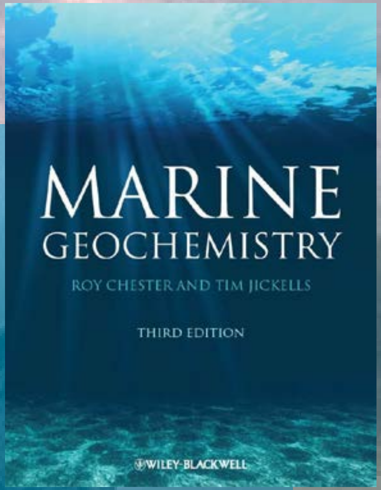
Marine Geosciences / Oceanography

Fields and disciplines

Marine Geosciences; Oceanography

- Chemical Oceanography
  - Marine chemistry; marine geochemistry
- Biological Oceanography
  - Marine biology; marine biogeochemistry
  - Marine ecology
- Physical Oceanography
  - Ocean circulation & Climate (change)
  - Dynamics of the ocean floor, Marine Geodynamics
- Marine Sedimentology



Chemical Oceanography

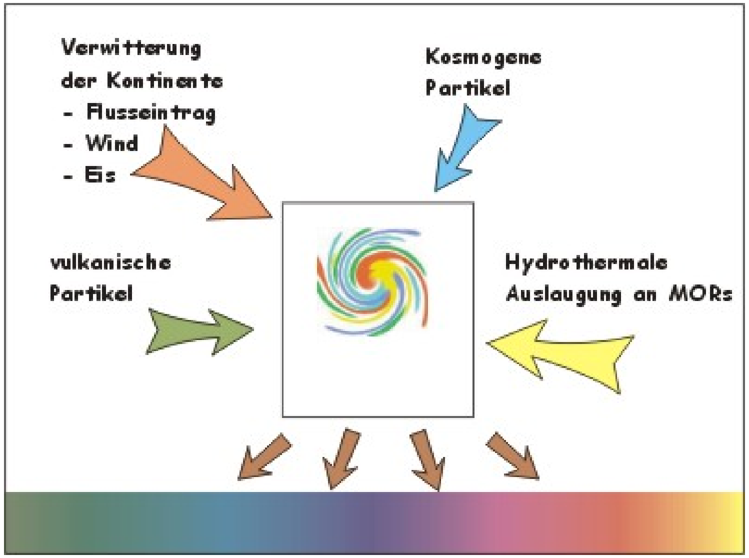
Where do the elements on the seawater come from?

1. Weathering of continents delivered to the oceans by rivers (also dust blown material)

2. Hydrothermal alteration of the oceanic crust

3. Volcanic degassing

The oceans as a chemical system



Quelle: http://www.meeresgeo-online.de/

Input:

rivers: **18.3 x 10^9 tons/yr**

Glaciers und ice: **2.0 x 10^9 tons/yr**

Wind (dust particles): **0.6 x 10^9 tons/yr**

Hydrothermal alteration of the oceanic crust

Volcanic degassing

Discharge:

Sedimentation
► anorganic
► biological

Processes along ocean floor and mid-ocean ridges

Chemical Oceanography

TABLE 1. COMPARISON OF RIVER WATER AND SEA WATER COMPOSITION

Ions	Average river water (mM/l)	Average sea water (mM/l)	River water ratio to Cl	Sea water ratio to Cl
HCO_3^-	0.86	2.38	5.375	0.0044
SO_4^-	0.069	28.2	0.43125	0.0517
Cl^-	0.16	545	1	1
Ca^{2+}	0.33	10.2	2.0625	0.0187
Mg^{2+}	0.15	53.2	0.9375	0.09761
Na^+	0.23	468	1.4375	0.8587
K^+	0.03	10.2	0.1875	0.0187

River water — Sea water

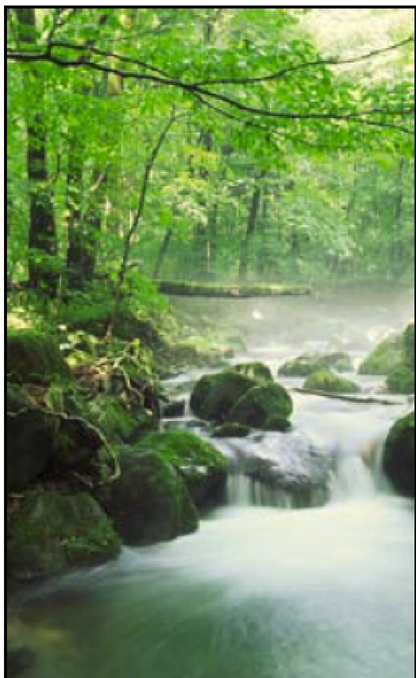
- **Georg Forchhammer (1794-1865)**
  Danish Mineralogist
  "*The quantity of different elements in seawater is not proportional to the quantity of elements which river water pours into the sea…*"

Marine mass balances

Source: Rivers

$[Mg^{+2}]_R$ * 3.5×10^{16} kg water yr^{-1}
= mmol Mg^{+2} / yr

$[Mg^{+2}]_R = 0.128$ mmol/kg



$[Mg^{+2}]_R$

Inventory: Ocean

$[Mg^{+2}]_O$ * 1.38×10^{21} kg water
= mmol Mg^{+2}

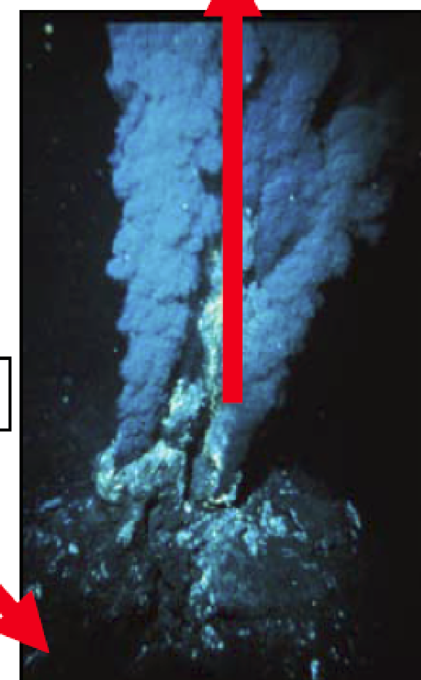
$[Mg^{+2}]_O = 52.8$ mmol/kg

$[Mg^{+2}]_O$

Sink: H.V. Systems

$[Mg^{+2}]_O$ * 1×10^{14} kg water yr^{-1}
= mmol Mg^{+2} / yr

$[Mg^{+2}]_{HV} = 0$ mmol/kg



Marine mass balances

Magnesium problem

units: 10^{14} g/yr

Supply of Mg^{2+}	Rivers	1.3	
	Total	1.3	
Removal of Mg^{2+}	**1** Original budget*		Percentage river flux
	Carbonate formation	0.075	
	Ion exchange	0.097	
	Glauconite formation	0.039	
	Mg–Fe exchange	0.29	
	Burial of interstitial water	0.11	
	Subtotal	0.61	47
	2 Modified budget		
Basalt-seawater interaction	Hydrothermal activity	0.60	
	Subtotal	0.60	46
	Total removal	1.21	93

* After Drever (1974).

Residence times in seawater of solutes

Element	A Concentration in rivers ppm (ppm)	B Input to ocean from rivers (grams/yr)	C Concentration in ocean (ppm)	D Amount in ocean (grams)	E Residence time in ocean (years)
Cl	6	$2x10^{14}$	19,350	$261x10^{20}$	$130x10^{6}$
Na	5	$2x10^{14}$	10,760	$145x10^{20}$	$72x10^{6}$
SO_4	8	$3x10^{14}$	2,712	$37x10^{20}$	$12x10^{6}$
Mg	3	$1x10^{14}$	1,294	$17x10^{20}$	$17x10^{6}$
Ca	13	$5x10^{14}$	412	$6x10^{20}$	$1x10^{6}$
K	1	$0.3x10^{14}$	399	$5x10^{20}$	$16x10^{6}$
HCO_3	52	$20x10^{14}$	145	$2x10^{20}$	$0.1x10^{6}$
Si	10	$4x10^{14}$	0.5-10 (6)	$0.08x10^{20}$	$.02x10^{6}$ (20k)

B: River Input of element = Concentration in rivers x Amount of water flowing from rivers to oceans

= A x $0.374x10^{20}$ grams/year

D: Amount of element in oceans = Concentration in oceans x Amount of water in oceans

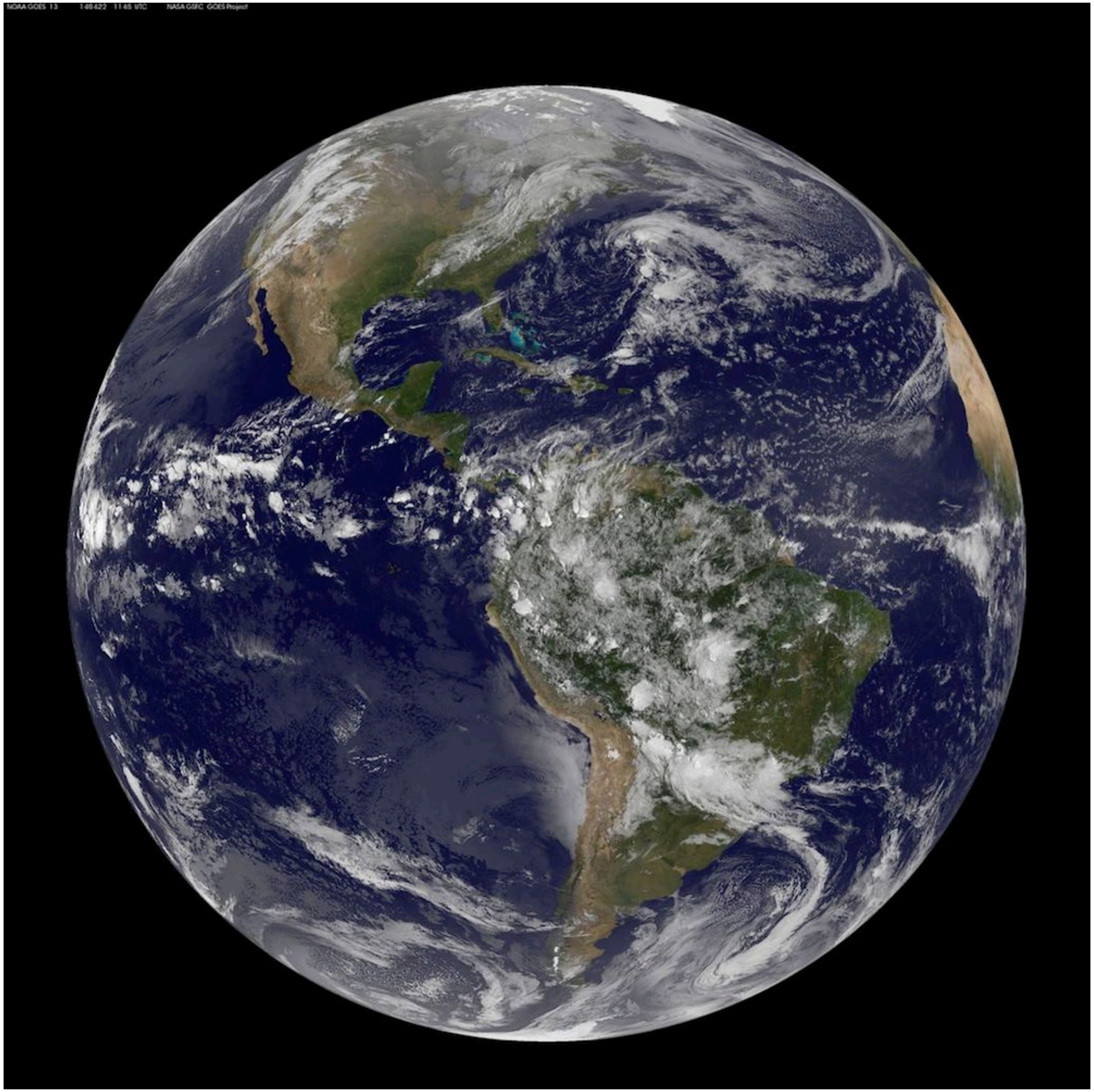
= C x 1.35×10^{24} grams / 10^{6}

E. Residence Time = Amount of element in ocean ÷ Rate of input from rivers

(i.e., how long it would take rivers to resupply oceans with their present mass of a given element)

= D ÷ B

The blue planet

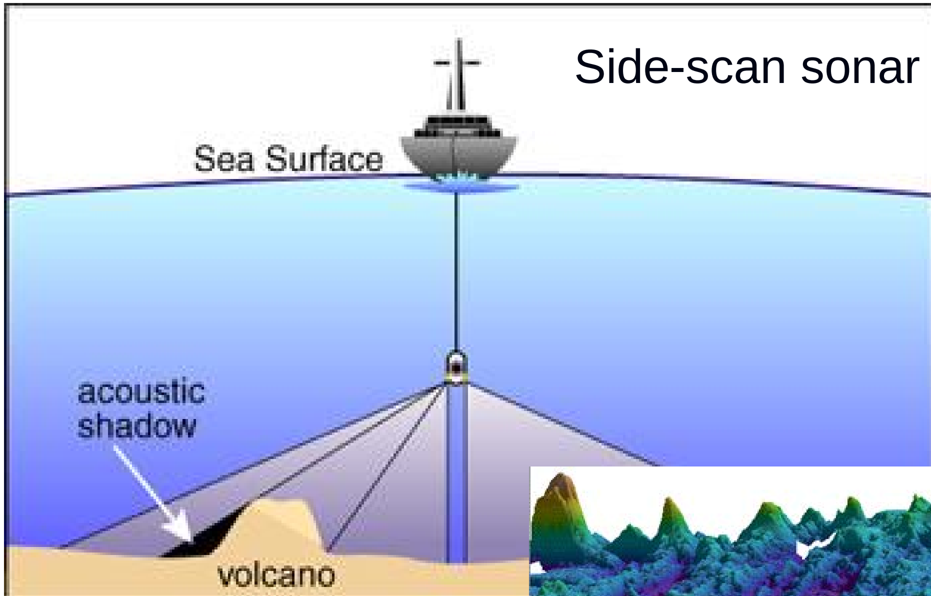


Where did the water in the oceans come from?

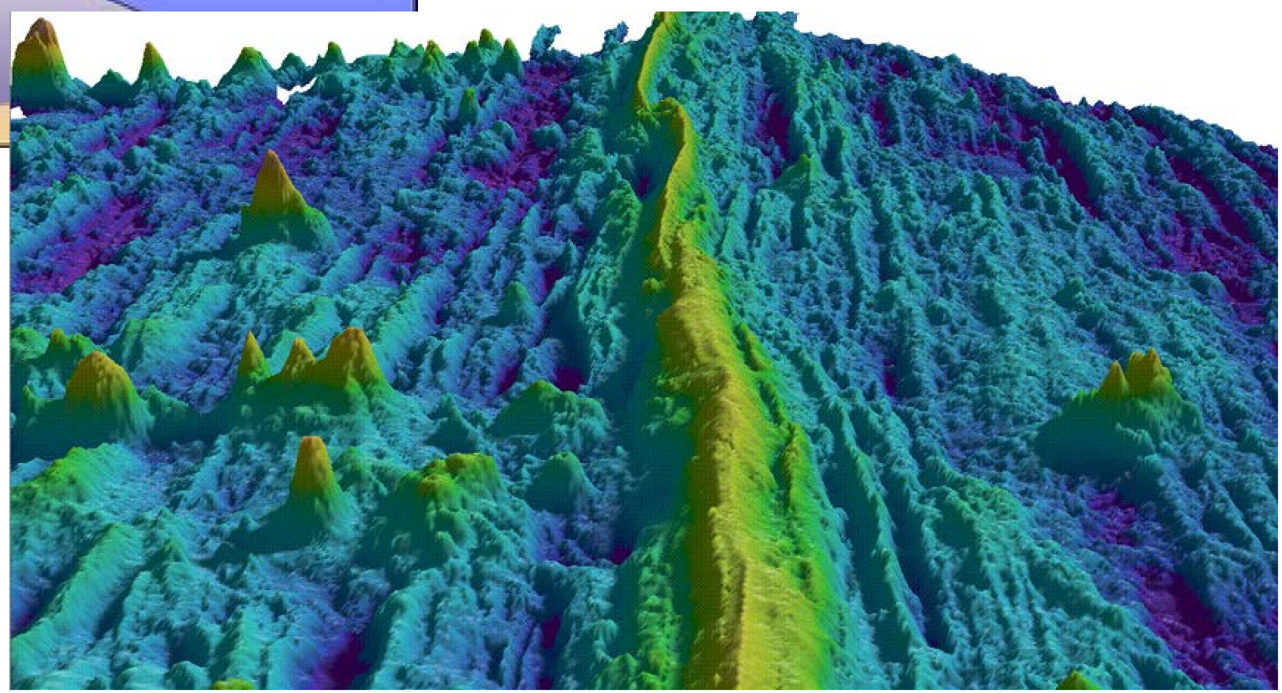
1. Earth held onto some water when it formed. Some of that water has remained with the Earth, and might be recycled through the planet's mantle layer.

2. delivered after Earth formed by ice-rich asteroids (carbonaceous chondrites) or comets.

Example *Physical Oceanography*



depicts the shape of the seafloor and objects on it

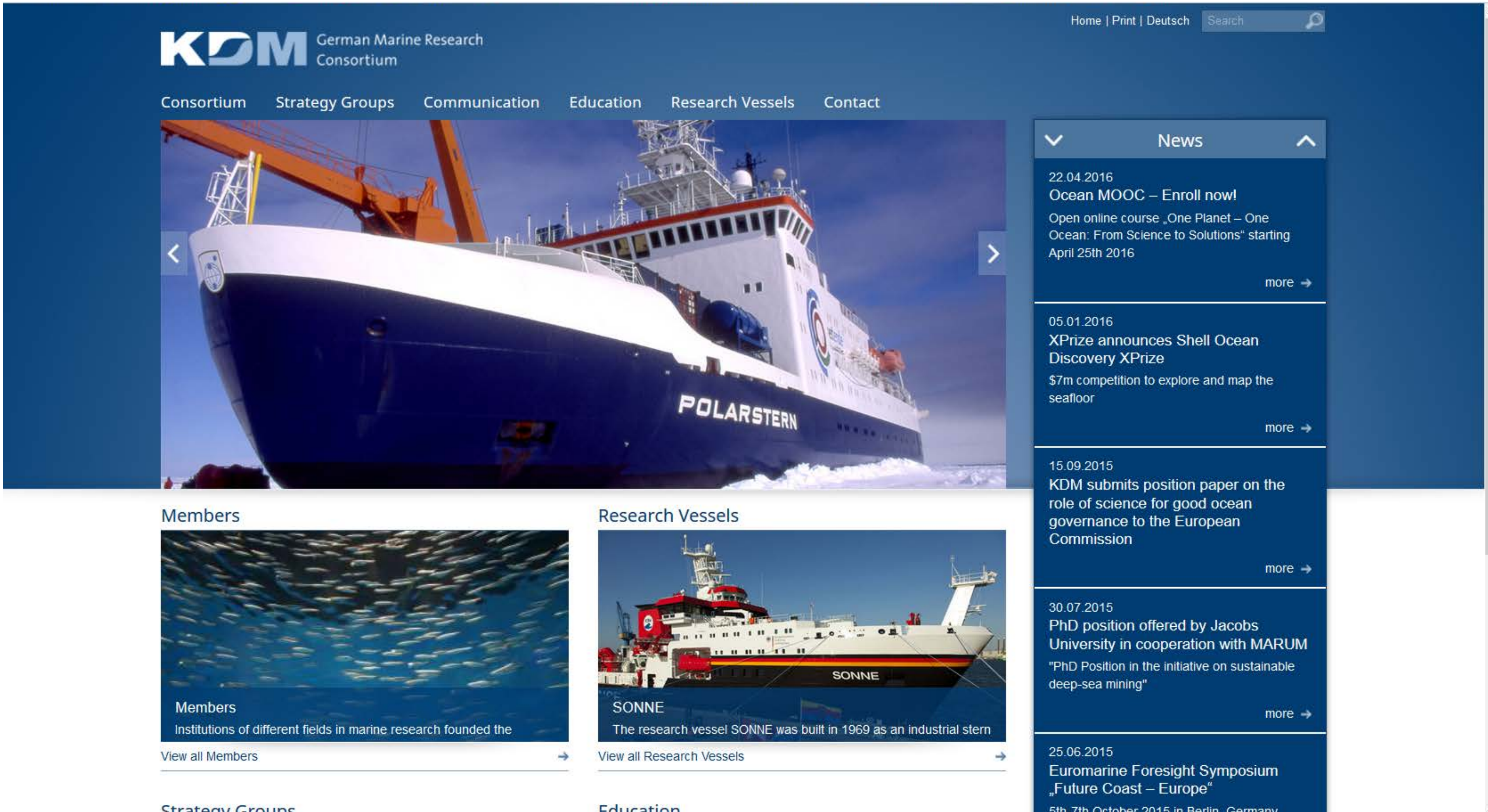


Research facilities for marine geosciences in Germany

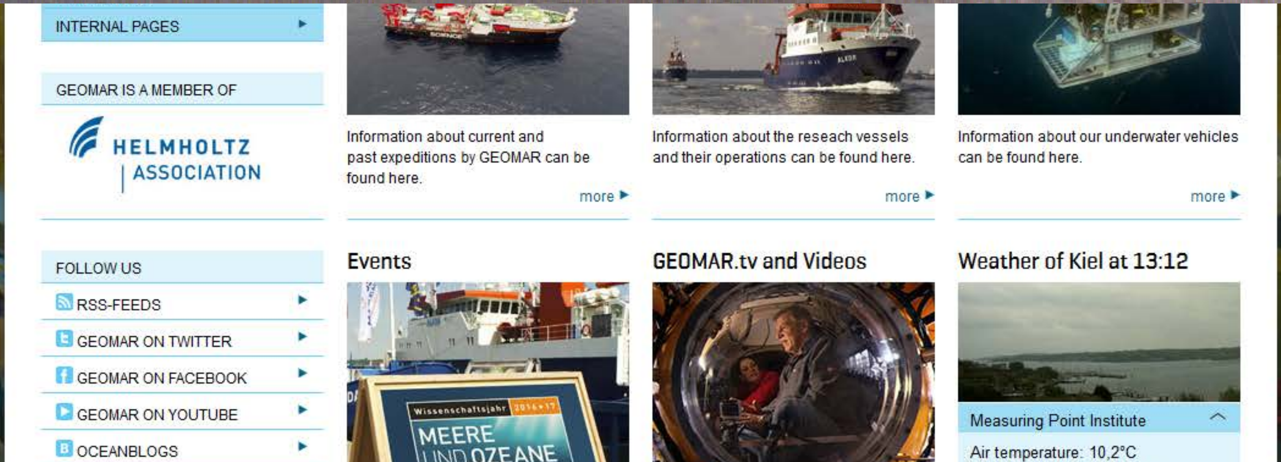
- GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
  from 2004-2012: IfM-GEOMAR
- MARUM – Zentrum für marine Umweltwissenschaften, Bremen
- Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven
- Max-Planck-Institut für marine Mikrobiologie, Bremen
- Institut für Meereskunde, Hamburg (focus on physical oceanography)
- Leibnitz-Institut für Ostseeforschung, Warnemünde (focus on shore lines and marginal basins)

http://www.deutsche-meeresforschung.de/en/members

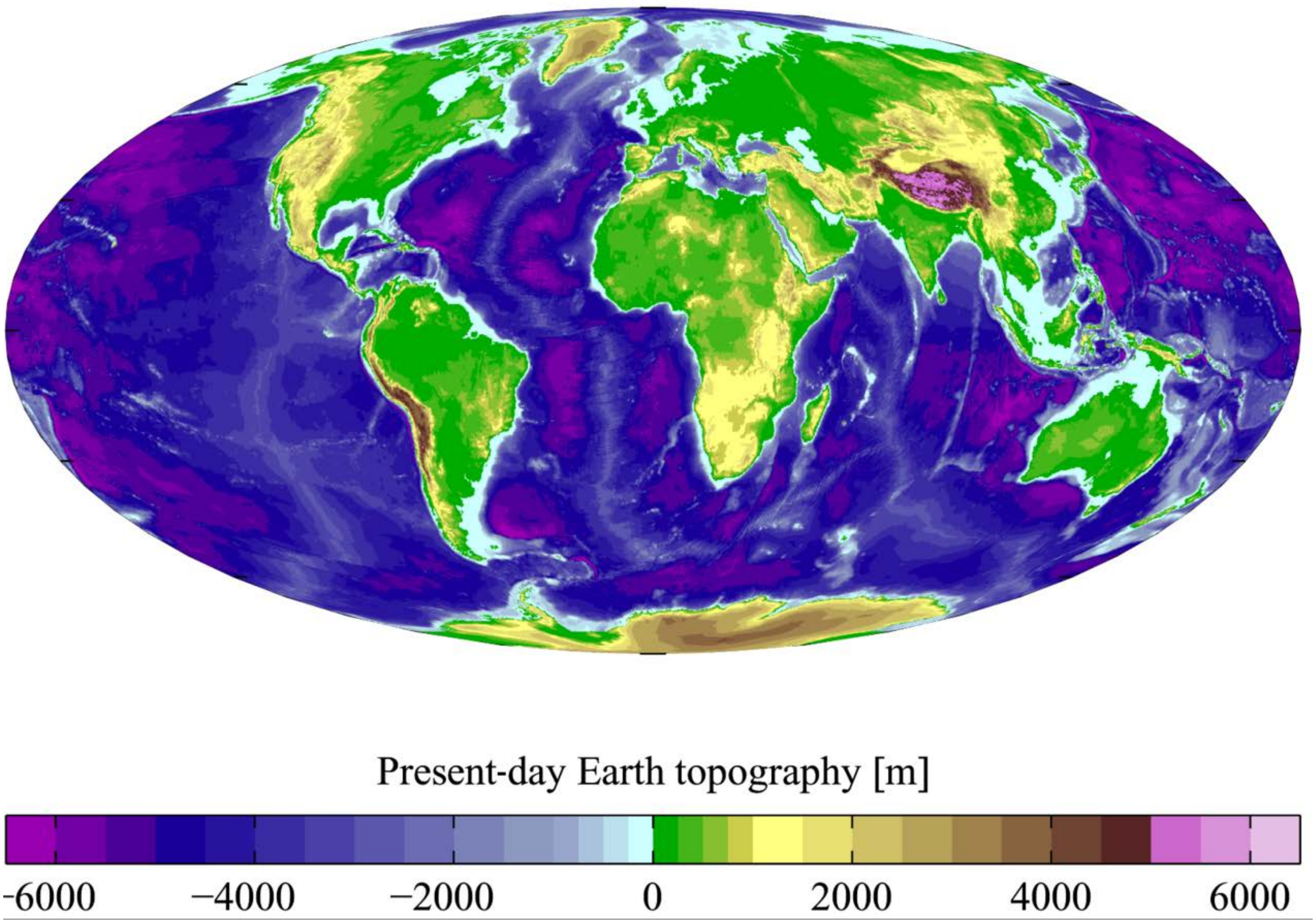
Research facilities for marine geosciences in Germany



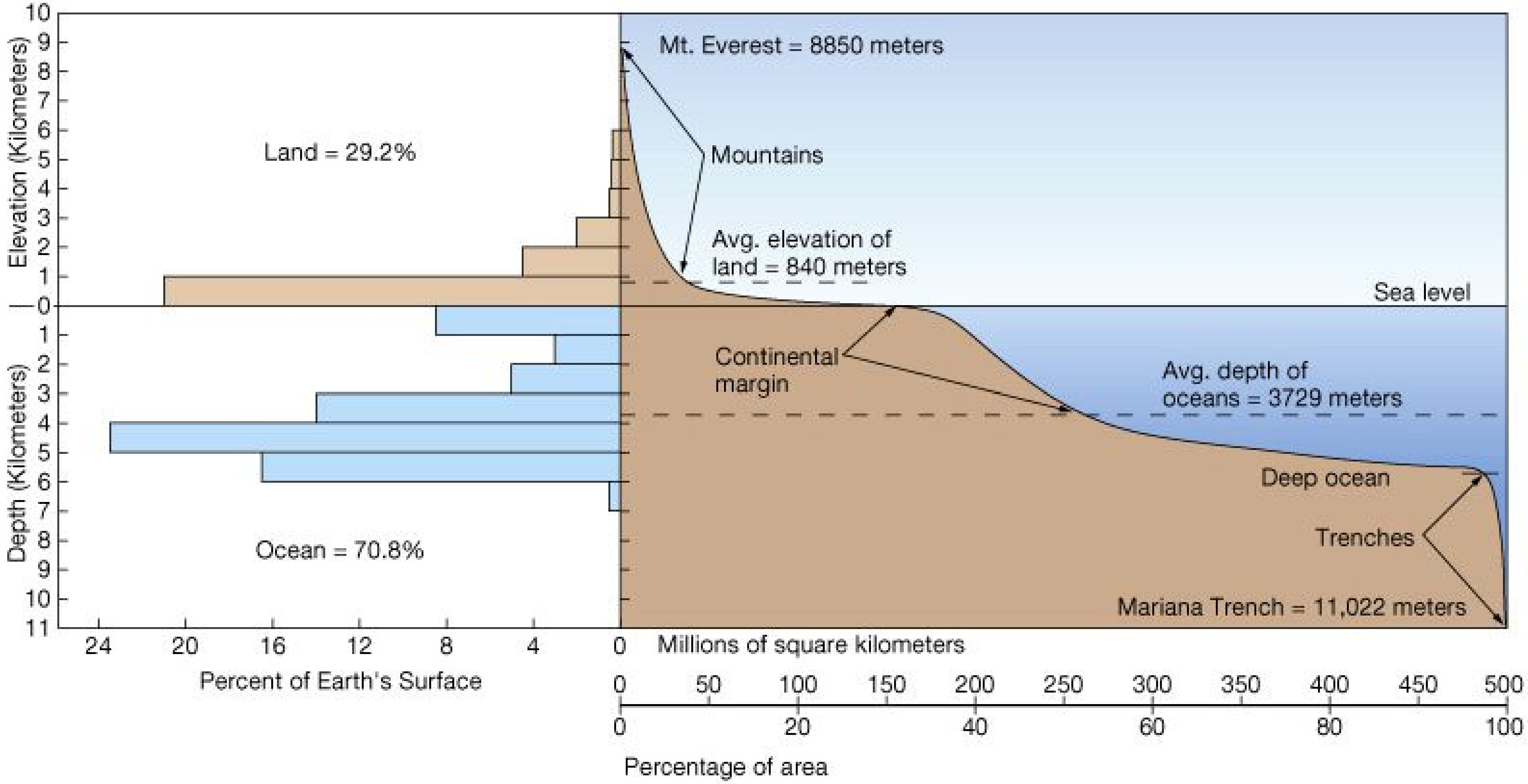
Research facilities for marine geosciences in Germany

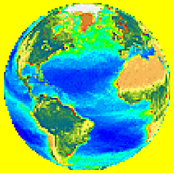


Ocean bathymetry



Hypsometric curve

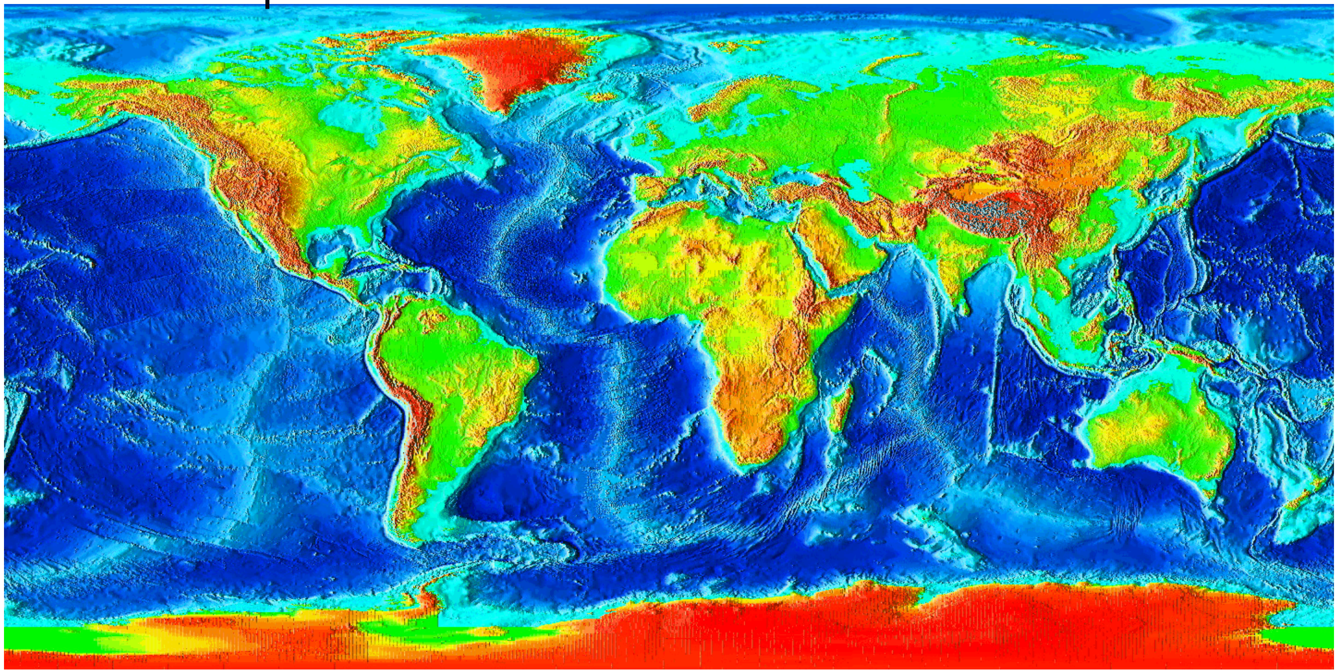




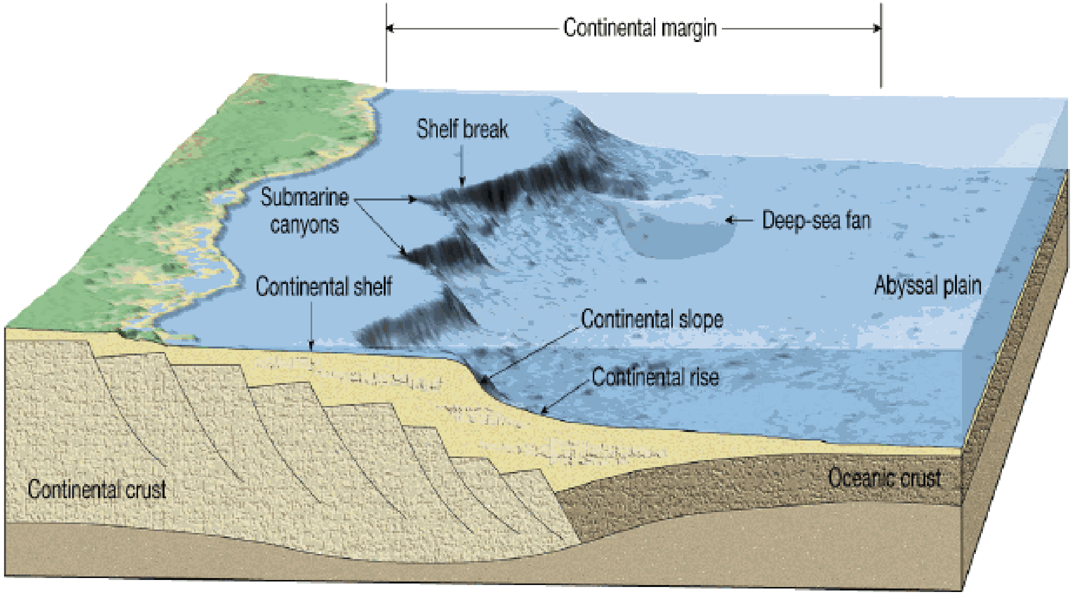
The Oceans

Ocean	Surface Area (million km^2)	Water Volume (million km^3)	Avg. Depth (km)	Max. Depth (km)
Pacific	177	700	4.0	11.0
Atlantic	98	335	3.6	9.2
Indian	77	285	3.7	7.5
Arctic	15	15	1.1	5.2

Pacific ocean: less than double size, but more than double volume compared to the Atlantic ocean



Continental Margins



Continental Shelf

Submerged part of the continent
Gently sloping (less than 1°)
Up to 1500 km wide;
averages 80 km wide
Locally cut by ***canyons***
(eroded by rivers during
the Ice age low sea level)

Continental Slope

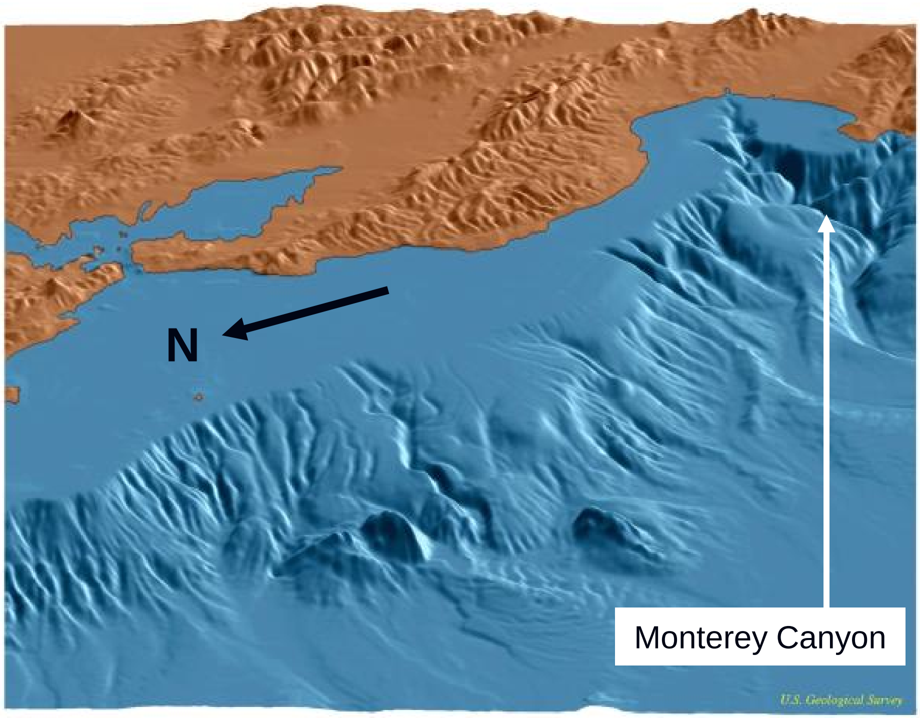
Boundary between continental and oceanic crust
Steeply sloping compared to shelf (averages
about 5° slope, up to 25°); about 20 km wide

Continental Rise

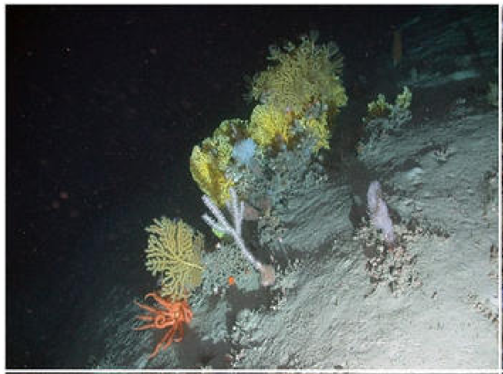
At base of continental slope; slope angle decreases
Thick accumulation of sediment transported downslope from continental shelf

At mouths of submarine canyons, *deep-sea fans* are present.
May be carved by turbidity currents - bottom-currents carrying suspended
sediment downslope

Submarine Canyons



Schelf und continental slope along California; source: USGS

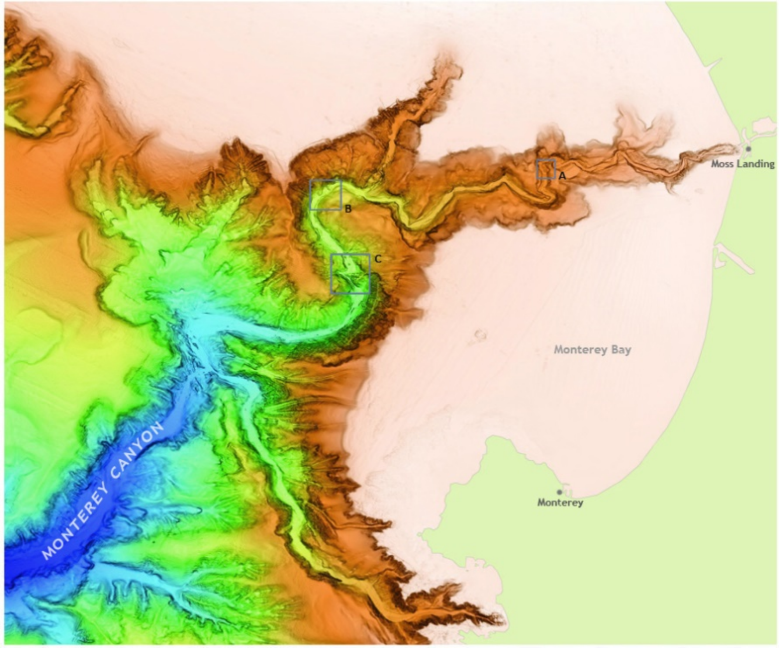


Submarine Canyons

("super-highways")

cut into the seabed of the continental slope

formation during lowstands of sea level



Deep-sea fan

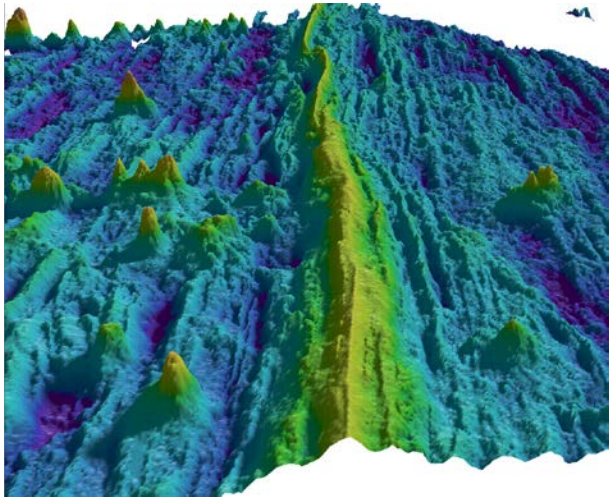
large-scale sediment deposition

sediments introduced through submarine canyons

formed by turbidity currents

examples: Amazonas fan; Bengal fan; Indus fan

Deep Ocean Basins



Abyssal plains *(Tiefseeboden)*
Flat, deep ocean floor
Depth may be 3 - 5 km
Sediments bury topography of oceanic crust

Deep sea trenches *(Tiefseerinnen)*
The deepest part of the oceans
May exceed 10.000 m deep
Deepest is Mariana trench in Pacific Ocean (more than 11.000 m)
Occur at subduction zones where oceanic crust is forced downward into the mantle

Mid-ocean ridges
continuous range of undersea mountains winding through 70.000 km of the world's oceans

Seamounts
Undersea volcanic peaks which formed along mid-ocean ridges or over hot spots
May be eroded flat on top and called *guyots*
May be ringed by coral reefs called *atolls*