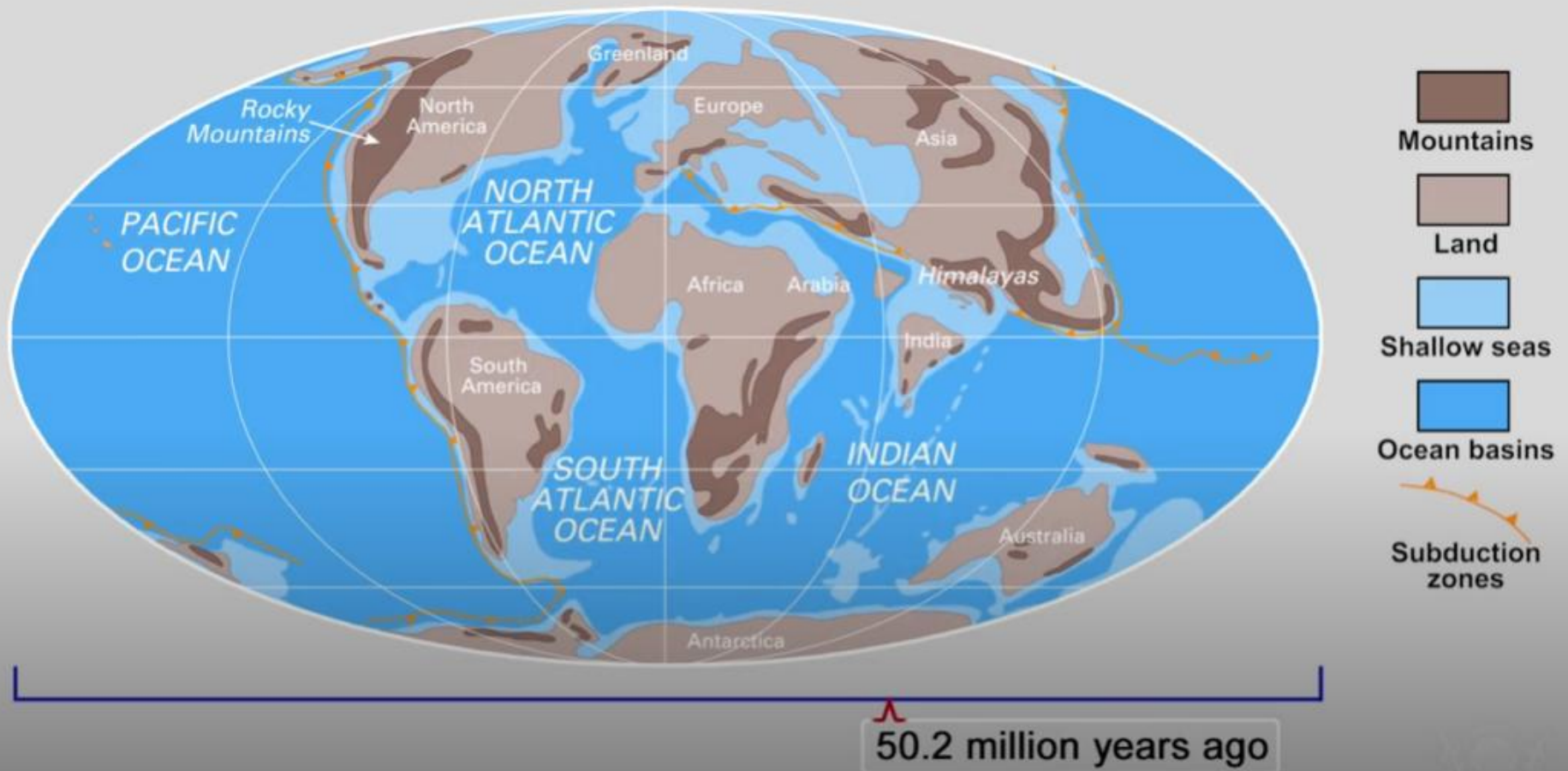


-  Mountains
-  Land
-  Shallow seas
-  Ocean basins
-  Subduction zones

94 million years ago

Late Cretaceous





Middle Eocene

00:49 / 01:14

AD CC Settings

<https://www.britannica.com/video/Earth-Pangea-Proxima-locations-continents-inset/-158683>

The Southern Ocean and the climate of Antarctica have not always been the way they are now.

- Opening up of the ocean between Tasmania and Antarctica (30-33 Million years ago) and of the Drake Passage (30-40? 23 Million years ago ?)

Antarctica became isolated from the ocean gyres that brought heat southwards. Antarctica became colder, enhancing the temperature gradient between the tropics and the poles and hence speeding up the westerly winds and ocean currents.

The opening of these two oceanic gateways over millions of years eventually resulted in unrestricted flow around the Antarctic continent, and the creation of the Antarctic Circumpolar Current (ACC).

This strong ocean current and westerly winds isolated Antarctica from the warmer latitudes and allowed it to cool. Once snow and ice formed it became a feedback loop leading to the deep ice that is there now.

The colder ocean can also absorb more carbon dioxide, so reducing the amount of this greenhouse gas in the atmosphere.

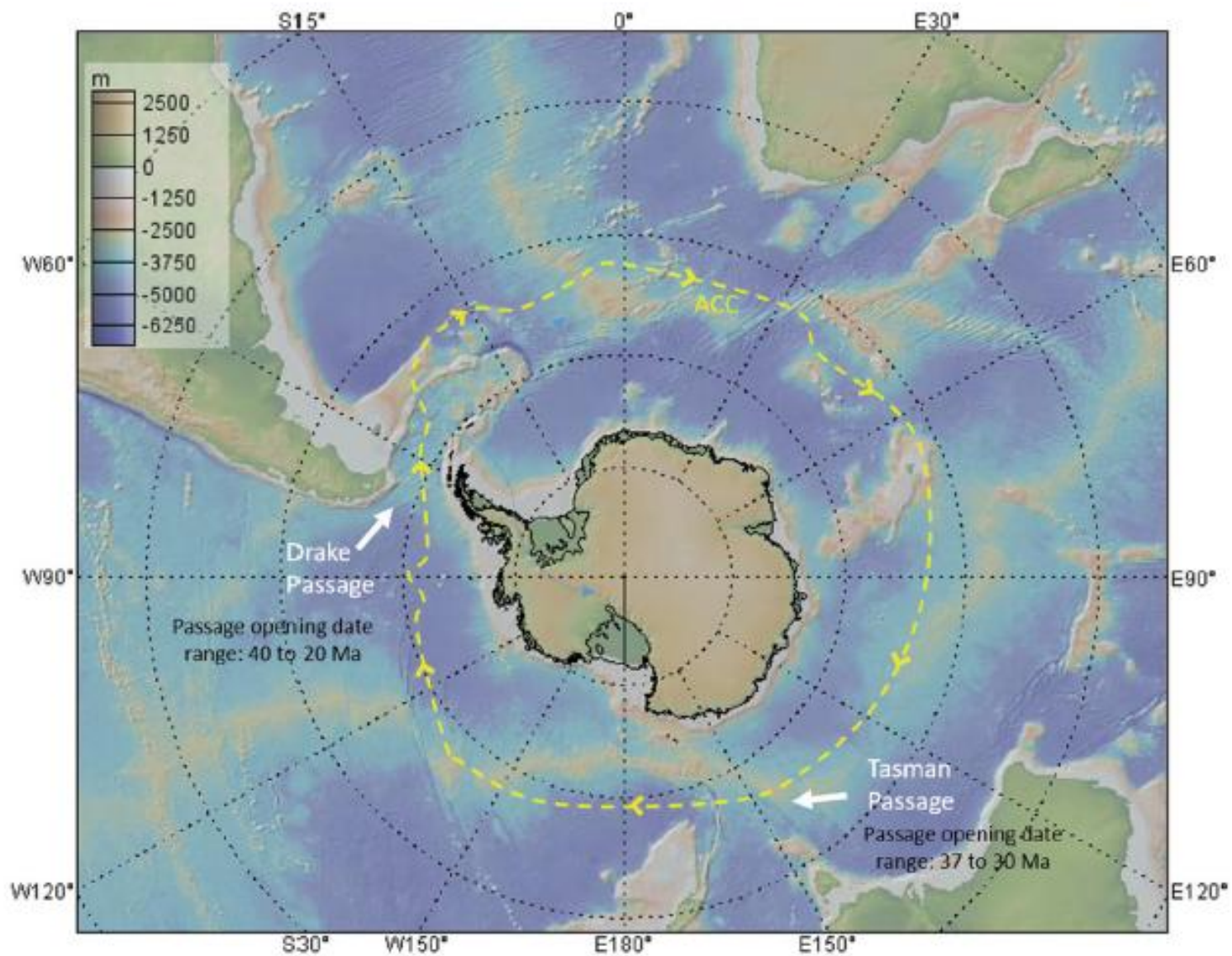


Fig. 14 Map showing the generalized position of the Antarctic Circumpolar Current (ACC), which developed after the opening of the Drake and Tasman Passages²⁹

How do they know this?

Sediment core samples indicate that the opening of the Tasman Passage began around 37 million years ago, with the presence of shallow waters in place about 35 million years ago, and a fully opened ocean gateway between Australia and Antarctica by about 33 to 30 million years ago.

Off-shore core samples show the presence of glacially influenced sediments, and hence the earliest Antarctic ice sheets, from about 35 million years ago.

Evidence for the opening Drake Passage is less precise but is between about 40 and 20 million years ago.

Widespread cooling and associated glaciation in the Arctic region didn't take place until over 30 million years later.

Changes in the positions of continents can have a significant effect on the winds and ocean currents.

9 November 2021

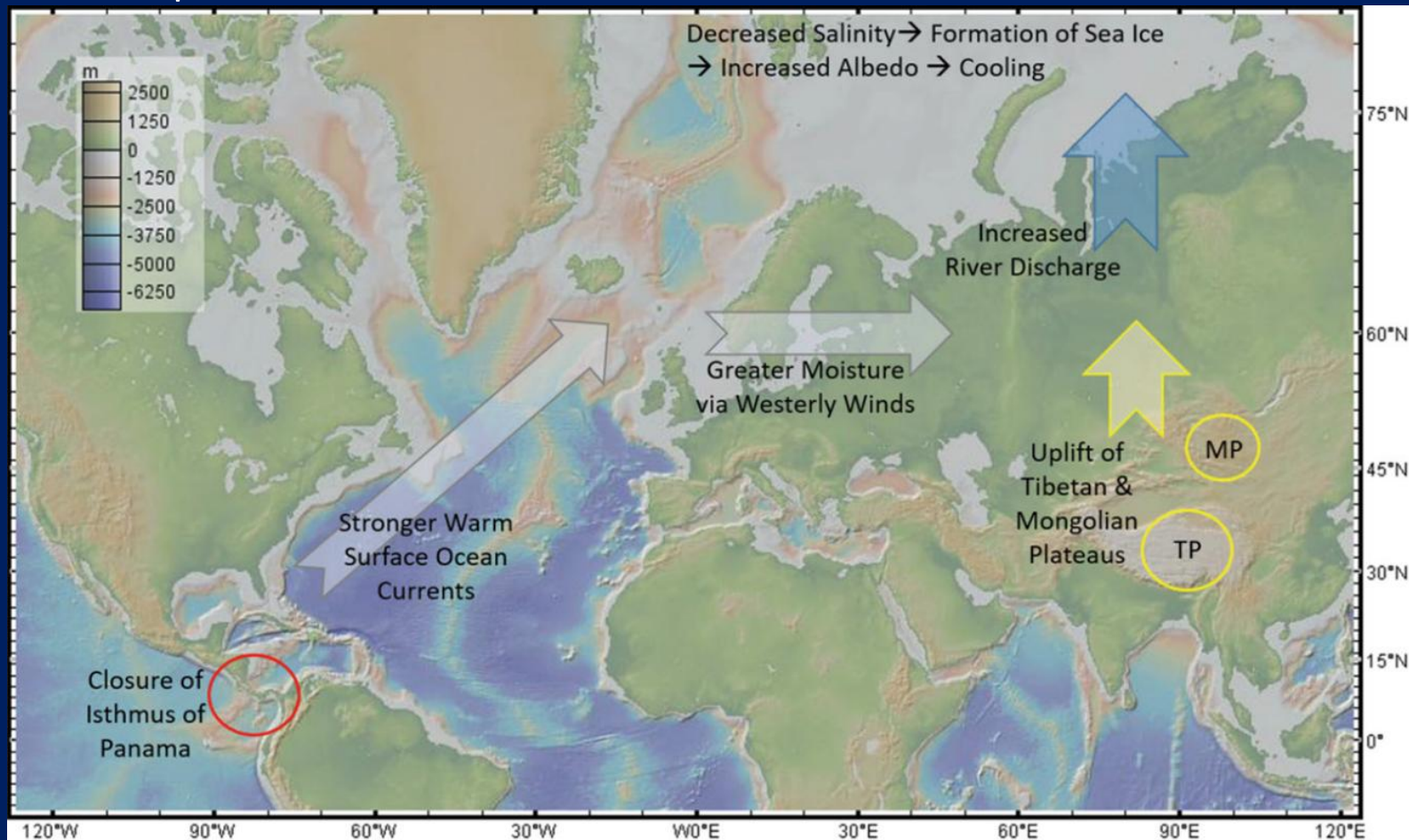
Plate tectonics as a driver for cooling around Antarctica during global climate transition from greenhouse to icehouse

High-resolution simulations of ocean circulations 34 million years ago are shedding a new light on the 50-year-old question about how and why the Antarctic ice sheets formed. The simulations show that the tectonic opening of Southern Ocean seaways caused a fundamental reorganisation of ocean currents, heat transport and initiated a strong Antarctic surface water cooling of 5 °C. The new study conducted by an international team of researchers has been published in the November 9th issue of *Nature Communications*.

<https://www.uu.nl/en/news/plate-tectonics-cooling-antarctica>

Closing of the Panama Isthmus (4.5 – 2 Mya) cutting off currents that once flowed between the tropical Pacific and Atlantic Oceans.

Pacific Ocean water was fresher than the Caribbean and cutting it off made the Caribbean saltier. The Gulf Stream, a western boundary current that flows from the tropics to the North Atlantic, intensified bringing more heat and moisture to northwestern Europe.



Cooling of the Arctic

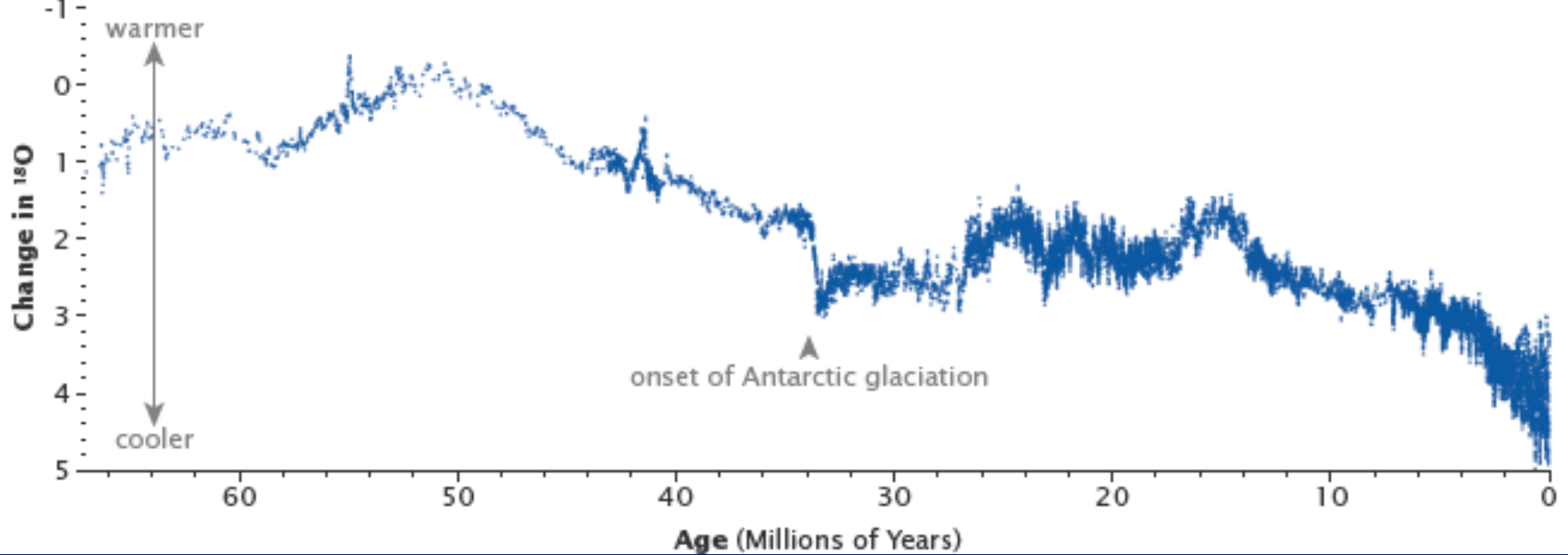
The collision of India with Eurasia resulted in the uplift of the Tibetan and Mongolian Plateaus, causing an increase in rainfall and flow of fresh water toward the Arctic Ocean.

With added freshwater (from the Gulf Stream and rivers) the Arctic region was primed for sea ice formation (lowering the salinity means it is easier for water to freeze).

There are several feedback mechanisms:

- Sea ice growth results in higher albedo reflecting more sunlight
- Sea ice also prevents heat stored in the ocean from escaping to the atmosphere.
- The colder ocean can absorb more CO₂ from the air.

The north polar latitudes cooled and glaciers formed on the cold land, again with the feedback of the high reflectivity reducing the sunlight absorbed by the land.



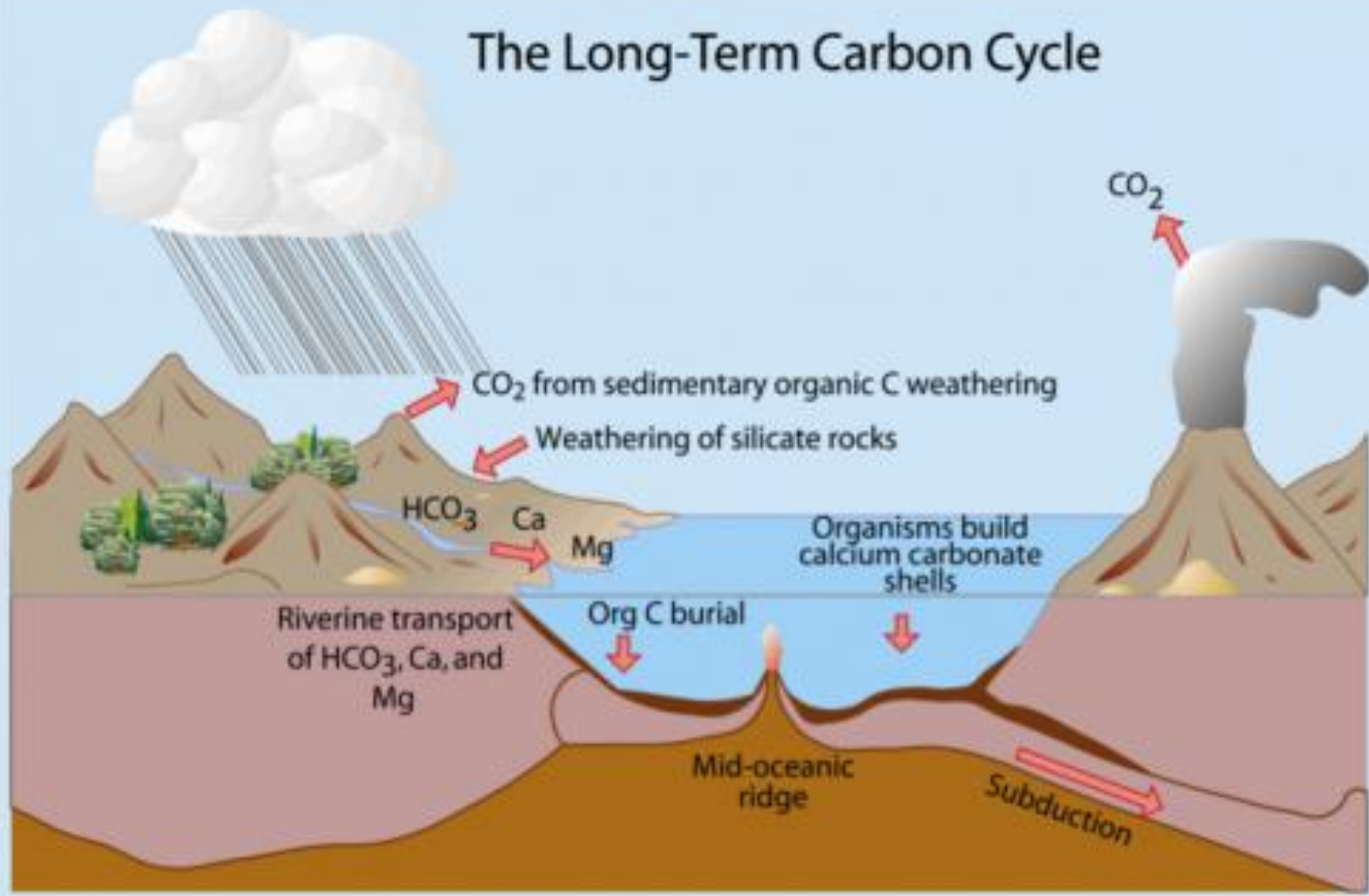
*The graph shows changes in the ratio of oxygen isotopes in the deep ocean – a **proxy** for temperature).*

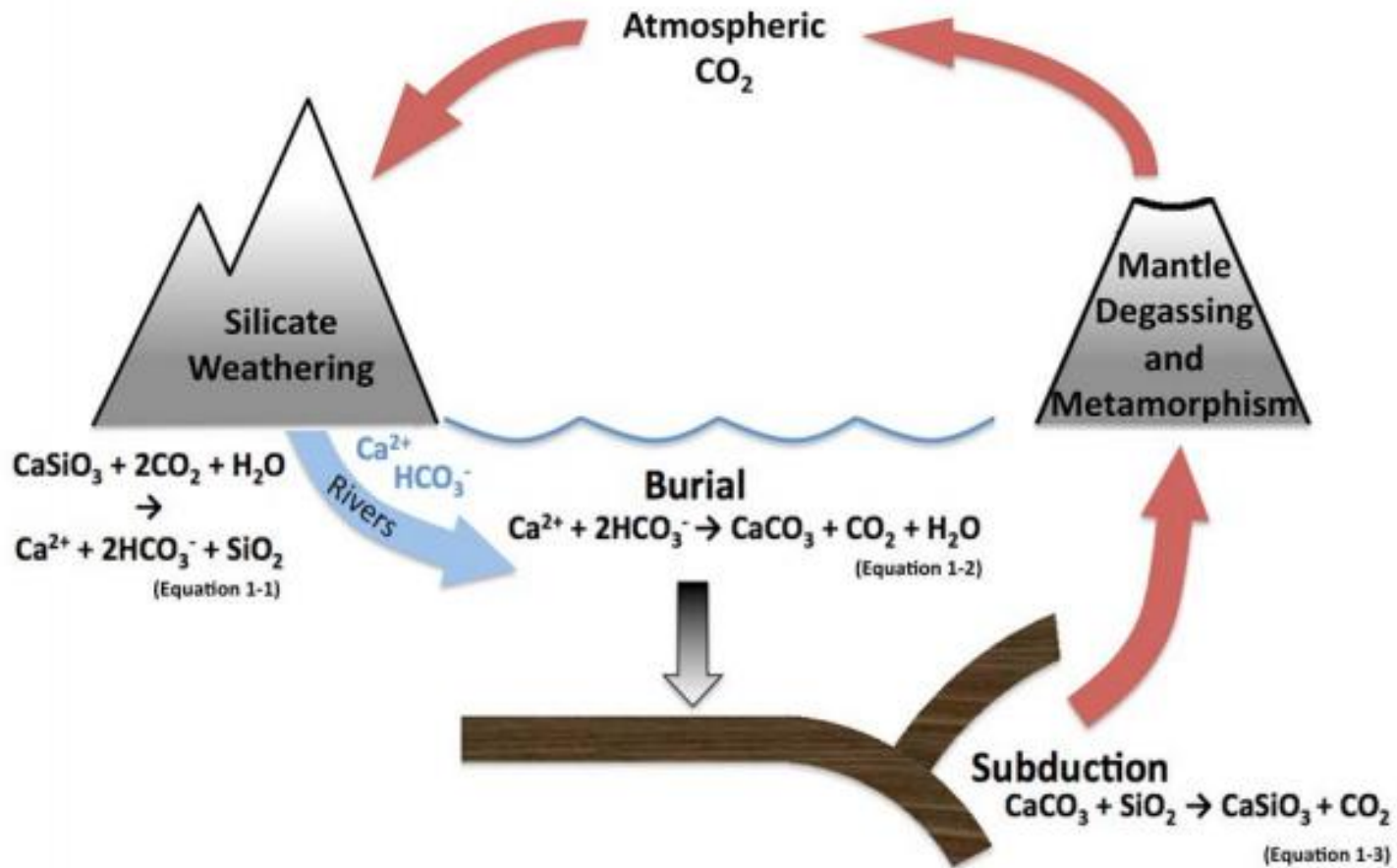
Cooling had commenced before Antarctica was isolated and appears related to the collision of India and Eurasia, beginning 50 million years ago, and the resulting uplift of the Tibetan-Himalayan and Mongolian Plateaus. A similar process led to the uplift of the Sierra-Coloradan Plateau in North America.

The mountain-building provided a large source of fresh rock to pull more carbon dioxide out of the atmosphere through weathering in the Long Term (or Slow) Carbon Cycle.

<https://science.nasa.gov/earth/earth-observatory/the-carbon-cycle/>

The Long-Term Carbon Cycle





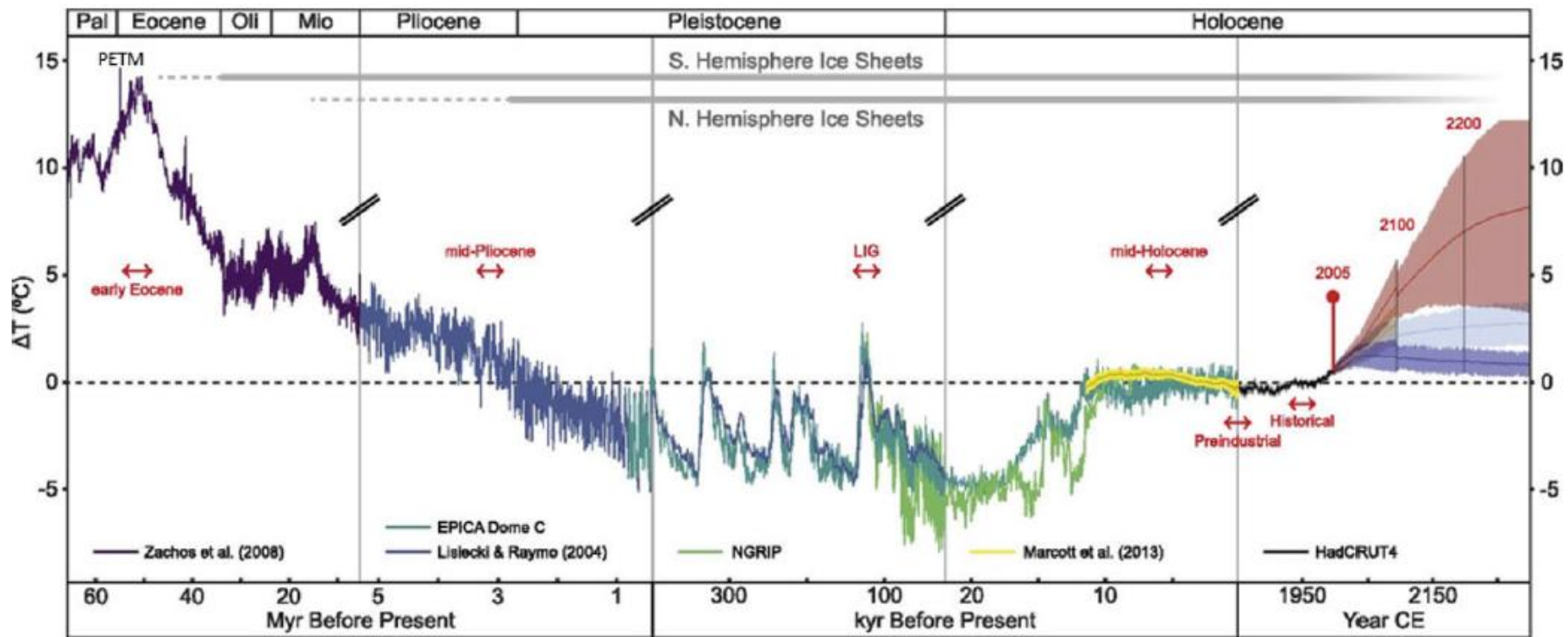
These processes operate on time-scales of hundreds of thousands or millions of years.

Plate tectonic reconstructions of this time interval show a fast-moving Indian subcontinent racing (in geologic terms; around 5–10 cm per year) toward Asia, and upon collision, uplifting the Himalayas and Tibetan Plateau at around a centimeter per year.

In addition to the change in river drainage (i.e., freshwater input) to the Arctic, this uplift of the collision zone increased the exposure, weathering and erosion of silicate minerals previously deeply buried on both continents.

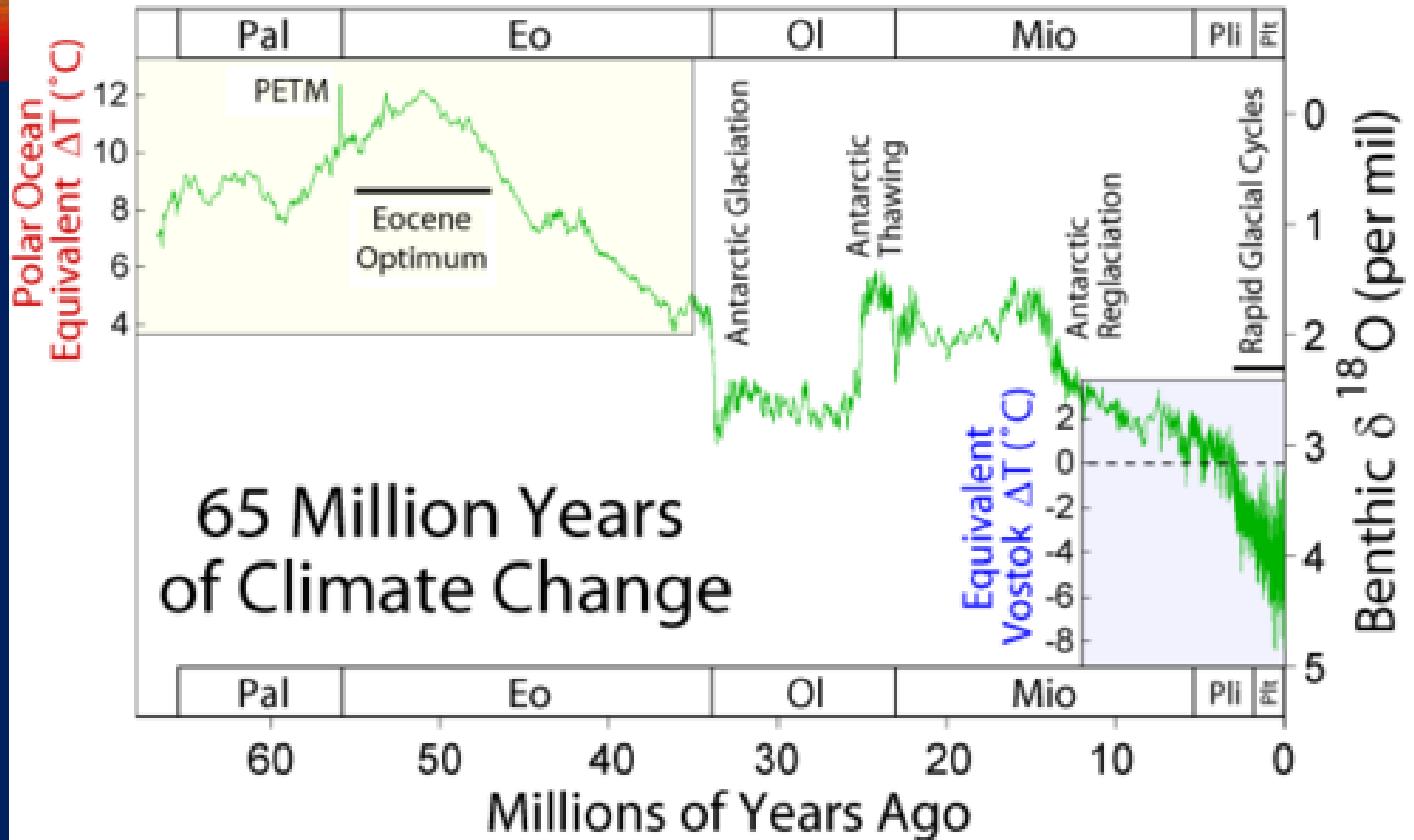
The scale of this event was sufficient in magnitude to increase the overall weatherability of the planet, and thus the global silicate weathering rate. The result was a drawdown in atmospheric CO₂, since weathering rates came to exceed the rate of volcanic CO₂ input.

Life – plants (e.g. roots, lichen) – assist weathering.



So **three main factors** in the cooling of the global atmosphere from about 50 million years ago to about 500,000 years ago:

- Mountain building from collision of land masses, leading to the exposure and subsequent weathering of silicate rocks, that ultimately saw CO_2 levels in the atmosphere decrease.
- Isolation of Antarctica leading to the glaciation and formation of a thick ice sheet with high reflectivity
- Increased moisture flow to high northern latitudes that led to the formation of sea ice and glaciers, also with increased reflectivity.



<https://www.smithsonianmag.com/smithsonian-institution/what-happened-the-last-time-the-climate-changed-1157388/>

https://en.wikipedia.org/wiki/File:65_Myr_Climate_Change.png

Impact on Australia's climate

(from Shaping a Nation – A Geology of Australia)

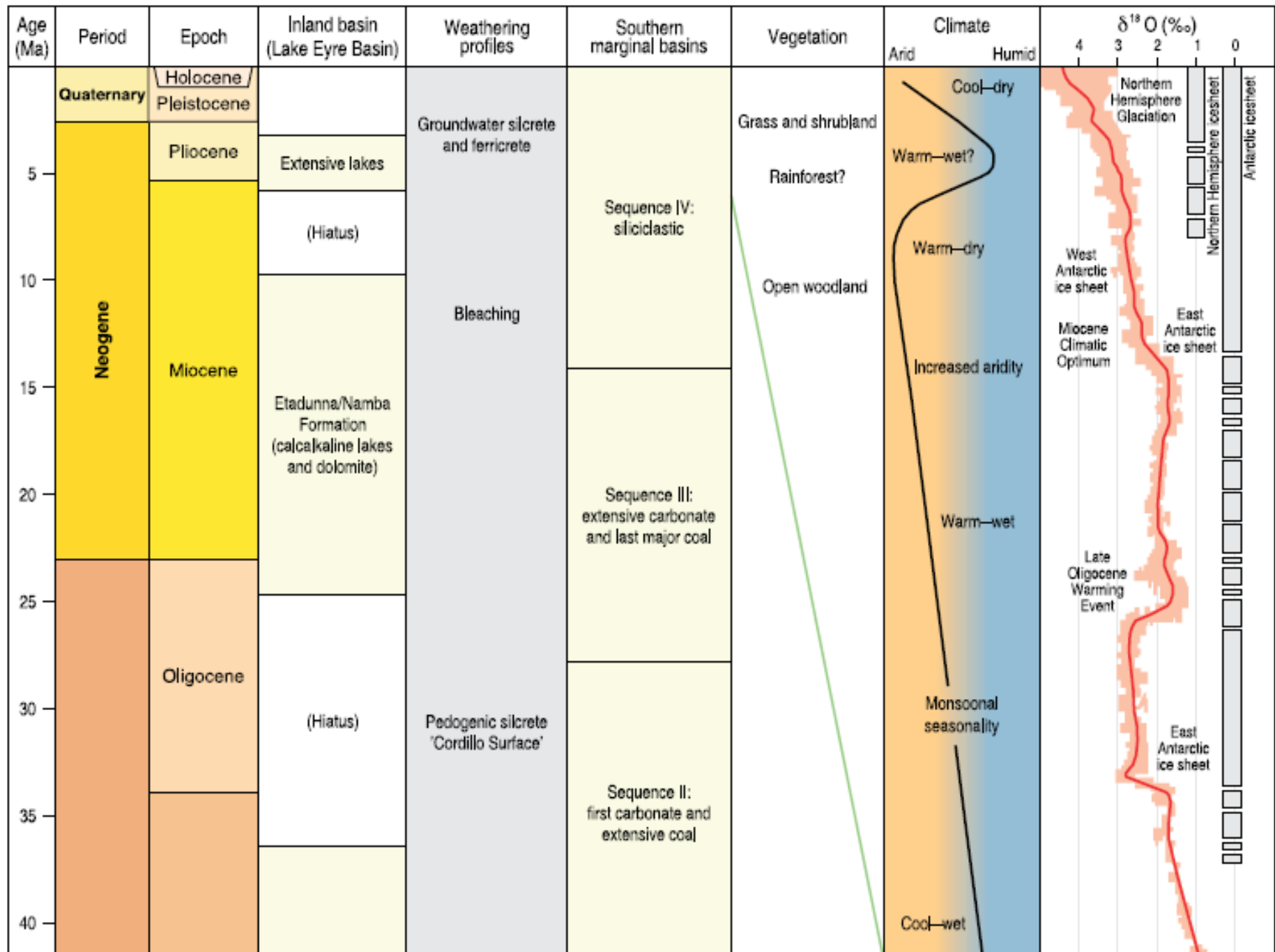
There were several phases of ice sheets after glaciation started in West Antarctica around 34 Ma.

The great ice sheet on Antarctica began to develop around 15–10 Ma in the east and 10 – 6 Ma in the west.

The formation of the Antarctic ice sheet fundamentally altered Earth's marine and terrestrial climate **and sea-levels**.

The impacts on Australia were large:

- The north-south (meridional) temperature difference increased, and the subtropical monsoon contracted northwards, which placed much of the continent in the drier mid-latitudes. (Figure 2.36 below).



Uncovering Australian stakeholder preferences for who should lead the deployment of novel carbon dioxide removal technologies

Dr Kerry Brent¹, Dr Yuwan Malakar², Talia Jeanneret², Dr Rod McCrea², Dr John Gardner²
1. CSIRO Hobart; 2. CSIRO, Brisbane

Novel carbon dioxide removal (CDR) approaches could significantly assist Australian governments and industries to achieve net zero. These approaches remove CO₂ directly from the atmosphere and store it in land, ocean and geological sinks. Stakeholders see government leadership as key to promote responsible CDR deployment in Australia.

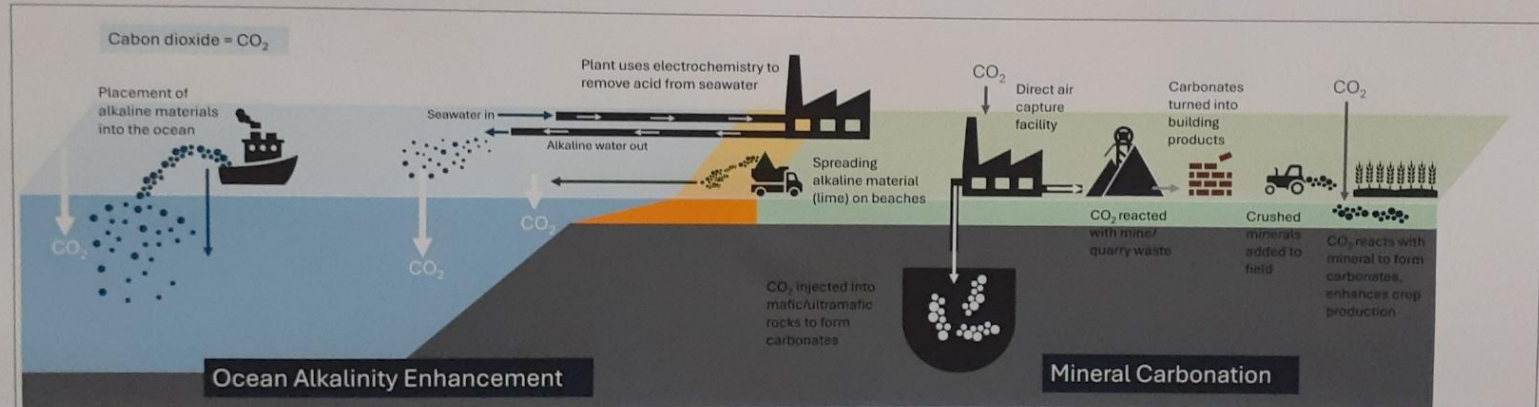


Figure 1: Novel CDR approaches that are the focus of this study

1. Introduction

CDR is essential to keep climate change within the 1.5-2°C temperature limits set under the Paris Agreement.¹ Conservative estimates suggest that Australia could achieve 330 Mt CO₂ removals per year via novel CDR.² This could see Australia exceed its domestic CDR requirements, creating opportunities to provide removals for other countries.²

Public support is essential to realise CDR at this scale. When it comes to evaluating public opinions on CDR, researchers should look beyond technological attributes and consider how other factors may influence perceptions.³⁻⁵ This includes the role of different actors in developing and deploying these technologies.

This study therefore asks: *what are Australian stakeholders' perspectives on who should lead novel CDR activities?*

2. Method

We conducted semi-structured interviews in three states: ocean alkalinity enhancement in Tasmania, and mineral carbonation in New England (NSW) and Central Queensland. These regions were selected because they are potentially suitability for these CDR activities. For Tasmania, 22 interviews were conducted with 23 participants. In total, 32 interviews were conducted with 36 participants for NSW/QLD. Participants were stakeholders who would likely have an interest in CDR being conducted in the target region, including representatives of government departments, NGOs and industry, as well as researchers.

Participants were invited to share their views on what responsible deployment of CDR would involve in Australia, including who should be involved. Thematic analysis was conducted using NVivo to identify themes from the data.

(CSIRO): Ocean Alkalinity Enhancement (OAE) works by speeding up the naturally occurring process in which the ocean removes CO₂ from the atmosphere.

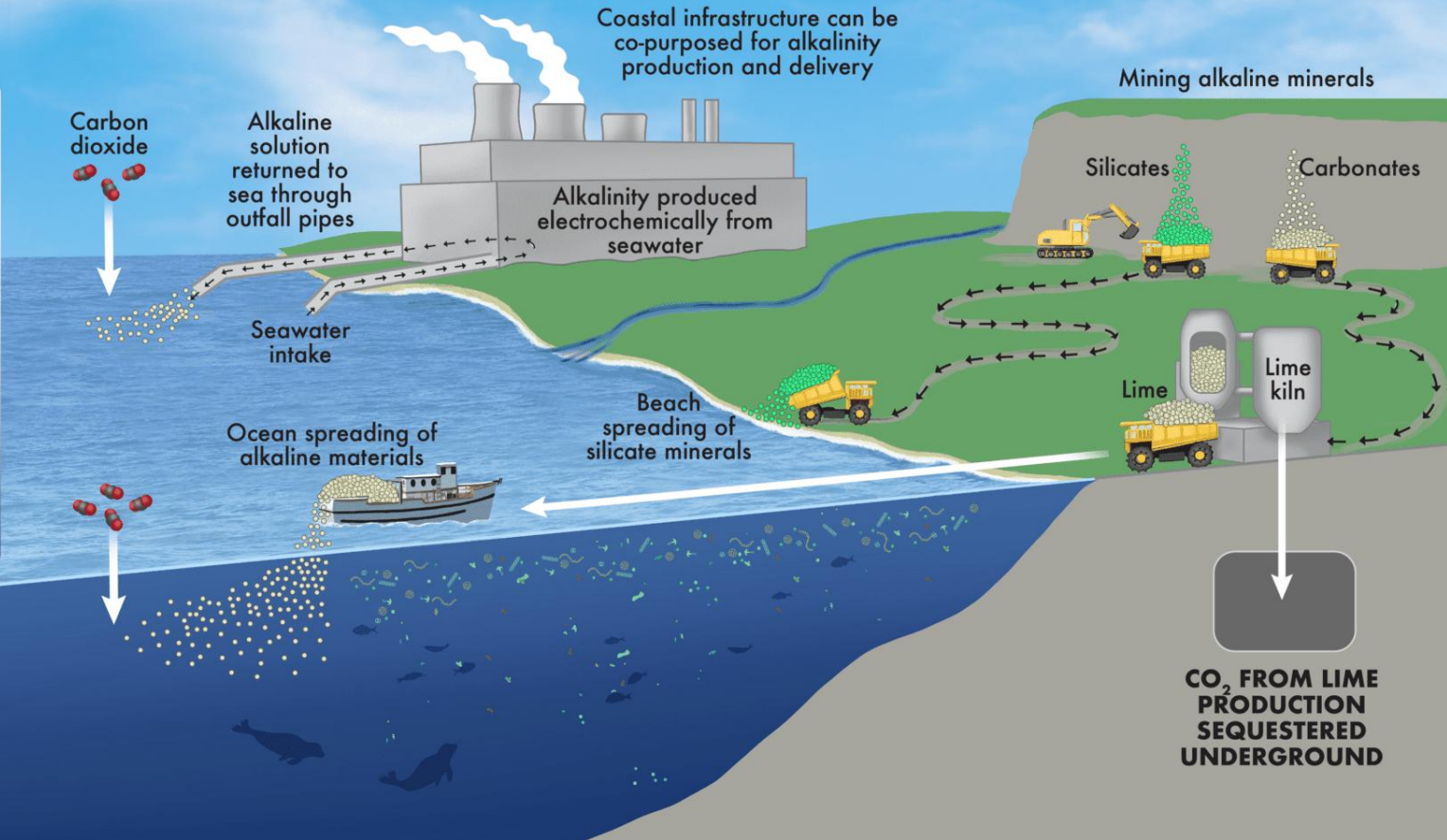
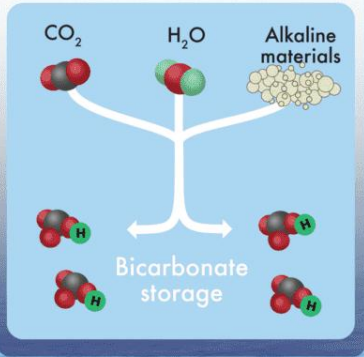
- Over hundreds of thousands of years, alkalinity is added to the rivers, and eventually the ocean, through the weathering of rocks on land, such as limestone or basalt.
- These dissolved minerals in the ocean react with CO₂ causing the ocean to then take up additional CO₂ from the atmosphere to restore its balance.
- Atmospheric CO₂ enters the ocean and reacts with seawater to form stable bicarbonate (HCO₃⁻) and later carbonates. So, CO₂ is locked away in the ocean.

Approaches to safely add more alkaline substances to the ocean:

- grinding naturally occurring minerals like basalt or olivine and dropping them in the ocean
- depositing alkaline industrial products, like lime, or waste products like steel slag and cement kiln dust to the ocean
- electrochemical processing of sea water to produce sodium hydroxide which can be pumped back into the ocean.

OCEAN ALKALINITY ENHANCEMENT

CARBON DIOXIDE IN SEAWATER + ALKALINITY = CARBON STORED IN THE OCEAN AS BICARBONATE



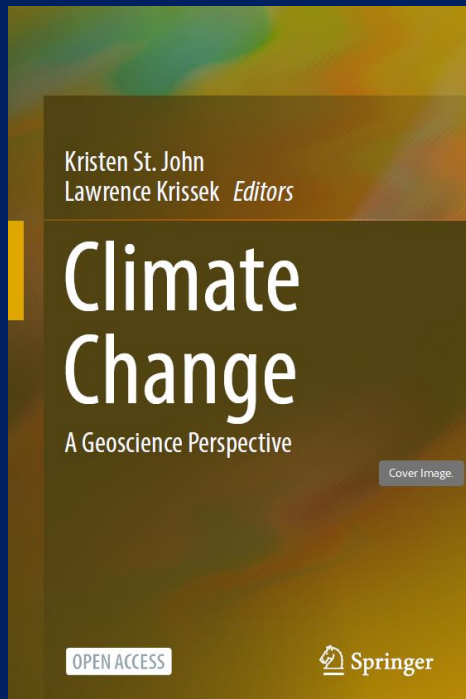
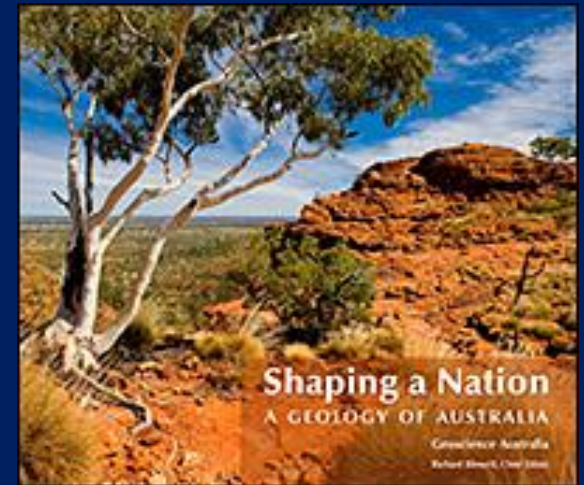
Note: The ocean contains about 50 times as much CO_2 as the atmosphere.

Open Access References

Shaping a Nation – A Geology of Australia –
(Chief Editor: Richard Blewett). Geoscience
Australia (2012)

A free pdf version available at:

<https://press.anu.edu.au/publications/shaping-nation>



Climate Change – A Geoscience
Perspective.

Open Access book – download pdf
from:

<https://link.springer.com/book/10.1007/978-3-031-82869-0>