Lecture 2: Sea-floor depth, age, and heat flow

- Why do we have ocean basins?
- Mid ocean ridges and the topography of the sea-floor
- Heat transport in the Earth

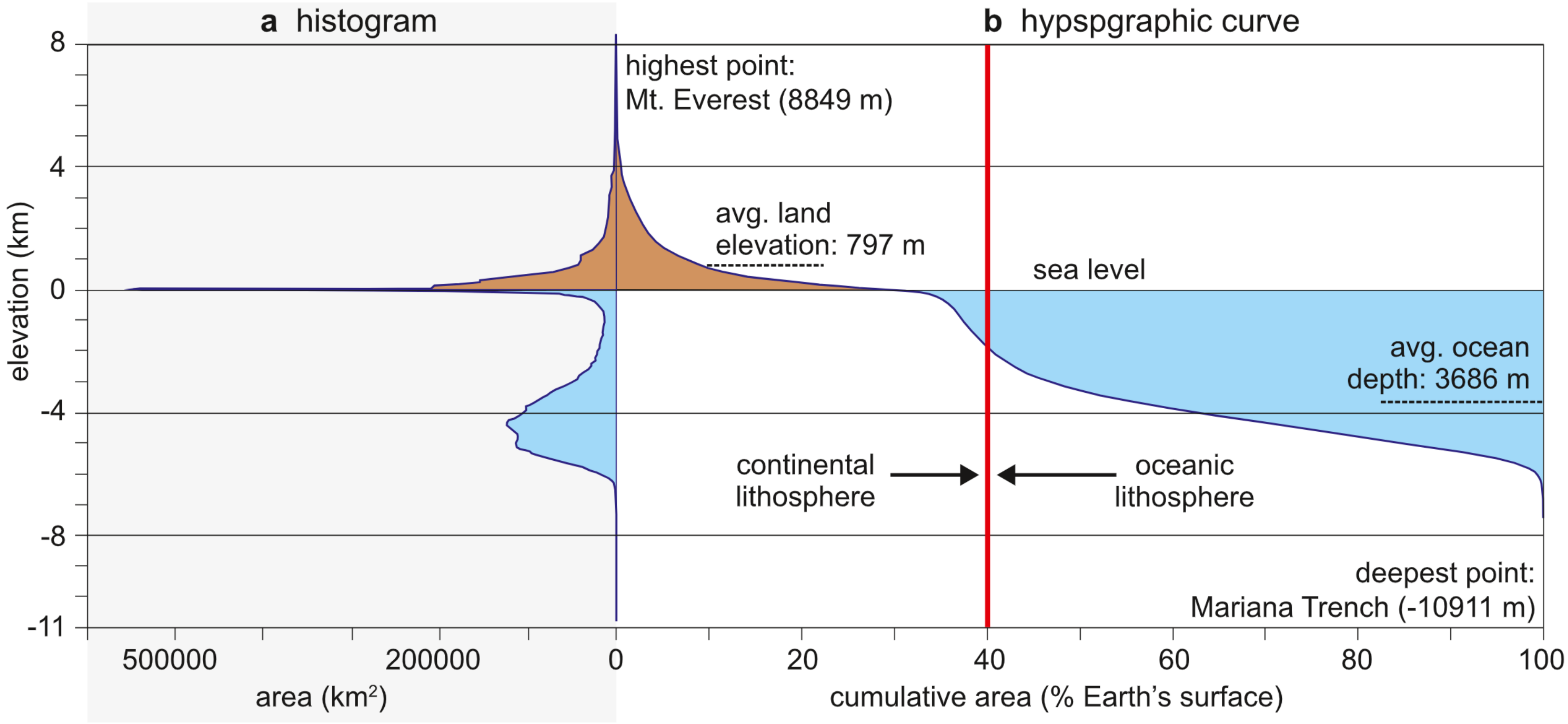
We acknowledge and respect the ləkʷəŋən peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

What are ocean basins?

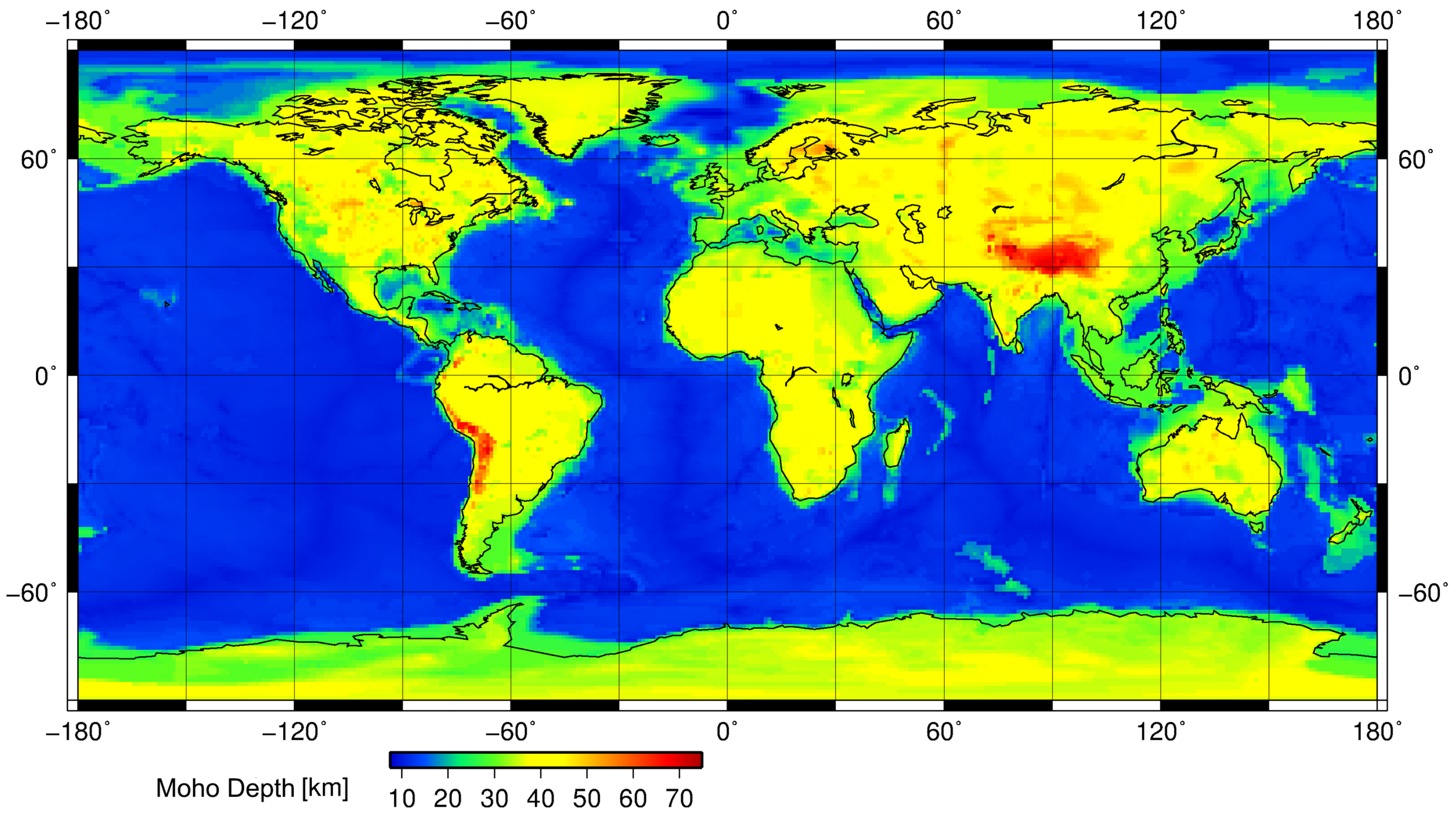
"We can only sense that in the deep and turbulent recesses of the sea are hidden mysteries far greater than any we have solved."

-Rachel Carson, *The Sea Around Us*, 1957

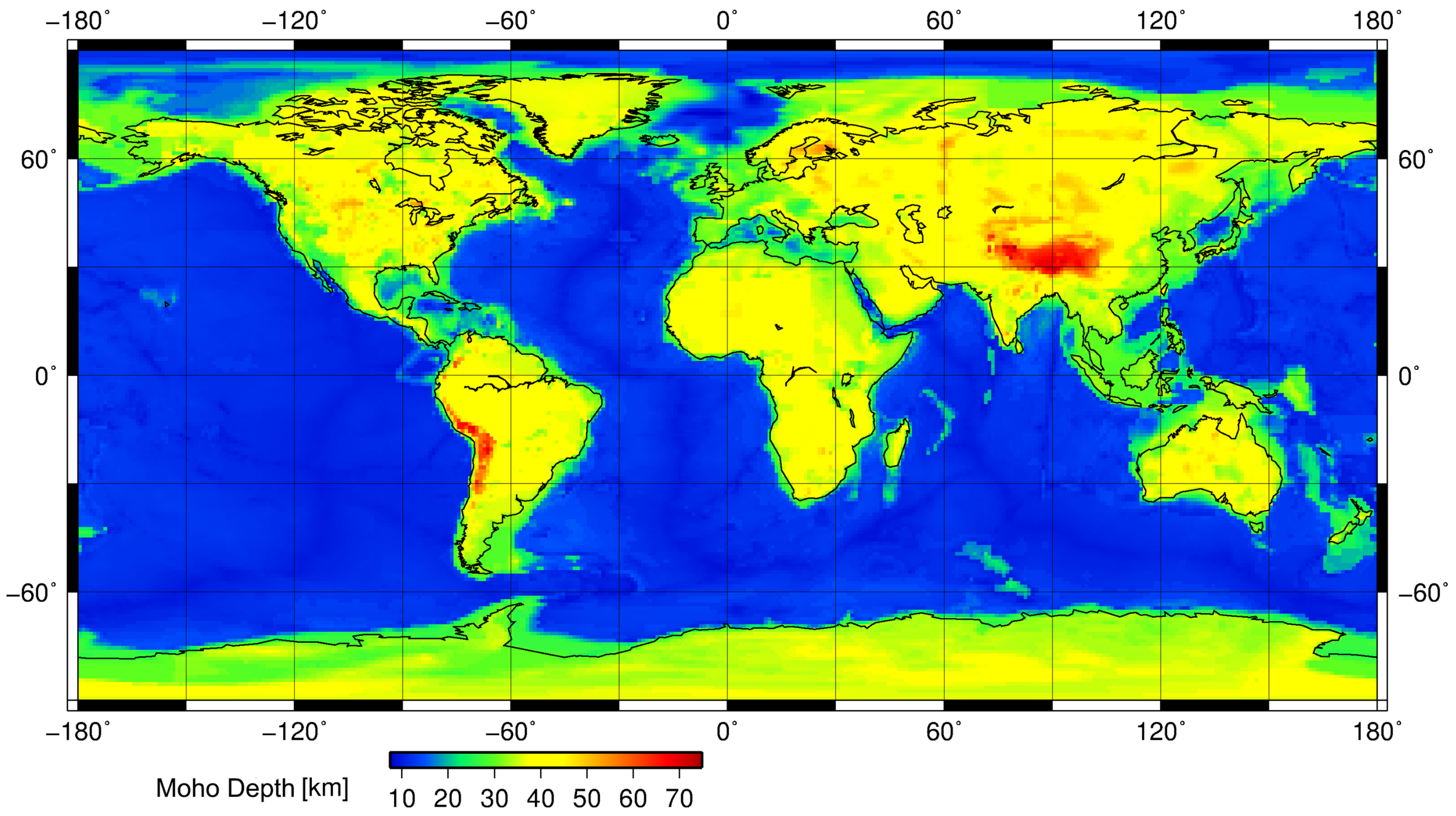
What are ocean basins?



Mohorovičić discontinuity



Mohorovičić discontinuity



What are the differences between lithosphere and asthenosphere and crust and mantle?

Mohorovičić discontinuity

"Seismic evidence shows that the so-called crustal thickness-depth to the M discontinuity-is 6 km under oceans and 34 km under continents on the average."

-Harry Hess, *History of Ocean Basins*, 1962

Mohorovičić discontinuity

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How can we test this assumption?

Testing isostatic equilibrium

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- Continental crust:
  - Mean elevation: 797 m
  - Mean thickness: 34 km
  - Andesite with density: 2.8 g/cm^3
- Oceanic crust:
  - Mean elevation: -3686 m
  - Mean thickness: 6 km
  - Basalt with density: 2.9 g/cm^3
- Density of water: 1 g/cm^3

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What is the density of the mantle in g/cm^3?

Testing isostatic equilibrium

The calculation is simplest if we assume compensation depth is the base of the continental crust (instead of the 40 km hypothetical posed by Hess). You should get **3.46 g/cm^3** (density of peridotite: 3.1–3.4 g/cm^3) using the following mass balance:

$$\Delta \mathrm{H}_{\mathrm{cc}}\rho_{\mathrm{cc}} = \Delta \mathrm{H}_{\mathrm{w}}\rho_{\mathrm{w}} + \Delta \mathrm{H}_{\mathrm{oc}}\rho_{\mathrm{oc}} + \Delta \mathrm{H}_{\mathrm{m}}\rho_{\mathrm{m}}$$

$$\Delta \mathrm{H}_{\mathrm{cc}}\rho_{\mathrm{cc}} - \Delta \mathrm{H}_{\mathrm{w}}\rho_{\mathrm{w}} - \Delta \mathrm{H}_{\mathrm{oc}}\rho_{\mathrm{oc}} = \Delta \mathrm{H}_{\mathrm{m}}\rho_{\mathrm{m}}$$

$$\frac{\Delta \mathrm{H}_{\mathrm{cc}}\rho_{\mathrm{cc}} - \Delta \mathrm{H}_{\mathrm{w}}\rho_{\mathrm{w}} - \Delta \mathrm{H}_{\mathrm{oc}}\rho_{\mathrm{oc}}}{\Delta \mathrm{H}_{\mathrm{m}}} = \rho_{\mathrm{m}}$$

$$\Delta \mathrm{H}_{\mathrm{m}} = \Delta \mathrm{H}_{\mathrm{cc}} - \Delta \mathrm{H}_{\mathrm{oc}} - \mathrm{E}_{\mathrm{cc}} - \mathrm{E}_{\mathrm{oc}}$$

where ΔH is thickness, E is elevation, ρ is density, and the subscripts w, cc, oc, and m correspond to the water in the ocean, the continental crust, the oceanic crust, and the mantle, respectively.

In [20]:

```
crust_thickness = 34
crust_elevation = 0.797
crust_density = 2.8  # kg/m^3
ocean_thickness = 6
ocean_elevation = -3.686
ocean_density = 2.9  # kg/m^3
water_density = 1
water_thickness = 3.686
mantle_root = crust_thickness - ocean_thickness - (crust_elevation - ocean_elevation)

# crust_thickness*crust_density = water_thickness*water_density + ocean_thickness*ocean_density +
#                                                                     mantle_density*mantle_root
mantle_density = (
    water_thickness * water_density
    + crust_thickness * crust_density
    - ocean_thickness * ocean_density
) / mantle_root
mantle_density
```

Out[20]: 3.4649827784156138