TEKNIK GEOFISIKA ITS SURABAYA
MGMP GEOGRAFI JAWA TIMUR

Webinar, 19 Februari 2022

GEOLOGI KELAUTAN INDONESIA

Google Earth

AWANG H. SATYANA
Geolog Independen

Diskusi

1. Dimensi Air di Bumi
2. Ilmu-Ilmu Kelautan
3. Geologi Kelautan
4. Geologi Kelautan Indonesia

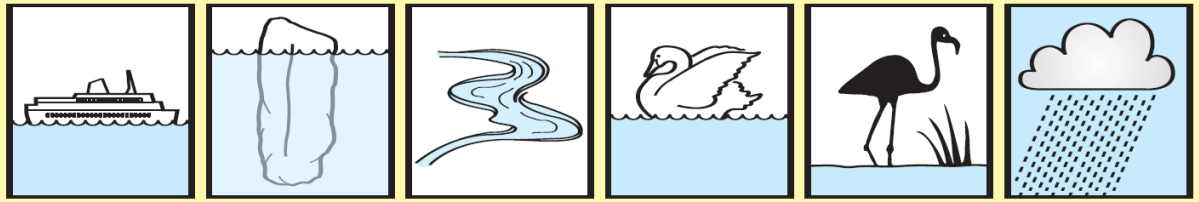
Diskusi

1. **Dimensi Air di Bumi**
2. Ilmu-Ilmu Kelautan
3. Geologi Kelautan
4. Geologi Kelautan Indonesia

https://sos.noaa.gov/catalog/datasets/etopo1-topography-and-bathymetry/

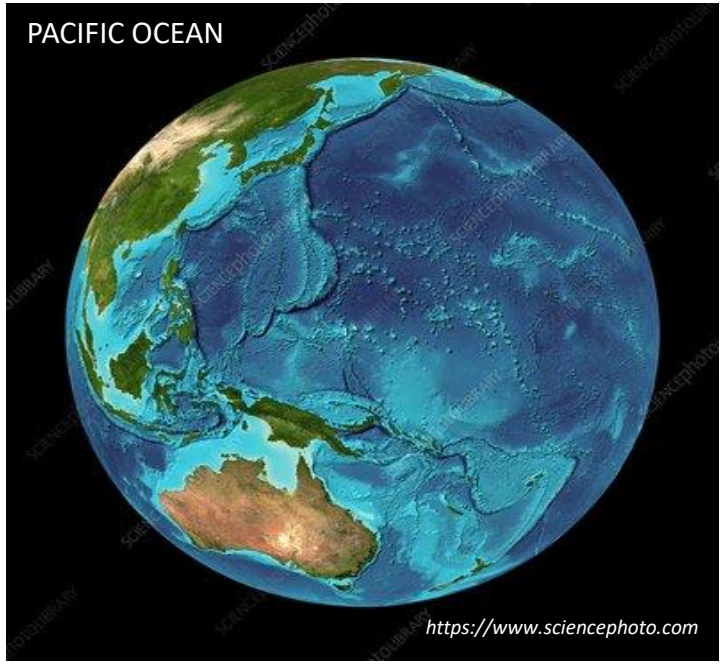
Dimensi Air di Permukaan Bumi

The partition of water on Earth's surface

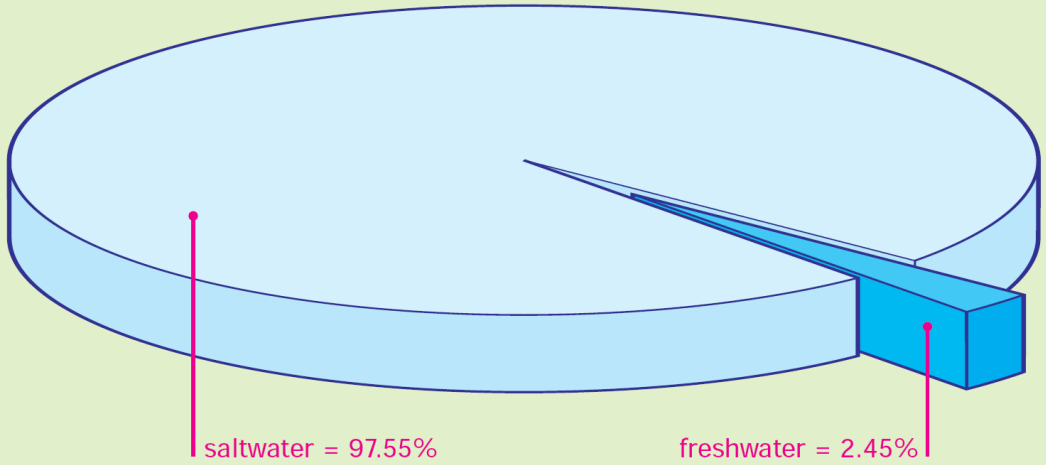


Seas and oceans	Ice	Groundwater	Lakes and rivers	Inland saltwater	Atmosphere	
97.54	1.81	0.63	0.009	0.007	0.001	% of total water
–	73.9	25.7	0.36	–	0.04	% of fresh water

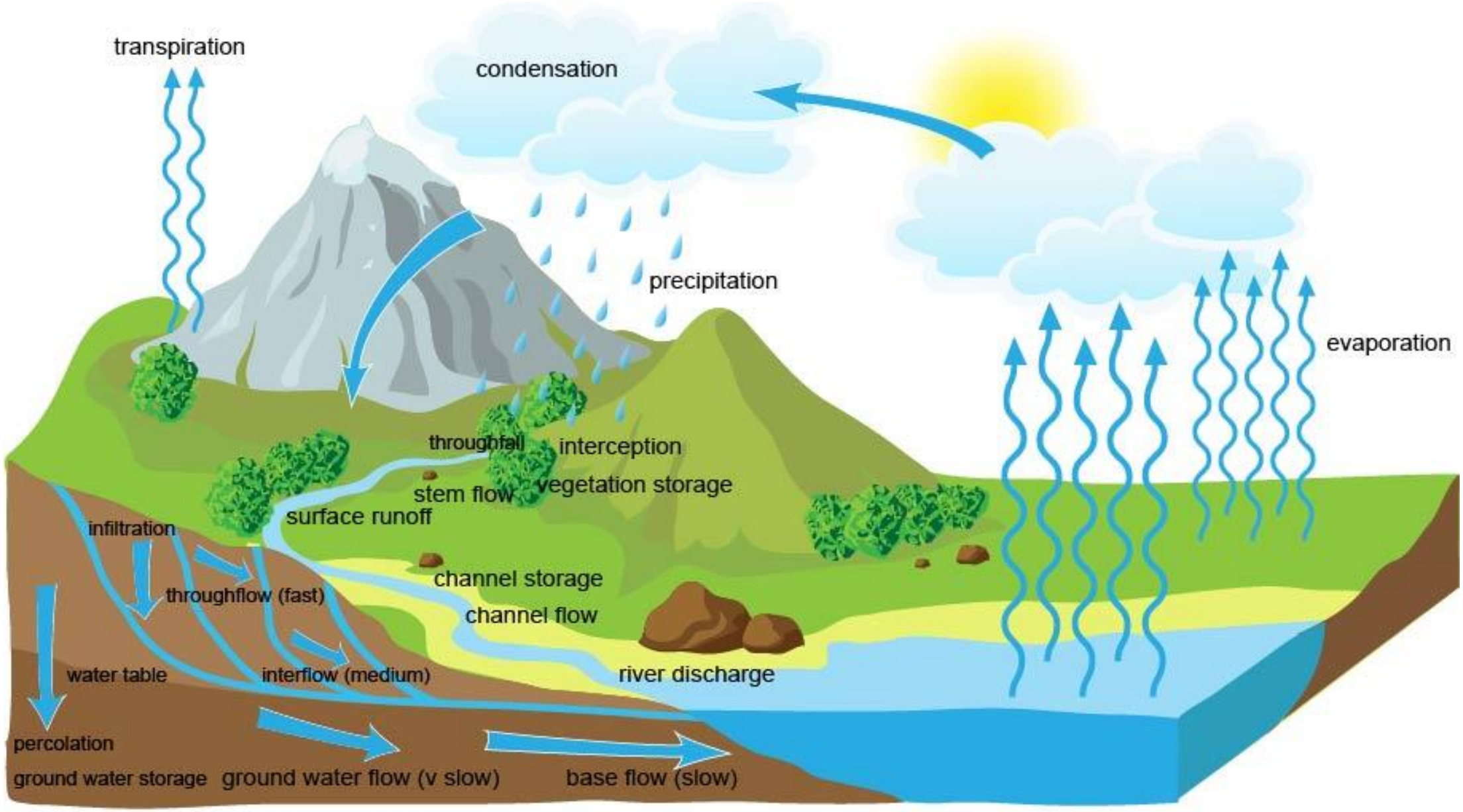
These figures do not include the tiny fraction of available water contained within living organisms.



The partition of surface water



Marine Science: An Illustrated Guide to Science *(The Diagram Group, 2006)*



The drainage basin hydrological system

https://www.alevelgeography.com/drainage-basin-hydrological-system/

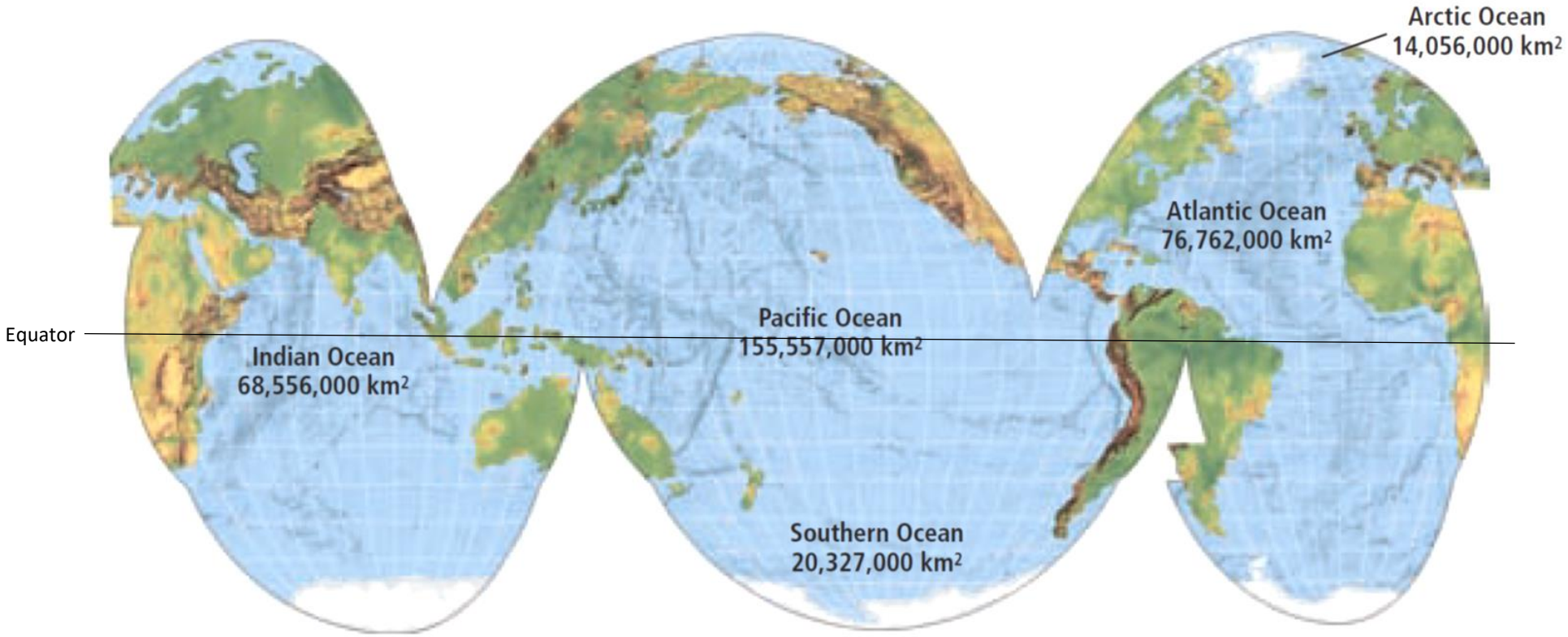


Figure 15.8 The Pacific, Atlantic, and Indian Oceans stretch from Antarctica to the north. The smaller Arctic Ocean and Southern Ocean are located near the north and south poles respectively.

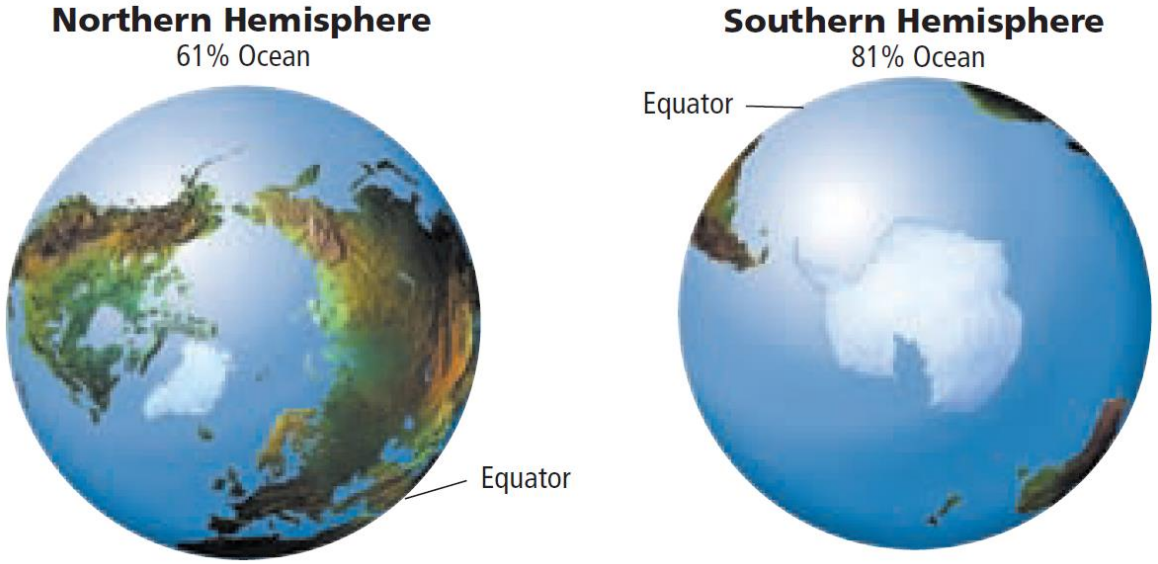
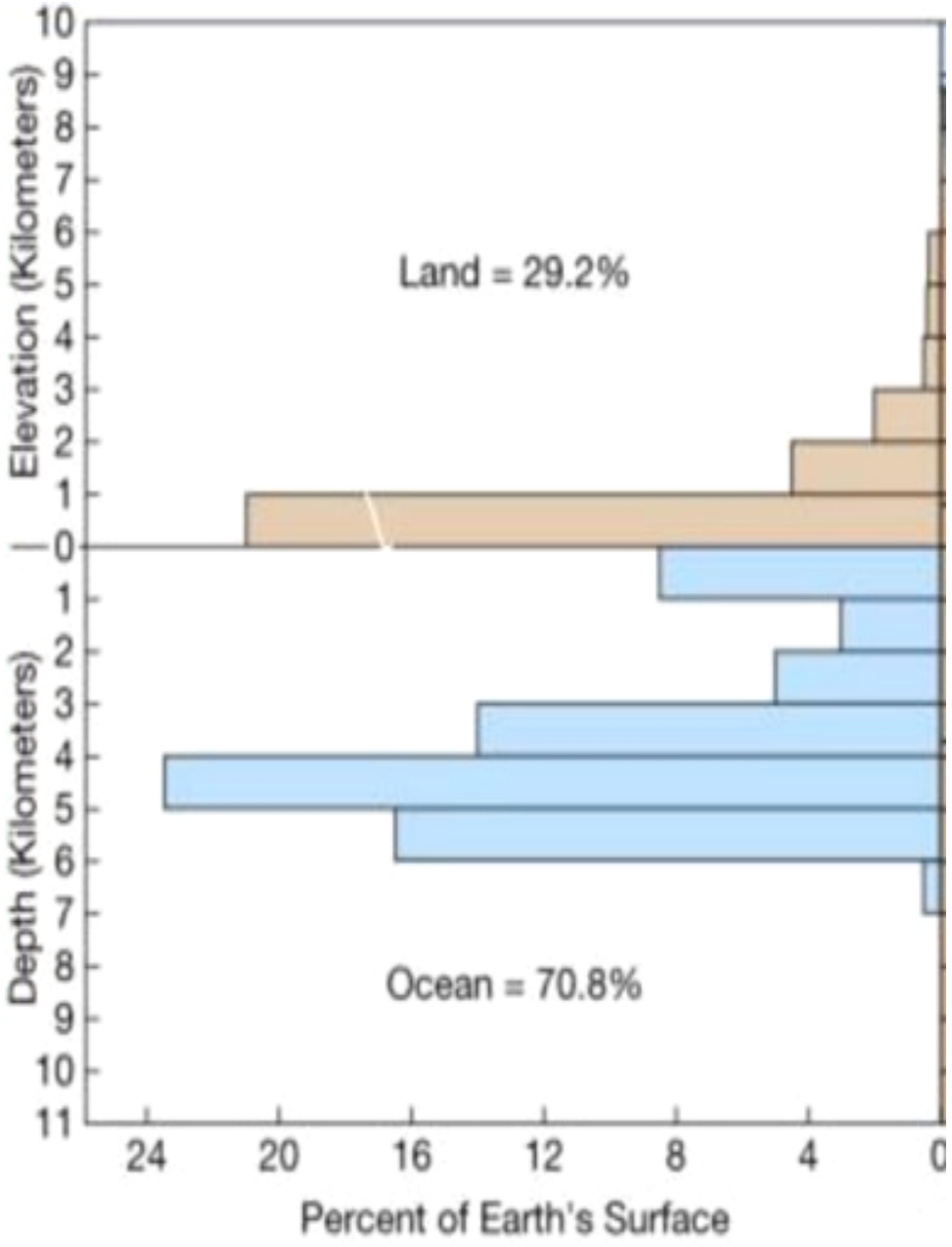
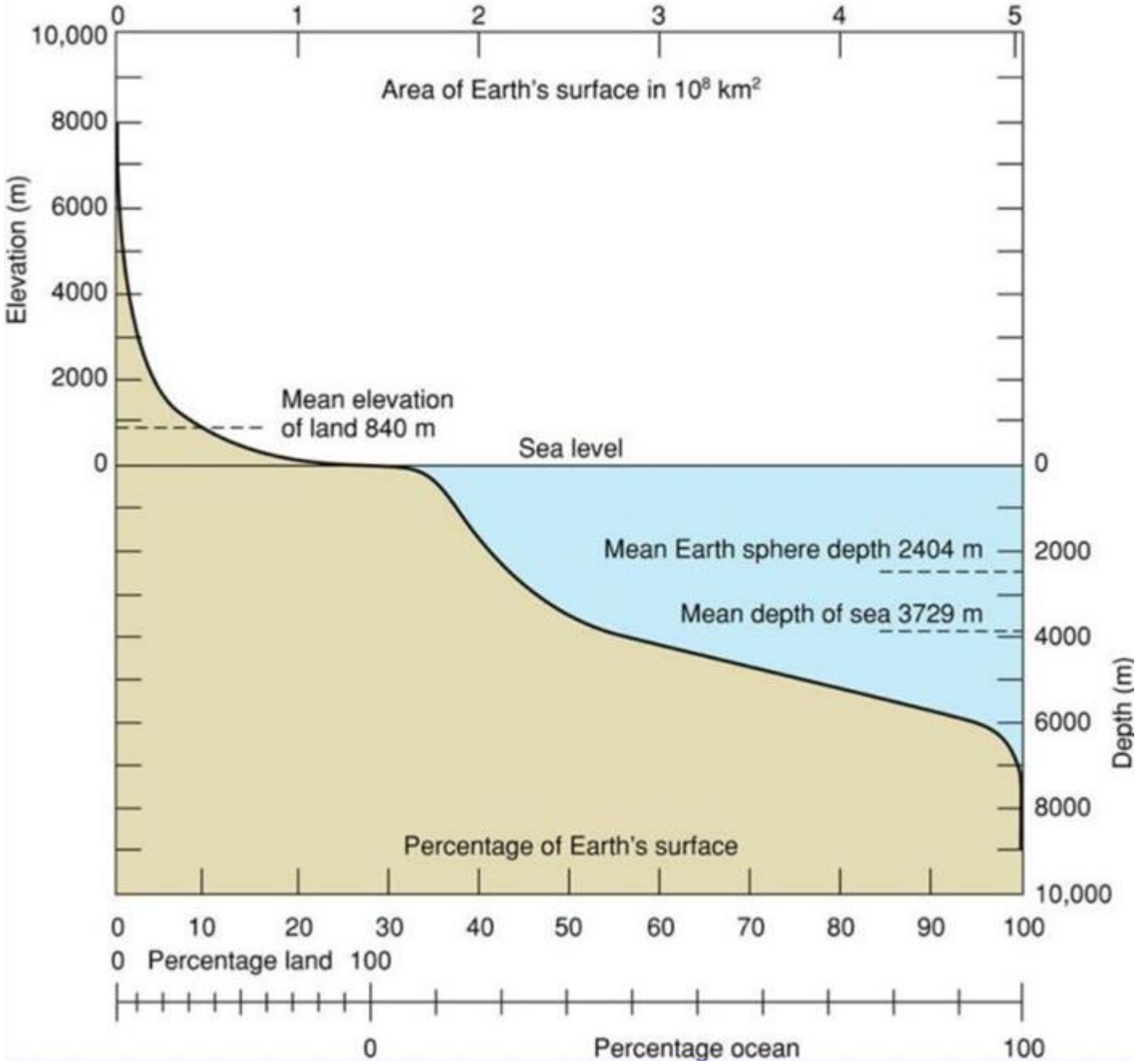


Figure 15.6 The northern hemisphere is covered by slightly more water than land. The southern hemisphere, however, is almost completely covered by water.

National Geographic and The McGraw-Hill Companies, Inc. (2008)

Kurva Hipsografik: Perbandingan Dimensi Daratan dan Lautan





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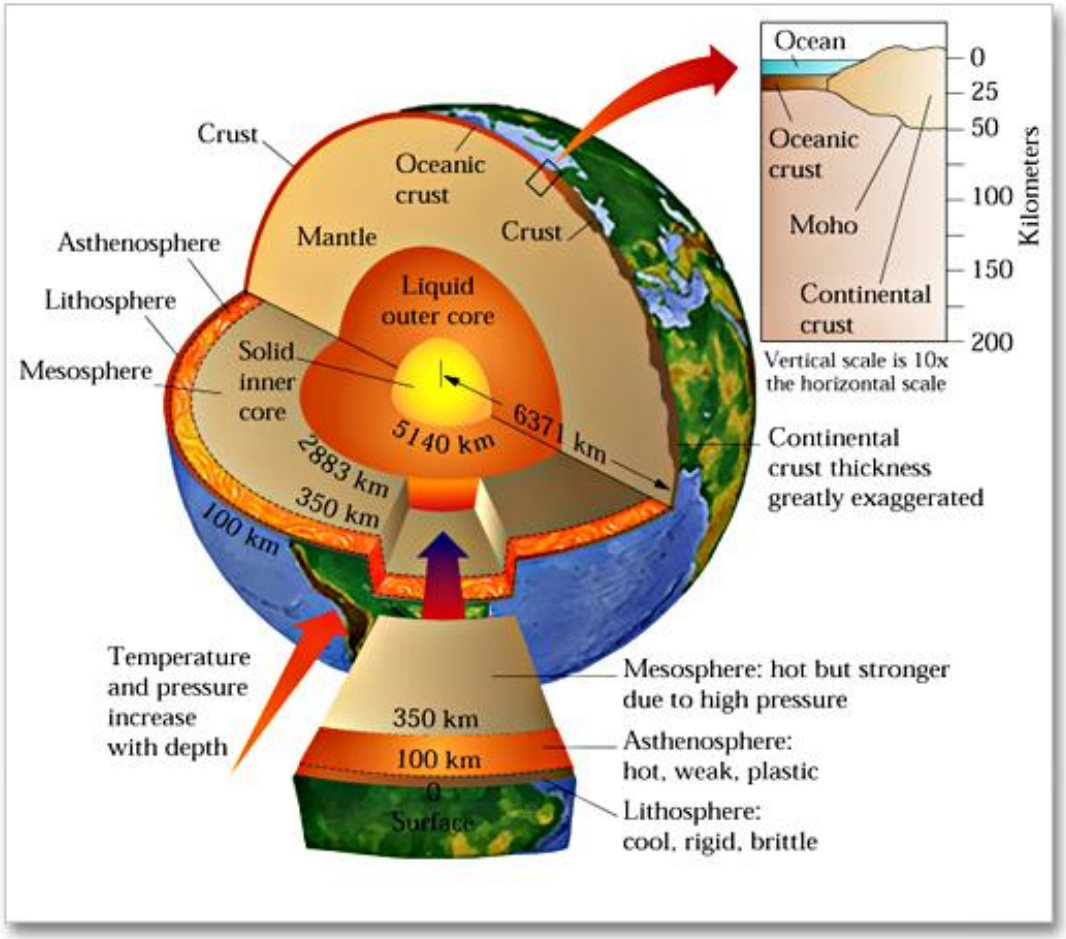
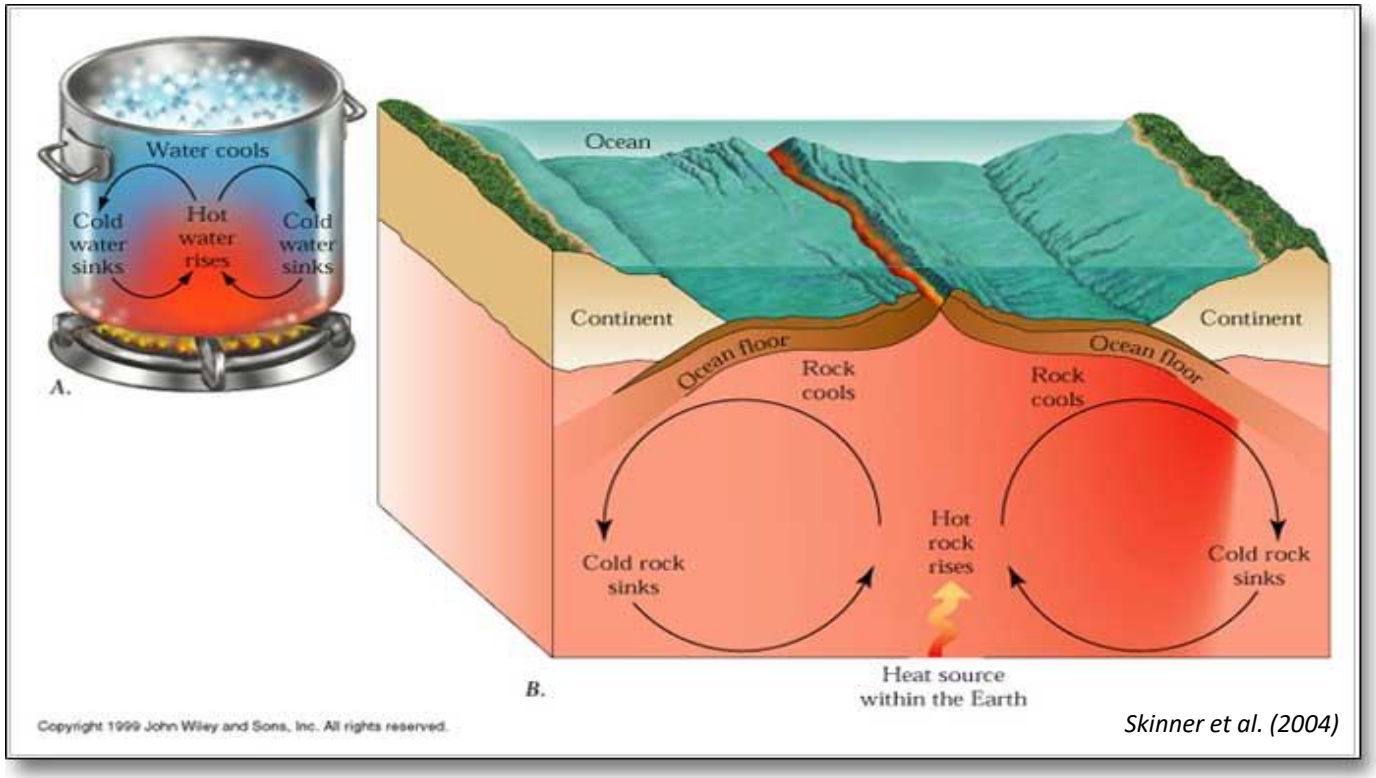
Air (Cairan) di Mantel dan Inti Luar Bumi



Skinner et al. (2004)



Skinner et al. (2004)

Diskusi

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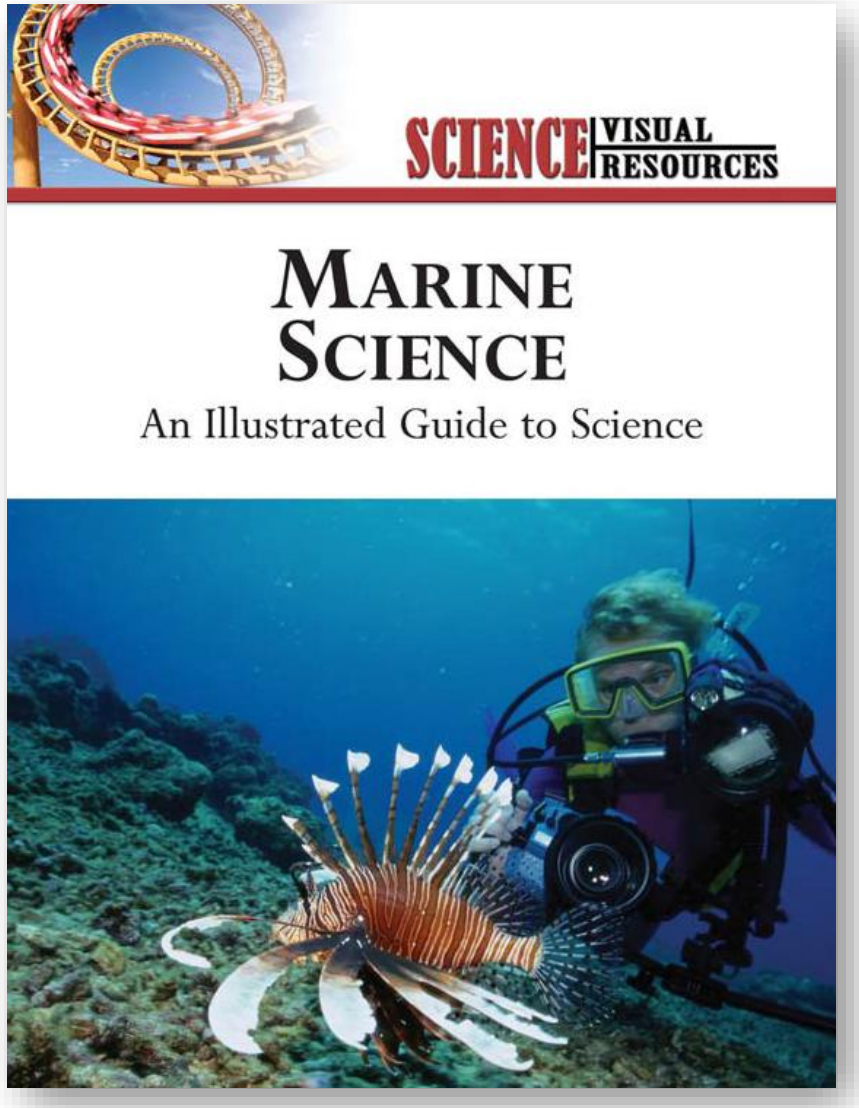


Marine Science: An Illustrated Guide to Science

Copyright © 2006 The Diagram Group

Editorial: Gordon Lee, Jamie Stokes

Geography of the oceans provides an overview of the physical dimensions of the bodies of water that cover 70 percent of Earth.

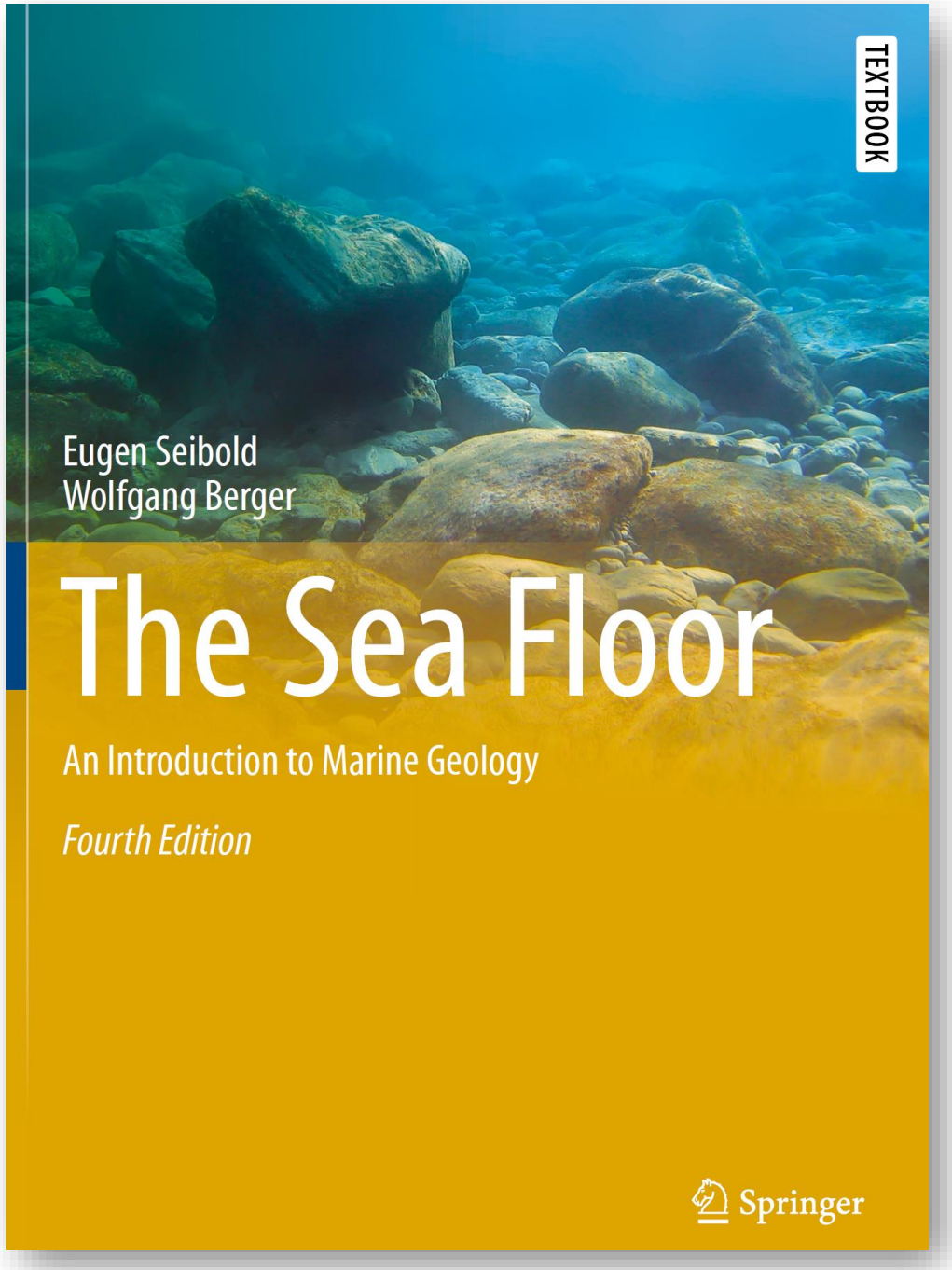
Geology of the oceans examines the geological processes that have shaped Earth's surface and features that are unique to the marine environment. It covers the regions of intense volcanic activity that lie deep beneath the sea, and the shifting boundaries between water and land.

Chemistry of the oceans is concerned with the nature of seawater and with the global cycles that carry vital elements, such as carbon and nitrogen, from the oceans to the atmosphere to the land, and back to the ocean again.

Ocean-atmosphere system details the engines that drive global climate. The cycling of heat from warmer to cooler latitudes, the impact of Earth's rotation on ocean currents, and the daily ebb and flow of the tides are covered here.

Biology of the oceans is an overview of the wealth of plant and animal life that lives in, on, or near the oceans. Food chains stretching from bacteria to blue whales are described, as well as the unique communities that thrive in the pitch black of the deep ocean floor. Every class of animal and plant found in the marine environment is articulated.

Marine exploration and **Marine economics** focus on the human relationship with the sea. It covers the technology that has allowed explorers to span the globe and probe the depths of the ocean. The vital role of marine food sources in the health and wealth of the world is also examined.



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What is Marine Geology?

- Marine geology is a discipline of geological sciences in oceans. (sea floor spreading & plate tectonic, ocean crust, sediments above ocean crusts, stratigraphy, chronostratigraphy, sea floor morphology)

- Investigations concentrate on ocean conditions relevant for sediment accumulation or transportation. Data acquisition (CTD, sediment traps, benthic sledges,current meters etc.) carried out from ships.

- Investigations concentrate on the sea floor and sub-sea floor geology. Data acquisition (seismic profiling, sediment coring) carried out from ships, submersibles or remotely operated vehicles.

Juergen Mienert, 2008

Adam Nugroho (Webinar Geotrek Indonesia, 27 Juni 2020)

Diskusi

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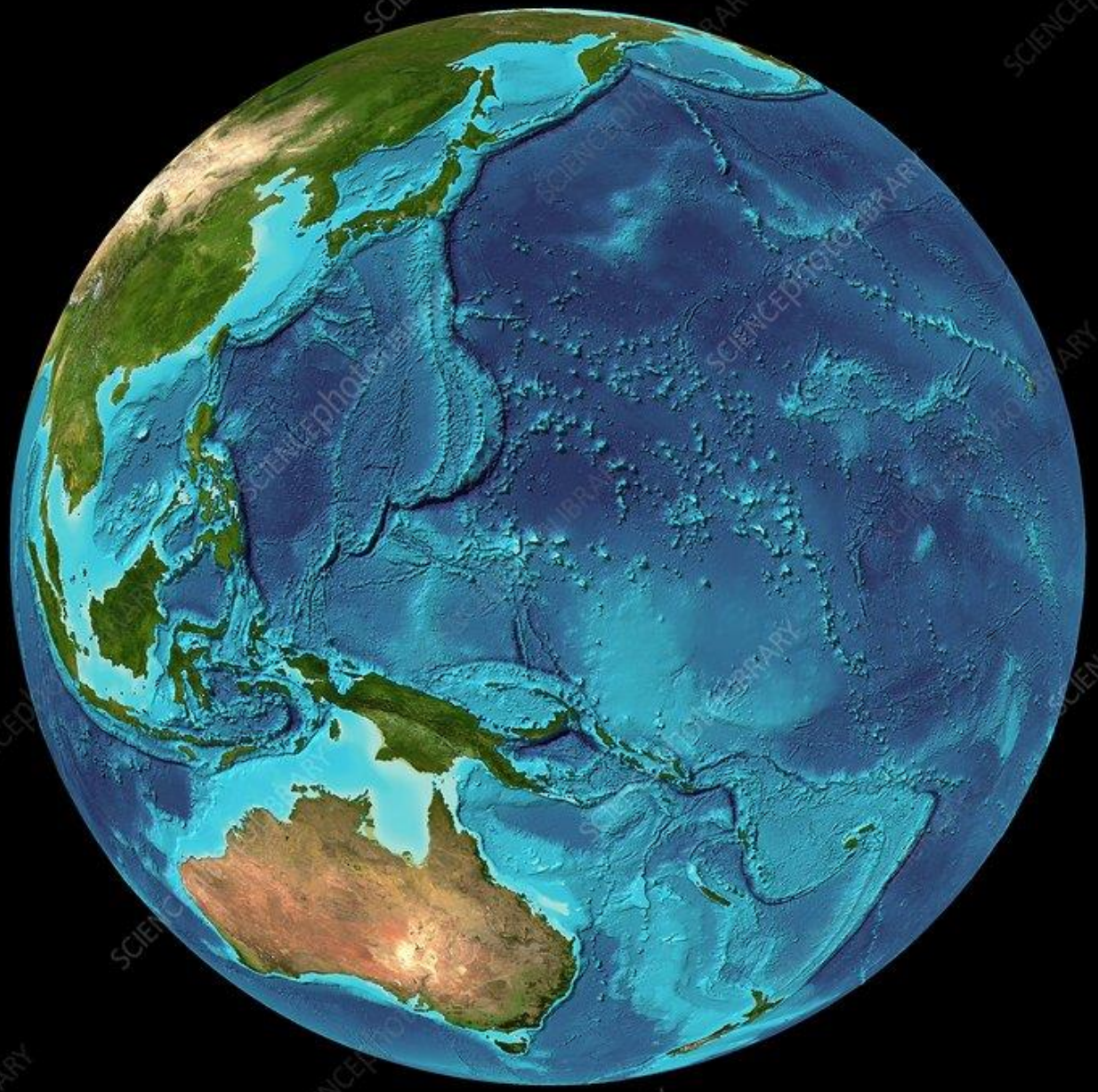
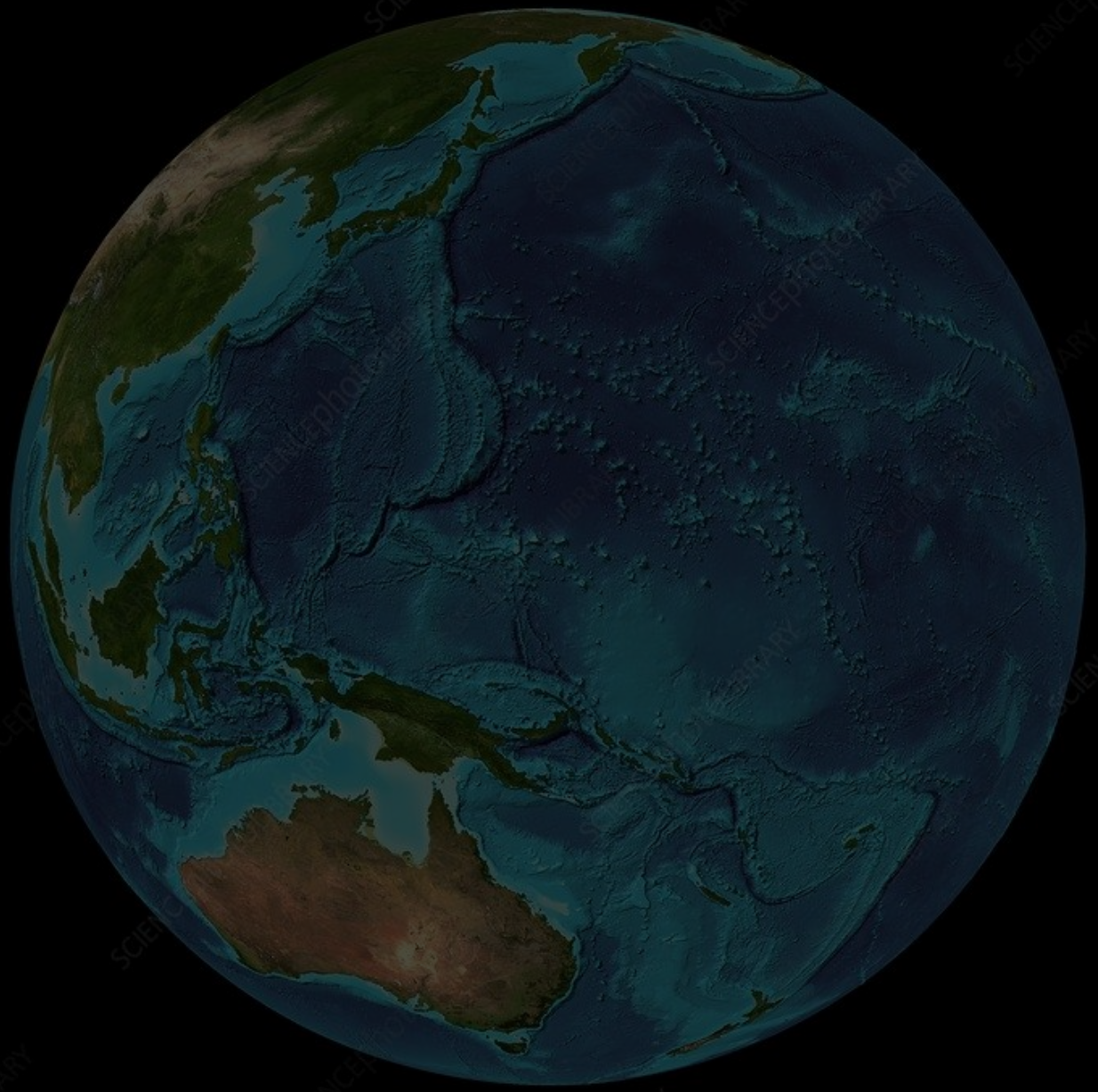


https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan

1. Sejarah Penyelidikan Kelautan
2. Asal Tektonik dan Evolusi Cekungan Laut - Samudra
3. Pola-Pola Topografi Dasar Laut - Samudra
4. Sedimentasi Tepi Benua - Tengah Samudra
5. Perubahan Muka Laut
6. Mikropaleontologi untuk Rekonstruksi Paleo-oseanografi
7. Kebencanaan Geologis Asal Bawah Laut
8. Sumber Daya dari Dasar Laut
9. Teknik Penelitian Geologi Kelautan



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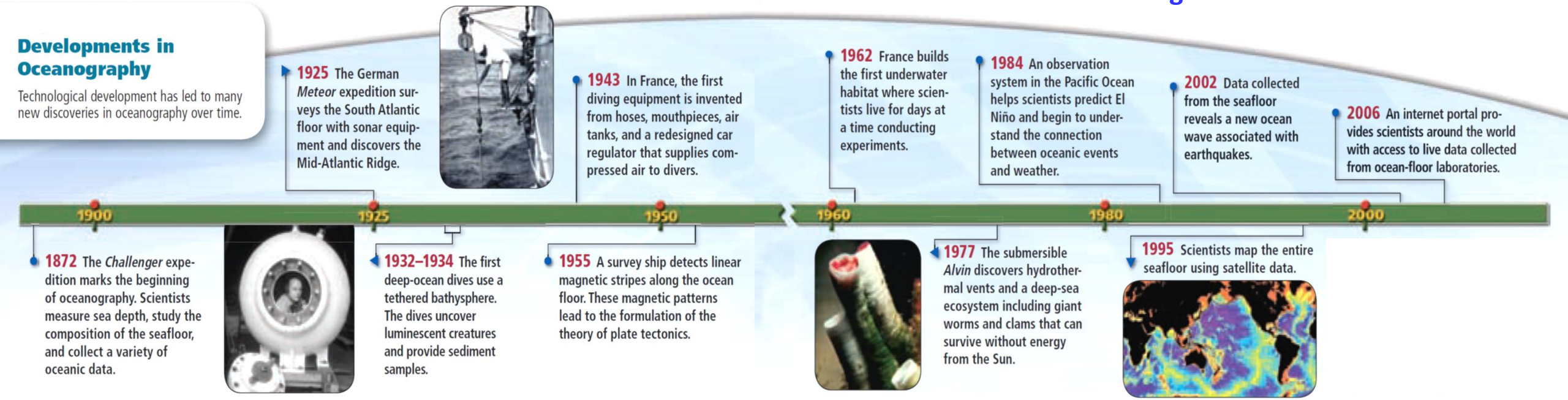
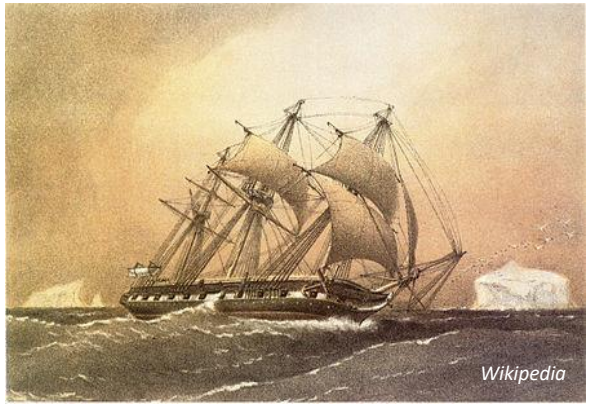
Perkembangan Teknik dan Ilmu Kelautan

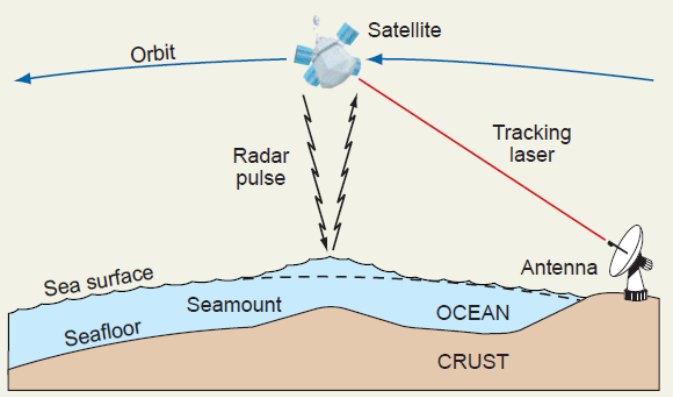


National Geographic and The McGraw-Hill Companies, Inc. (2008)



HMS Challenger. The first global marine research expedition: Challenger carried a complement of 243 officers, scientists and crew when she embarked on her 68,890-nautical-mile (127,580 km) journey.

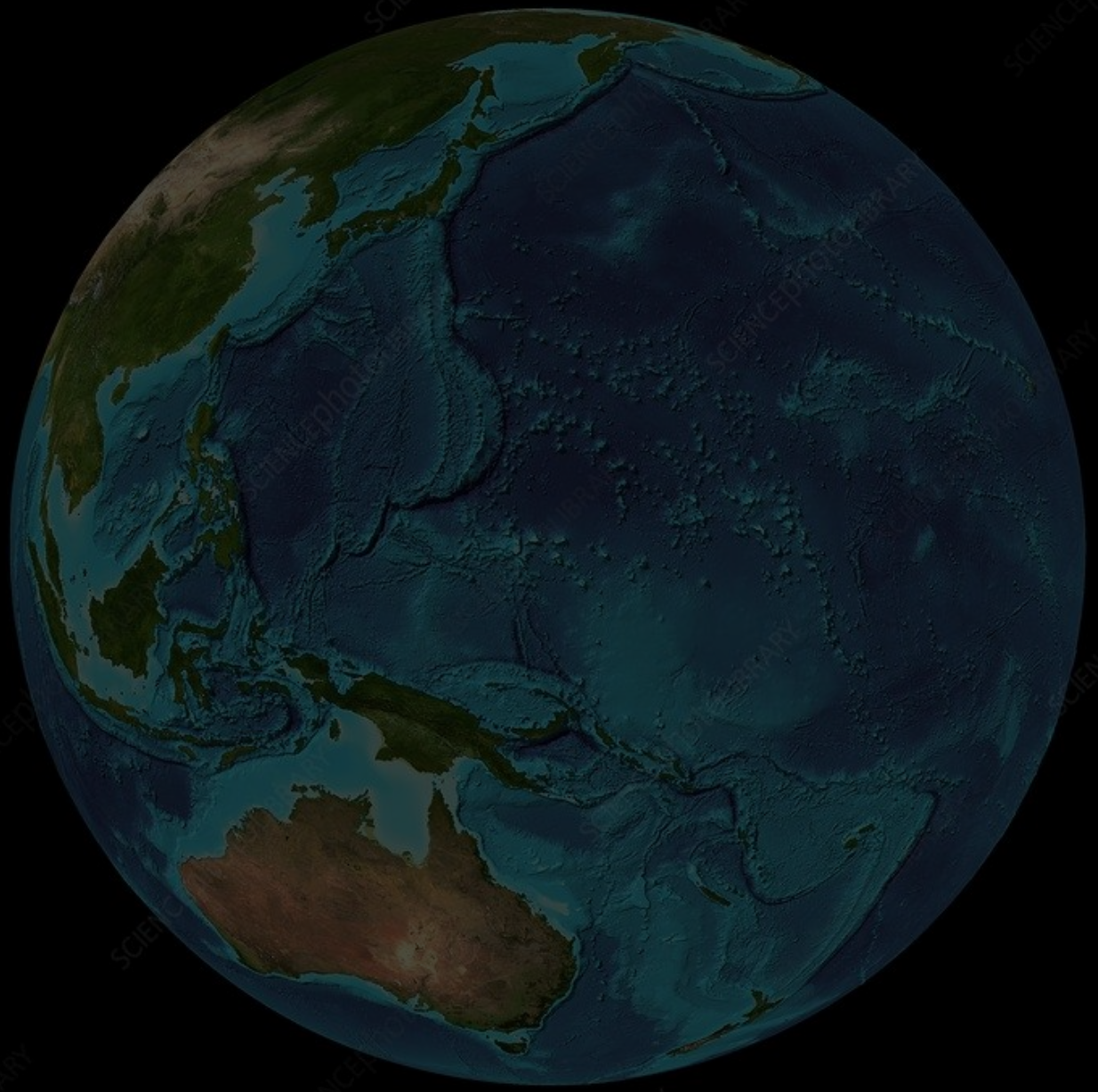
Glomar Challenger (1968). Deep sea research and scientific drilling vessel for oceanography and marine geology studies. It can drill to a depth of 6,900 m, in a water depth of up to 6,100 m.



New way to make global maps of the seafloor is carried out by an orbiting spacecraft instead of a ship. The satellites use radar to carefully map the elevation of the sea surface

Hamblin & Christiansen (2009)

Scientists are working in lab. of research vessels



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

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Asal Air/Lautan di Bumi

1. **Dari kapan air ada di Bumi? Dari sekitar 4 Ma, hampir seumur Bumi (4,56 Ma)**
   - *Scientists have found rocks nearly as old as Earth that formed from sediments deposited in water.*
   - *Ancient lava flows are another clue — some of these lava flows have glassy crusts that form only when molten lava is chilled rapidly underwater.*
   - *Radioactive studies and lava flows offer evidence that there has been abundant water throughout Earth's geologic history.*

2. **Dari mana asal air di Bumi? Dua hipotesis: terestrial dan ekstraterestrial**
   - Terestrial*: Volcanism/Outgassing - During volcanic eruptions, significant quantities of gases are emitted. These volcanic gases consist mostly of water vapor and carbon dioxide. Shortly after the formation of Earth, when the young planet was much hotter than it is today, an episode of massive, violent volcanism took place over the course of perhaps several hundred million years.*
   - Ekstraterestrial*: Comets are composed of dust and rock particles mixed with frozen water and gases. Comet impacts with Earth may have released enough water to help fill ocean basins. Meteorites contain up to 0.5 percent water.*

National Geographic and The McGraw-Hill Companies, Inc. (2008)

Asal Air di Bumi: Hipotesis Terestrial

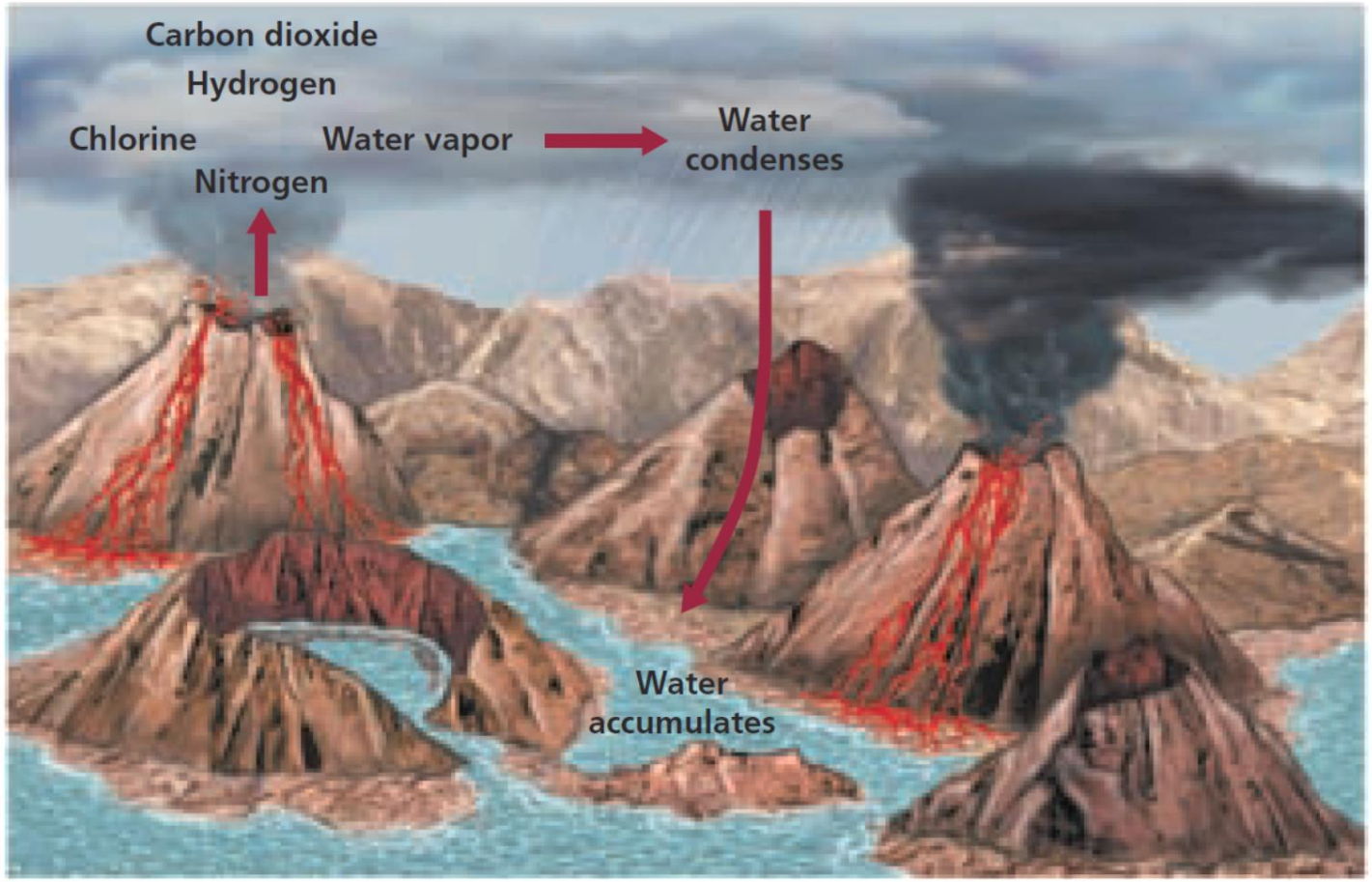
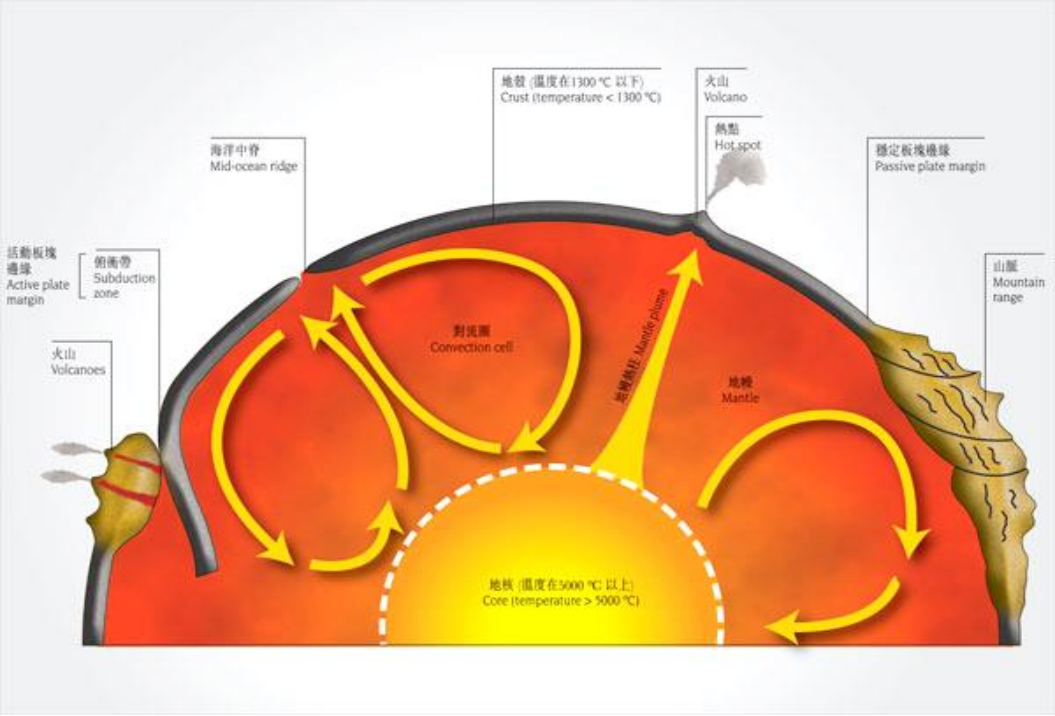


Figure 15.4 In addition to comets, water for Earth's early oceans might have come from volcanic eruptions. An intense period of volcanism occurred shortly after the planet formed. This volcanism released large quantities of water vapor and other gases into the atmosphere. The water vapor eventually condensed into oceans.

National Geographic and The McGraw-Hill Companies, Inc. (2008)

Mekanisme Volkanisme/ *Outgassing*



https://hkss.cedd.gov.hk/hkss/eng/education/gs/eng/hkg/chapter2.htm

Asal Air di Bumi: Hipotesis Ekstraterestrial

Comet

Meteorite

National Geographic and The McGraw-Hill Companies, Inc. (2008)

EarthSky

Tektonik Cekungan Samudra: Pemetaan Dasar Lautan

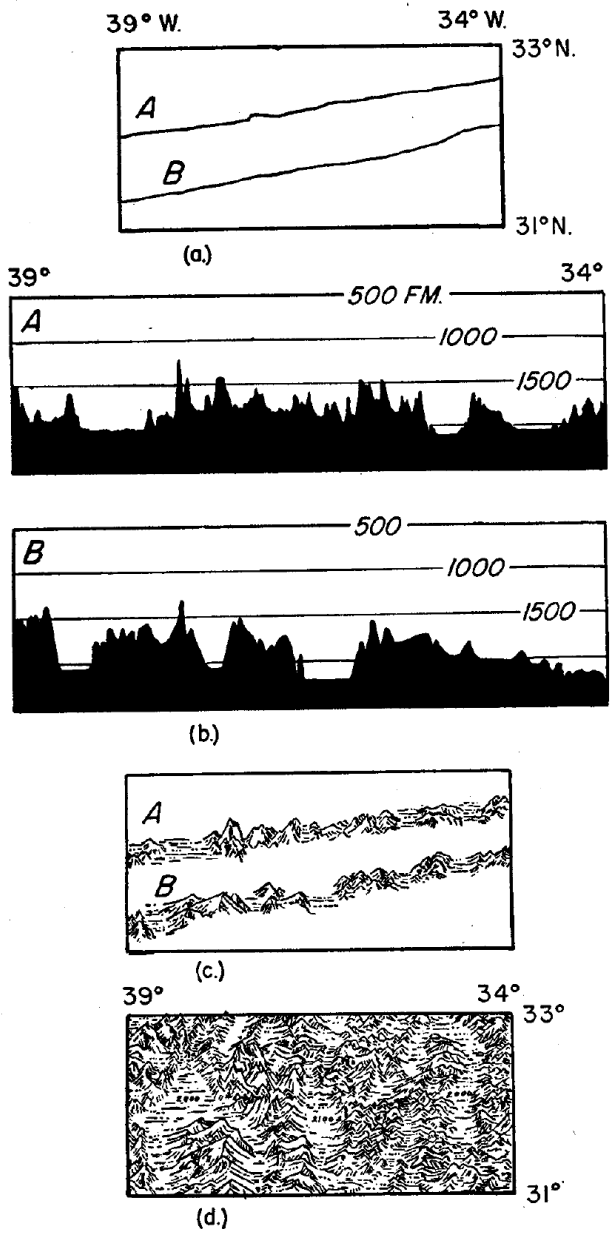


FIGURE 1.—*Method of preparation of physiographic diagram*

(a) Positions of sounding lines (A, B) are plotted on chart; (b) Soundings are plotted as profiles (A, B) at 40:1 vertical exaggeration; (c) Features shown on profiles (A, B) are sketched on chart along tracks; (d) After all available sounding profiles are sketched the remaining unsounded areas are filled in by extrapolating and interpolating trends observed in a succession of profiles.

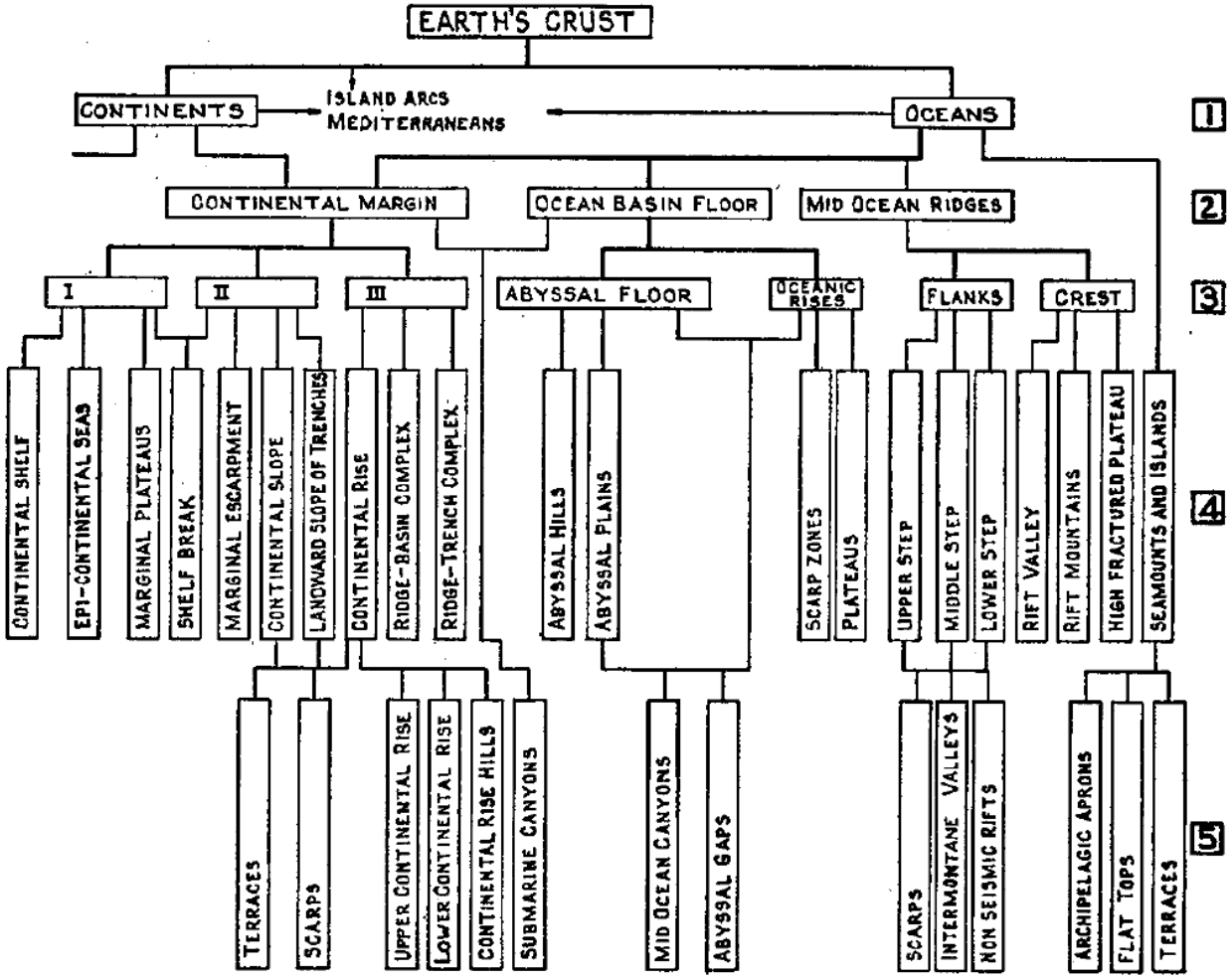
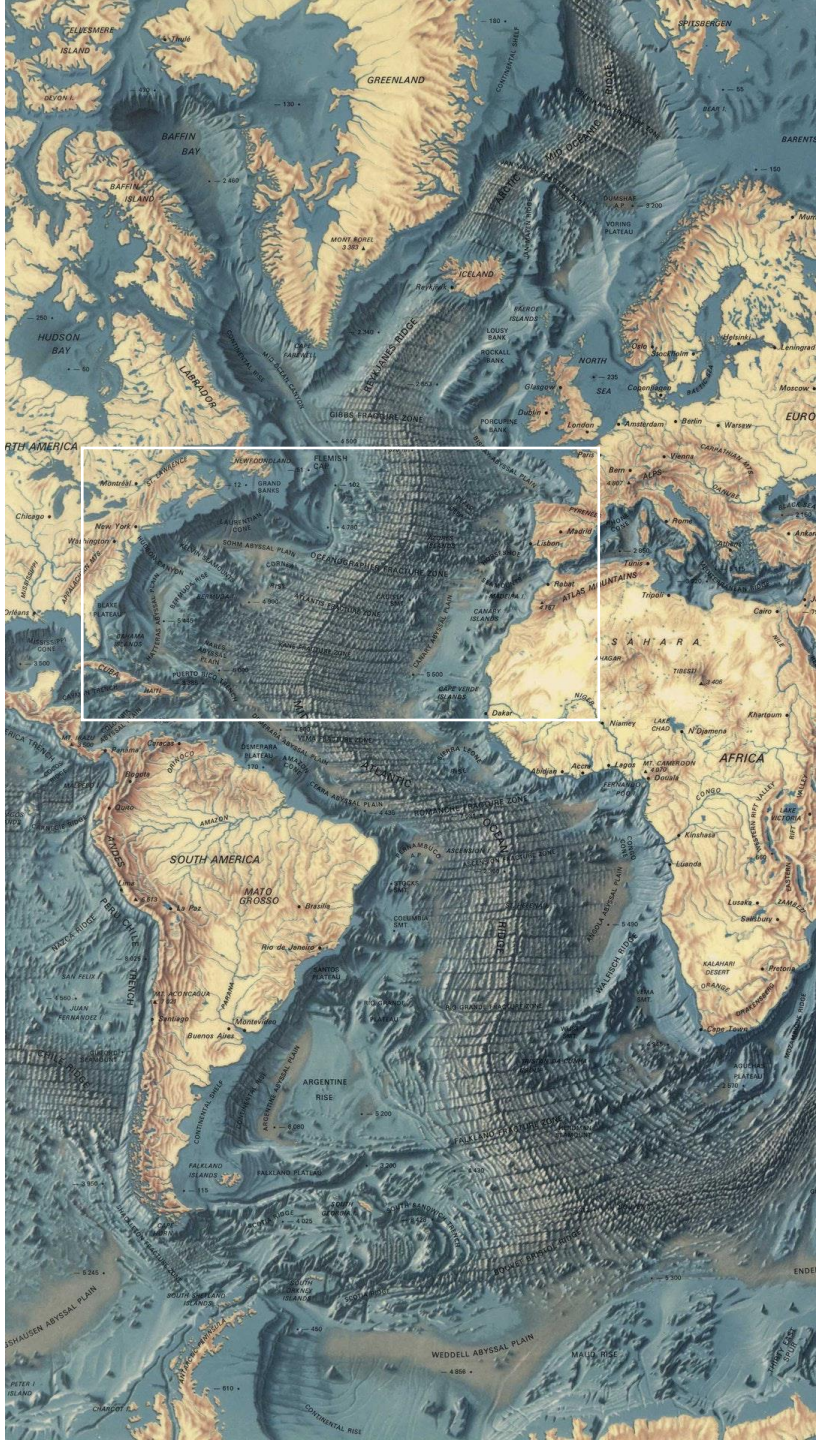


FIGURE 8.—*Outline of submarine topography*

Line 1, first-order features of the crust; line 2, major topographic features of the ocean; line 3, categories of provinces and superprovinces; line 4, provinces; line 5, subprovinces and other important features.

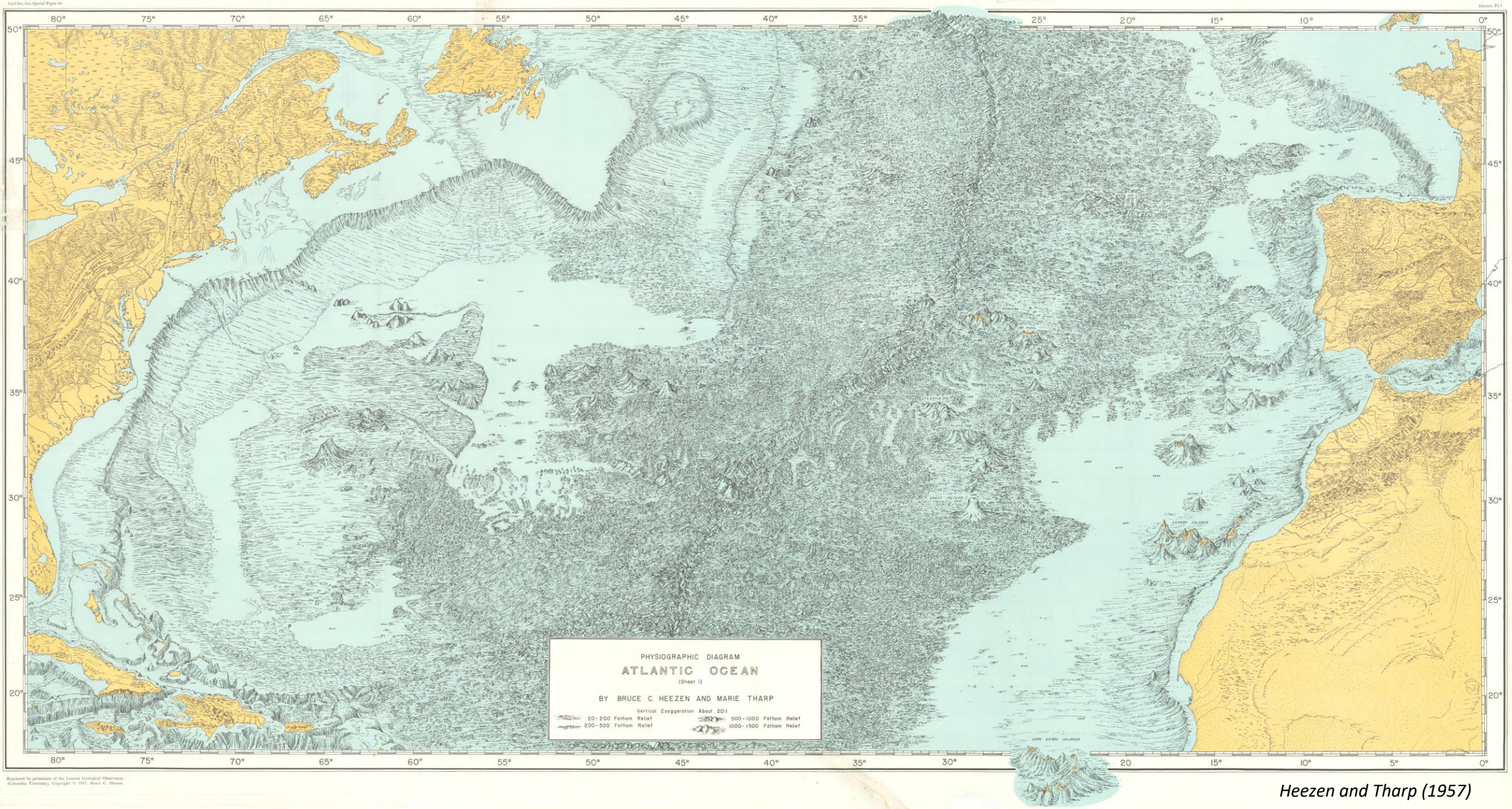
Heezen and Tharp (1959)



In the Beginning: North Atlantic Ocean Mapping

by Bruce Heezen & Marie Tharp (1948-1957)

Bruce Charles Heezen, an American geologist worked with oceanographic cartographer Marie Tharp at Columbia University to map the Mid-Atlantic Ridge in the 1950s. Their collaboration supported the continental drift proposed by Alfred Wegener in 1912. Tharp was Heezen's assistant while he was a graduate student and he gave her the task of drafting seafloor profiles. When she showed Heezen that her plotting of the North Atlantic revealed a rift valley, Heezen dismissed it as "girl talk". She persisted and they eventually discovered that not only was there a North Atlantic rift valley, but a mountain range with a central valley that spanned the earth. They also realized that the oceanic earthquakes they had been separately plotting fell within the rift, a revolutionary theory at the time. Heezen presented this mid-ocean rift and earthquake theory at Princeton in 1957. At that lecture, preeminent geologist Harry Hess[6] told Heezen, "Young man, you have shaken the foundations of geology!" (Wikipedia)



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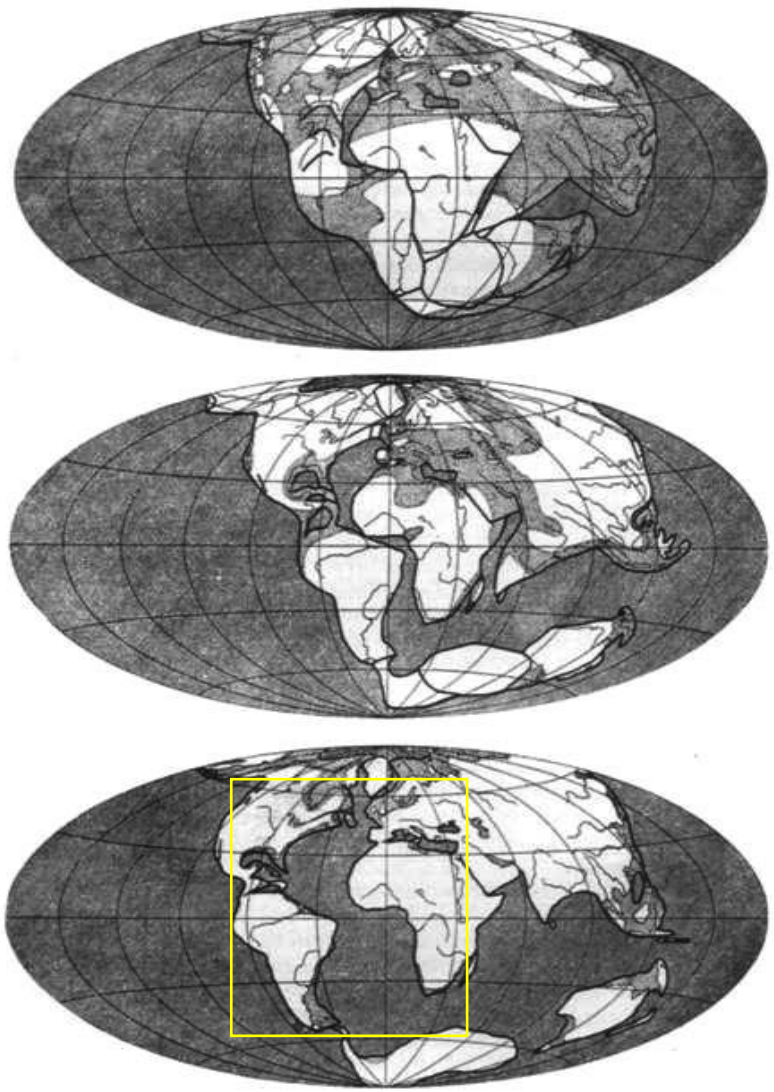
Heezen and Tharp (1957)

Pemetaan dasar lautan oleh Heezen & Tharp (1957) membuka konsep-konsep:

- Pemekaran dasar lautan (*oceanic-floor spreading*) - Hess (1962)
- Anomali magnetik berpasangan di punggung tengah Samudra - Vine & Matthews (1963)
- Sesar *transform* di punggung tengah samudra - (Wilson, 1965)
- Teori teknonik lempeng (1968)

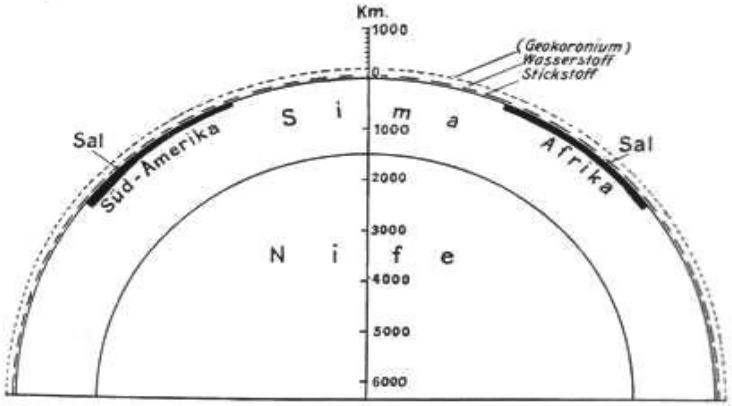
https://www.pinterest.com/pin/347692033721494692/

Pemetaan Dasar Samudra Mendukung Konsep Apungan Benua



Wegener (1915)

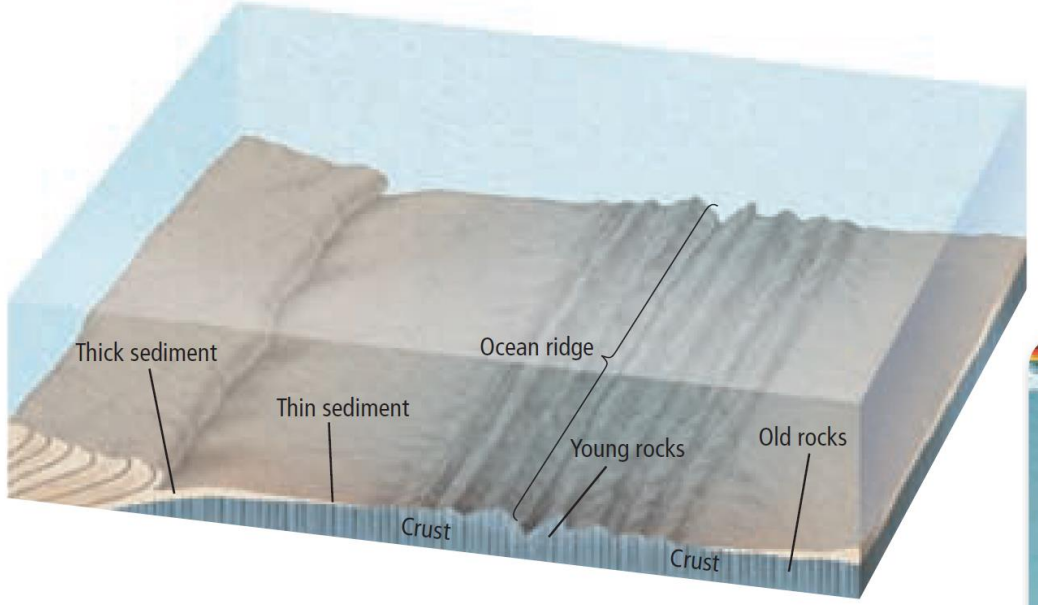
Alfred Wegener 1915's Continental Drift Theory



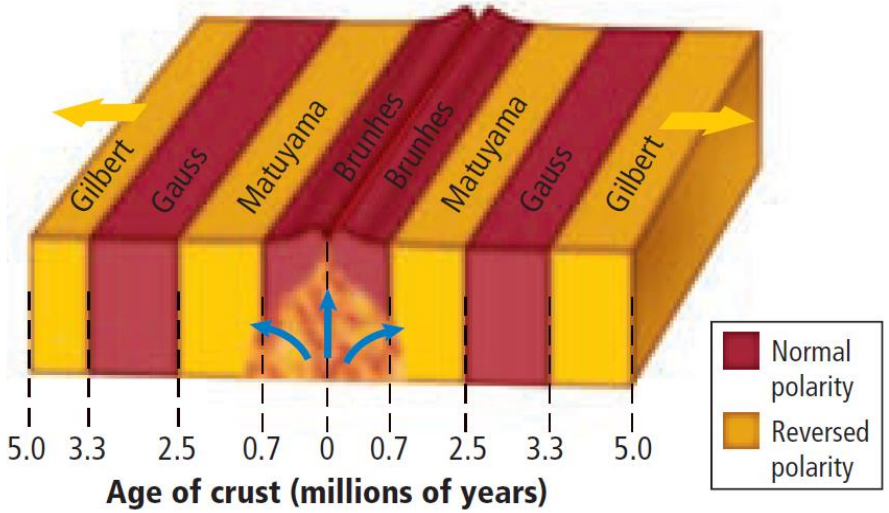
Alfred Wegener 1915's SiAl continents float on SiMa denser rocks like a raft

Miller (1983)

Beberapa Karakter Dasar Samudra

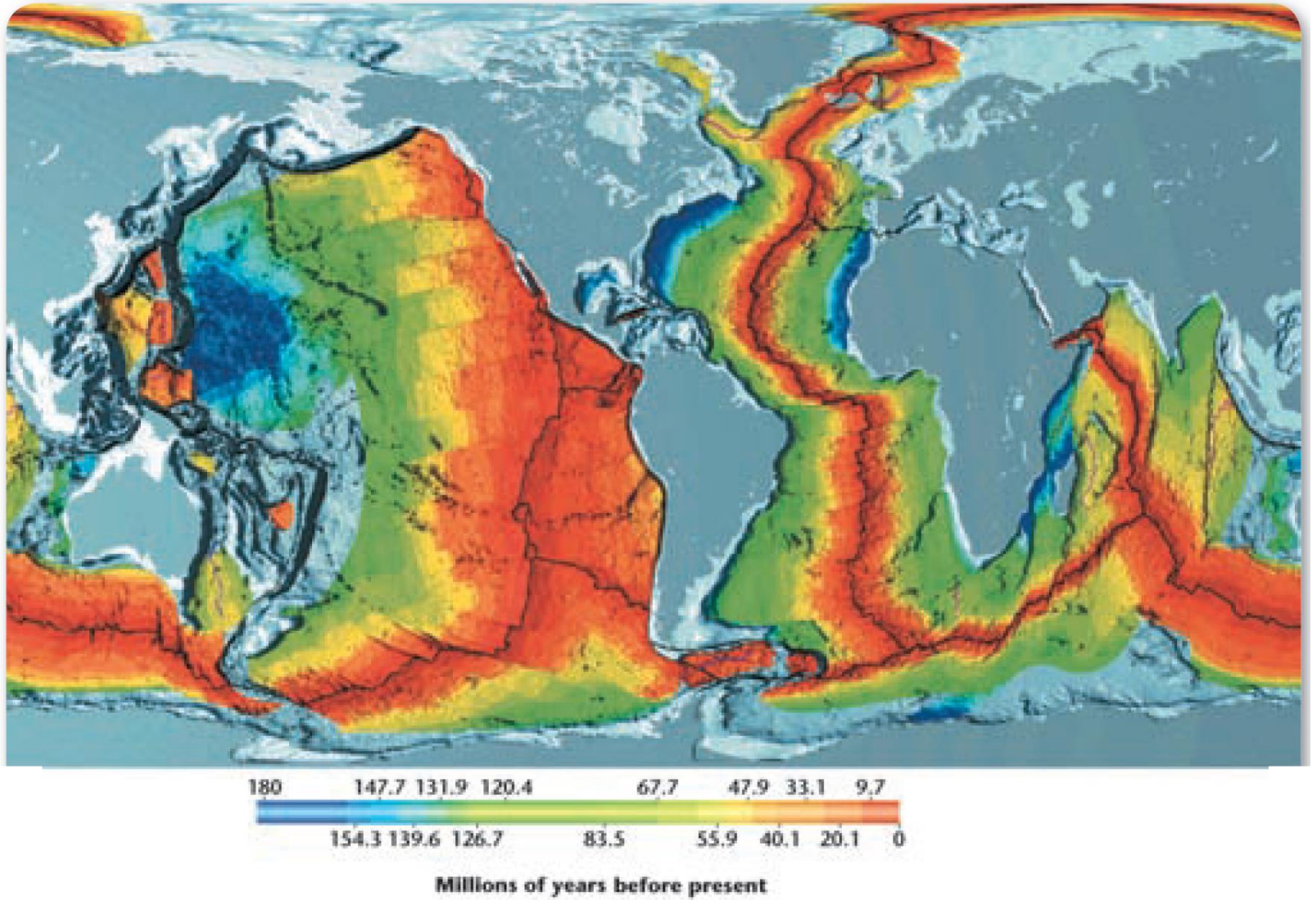


The ages of ocean crust and the thicknesses of ocean-floor sediments increase with distance from the ridge.

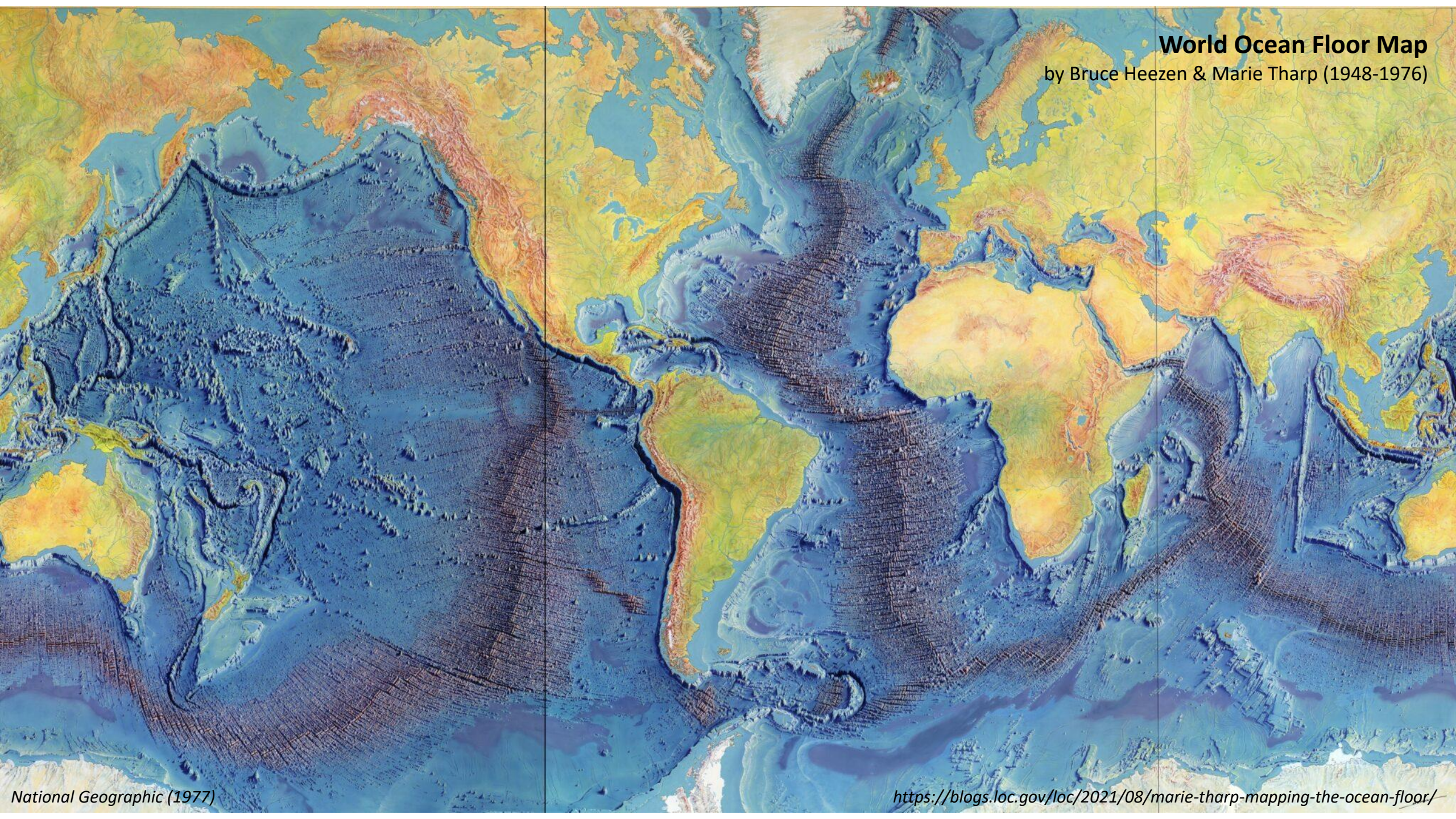


Anomali magnetik berpasangan di punggung tengah samudra

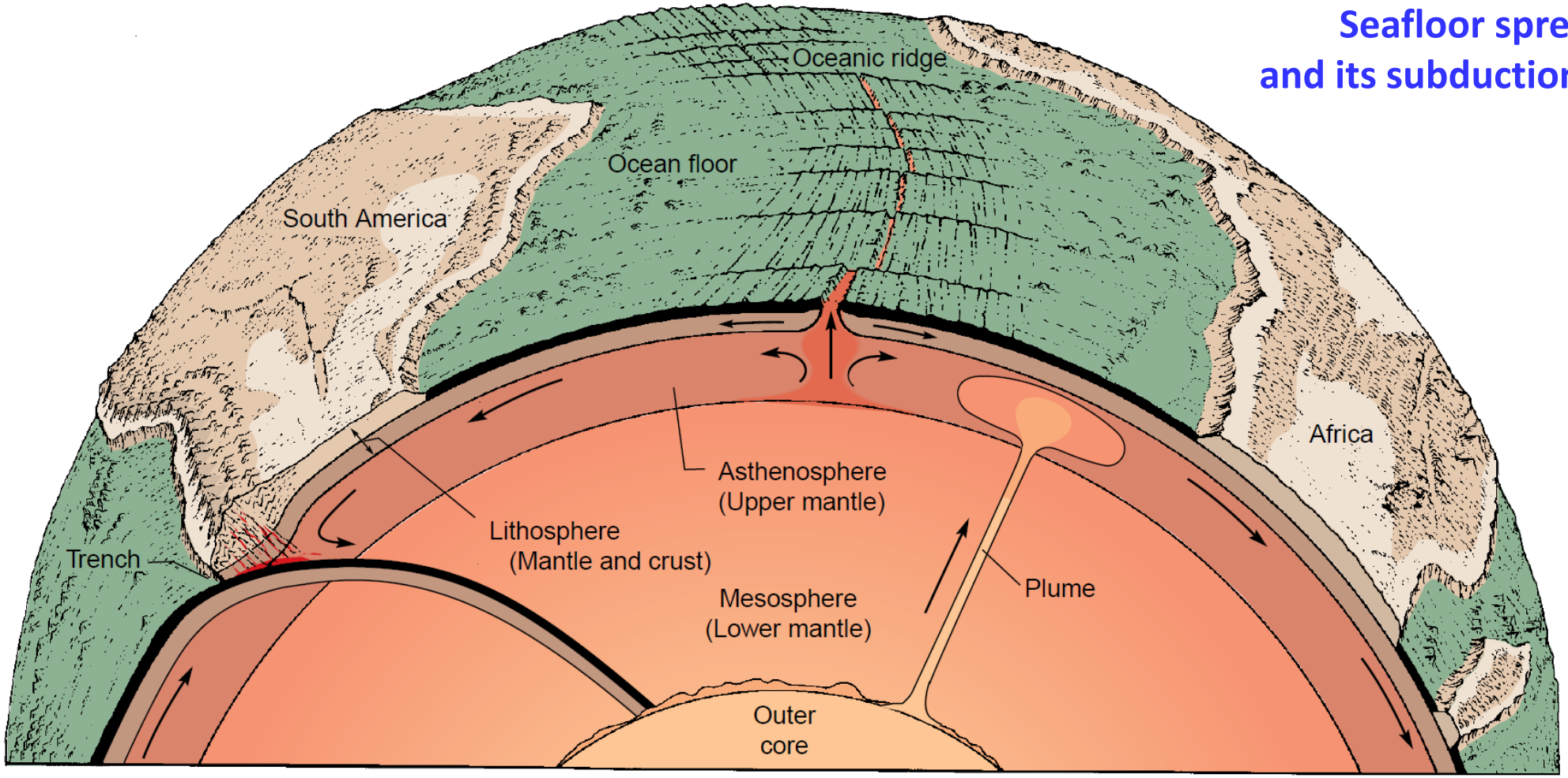
Isochron map of the ocean floor represents the age of that strip of the crust



National Geographic and The McGraw-Hill Companies, Inc. (2008)


World Ocean Floor Map
by Bruce Heezen & Marie Tharp (1948-1976)
National Geographic (1977)
https://blogs.loc.gov/loc/2021/08/marie-tharp-mapping-the-ocean-floor/

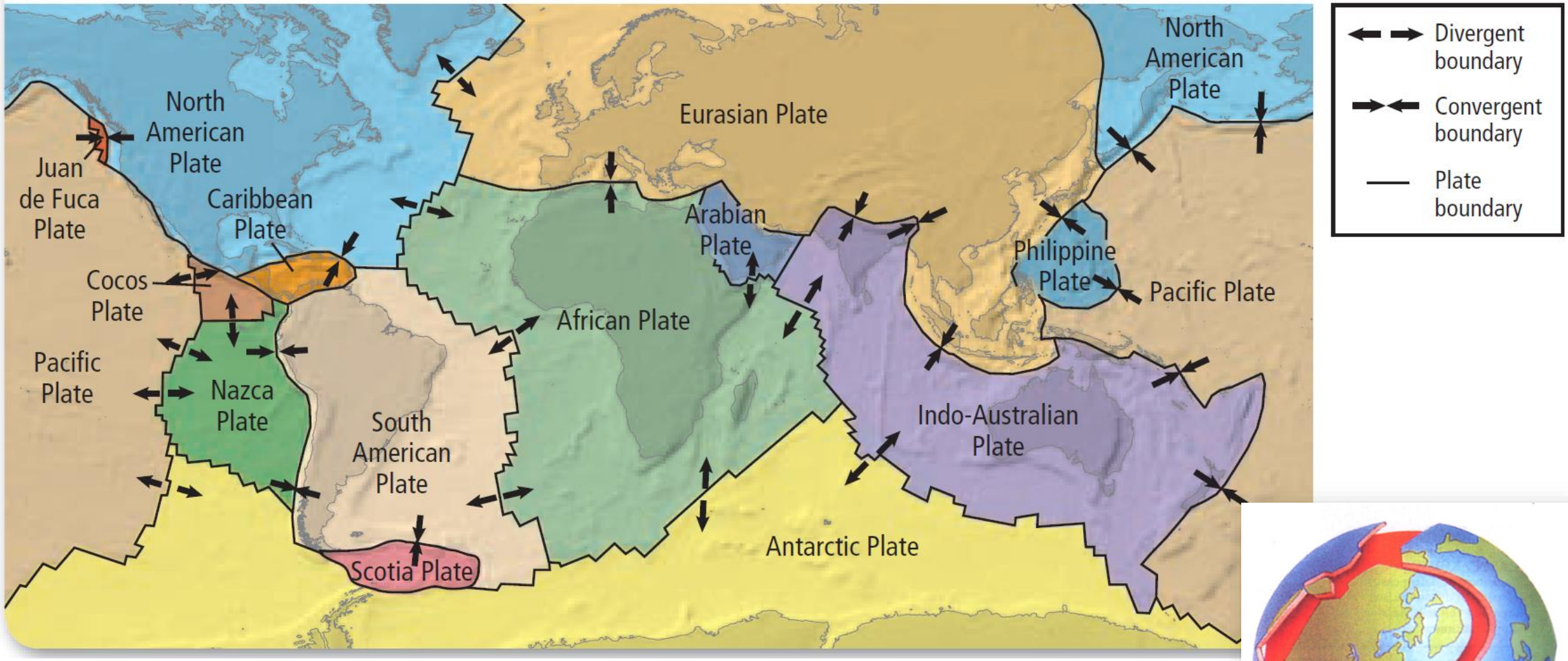
Seafloor spreading and its subduction in trench



The tectonic system is powered by Earth's internal heat.The asthenosphere is more plastic than either the overlying lithosphere or the underlying lower mantle. Above the plastic asthenosphere, relatively cool and rigid lithospheric plates split and move apart as single mechanical units (along the ocean ridges). As this happens, molten rock from the asthenosphere wells up to fill the void between the lithospheric plates and thus creates new lithosphere.Very slow convection occurs in the mantle. Some plates contain blocks of thick, lower-density continental crust, which cannot sink into the denser mantle. As a result, where a plate carrying continental crust collides with another plate, the continental margins are deformed into mountain ranges. Plate margins are the most active areas on Earth—the sites of the most intense volcanism, seismic activity, and crustal deformation. Locally, convection in the deep mantle creates rising mantle plumes.

Willie (1971), Hamblin & Christiansen (2010)

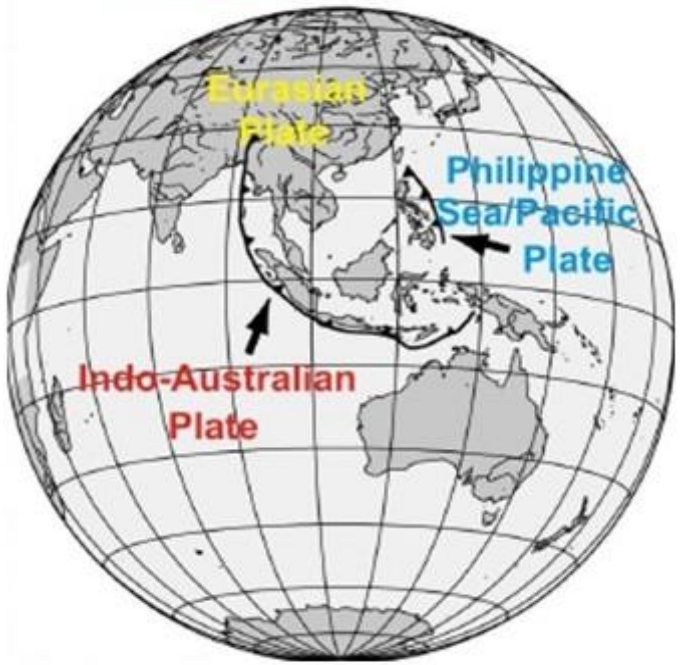
Tektonik Lempeng

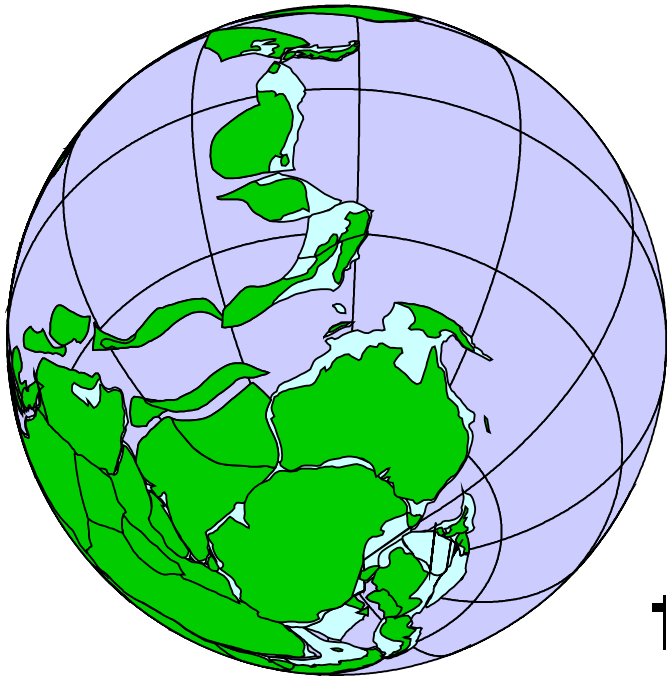


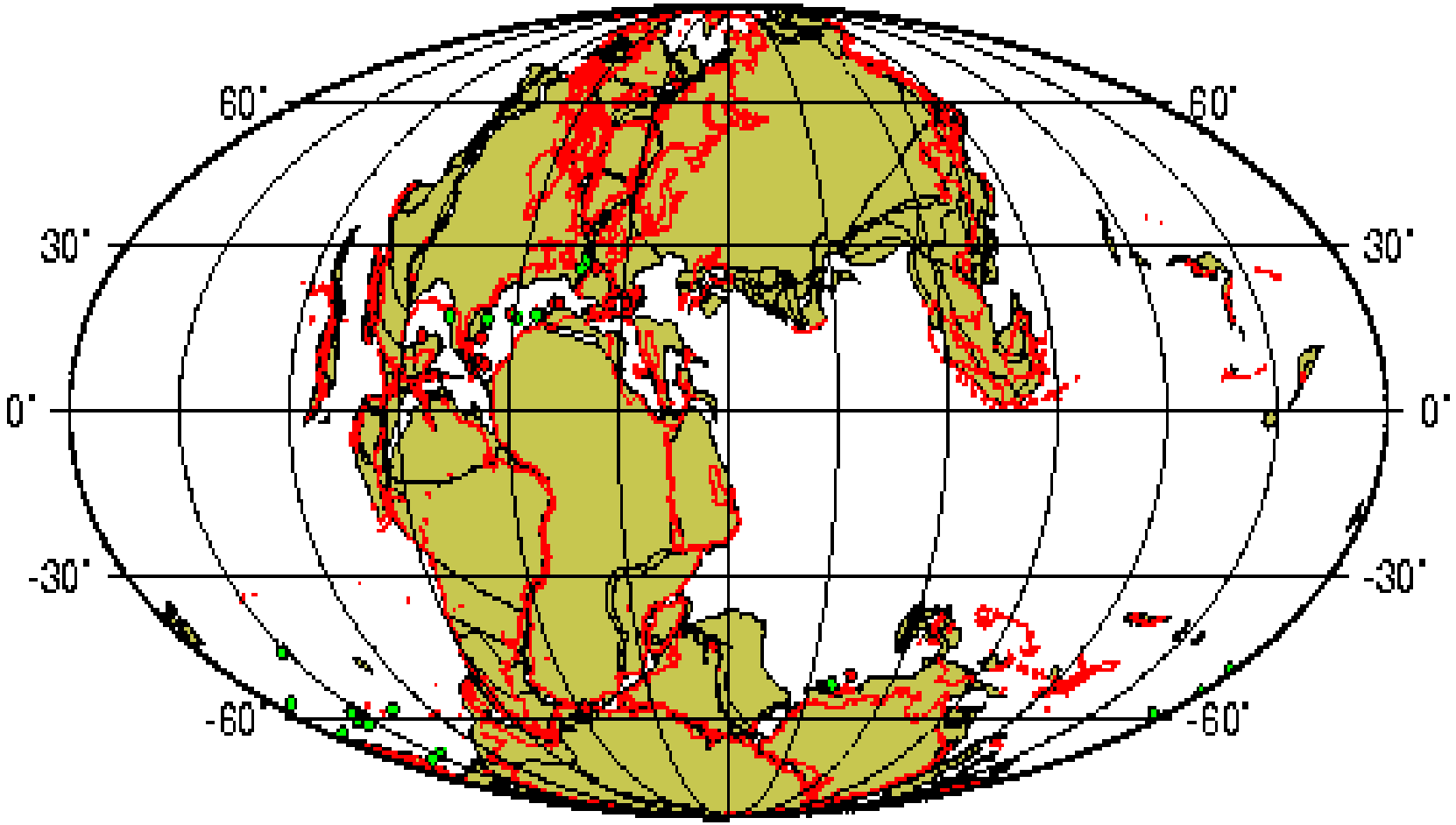
Earth's crust and rigid upper mantle are broken into enormous slabs called tectonic plates that interact at their boundaries.

National Geographic & The McGraw-Hill Companies, Inc. (2008)

Apungan Benua, Pembukaan dan Penutupan Laut-Lautan

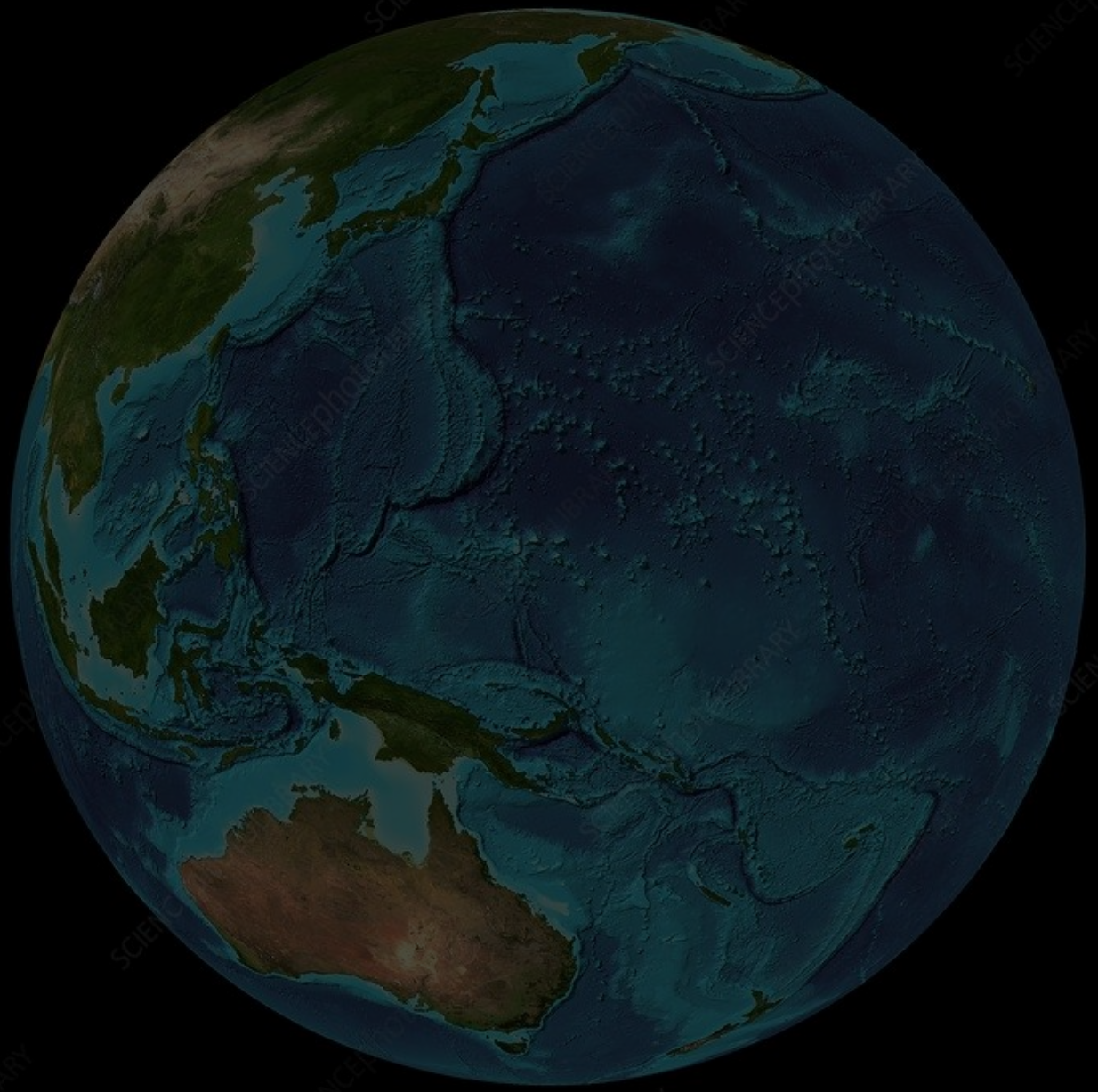






150 My Reconstruction

Scotese (2019)



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

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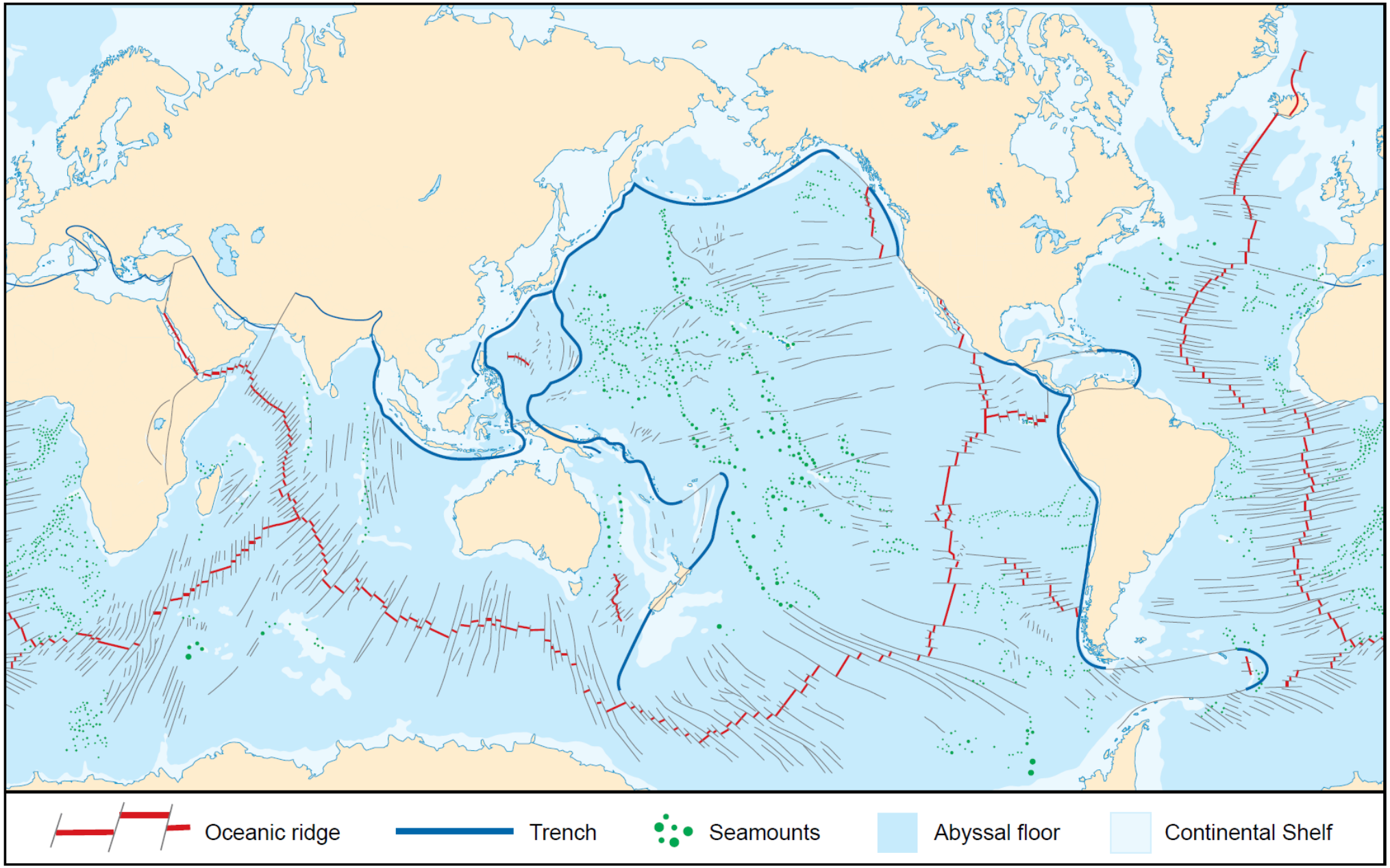
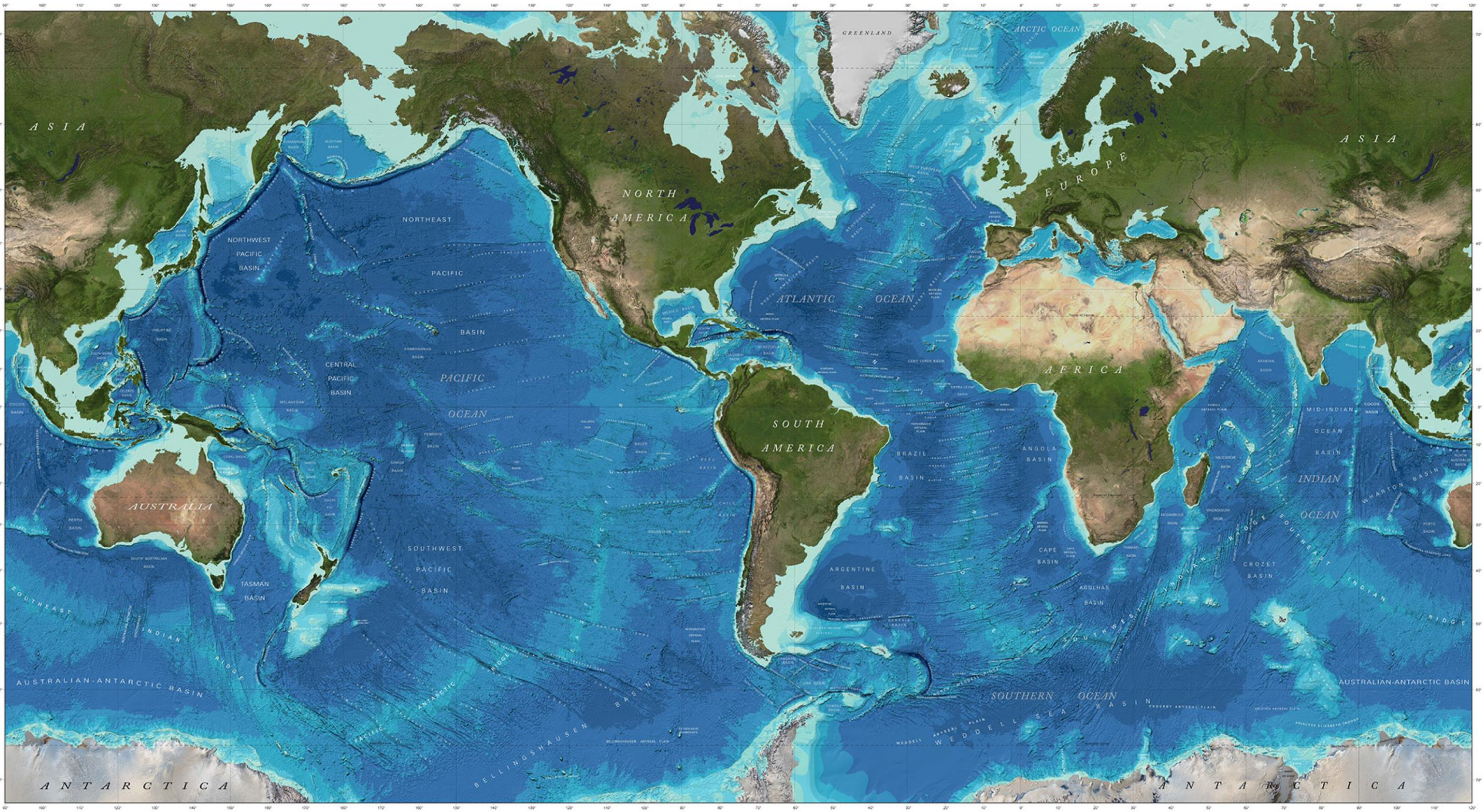
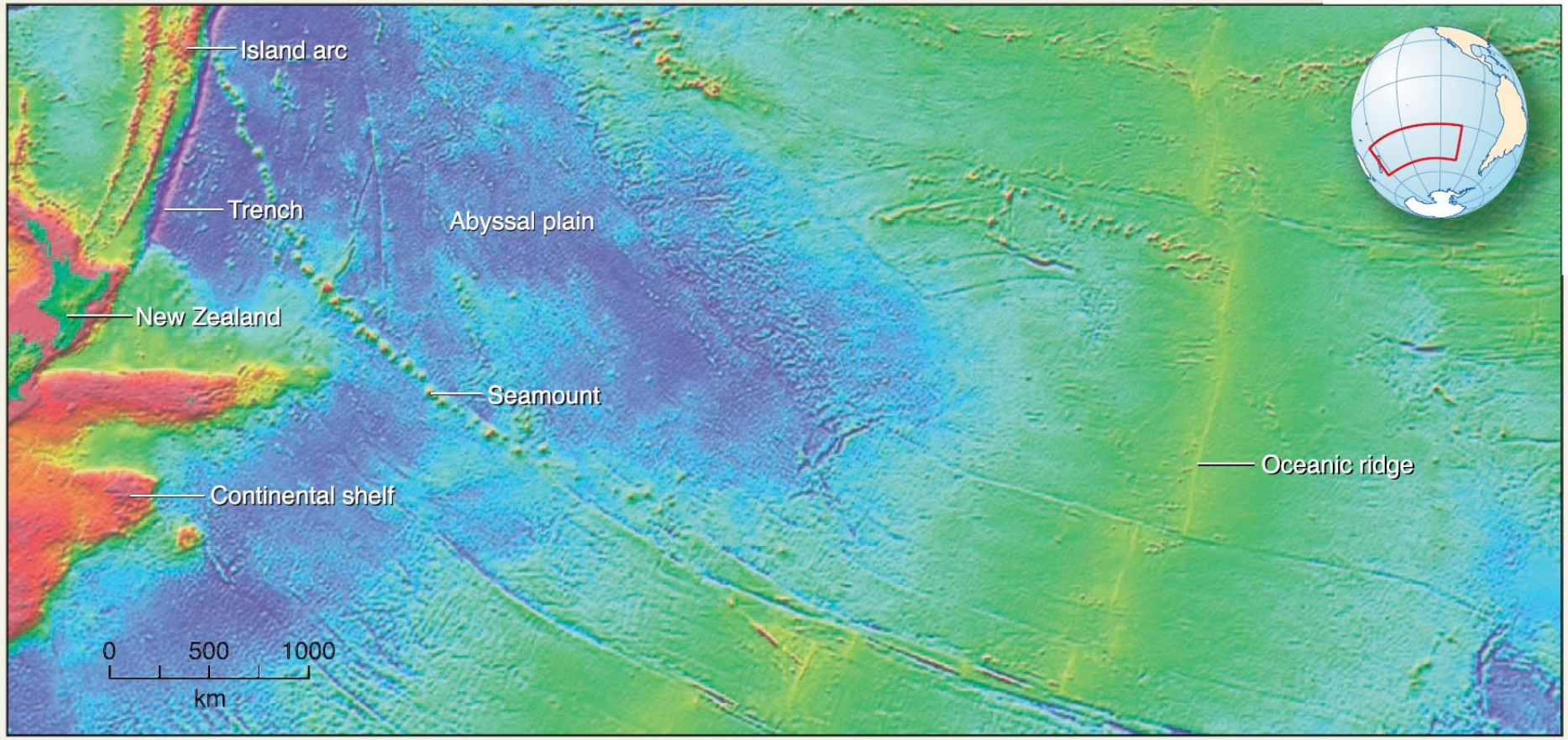


The major features of the ocean floor include the oceanic ridge, the deep-sea trenches, and the abyssal floor. Seamounts rise above the deep-ocean floor and are formed by volcanic eruptions.

Hamblin & Christiansen (2010)

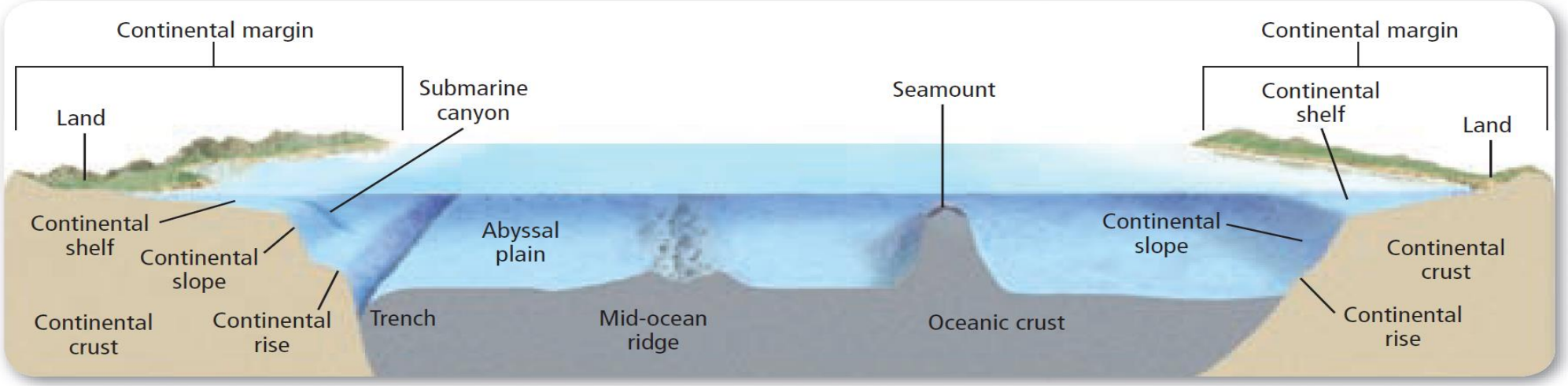


GEBCO world map 2014, www.gebco.net.



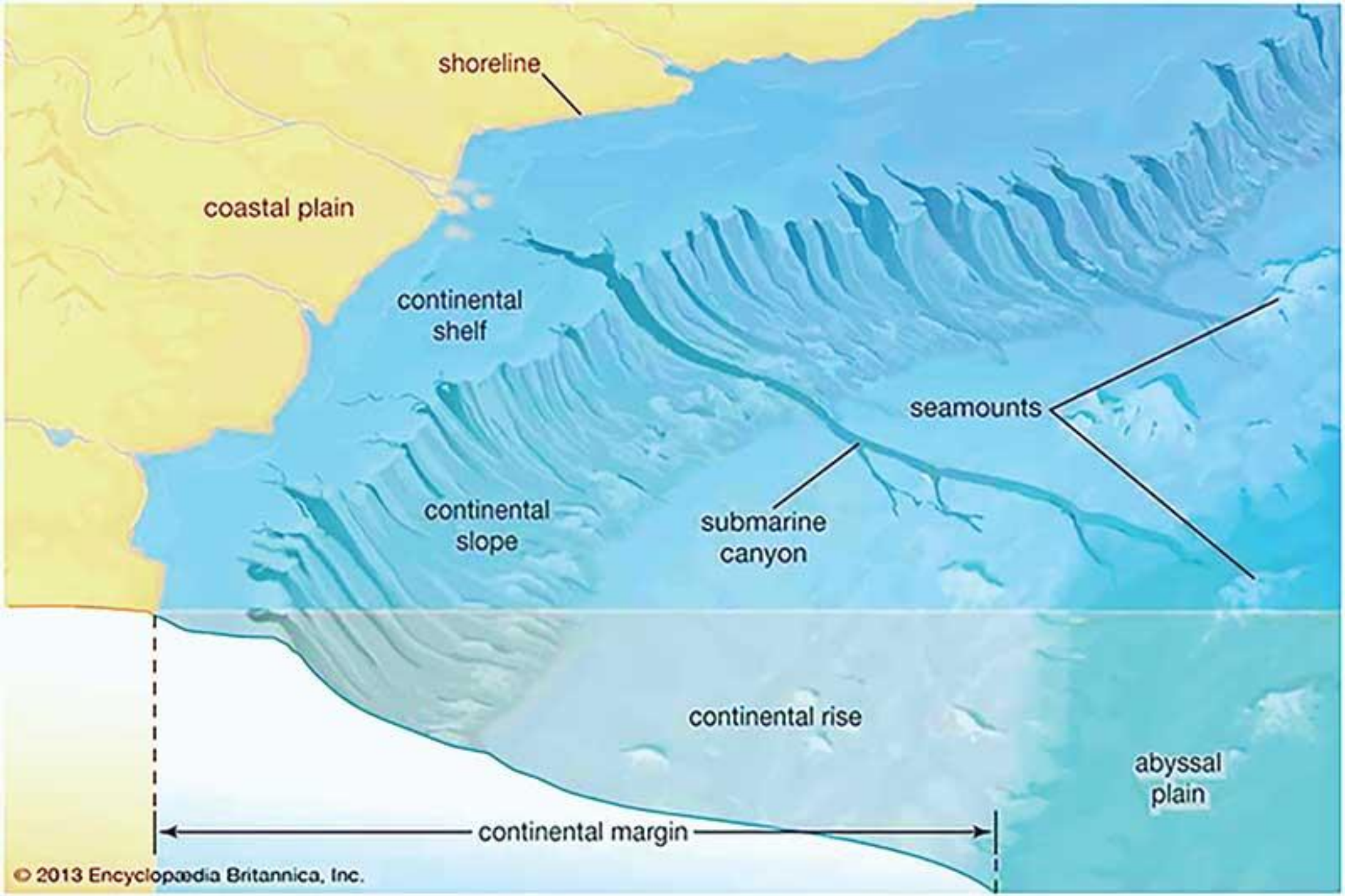
Ocean structures mapped by satellite. The map shown here of a swath across the Pacific Ocean with New Zealand on the west.

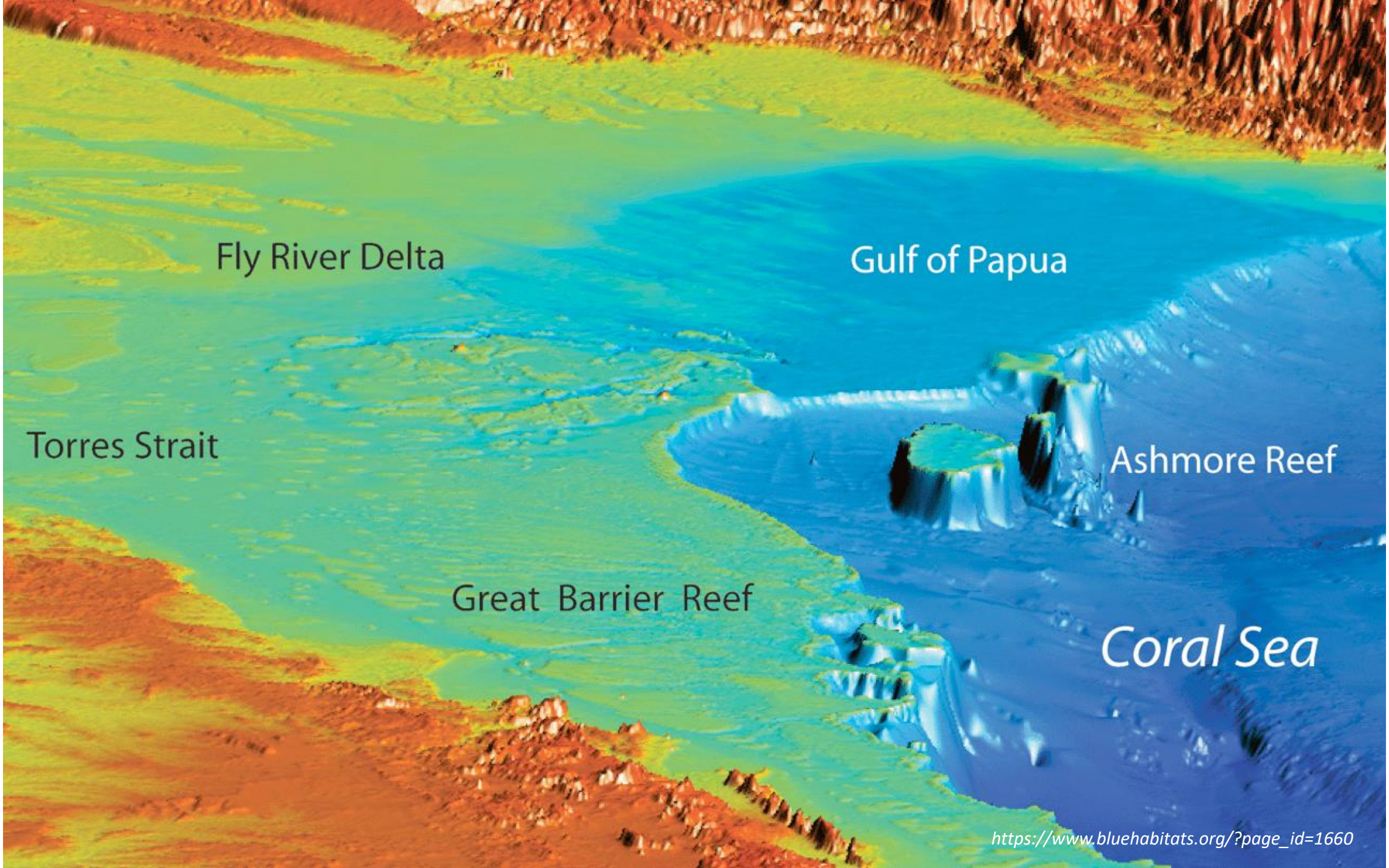
Hamblin & Christiansen (2010)



A cross section of the ocean reveals a diverse topography with many features that are similar to those on land.

National Geographic & The McGraw-Hill Companies, Inc. (2008)


shoreline
coastal plain
continental shelf
seamounts
continental slope
submarine canyon
continental rise
abyssal plain
continental margin
© 2013 Encyclopædia Britannica, Inc.



https://www.bluehabitats.org/?page_id=1660

The ocean floor topographic features

Fracture zones run perpendicular to mid-ocean ridges.

Abyssal plains are smooth, flat areas of the deep ocean covered with fine-grained sediments.

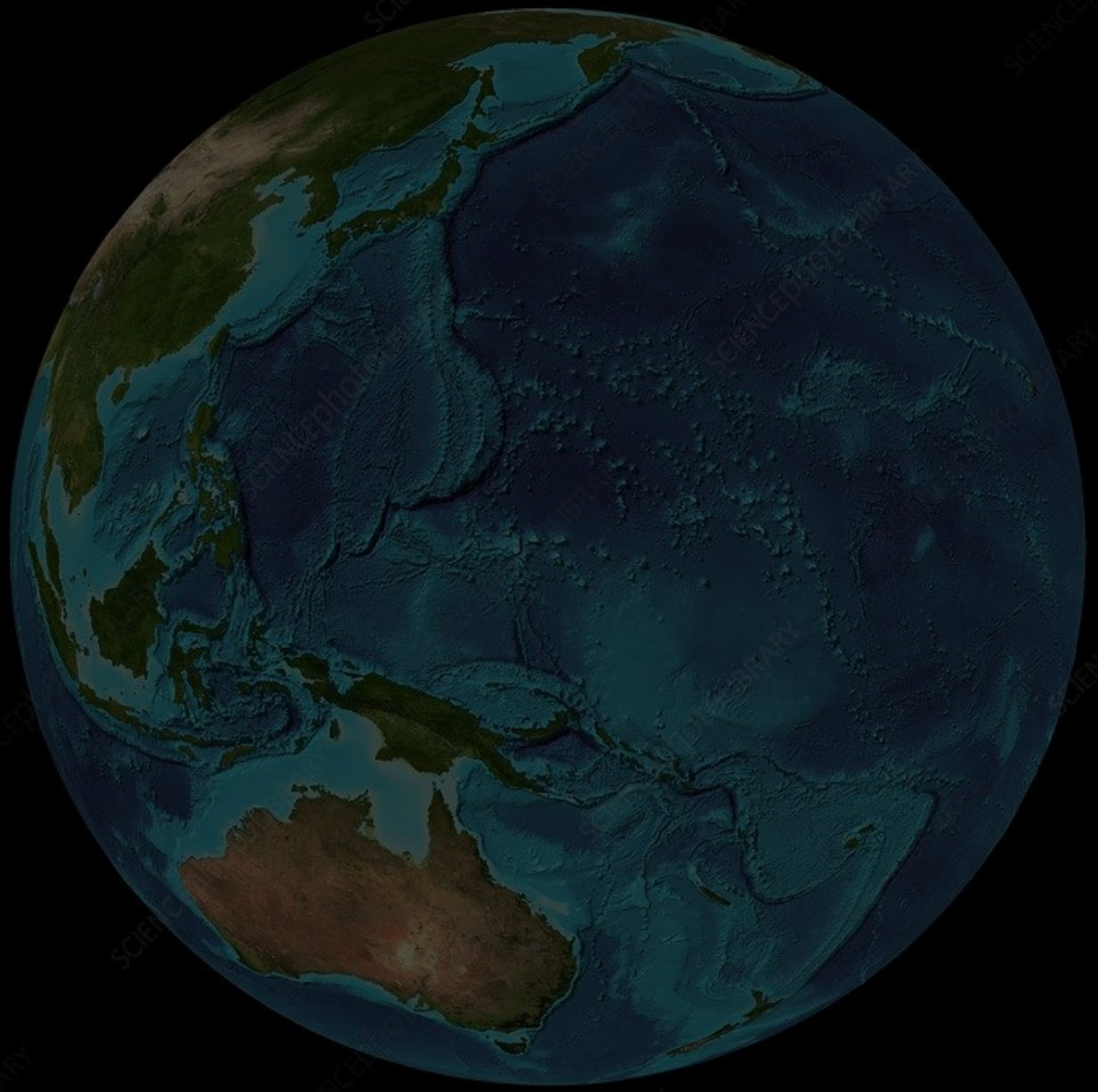
Seamounts are submerged volcanoes that are more than 1 km high.

Mid-ocean ridges run through all ocean basins.

Trenches are the deepest areas of the ocean.

Submarine canyons

https://www.pinterest.com/pin/347692033721494692/



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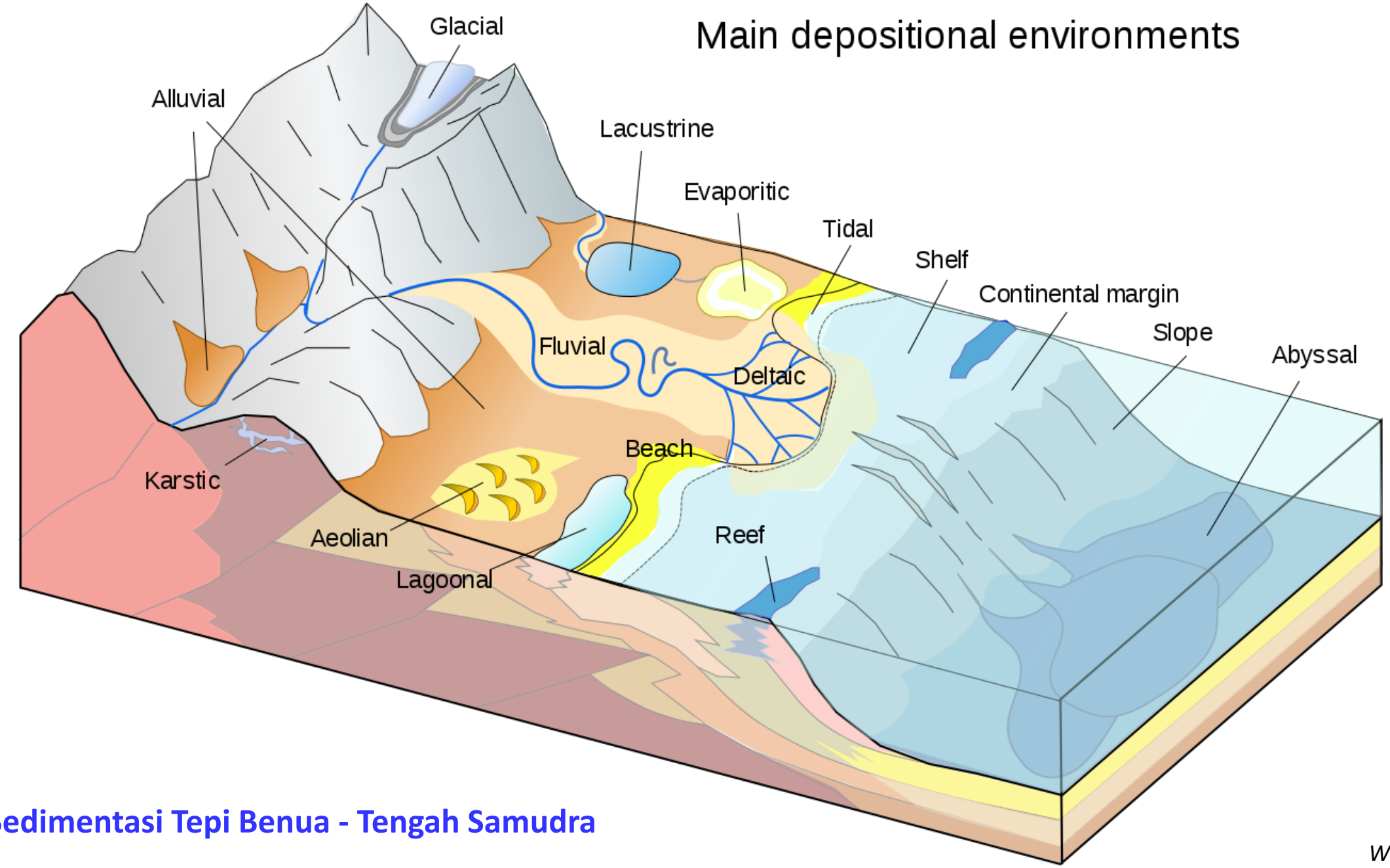
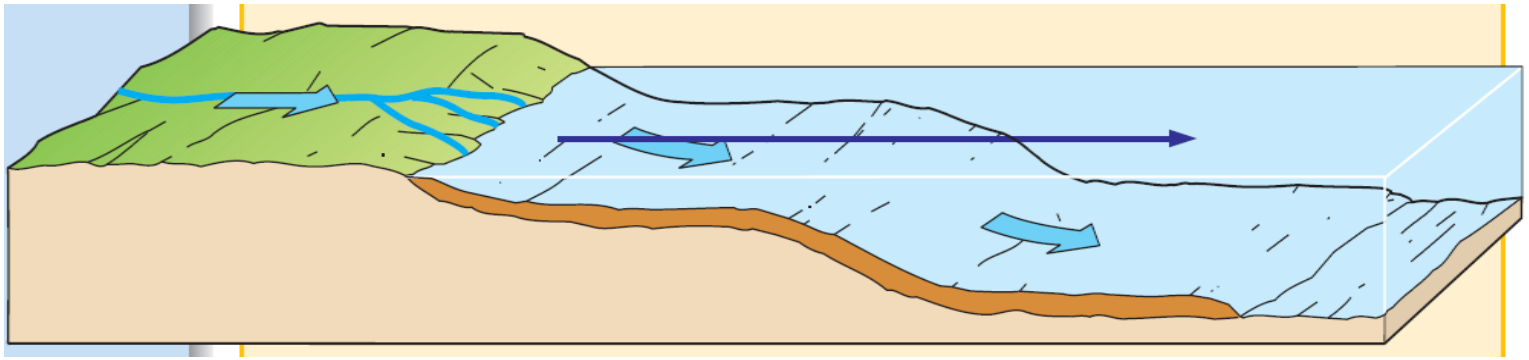


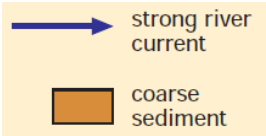
Sedimentasi Tepi Benua - Tengah Samudra

Wikipedia

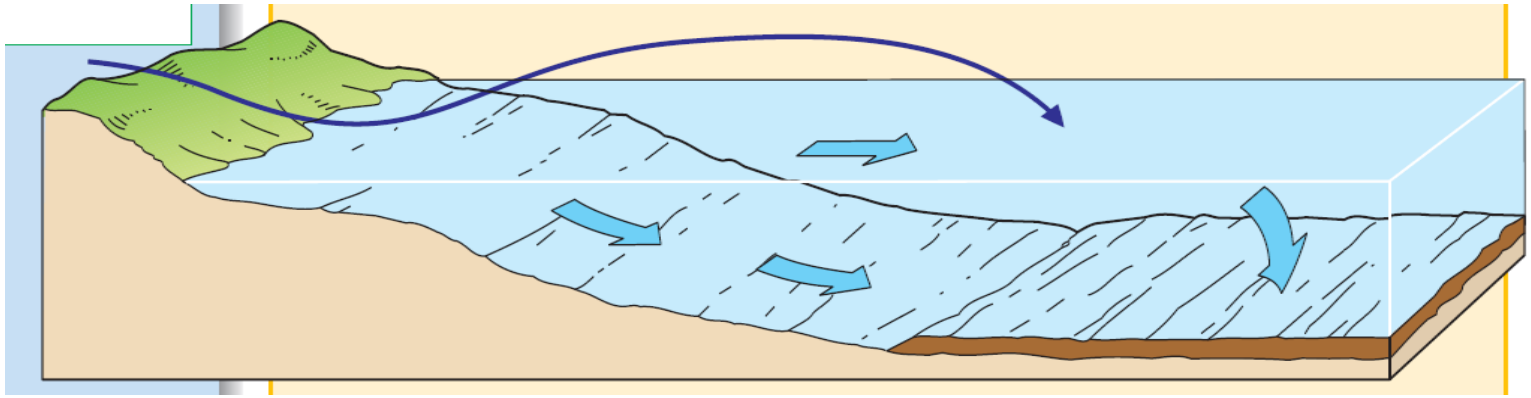
Terrigenous sediments



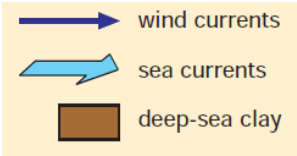
Coarse terrigenous sediments



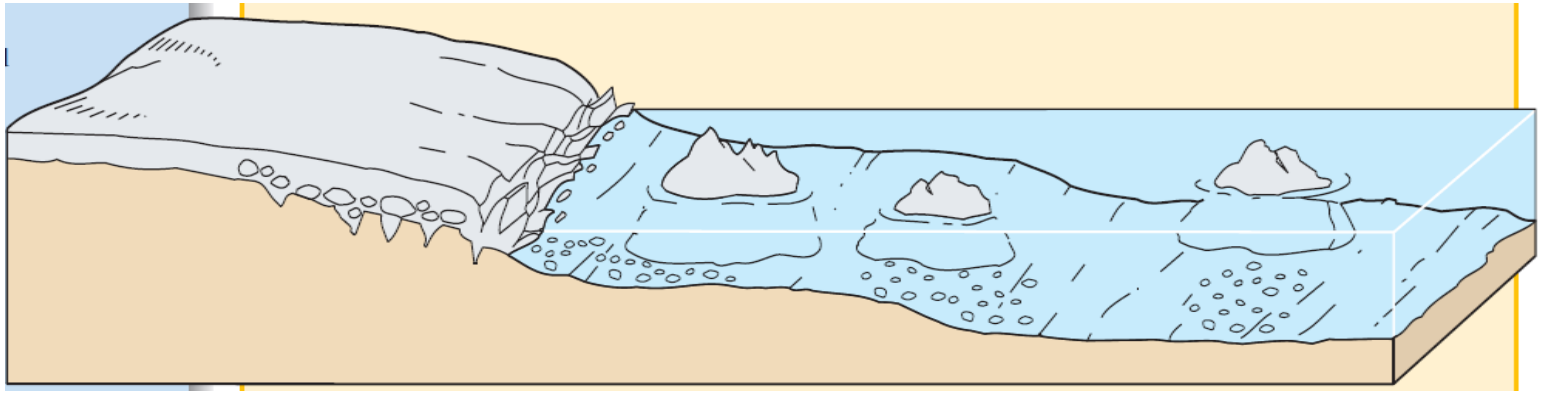
Coarse sediments are typically deposited by rivers via estuaries. They are found primarily in shallow waters on the continental shelf. Turbidity currents can also convey coarse sediments to the deep ocean floor.



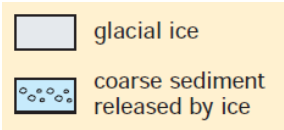
Deep-sea clay



Deep-sea clay covers large areas of the deep ocean floor. l It consists of material conveyed from land by wind and water currents. Deposition from other sources is very low in these areas. Deposition rates are very low - typically 1 mm per thousand years.



Glacial sediments



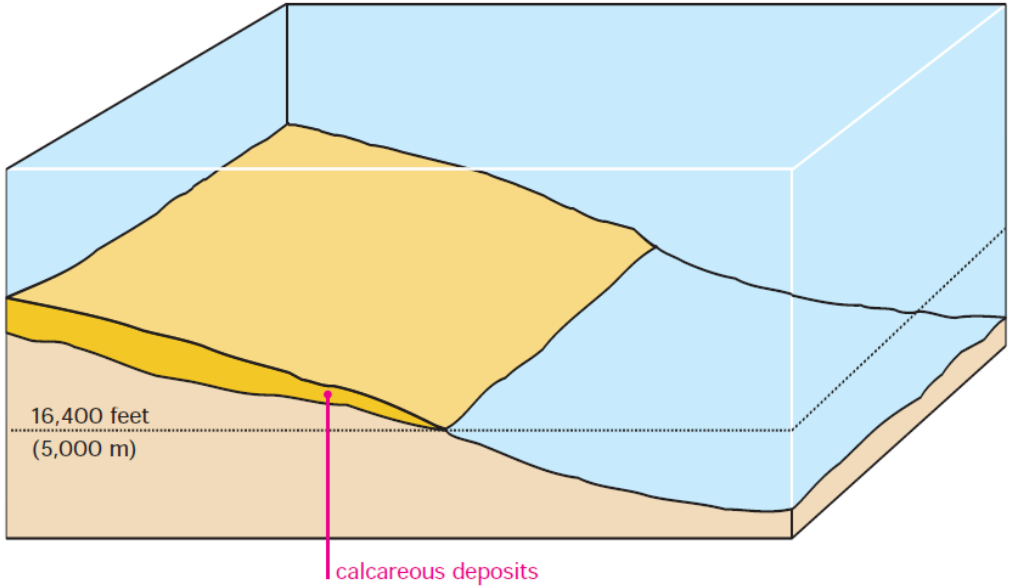
Glacial sediments are found primarily on continental shelves where glaciers flowed during periods of low sea level. They are of mixed coarseness, from clay to boulder-sized particles. They are also found in deeper water where free floating icebergs have melted and deposited their sediment.

Marine Science: An Illustrated Guide to Science *(The Diagram Group, 2006)*

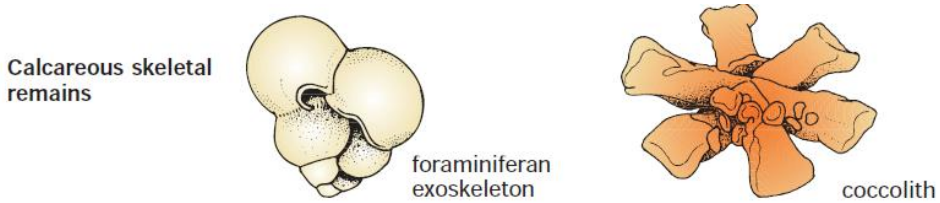
Biogenous sediments

Sediments formed from the remains of once living organisms

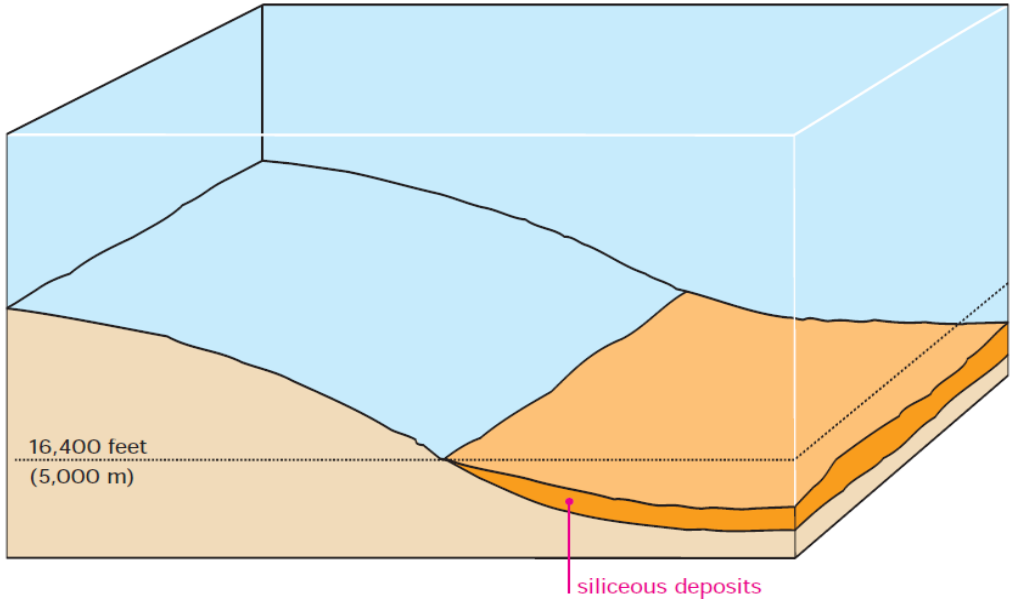
Calcareous sediments



Calcareous sediments are biogenous sediments formed from calcium carbonate. The calcium carbonate comes from the exoskeletons of tiny creatures such as foraminiferans and coccoliths. Foraminiferans and coccoliths are single-celled animals that live in the oceans in huge numbers. Calcareous sediments are found at moderate depths in subtropical and temperate waters. They are not found at depths greater than 4,500–5,000 m.



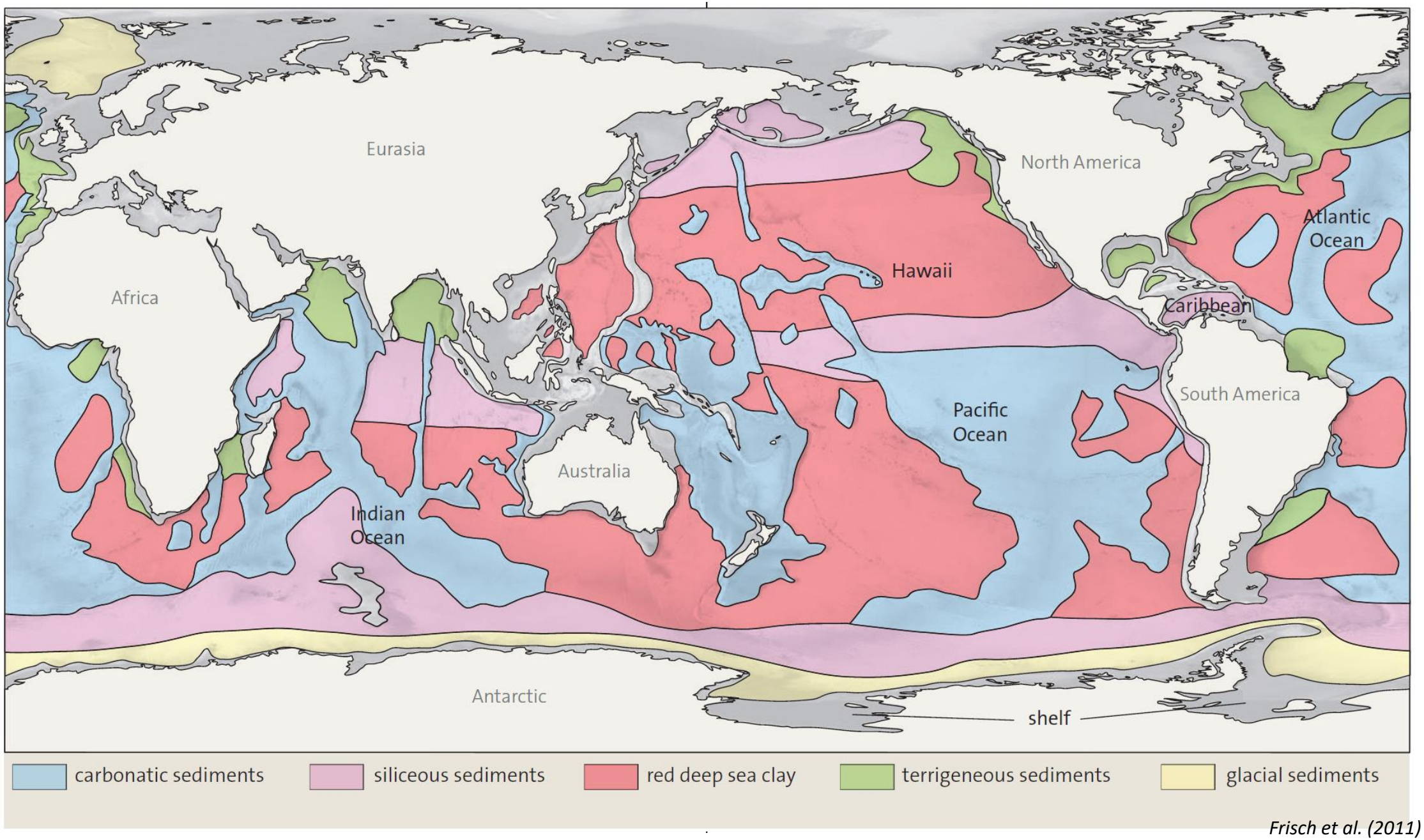
Siliceous sediments



Siliceous sediments are biogenous sediments formed from the glasslike (siliceous) exoskeletons of tiny creatures known as diatoms, radiolarians, and silicoflagellates. Siliceous sediments are found in cooler and deeper waters than calcareous sediments. They accumulate where deposition of calcareous exoskeletons is low, where there are high concentrations of dissolved silica, and at depths greater than 4,500–5,000 m where calcium carbonate tends to dissolve.

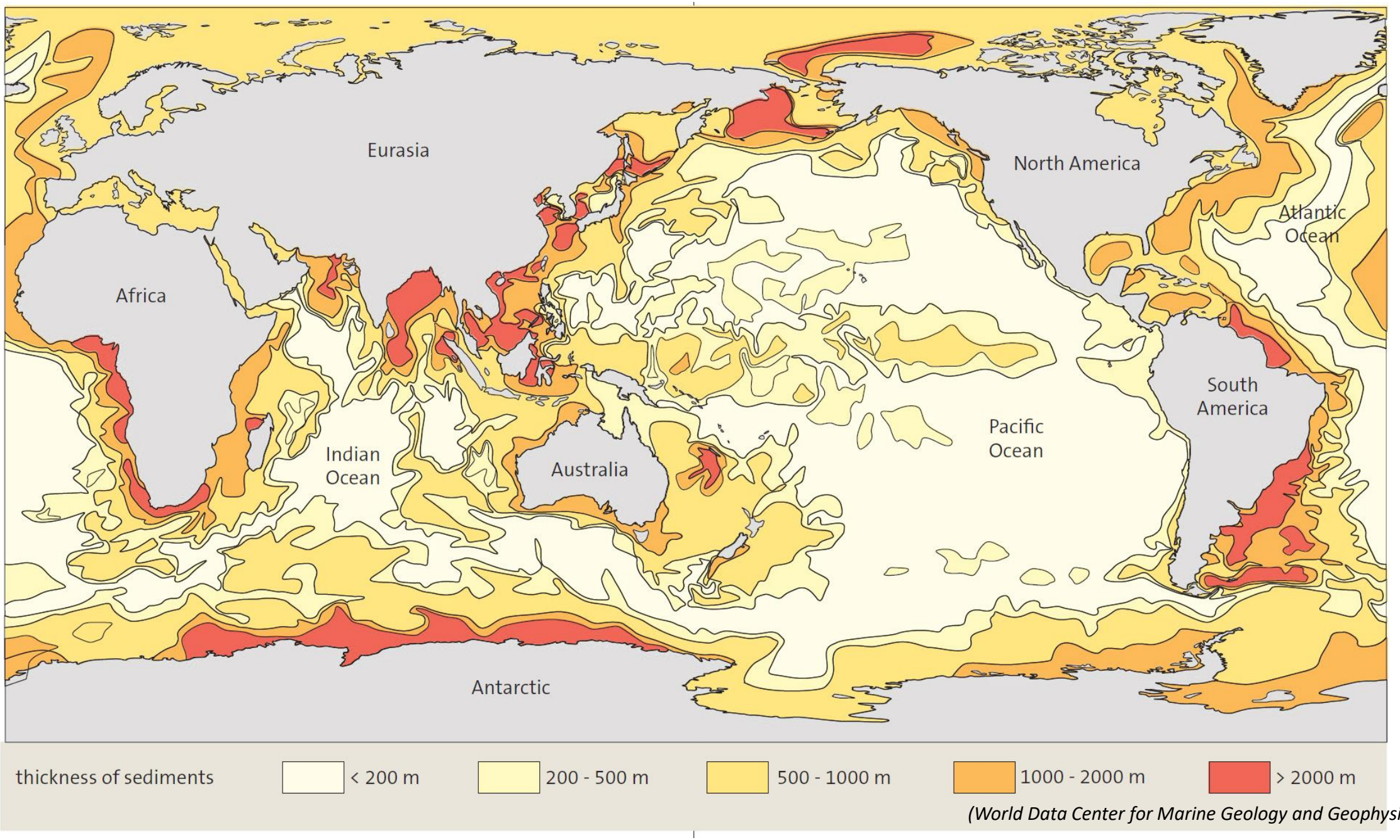
Marine Science: An Illustrated Guide to Science *(The Diagram Group, 2006)*

Map showing present global distribution of sediments in the oceans



Frisch et al. (2011)

Map showing distribution of sediment thicknesses in the global ocean basins and adjacent shelf areas

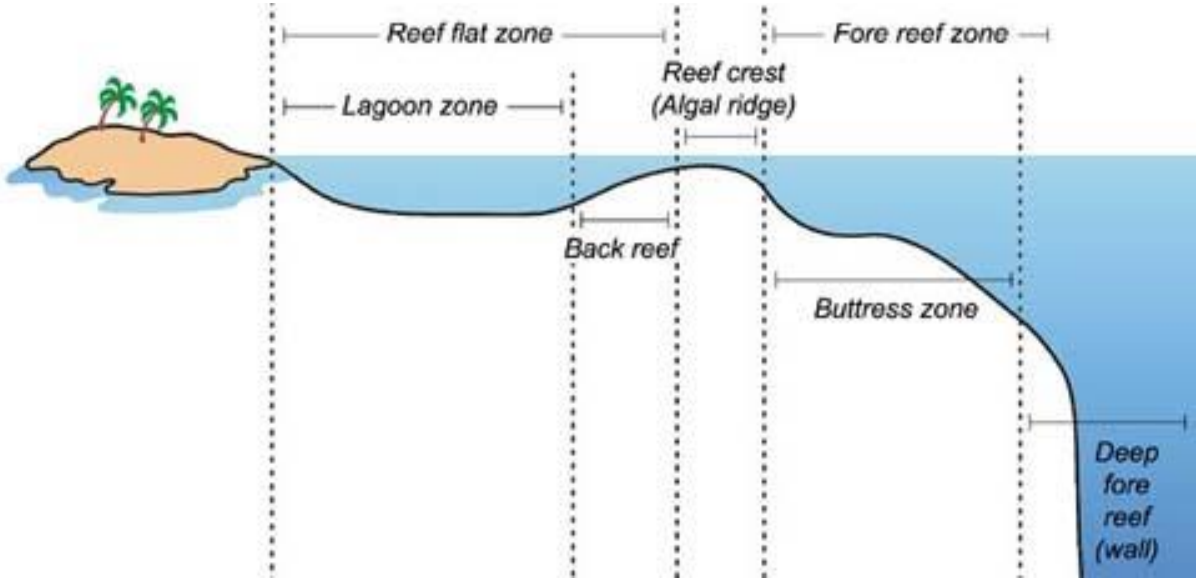


(World Data Center for Marine Geology and Geophysics, 2003)

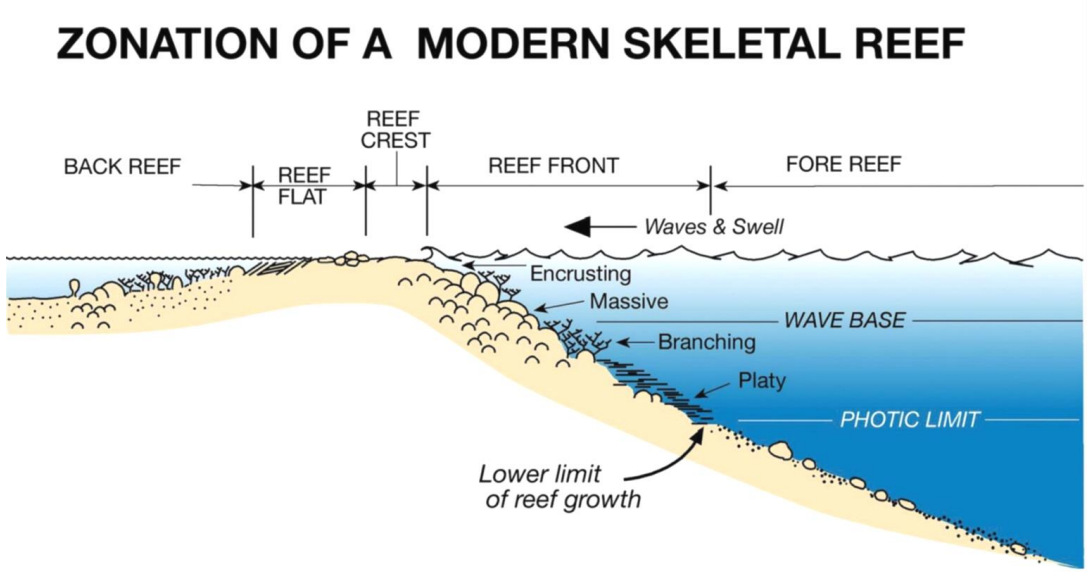
Lingkungan Terumbu Karang

https://coral.org/en/coral-reefs-101/types-of-coral-reef-formations/

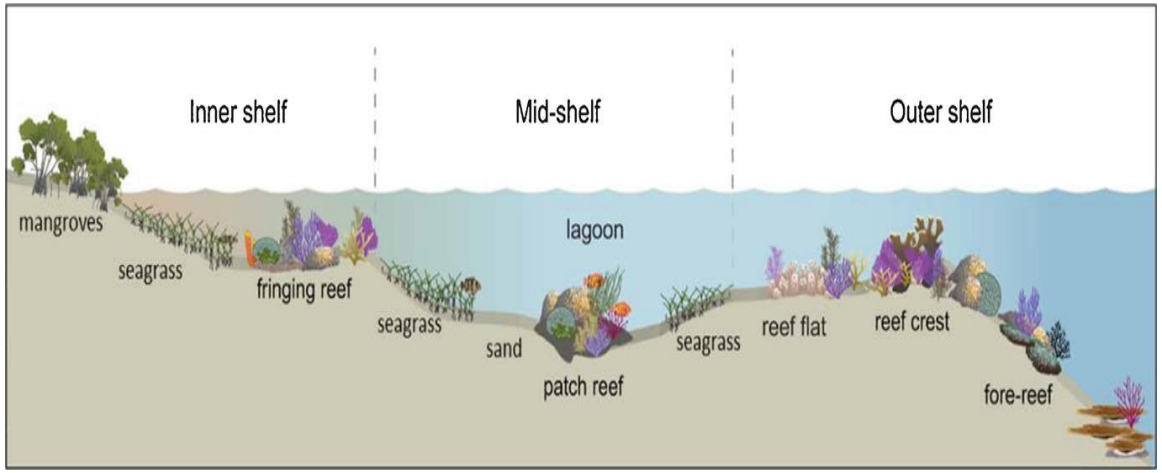
Lingkungan Terumbu Karang



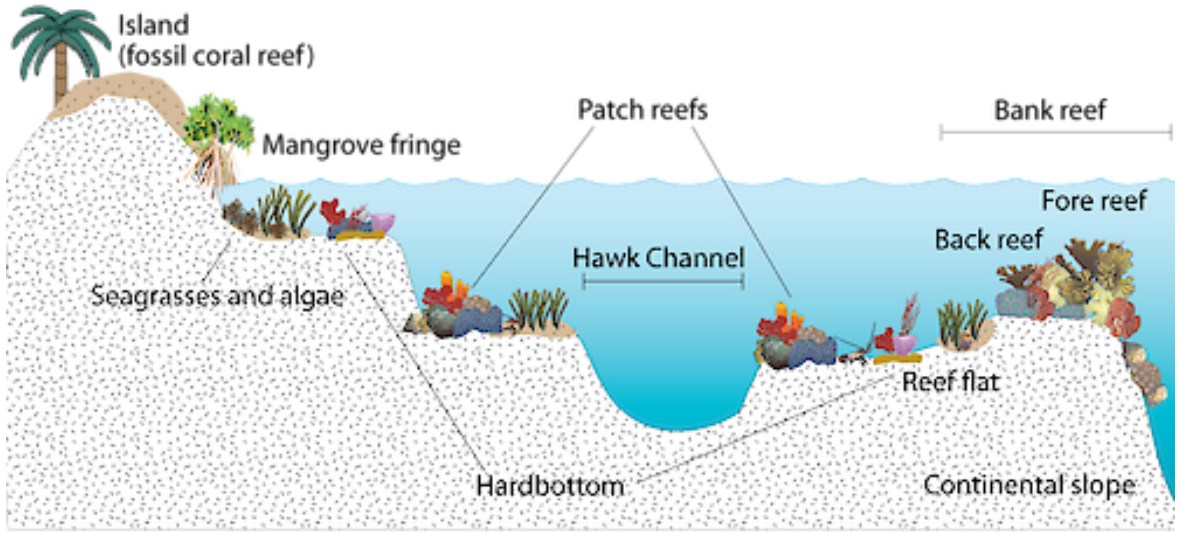
https://oceanservice.noaa.gov/education/tutorial_corals/media/supp_coral04b.html



James & Wood (2010)

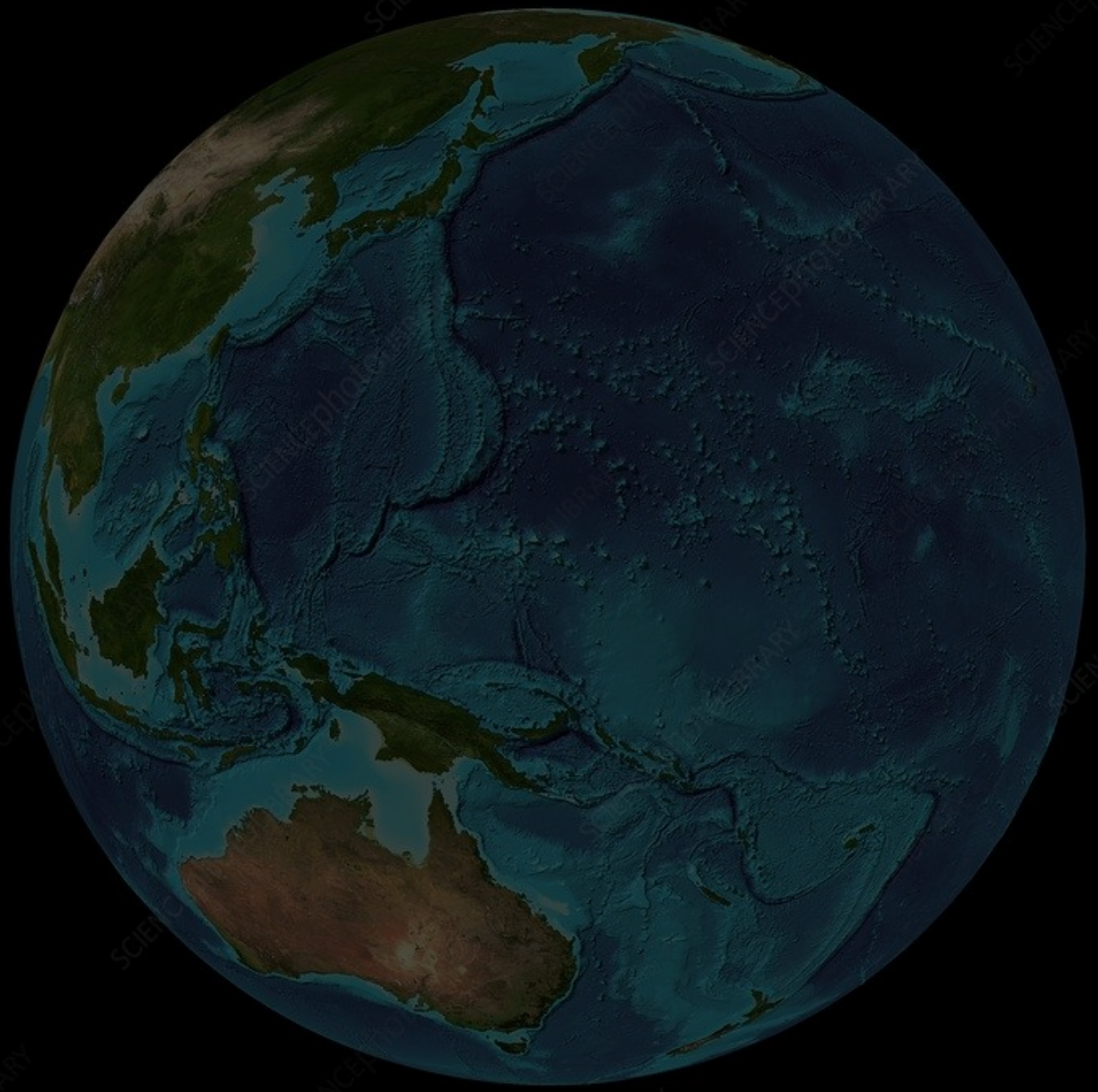


https://link.springer.com/chapter/10.1007/978-3-030-52383-1_14



Conceptual diagram illustrating coral habitats, including hardbottom, patch reefs, and deep and shallow bank reefs.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

https://ian.umces.edu/media-library/coral-habitats/



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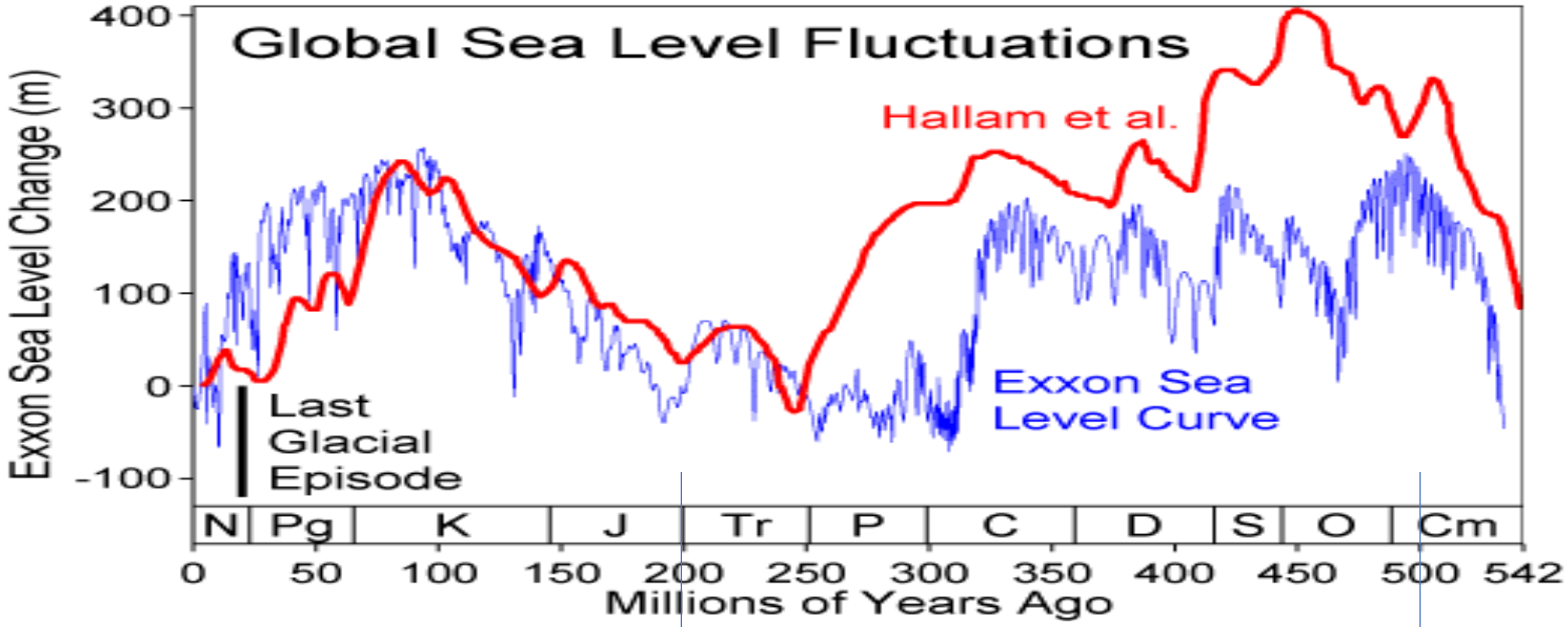
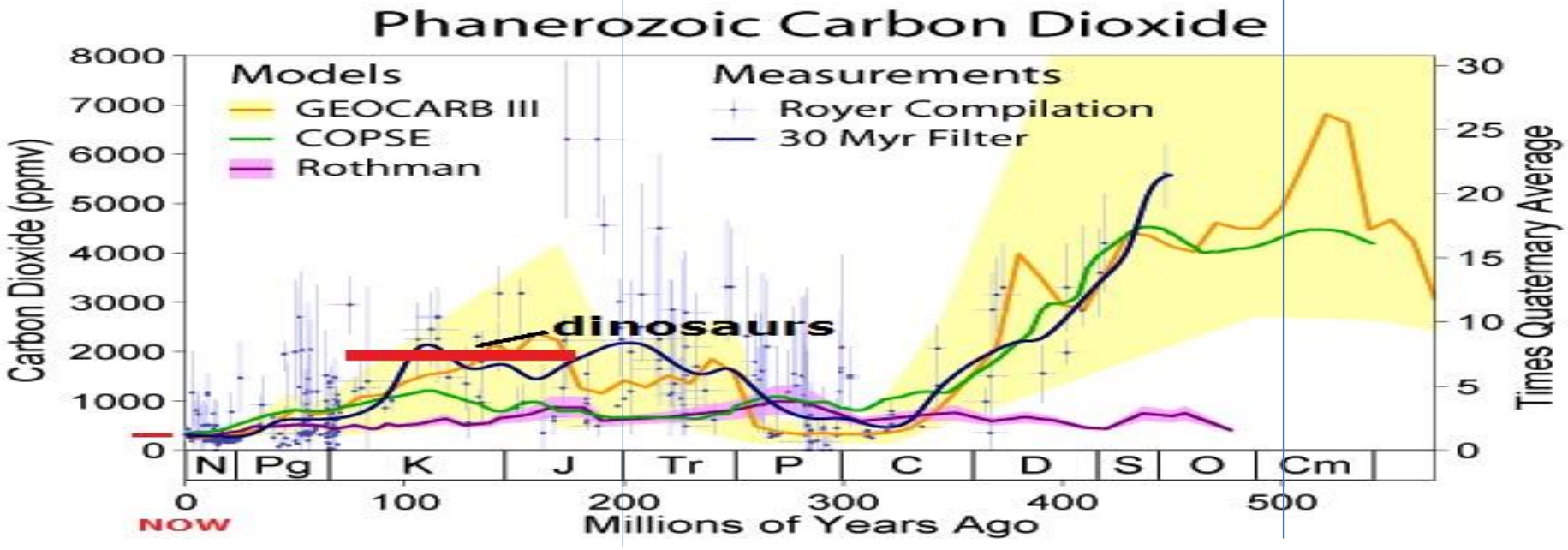
Hubungan antara fluktuasi muka laut global dengan kandungan CO_2 di atmosfer selama 500 juta tahun terakhir

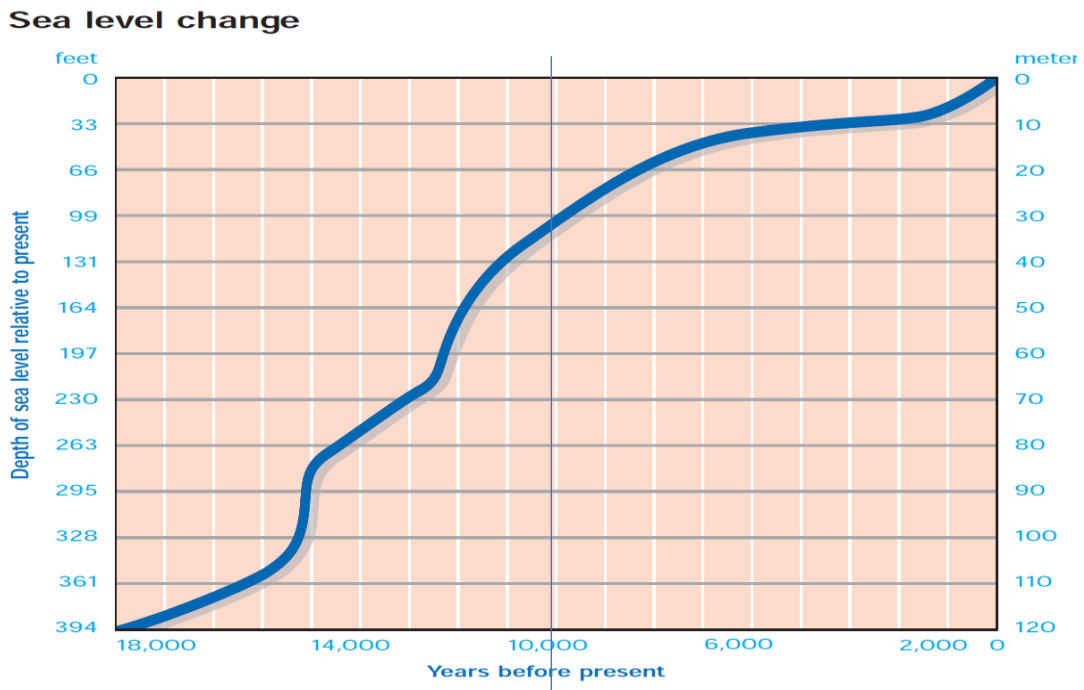


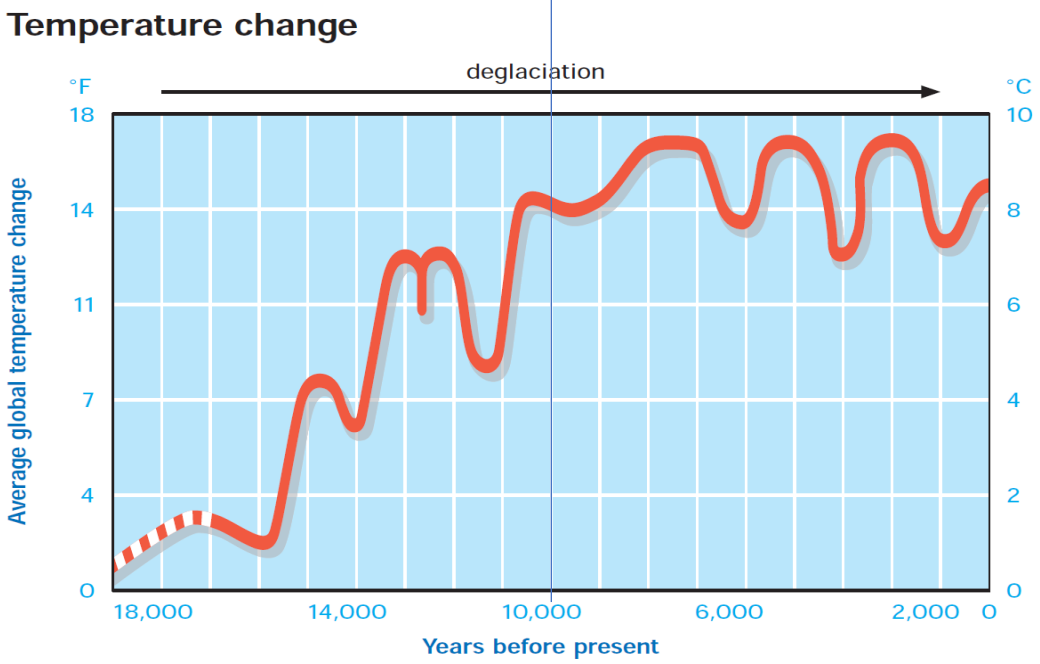
https://en.wikipedia.org/wiki/Past_sea_level#/media/File:Phanerozoic_Sea_Level.png



https://commons.wikimedia.org/wiki/File:Phanerozoic_Carbon_Dioxide.png

Sea level change in recent geologic time





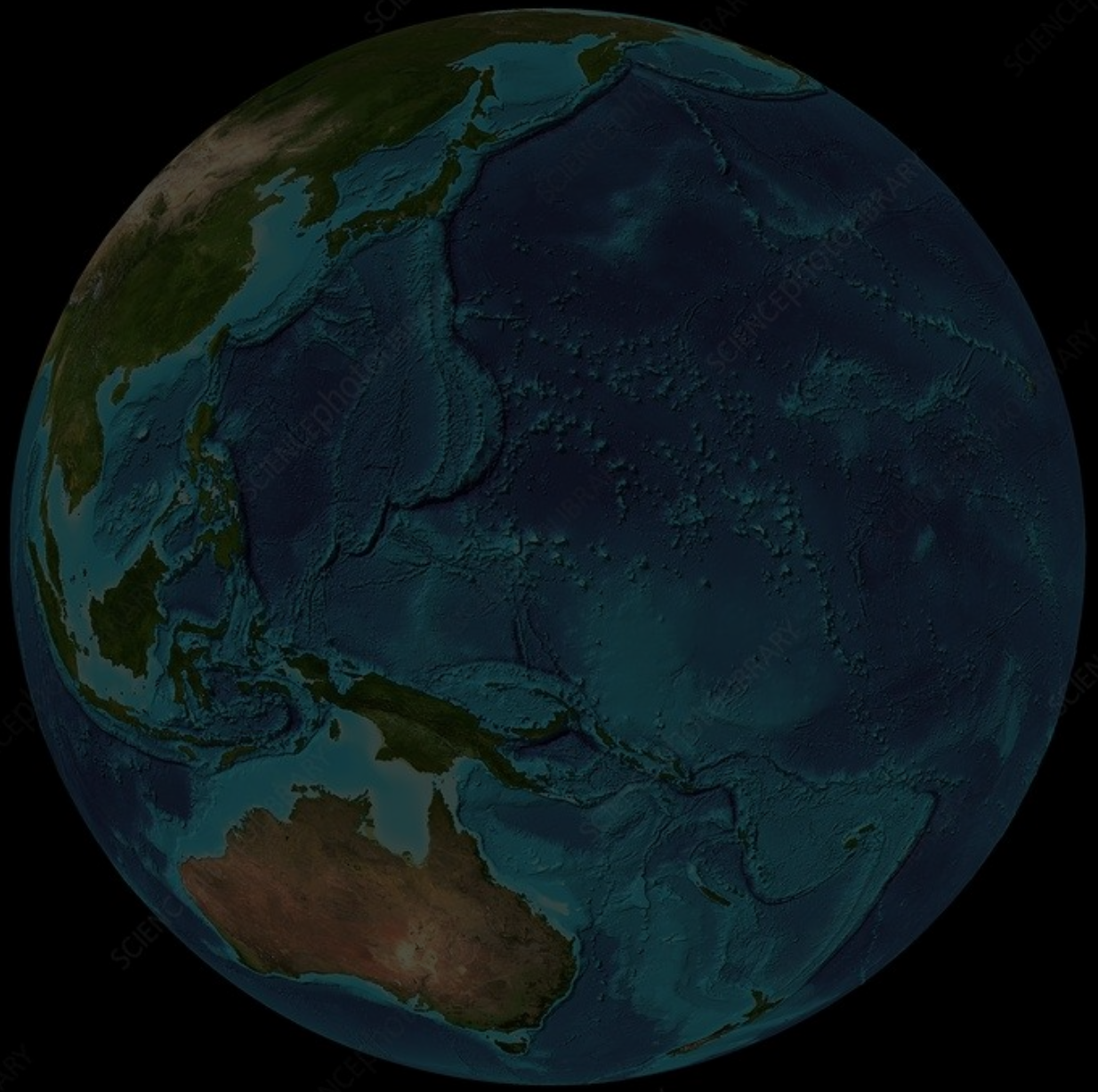
Global sea level

- Global sea level has been rising since the peak of the last ice age about 20,000 years ago.
- The most rapid rise occurred between 20,000 and 6,000 years ago.
- Between 6,000 years ago and the year 1900, global sea level rose at a constant but slower rate.
- Between 1900 and the present day global sea level has also risen at a constant but slightly increased rate.
- Global sea level is thought to have risen by a total of about 395 feet (120 m) in the last 20,000 years.
- Average global temperature has risen by about 18°F (10°C) over the same period.

Factors for change

- Many factors contribute to global sea level changes:
- Increasing temperatures cause glaciers to melt, which adds water to the oceans.
- Increasing temperatures also cause the water in the oceans to expand, increasing the overall volume of the oceans. This factor is thought to be more significant than the addition of water from melting ice.
- The amount of water retained in the atmosphere and trapped on land also influences global sea levels.

Marine Science: An Illustrated Guide to Science *(The Diagram Group, 2006)*



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Mikropaleontologi untuk Rekonstruksi Paleo-oseanografi

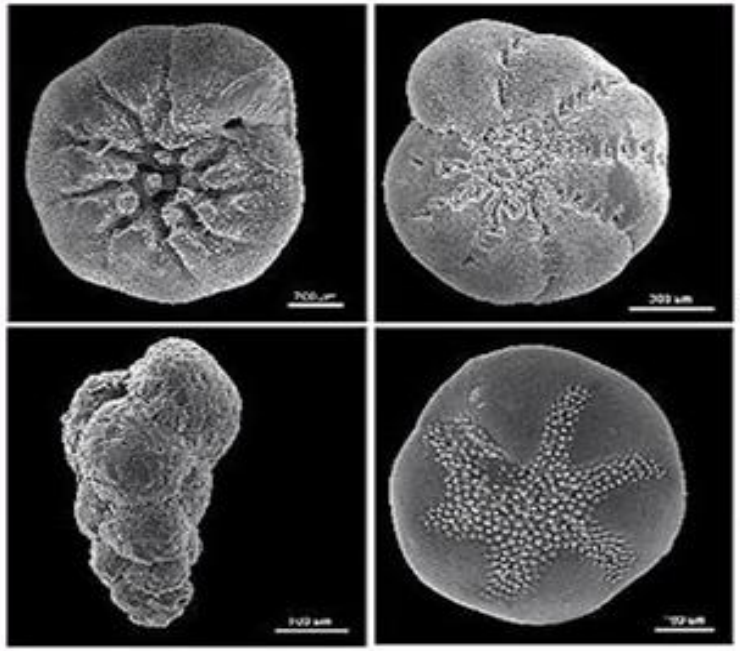
- Continuous sediments from Mesozoic to Recent are deposited in the ocean.
- Many geological information are present in the sediments.
- Method of taking samples of sediments: deep sea drilling
  - DSDP – Deep Sea Drilling Project (1968 – early 1970's) to confirm plate tectonics
  - IPOD – International Phase of Ocean Drilling Program (1975-1983)
  - ODP – Ocean Drilling Program (1985-2002), to study paleoceanography, paleoclimatology
  - IODP – Integrated Ocean Drilling Program (since 2003), changed to Internatioal Ocean Discovery Program

Sato (2021)

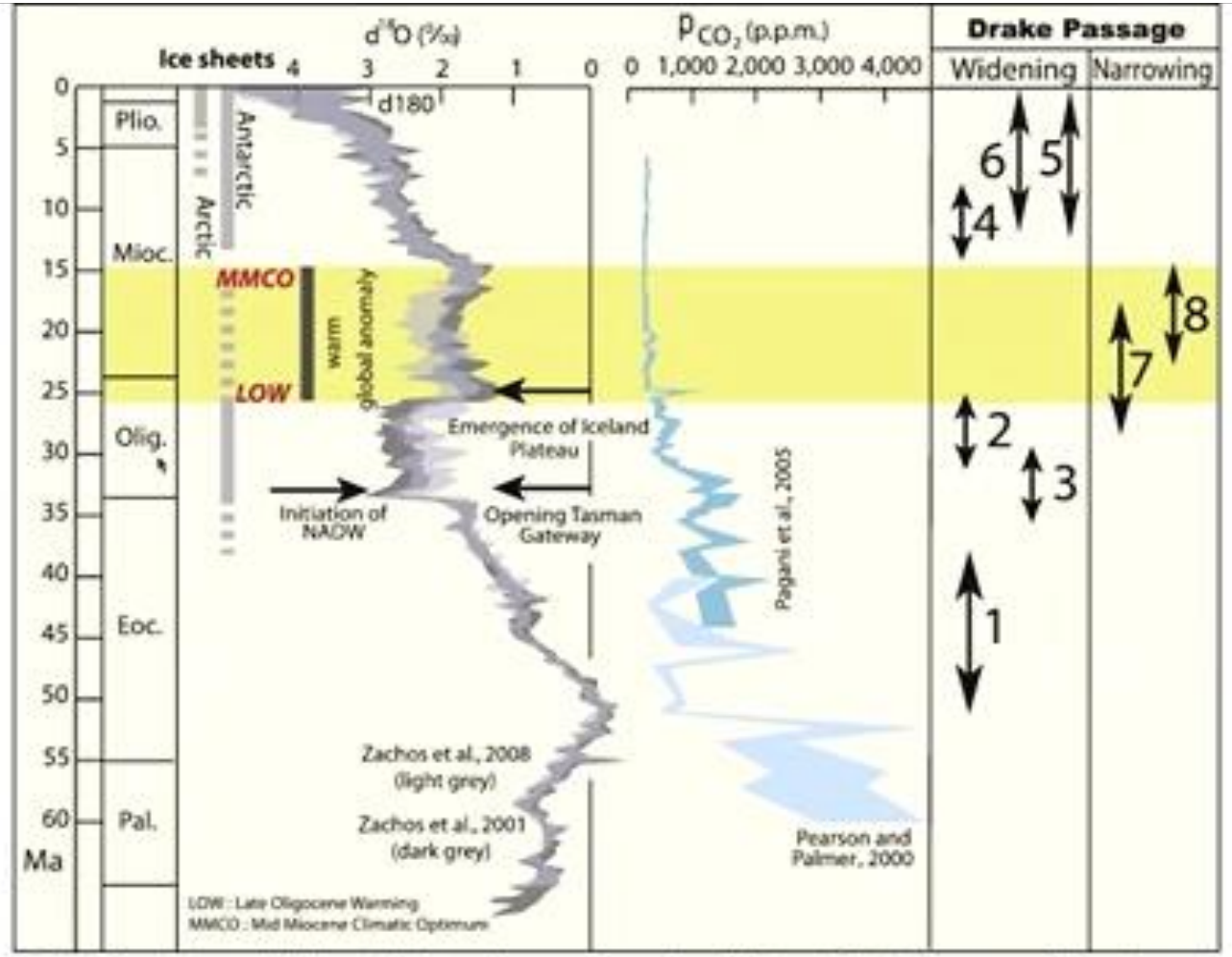
$\delta^{18}O$ of Benthic foraminifera from Deep Sea sediments indicates the average of whole sea water at the time

sea water mass circulates from surface to deep sea during 3k.y.

Analyze the $\delta^{18}O$ of benthic foraminifera



shell of foraminifera is made of $CaCO_3$



1. Crustal extension, subsidence, block rotation, opening of small basins in Drake Passage and formation of shallow gateways.
2. Subsidence of marine basins in present-day Tierra del Fuego and North Scotia Ridge (NSR).
3. Spreading on West Scotia Ridge (WSR, fig. 1) commences.
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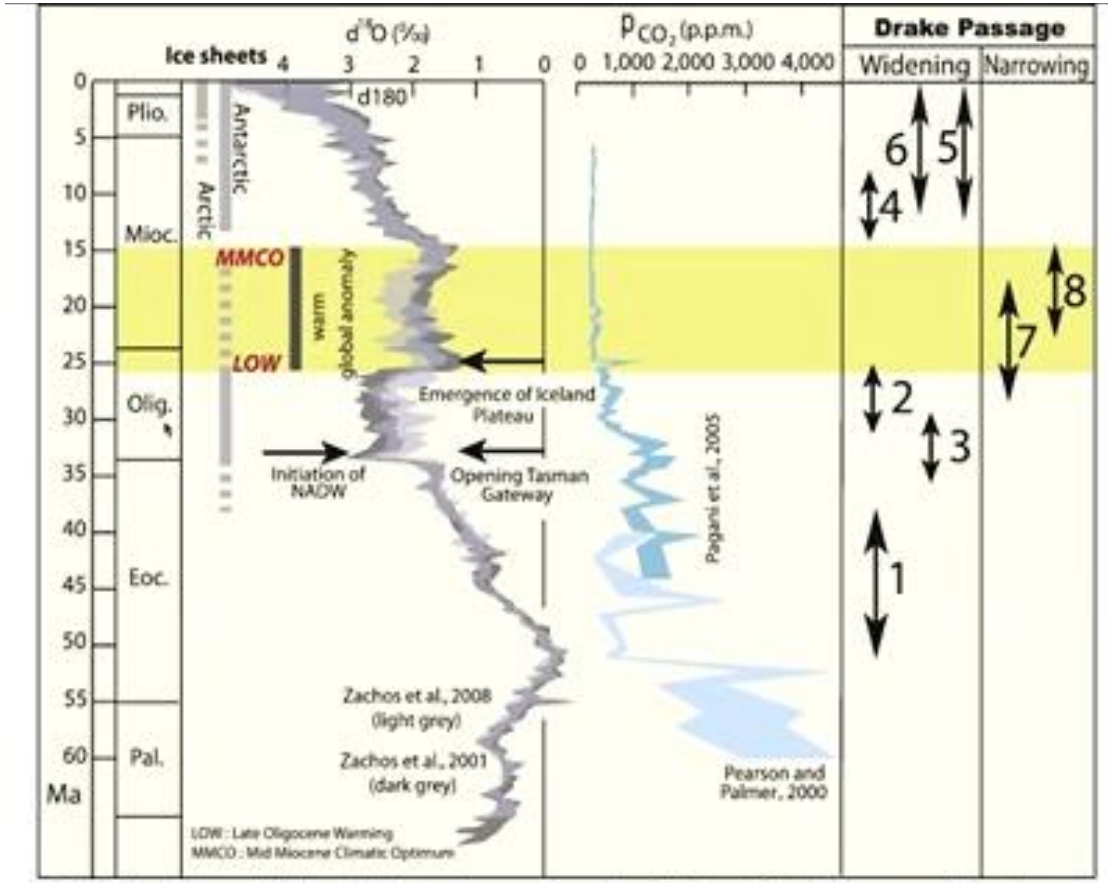
5. Normal faulting and collapse in Southern Patagonia due to slab window.
6. Spreading along the East Scotia Ridge (ESR, fig. 1) and rapid eastward migration of the Scotia arc.
7. Closure of proto-Drake seaways : inversion of marine basins in Tierra del Fuego and along the North Scotia Ridge (NSR) (e.g. Burdwood Bank).
8. Uplift of the Patagonian Cordillera, change from marine to continental environments in Patagonia.

Sato (2021)

Foraminifera bentik untuk rekonstruksi tektonik



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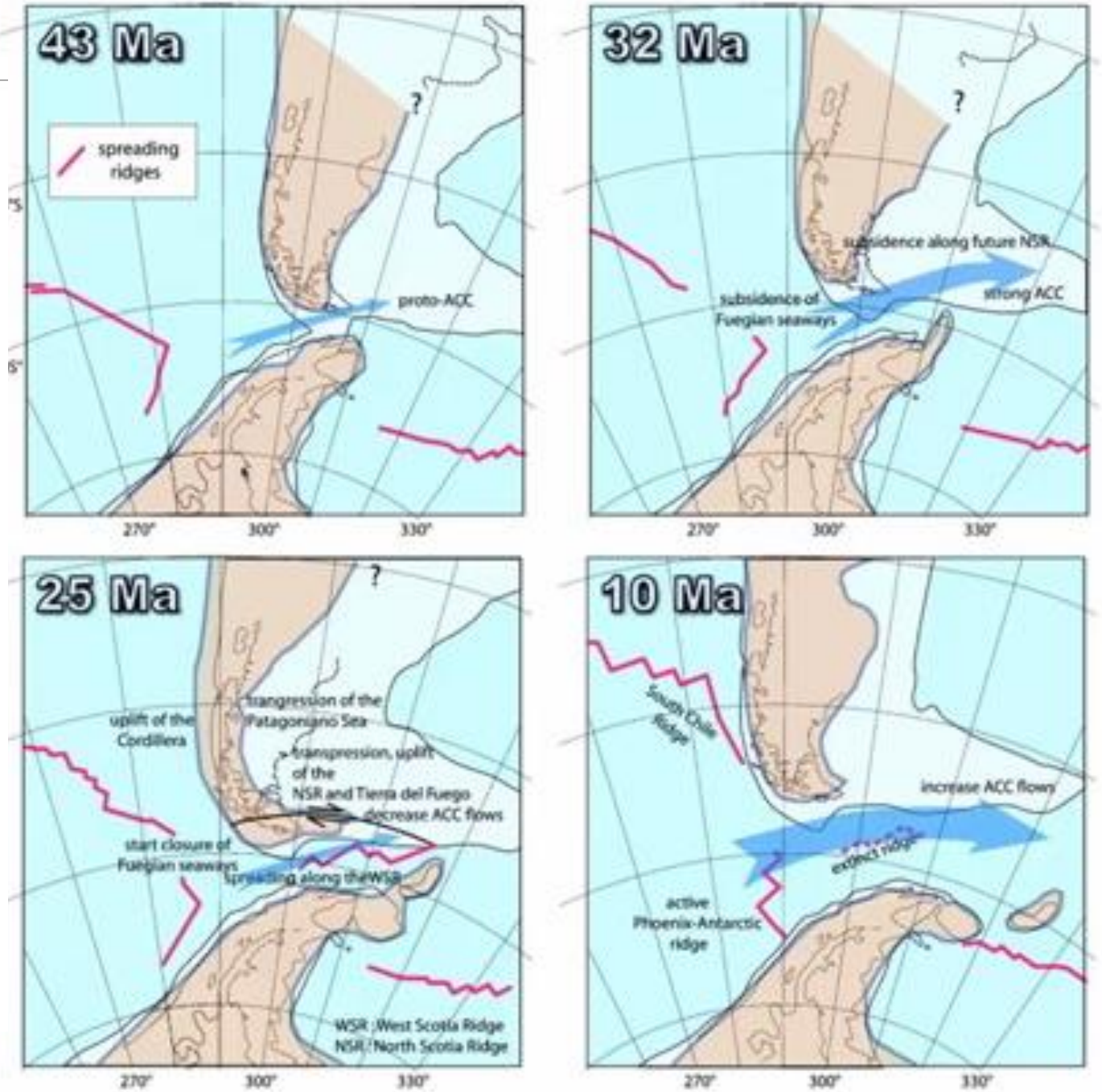
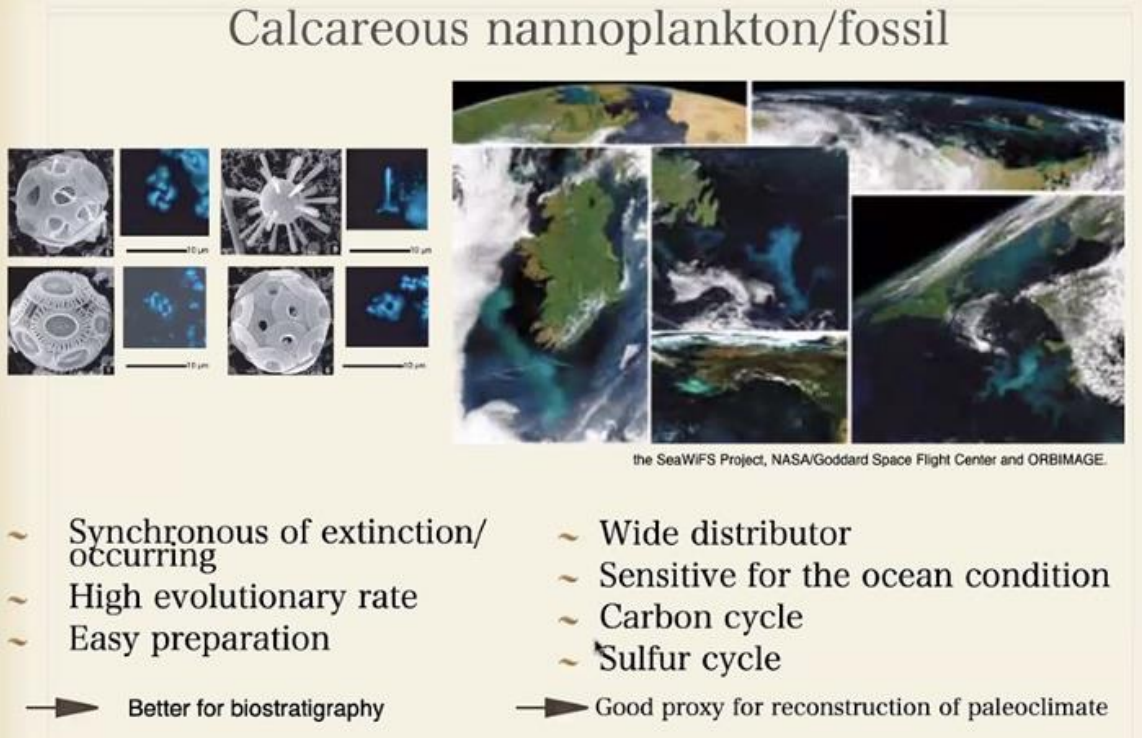
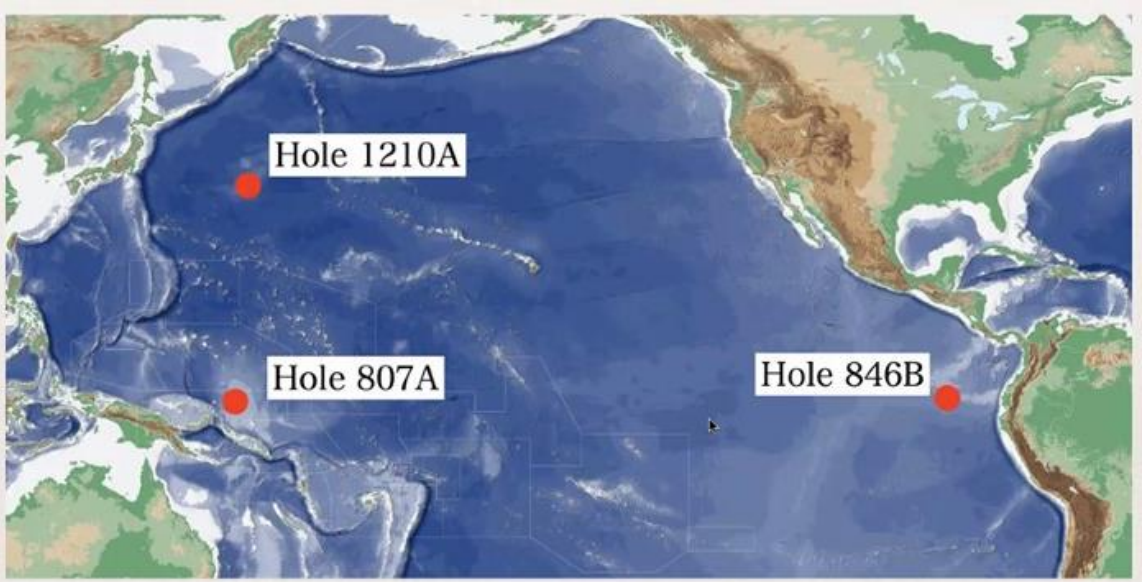
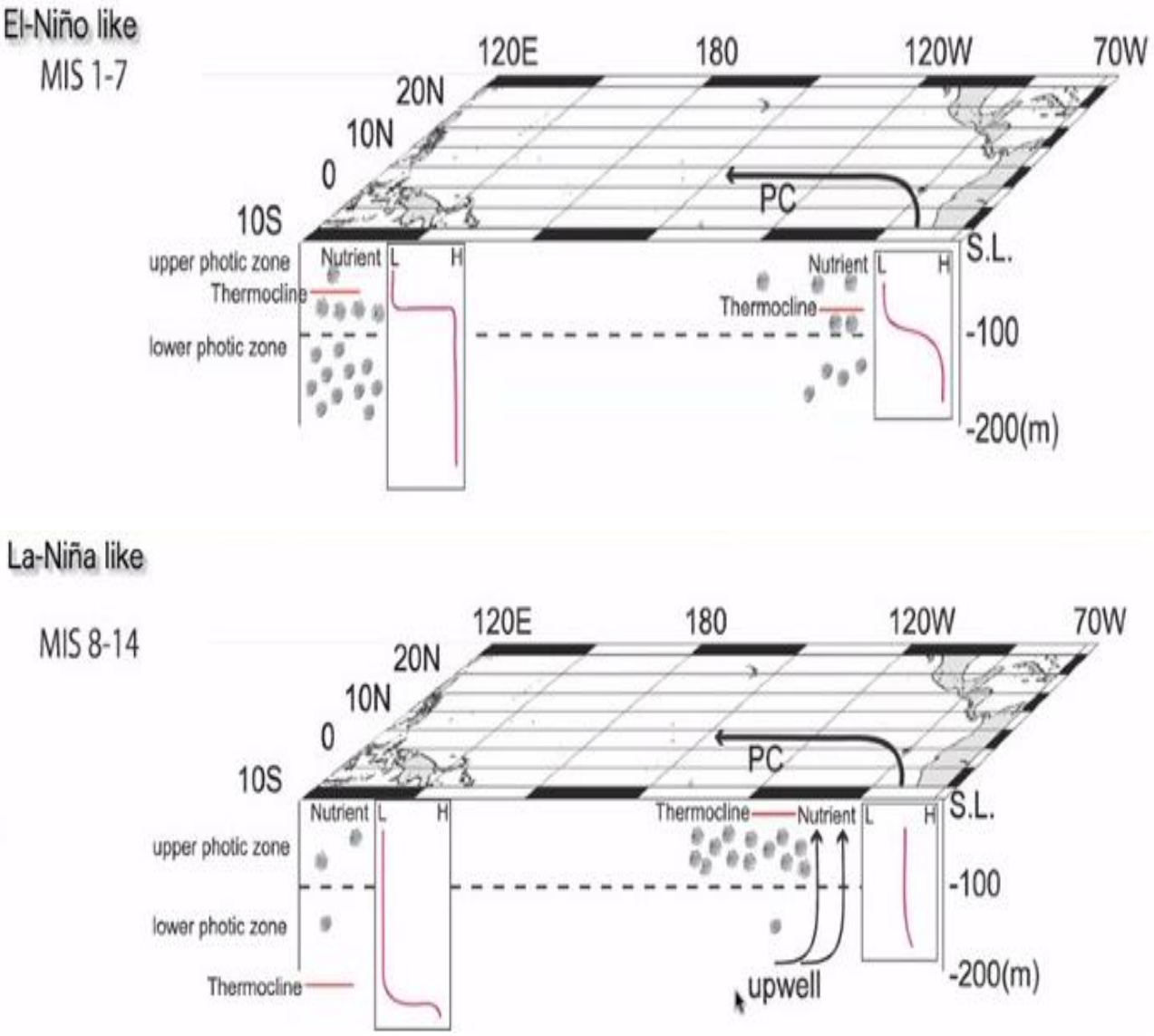
Sato (2021)



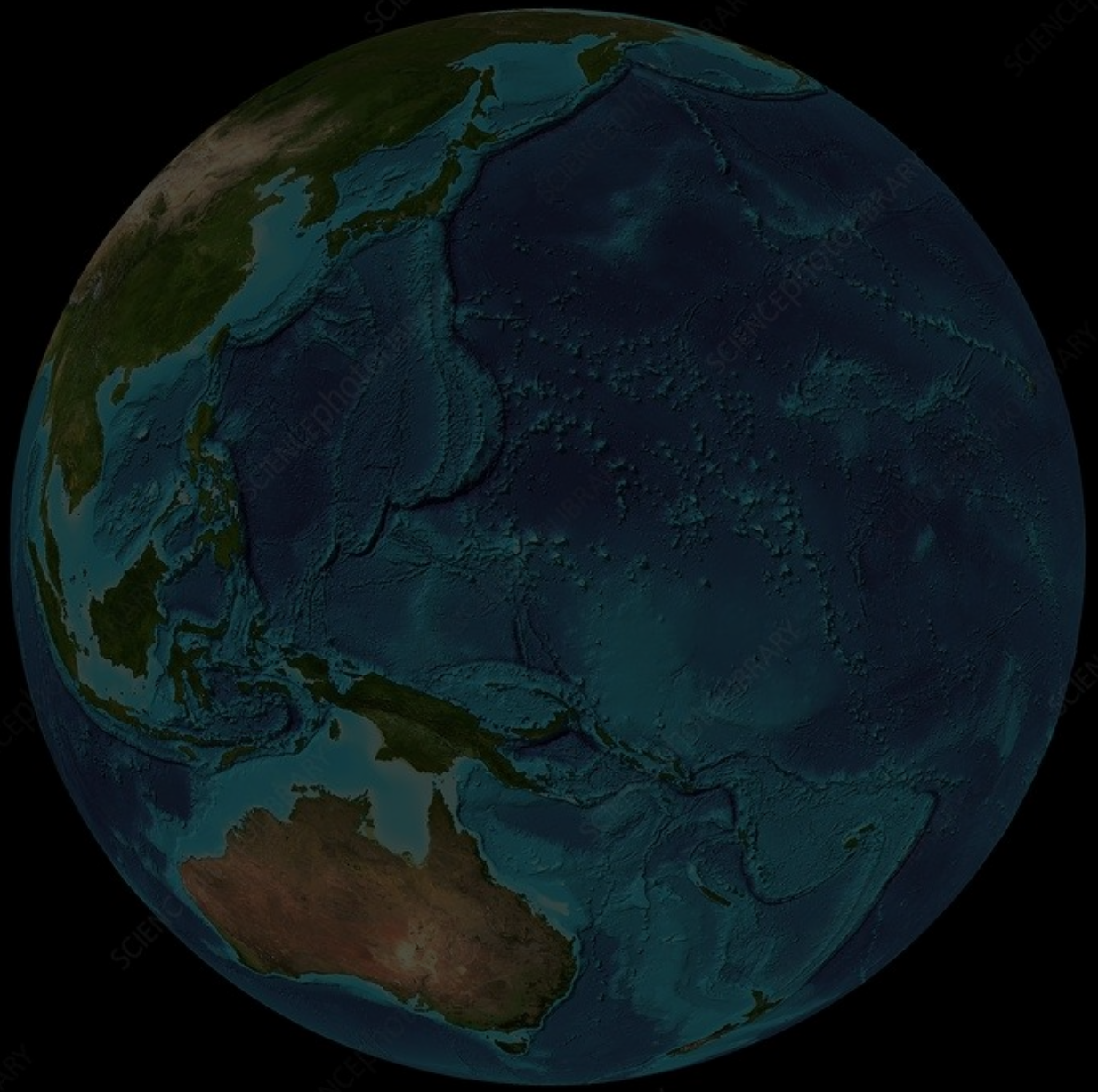
Nannoplankton untuk rekonstruksi paleoseanografi-paleoklimatologi







Chiyonobu (2021)



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan

1. Sejarah Penyelidikan Kelautan
2. Asal Tektonik dan Evolusi Cekungan Laut - Samudra
3. Pola-Pola Topografi Dasar Laut - Samudra
4. Sedimentasi Tepi Benua - Tengah Samudra
5. Perubahan Muka Laut
6. Mikropaleontologi untuk Rekonstruksi Paleo-oseanografi
7. **Kebencanaan Geologis Asal Bawah Laut**
8. Sumber Daya dari Dasar Laut
9. Teknik Penelitian Geologi Kelautan

Kebencanaan Geologis Asal Bawah Laut

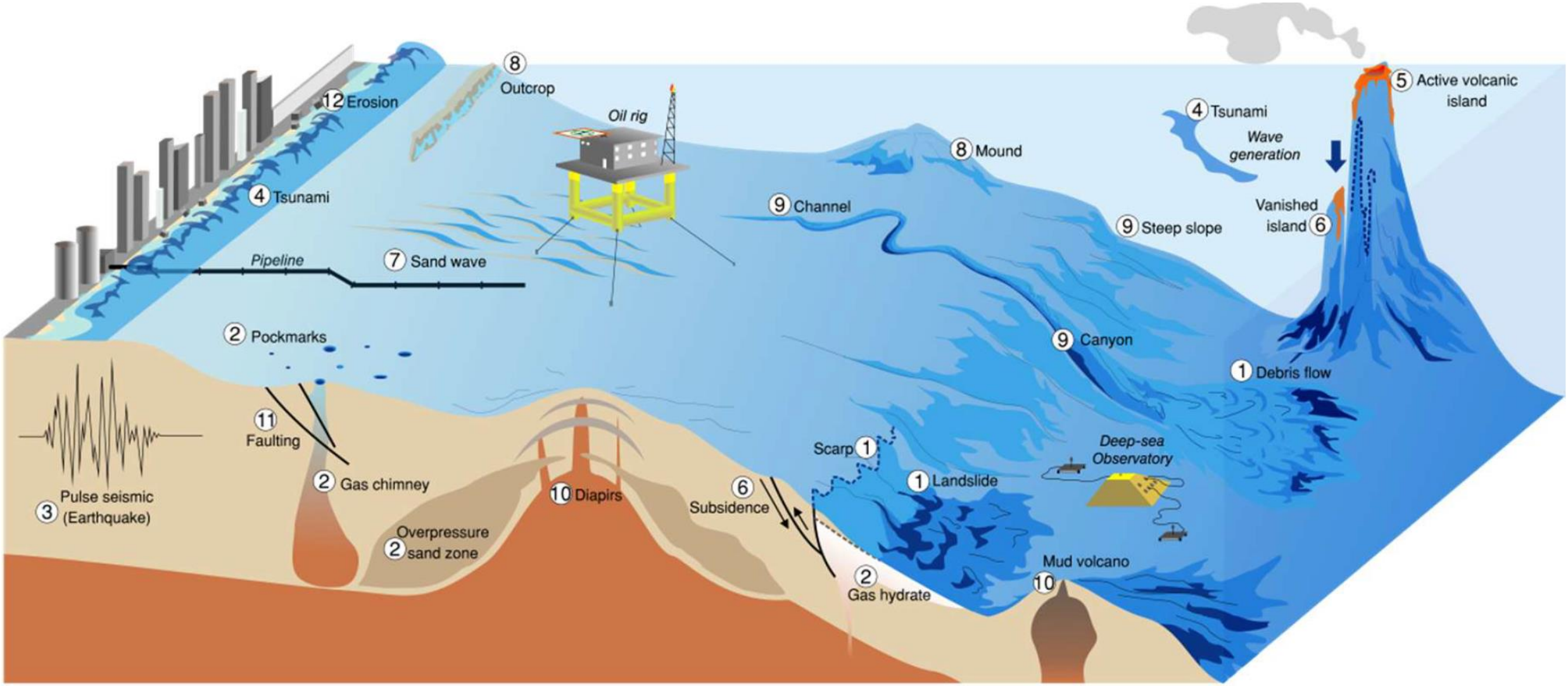
- Marine geologic hazards refer to marine geologic conditions related with nature or human activities which can impose risks or potential risks to human's health and property as well as the environment quality (Lu et al., 2001).
- Marine geohazards could happen in almost all of the marine geological environments, however, mainly in continental margins (Jiu et al., 2016)

Table 1. Categories of geohazards defined after the grouping of features, process, and related events with a similar nature.

Marine Geohazard Categories	Geological Feature, Process or Event
Slope failure	Creep, slumps, debris flow, mud flows, turbidity currents, landslides, slope failure, scars, scarps, slide blocks, slope instability
Fluids seepage	Pockmarks, gas chimney, mud volcanoes, shallow gas, charged sediments, gas hydrate, overpressured sands, shallow-water flows, seeps, free gas accumulations, fluid flow
Earthquake	Earthquakes
Tsunami	Tsunamis
Volcanism	Submarine eruptions, submarine volcanoes, flank collapse, volcanic tremor
Subsidence	Vanished islands, subsidence
Bedforms	Sediment waves, mudwaves, sandwaves, boulder fields, mobile sediments
Positive reliefs	Outcrops, mounds, ridges, seamounts, volcanic highs
Negative reliefs	Canyons, steep slope, channels, gullies, escarpments, iceberg plough marks
Diapirs	Salt bodies, diapirs, mud diapirism
Faulting	Faults
Erosion	Cliff erosion, beach erosion, submarine erosion

Camargo et al. (2019)

Categories of marine geohazards

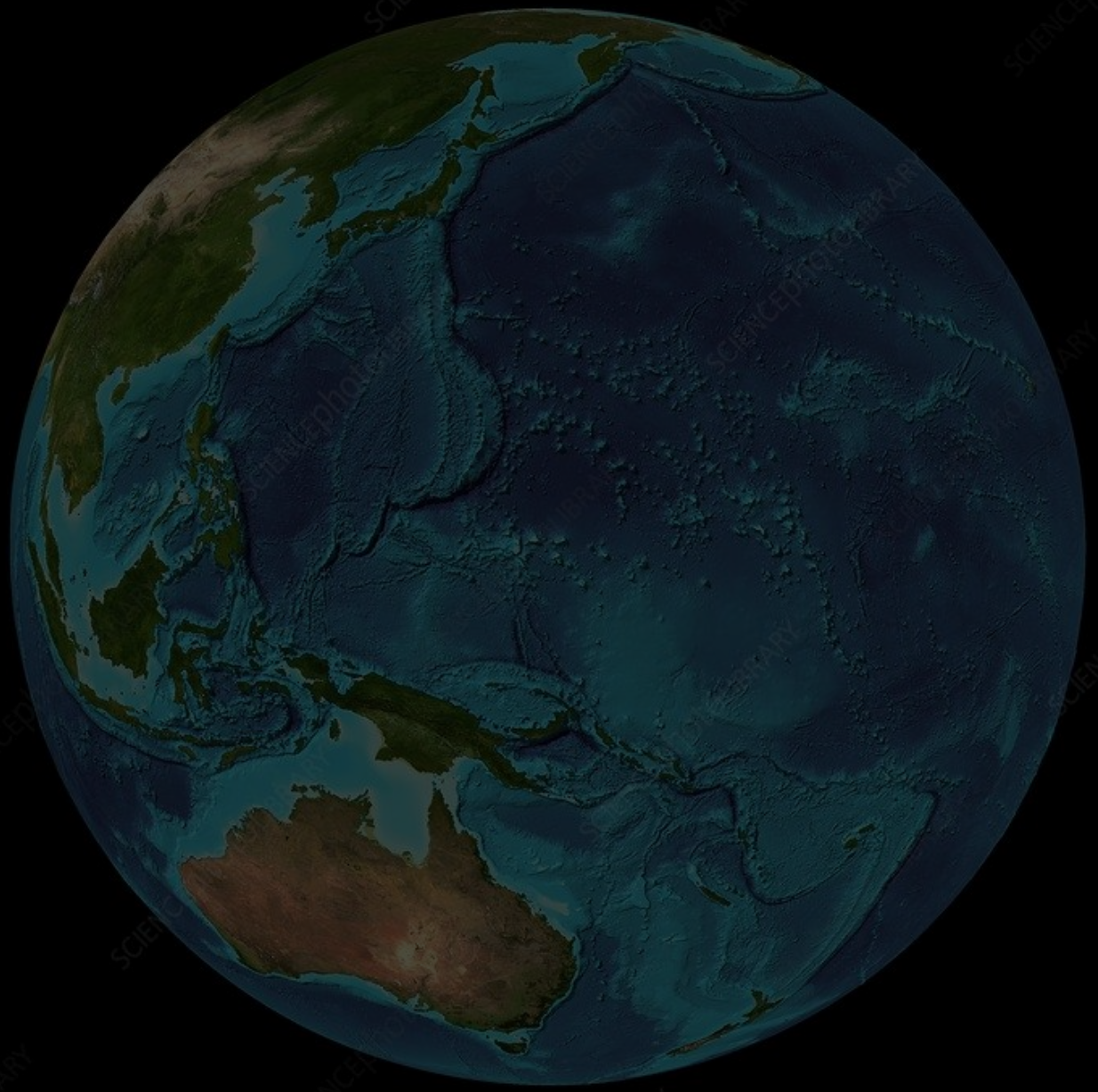


1- Slope failure
2- Fluids seepage
3- Earthquake
4- Tsunami
5- Volcanism
6- Subsidence
7- Bedforms
8- Positive reliefs
9- Negative reliefs
10- Diapirs
11- Faulting
12- Erosion

Camargo et al. (2019)

Fig. 2. Coastal population and altered land cover in coastal zones (after UNEP, 2009).

Jiu et al. (2016)



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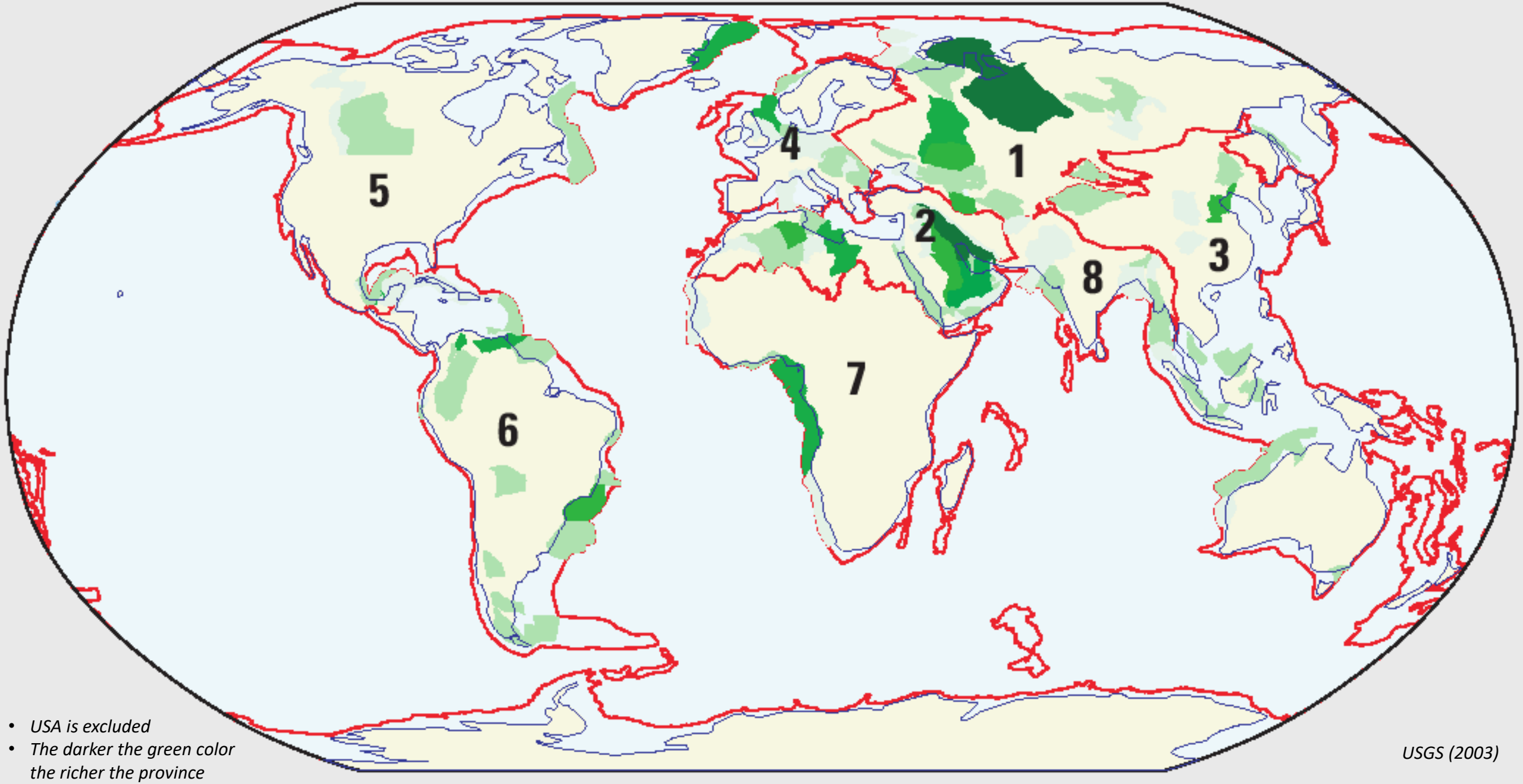
Sumber Daya dari Dasar Laut

- Offshore gas and oil production began more than a century ago. With many shallow water fields already exhausted, these natural resources are now being extracted at ever greater depths. Production rates are higher than ever, while oil pollution is decreasing. *(Tim Schröder - www.maribus.com)*
- Deep-ocean mineral deposits could make a significant contribution to future raw material supply. Growing metal demand and geopolitics are focusing increasing attention on their resource potential and economic importance. However, accurate assessment of the total amounts of metal and its recoverability are very difficult. Exploration for, and potential extraction of, deep-ocean mineral deposits poses many geological, technical, environmental and economic challenges, as well as regulatory and philosophical questions. *(Lusty & Murton, 2018)*

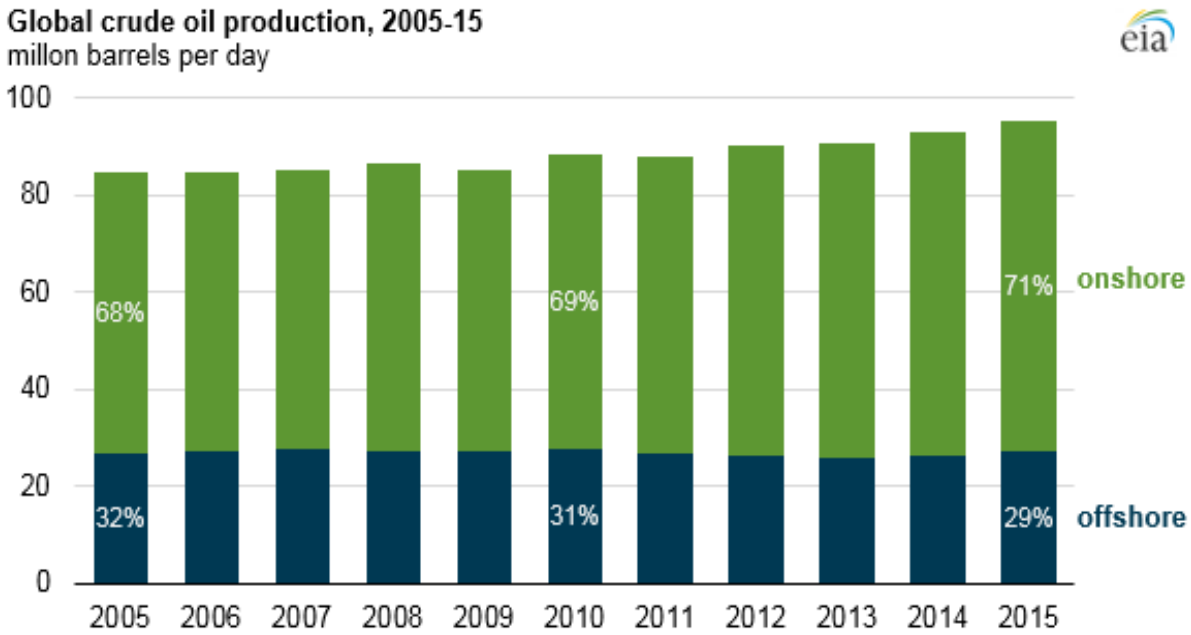
Petroleum Provinces of the World



- *USA is excluded*
- *The darker the green color the richer the province*

USGS (2003)

Produksi minyak dan gas dari laut

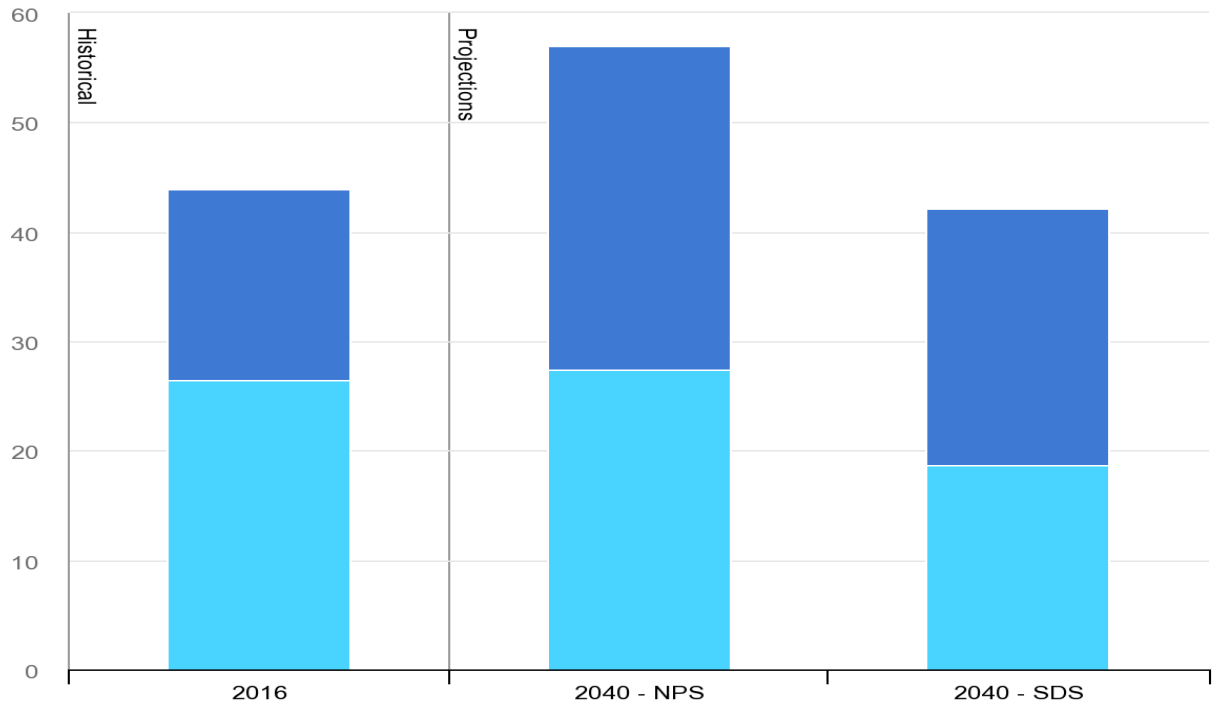


Source: U.S. Energy Information Administration, based on Rystad Energy
Note: Includes lease condensate and hydrocarbon gas liquids.

https://www.eia.gov/todayinenergy/detail.php?id=28492

Offshore oil and gas production has become routine. There are currently around 900 large-scale oil and gas platforms around the world. Over time, engineers have penetrated ever greater depths, for with oil prices rising, deep water oil and gas production, although costly, is now a lucrative business. With drilling and extraction technology also becoming increasingly sophisticated, it is now possible to extract oil and gas at ever greater depths.

Offshore oil and gas production by scenario, 2016-2040



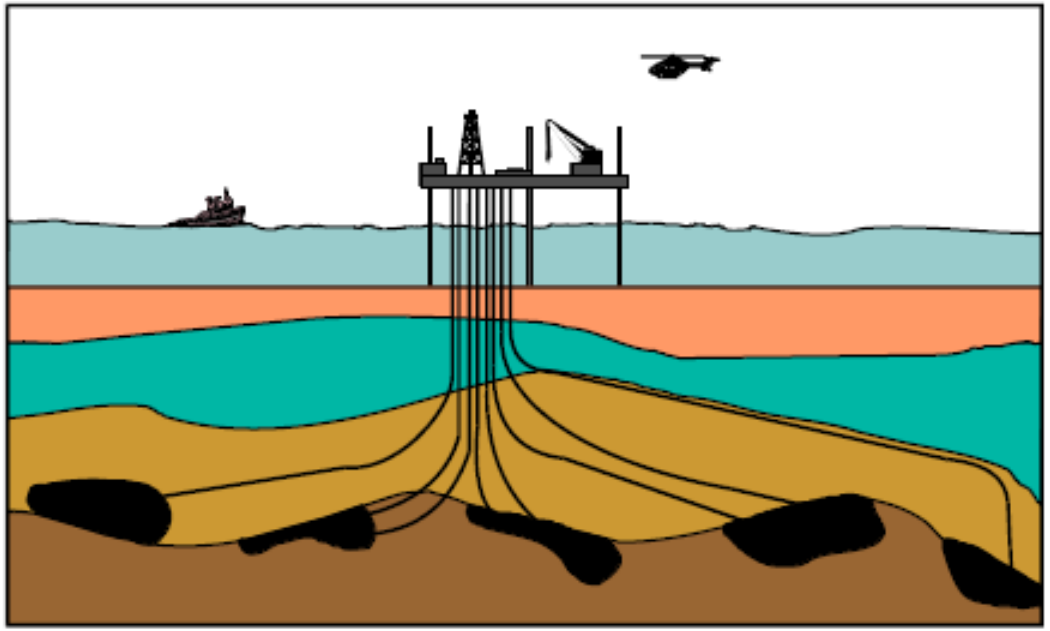
https://www.iea.org/data-and-statistics/charts/offshore-oil-and-gas-production-by-scenario-2016-2040

The water depth record for oil production is currently held by an international oil company which produces oil from a well, located in the Tobago field, 2934 metres below the surface of the Gulf of Mexico. The water depth record for subsea gas production is currently around 2700 m and is held by a platform located in the Cheyenne gas field, also in the Gulf of Mexico.

Produksi minyak dan gas dari laut

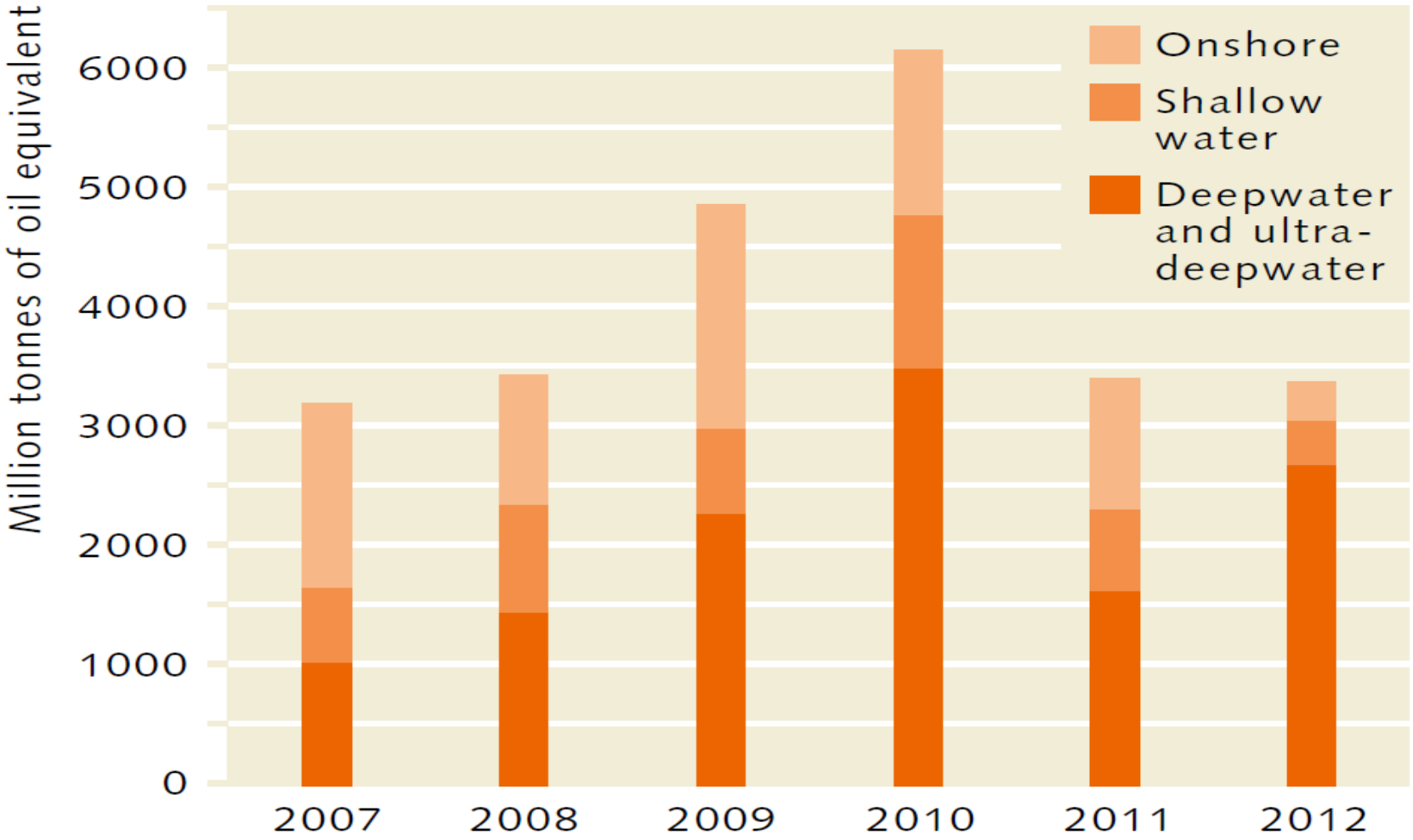
Henry L. Williams, who began extracting oil from the Summerland field off the Californian coast near Santa Barbara in the 1890s.

www.maribus.com



TNeutron

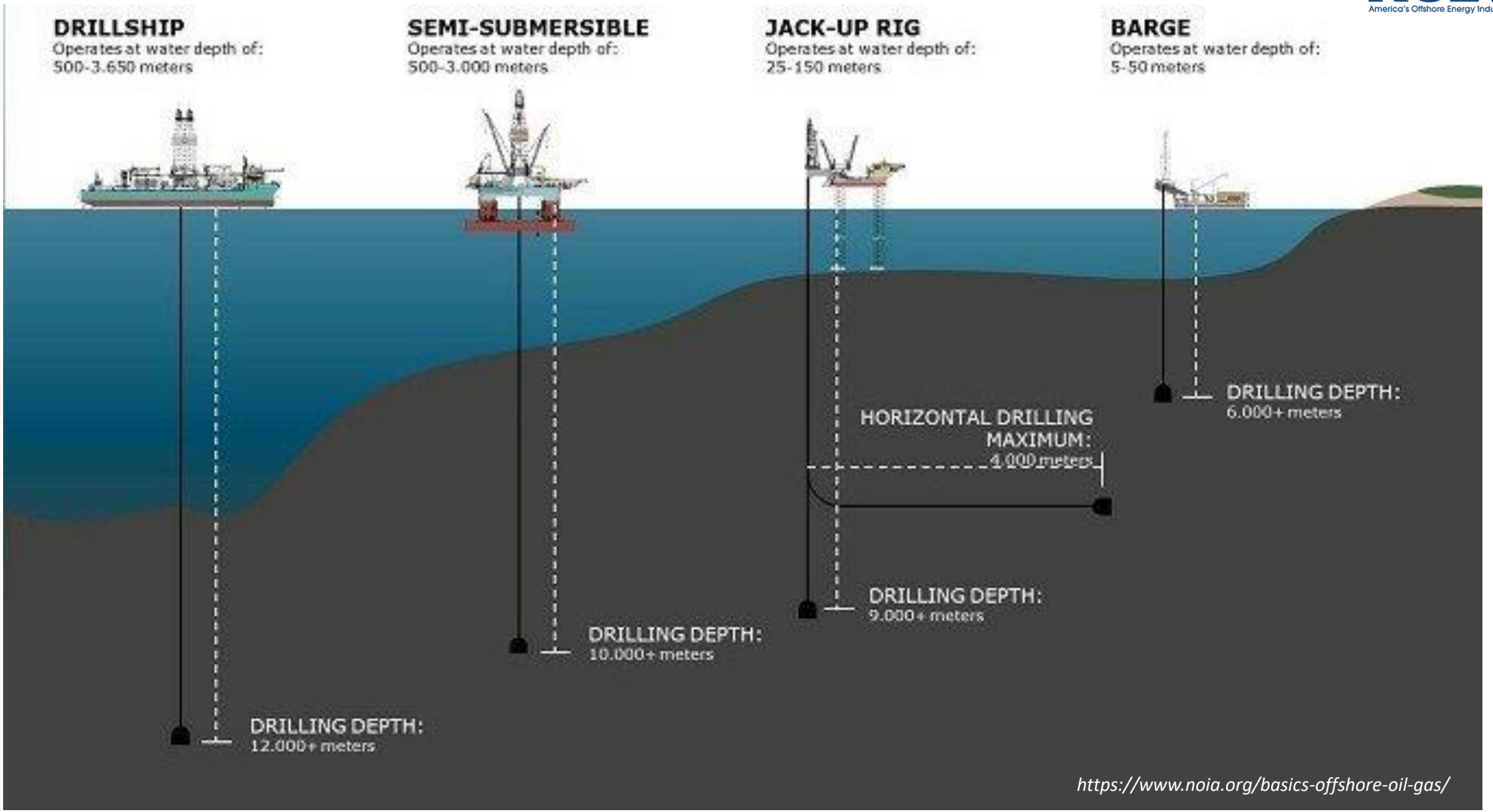
www.maribus.com



1.12 > A glance at the volumes of offshore oil and gas fields newly discovered between 2007 and 2012 clearly shows that the bulk of the resource is located at depths of more than 400 metres.

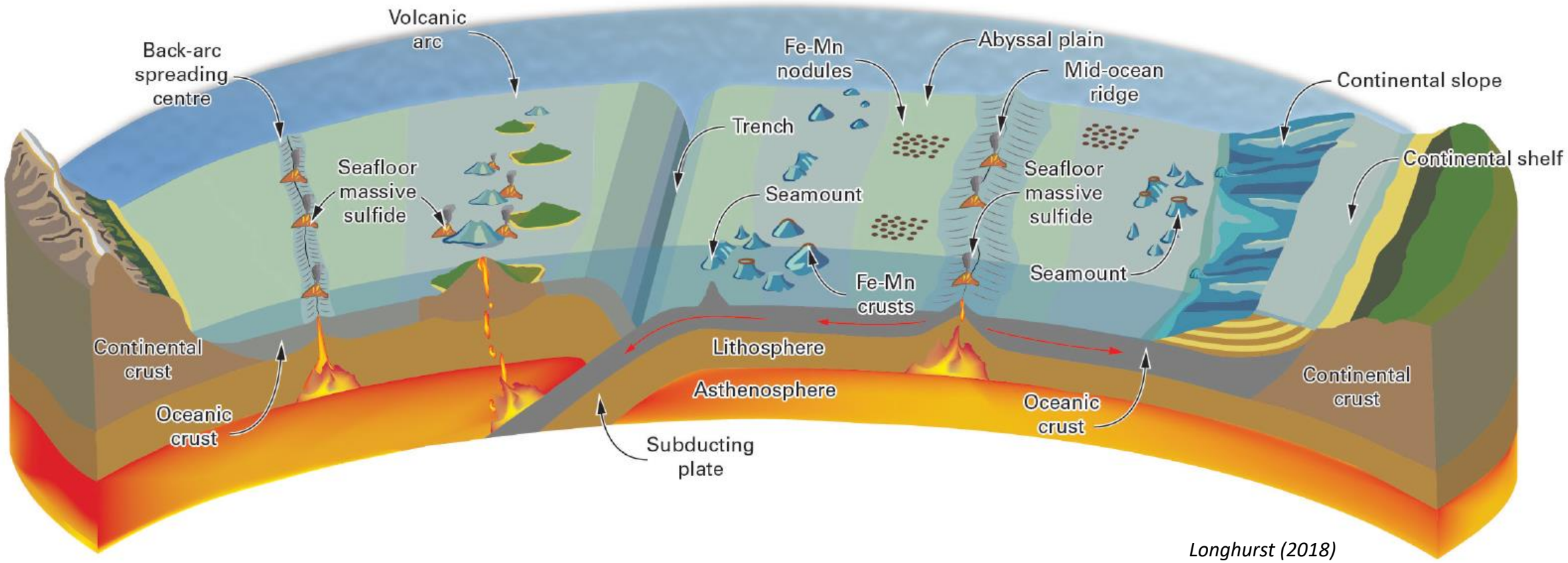
www.maribus.com

Teknologi Pengeboran Laut – Laut Dalam



https://www.noia.org/basics-offshore-oil-gas/

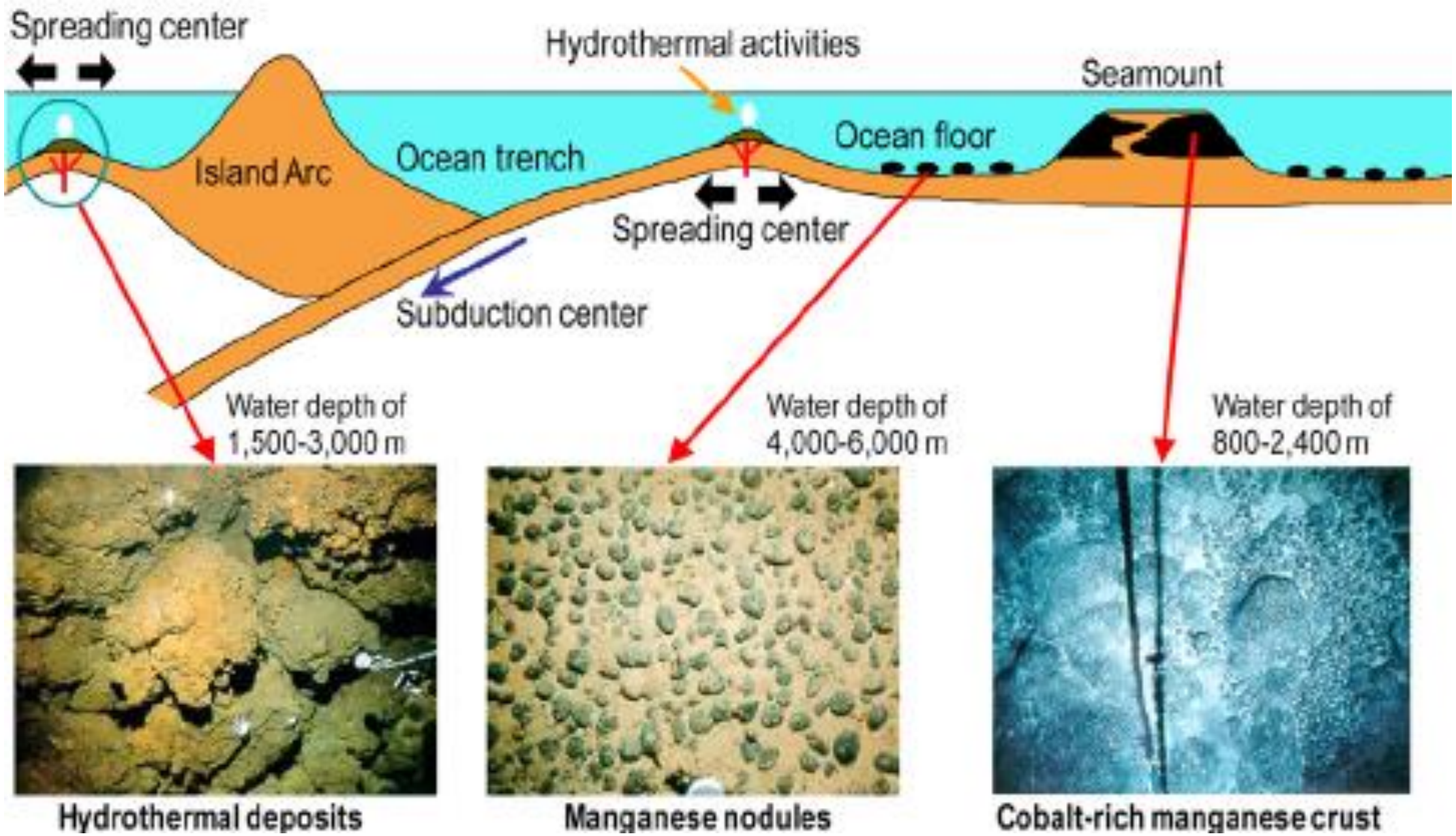
Mineralisasi Dasar Laut



Longhurst (2018)

Cross-section through the Earth's crust showing the different types of plate boundary, the topography of the ocean floor and the distribution of the major metal-rich deep ocean mineral deposits.

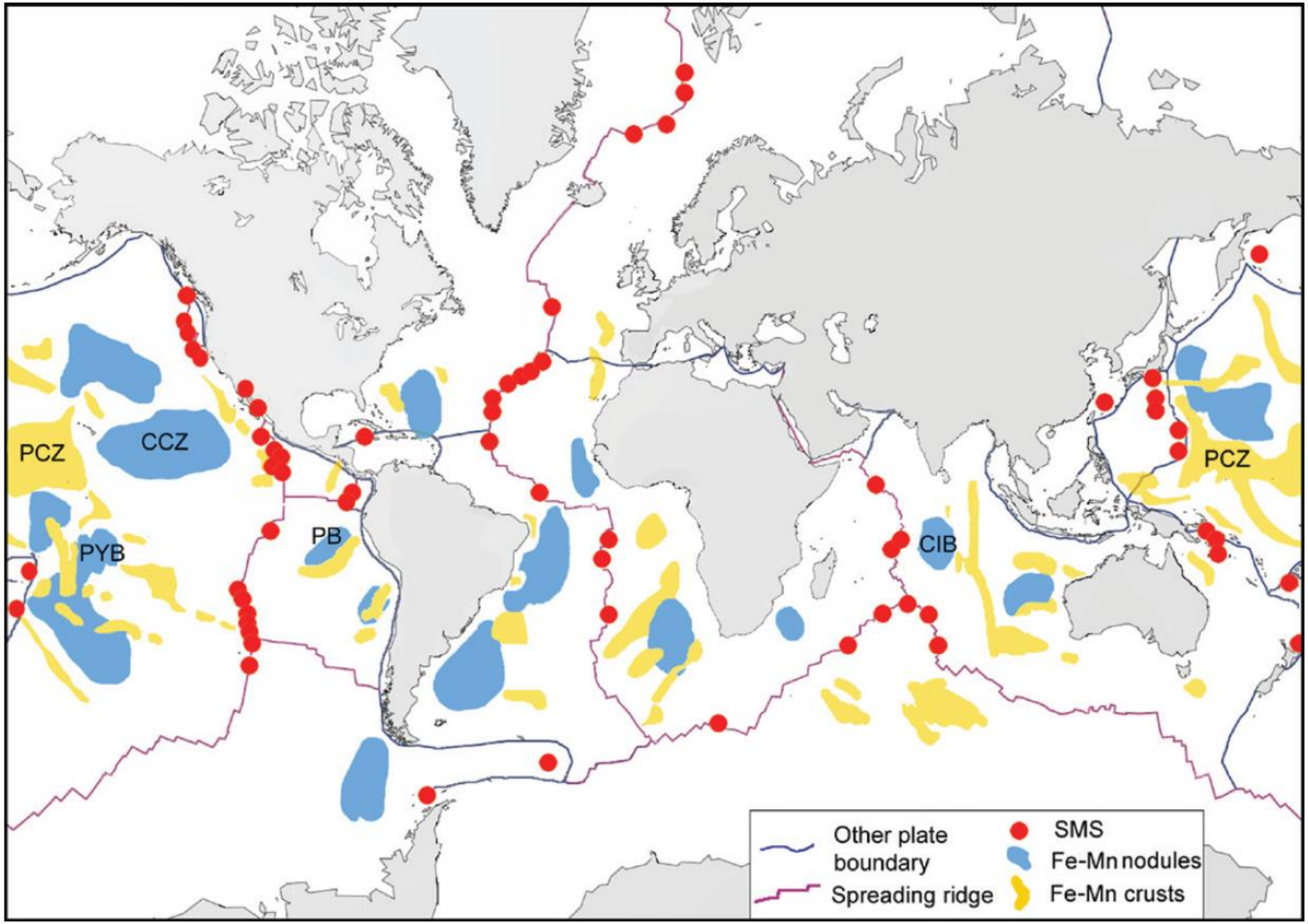
The traditional interests have been in Ni–Cu–Mn for nodules, Co–Ni–Mn for crusts, and Cu–Zn–Au–Ag for seafloor massive sulfides (SMS)



Lee et al (2013)

https://www.researchgate.net/figure/Hydrothermal-deposits-Manganese-nodules-and-Cobalt-rich-manganese-crust_fig1_263636893

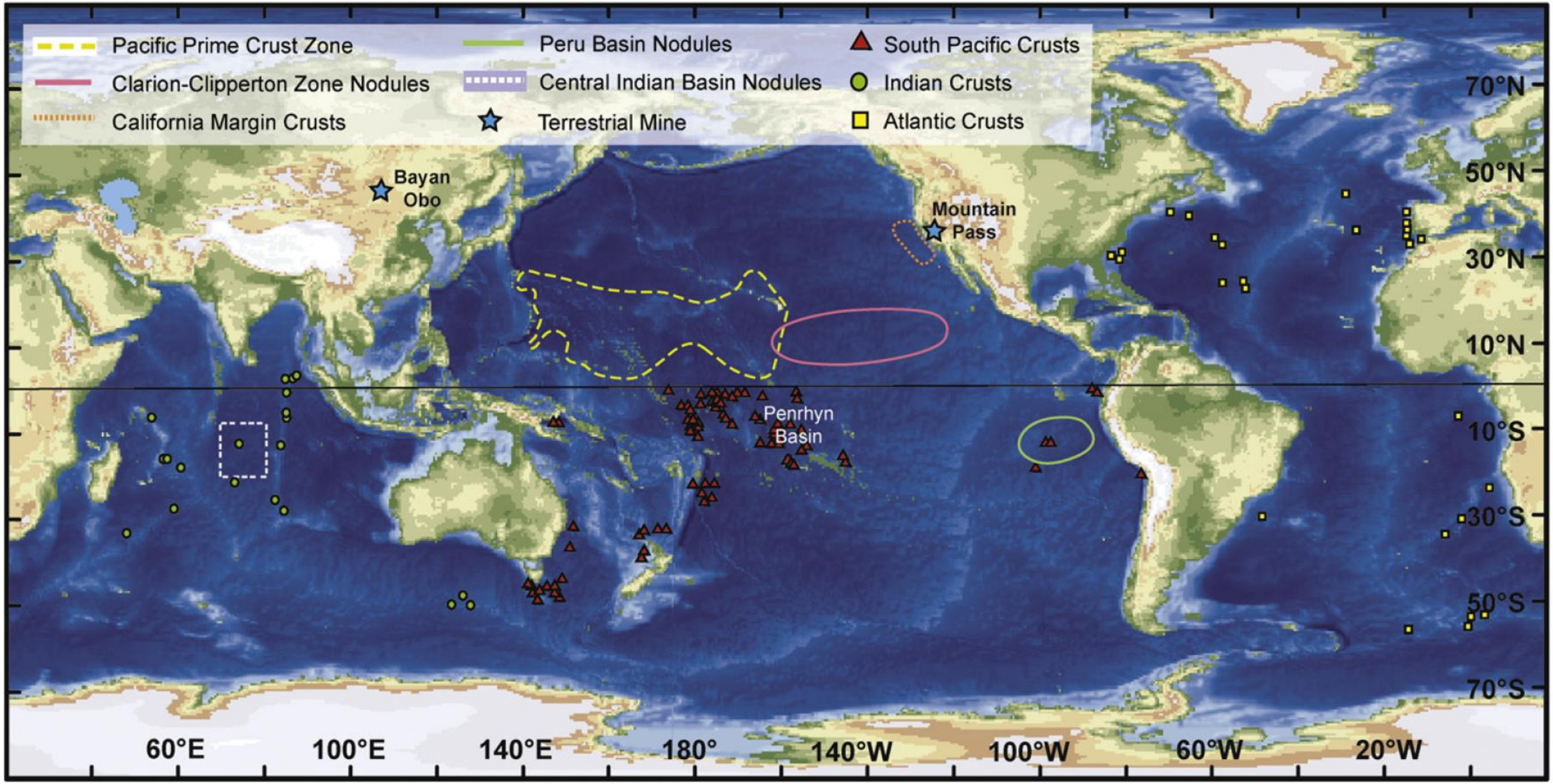
Potensi Mineralisasi Dasar Laut



Global distribution of the three primary classes of metal-rich deep-ocean mineral deposits: seafloor massive sulfides (SMS); ferromanganese (Fe–Mn) nodules; and ferromanganese (Fe–Mn) crusts. Spreading ridges and other plate boundaries are shown.

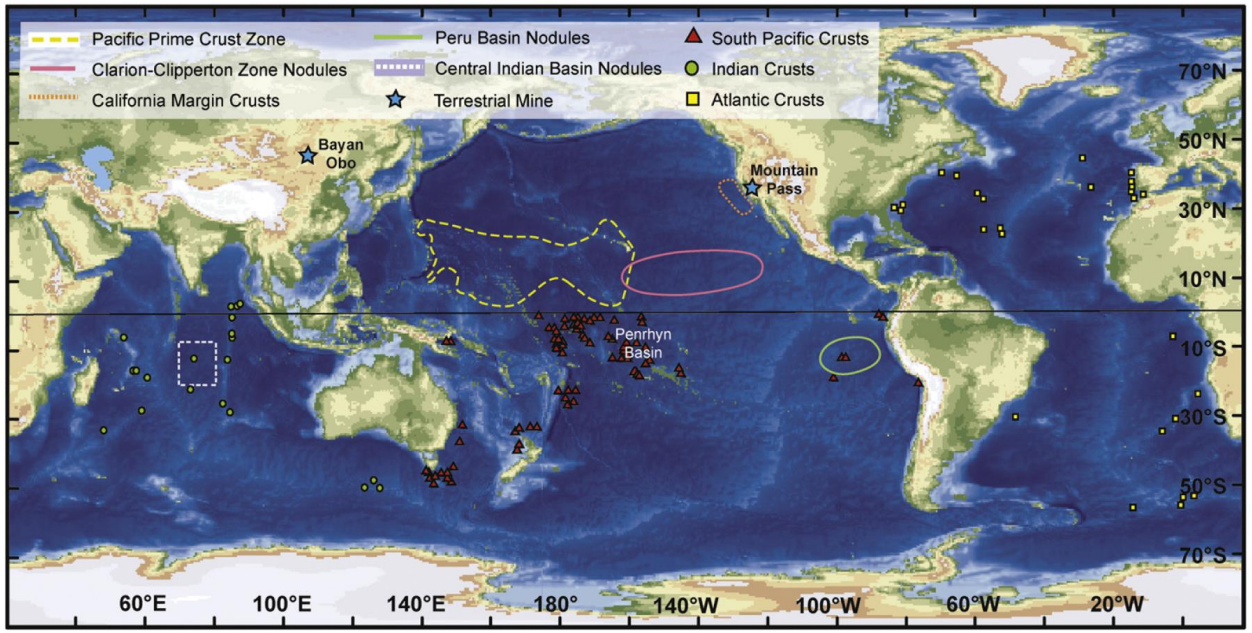
Abbreviations: CCZ = Clarion−Clipperton Zone; CIB = Central Indian Ocean Basin; PB = Peru Basin; PCZ = Prime Crust Zone; PYB = Penrhyn Basin.

Lusty & Murton (2018)



Map of all well-studied areas for marine mineral deposits

Potensi Mineral Dasar Laut Dalam



Map of all well-studied areas for marine mineral deposits

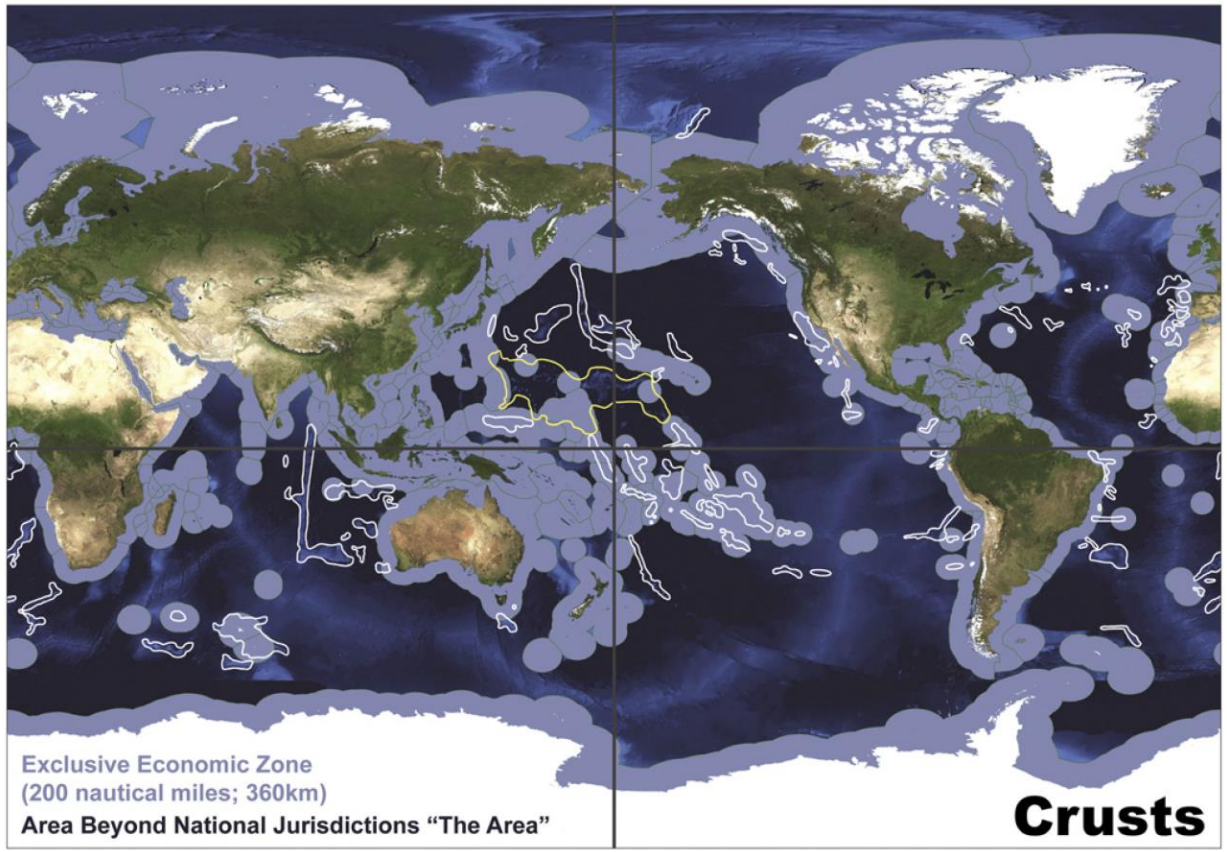
Ferromanganese (Fe–Mn) crusts are strongly enriched relative to the Earth's lithosphere in many rare and critical metals, including Co, Te, Mo, Bi, Pt, W, Zr, Nb, Y, and rare-earth elements (REEs). Fe–Mn nodules are strongly enriched in Ni, Cu, Co, Mo, Zr, Li, Y, and REEs. Compared to Fe–Mn crusts, nodules are more enriched in Ni, Cu, and Li, with subequal amounts of Mo and crusts are more enriched in the other metals. Seafloor massive sulfides (SMS), especially those in arc and back-arc settings, can also be enriched in rare metals and metalloids, such as Cd, Ga, Ge, In, As, Sb, and Se. Metal grades for the elements of economic interest in SMS (Cu, Zn, Au, Ag) are much greater than those in land-based volcanogenic massive sulfides. The Clarion–Clipperton Fe–Mn Nodule Zone (CCZ) in the NE Pacific and the prime Fe–Mn crust zone (PCZ) in the central Pacific are the areas of greatest economic interest for nodules and crusts and grades and tonnages for those areas are moderately well known.

Contained metal tonnages ($\times 10^6$ tonnes).[a]

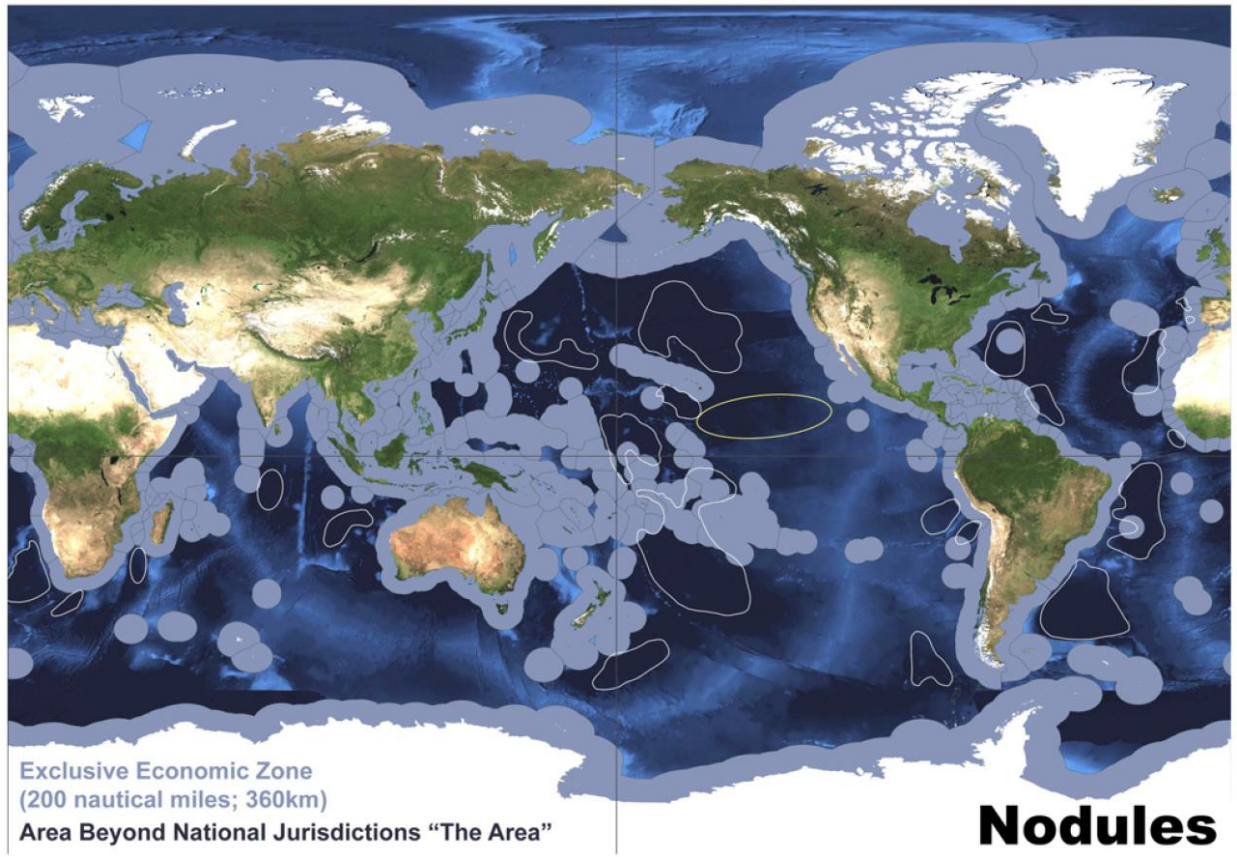
	Clarion-Clipperton Zone Nodules [b]	Global Terrestrial Reserve Base [c]	Global Terrestrial Reserves [c]	Prime Crust Zone [b]
Manganese	5,992	5,200	630	1714
Copper	226	1,000+	690	7.4
Titanium	67	899	414	88
TREO [d]	15	150	110	16
Nickel	274	150	80	32
Vanadium	9.4	38	14	4.8
Molybdenum	12	19	10	3.5
Lithium	2.8	14	13	0.02
Cobalt	44	13	7.5	50
Tungsten	1.3	6.3	3.1	0.67
Niobium	0.46	3.0	3.0	0.40
Arsenic	1.4	1.6	1.0	2.9
Thorium	0.32	1.2	1.2	0.09
Bismuth	0.18	0.7	0.3	0.32
Yttrium	2.0	0.5	0.5	1.7
PGM [e]	0.003	0.08	0.07	0.004
Tellurium	0.08	0.05	0.02	0.45
Thallium	4.2	0.0007	0.0004	1.2

[a] Metals highlighted in red are those with greater tonnages than terrestrial reserves or terrestrial reserve bases.
[b] Nodule tonnage used is 21,100 million dry tonnes and crust tonnage used is 7533 million dry tonnes (from Hein and Koschinsky, 2013).
[c] USGS 2009 reserve base & 2012 reserves (reserve base includes those resources that are currently economic (reserves), marginally economic, and subeconomic).
[d] Total Rare Earth Elements as Oxides.
[e] Total Platinum Group Metals.

Potensi mineral di dasar laut dalam terutama di wilayah *ISA (International Seabed Authority)*

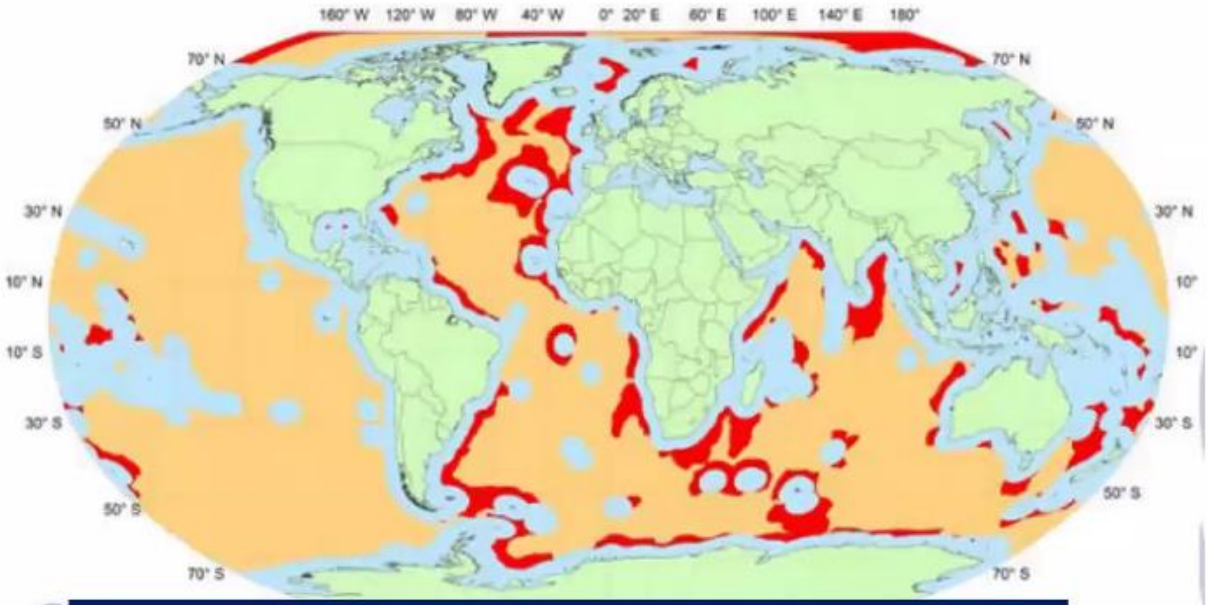


Map of global distribution of Exclusive Economic Zones (gray shading), areas beyond national jurisdictions (dark black-blue to pale gray-blue), and global permissive areas for cobalt-rich crust development; the central Pacific prime crust zone (PCZ) is the zone of greatest economic interest and is marked by a yellow line; all other areas are marked with a white line; a permissive area does not mean that economic crust deposits will be found in that area. The equator and 180th parallel are marked by gray lines.



Map of global distribution of Exclusive Economic Zones (gray shading), areas beyond national jurisdictions (dark black-blue to pale gray-blue), and global permissive areas for development of abyssal plain manganese nodules; the Clarion–Clipperton Zone (CCZ) is the zone of greatest economic interest and is marked by a yellow line; all other areas are marked with a white line; a permissive area does not mean that economic nodule deposits will be found in that area. Small patches of scattered nodules will occur in other areas.

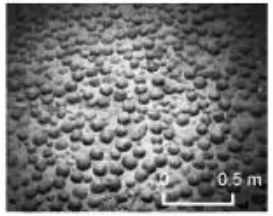
CADANGAN MASA DEPAN BANGSA (WARISAN)



KAWASAN DASAR LAUT INTERNASIONAL [KDLI]

1. 54 % dasar laut dunia;
2. Kaya Sumber Daya Mineral;
3. Warisan Bersama Umat Manusia, mandat pengelolaan pada Otoritas Dasar Laut Internasional
4. **Pengelolaan terkait dengan persaingan sumber daya global**
5. **Penguasaan dan Pengelolaan KDLI terkait dengan aspek Kedaulatan**

POLYMETALIC NODULLES

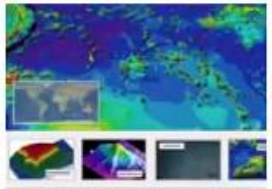


- Mengandung Copper, cobalt, nickel,besi, manganese
- Terdapat di mayoritas dasar laut dengan kedalaman > 4,000m
- Area deposit terbesar di Clarion-Clipperton Zone in Samudera Pasifik

POLYMETALIC SULPPHIDES

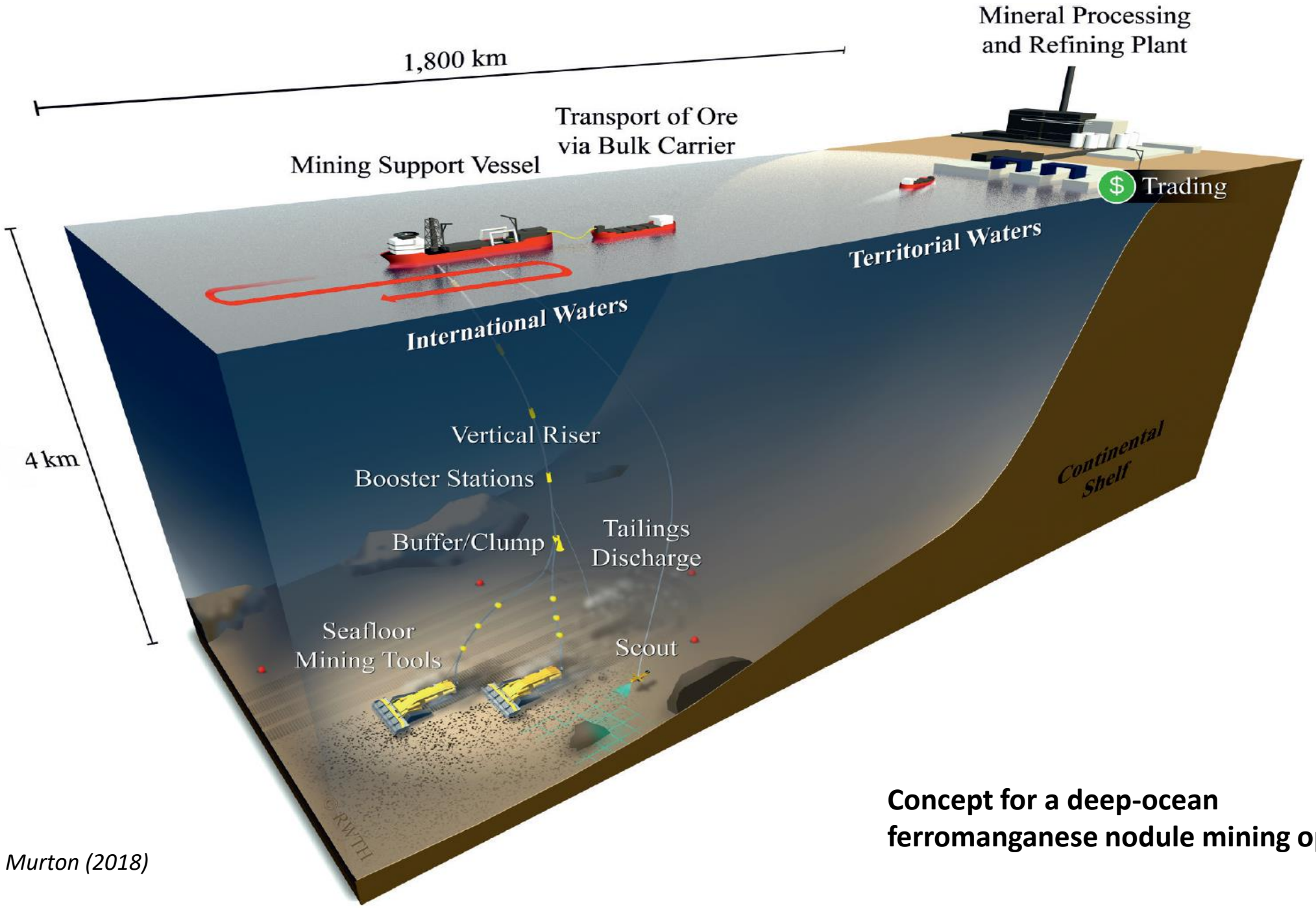
- terkait hydrot
- Mengandung , copper, cobalt, gold, silver, rare earth elements (e.g. tellurium)

FEROMANGANESE-CRUST/COBALT CRUST



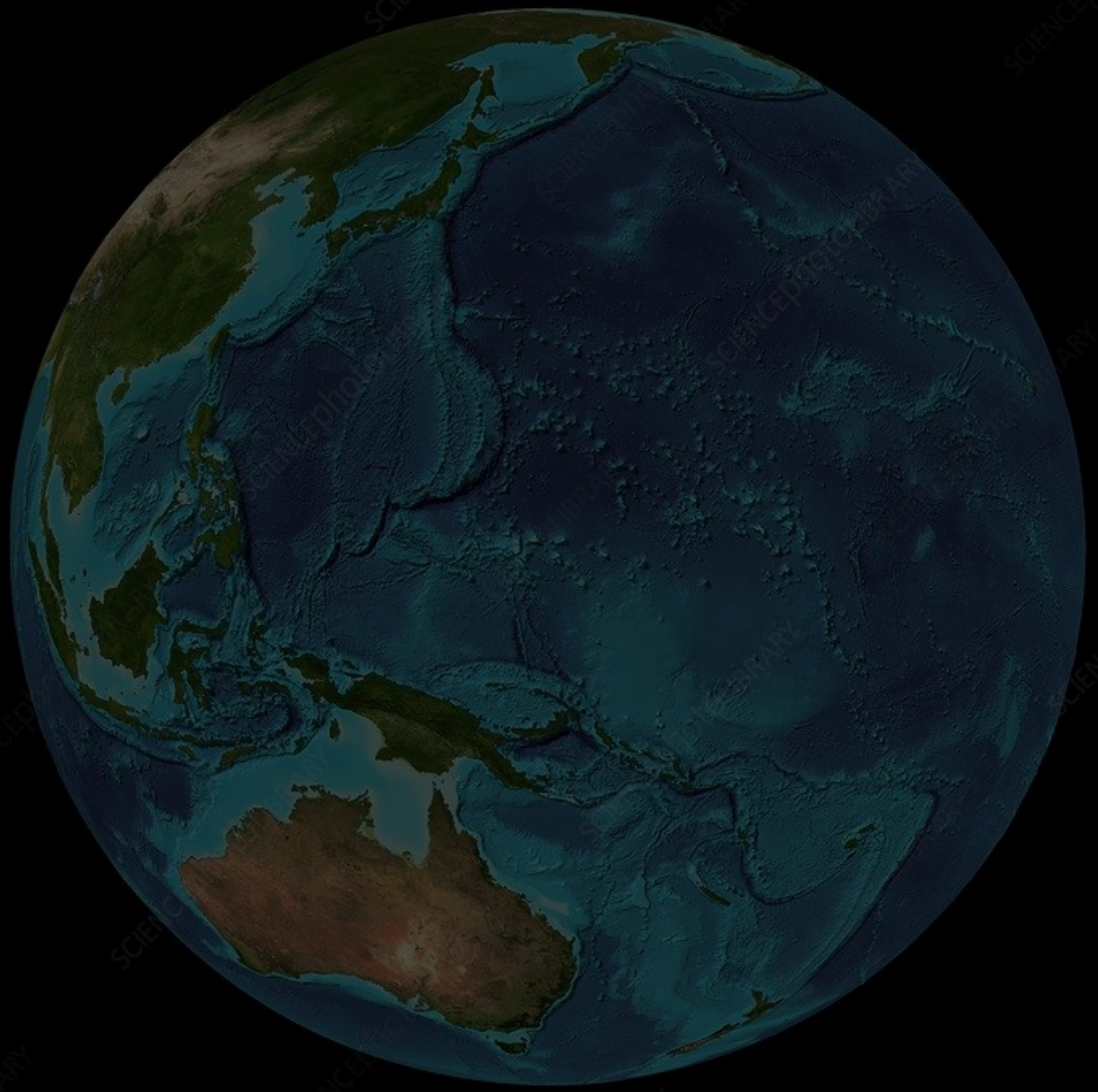
- Konstentrasi tinggi Cobalt dan rare ellements untuk aplikasi high-tech.
- Terdapat di kedalaman < 4,00 m s.d 5000 m di Kawasan dasar laut dengan aktivitas vulkanik yang tinggi.

Sora Lokita (webinar BPPT, 22 Juli 2021)



Concept for a deep-ocean ferromanganese nodule mining operation.

Lusty & Murton (2018)



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8. Sumber Daya dari Dasar Laut
9. **Teknik Penelitian Geologi Kelautan**

Methodology

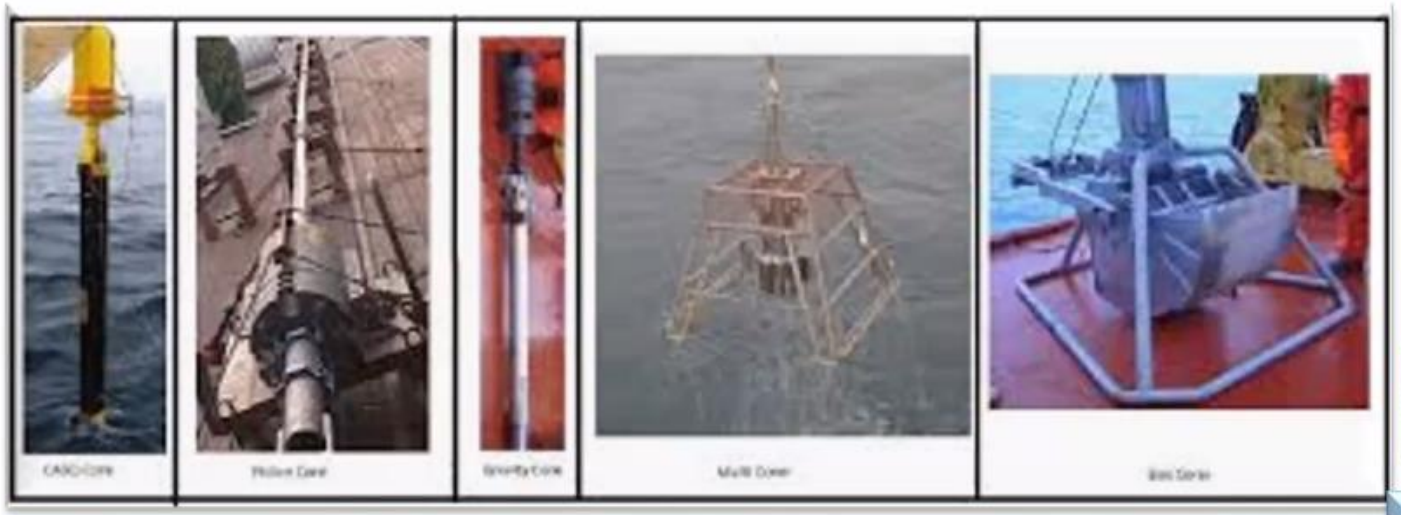
A. Geo Acoustics
- Single Beam & Multibeam Echosounder
- SideScan Sonar
- Sub bottom
- Multichannel Seismik 2D&3D
- Marine Gravity
- Marine Magnetics
- Marine Geotechnics
- Marine Electromagnetics
- Marine Resistivity
- Heat Flow

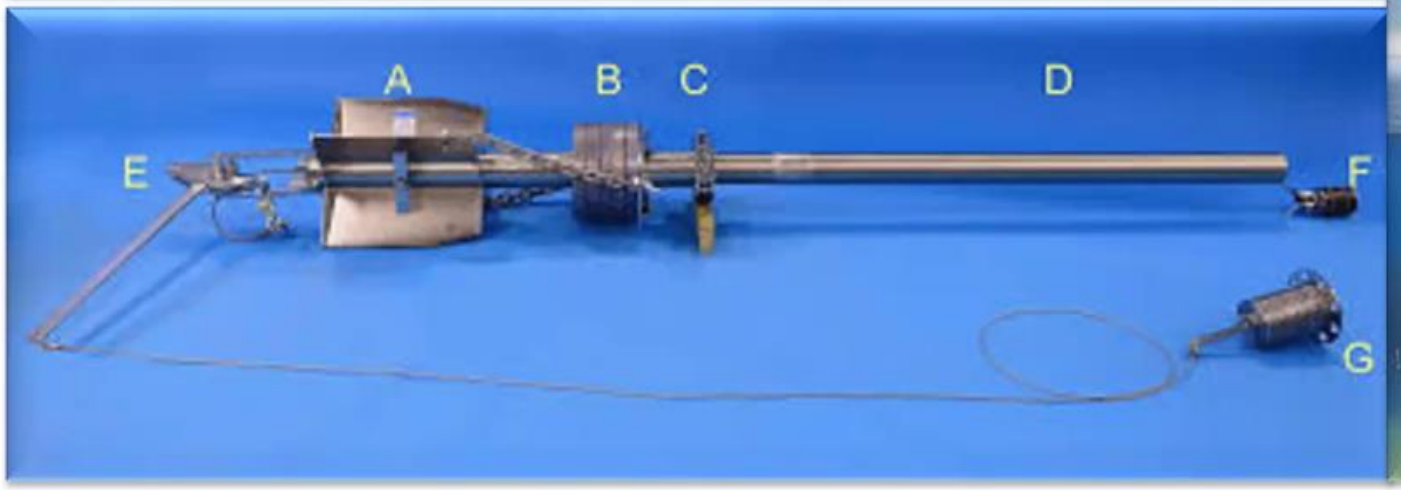
B. Sediment sampling.
- Grab sampler
- Box corer
- Gravity corer
- Piston corer
- Ocean Drilling Program
- Underwater Camera

C. Robotic.
- Remotely Operated Vehicle (ROV)
- Autonomous underwater vehicles (AUV)

Adam Nugroho (Webinar Geotrek Indonesia, 27 Juni 2020)

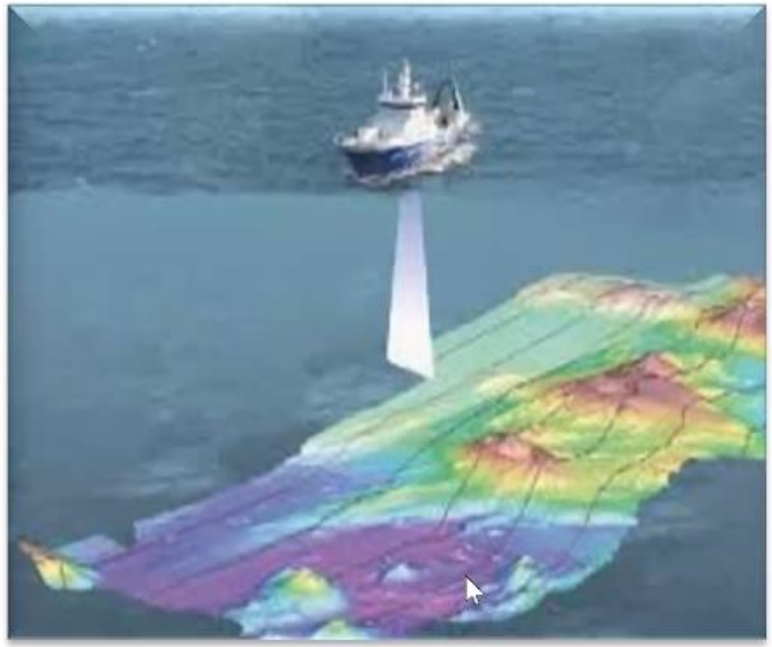
METODE GEOLOGI KELAUTAN

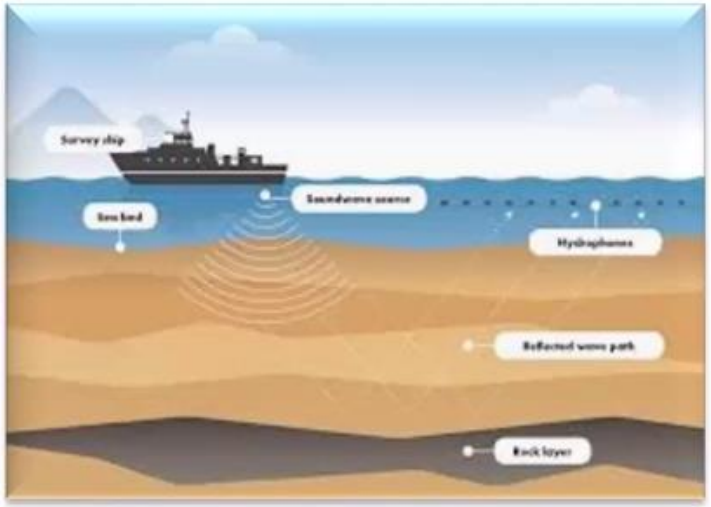


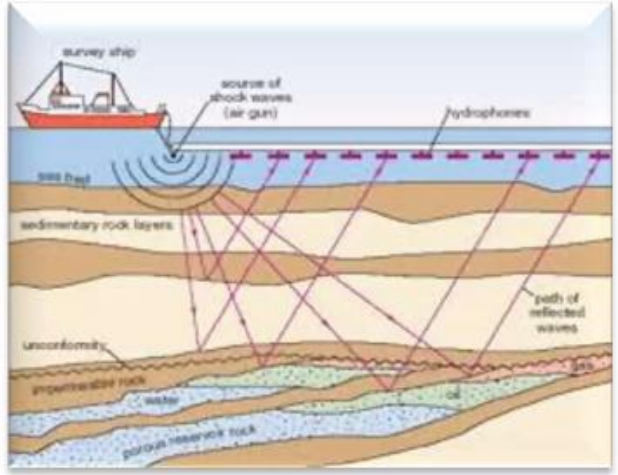


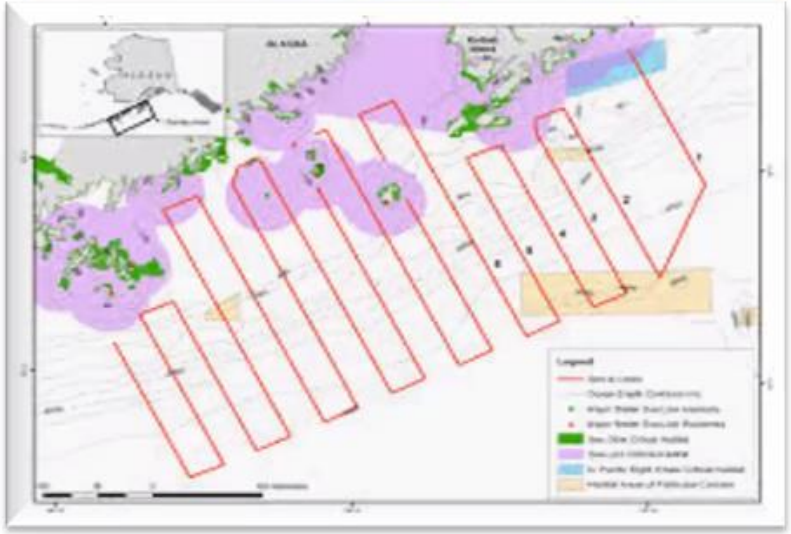
Hananto Kurnio (webinar BPPT, 22 Juli 2021)

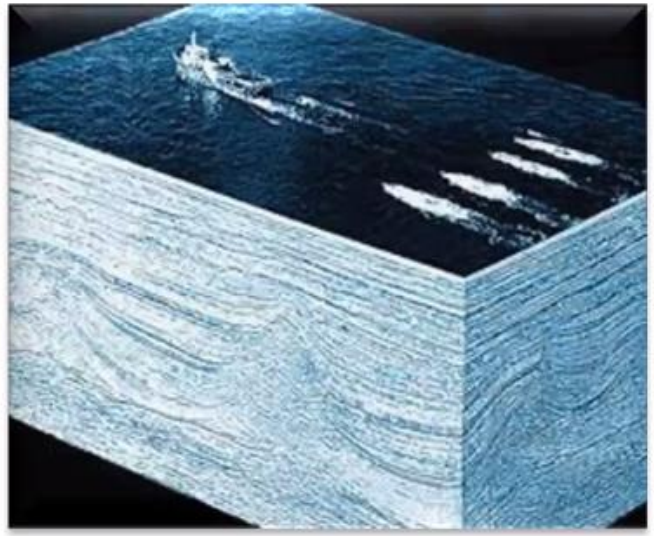
METODE GEOFISIKA KELAUTAN







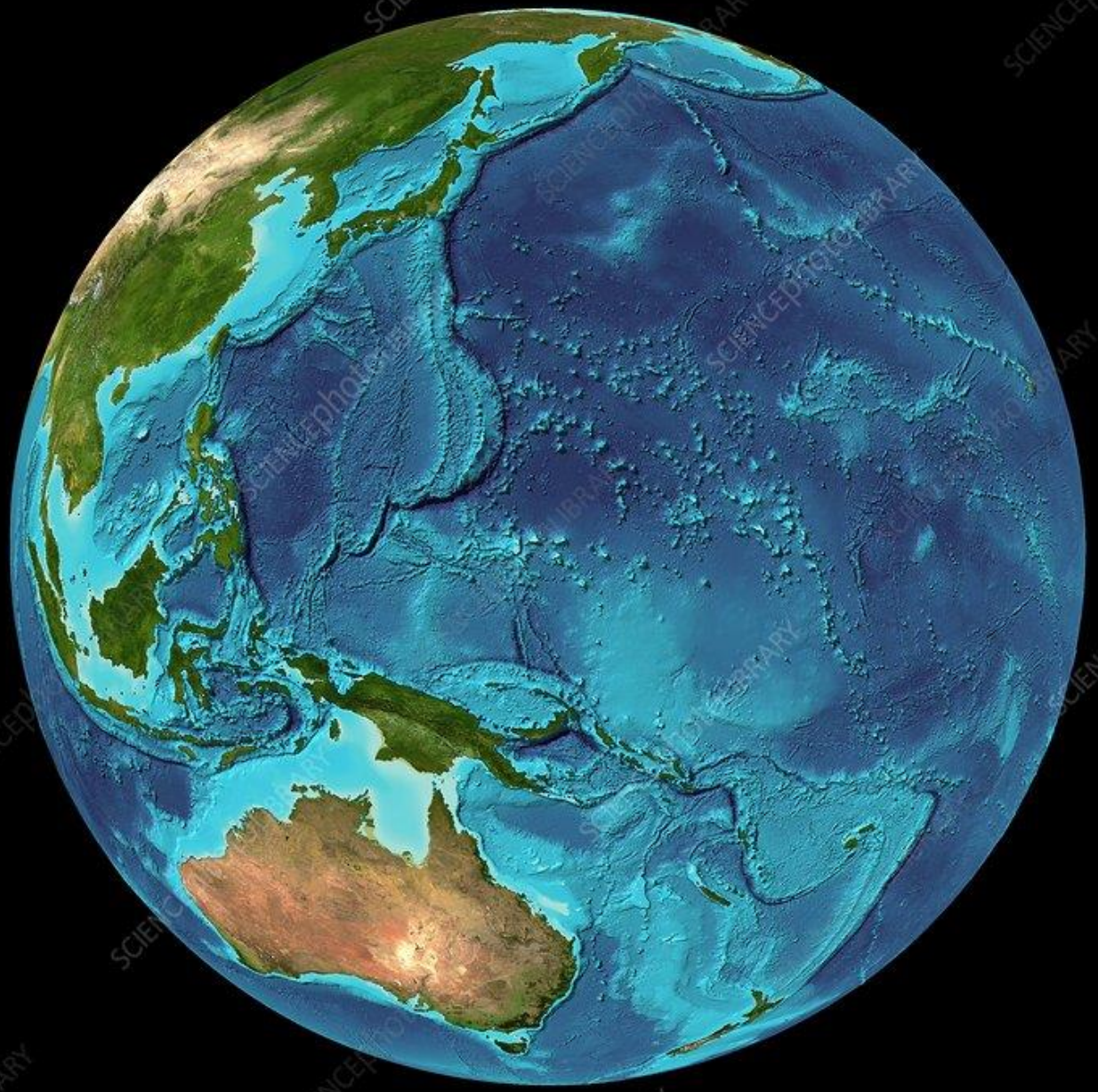




Hananto Kurnio (webinar BPPT, 22 Juli 2021)

Diskusi

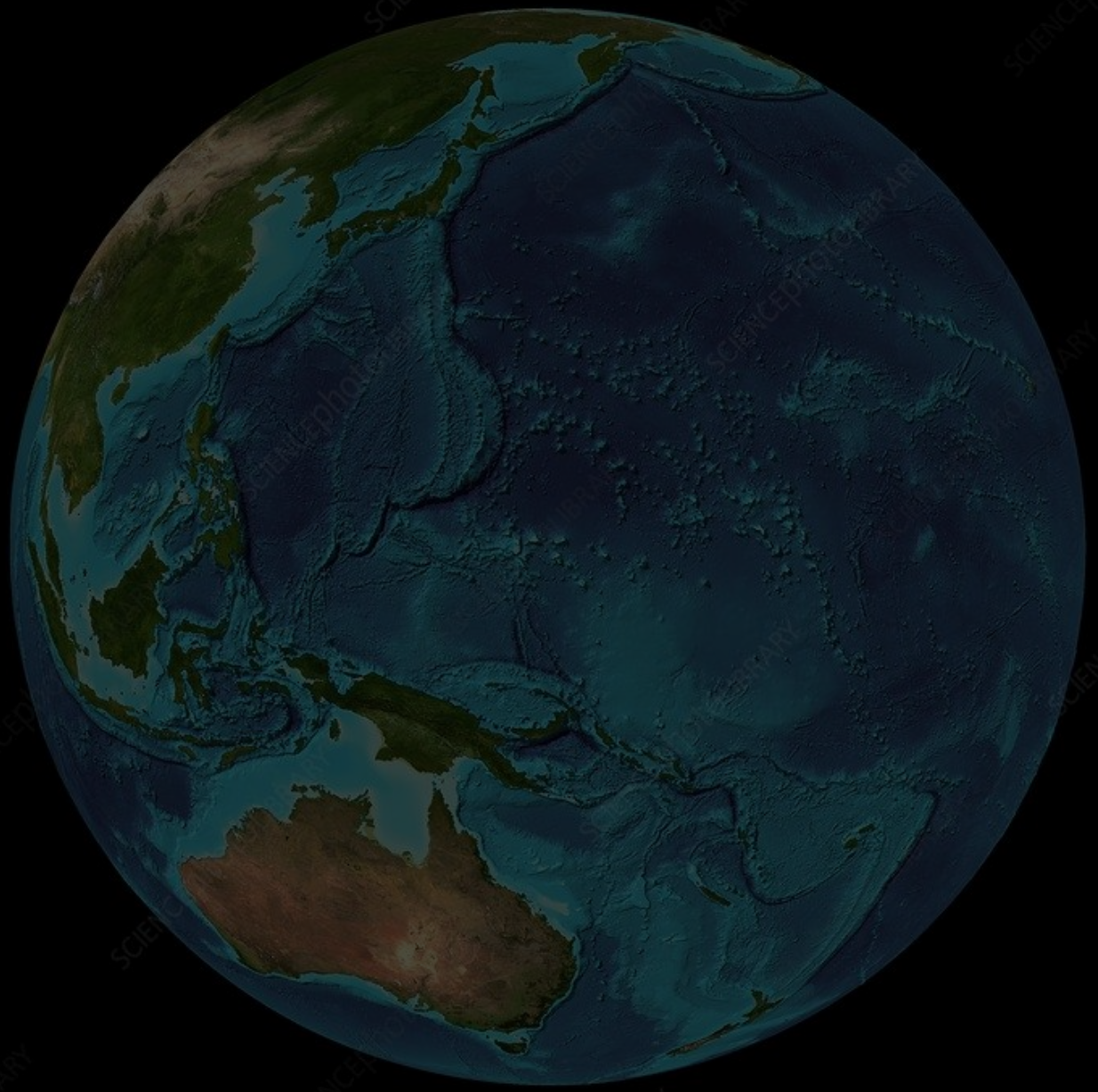
1. Dimensi Air di Bumi
2. Ilmu-Ilmu Kelautan
3. Geologi Kelautan
4. **Geologi Kelautan Indonesia**



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan Indonesia

1. Wilayah Kelautan Indonesia
2. Sejarah Penyelidikan Kelautan Indonesia
3. Tektonik dan Evolusi Cekungan Kelautan Indonesia
4. Topografi Dasar Kelautan Indonesia
5. Sedimentasi Kelautan Indonesia
6. Status Masa Kini Penelitian Kelautan Indonesia
7. Pengelolaan Kelautan Indonesia
8. Bencana Geologis Kelautan Indonesia
9. Sumber Daya Geologis Kelautan Indonesia
10. Konservasi Laut Indonesia



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan Indonesia

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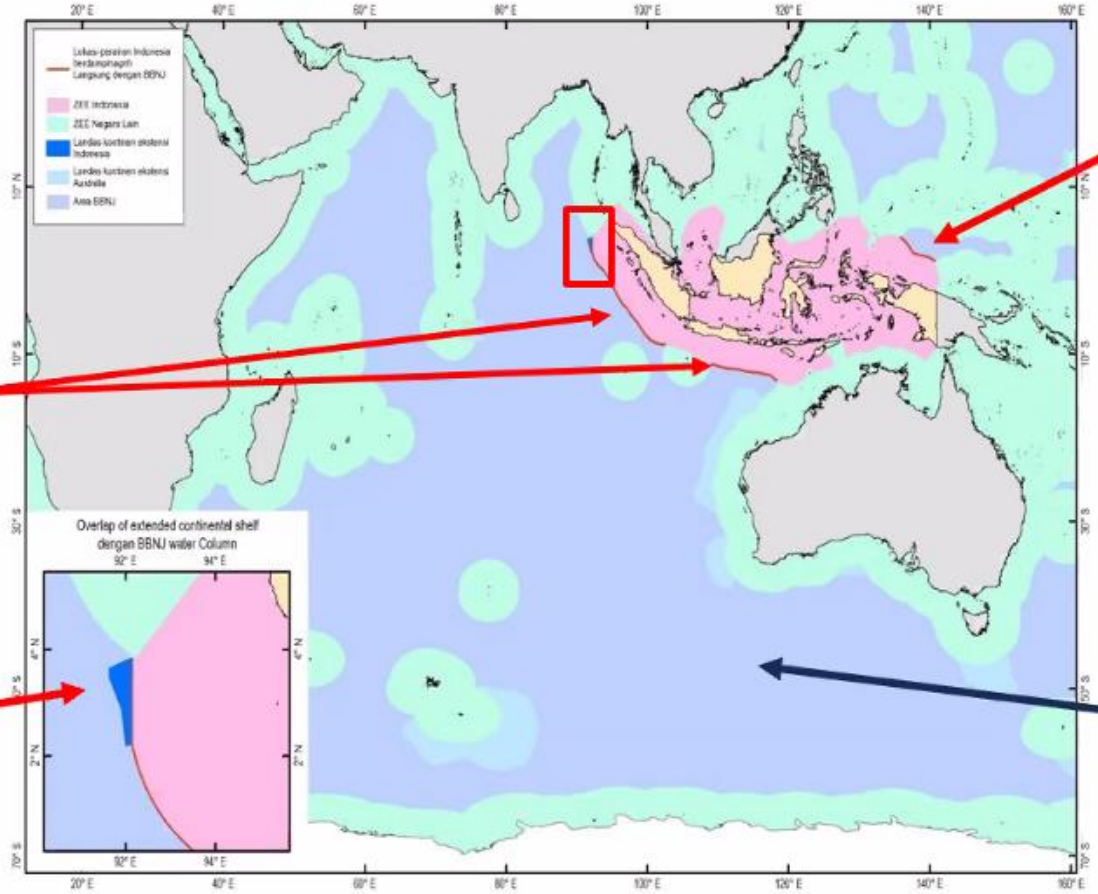
KEMENTERIAN KOORDINATOR
BIDANG KEMARITIMAN DAN INVESTASI
REPUBLIK INDONESIA

LOKASI GEOGRAFIS

UNCLOS 1982

Samudera Hindia

Landas Kontinen di luar 200 mil laut
Dasar lautnya dibawah kewenangan Indonesia, namun kolom airnya milik masyarakat internasional



Samudera Pasifik

Warna biru adalah kawasan dasar laut internasional dan laut bebas

Sora Lokita (webinar BPPT, 22 Juli 2021)

RUJUKAN LUAS WILAYAH NKRI

BRSDM Kelautan dan Perikanan

BERITA ACARA RUJUKAN NASIONAL DATA KEWILAYAHAN REPUBLIK INDONESIA

Pada hari Jum'at tanggal 10 Agustus 2018 telah diluncurkan Rujukan Nasional Data Kewilayahan Republik Indonesia yaitu;

1. Luas perairan pedalaman dan perairan kepulauan Indonesia adalah 3.110.000 km²;
2. Luas laut teritorial Indonesia adalah 290.000 km²;
3. Luas zona tambahan Indonesia adalah 270.000 km²;
4. Luas zona ekonomi eksklusif Indonesia adalah 3.000.000 km²;
5. Luas landas kontinen Indonesia adalah 2.800.000 km²;
6. Luas total perairan Indonesia adalah 6.400.000 km²;
7. Luas NKRI (darat + perairan) adalah 8.300.000 km²;
8. Panjang garis pantai Indonesia adalah 108.000 km;
9. Jumlah pulau di Indonesia kurang lebih 17.504, dan yang sudah dibakukan dan disubmisi ke PBB adalah sejumlah 16.056 pulau;

Ditandatangani Oleh:

KEPALA
BADAN INFORMASI GEOSPASIAL

KEPALA
PUSAT HIDROGRAFI DAN OSEANOGR
TNI ANGKATAN LAUT

Disaksikan Oleh:

MENTERI KOORDINATOR
BIDANG KEMARITIMAN

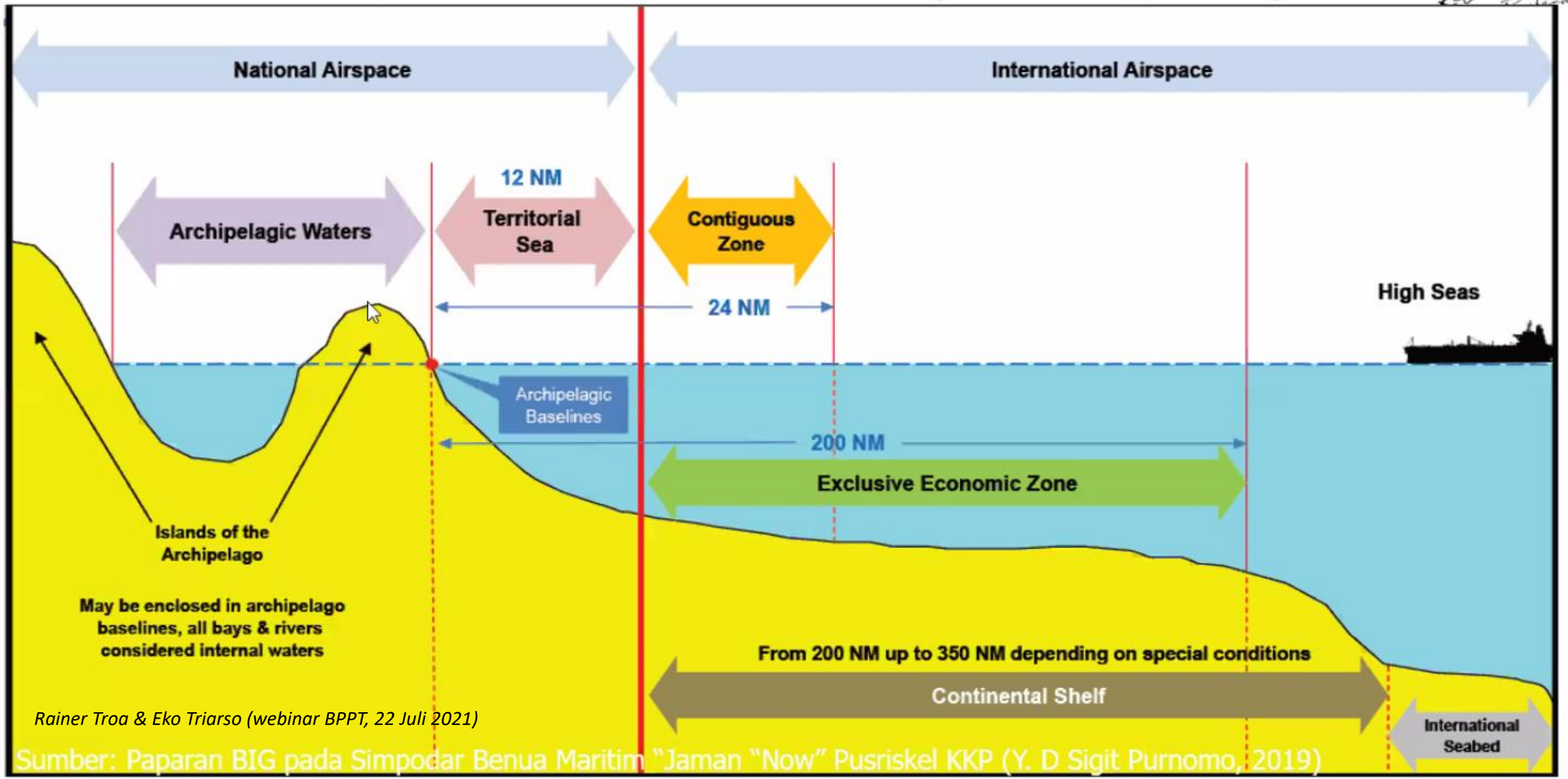
Komponen	Luas
Luas Daratan (menggunakan data KSP)	1.900.000 Km²
Luas Wilayah Kedaulatan:	
• Perairan Pedalaman dan Perairan Kepulauan	3.110.000 Km²
• Laut Teritorial	290.000 Km²
Luas Wilayah Berdaulat:	
• Zona Tambahan	270.000 Km²
• Zona Ekonomi Eksklusif	3.000.000 Km²
• Landas Kontinen	2.800.000 Km²
Luas Perairan Indonesia	6.400.000 Km²
Luas NKRI (Darat + Perairan)	8.300.000 Km²

Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)

Sumber: Paparan BIG pada Simpodar Benua Maritim "Jaman "Now" Pusriskel KKP (Y. D Sigit Purnomo, 2019)

PEMBAGIAN ZONA MARITIM (UNCLOS, 1982)

BRSDM

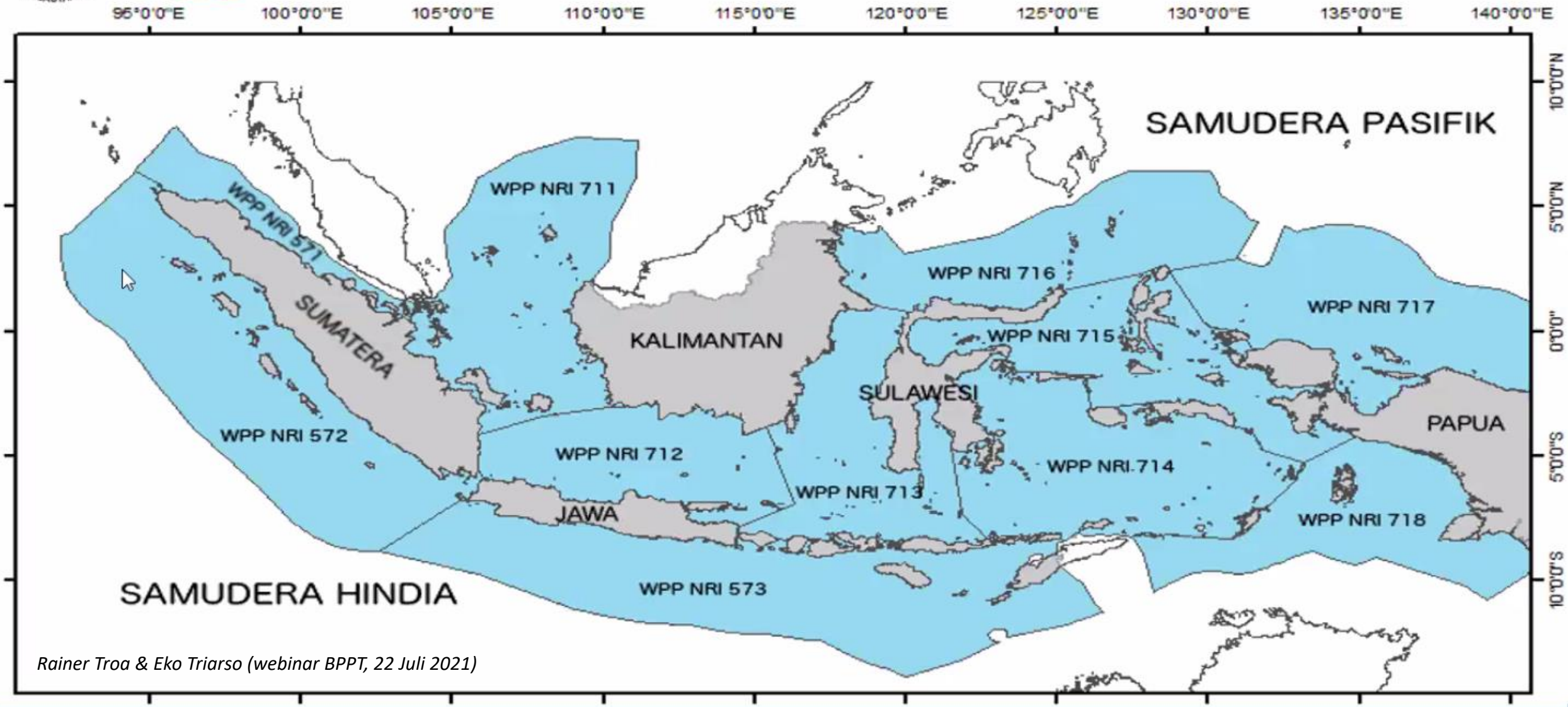


Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)

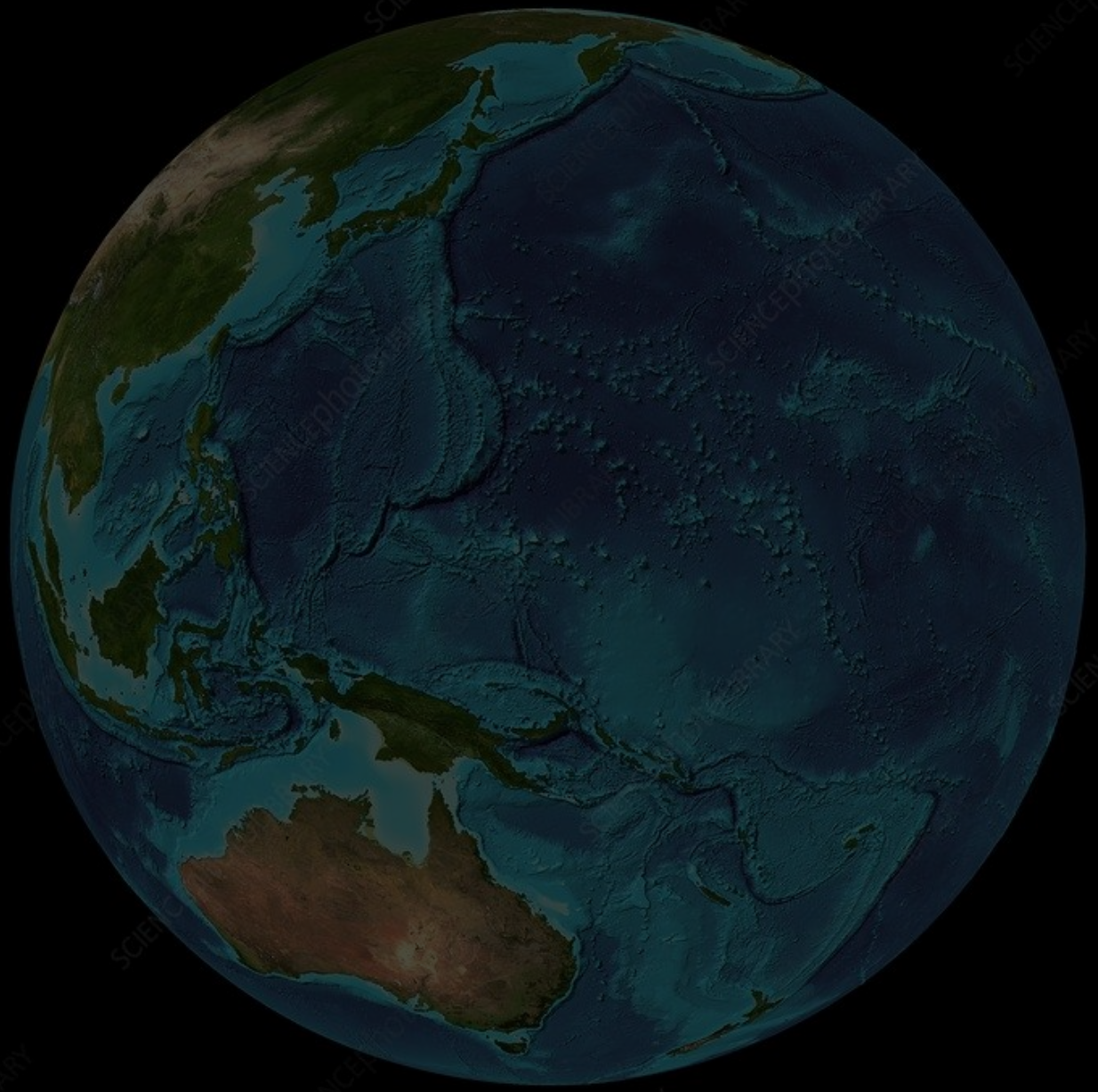
Sumber: Paparan BIG pada Simpodar Benua Maritim "Jaman "Now" Pusriskel KKP (Y. D Sigit Purnomo, 2019)

Peta Wilayah Pengelolaan Perikanan Negara Republik Indonesia (WPPNRI)

Peraturan Menteri Kelautan dan Perikanan 18/Permen-KP/2014



Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)



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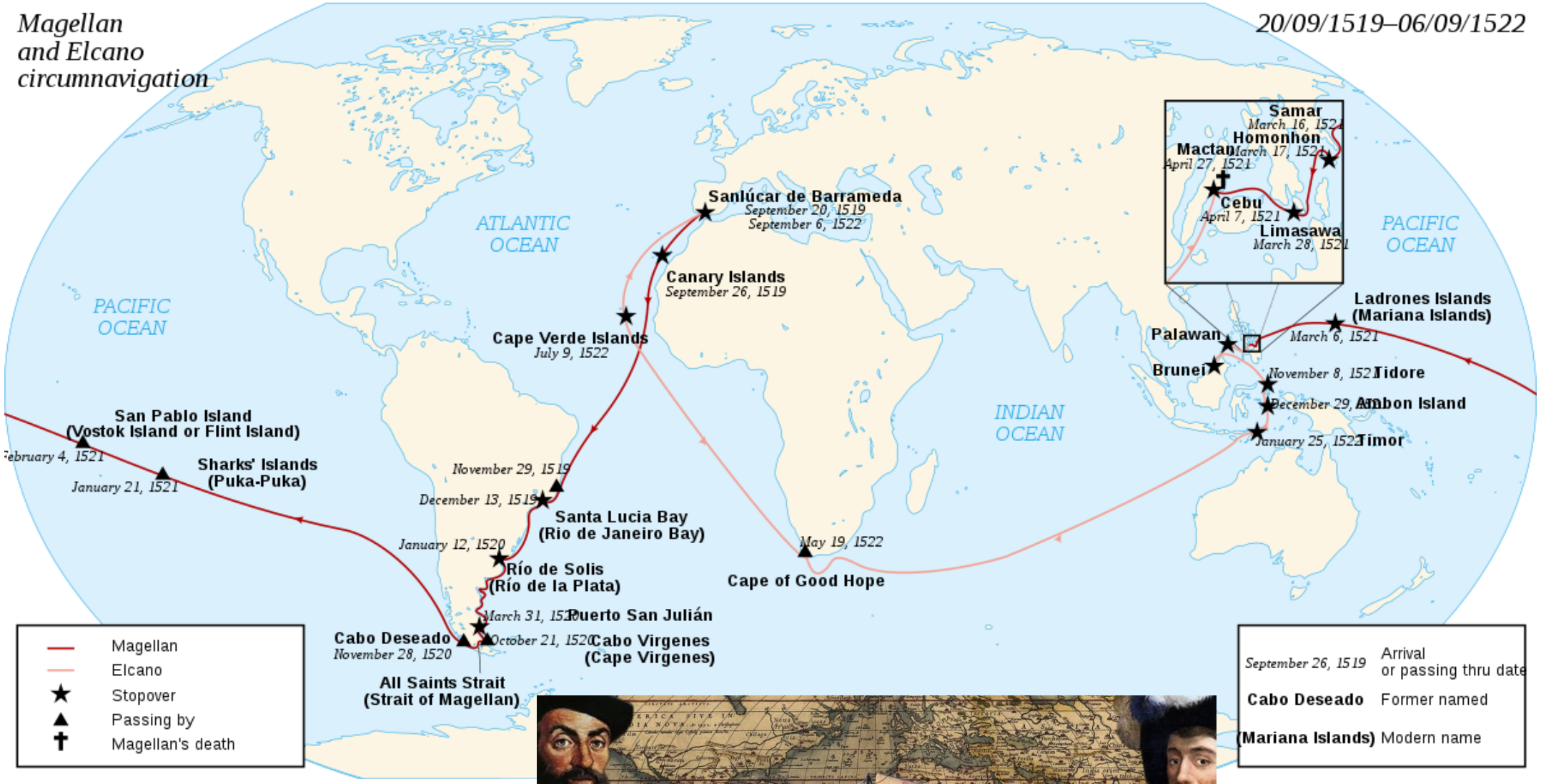
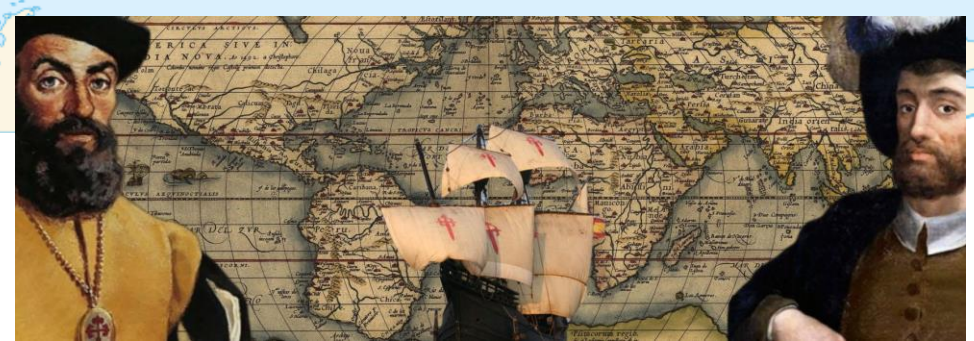
10. Konservasi Laut Indonesia

Penjelajahan Mengelilingi Dunia oleh Magellan dan Elcano (1519-1522)



Wikipedia



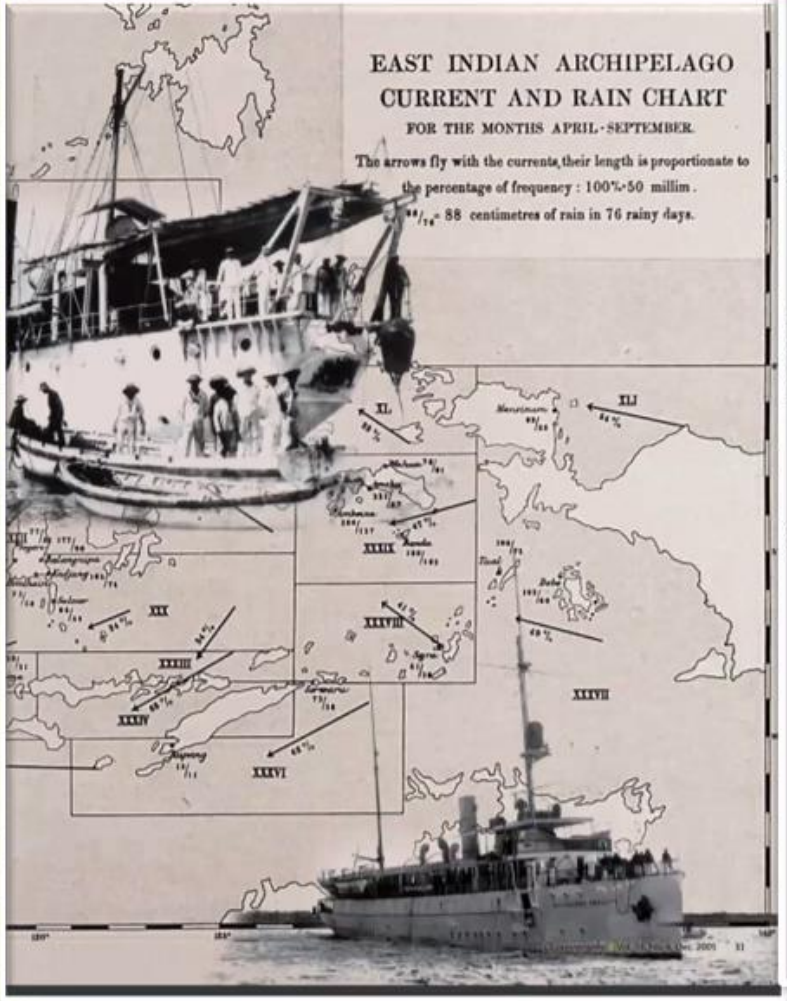
https://www.bbvaopenmind.com/en/science/leading-figures/magellan-elcano-and-the-ordeal-of-the-first-circumnavigation-of-the-earth/

Penjelajahan Mengelilingi Dunia oleh Magellan dan Elcano (1519-1522)

SEJARAH PENELITIAN GEOLOGI KELAUTAN DI INDONESIA

Table 1. Scientific surveys of the deep waters in the Indonesian seas from the 18th and 19th centuries (after L'Hornoré Naber, 1922)

Leader	Ship(s)	Nationality	Years
De Bouganville	*Boudeuse* and *Etoile*	French	1768
James Cook	*Endeavour*	British	1770
Dentrecasteaux/ d'Auribeau	*Recherche* and *Esperance*	French	1793–1794
Baudin	*Geographe* and *Nauraliste* and *Casuarina*	French	1800–1804
De Feycinet	*Uranie* and *Physicienne*	French	1817–1820
Duperry	*Coquille*	French	1822–1825
De Bouganville Jr.	*Thetis* and *Esperance*	French	1824–1826
Kolff	*Dourga*	Dutch	1825–1826
Dumont d'Urville	*Astrolabe*	French	1826–1829
Fitzroy	*Adventure* and *Beagle*	British	1826–1836
Steenboom	*Triton* and *Iris*	Dutch	1828
Laplace	*Favorite*	French	1830–1832
Laplace	*Artemise*	French	1837–1840
Dumont d'Urville	*Astrolabe* and *Zele*	French	1837–1840
Belcher	*Sulphur*	British	1837–1842
Unknown	*Samarang*	British	1843–1846
von Wüllerstorf-Urbair	*Novara*	Austrian	1858
Siedenburg	*Cachelot*	Dutch	1858
Bullock	*Serpent*	British	1863
Wyville Thomson	*Challenger*	British	1875
Von Schleinitz	*Gazelle*	German	1875
Unknown	*Borneo*	Dutch	1881
Barker	*Enterprise*	American	1883
Jewell	*Essex*	American	1886
Unknown	*Flying Fish*	British	1886–1887
Aldrich	*Egeria*	British	1887–1888
Unknown	*Recorder*	British	1888
Unknown	*Benkoelen*	Dutch	1889
Vereker	*Rambler*	British	1890
Unknown	*Banda*	Dutch	1896
Chun	*Valdivia*	German	1898–1899
Weber	*Siboga*	Dutch	1899–1900



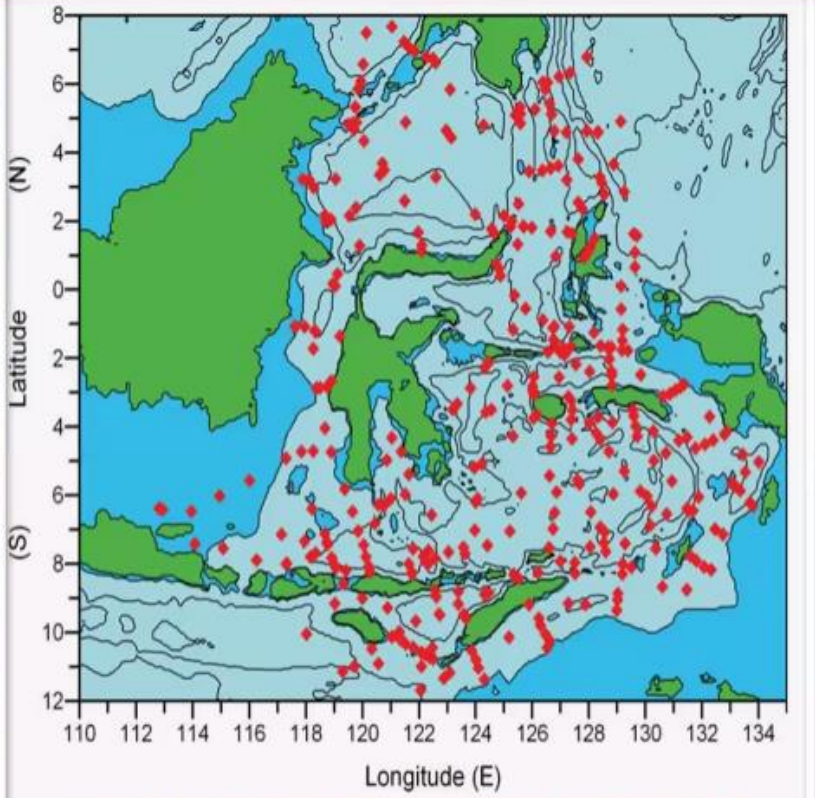


Figure 4. Positions of the hydrographic stations, occupied during the *Snellius* Expedition. Between these stations, the sea-water temperature was monitored continuously with an electric sensor, mounted on the hull, while the water depth was recorded with an echo sounder. In addition to the hydrographic program, bottom samples were collected, coral reefs were visited with boat parties to collect biological and geological samples, and the geologist of the expedition, Dr. Kuenen, did additional research on some islands.

Hananto Kurnio (webinar BPPT, 22 Juli 2021)

ABAD 18-19:

33 EKSPEDISI ILMIAH KELAUTAN KE NUSANTARA:

- PERANCIS 11
- INGGERIS 10
- BELANDA 7
- AUSTRIA 1
- JERMAN 2
- AMERIKA 2

Louis Antoine de Bougainville

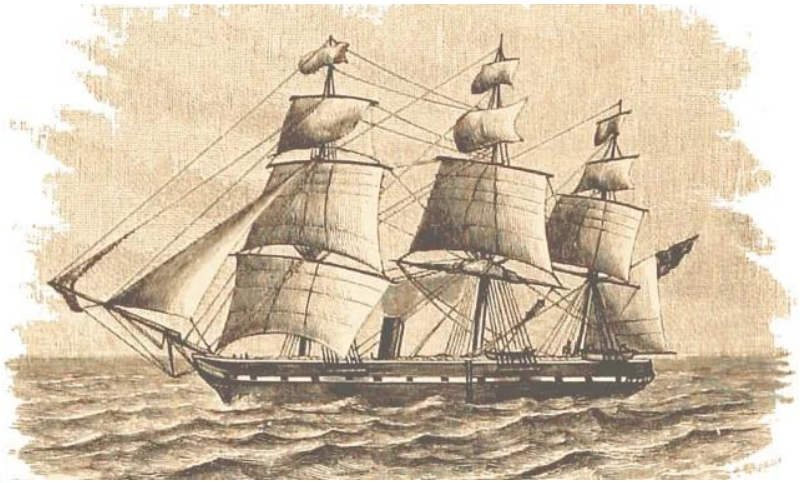
Bunga Bougainvillea

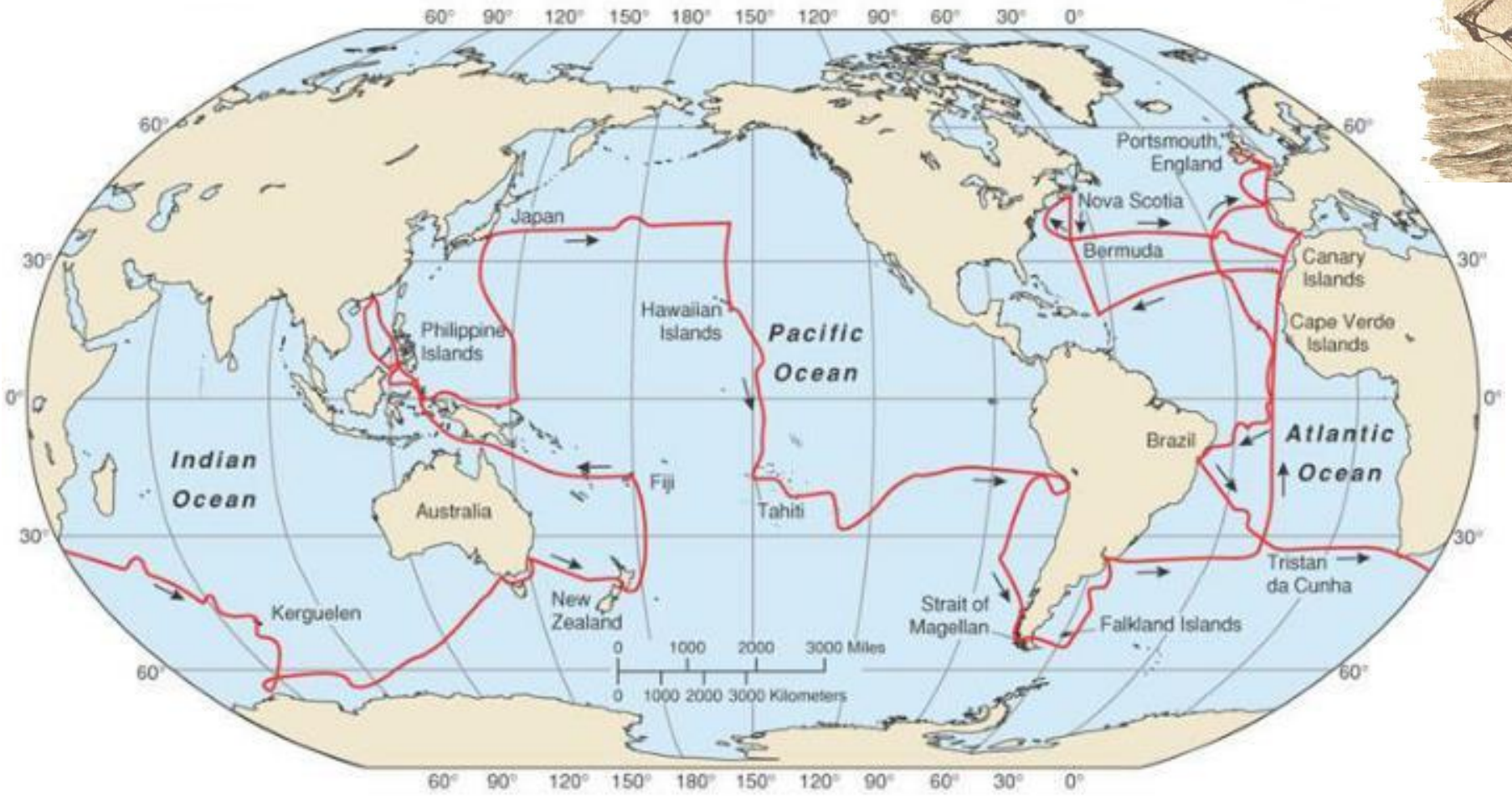
Selat Bougainville

"Astrolabe"

Nontji (2010)

Challenger expedition 1872-1876



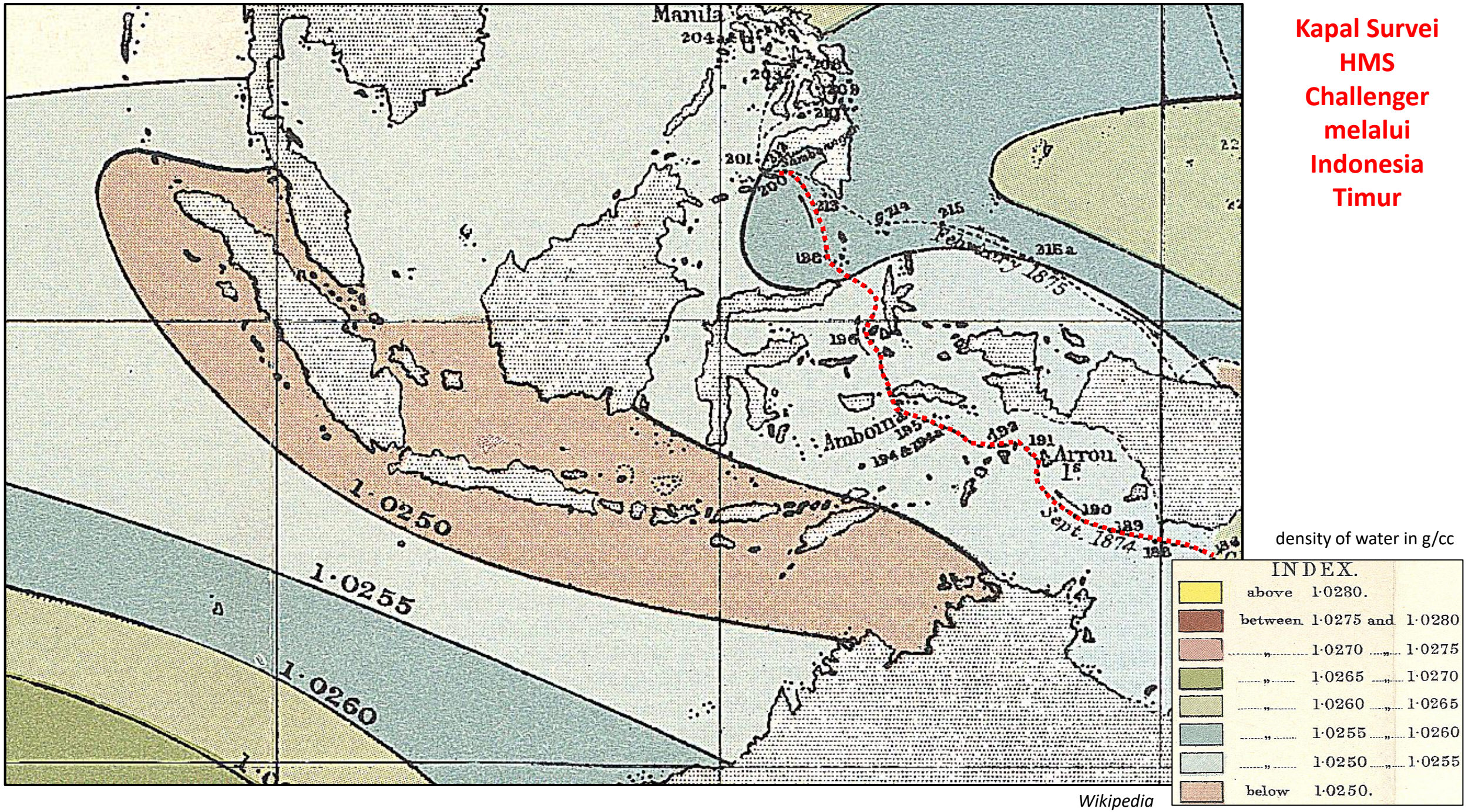


Wikipedia

She undertook the first global marine research expedition: the Challenger expedition. Challenger carried a complement of 243 officers, scientists and crew when she embarked on her 68,890-nautical-mile (127,580 km) journey.

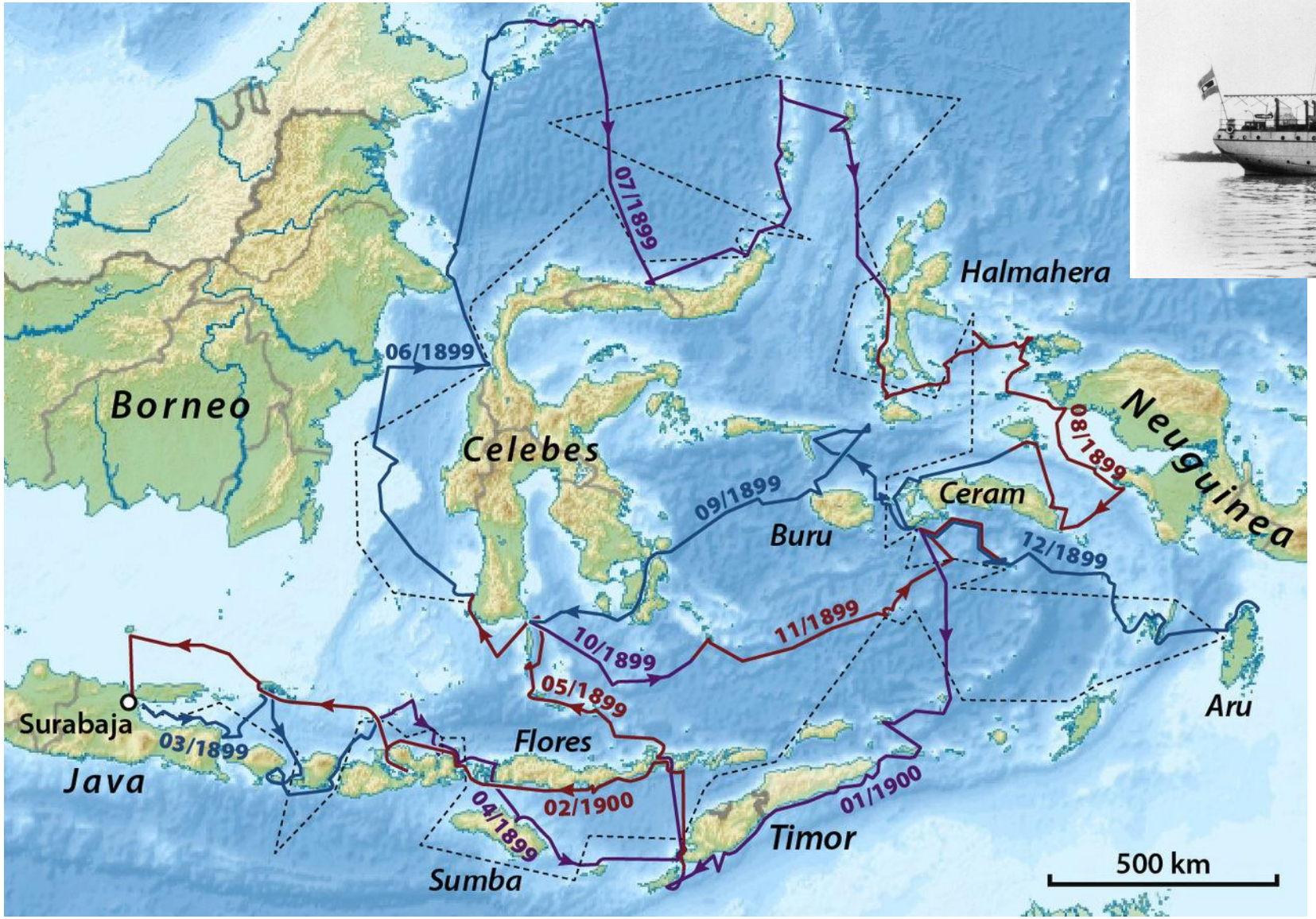
She was loaded with specimen jars, alcohol for preservation of samples, microscopes and chemical apparatus, trawls and dredges, thermometers and water sampling bottles, sounding leads and devices to collect sediment from the sea bed and great lengths of rope with which to suspend the equipment into the ocean depths.

Kapal Survei HMS Challenger melalui Indonesia Timur

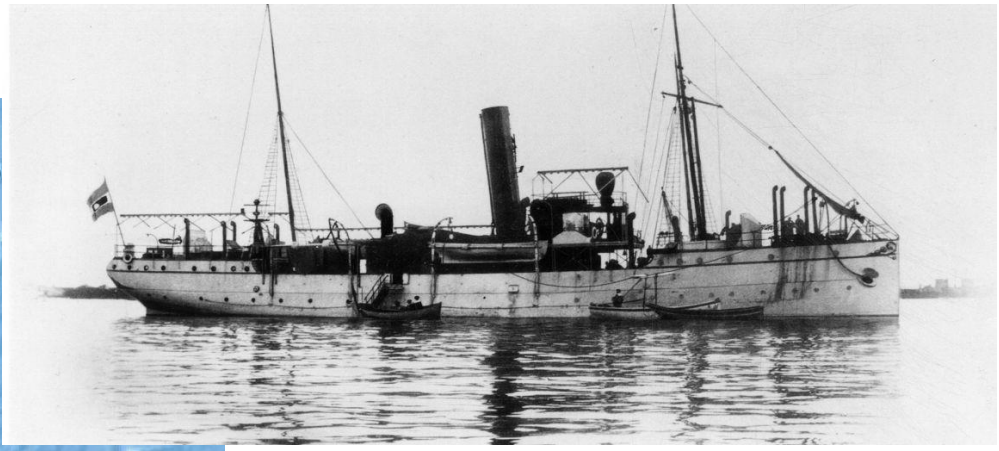


Wikipedia

Kapal Pertama Ekspedisi Ilmiah Khusus di Indonesia: Siboga (1899-1900)



Route of the Siboga-Expedition; black=proposed route from 1898; coloured=course of the expedition 1899–1900.



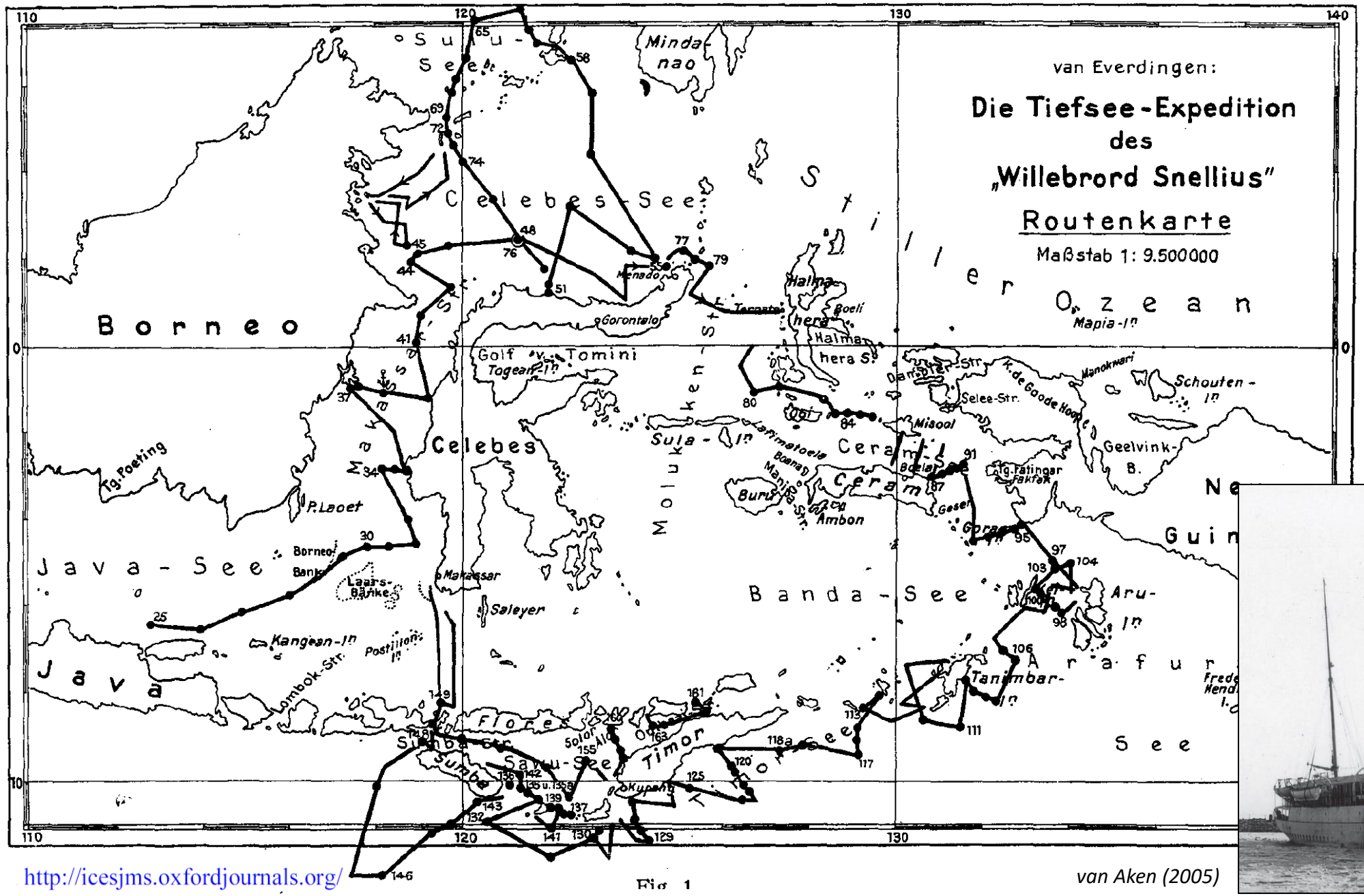
https://www.hydro-international.com/content/article/the-siboga-expedition

University of Amsterdam

The **Siboga expedition** was a Dutch zoological and hydrographic expedition to Indonesia from March 1899 to February 1900.

Wikipedia

Ekspedisi Geologi Kelautan dan Oseanografi Indonesia Timur: Snellius (1929-1930)

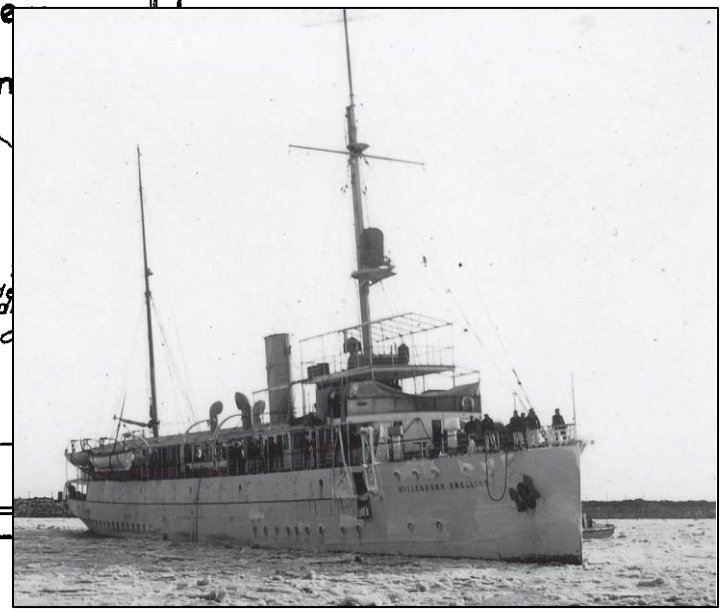


http://icesjms.oxfordjournals.org/

Fig. 1

van Aken (2005)

The Snellius Expedition was an oceanography expedition organized by the Dutch with emphasis on the fields of geology and oceanography in the waters of eastern Indonesia. This expedition is famous as the largest oceanological expedition ever undertaken in these waters. This study took place from July 27, 1929 until 25 November 1930.



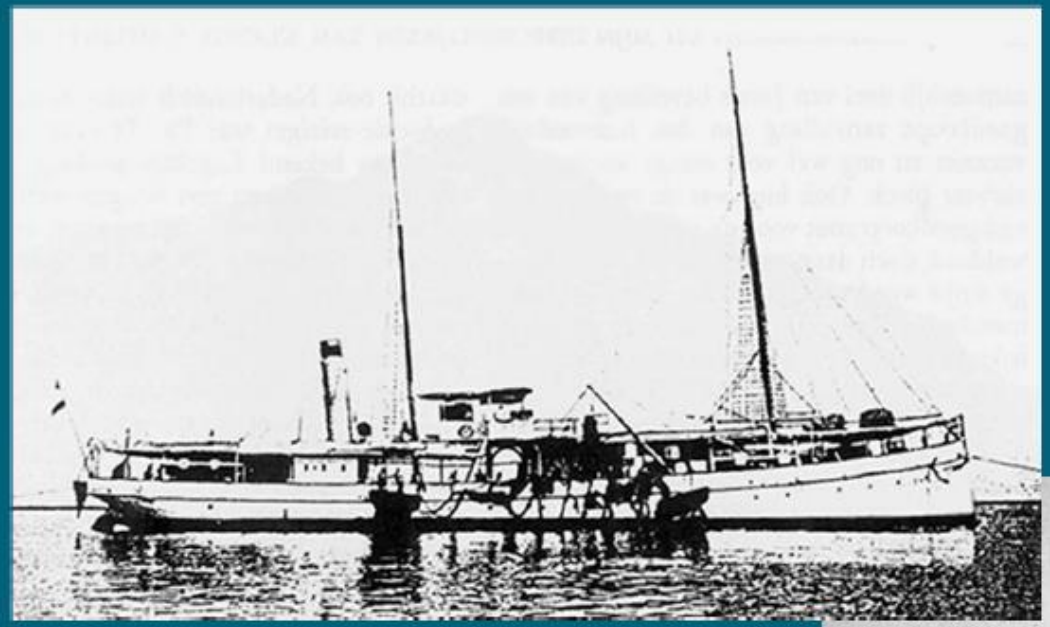
LABORATORIUM PENELITIAN LAUT YANG PERTAMA DI INDONESIA, 1905

'VISSCHERIJ LABORATORIUM" DIDIRIKAN DI PASAR IKAN, JAKARTA, 1905. CIKAL BAKAL PUSLIT OSEANOGRAFI LIPI SEKARANG

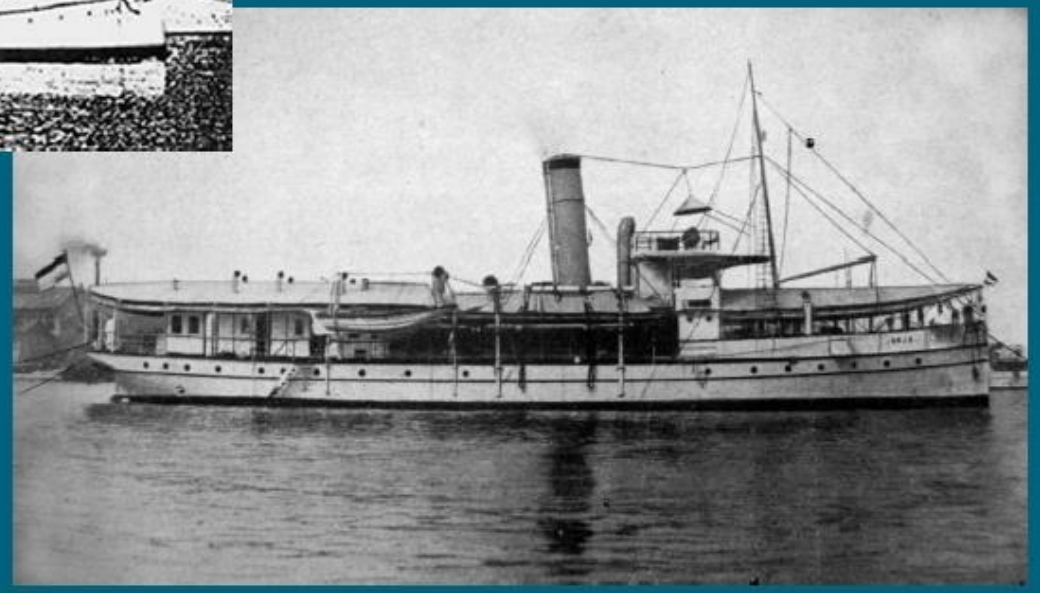
" LABORATORIUM VOOR HET ONDERZOEK DER ZEE", 1922. MERUPAKAN LABORATORIUM PENELITIAN LAUT YANG PERTAMA DI DAERAH TROPIS

Nontji (2010)

KAPAL RISET PERTAMA DI NUSANTARA



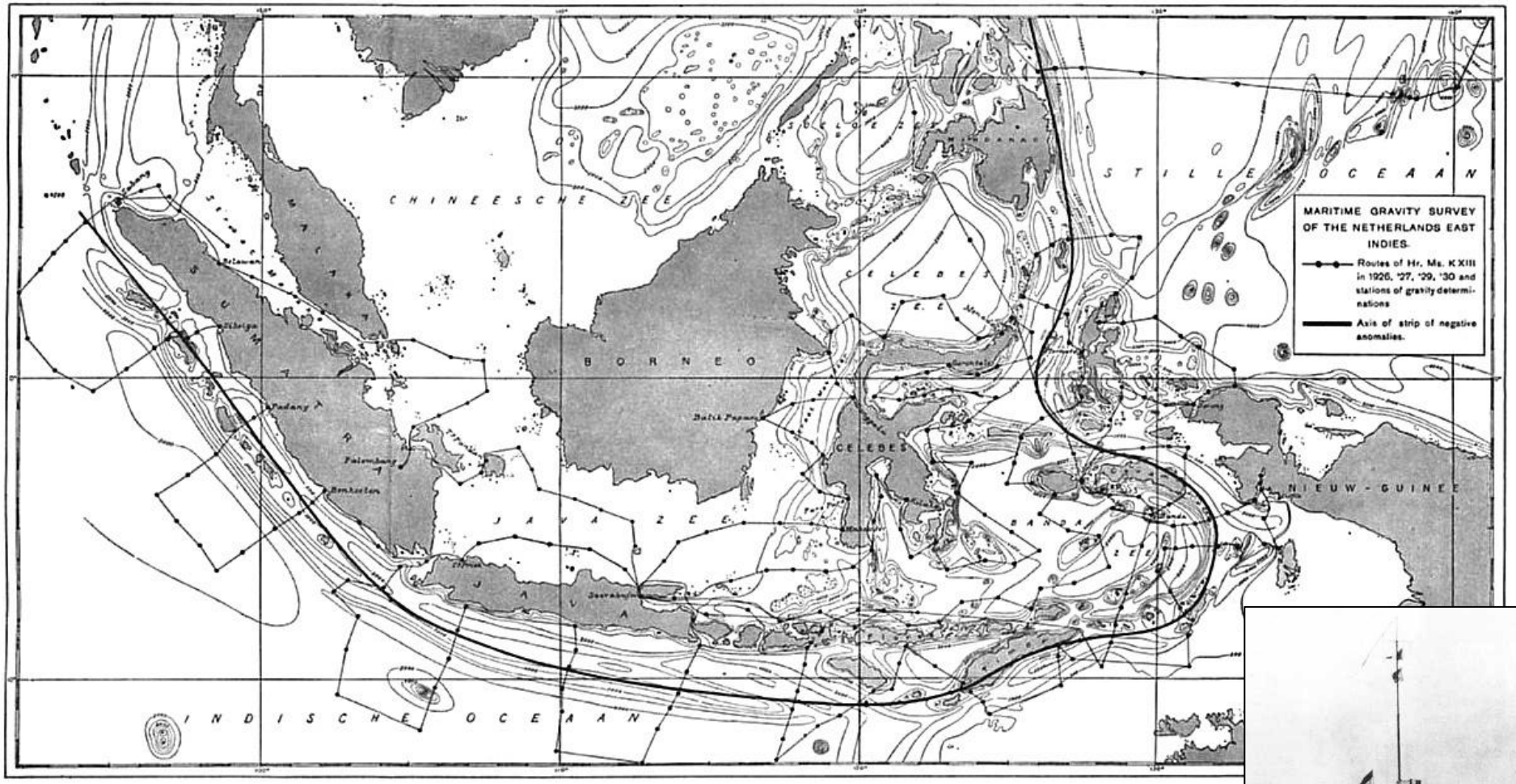
"GIER" : KAPAL RISET PERTAMA DI NUSANTARA, DIBAWAH "VISSCHERIJ STATION TE BATAVIA", 1905



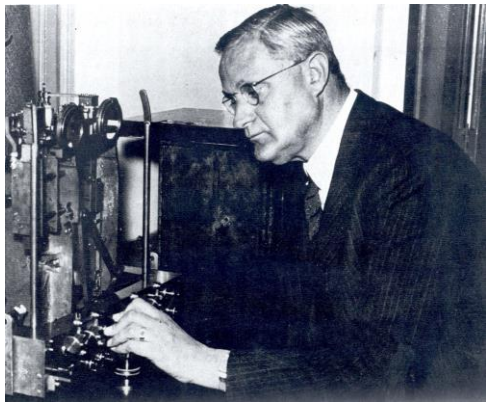
KAPAL RISET "BRAK" , ~ 1915, DARI "LABOTAORIUM VOOR HET ONDERZOEK DER ZEE", BATAVIA

Nontji (2010)

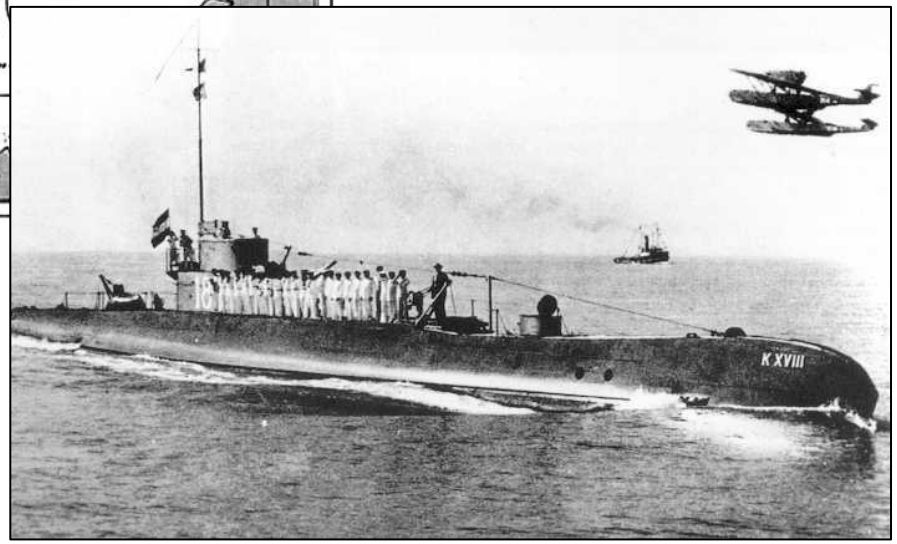
Penelitian Gravitasi di Laut dengan Kapal Selam



Vening Meinesz (1930)

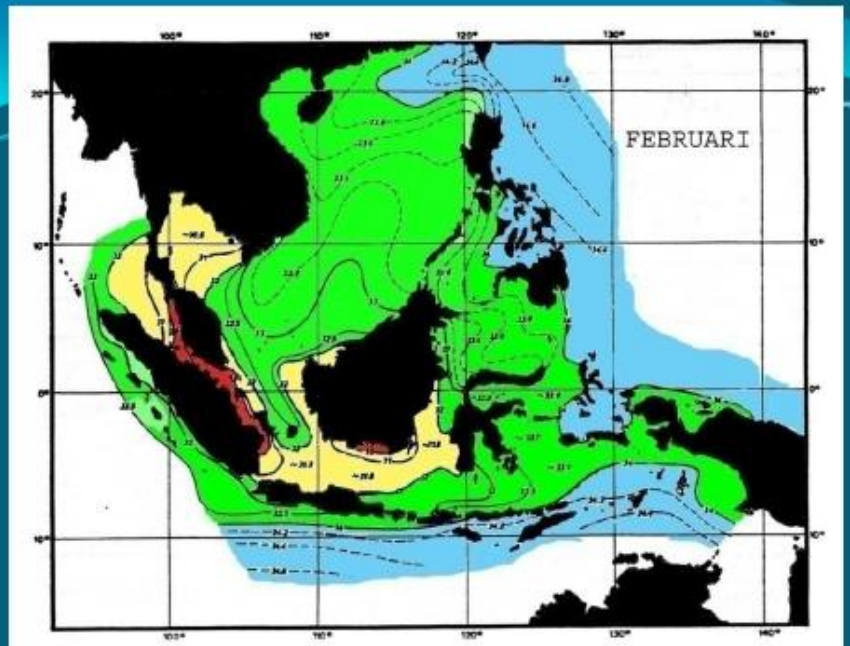


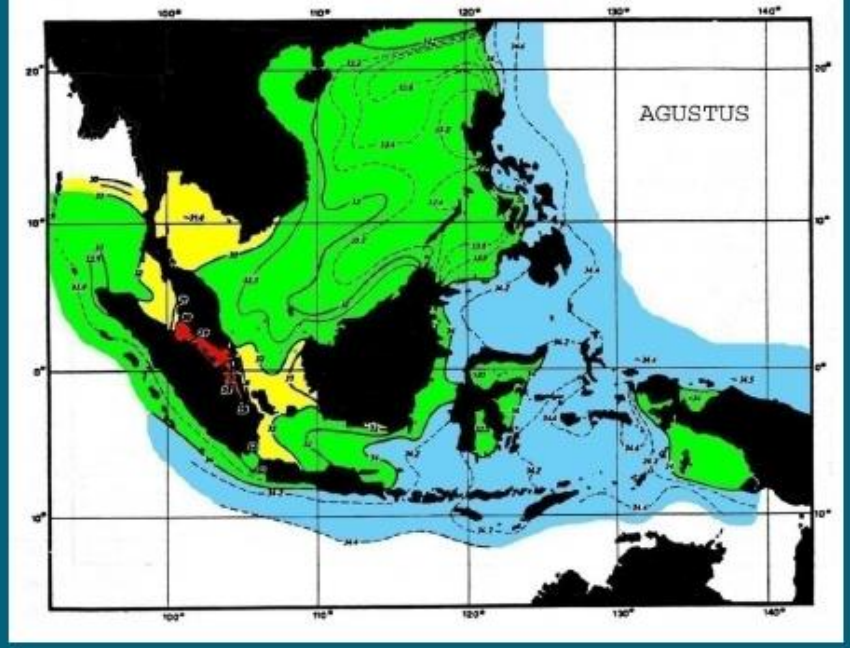
F.A. Vening Meinesz



HNLMS K XVIII *Wikipedia*

- Penelitian gravitasi di laut dengan kapal selam AL Belanda 1923-1930
- Menemukan jalur anomali gravitasi negatif di barat Sumatra, selatan Jawa – Nusa Tenggara, Busur Luar Banda, Laut Maluku-timur Filipina
- Jalur anomali gravitasi tersebut berhubungan dengan jalur tekukan kerak Bumi oleh subduksi lempeng (40 tahun mendahului tektonik lempeng)





PEMETAAN SEBARAN SALINITAS DI PERAIRAN NUSANTARA (1950-1953) OLEH LEMBAGA PENELITIAN LAUT

R.E. SOERIAATMADJA

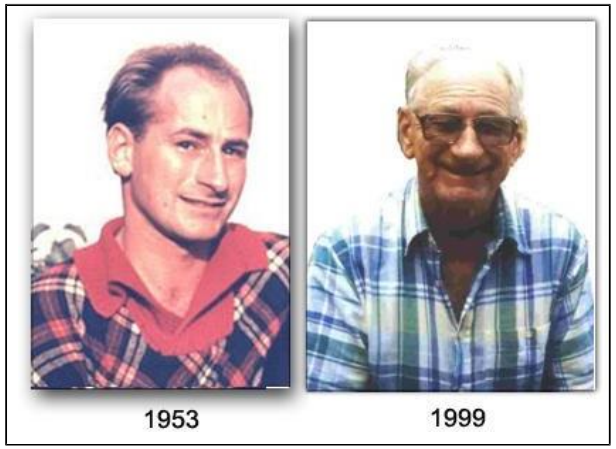
OSEANOGRAFER INDONESIA YANG PERTAMA

- KEIKUT-SERTAAN KAPAL-KAPAL MASKAPAI PELAYARAN, KAPAL-KAPAL DJAWATAN PELAYARAN, PELABUHAN, PENJAGA SUAR, UNTUK MENGAMBIL SAMPLE SALINITAS SECARA TERATUR SEPANJANG TAHUN
- 147.000 SAMPLE (1950 -1954)
- PEMETAAN SEBARAN SALINTAS MENURUT MUSIM

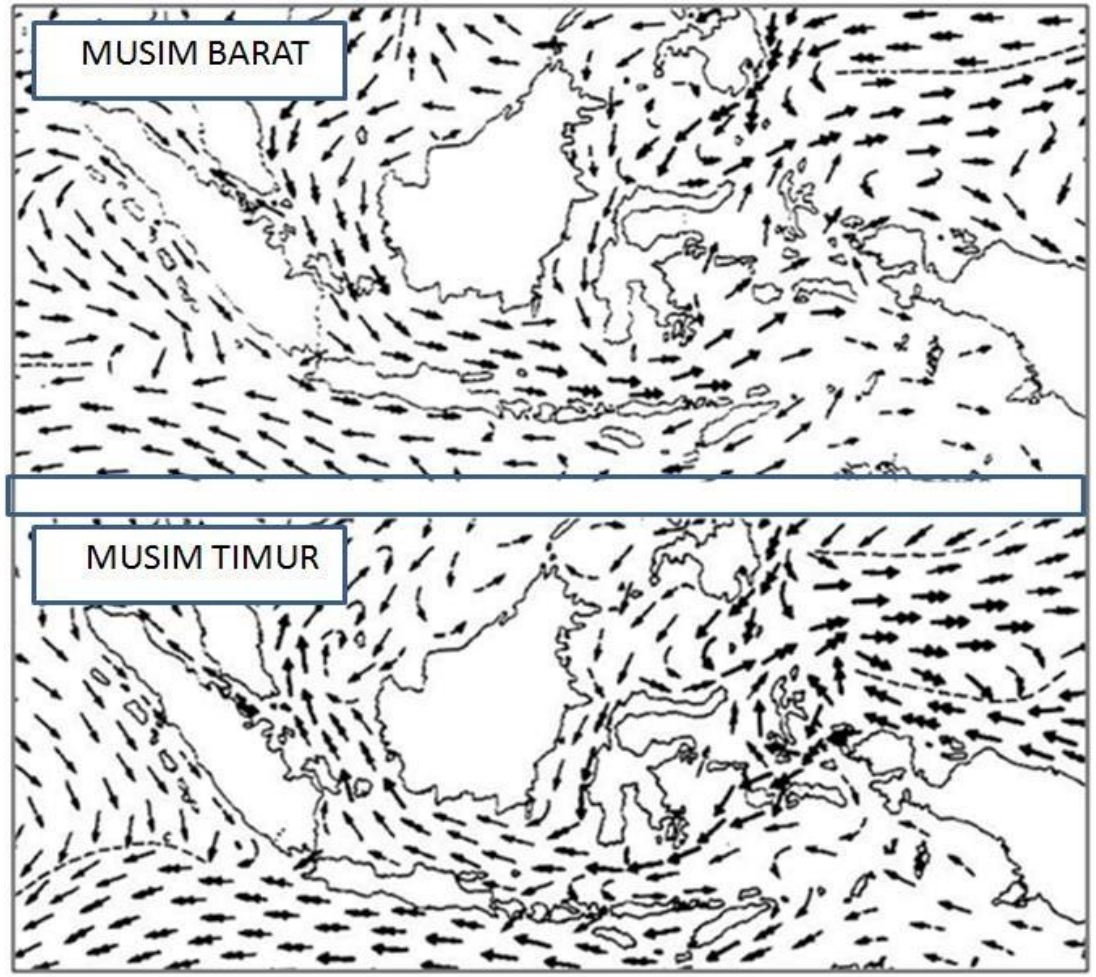
Nontji (2010)

Kapal Riset Samudera (1954-1957) dan Klaus Wyrtki – Bapak Oseanografi Nusantara

Klaus Wyrtki



Anugerah Nontji (2017)



Pola arus di perairan Nusantara di musim barat dan musim timur (Wyrtki, 1961)

Wyrtki, K. 1961. Physical oceanography of the Southeast Asian waters. NAGA Report vol. 2. The University of California, Scripps Institution of Oceanography, La Jolla, Clifornia: 195 pp.

Wyrtki, K. 1971. Oceanographic atlas of the International Indian Ocean Expedition. National Science Foundation. Washington DC: 531 pp.

Wyrtki, K. 1973. An equatorial jet in the Indian Ocean. *Science* 181: 262-264.

Wyrtki, K. 2005. Discovering the Indonesia Through Flow. *Oceanography* 18 (4): 28-39.

Ekspedisi Baruna (9 Mei – 27 Juli 1964)

Ekspedisi pertama yang dikoordinasi secara nasional

*"Untuk menjadi negara adil makmur kita harus **sanggup mengeksplorasi kekayaan alam** kita. Tetapi di samping itu kita harus pula **memiliki national pride (kebanggaan nasional)** karena kedua unsur itu bergandengan satu sama lain."*

Instruksi Bung Karno:

Segera menggelar ekspedisi ilmiah kelautan yang dinamainya Ekspedisi Baruna guna menyelidiki kekayaan laut dan segala rahasia yang terpendam didalamnya

Baruna terdapat dalam mitologi Hindu yang berkembang di Indonesia pada abad pertama, dan dikenal sebagai Dewa Laut. Di samping Baruna dikenal juga banyak dewa-dewa lainnya, antara lain Kuwera sebagai Dewa Kekayaan. Kuwera yang terdapat pada relief candi Borobudur selalu berdekatan dengan Baruna. Menurut Presiden Soekarno, ini penting artinya, bahwa kekayaan ada hubungannya bahkan erat hubungannya dengan laut.

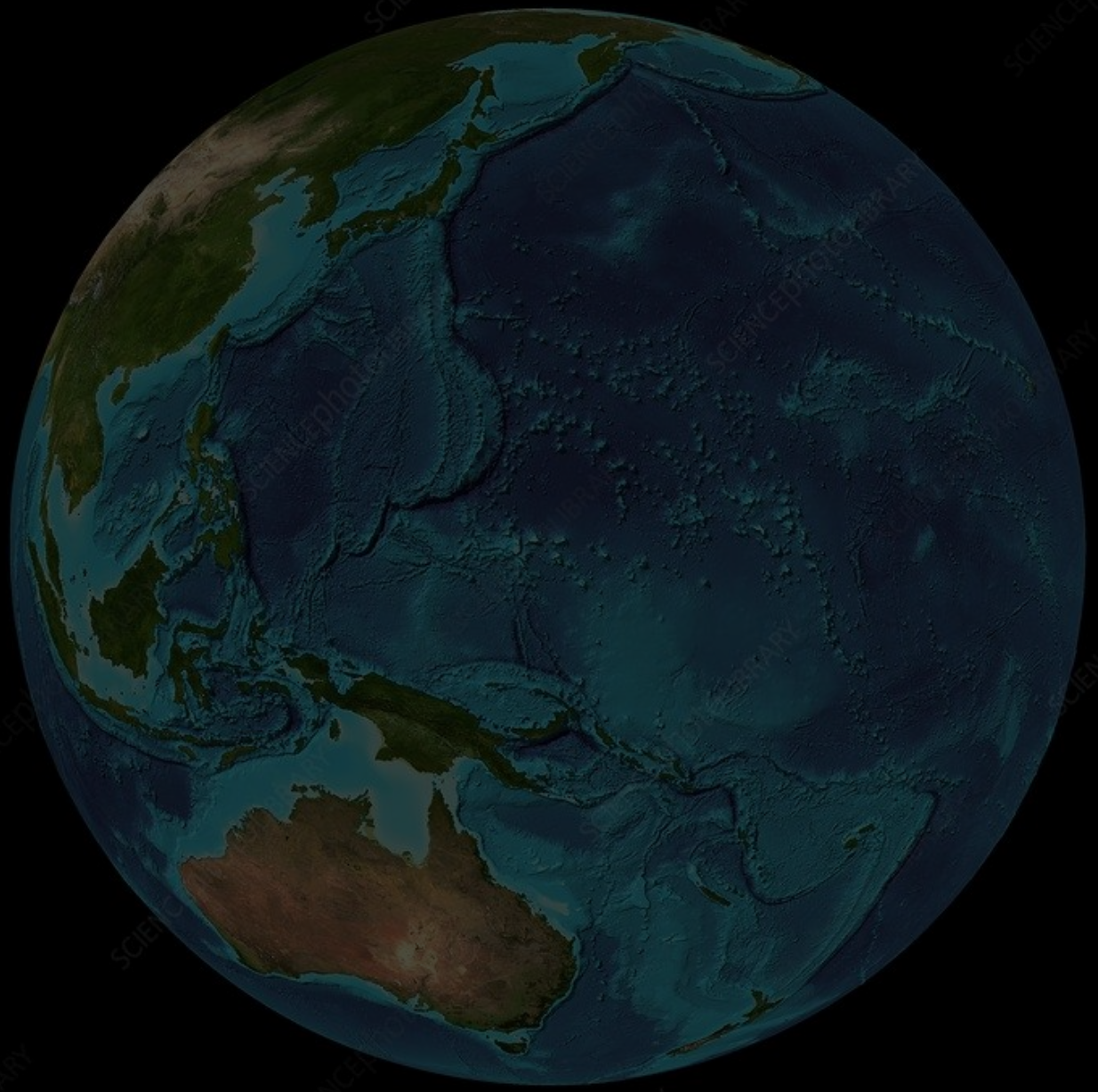
Ekspedisi Baruna di lapangan berada dibawah komando Letkol Laut Sugeng Harjanto, sedangkan sebagai Ketua Tim Ilmiah adalah Dr. Gatot Rahardjo dari MIPI. Seluruh peserta ekspedisi berjumlah 308 orang dari berbagai instansi, termasuk tiga orang wanita peneliti. Dalam bidang biologi ada peneliti dari ITB, Dr. Mahhargo Suprapto dan Prof. Dr. Doddy Tisna Amidjaja (yang dikemudian hari menjadi Ketua LIPI). Dalam bidang geologi laut ada pakar-pakar Prof. de Neve (Unpad), Prof. Tjia Hong Djin (ITB), Drs. HMS Hartono (Ditjen Geologi).

Wilayah yang menjadi sasaran penelitian adalah perairan Laut Jawa, Laut Banda dan Laut Arafura, sedangkan pulau-pulau atau pantai yang dikunjungi antara lain Masalembo, Kangean, Bima (Sumbawa), Satengar, Komodo, Taka Bonerate, Tukang Besi (sekarang Wakatobi), Ambon, Seram, Banda, Tanimbar, Aru dan Kei.

KRI Jalanidhi
p: 53,9 m, l: 9.5, GT 985, 12 kts, Sasebo Jpn 1963
Majelis Ilmu Pengetahuan Indonesia
Pengawakan oleh TNI AL

Anugerah Nontji (www.oseanografi.lipi.go.id)

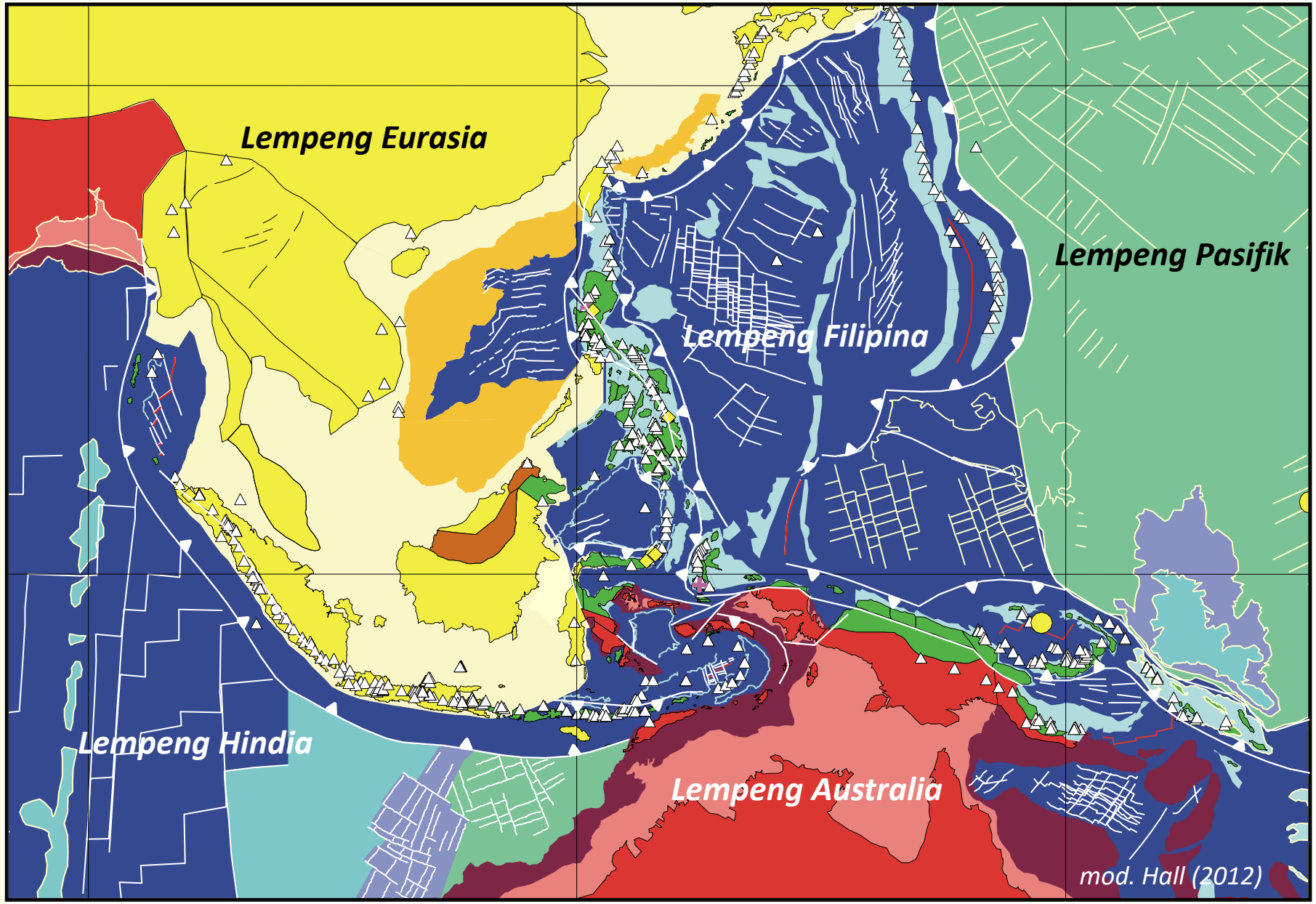
Hananto Nugroho (Webinar IAGI Maluku, 8 Feb. 2022)



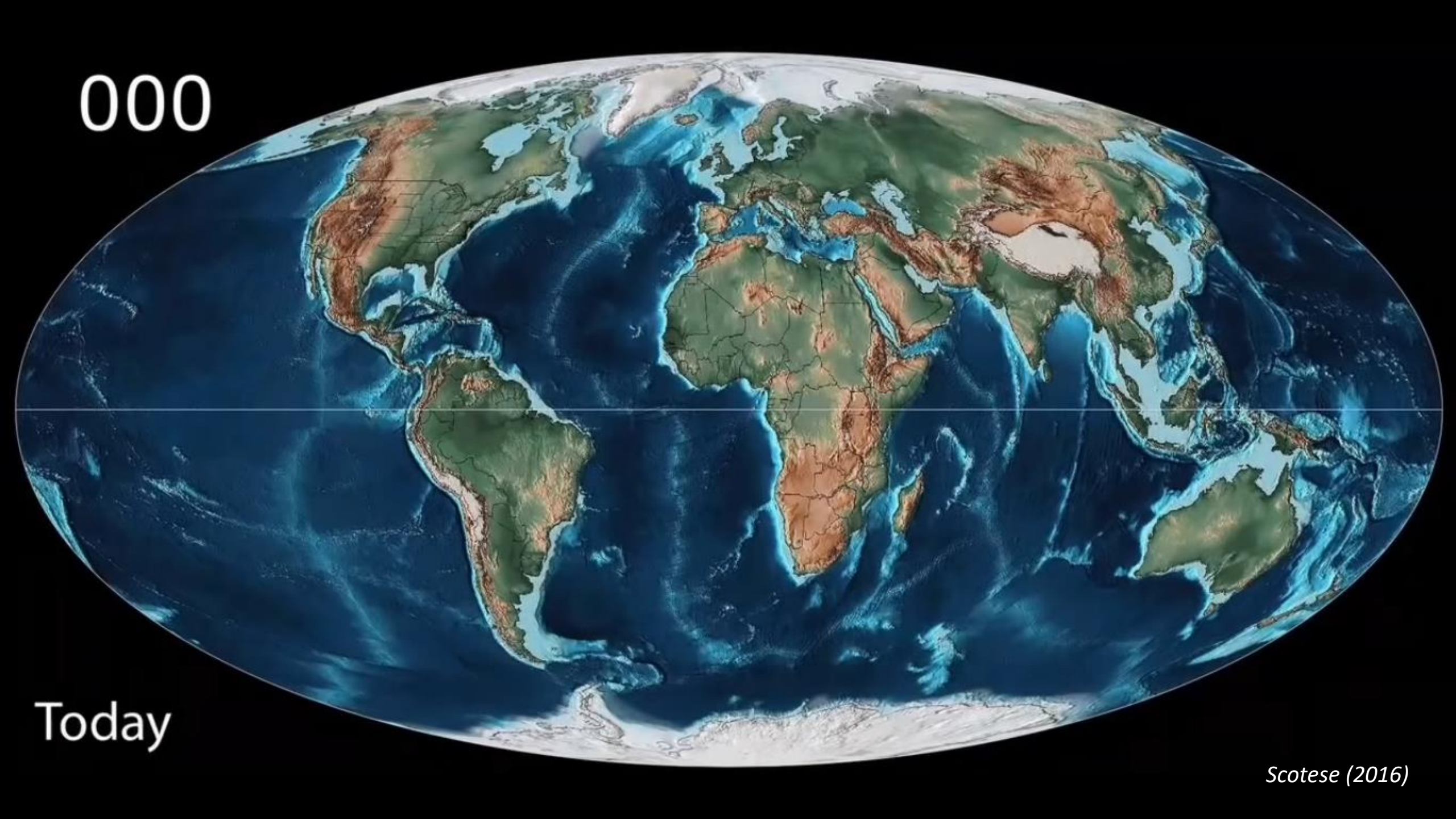
https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan Indonesia

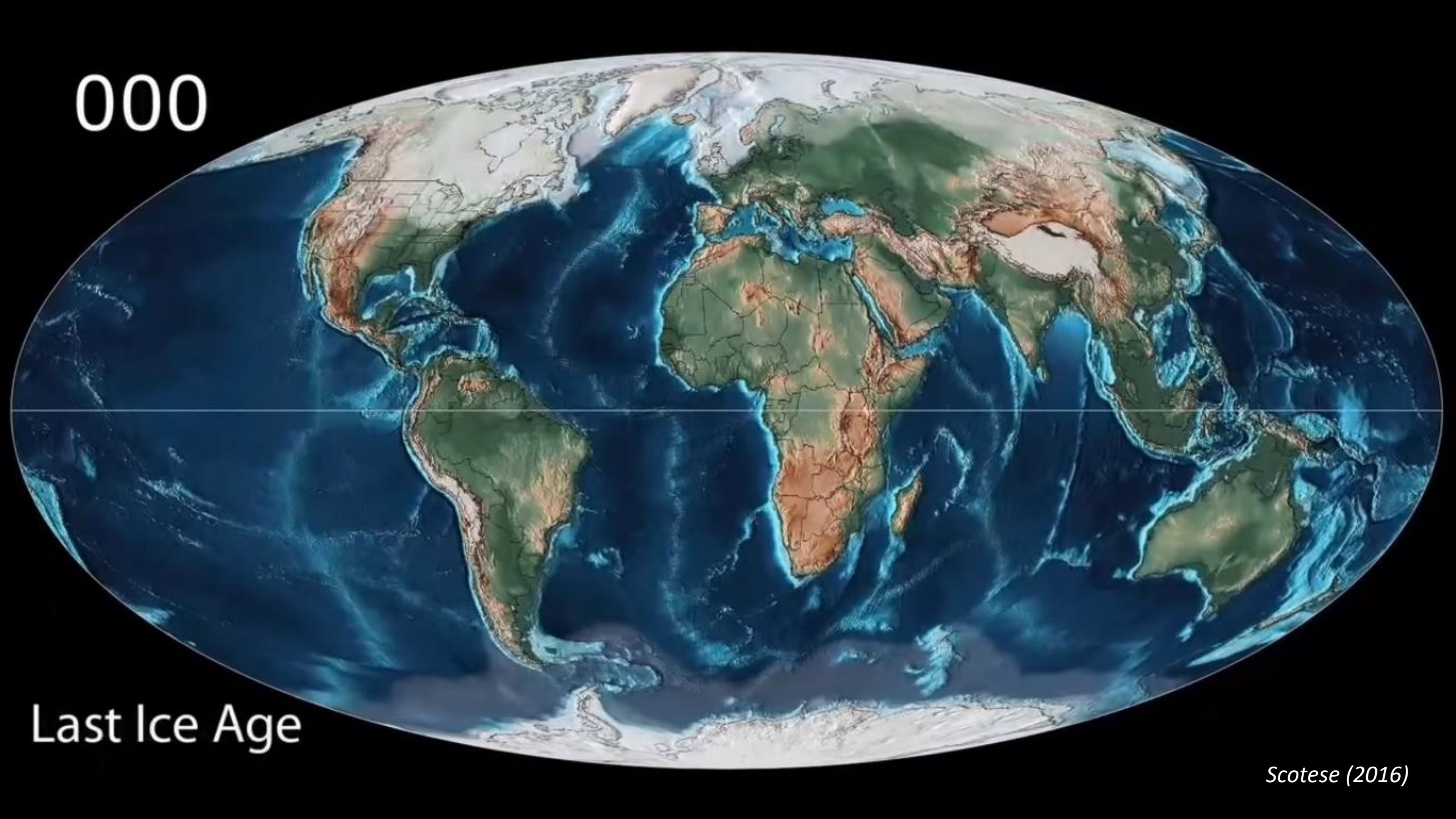
1. Wilayah Kelautan Indonesia
2. Sejarah Penyelidikan Kelautan Indonesia
3. **Tektonik dan Evolusi Cekungan Kelautan Indonesia**
4. Topografi Dasar Kelautan Indonesia
5. Sedimentasi Kelautan Indonesia
6. Status Masa Kini Penelitian Kelautan Indonesia
7. Pengelolaan Kelautan Indonesia
8. Bencana Geologis Kelautan Indonesia
9. Sumber Daya Geologis Kelautan Indonesia
10. Konservasi Laut Indonesia



Tataan Tektonik Lempeng Masa Kini untuk Indonesia



Scotese (2016)



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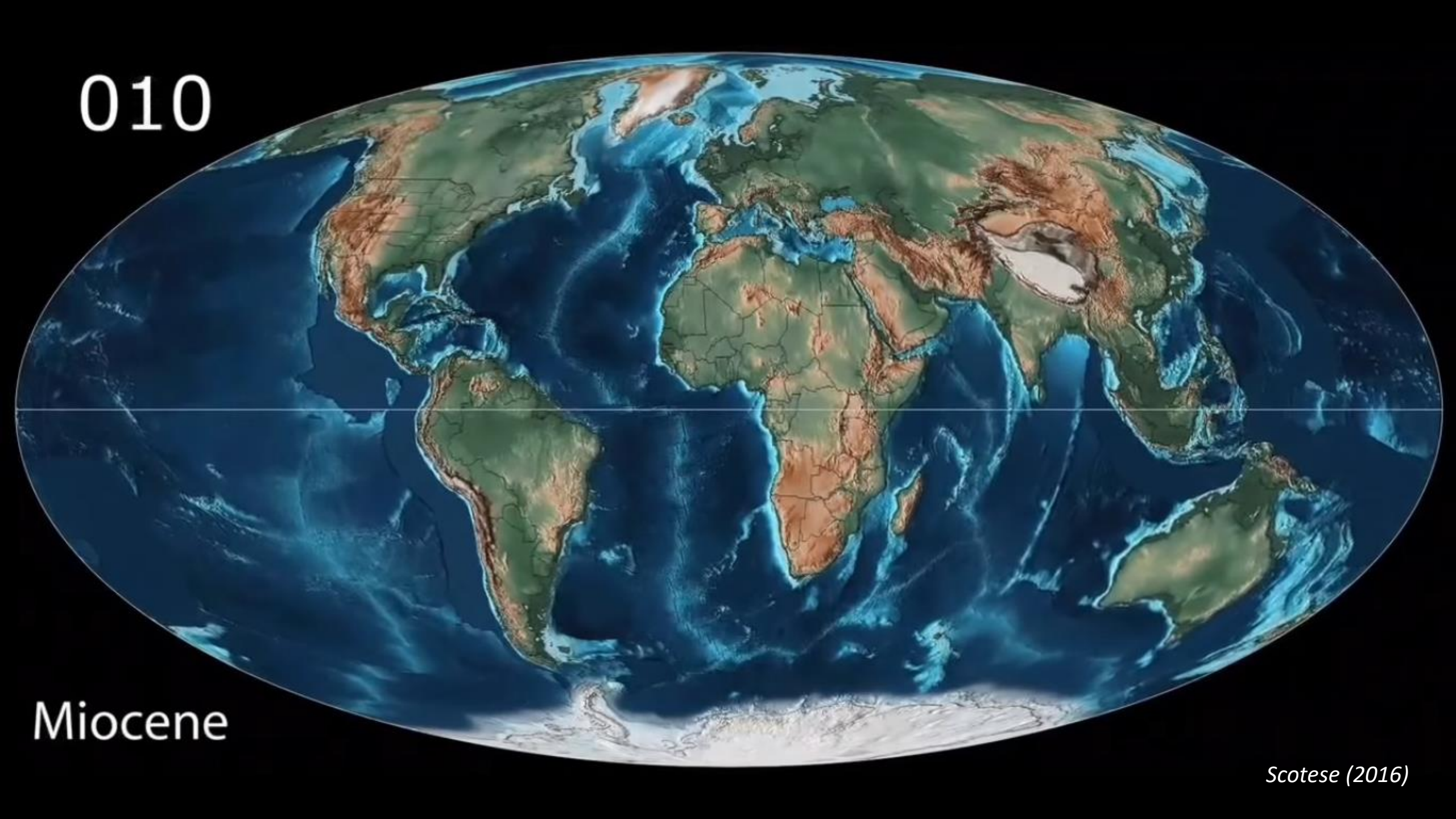

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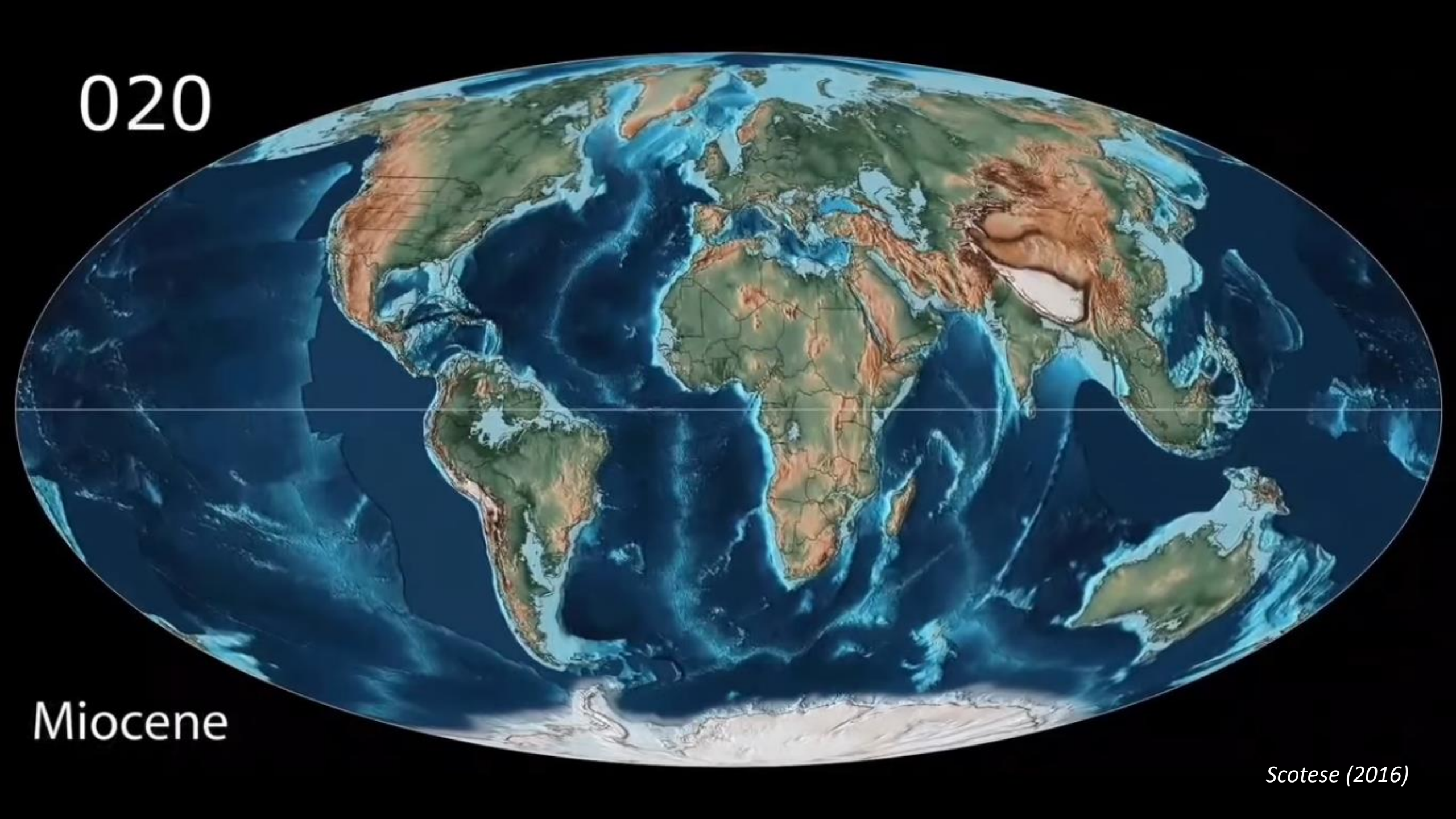

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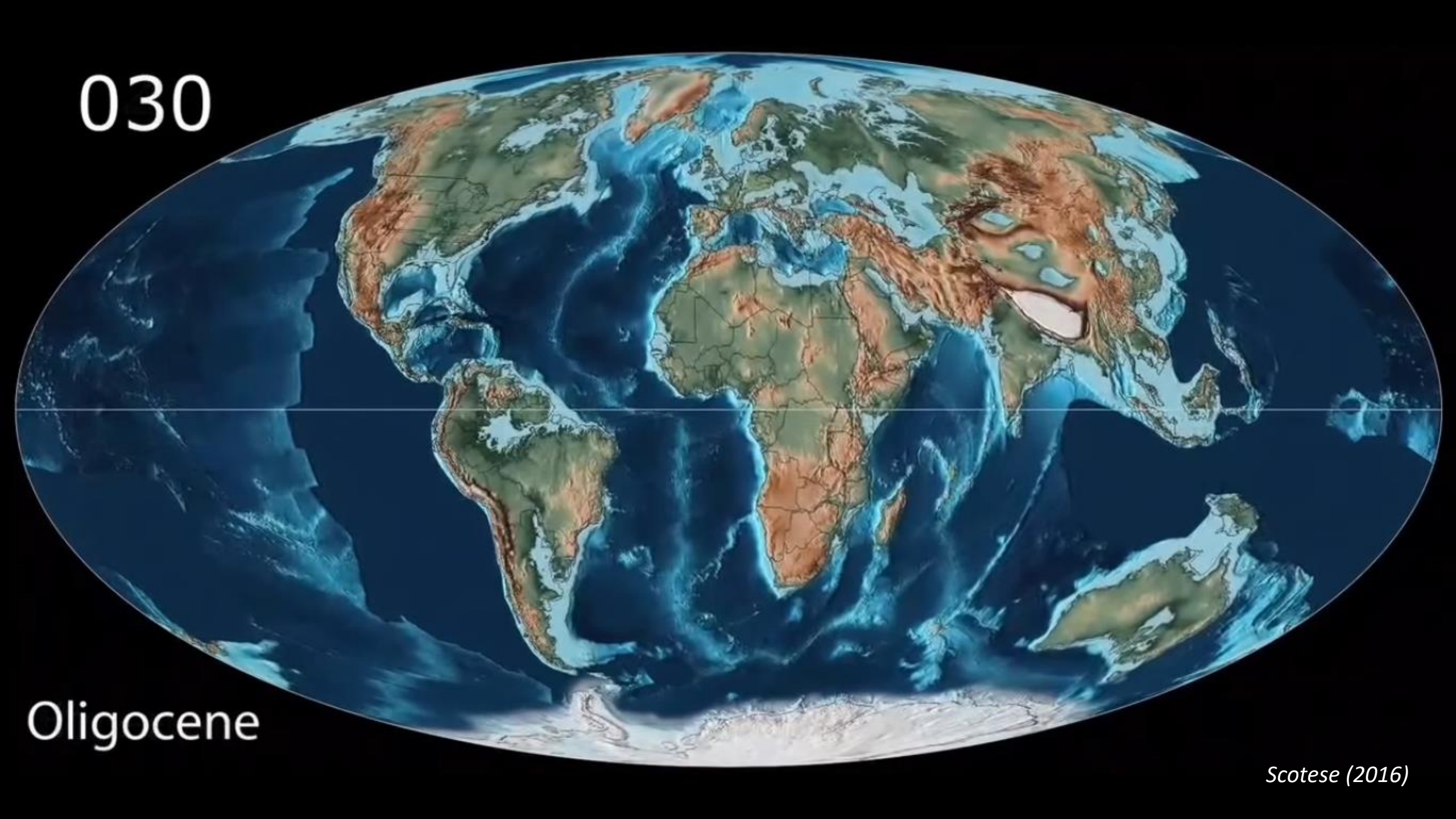

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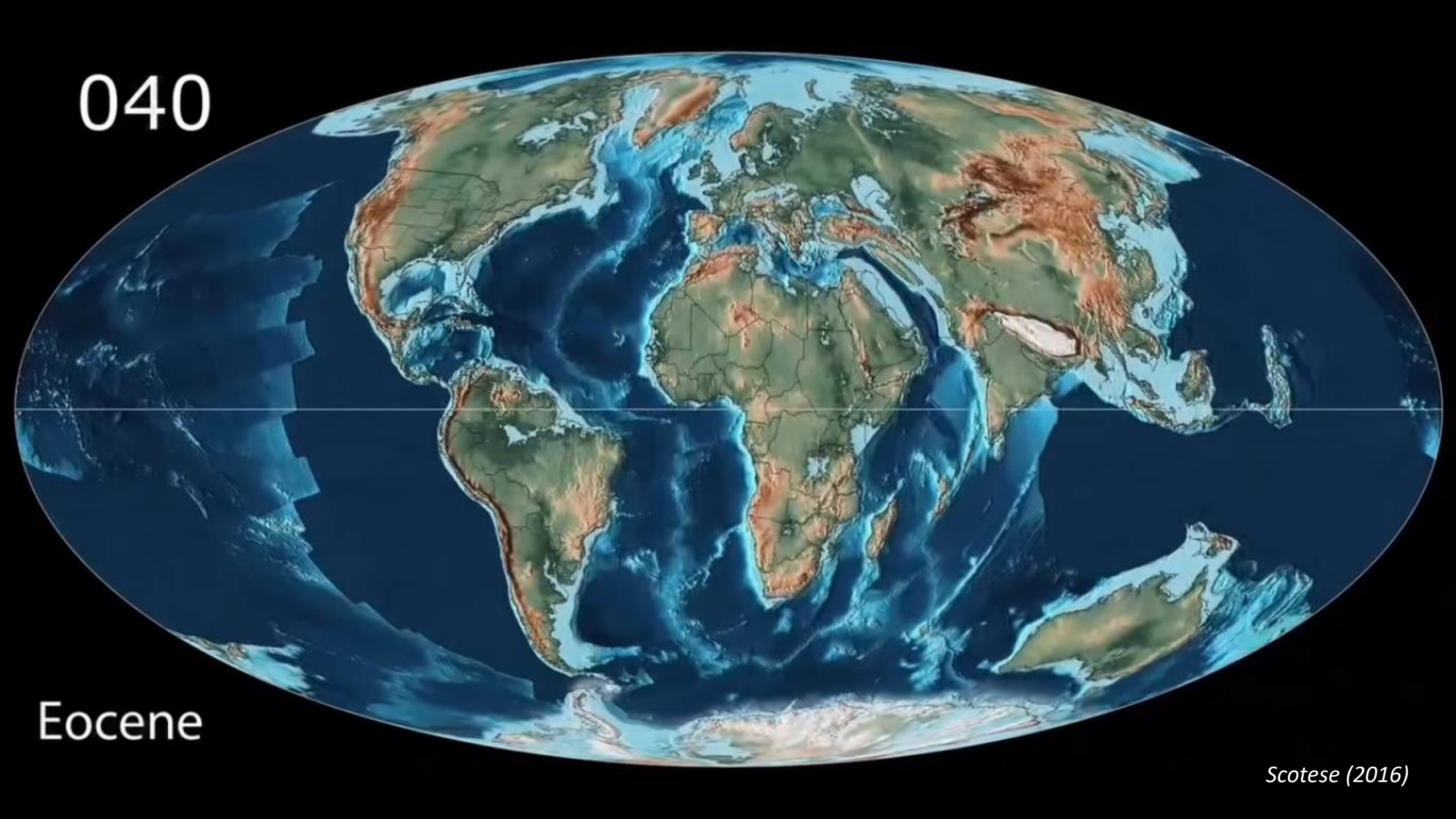
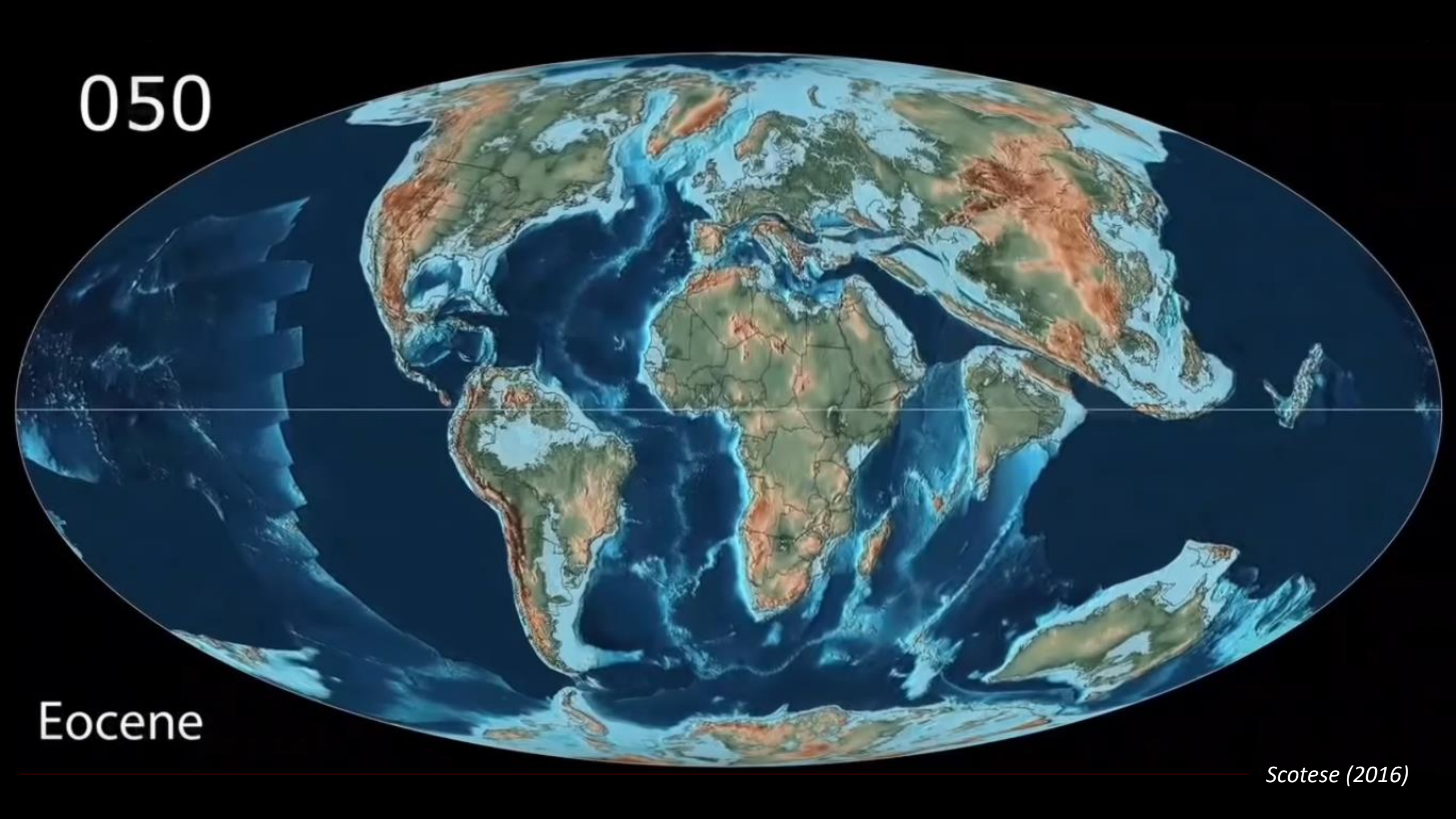


Scotese (2016)



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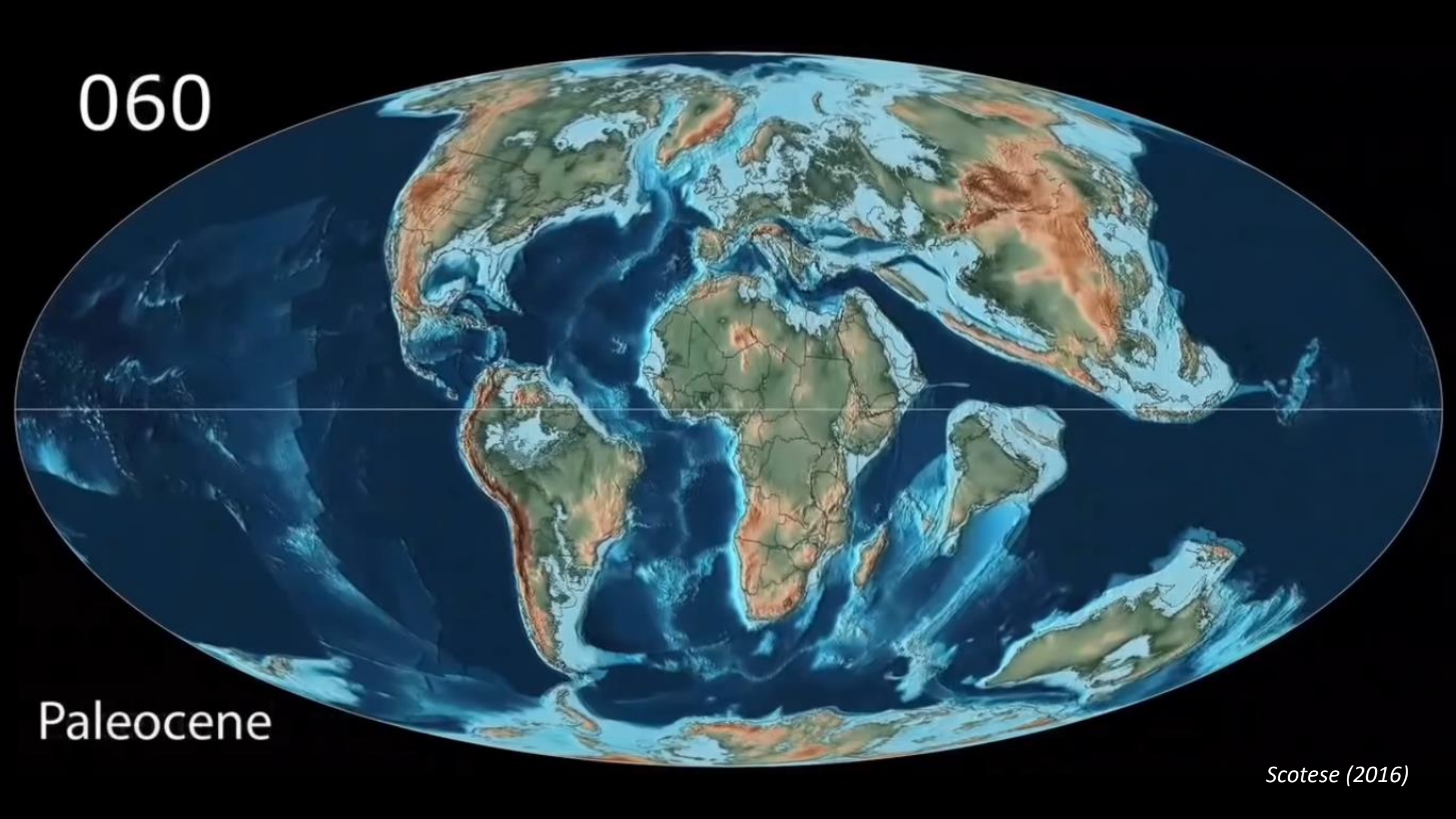

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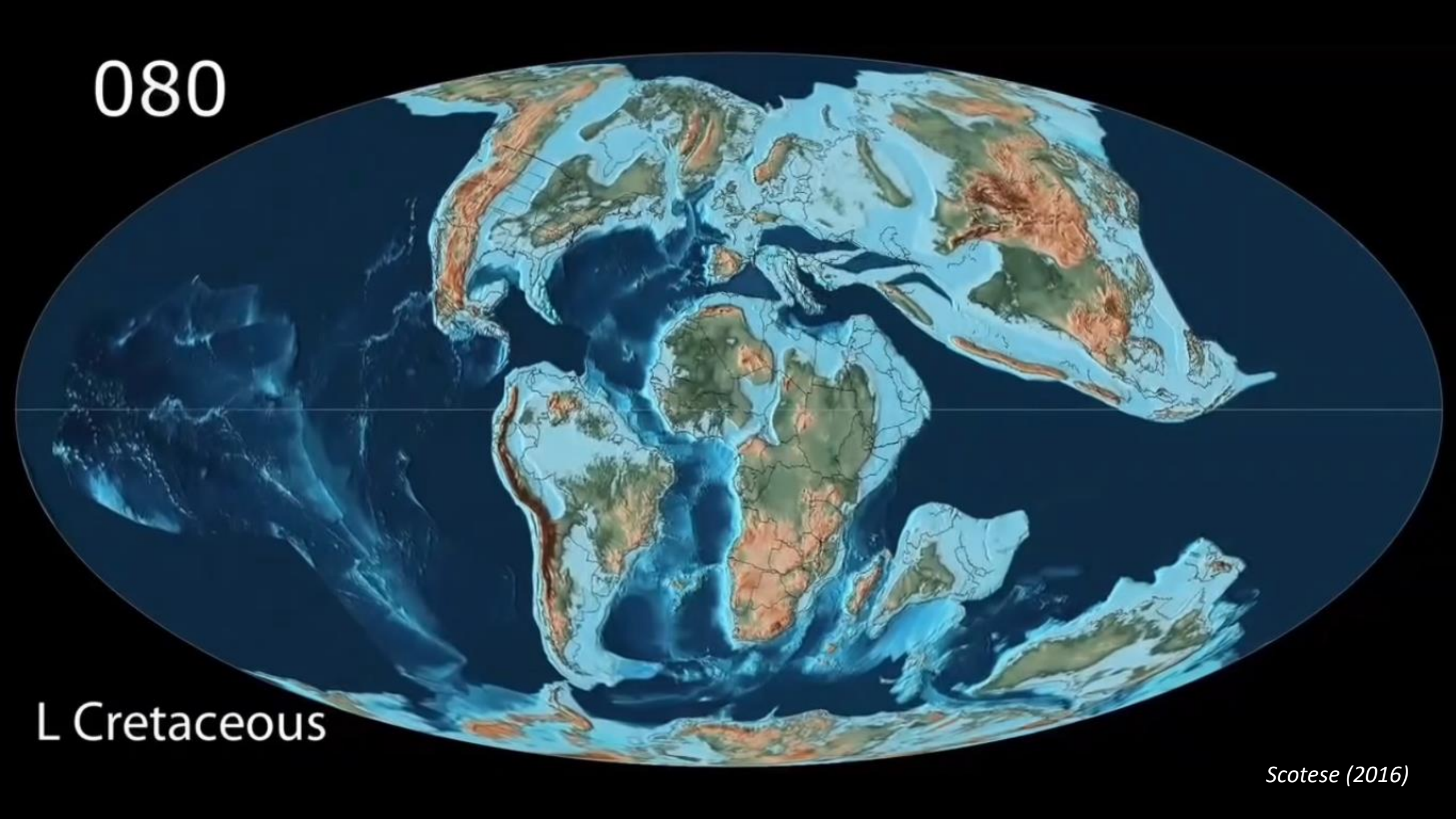

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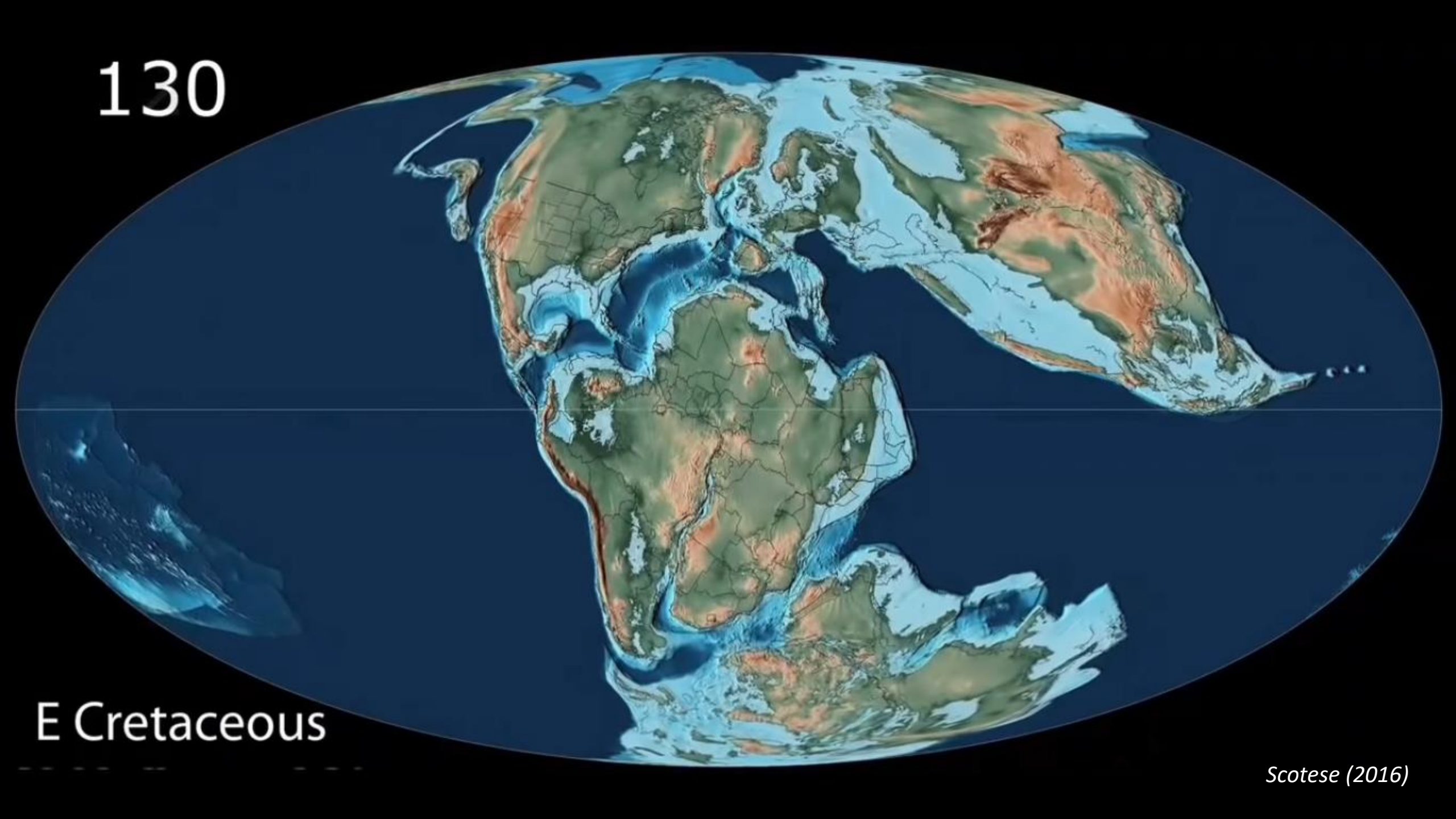

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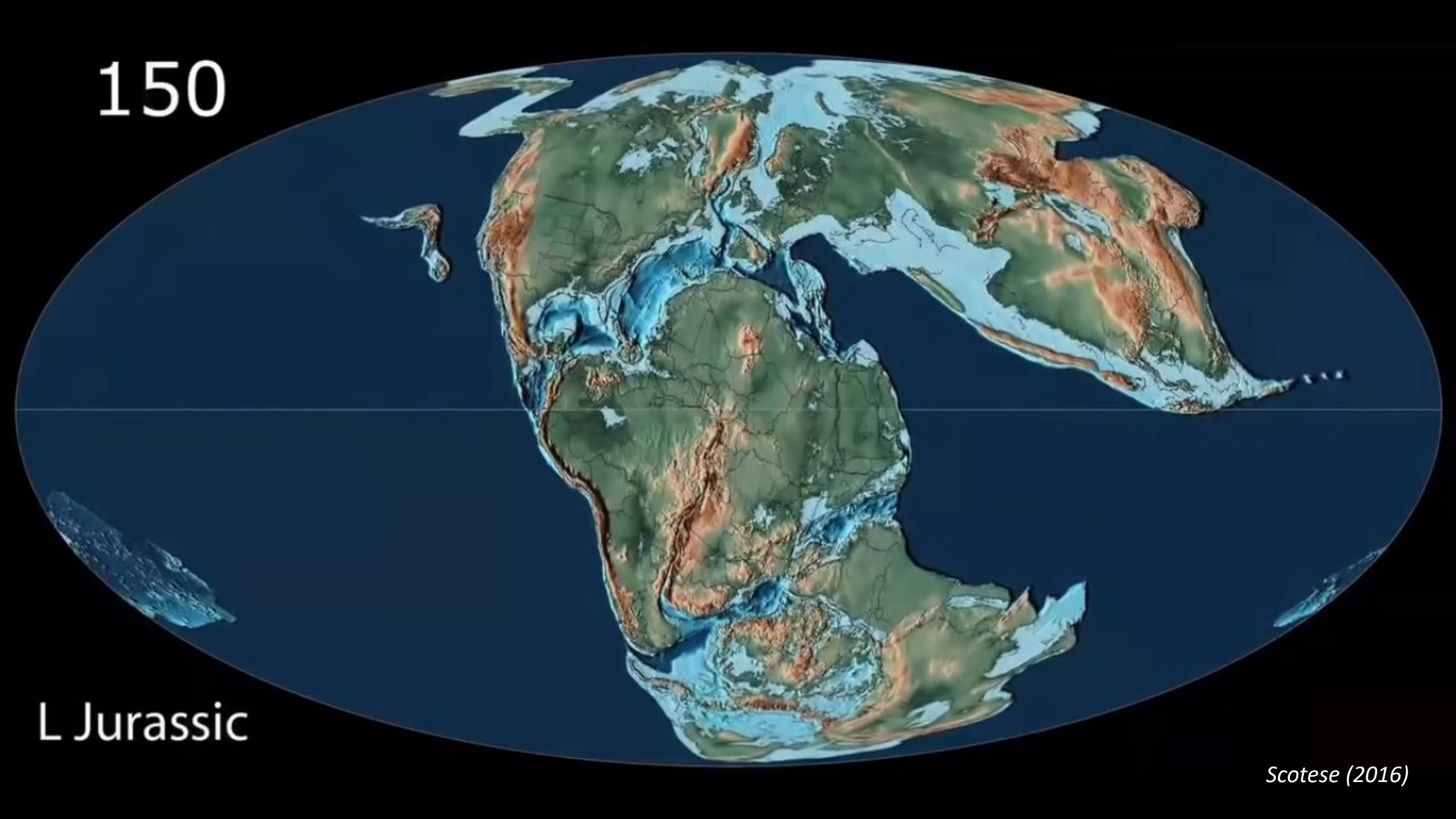

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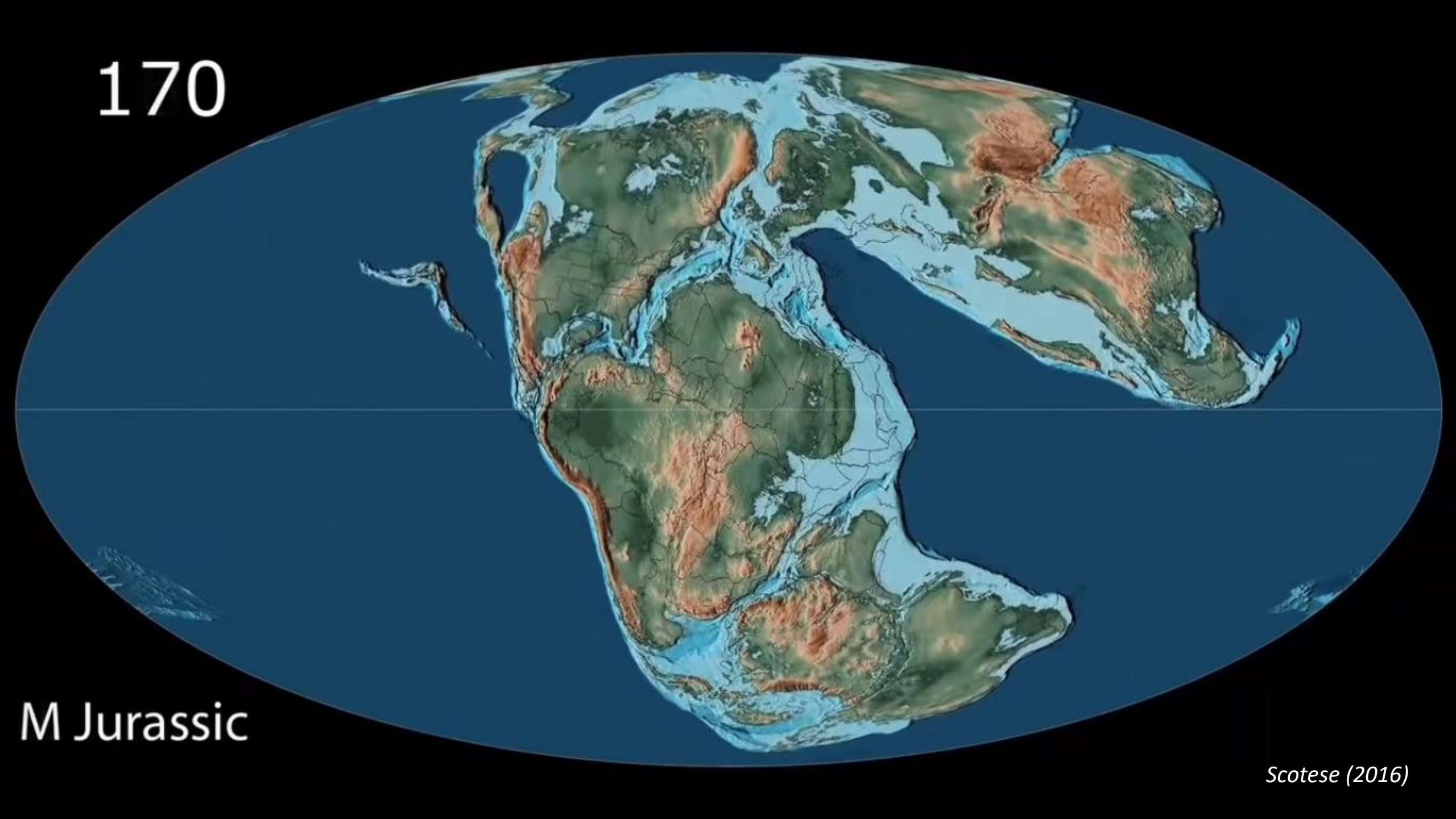
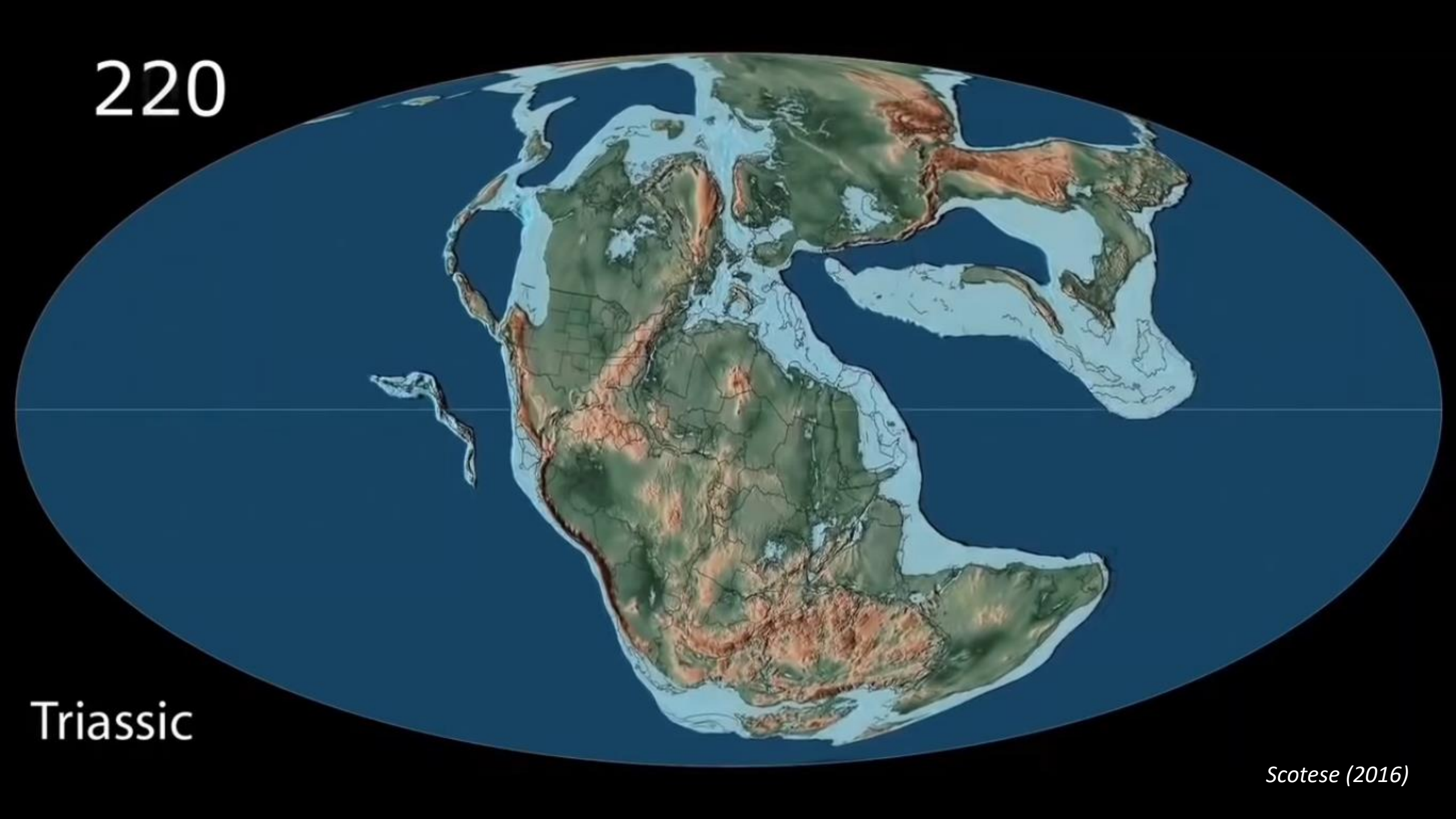


Scotese (2016)

Scotese (2016)



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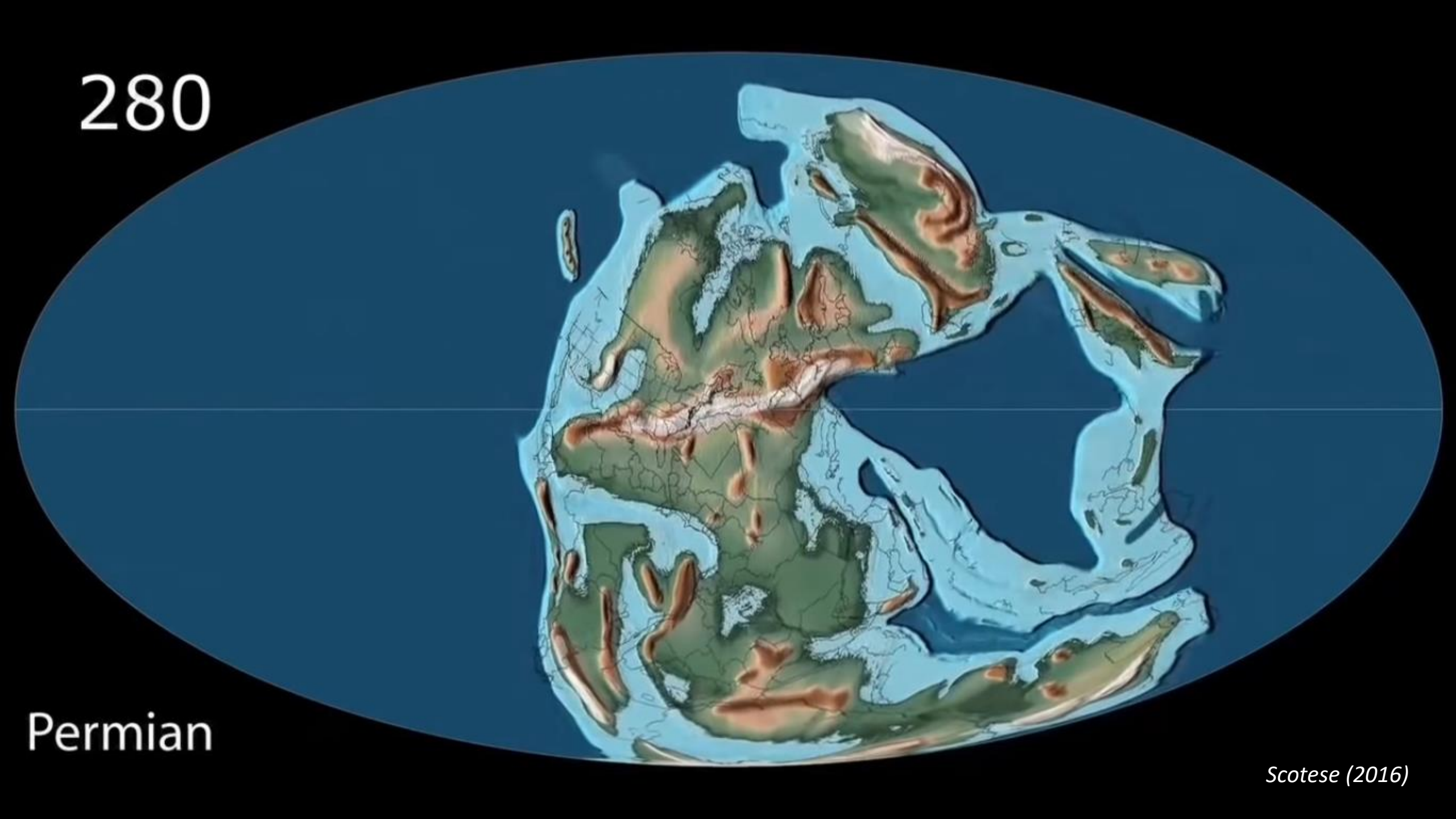

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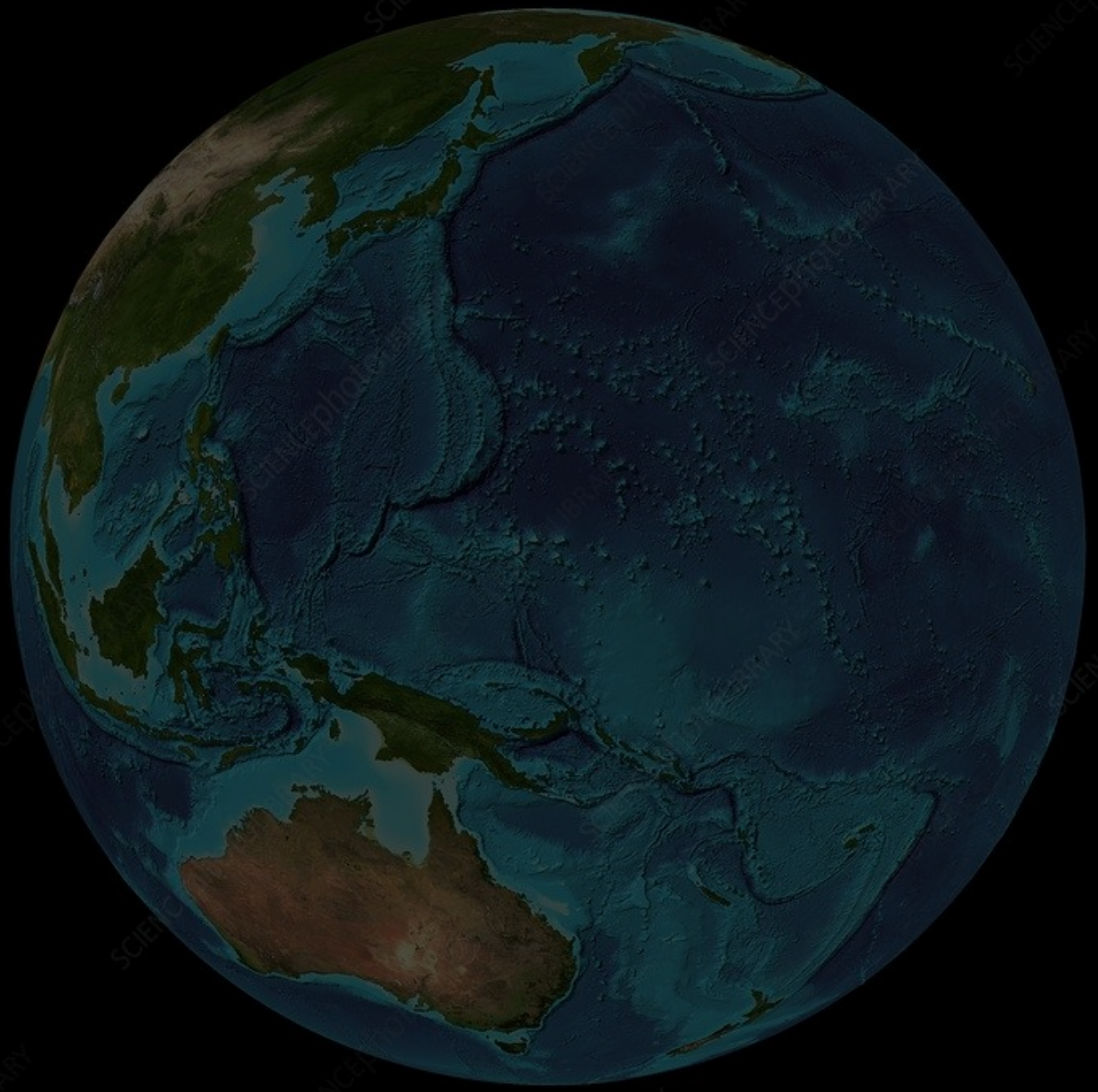

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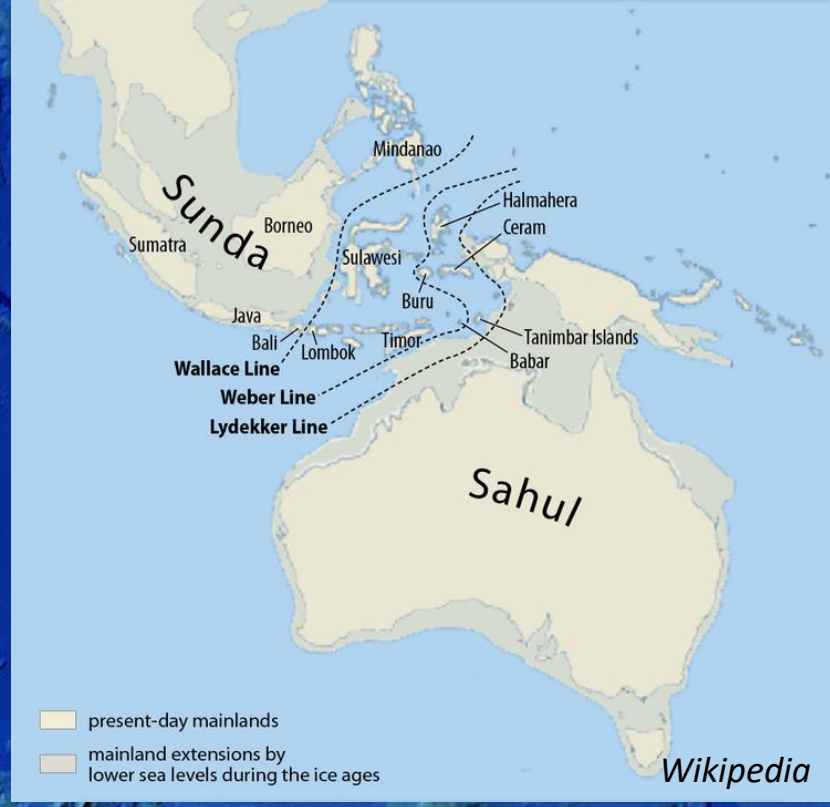
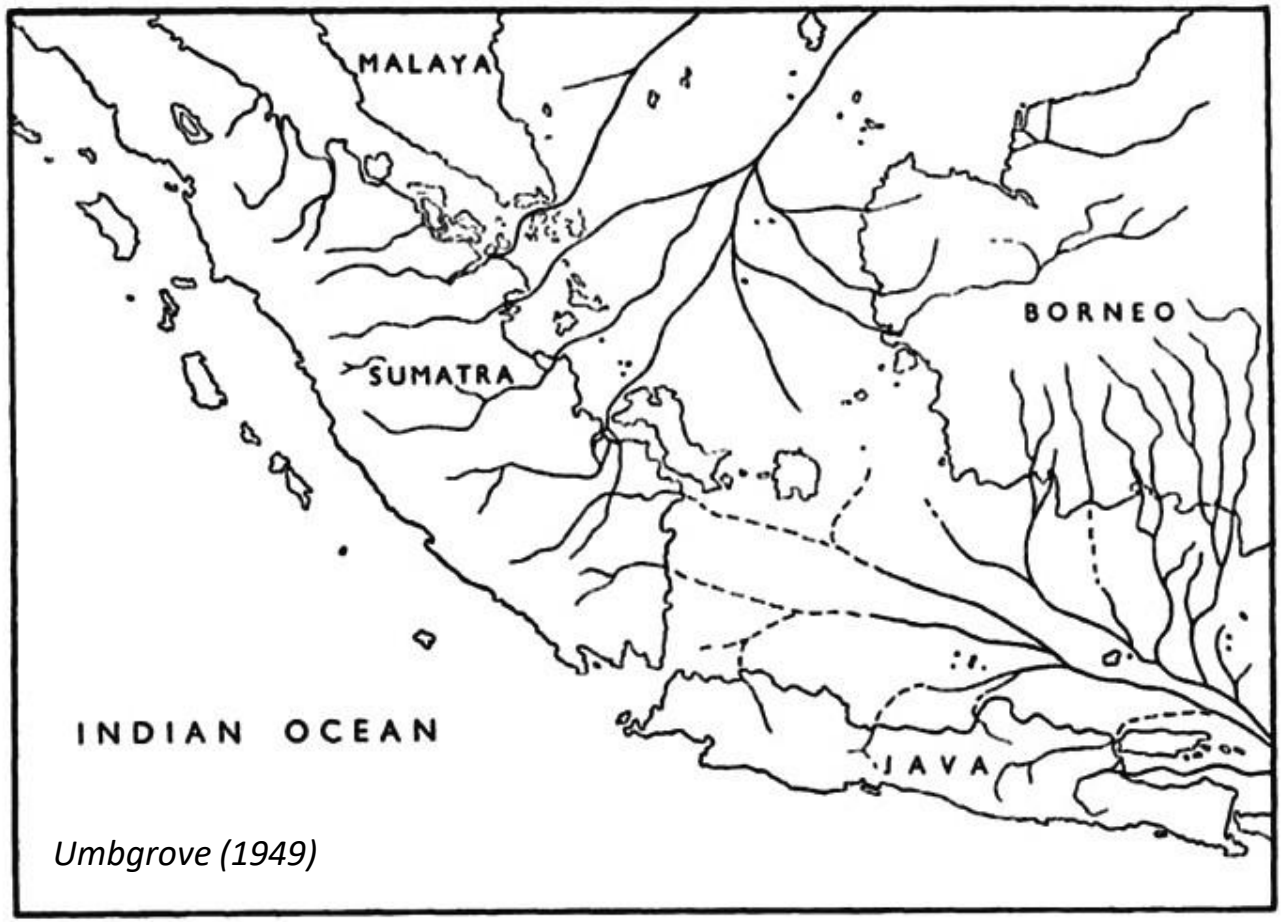
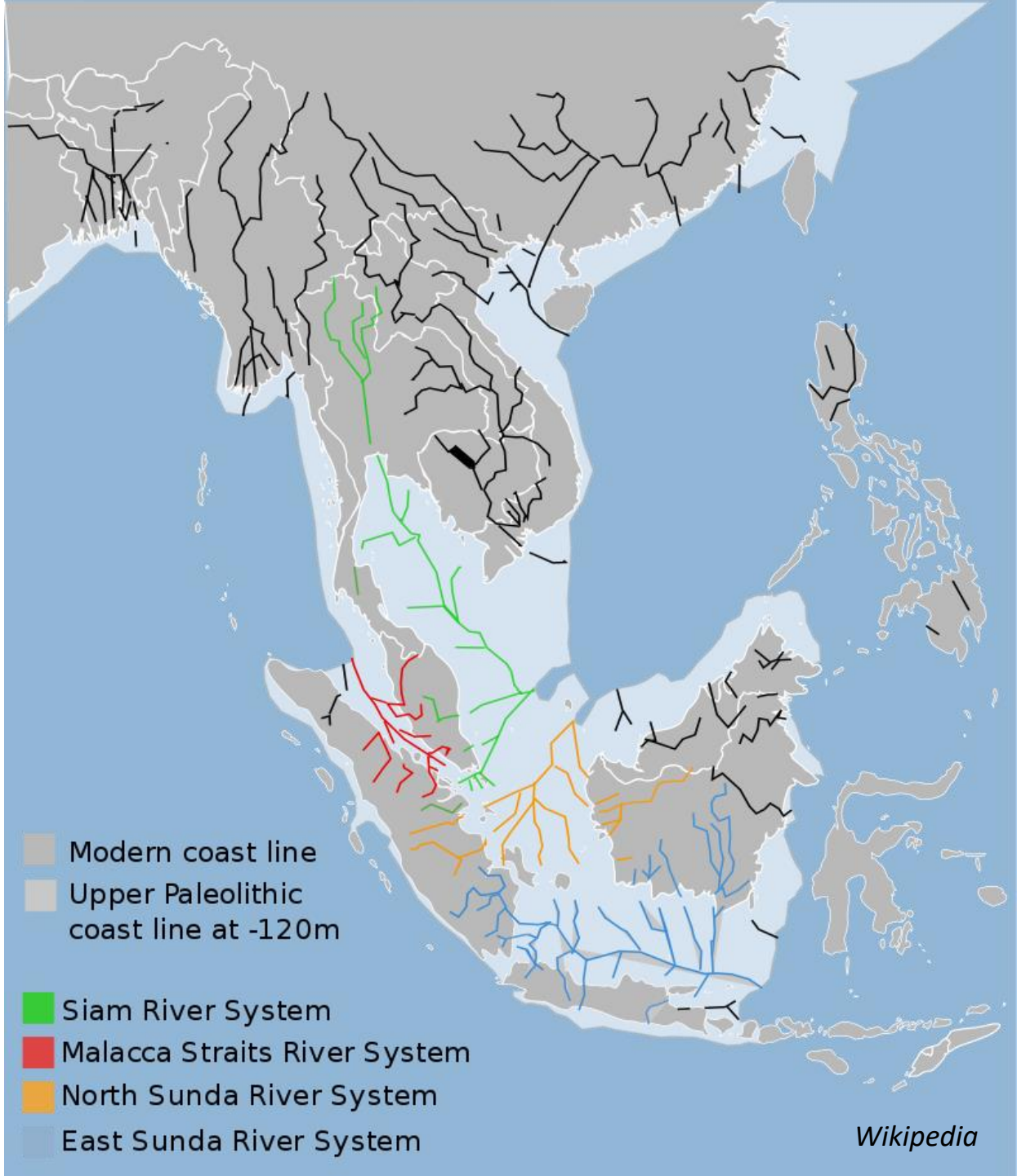
Fisiografi Indonesia



Wikipedia

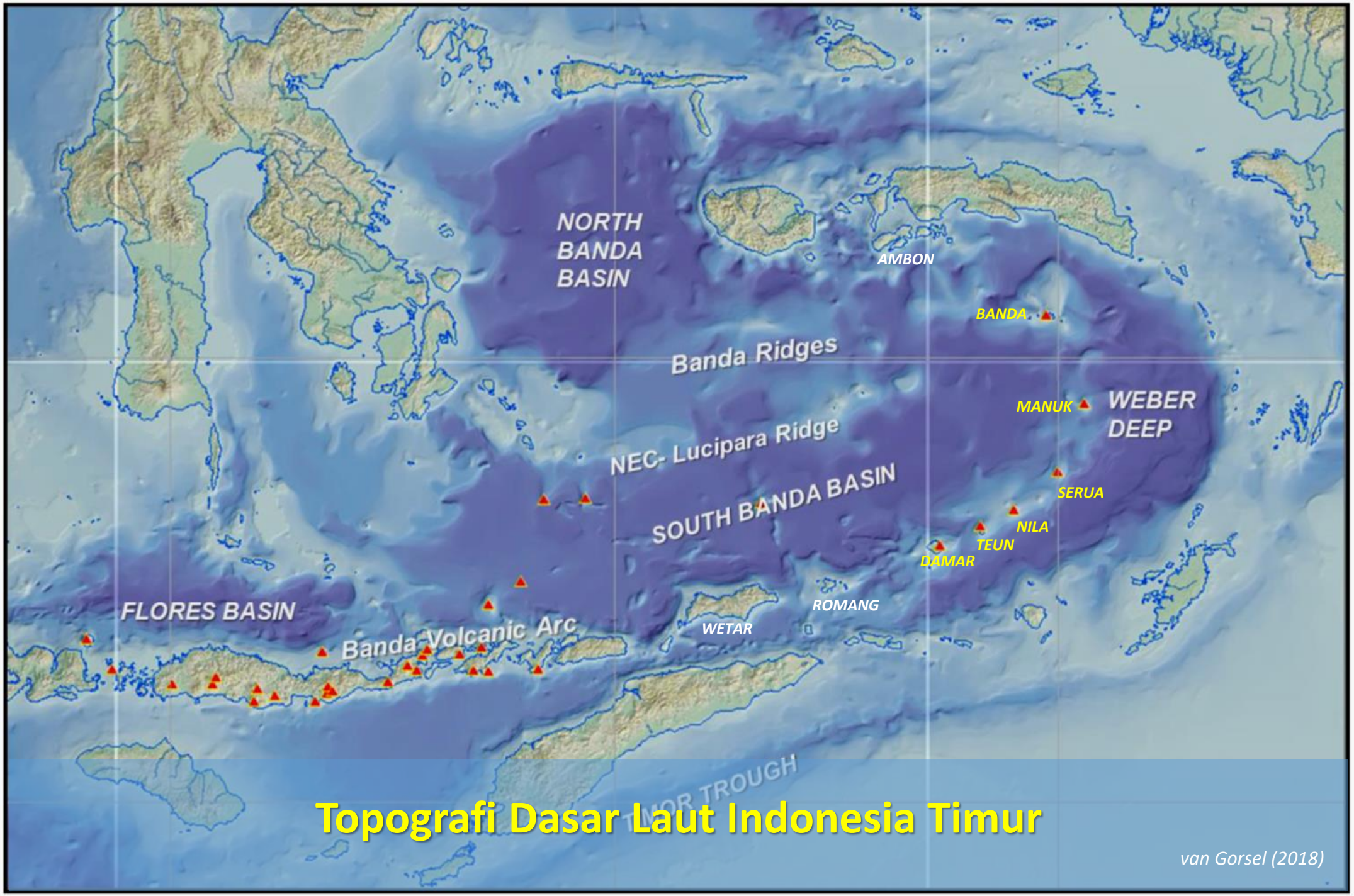


Umbgrove (1949)



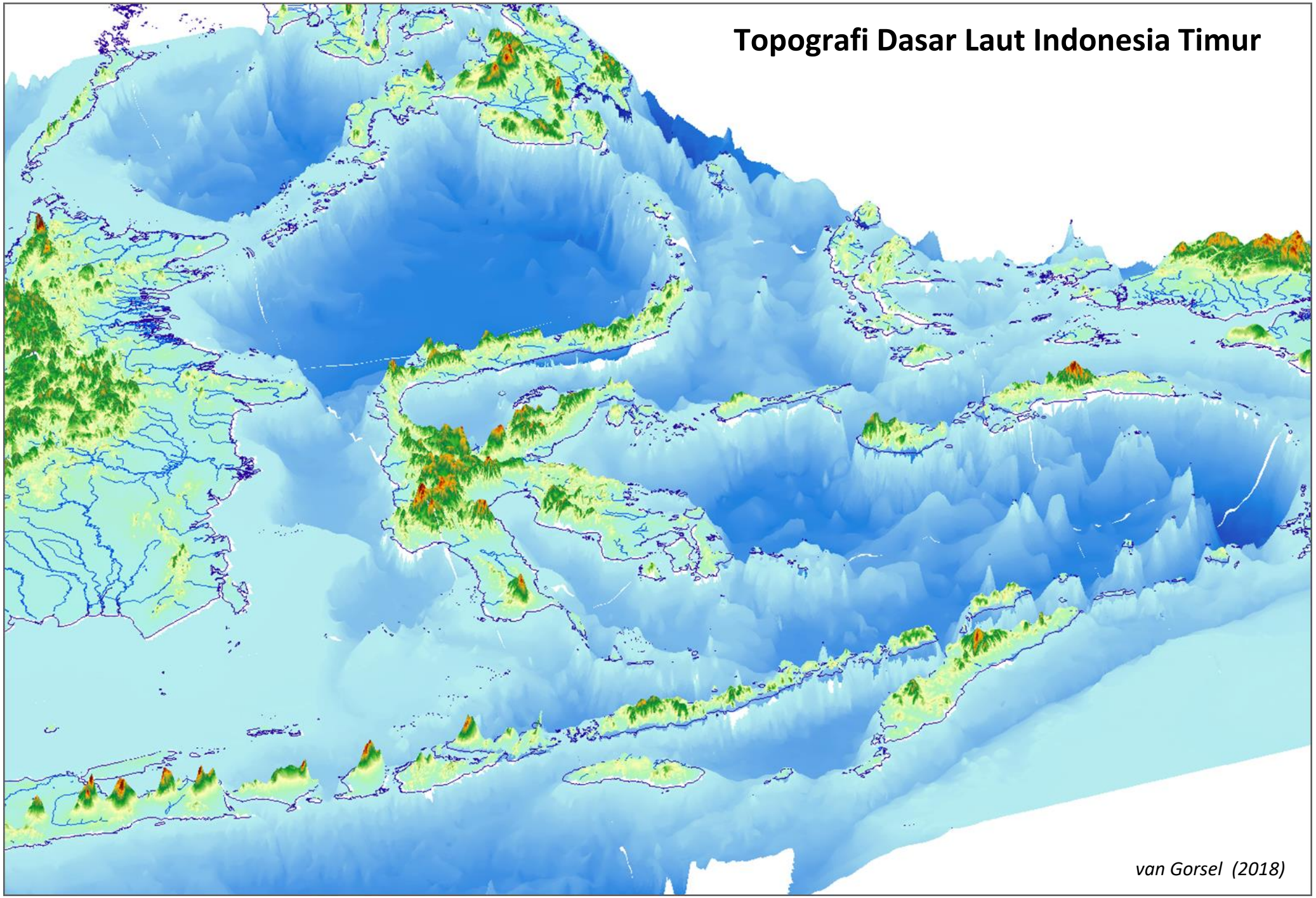
Wikipedia

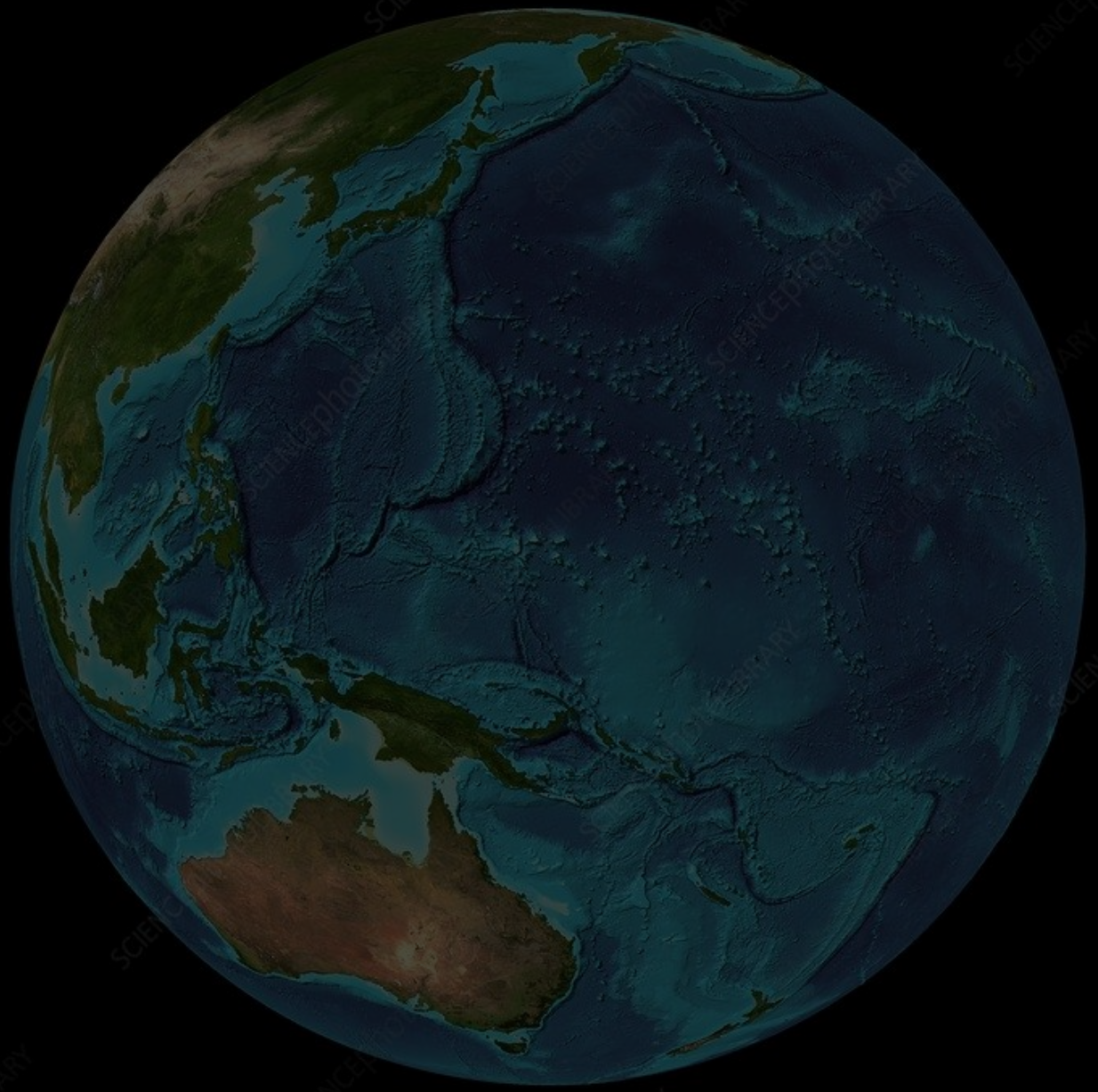
“Molengraaff’s Sunda River System



Topografi Dasar Laut Indonesia Timur

van Gorsel (2018)


Topografi Dasar Laut Indonesia Timur
van Gorsel (2018)



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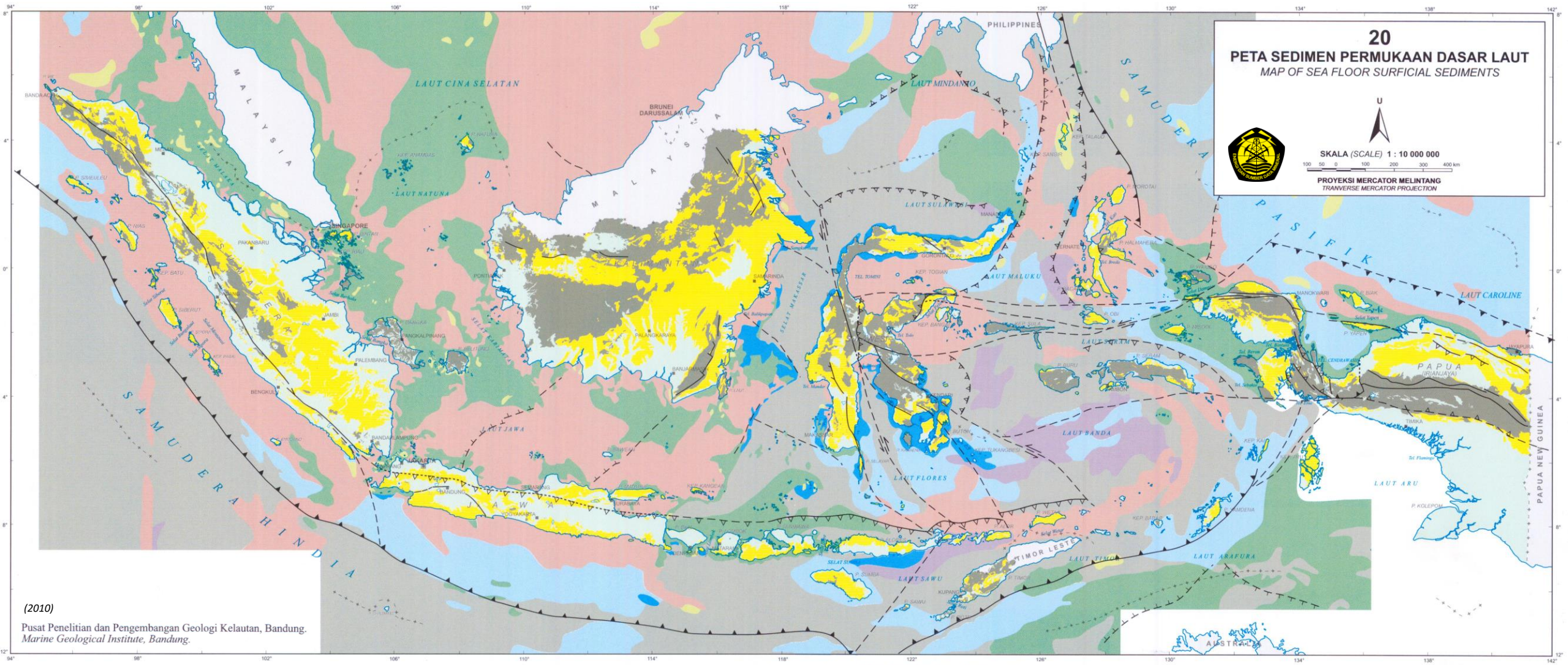
20
PETA SEDIMEN PERMUKAAN DASAR LAUT
MAP OF SEA FLOOR SURFICIAL SEDIMENTS
U
SKALA (SCALE) 1 : 10 000 000
100 50 0 100 200 300 400 km
PROYEKSI MERCATOR MELINTANG
TRANVERSE MERCATOR PROJECTION
PHILIPPINES
LAUT CINA SELATAN
LAUT MINDANAO
SAMUDERA PASIFIK
BRUNEI DARUSSALAM
MALAYSIA
SINGAPORE
PAKANBARU
JAMBI
PALEMBANG
BENGKULU
JAKARTA
BANDUNG
SEMARANG
SURABAYA
YOGYAKARTA
SAMARINDA
PALANGKARAYA
BANJARMASIN
MAKASSAR
KUPANG
TIMOR LESTE
LAUT NATUNA
LAUT JAWA
LAUT SULAWESI
LAUT MALUKU
LAUT BANDA
LAUT FLORES
LAUT SAWU
LAUT TIMOR
LAUT ARAFURA
LAUT ARU
LAUT CAROLINE
PAPUA (IRIANJAYA)
PAPUA NEW GUINEA
SAMUDERA HINDIA
AUSTRALIA
SELAT MAKASSAR
SELAT SUNDA
SELAT MALAKA
SELAT KARIMATA
MANOKWARI
TIMIKA
JAYAPURA
P. KOLEPOM
P. SUMBA
P. SAWU
P. TIMOR
P. BURU
P. SERAM
P. HALMAHERA
P. OBI
P. MOROTAI
P. NIAS
P. SIMEULUE
P. BATU
P. SIBERUT
P. BIAK
P. YAPEN
P. MEUTAI
P. MALAYAN
P. KANGEAN
P. BELITUNG
P. BATAM
P. TIOMAN
P. NATUNA
KEP. ANAMBAS
KEP. TOGIAN
KEP. SULA
KEP. BANGGAI
KEP. BURU
KEP. TANIMBAR
KEP. KAI
KEP. BABAR
KEP. TIMOR
KEP. KANGEAN
KEP. PADAI
KEP. BATU
KEP. PALAUD
KEP. SANGIR
TEL. TOMINI
TEL. TOLO
TEL. MANDAR
TEL. TUKANGBESI
TEL. BERAU
TEL. SAWU
TEL. FLAMINGO
SELAT SUNDA
SELAT SAWU
SELAT BERAU
SELAT MAMBERAMO
SELAT LAPEN
SELAT MALAKA
SELAT SIBERUT
SELAT BANGKA
SELAT BELITUNG
SELAT KARIMATA
SELAT MAKASSAR
SELAT BALIKPAPAN
SELAT TIOMAN
SELAT MAMBERAMO
SELAT LAPEN
SELAT SAWU
SELAT WETAR
SELAT TIMOR
SELAT SUNDA
BANDA ACEH
MEDAN
PANGKALPINANG
BANDAR LAMPUNG
TERNATE
MANADO
GORONTALO
KUPANG
MAMUDEA
CENDERAWASIH
KEP. KAI
KEP. BABAR
KEP. TIMOR
KEP. TANIMBAR
KEP. SULA
KEP. BANGGAI
KEP. TOGIAN
KEP. PALAUD
KEP. SANGIR
KEP. ANAMBAS
KEP. KANGEAN
KEP. PADAI
KEP. BATU
KEP. BELITUNG
KEP. TIOMAN
KEP. BATAM
KEP. SIMEULUE
KEP. NIAS
KEP. BATU
KEP. SIBERUT
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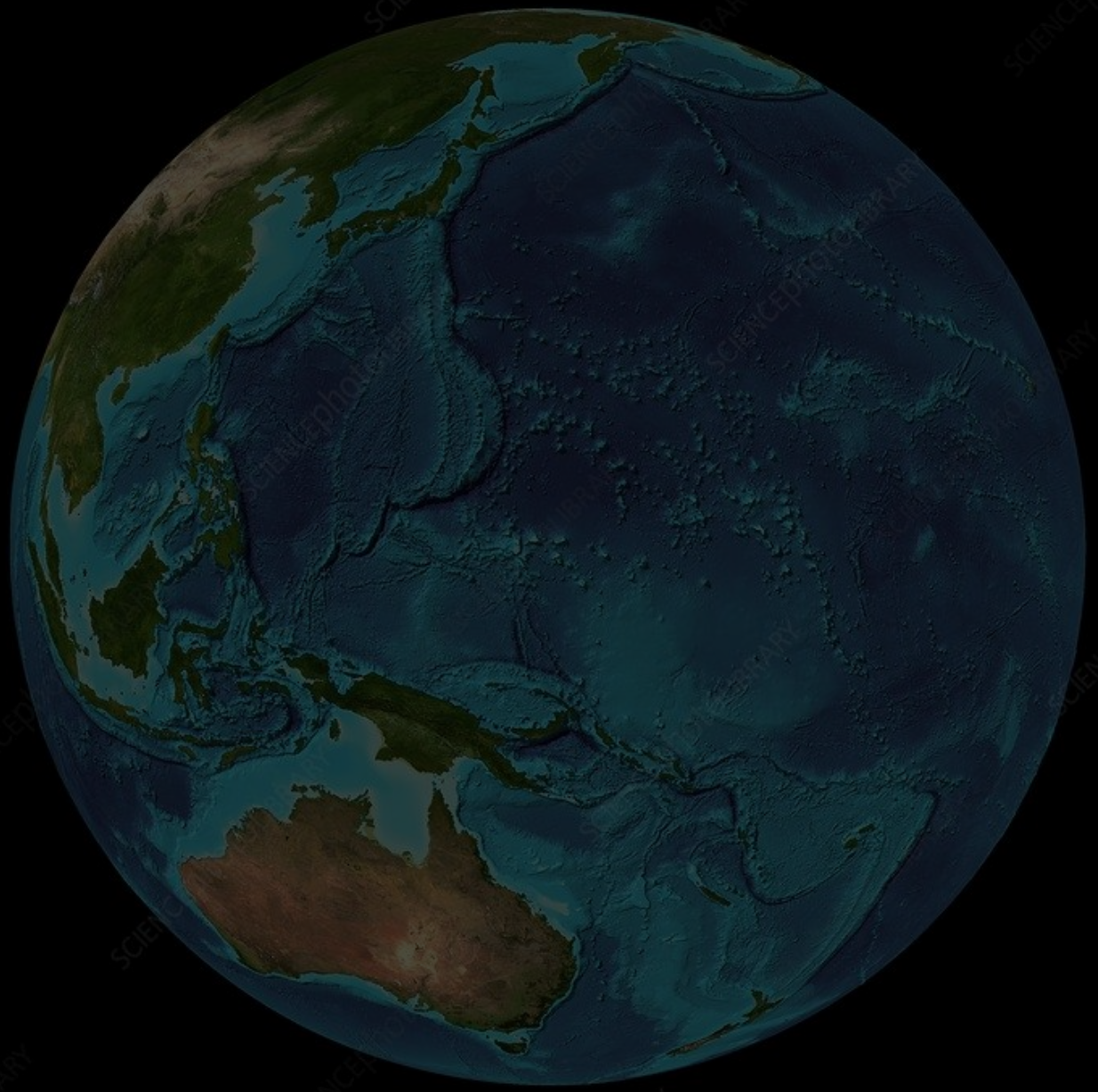
KEP. TANIMBAR
KEP. KAI
KEP. BABAR
KEP. TIMOR



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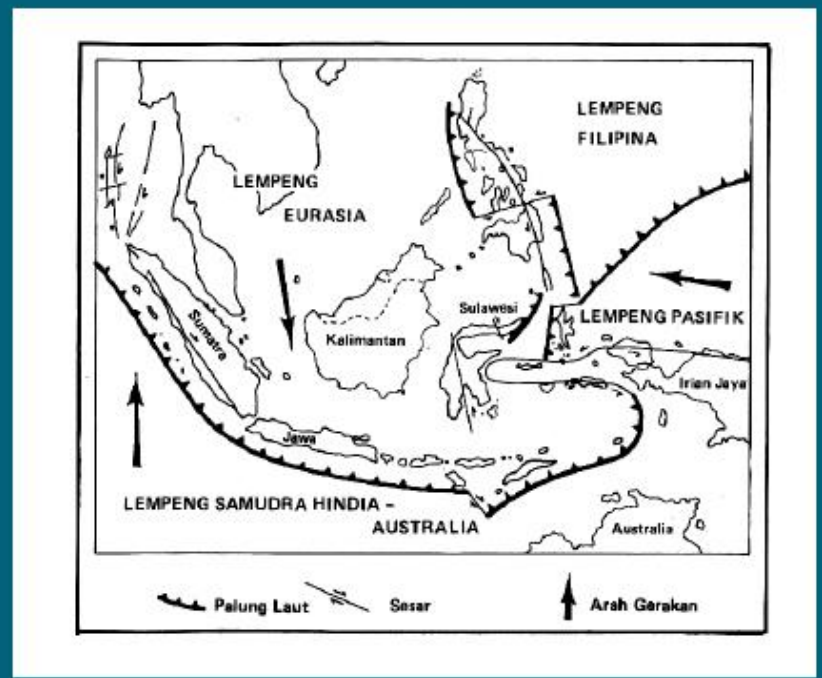
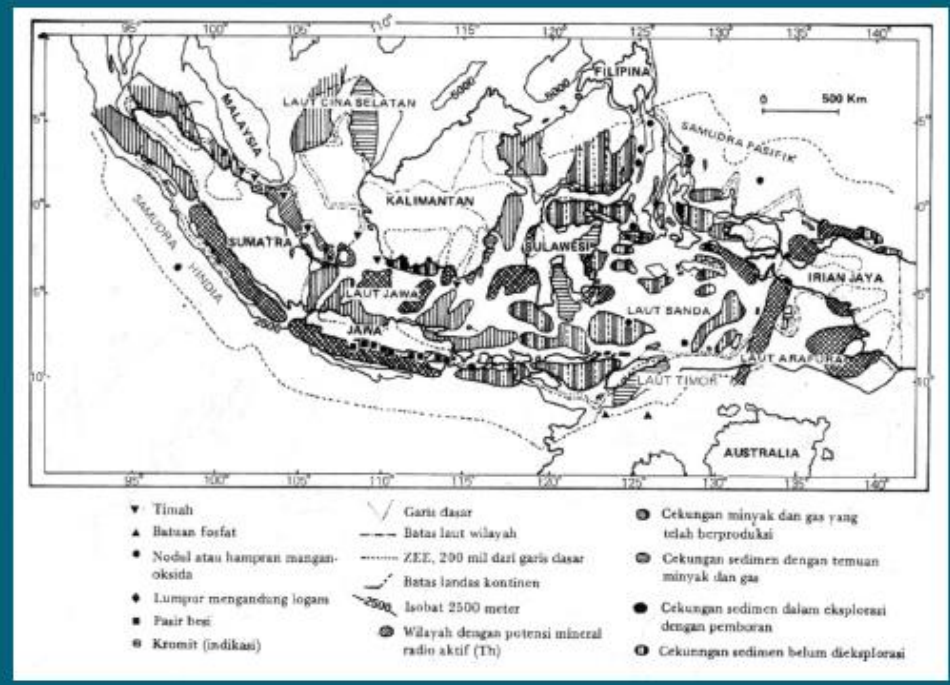
9. Sumber Daya Geologis Kelautan Indonesia
10. Konservasi Laut Indonesia

J.A. KATILI

SEATAR (STUDIES ON SOUTHEAST ASIA TECTONIC AND RESOURCES), **1973 - 1988**

- MELIBATKAN LEBIH 10 KAPAL RISET
- GAMBARAN YG LEBIH JELAS TTG KARAKTERISTIK TEKTONIK DAN STRUKTUR GEOLOGI PERAIRAN NUSANTARA
- MEMBUKA PELUANG PENAMBANGAN LEPAS PANTAI





Nontji (2010)

EKSPEDISI SNELLIUS II (1984 – 1985)

EKSPEDISI OSEANOG. TERBESAR KERJASAMA IND.- BELANDA ,DGN KAPAL "TYRO" SBG KPL UTAMA

LIMA TEMA PENELITIAN:

1. **PELAGIC ECOSYSTEM**
2. **VENTILATION OF DEEP-SEA BASINS**
3. **RIVER INPUT AND OCEAN SYSTEMS**
4. **GEOLOGY AND GEOPHYSICS**
5. **CORAL REEFS**

MELIBATKAN 450 ORANG PENELITI DAN TEKNISI, INDONESIA DAN BELANDA

Nontji (2010)

Program Baruna Jaya dimulai tahun 1980

Pelaksanaan program Baruna Jaya untuk inventarisasi potensi sumber daya laut di Indonesia secara Mandiri oleh Menteri Negara Riset dan Teknologi/Kepala Badan Pengkajian dan Penerapan Teknologi (BPPT), Prof Dr. Ing. BJ. Habibie pada tahun 1980.

Pengadaan Kapal Riset Baruna Jaya I, II dan III antara Badan Pengkajian dan Penerapan Teknologi(BPPT)–dengan Arteliers et Chantiers de la Manche(ACM)–Perancis tanggal 11 Februari 1985. Kapal tersebut masing-masing mempunyai dedikasi sebagai Kapal Riset Oseanografi, Hidrooseanografi,Multipurpose Geologi-Geofisika (1986).

Penandatanganan kontrak pengadaan Kapal Riset Baruna Jaya IV antara BPPT dengan Sociate D'Armement Maritme et de Transports (SAMT)/Contructions Mecaniques de Normandie(CMN) pada tanggal 19 Oktober 1993 yang didekasikan untuk riset khusus perikanan dan oseanografi.

Berdasarkan persetujuan Menpan Nomor : B/569/M.OAN/3/2004 tanggal 25 Maret 2004 dan keputusan Kepala BPPT Nomor : 046/Kp/KA/IV/2004 tertanggal 21 April 2004, UPT Baruna Jaya digantikan dengan unit kerja baru yang disebut Balai Teknologi Survei Kelautan–BPPT.

Hananto Nugroho (Webinar IAGI Maluku, 8 Feb. 2022)

KAPAL-KAPAL OSEANOGRAFI GENERASI BARU

PENINGKATAN KEMAMPUAN DAN KERAGAMAN SURVEI DAN PENELITIAN LAUT

Nontji (2010)

BPPT #INOVASI INDONESIA #BPPT2021 SOLIDSMARTSPEED

Kapal Riset Di Indonesia

Baruna Jaya 1 (BPPT)

Baruna Jaya 2 (BPPT)

Baruna Jaya 3 (BPPT)

Baruna Jaya 4 (BPPT)

Baruna Jaya 7 (LIPI)

Baruna Jaya 8 (LIPI)

KRI 933 Rigel (PUSHIDROS)

KRI 934 Spica (PUSHIDROS)

Madidihang 3 (KKP)

Madidihang 2 (KKP)

Bawal Putih 3 (KKP)

Geomarine 3 (ESDM)

Yudo Haryadi (webinar BPPT, 22 Juli 2021)

Peralatan Riset di Indonesia

- **Remote Operate Vehicle (ROV)**

BPPT, Pushidros, PPGL

- **Autonomous Underwater Vehicle (AUV)**

Pushidros

- **Multibeam Echosounder (MBES)**

BPPT :~3km, ~7km, ~11km

Pushidros : ~7km

PPGL ; ~3km

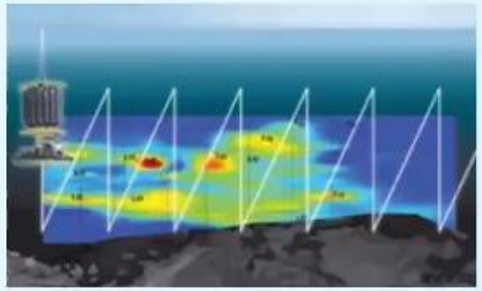
LIPI ; ~3km

Yudo Haryadi (webinar BPPT, 22 Juli 2021)

Peralatan Riset Di Indonesia

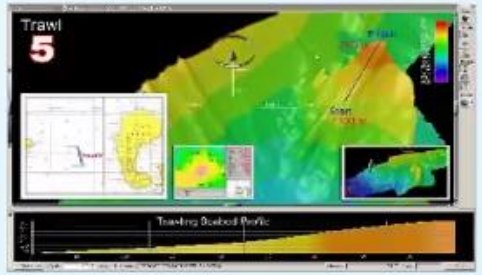
- **CTD 7 WATER SAMPLER**

BPPT, PUSHIDROSAL, LIPI, PPGL



- **DREDGENG, BOX CORER**

BPPT, PUSHIDROSAL, LIPI, PPGL



- **VIDEO & SSS**

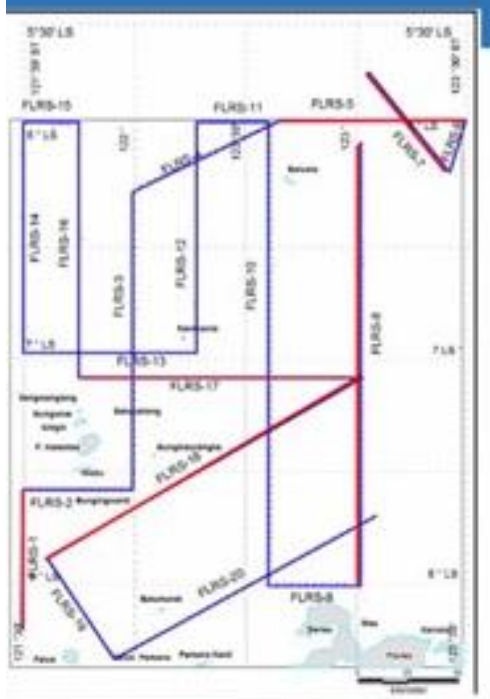
BPPT, PUSHIDROSAL, PPGL

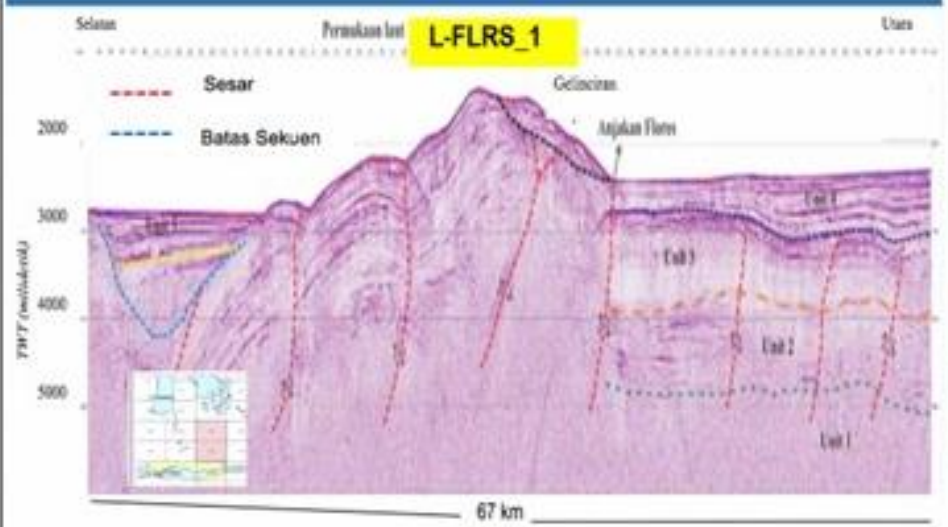
- **CSEM ;**

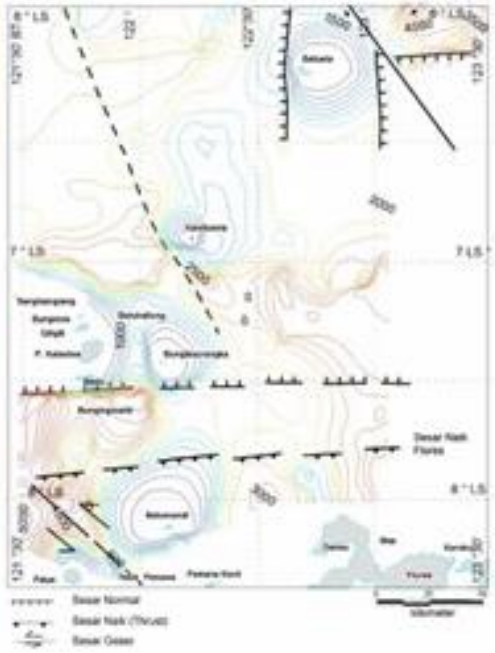
Belum tersedia

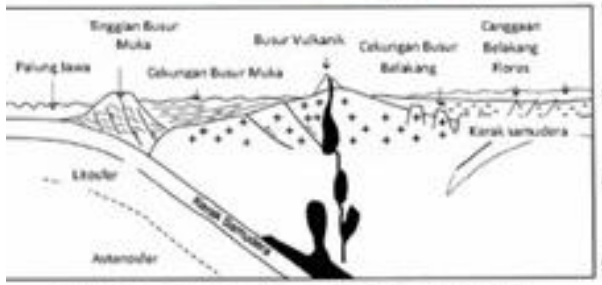
Yudo Haryadi (webinar BPPT, 22 Juli 2021)

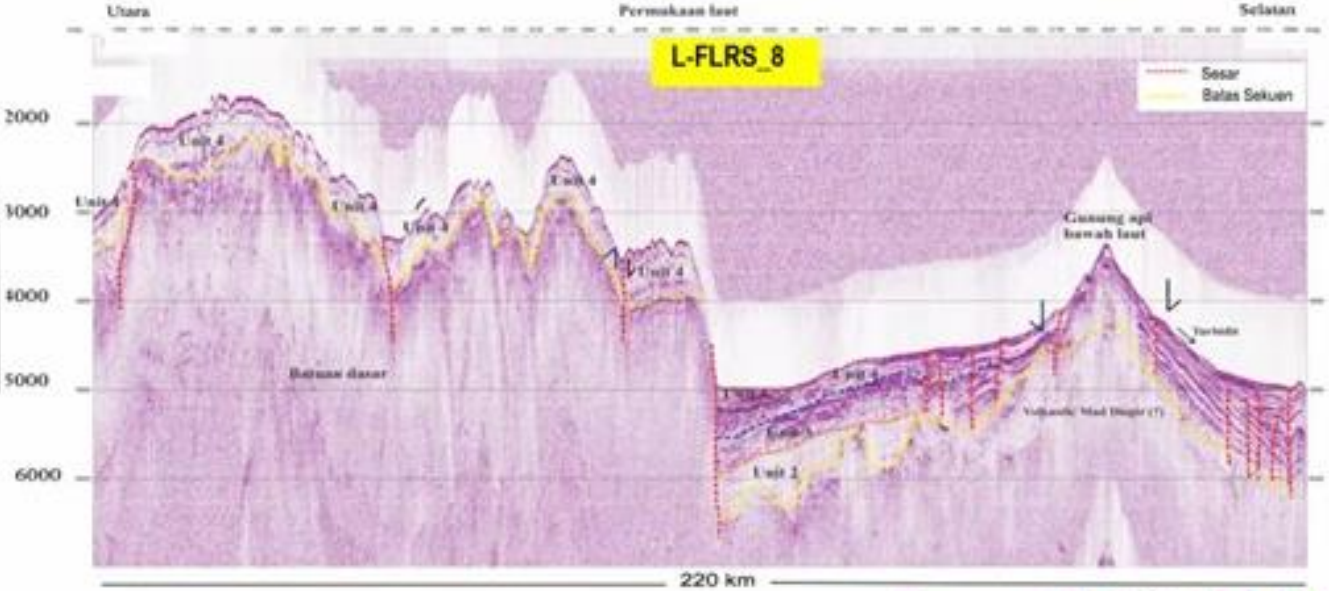
Perairan Laut Flores, NTT









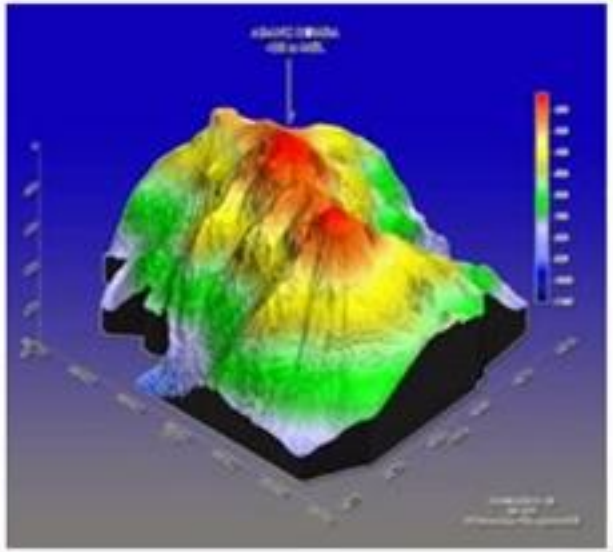


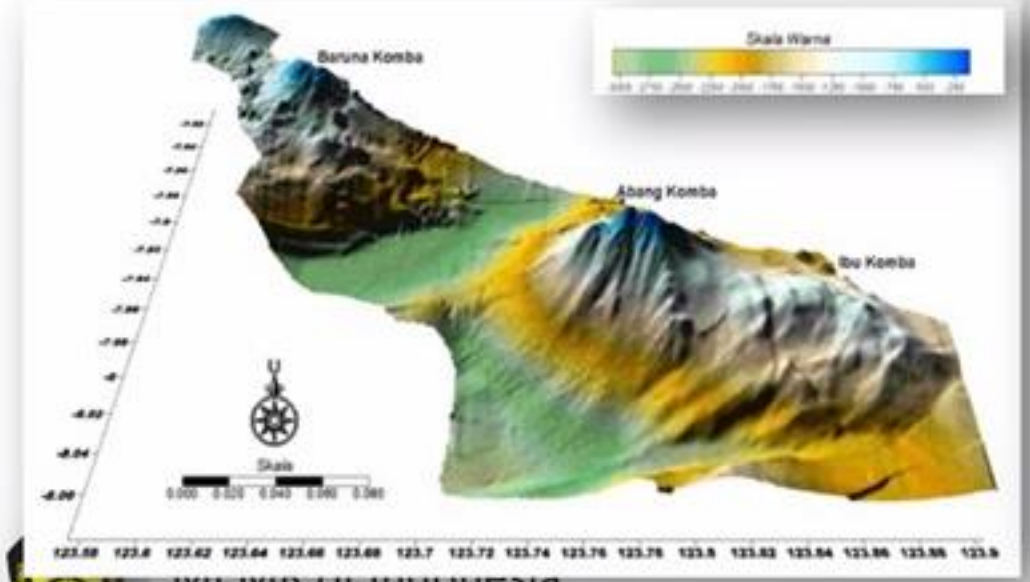
Noor Cahyo (Webinar IAGI Maluku, 8 Feb. 2022)

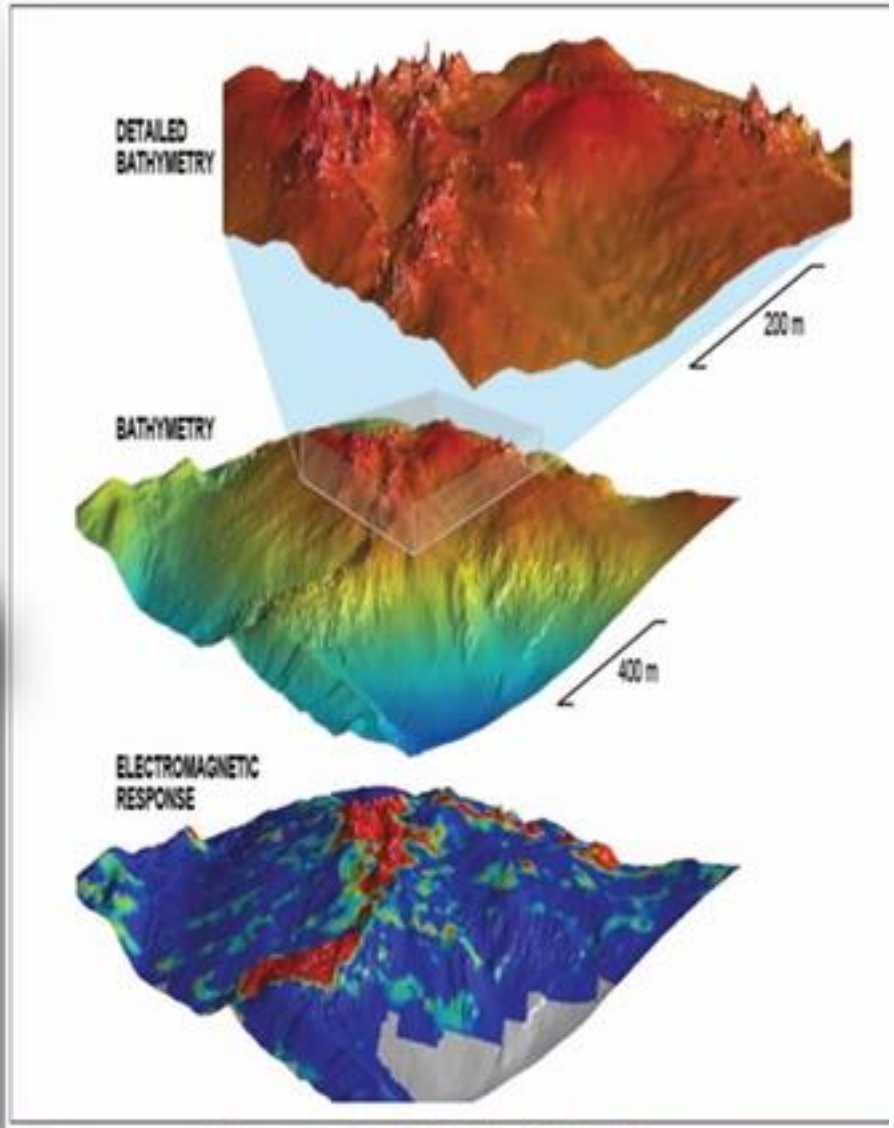
Rahardiawan & Purwanto, 2014

MEMR of Indonesia

Submarine volcano characterization (2009)

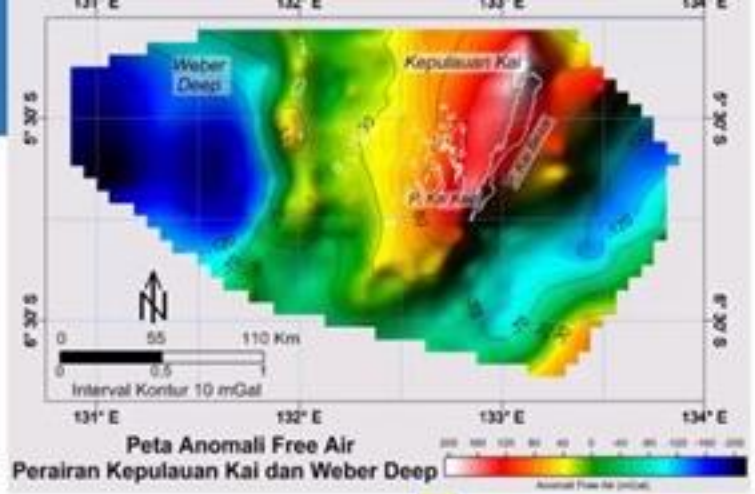




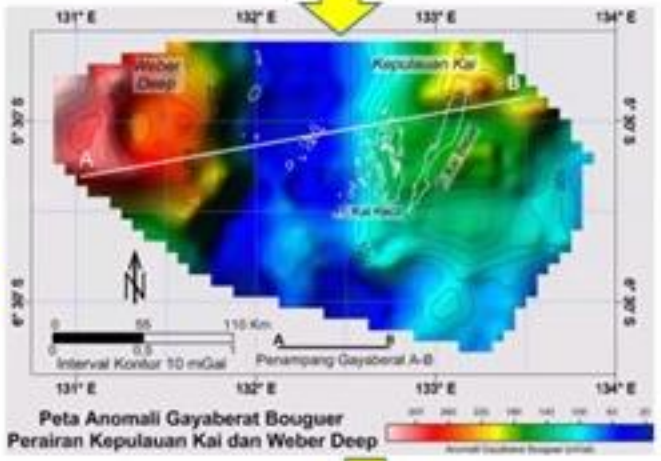


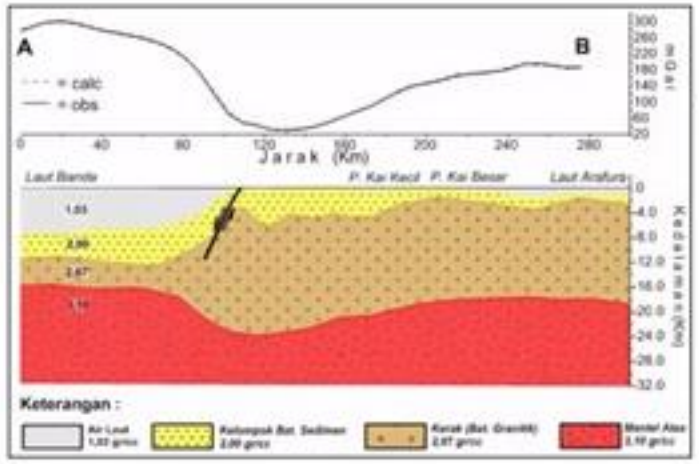
Noor Cahyo (Webinar IAGI Maluku, 8 Feb. 2022)

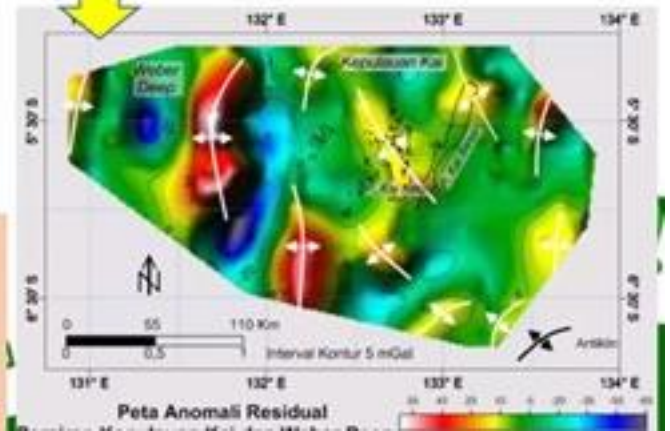
Perairan Kep. Kai, Maluku



(Miranda, dkk., 2020)







Noor Cahyo (Webinar IAGI Maluku, 8 Feb. 2022)

Nilai anomaly tinggi pada peta anomali residual daerah penelitian, diinterpretasikan tinggian (basement high) yang memisahkan cekungan Weber dan cekungan Aru, sedangkan anomali rendah diduga sebagai deposenter dari sub cekungan yang ada pada cekungan utama

Secara umum riset samudera dapat dikelompokkan dalam 4 tema besar

Geosains Kelautan

- Membangun model konseptual tentang dinamika kerak samudera, zona subduksi dan sesar aktif berdasarkan termuan baru data geosains kelautan
- Pemahanan sumber bencana dari laut dan upaya mitigasinya.
- Aktivitas hidrotermal bawah laut dan potensi sumberdaya alam terkait (mineral and bioresources)
- Area Beyond National Jurisdiction (ABNJ), mineral dasar laut
- Dinamika busur belakang dan eksplorasi migas frontier termasuk gas hidrat

Biologi Kelautan termasuk Perikanan

- Deskripsi dan kajian keanekaragaman hayati pada berbagai skala mulai dari ekosistem, spesies, mikro hingga molekuler serta potensi pemanfaatan dan pemuliaan
- Koleksi data dan informasi sumber daya hayati makro, mikro dan molekuler (DNA barcoding, environmental DNA, sekuensing dan analisis bioinformatika serta database genome, marine debris).
- Silkus hidup ikan dan hewan laut berpotensi ekonomi tinggi di WKP RI
- Pemahaman interaksi lingkungan laut dalam dari aspek mikroorganisme dan fauna beserta proses evolusinya
- Ekosistem ekstrim laut dalam

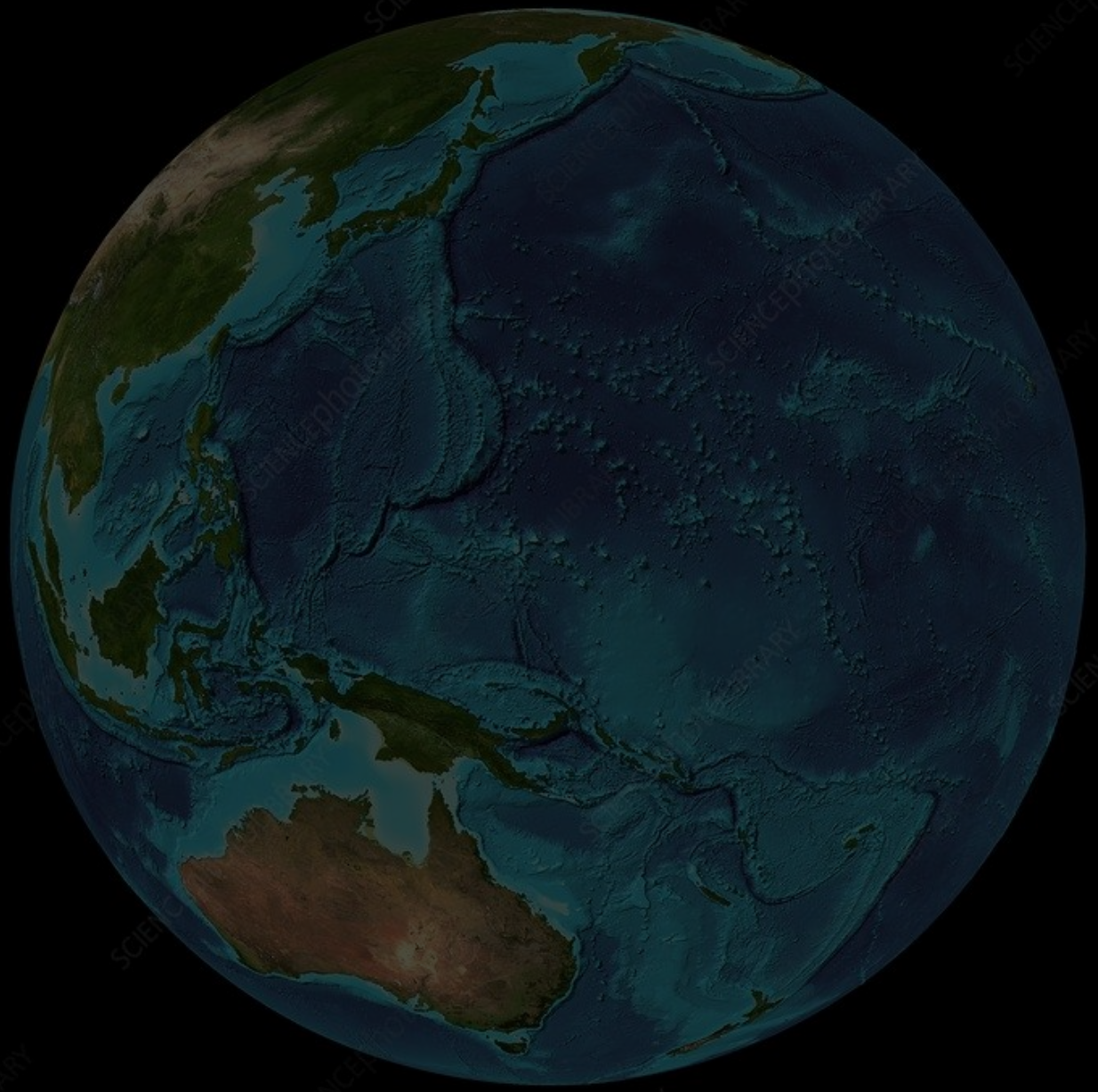
Oseanografi dan Sains Atmosfer

- Riset tentang Arlindo (Indonesian Trough Flow, ITF), upwelling dan mixing, internal wave serta fenomena oseanografi lainnya
- Riset tentang interaksi samudera – atmosfer dan implikasnya
- Riset pengasaman laut dan dampaknya pada ekosisistem tropis.
- Kesehatan dan pencemaran laut serta marine debris (makro dan mikro)
- **Oseanografi observasi, instrumentasi, komputasi dan IOT**

Pemetaan Lantai Samudera

- Pemetaan dasar laut pesisir, lautan dan samudera
- Pemetaan landas kontinen dan potensi ekstensi landas kontinen
- Pemetaan morofolgi khusus dasar laut seperti gunung laut, patahan dasar laut dan gunung lumpur
- Pemetaan resolusi tinggi untuk keperluan industri

Hananto Nugroho (Webinar FTG Unpad, 3 Feb. 2022)



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan Indonesia

1. Wilayah Kelautan Indonesia
2. Sejarah Penyelidikan Kelautan Indonesia
3. Tektonik dan Evolusi Cekungan Kelautan Indonesia
4. Topografi Dasar Kelautan Indonesia
5. Sedimentasi Kelautan Indonesia
6. Status Masa Kini Penelitian Kelautan Indonesia
7. **Pengelolaan Kelautan Indonesia**
8. Bencana Geologis Kelautan Indonesia
9. Sumber Daya Geologis Kelautan Indonesia
10. Konservasi Laut Indonesia

PENGELOLAAN RUANG LAUT DALAM RPJMN 2020 - 2024

Arifin Rudiyanto (webinar BPPT, 22 Juli 2021)

Kementerian PPN/ Bappenas

PN 1

PP : Peningkatan pengelolaan kemaritiman, perikanan dan kelautan

KP : Peningkatan pengelolaan Wilayah Pengelolaan Perikanan (WPP) dan penataan ruang laut dan rencana zonasi pesisir serta pengelolaan ruang laut

ProP : Penataan Ruang Laut dan Rencana Zonasi Pesisir

- Perairan laut antar wilayah yang memiliki dokumen RZ Kawasan Antar Wilayah yang ditetapkan melalui peraturan perundangan
- Kawasan Strategis Nasional dan Kawasan Strategis Nasional Tertentu yang memiliki Rencana Zonasi KSN dan Rencana Zonasi KSNT yang ditetapkan melalui peraturan perundangan
- Provinsi yang memiliki dokumen penyelenggaraan rencana zonasi

ProP : Pengendalian Pemanfaatan Ruang Laut

- Pengendalian Pemanfaatan Ruang laut
- Fasilitasi Pengelolaan Reklamasi

KP : Peningkatan ekosistem kelautan dan pemanfaatan jasa kelautan

ProP : Pengembangan wisata bahari dan jasa maritim

- Kawasan yang dibangun sarana prasarana Wisata Bahari dan BMKT
- Kawasan konservasi yang dimanfaatkan secara berkelanjutan

KP : Peningkatan produksi, produktivitas, standardisasi mutu dan nilai tambah produk kelautan dan perikanan

ProP : Peningkatan Produksi garam

- Lahan Garam yang difasilitasi
- Pembangunan Sarana Niaga Garam Rakyat

PN 4

PP : Meningkatkan Pemajuan Dan Pelestarian Kebudayaan

KP : Pengembangan dan Pemanfaatan Kekayaan Budaya untuk memperkuat karakter bangsa dan kesejahteraan rakyat

ProP : Pengembangan budaya bahari dan sumber daya maritim

Masyarakat hukum adat, tradisional dan lokal di Pesisir dan PPK yang diakui dan dikuatkan kelembagaannya

PN 6

PP : Peningkatan kualitas lingkungan hidup

KP : Pencegahan Pencemaran dan Kerusakan Sumber Daya Alam dan Lingkungan Hidup

ProP : Pencegahan Kehilangan Keanekaragaman Hayati dan Kerusakan Ekosistem

- Kawasan Konservasi perairan, pesisir dan pulau pulau kecil baru (nasional dan daerah) yang ditetapkan
- Kawasan konservasi perairan, pesisir dan pulau pulau kecil yang operasional
- Jejaring, Kemitraan/Kerjasama Konvensi Konservasi Keanekaragaman Hayati Laut
- Keanekaragaman hayati perairan terancam punah yang dilindungi dan/atau dilestarikan
- Pelaku usaha pemanfaatan kawasan konservasi perairan nasional yang diperiksa kepatuhannya

KP : Peningkatan Ketahanan Iklim

ProP : Perlindungan Kerentanan Pesisir dan Sektor Kelautan

- Kawasan pesisir dan pulau pulau kecil yang meningkat ketangguhannya terhadap bencana dan dampak perubahan iklim
- Data dan/atau Informasi Pemetaan Sumberdaya Kawasan Pesisir
- Data dan/atau Informasi Pemetaan Karakteristik dan Dinamika Laut di WPP
- Kawasan di pesisir dan pulau pulau kecil yang direhabilitasi

PENETAPAN RENCANA ZONASI KAWASAN ANTAR WILAYAH (RZ KAW) DALAM PP 32/2019 TENTANG RENCANA TATA RUANG LAUT

sumber: Direktorat Perencanaan Ruang Laut, Ditjen PRL KKP (2019)

1 Laut Natuna & Natuna Utara	6 Laut Sulawesi	11 Laut Sawu	16 Teluk Tomini
2 Laut Jawa	7 Laut Halmahera	12 Selat Makassar	17 Teluk Cendrawasih
3 Laut Bali	8 Laut Seram	13 Selat Malaka	18 Laut Barat Sumatera
4 Laut Banda	9 Laut Maluku	14 Selat Sunda	19 Laut Selatan Jawa, Bali & Nustra
5 Laut Aru	10 Laut Flores	15 Teluk Bone	20 Laut Utara Papua

Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)

RENCANA ZONASI KAWASAN ANTAR WILAYAH LAUT FLORES
RENCANA POLA RUANG LAUT

sumber: Direktorat Perencanaan Ruang Laut, Ditjen PRL KKP (2021)

RENCANA POLA RUANG LAUT DI PERAIRAN PESISIR

Kawasan Pemanfaatan Umum

Kawasan Pemanfaatan Umum, masih dimungkinkan untuk menjadi peruntukan lainnya dalam rencana zonasi yang lebih detil

Kawasan Konservasi

Pencadangan Kawasan

Kawasan Konservasi Lainnya sesuai Peraturan Perundang-undangan

Kawasan Konservasi, masih dimungkinkan untuk menjadi peruntukan lainnya dalam rencana zonasi yang lebih detil

Alur Laut

Alur Pelayaran Umum dan Perlintasan
Alur Kabel Bawah Laut
Alur Migrasi Penyu
Alur Migrasi Cetacea
Alur Migrasi Tuna
Alur Migrasi Lumba-lumba

Alur Laut, masih dimungkinkan untuk menjadi peruntukan lainnya dalam rencana zonasi yang lebih detil

Kawasan Pemanfaatan Umum

- Zona Perikanan Tangkap
- Zona Perikanan Budidaya
- Zona Pariwisata
- Zona Pengelolaan Energi Baru dan Terbarukan

Kawasan Konservasi

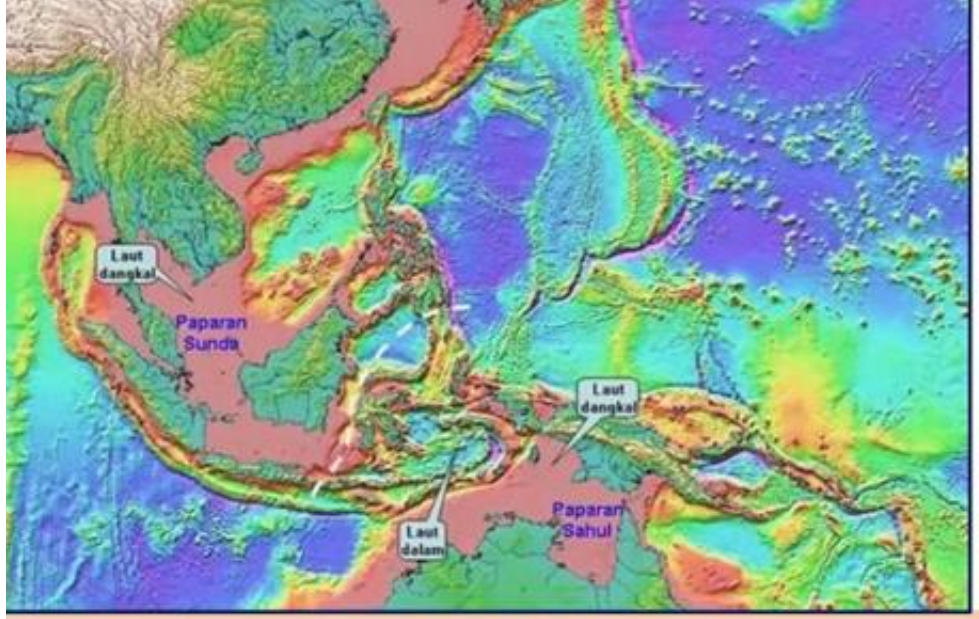
- Kawasan Konservasi Perairan

Alur Laut

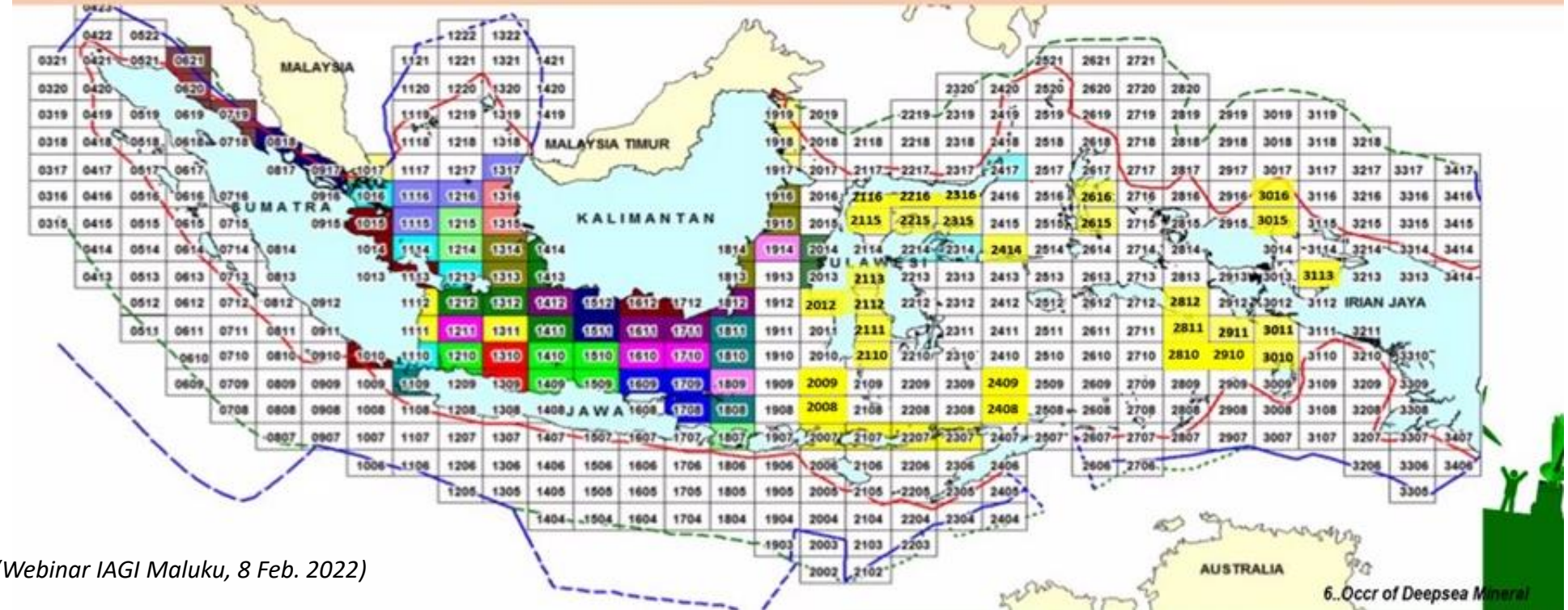
- Alur Pelayaran yang berupa Alur Pelayaran Umum dan Perlintasan
- Alur Pipa/Kabel Bawah Laut
- Alur Migrasi Penyu
- Alur Migrasi Cetacea
- Alur Migrasi Tuna
- Alur Migrasi Lumba-Lumba

Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)

Sebaran Laut *dalam* indeks peta



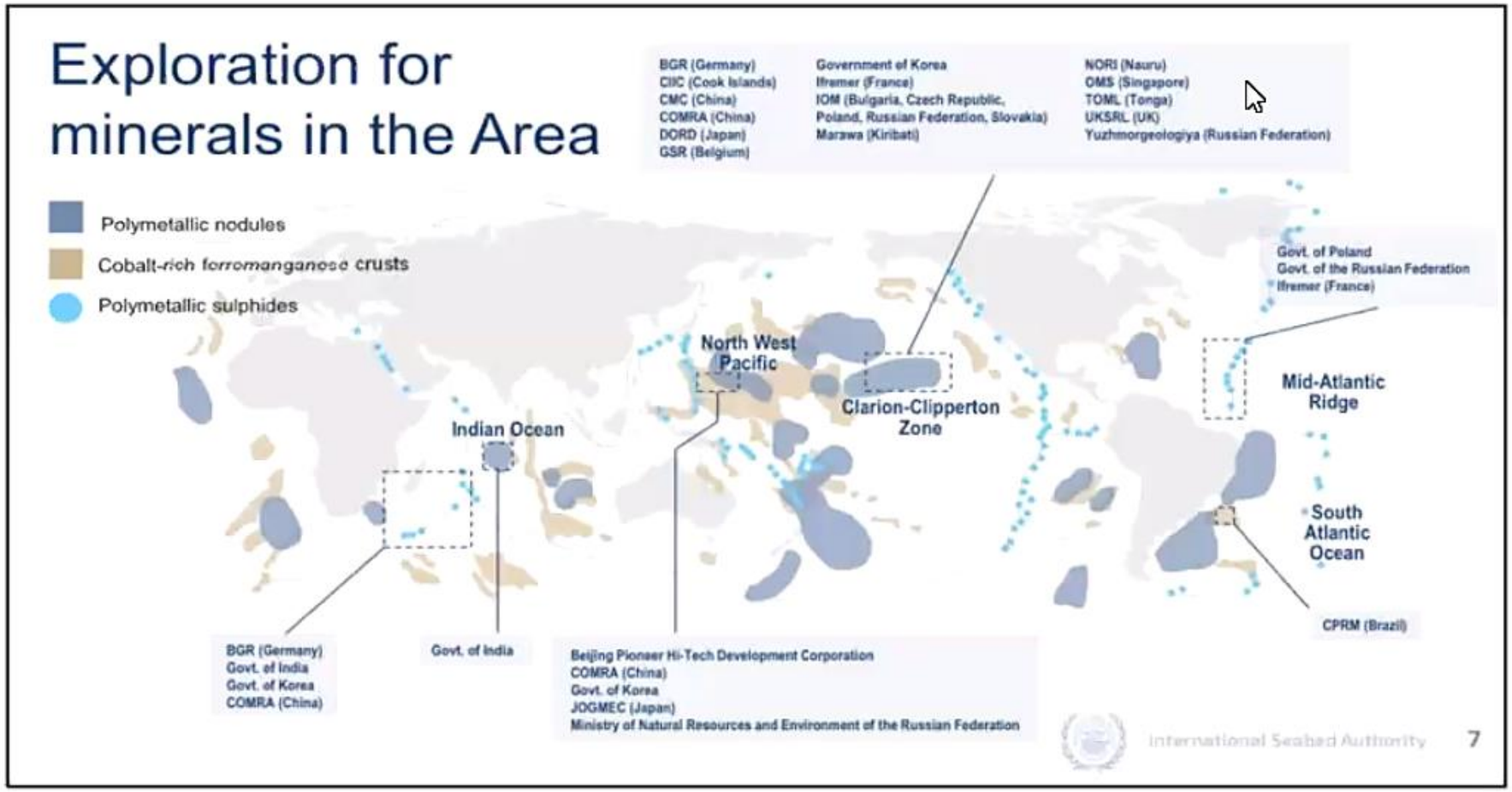
Sejak tahun 1986 - 2018 telah dipetakan 130 dari 365 lembar peta skala 1:250.000 (±35 %).



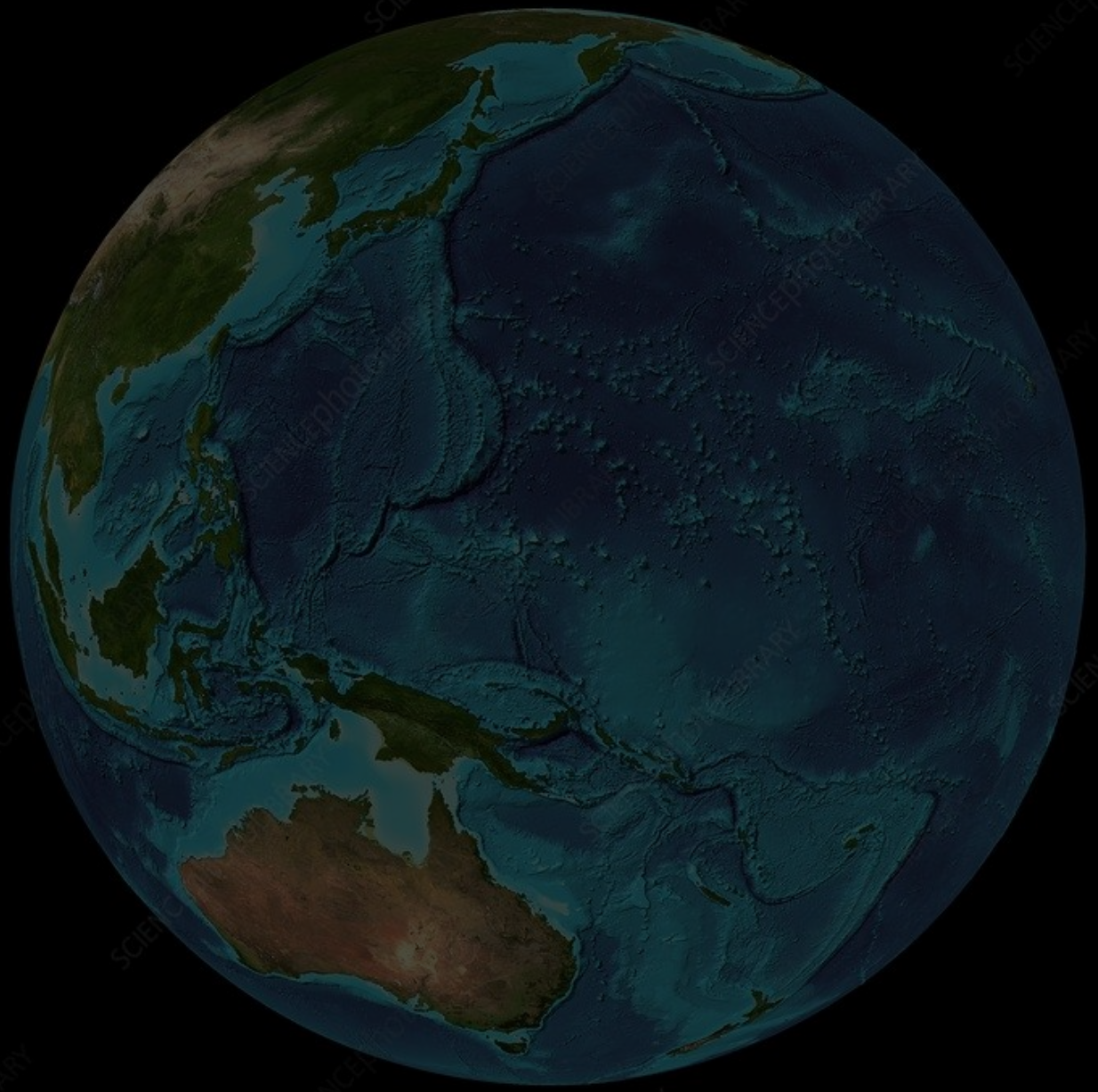
Noor Cahyo (Webinar IAGI Maluku, 8 Feb. 2022)

Indonesia harus segera berperan aktif

Indonesia harus segera berperan aktif dalam pengelolaan sumber daya mineral di Kawasan Dasar Laut Internasional (KDLI) di luar wilayah yurisdiksi negara pada kawasan dasar laut Samudera Hindia dan Samudera Pasifik setelah mendapatkan persetujuan Otoritas Dasar Laut Internasional (ISA) sebagai organisasi yang mendapat mandat PBB.



Ridwan Djamaluddin (webinar BPPT, 22 Juli 2021)



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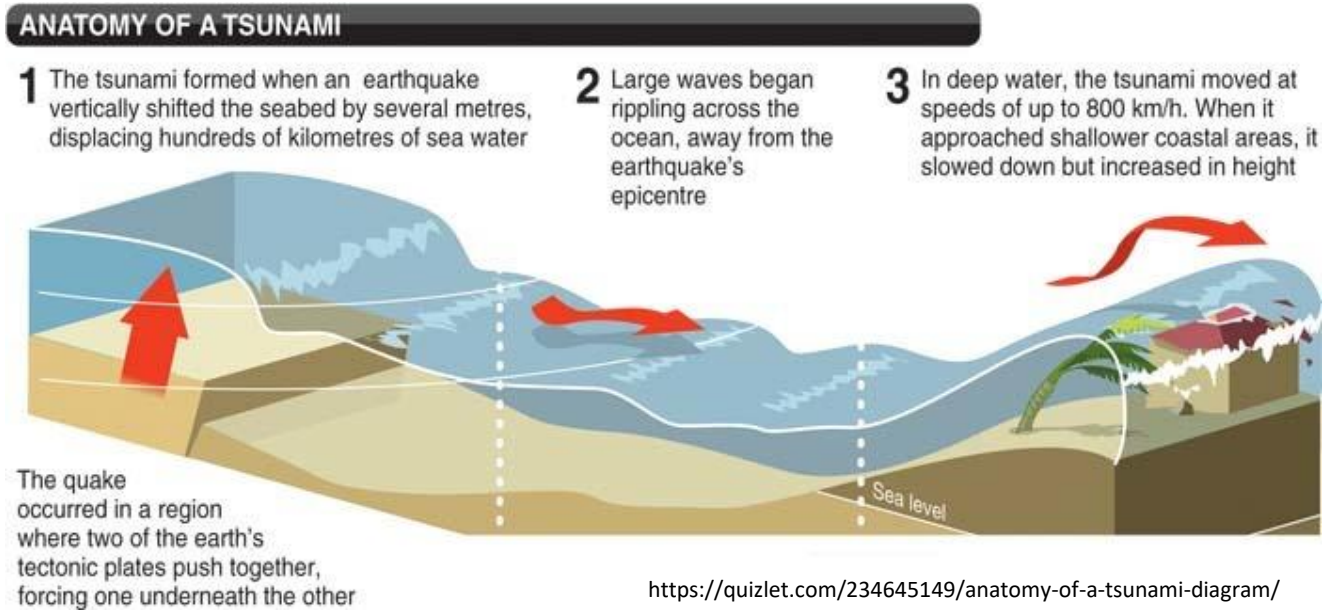
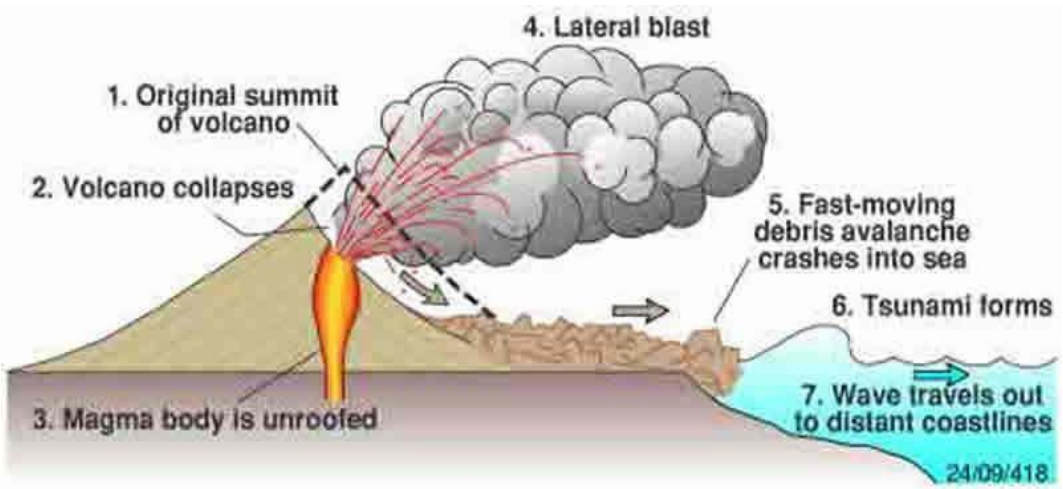
Daryono - BMKG (2021)

Sources of Tsunami



https://quizlet.com/234645149/anatomy-of-a-tsunami-diagram/

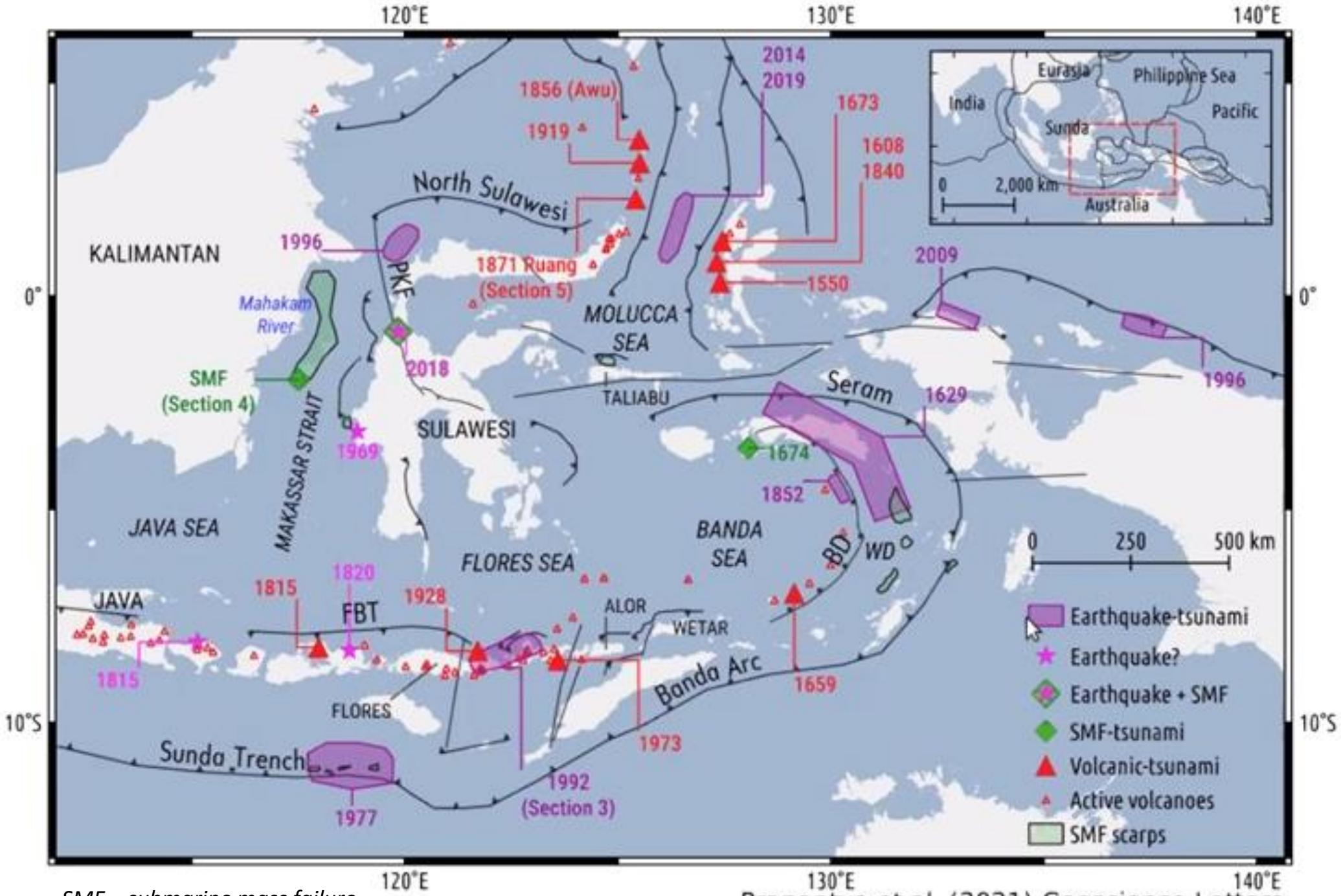


https://www.pinterest.at/pin/462111611746638959/

https://earthquake-report.com/2010/12/15/understanding-the-very-dangerous-underwater-landslide-tsunamis

Earthquakes can also trigger landslides both underwater and at the surface. Tsunamis caused by landslides can also be created around subduction zones.

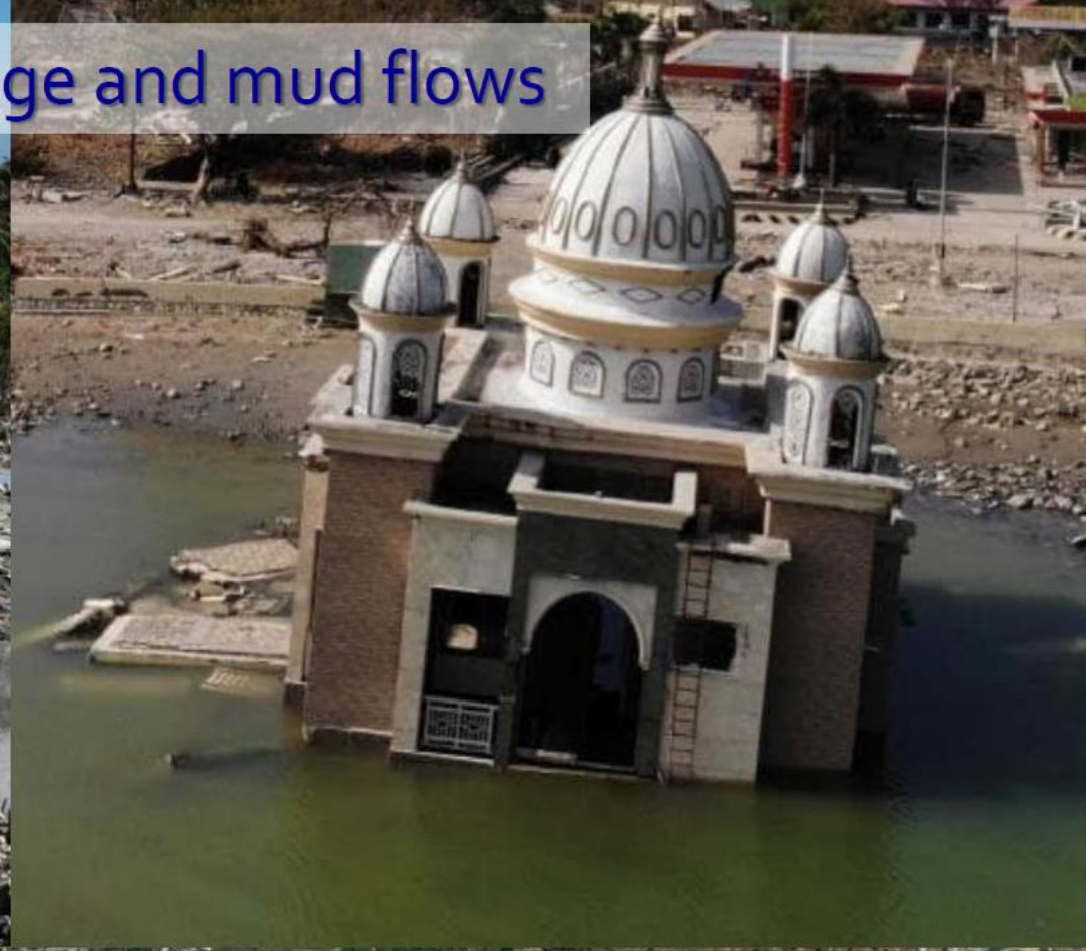
Sumber Kejadian Tsunami yang Sudah Diketahui



SMF – submarine mass failure

Pranantyo et al. (2021) Geoscience Letters

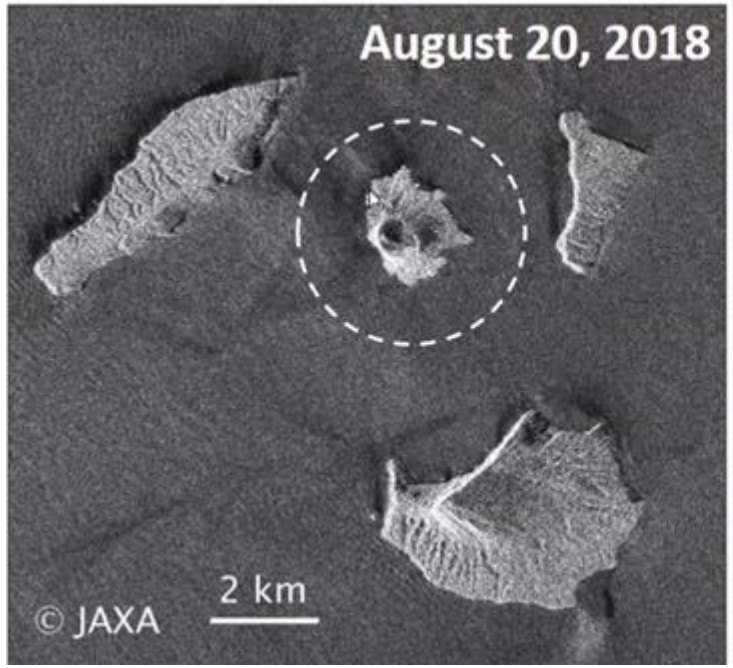
Sulawesi 2018: Tsunami damage and mud flows

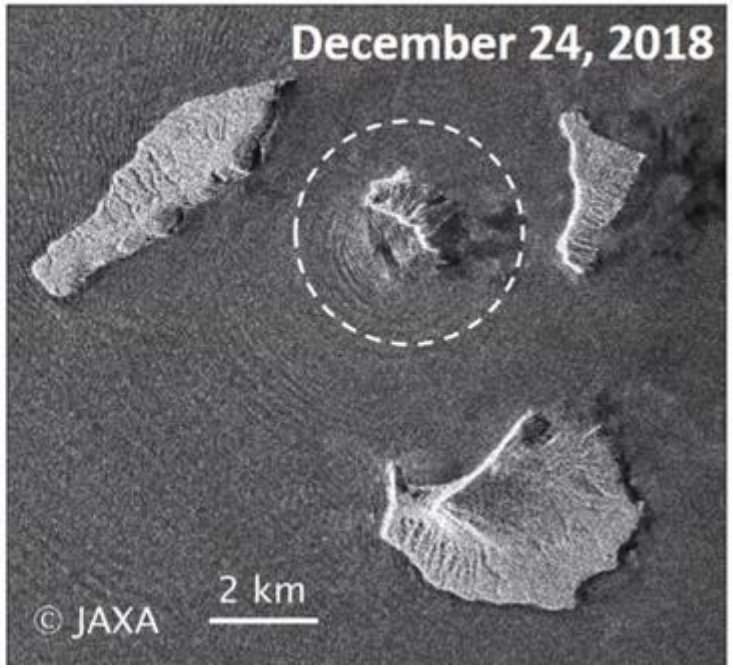


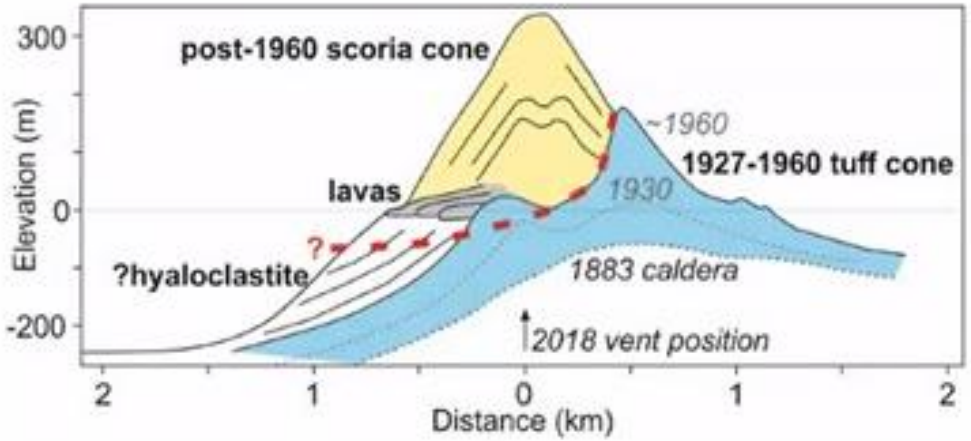
Potential risks in Banda region too

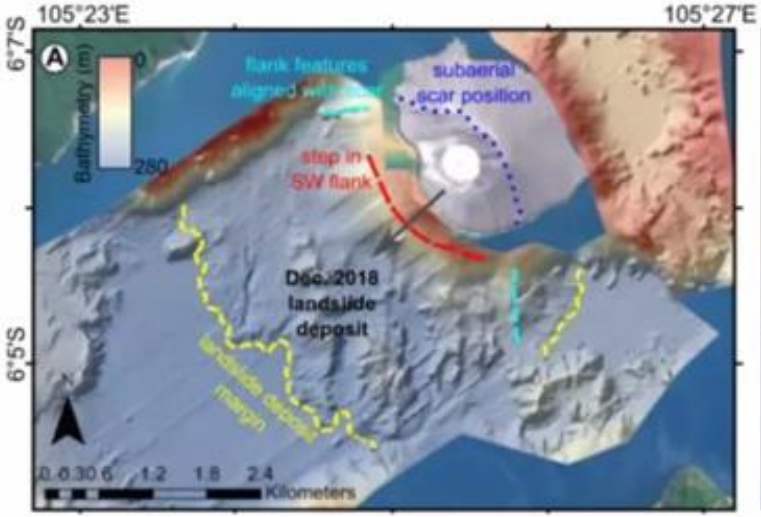
Hall (2020)

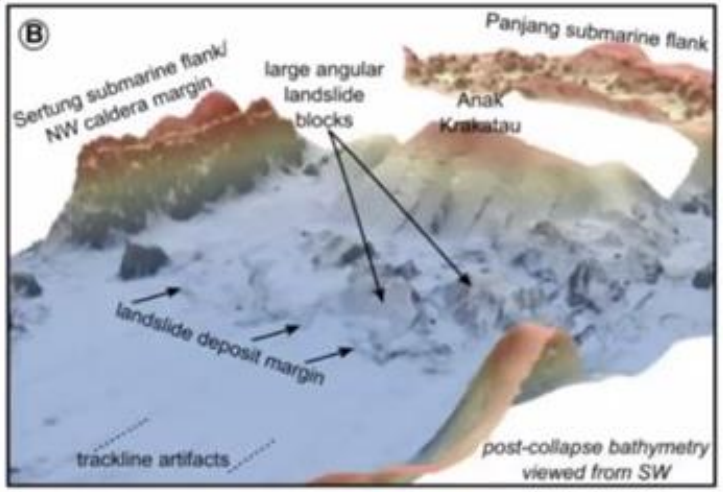
Tsunami oleh Runtuhan Lereng Gn. Anak Krakatau

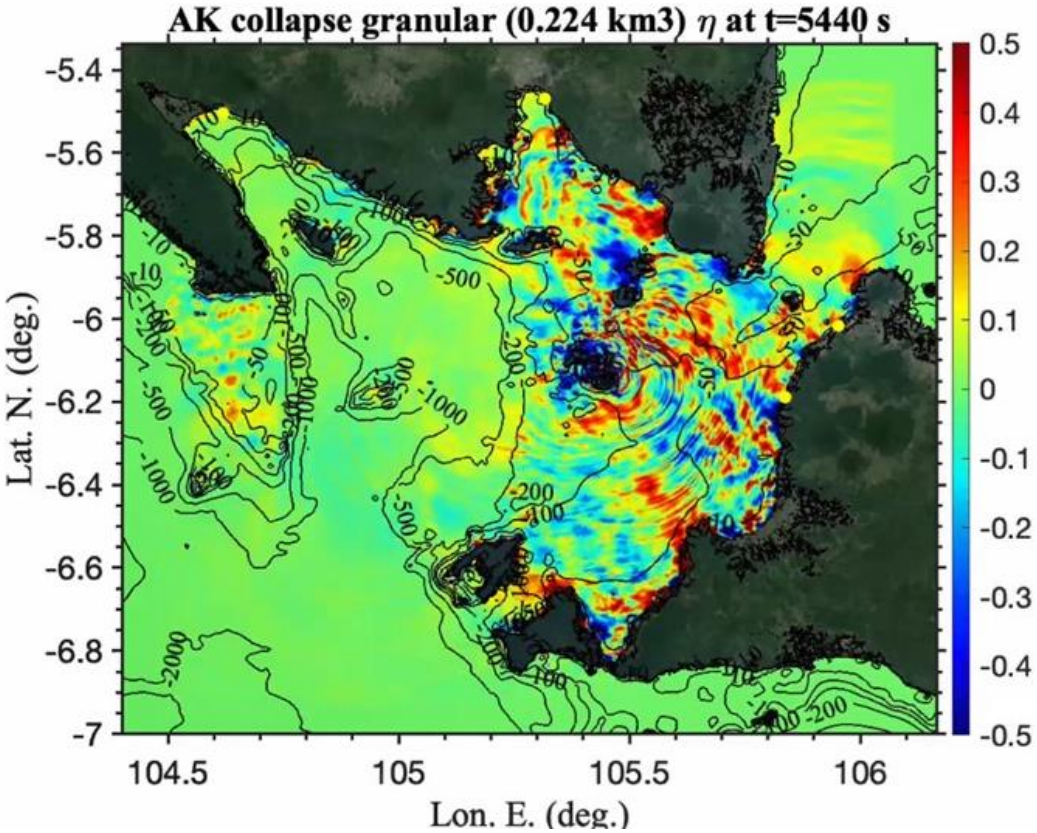




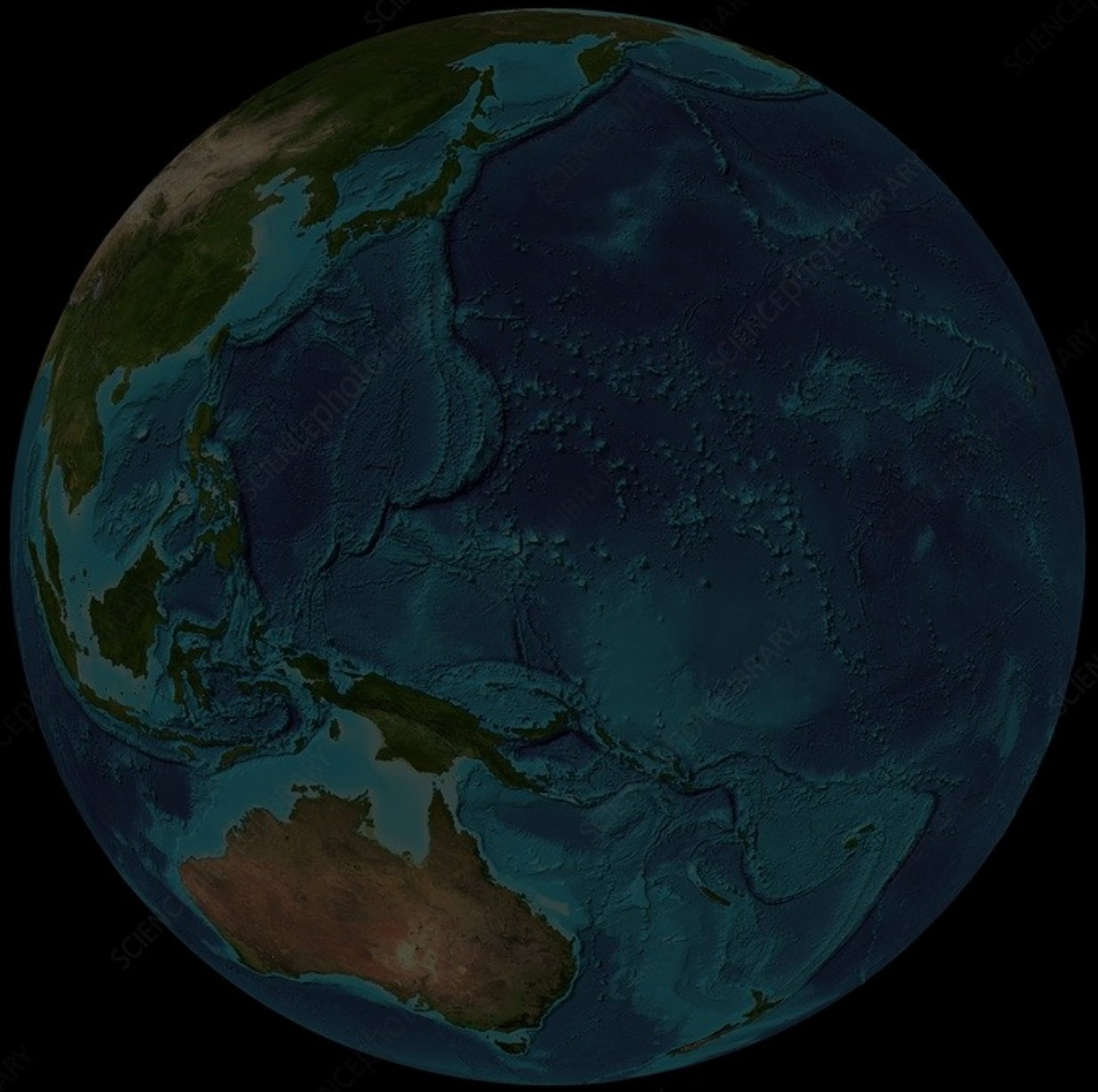








Sebastian Watt (Webinar ITB, 16 Sep. 2021)



https://www.sciencephoto.com/media/166943/view/western-pacific-ocean-seafloor-map

Geologi Kelautan Indonesia

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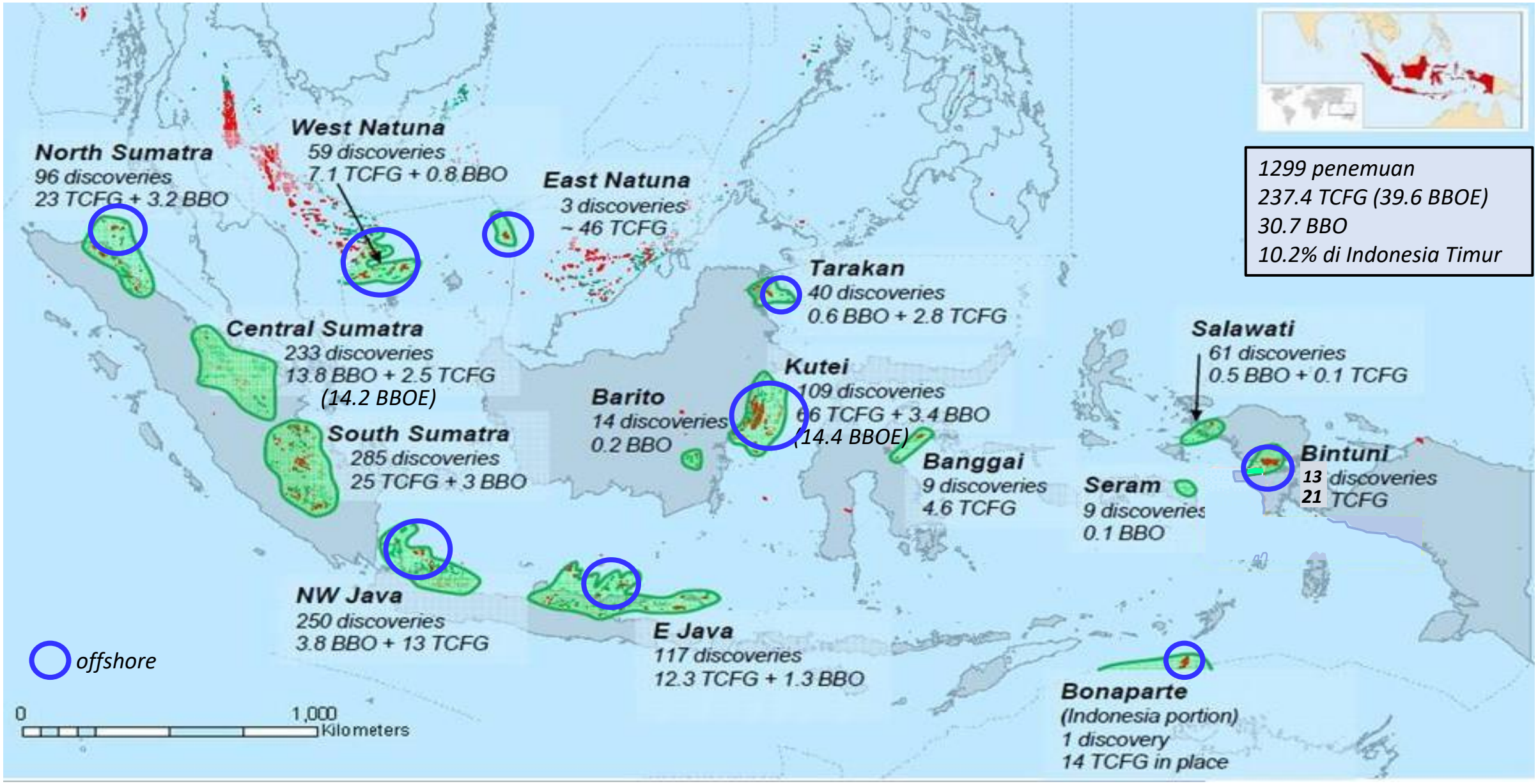
9. **Sumber Daya Geologis Kelautan Indonesia**
10. Konservasi Laut Indonesia

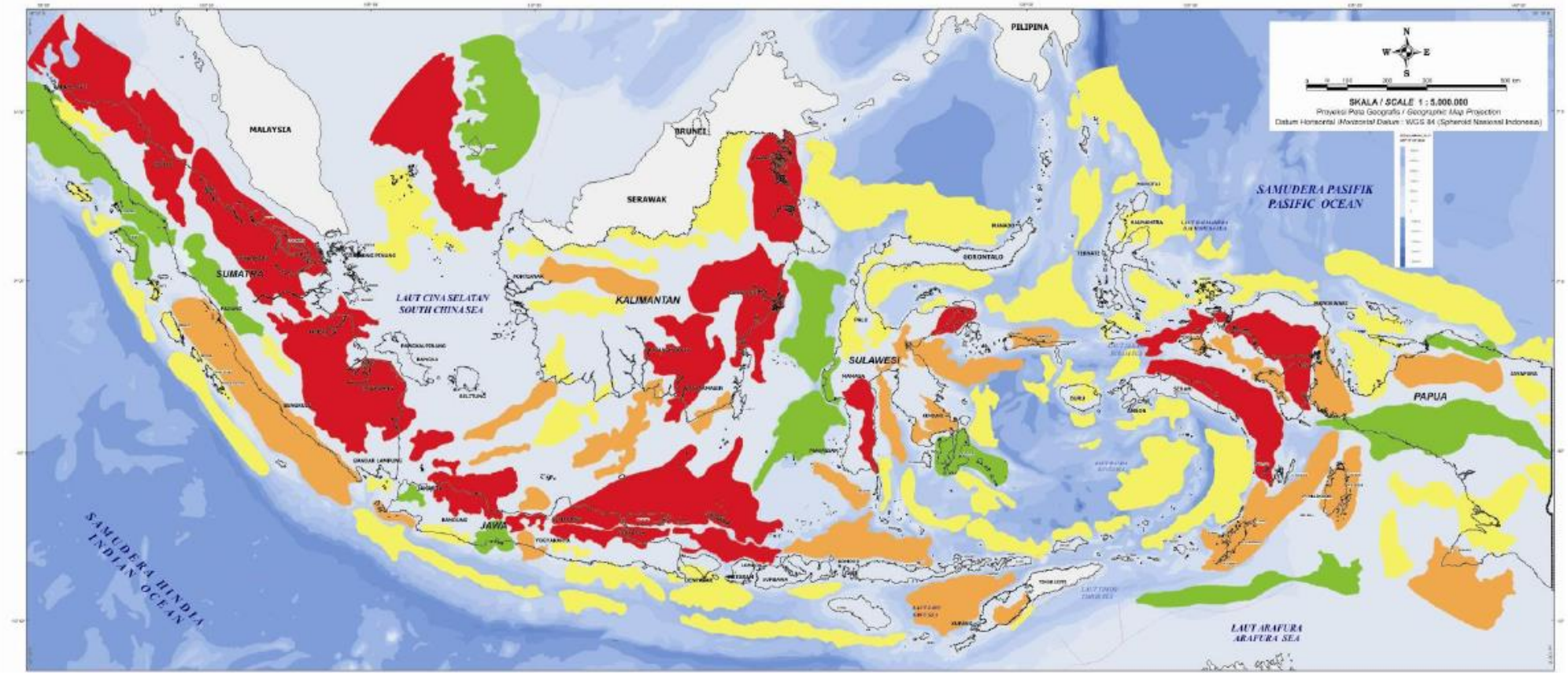
Lapangan Minyak dan Gas Indonesia



dimodifikasi dari IHS (2008)

https://www.cnbcindonesia.com/news/20201229103209-4-212141/phe-wmo-reaktivasi-sumur-produksi-minyak-nambah-1000-bph

Cekungan Sedimen Indonesia



basin mapping by Geological Agency of Indonesia (2010),
basin's status by Satyana (2012)

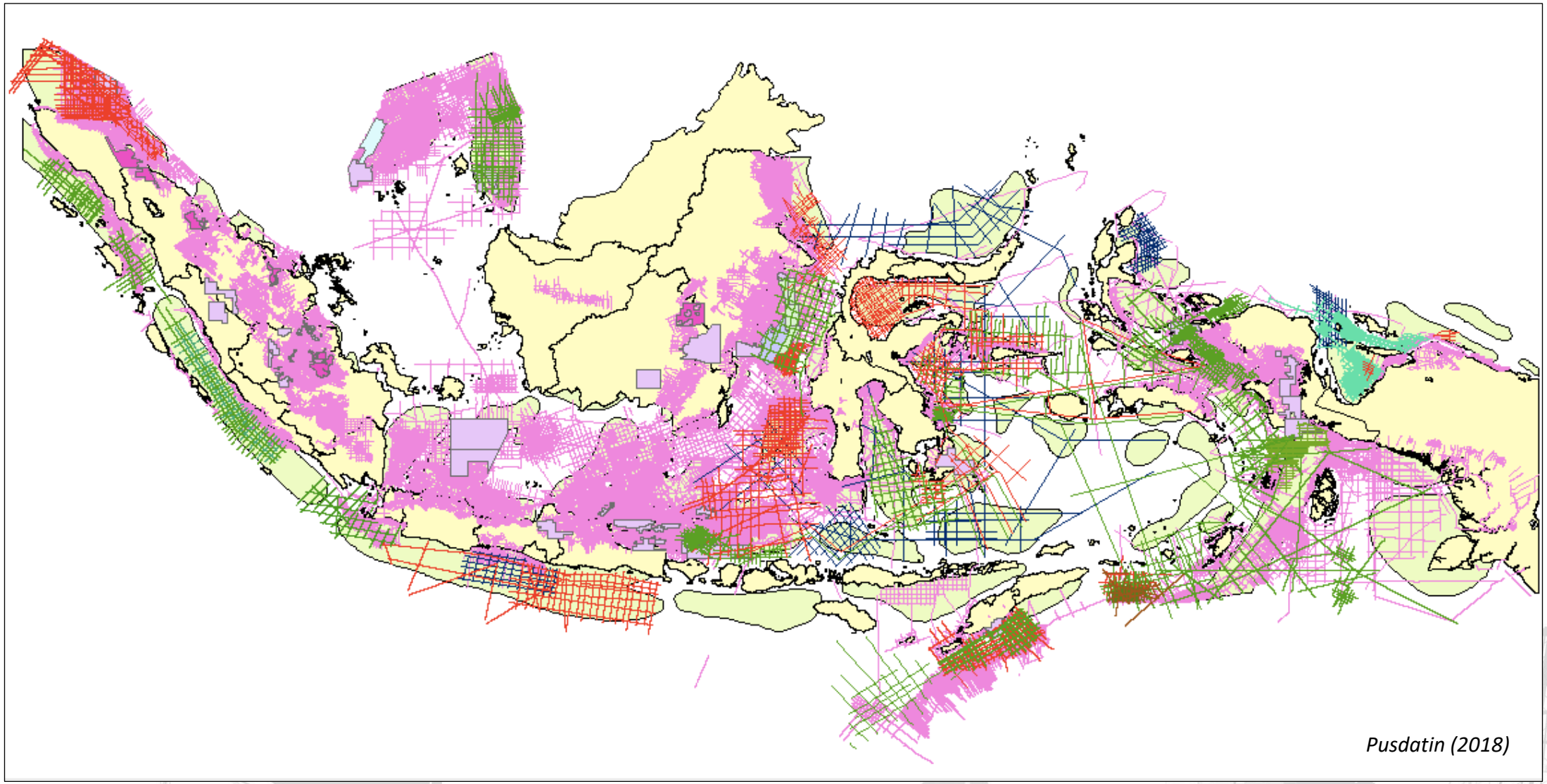
PRODUCING (18 BASINS)

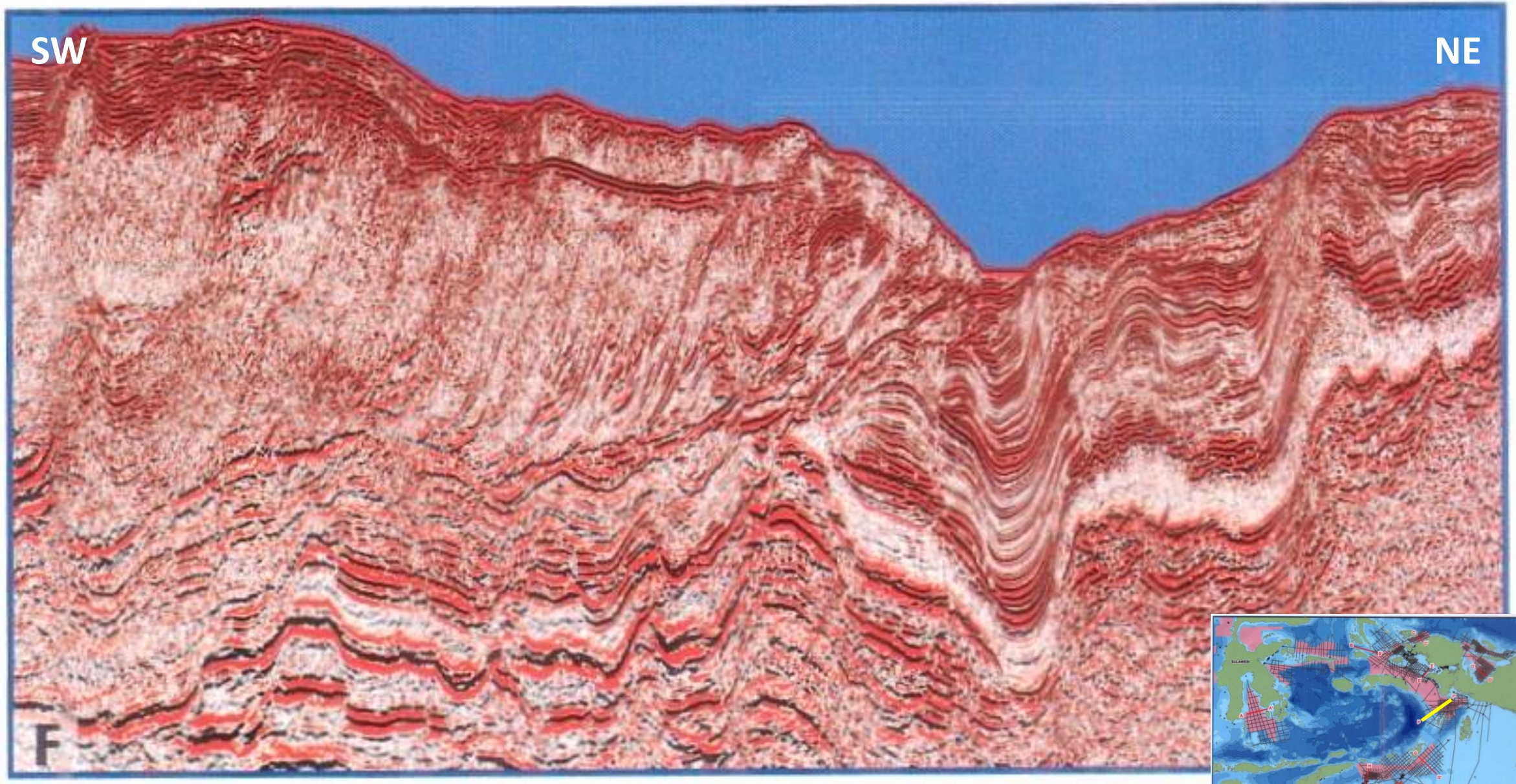
DRILLED WITH DISCOVERY (12 BASINS)

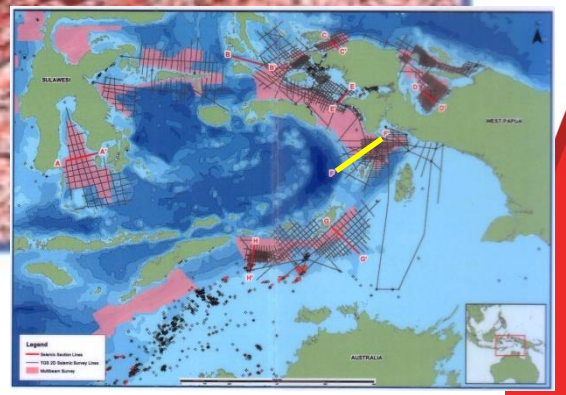
DRILLED WITH NO DISCOVERY YET (24 BASINS)

UNDRILLED (74 BASINS)

Ketersediaan Data Seismik
(survei dari berbagai perusahaan dan Pemerintah)



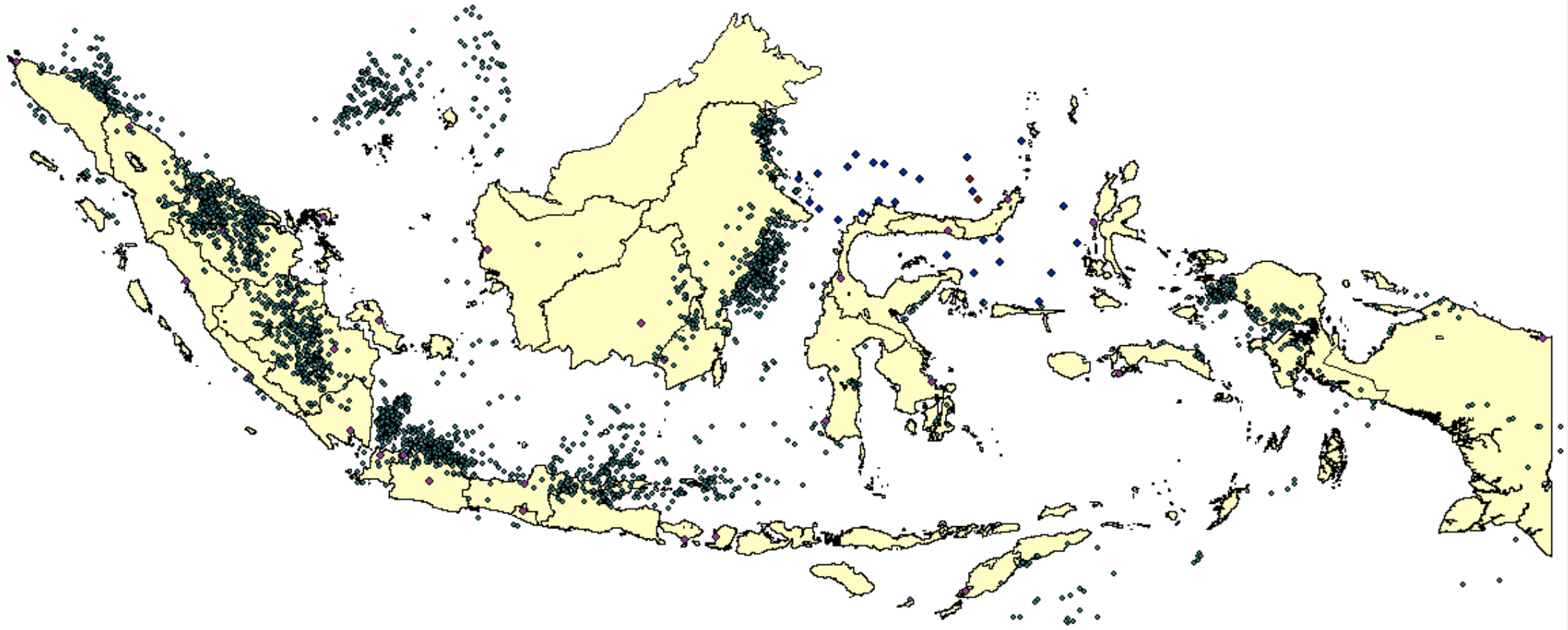




Kumawa

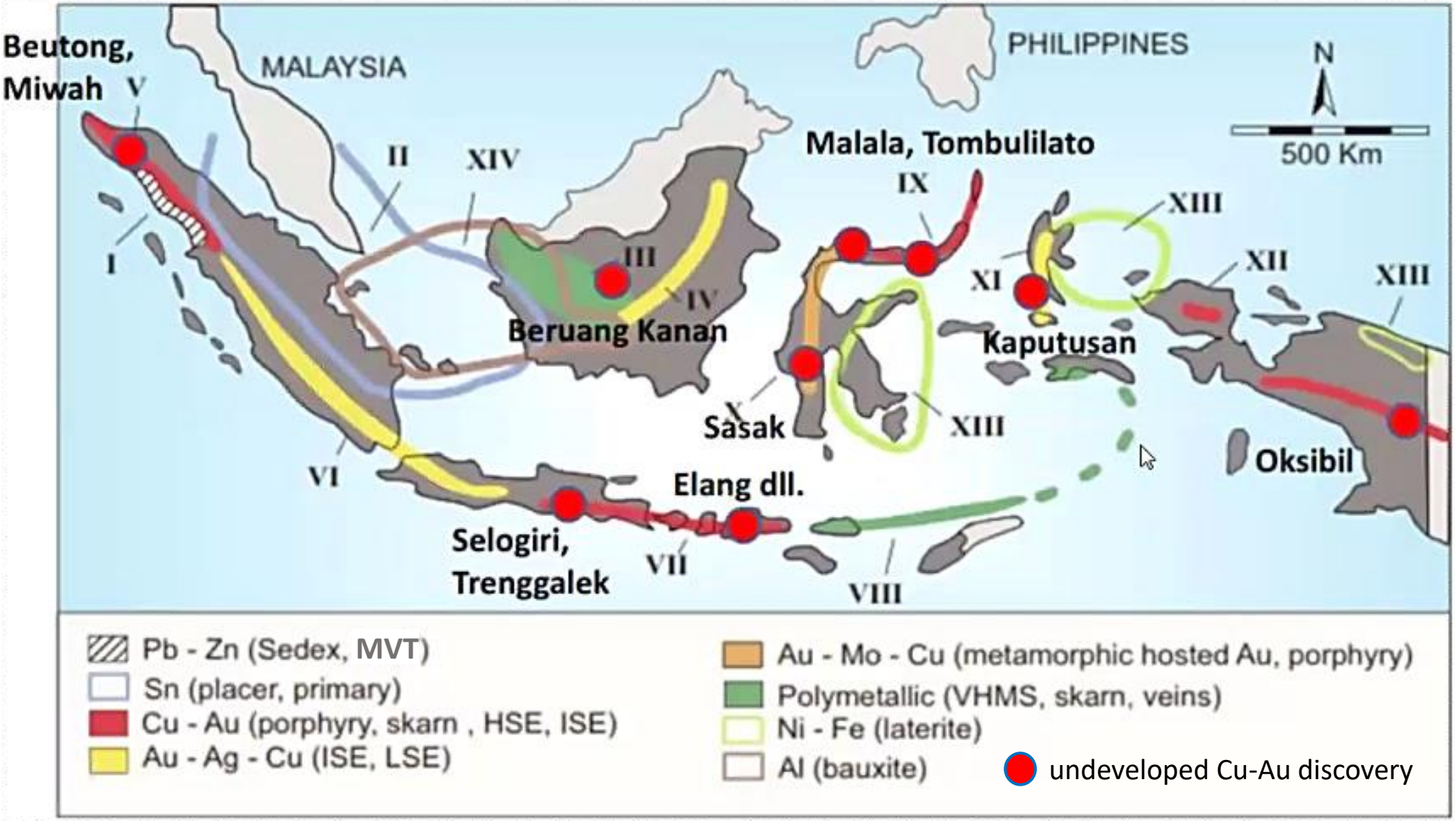
Australian Passive Margin and Banda Arc Collision

Ketersediaan Data Sumur Eksplorasi



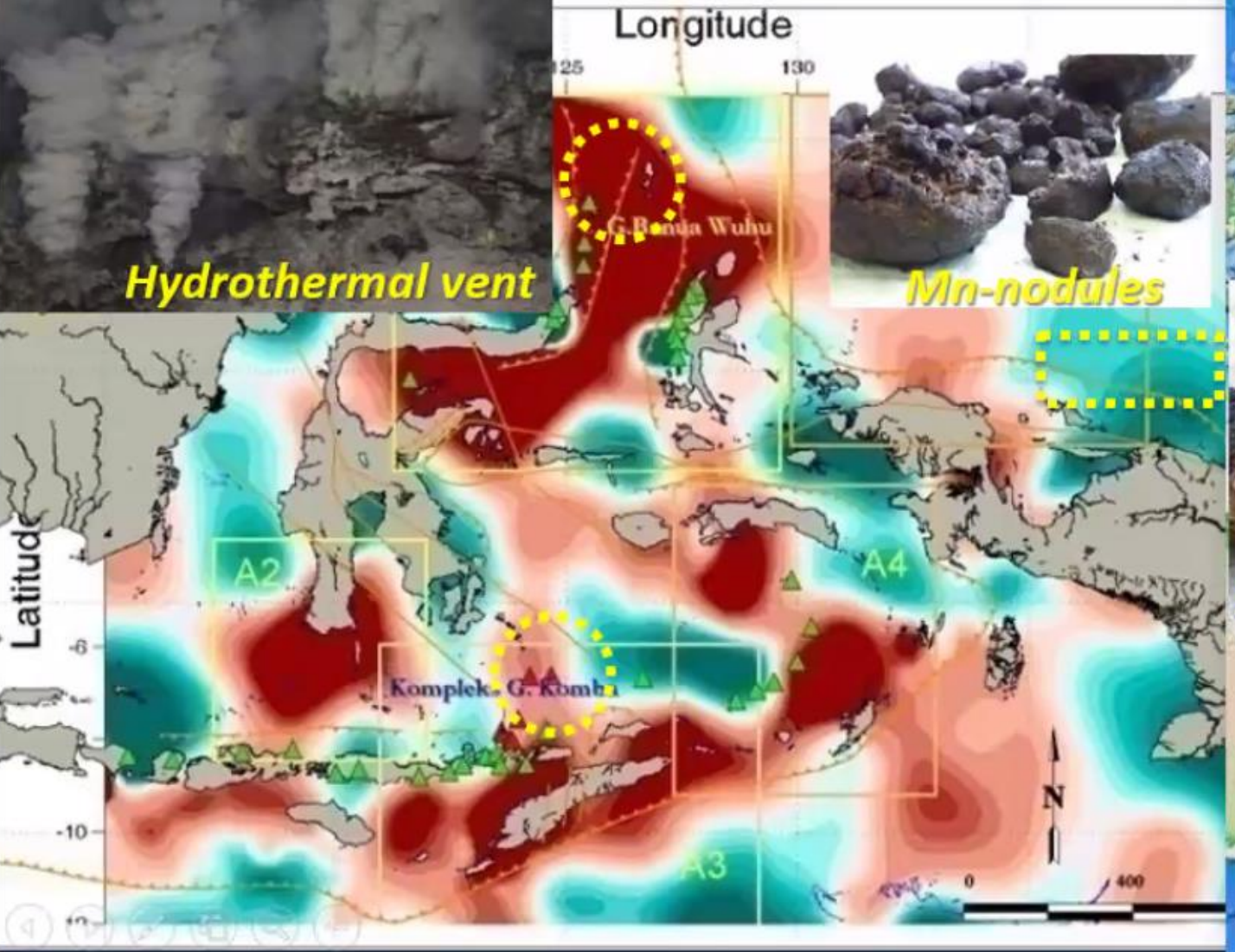
Pusdatin (2018)

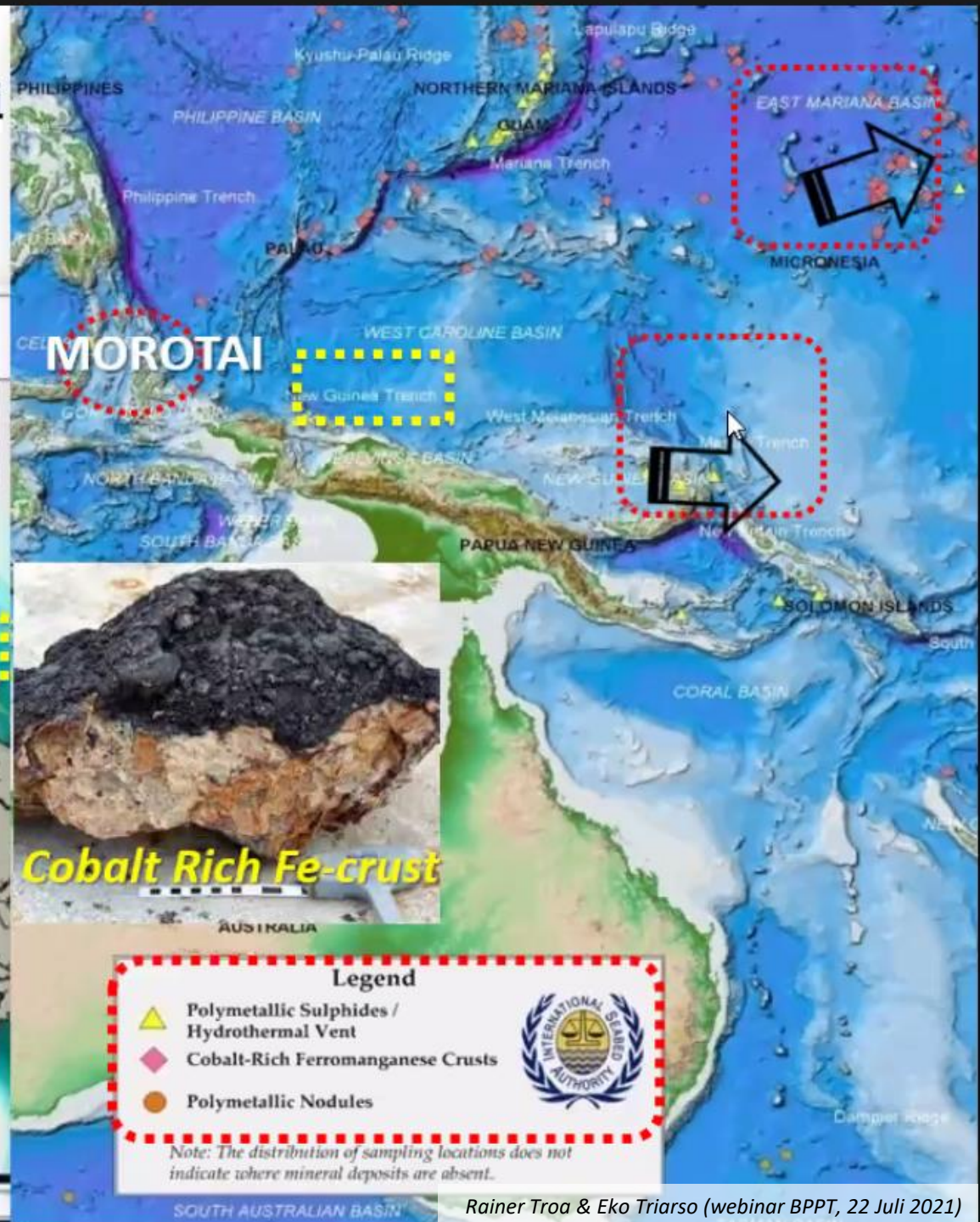
Metalogeni Indonesia



van Leeuwen (2018)

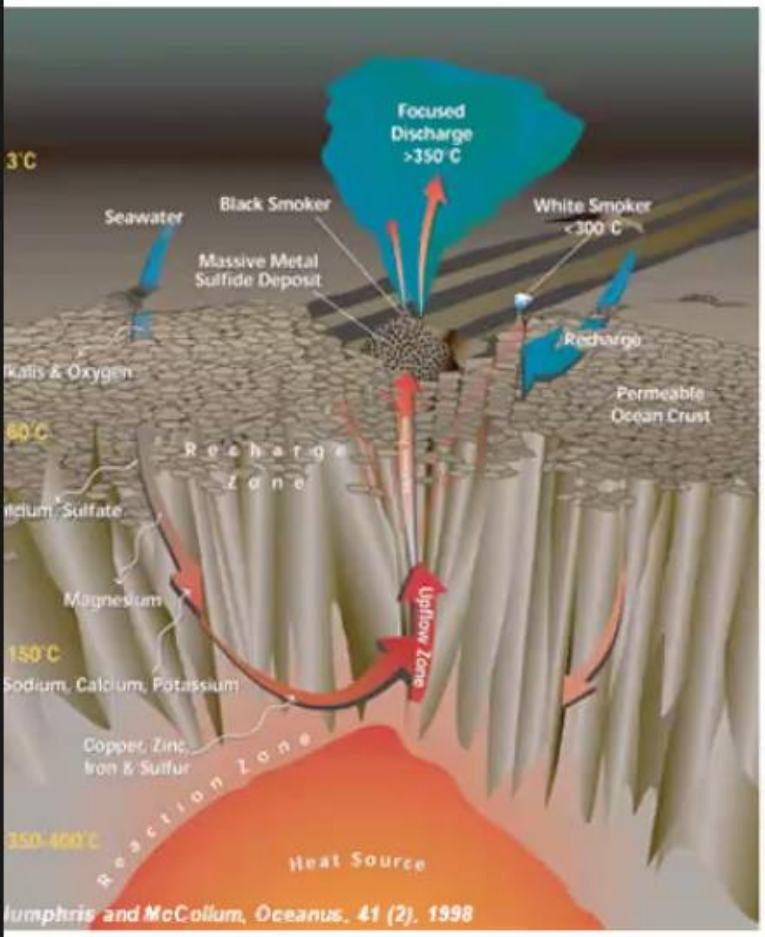
Pelayaran Ilmiah Kelautan mengungkap potensi mineral dasar laut dan fitur geologi SDNHL

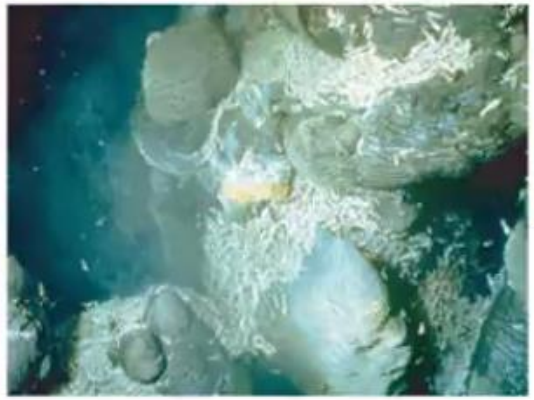


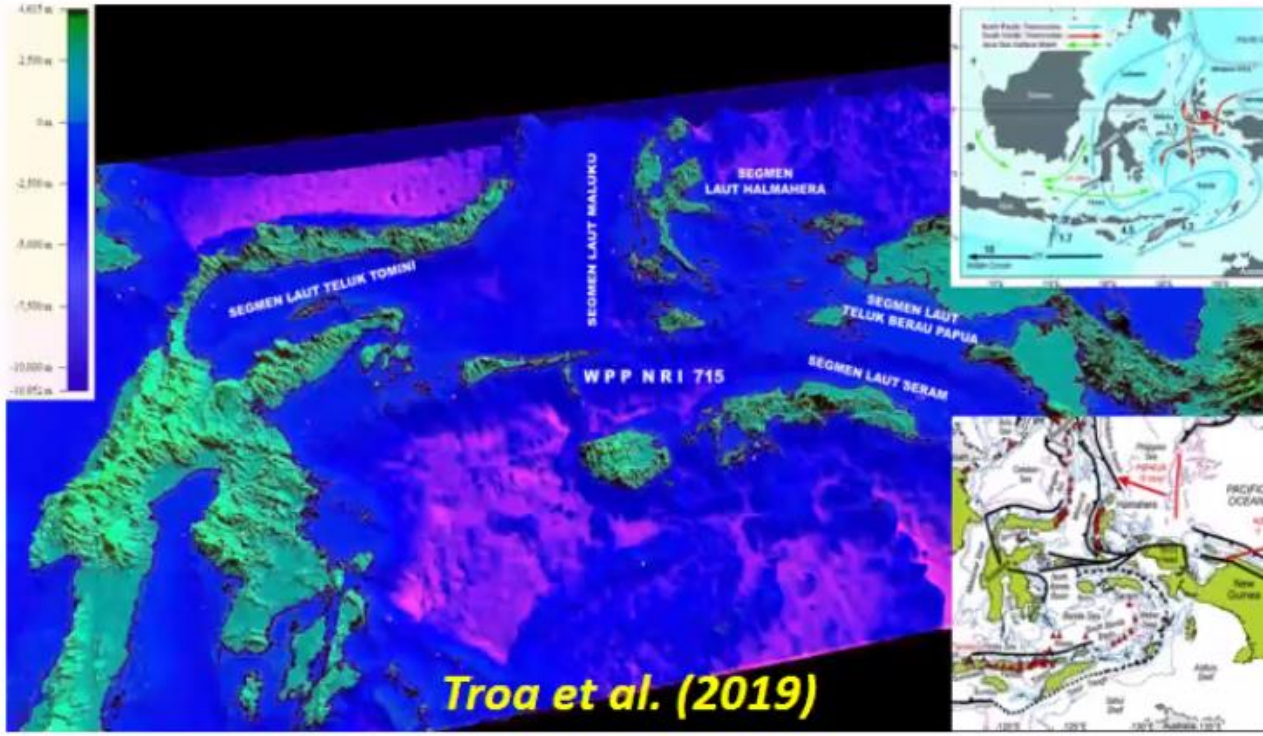


Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)

"Konservasi Fitur Geologi Sumber Daya Non Hayati Laut (SDNHL)"







Tinjauan Geodinamika dan Potensi Sumber Daya Non Hayati Laut Kawasan Timur Indonesia pada WPP NRI 715 (Rainer A. Troa, E. Triarso, dan I. Dillenia, 2019)

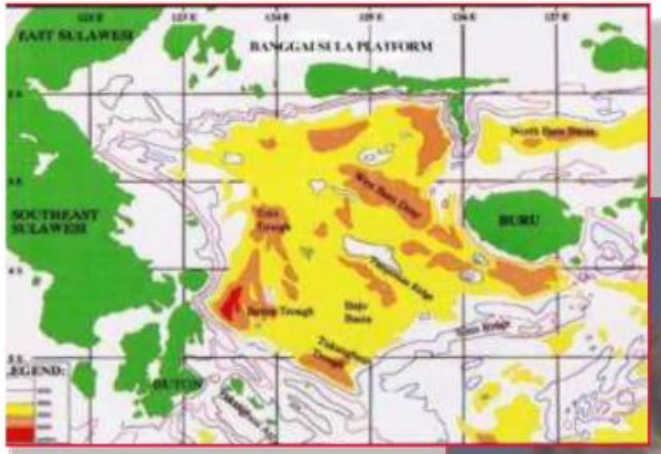
03/12/2010/Index Satal 2010,@ america lecturing program, Pacific Place Jakarta (H. Permana, E. Triarso, Rainer A. Troa et al., 2010)

Rainer Troa & Eko Triarso (webinar BPPT, 22 Juli 2021)

Manganese Crust:

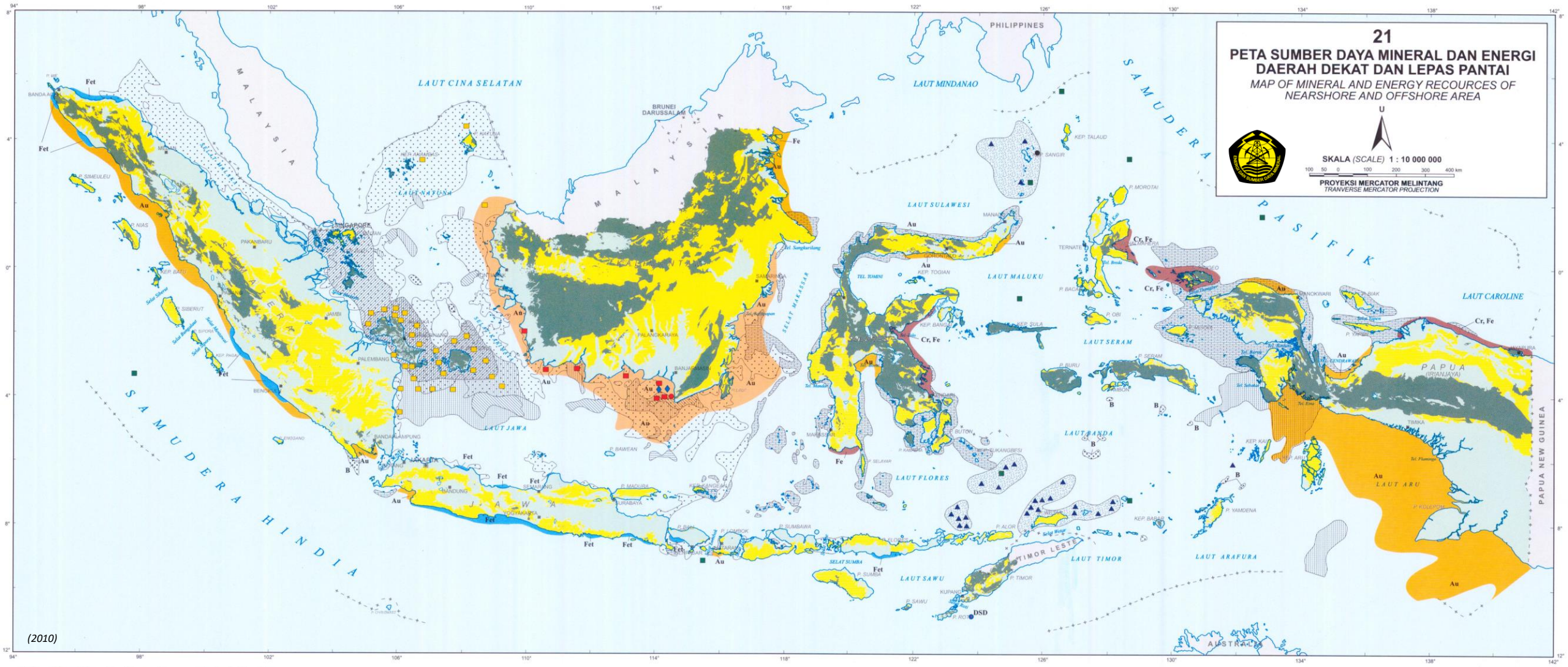
The history of polymetallic crust discovery was conducted in 1996, when the GEOBANDUT Expedition scientists haulded up the first sample of polymetalic crusts from a depth of 3956 m at the crest of the Tampomas Ridge, northern Banda Sea. The crust containing a high concentration of Fe (46,829 ppm), Mn (24,780 ppm), Mg (2,910 ppm), Co (102 ppm), and Ni (1,288 ppm).

DEPOSIT MINERAL LAUT DALAM DI INDONESIA (SUMBER : ARYANTO & USMAN, 2017)



Code Number of Sample20		
Elements	SBU 1	SBU 2
Cu (ppm)	170	216
Pb (ppm)	33	109
Zn (ppm)	214	195
Co (ppm)	102	91
Ni (ppm	1288	750
Mn (ppm)	24780	20609
S (ppm)	320	280
Mg (ppm)	2910	5303
Fe (ppm)	46829	59677
Cr (ppm)	250	350

Hananto Kurnio (webinar BPPT, 22 Juli 2021)



(2010)

1. Pusat Penelitian dan Pengembangan Geologi, Bandung.
   Geological Research and Development Centre, Bandung.
2. Pusat Penelitian dan Pengembangan Geologi Kalautan, Bandung.
   Marine Geological Institute, Bandung.

PETA GEOLOGI DISEDERHANAKAN *(SIMPLIFIED GEOLOGICAL MAP)*

Daerah lepas pantai *(offshore area)*

- Terumbu koral
  Coral reef
- Pasir dan kerikil
  Sand and gravel
- Batuan dasar : Granit dan vulkanik
  Basement rocks : Granites and volcanics

Daratan *(on land)*

- Batuan Kuarter : Sedimen klastika, vulkanit dan karbonat.
  Quaternary Rocks : Clastic sediments, volcanites, and carbonates.
- Batuan Tersier : Sedimen klastika, vulkanit, dan karbonat.
  Tertiary Rocks : Clastic sediments, volcanites, and carbonates.
- Batuan Pratersier : Sedimen klastika, karbonat, vulkanit, plutonit, metamorfit, dan ofiolit.
  Pre-Tertiary Rocks : Clastic sediments, carbonates, volcanites, plutonites, metamorphites, and ophiolites.

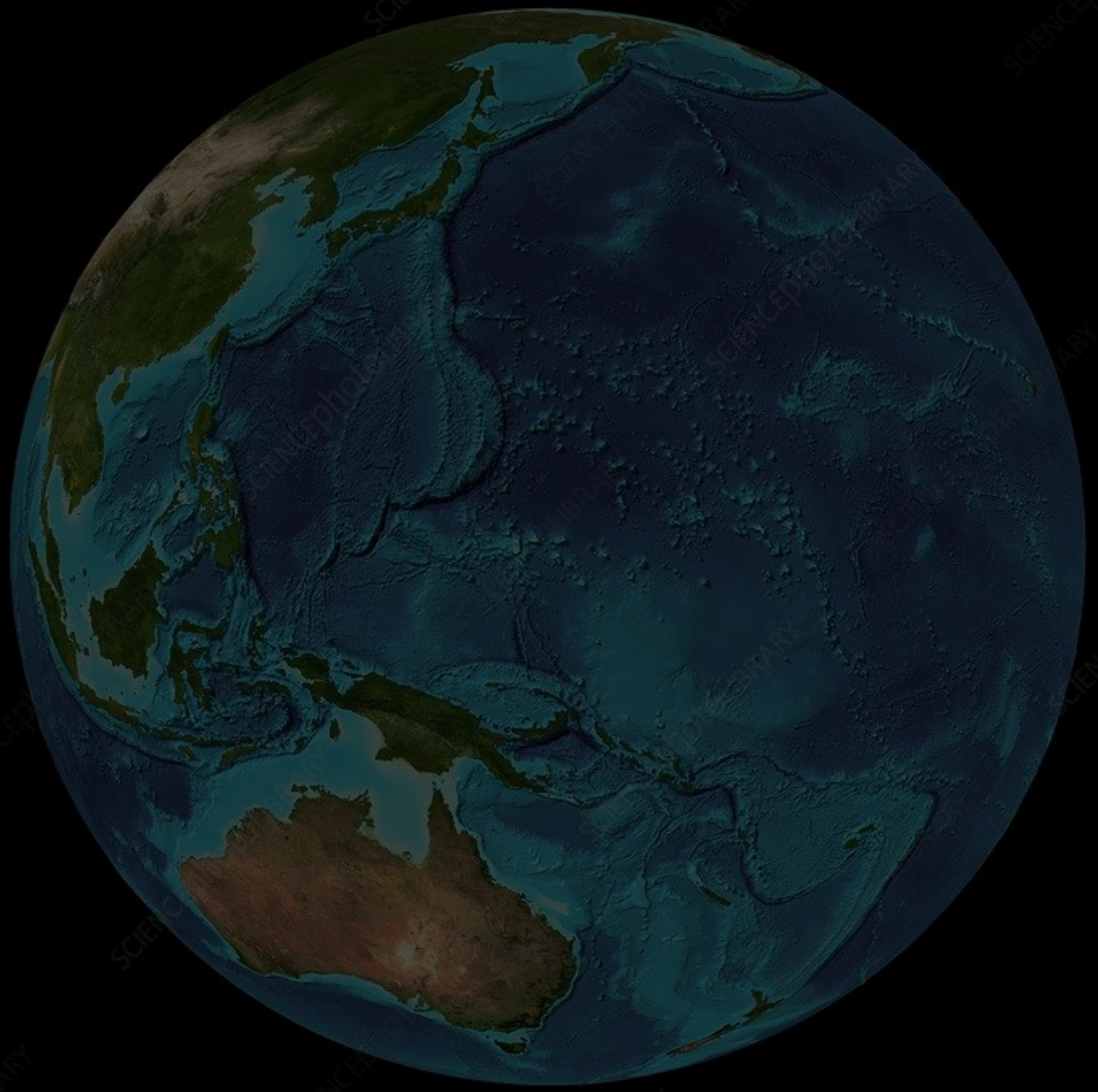
POTENSI SUMBER DAYA *(RESOURCES POTENTIAL)*

Keterdapatan *(occurrences)*

- Letakan emas
  Gold placers
- Letakan intan
  Diamond placers
- Letakan timah
  Tin placers
- Letakan mangan
  Manganese placers
- Kromit dan platina
  Cromite and platinum
- Mineral logam paduan besi
  Ferometallic mineral

Sebaran potensi *(Potential distribution)*

- Au — Berpotensi letakan emas
  Gold placer potential
- Berpotensi emas primer
  Primary gold potential
- Fet — Berpotensi letakan besi-titan
  Potential of titanic-iron placers
- Cr, Fe — Berpotensi letakan kromit dan magnetit
  Potential of cromite and magnetite placers
- Vulkanik bawah laut
  Submarine volcanoes
- Berpotensi gambut
  Peat potential
- Mengandung zirkon 10%-80%
  10%-80% content of zirconium
- Mengandung rutil 10%-15%
  10%-15% content of rutile
- Berpotensi torium sampai kedalaman 30 m
  Thorium potential until 30 m depth
- DSD — Pemboran laut dalam
  Deepsea drilling



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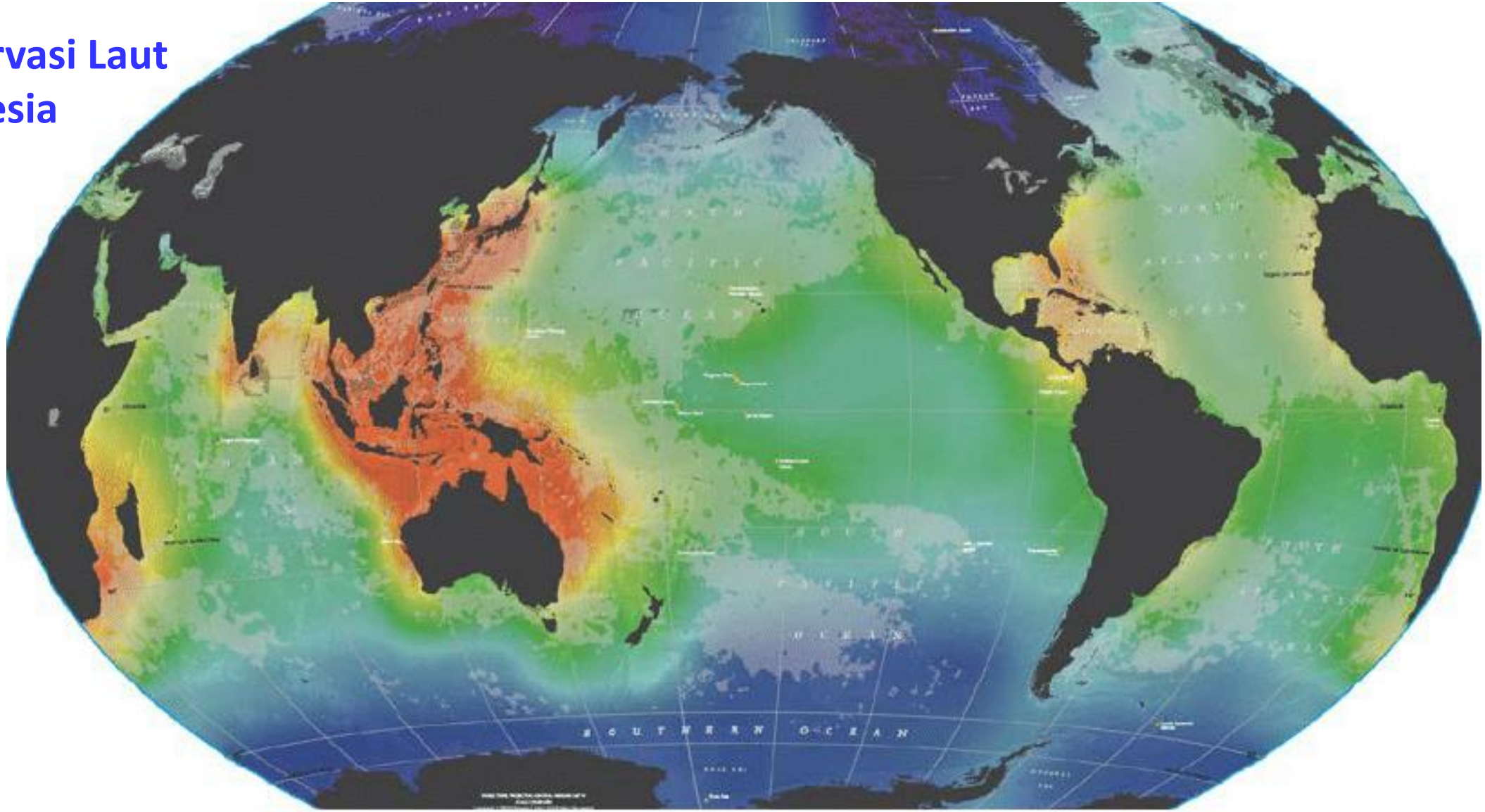
Konservasi Laut Indonesia

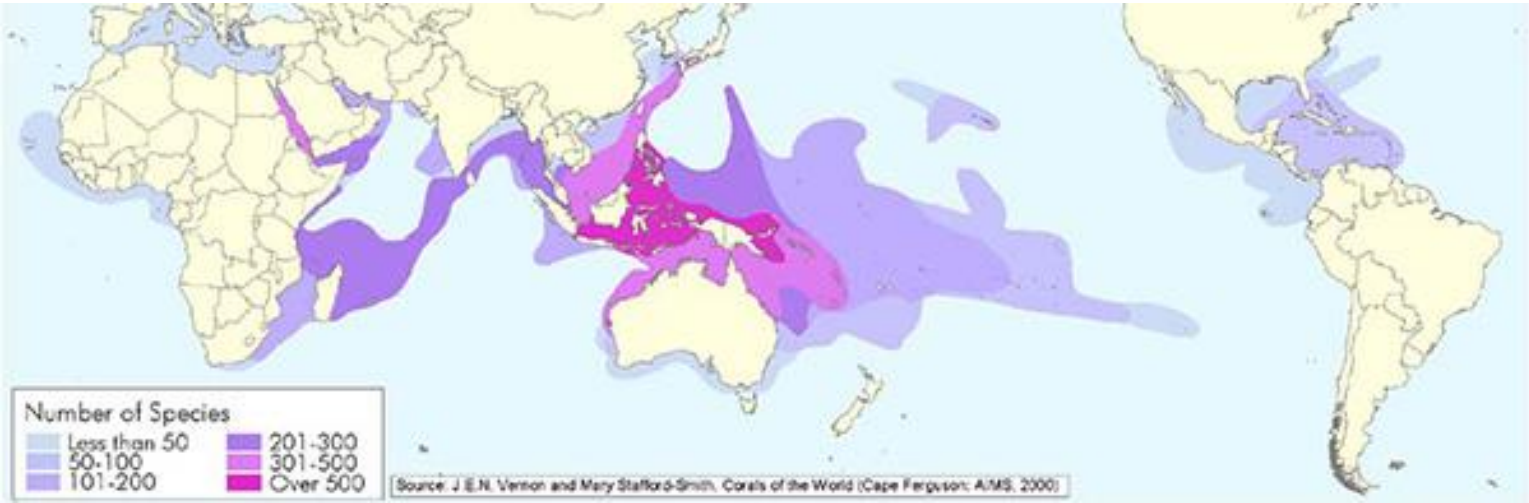


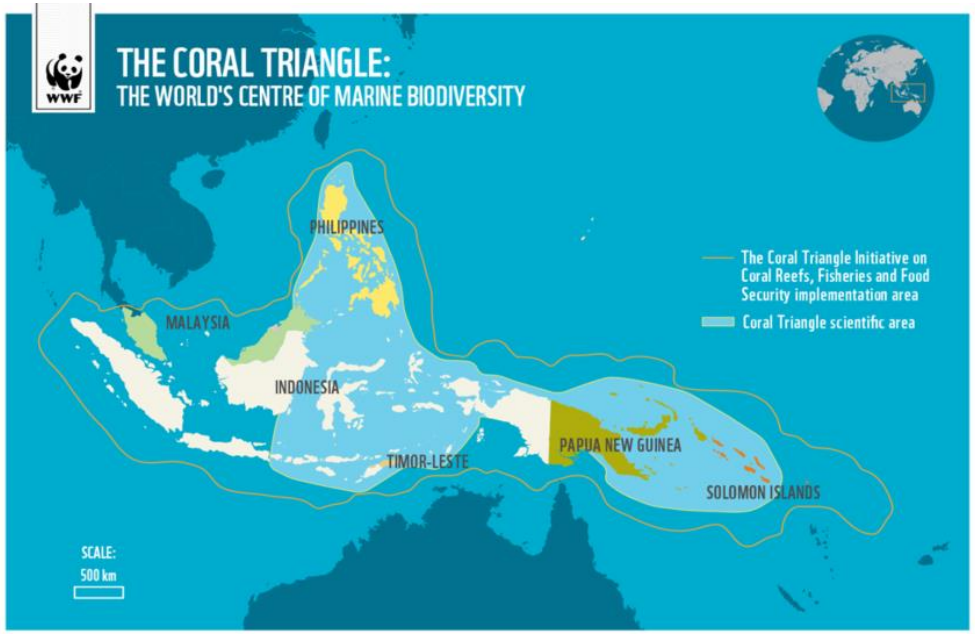
Distribution of biodiversity in the oceans

Biodiversity data: Tittensor et al., 2010. Human impact data: Halpern et al., 2008, Map: Census of Marine Life, 2010; Ausubel et al., 2010; National Geographic Society, 2010; Harris, 2016

Laut-Laut Indonesia: Biodiversitas Terumbu Karang Tertinggi di Dunia

https://www.marinebio.org/creatures/coral-reefs/
https://youtu.be/bghZ2KHMjGI





Terima kasih atas perhatian Anda.

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e-mail: aharunsatyana@gmail.com

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