Lithosphere

Module: Ecological geology

Lecture 2

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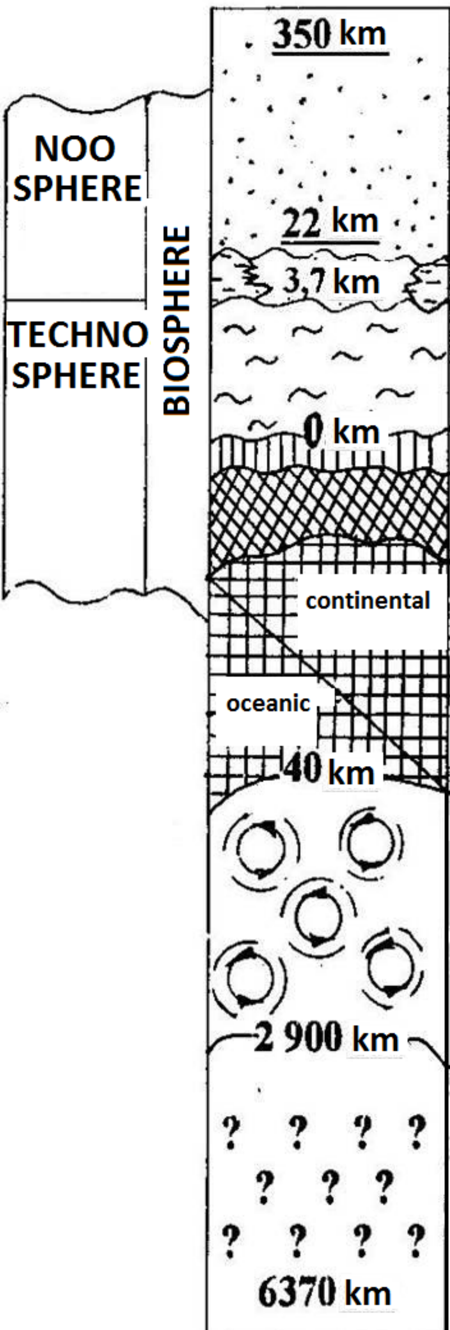
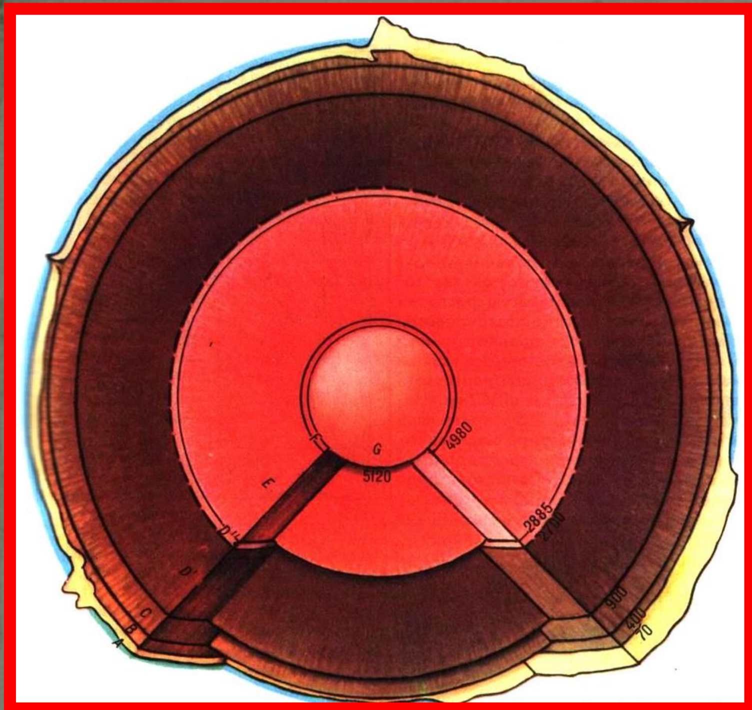
- The lithosphere is the solid, outer part of the Earth. The lithosphere, which is about 100 kilometers deep in most places, includes the brittle upper portion of the mantle and the crust.

Geospheres of the Earth

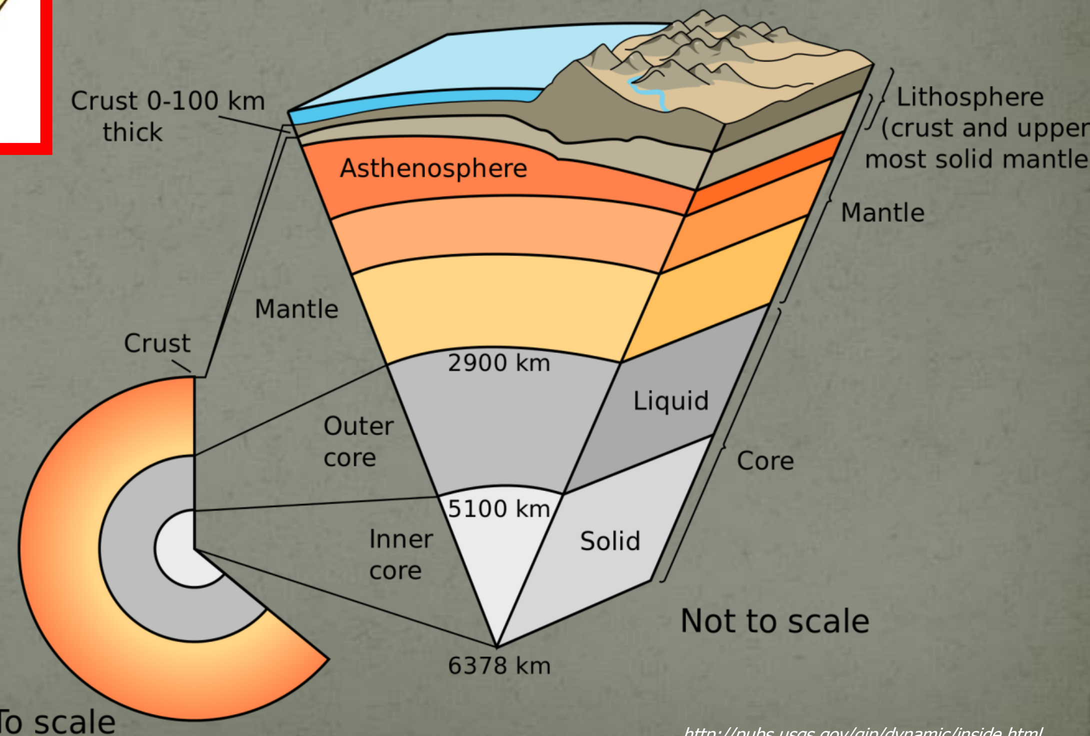


Exosphere	Ionosphere	***Atmosphere*** (atmos - vapor)	He, H, O_3, N O_2 Ar CO_2 Ne
Mesosphere	Ionosphere		
Stratosphere			
Troposphere			
Ice (Icesphere?)		***Hydrosphere*** (hydro - water)	H(H_2O), O Cl Na
Surface and underground waters of continents and oceans			
Global Ocean sediment floor		***Lithosphere*** (litos - rock) Relatively hard, rigid outer shell of the Earth (Earth crust).	O, Si, Al, P, K, Na, Ca, Mg, Ti, Fe, Ni
Soil (Pedosphere) Crustal weathering , zone of oxidation			
Hard silicate rocksof different origin (magmatic, metamorphic, sedimentary)			
Mantle (mantle - cover)	Upper	***Asthenosphere*** (asthenes - weak) Layer with low hardness density, velocity. Deep geologically active layer.	
	Lower		
Earth core	Outer		Fe ?, Ni ?, C (?), H (?), U (?)
	Transition zone		
	Inner		

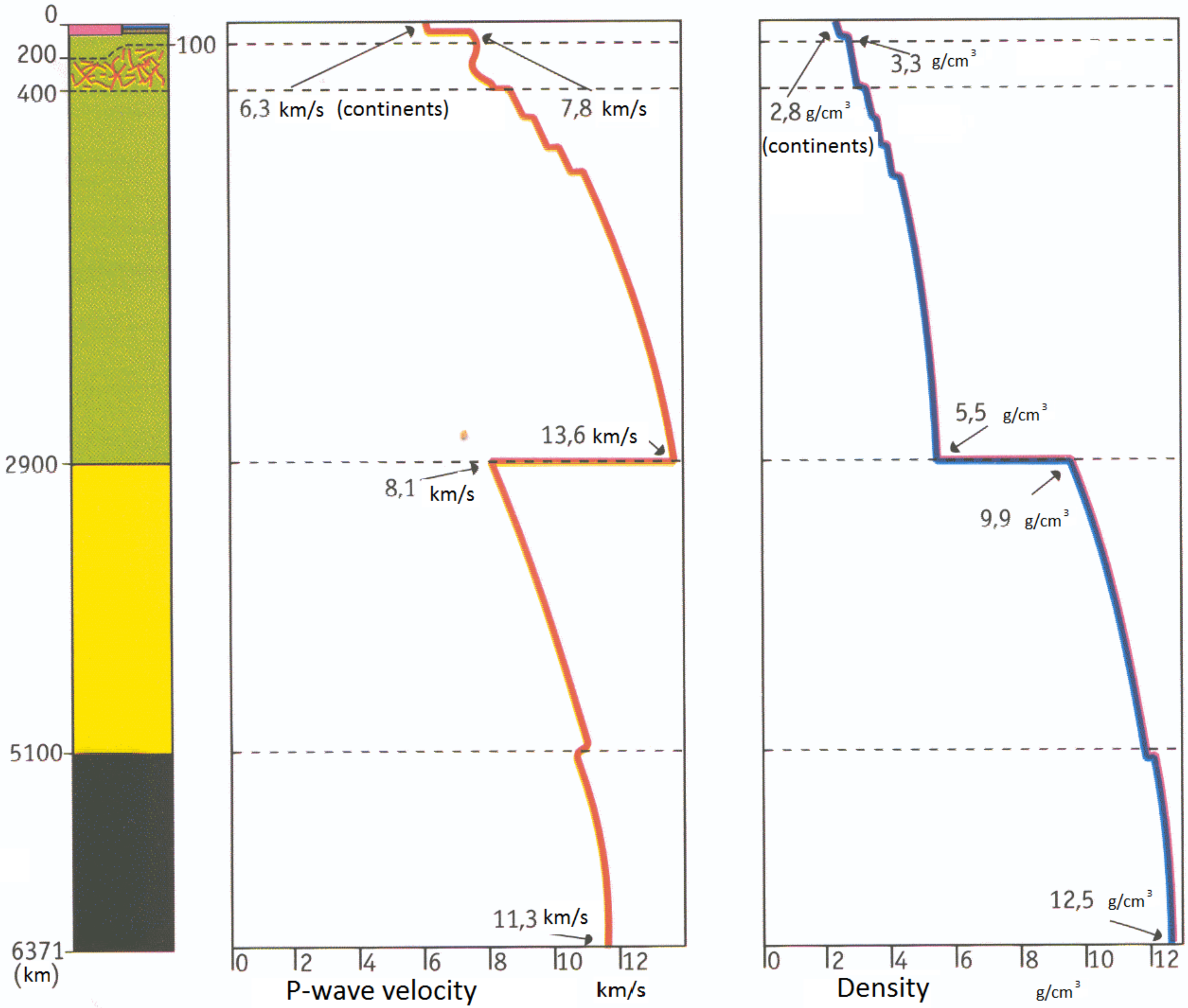
Earth structure



The Earth consists of three main layers: the core, or the inner layer; the mantle, in the middle; and the crust, which includes the continents and ocean floor.



http://pubs.usgs.gov/gip/dynamic/inside.html


0
200
400
100
2900
5100
6371
(km)
6,3 km/s (continents)
7,8 km/s
13,6 km/s
8,1 km/s
11,3 km/s
0 2 4 6 8 10 12
P-wave velocity
km/s
3,3 g/cm³
2,8 g/cm³
(continents)
5,5 g/cm³
9,9 g/cm³
12,5 g/cm³
0 2 4 6 8 10 12
Density
g/cm³

Inner Earth structure (Voronov, 1968)

Index	Layer		Depth interval	Density (g/sm^3)	Probable Temperature, ^{o}C	Probable Pressure (mln.atm.)*	Part of total mass (%)
A	Earth crust		0-40	2.7-2.9	1000-1100	0.01	0.8
B	Mantle (atmosphere)	Upper	40-400	3.3-3.6	1499-1700	0.14	10.4
C			400-960	3.6-4.7	} 1600-2400		16.4
D'		Lower	960-2740	4.7-5.6		0.39	
D''			2740-2900	5.6-5.7	} 2200-4700		} 41.0
E	Inner core		2900-4990	9.4-11.5		1.37	
F	Transition zone		4990-5150	11.5-14.2(?)	} 5000		} 31.5
G	Outer core		5150-6371	16.8(?)-17.2(?)		3.3-3.6	

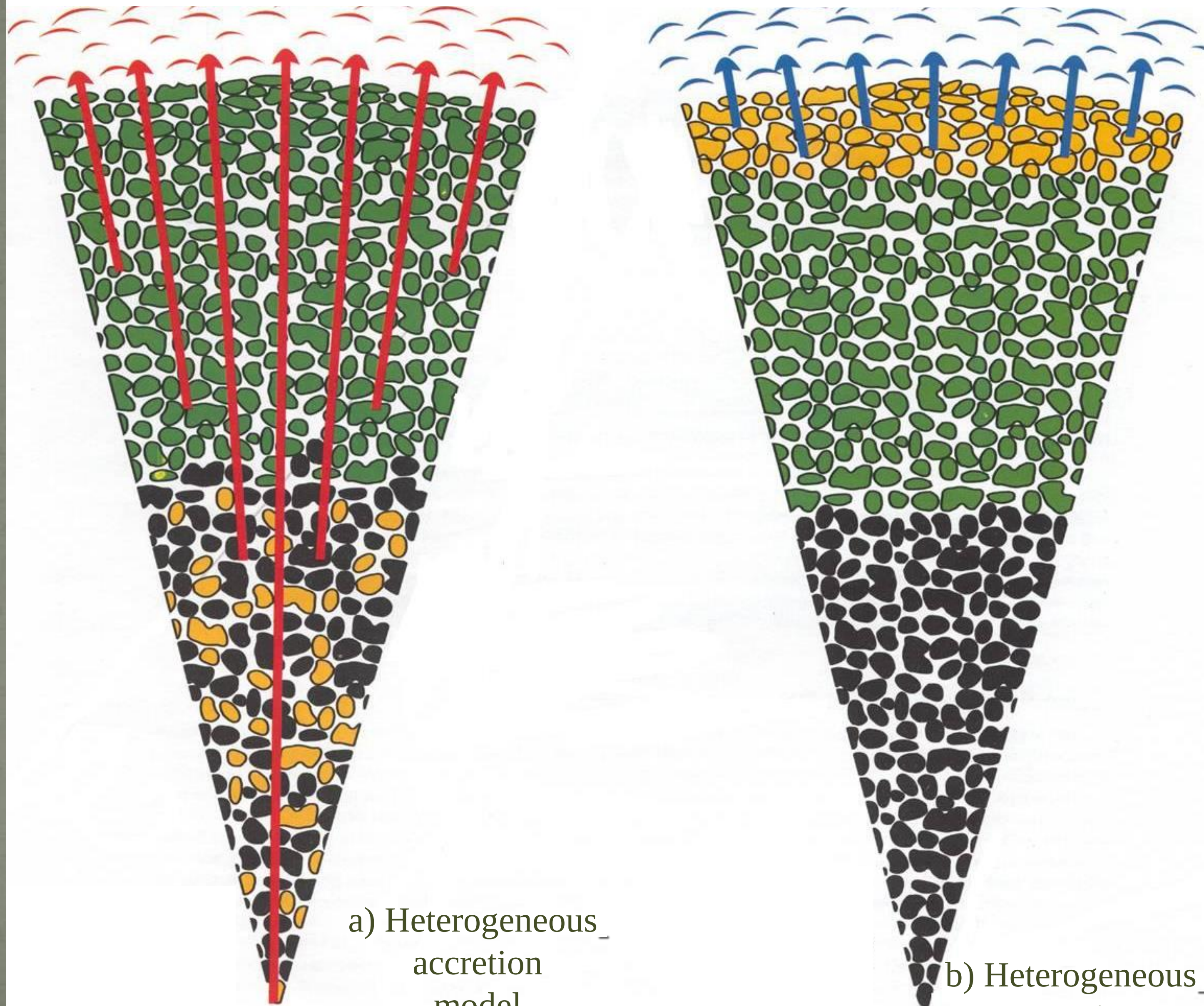
- According to statistics of K.E. Bullen [1961], V.A.Magnitskiy [1965] and I.Verhugen [1958]. *atm = 10^5 Pa

Heterogeneous accretion

- A model for the accretion of the planetary bodies from the primitive solar nebula (PSN), in which the rate of accretion of solid particles into the planets is slow relative to the rate at which the PSN cools.
- The consequence is that the surface layer of each body at any one time is in equilibrium with the pressure and temperature conditions prevailing in the nebula, and thus each planet accretes successive ‘onion-skin’ layers of material with different compositions. According to this model, the layered structure of planets may be partly of primary origin.

Sharp reducing primary atmosphere, consisting of H_2, CH_3, NH_4

Neutral primary atmosphere with predominating H_2O, CO, N_2, CO_2



a) Heterogeneous accretion model

b) Heterogeneous accretion model

The continental lithosphere

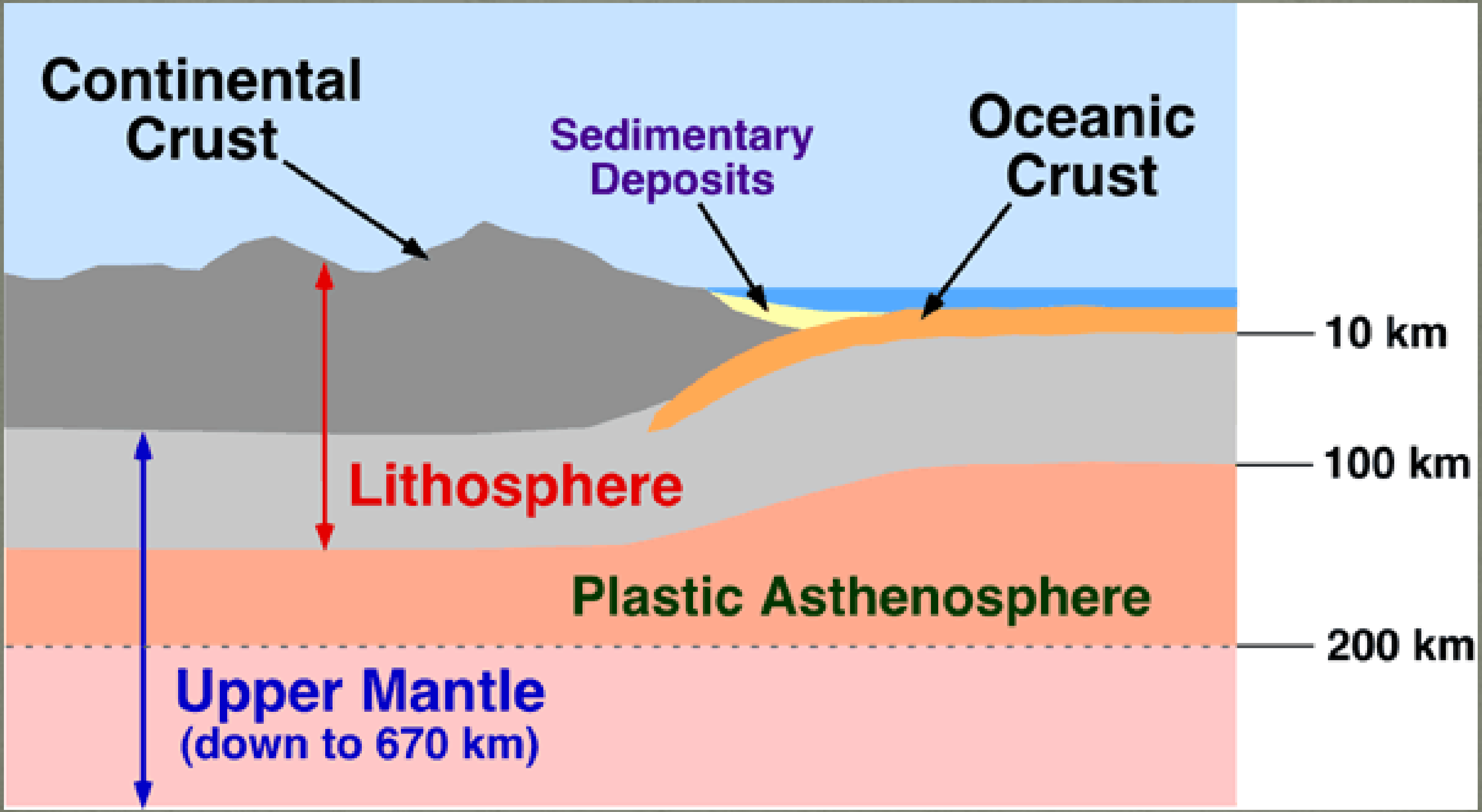
- is also called the continental crust - is the layer of igneous, sedimentary rocks that forms the continents and the continental shelves.
- This layer consists mostly of granitic rocks. Continental crust is less dense than oceanic crust although it is considerably thicker (25 to 70 km versus 7-10 km). About 40% of the Earth's surface is now covered by continental crust, but continental crust makes up about 70% of the volume of Earth's crust.

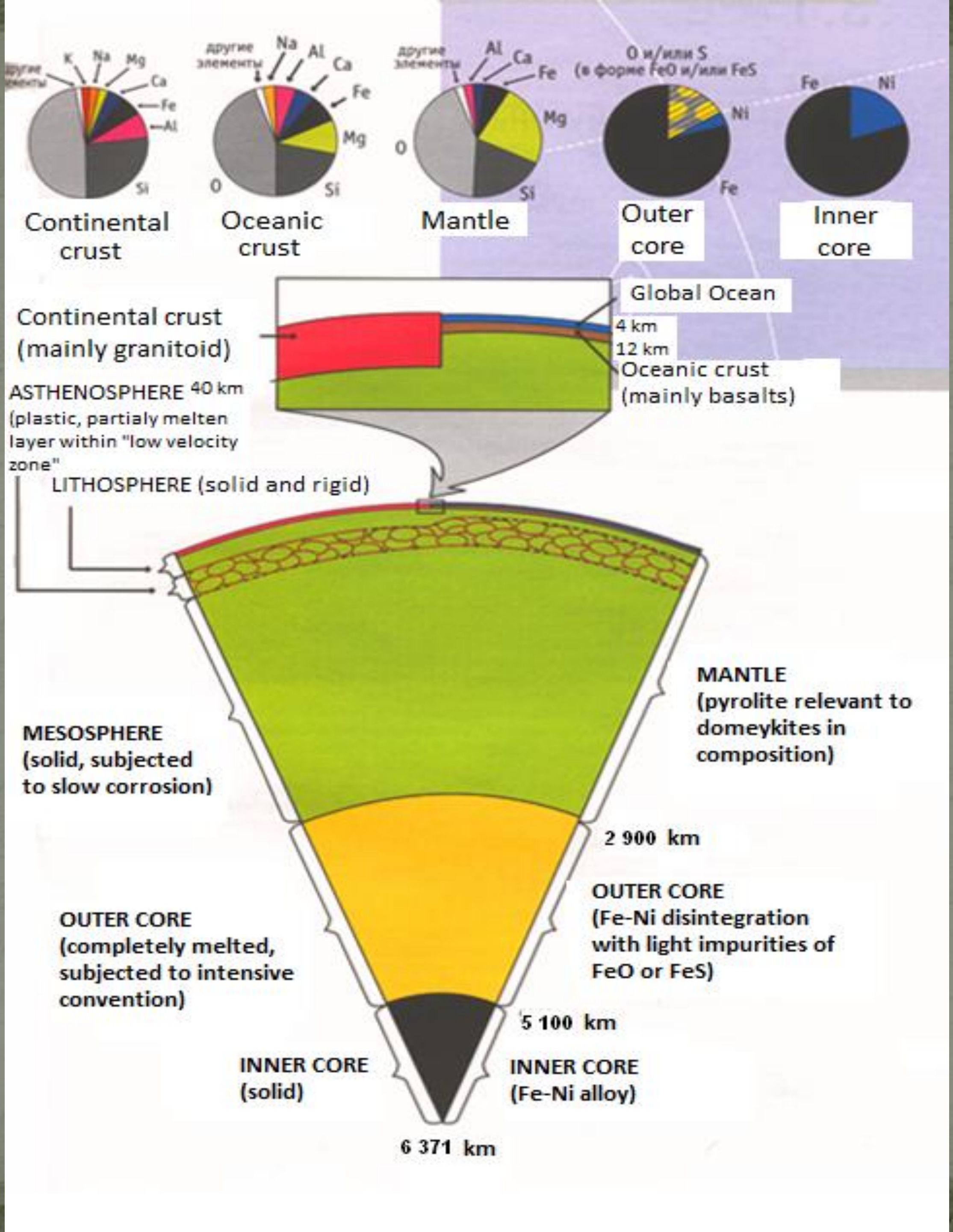
Oceanic lithosphere

- Oceanic lithosphere consists mainly of mafic (rich in magnesium and iron) crust and ultramafic (over 90% mafic) mantle and is denser than continental lithosphere.
- It thickens as it ages and moves away from the mid-ocean ridges. This thickening occurs by conductive cooling, which converts hot asthenosphere into lithospheric mantle.
- It was less dense than the asthenosphere for tens of millions of years, but after this becomes increasingly denser.
- The gravitational instability of mature oceanic lithosphere has the effect that when tectonic plates come together, oceanic lithosphere invariably sinks underneath the overriding lithosphere.
- New oceanic lithosphere is constantly being produced at mid-ocean ridges and is recycled back to the mantle at subduction zones, so oceanic lithosphere is much younger than its continental counterpart.

The oldest oceanic lithosphere is about 170 million years old compared to parts of the continental lithosphere which are billions of years old.

Structure of the Earth's crust and top most layer of the upper mantle

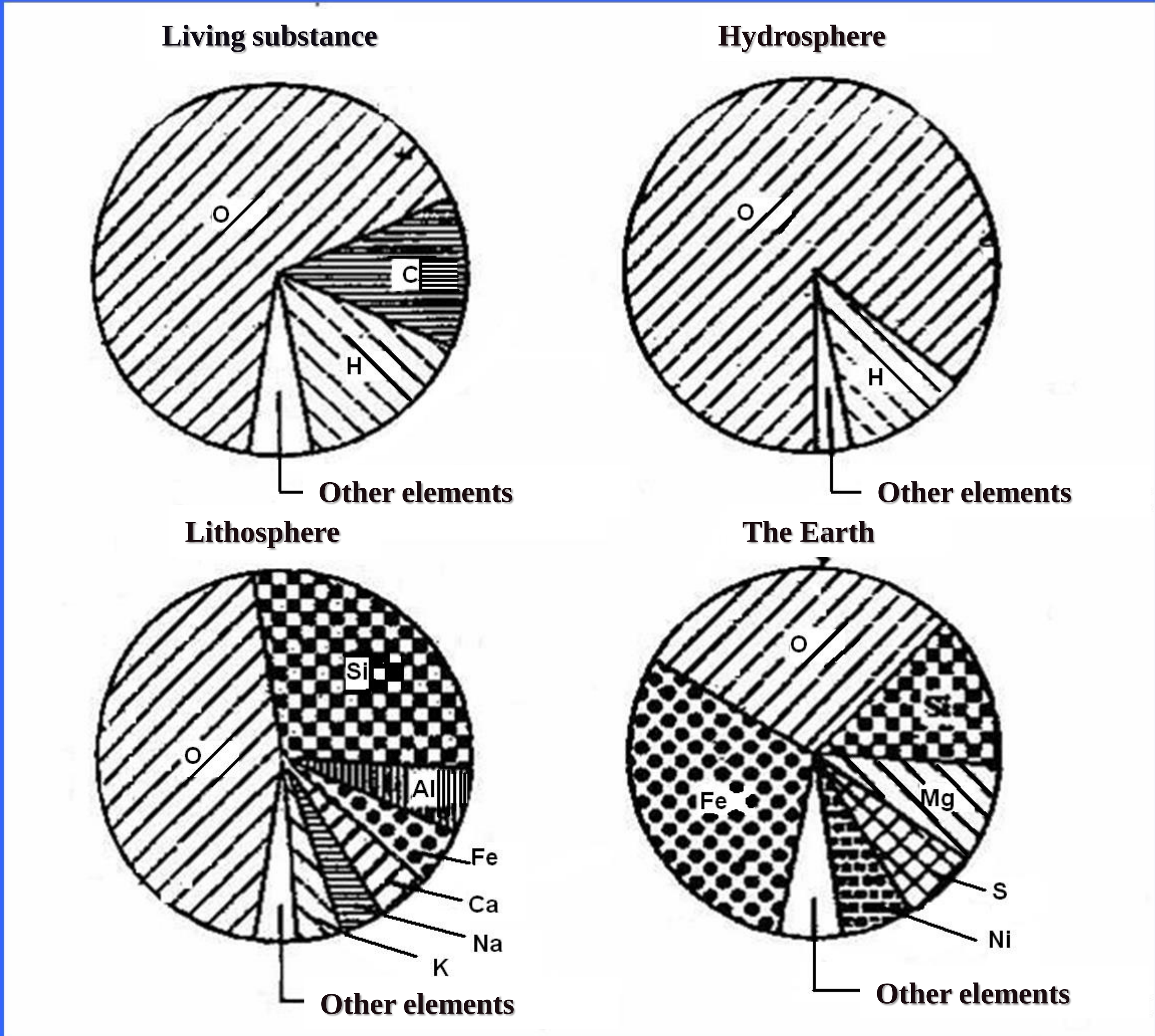




другие элементы
K
Na
Mg
Ca
Fe
Al
Si
Continental crust
O
Si
Oceanic crust
Mantle
O и/или S (в форме FeO и/или FeS)
Ni
Fe
Outer core
Inner core
Global Ocean
Continental crust (mainly granitoid)
4 km
12 km
Oceanic crust (mainly basalts)
ASTHENOSPHERE 40 km
(plastic, partialy melten layer within "low velocity zone"
LITHOSPHERE (solid and rigid)
MANTLE (pyrolite relevant to domeykites in composition)
MESOSPHERE (solid, subjected to slow corrosion)
2 900 km
OUTER CORE (Fe-Ni disintegration with light impurities of FeO or FeS)
OUTER CORE (completely melted, subjected to intensive convention)
5 100 km
INNER CORE (solid)
INNER CORE (Fe-Ni alloy)
6 371 km

Element composition of the Earth

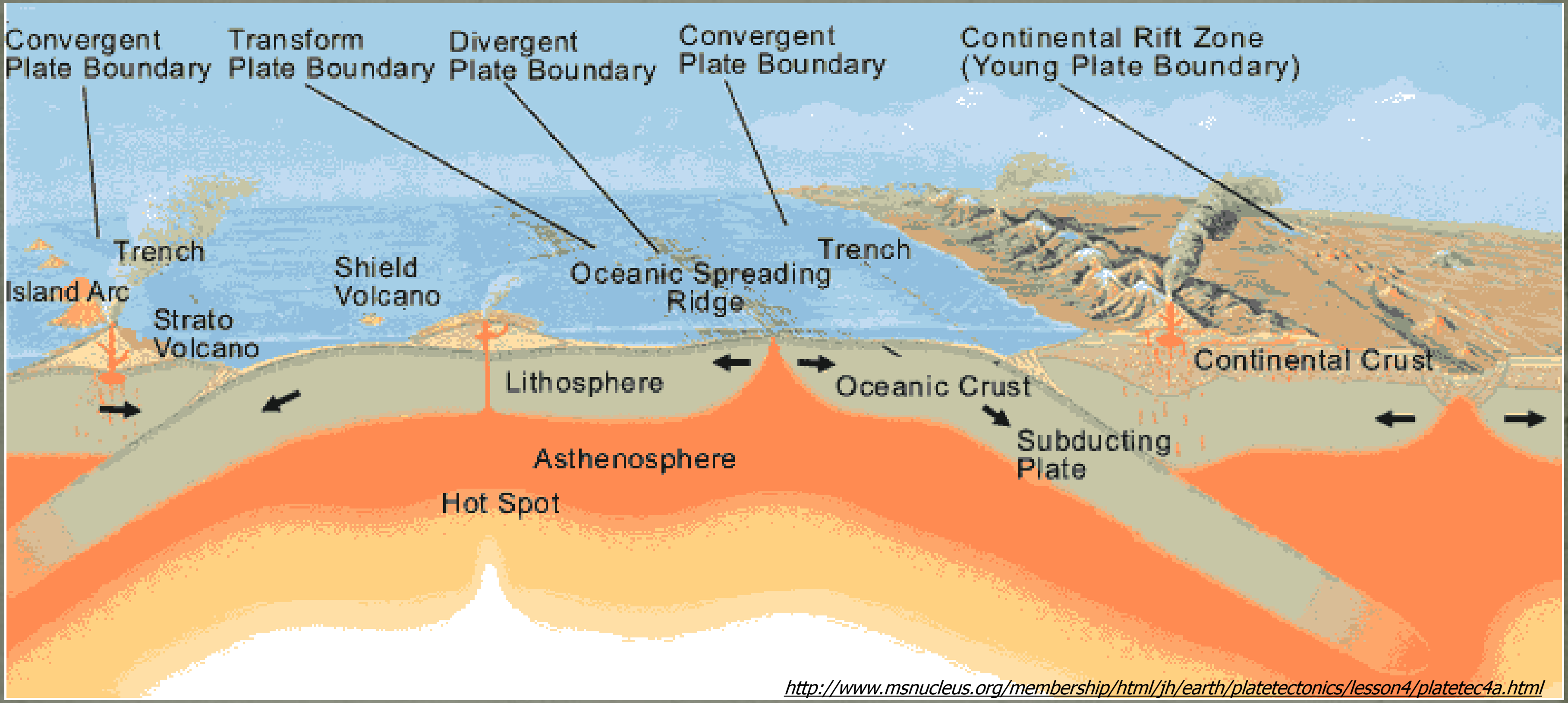
Chemical element	Weight percentage	Chemical element	Weight percentage
Iron	34.63	Sodium	0.57
Oxygen	29.53	Chromium	0.26
Silicon	15.20	Manganese	0.22
Magnesium	12.70	Cobalt	0.13
Nickel	2.39	Phosphorus	0.10
Sulfur	1.93	Potassium	0.07
Calcium	1.13	Titanium	0.5
Aluminum	1.09		

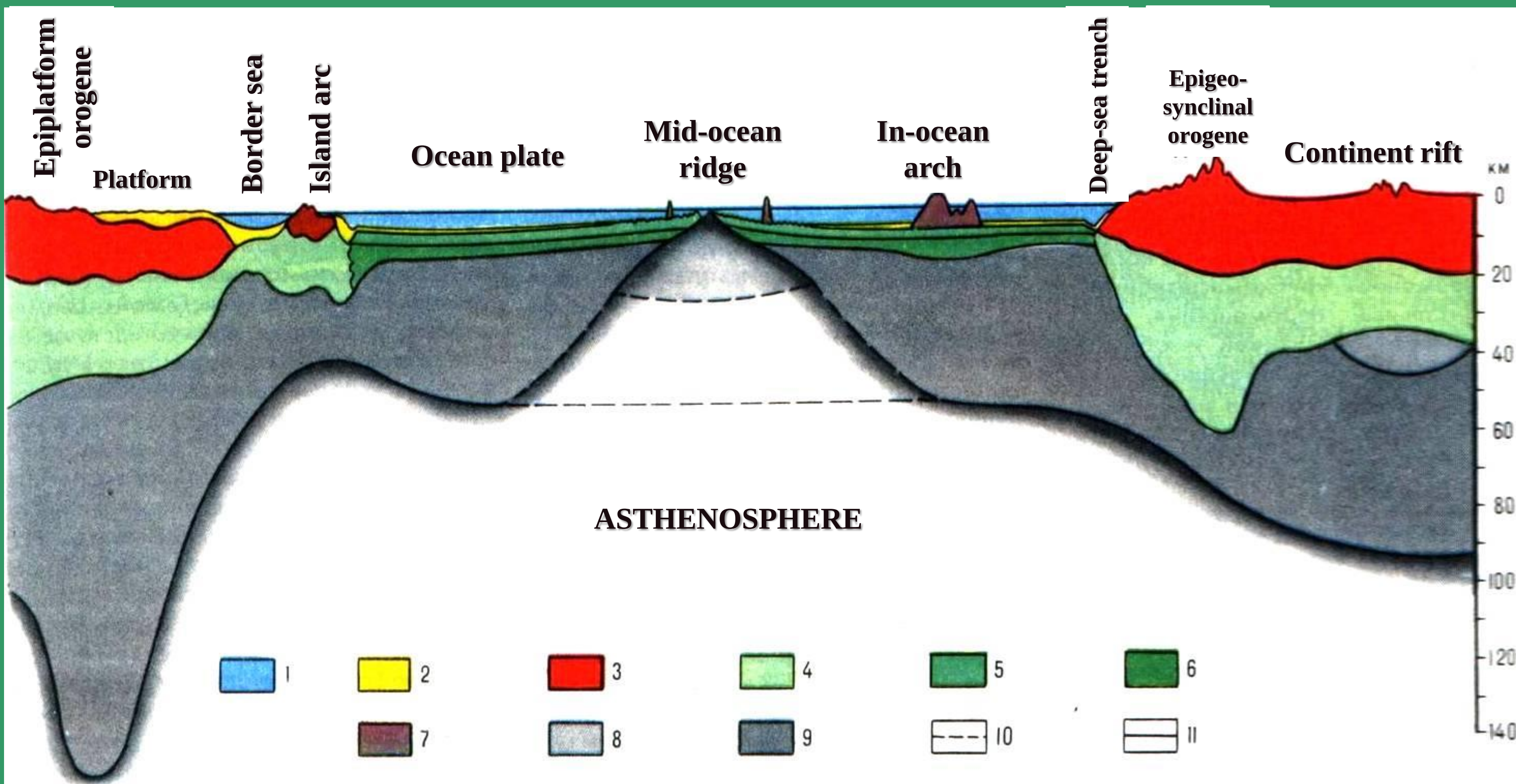

Living substance
O
C
H
Other elements
Hydrosphere
O
H
Other elements
Lithosphere
O
Si
Al
Fe
Ca
Na
K
Other elements
The Earth
O
Si
Fe
Mg
S
Ni
Other elements

Average content of some chemical elements in the Earth crust, soil and living organisms (weight %, dated 1968)

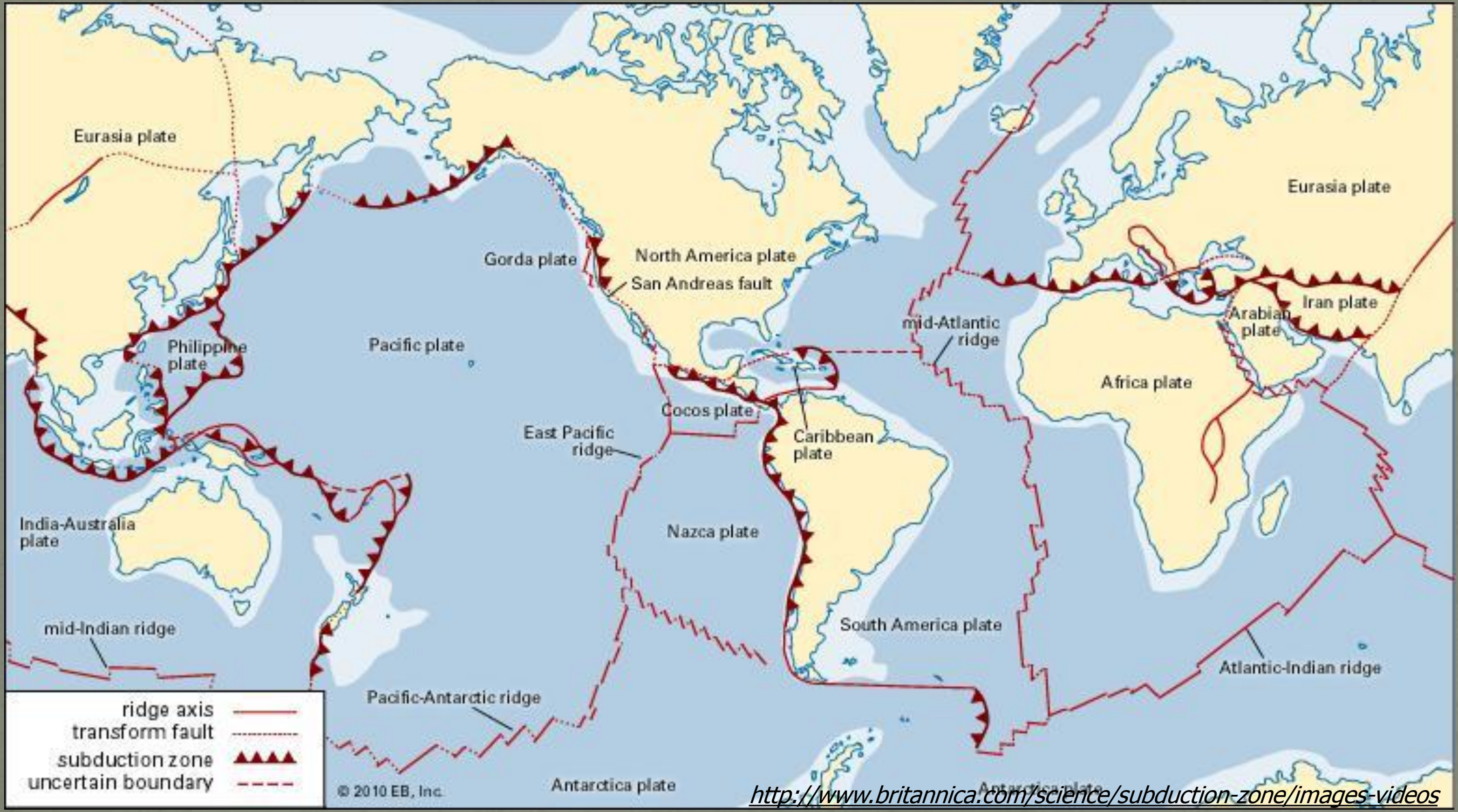
Chemical elements	The Earth crust (sedimentary rocks)	Soil	Living organisms (plants)
B	$1*10^{-2}$	$1*10^{-3}$	$1*10^{-4}$
C	1,0	2,0	18,0
N	$6*10^{-2}$	$1*10^{-1}$	$3*10^{-1}$
O	52,8	49,0	70
F	$5*10^{-2}$	$2*10^{-2}$	$1*10^{-5}$
Na	0,66	0,63	$2*10^{-2}$
Mg	1,34	0,63	$7*10^{-2}$
Al	10,45	7,1	$2*10^{-2}$
Si	23,8	33,0	$1,5*10^{-1}$
P	$7*10^{-2}$	$8*10^{-2}$	$7*10^{-2}$
S	$3*10^{-1}$	$8*10^{-2}$	$5*10^{-2}$
Cl	$1,6*10^{-2}$	$1*10^{-2}$	10^{-2}
K	2,28	1,36	$3*10^{-1}$
Ca	2,53	1,37	$3*10^{-1}$
Ti	0,45	$4,6*10^{-1}$	$1*10^{-4}$
Mn	$6,7*10^{-2}$	$8*10^{-2}$	$1*10^{-3}$
Fe	3,3	3,8	$2*10^{-2}$
Cu	$5,7*10^{-3}$	$2*10^{-3}$	$2*10^{-4}$
Sr	$4,5*10^{-2}$	$3*10^{-2}$	$4*10^{-4}$
Zr	$2*10^{-2}$	$3*10^{-2}$	10^{-4}
I	$1*10^{-4}$	$5*10^{-4}$	$1*10^{-5}$
Ba	$8*10^{-2}$	$5*10^{-2}$	10^{-4}
U	$3*10^{-4}$	$5*10^{-5}$	$5*10^{-7}$

- The lithosphere is always moving, but very slowly. It is broken into huge sections called tectonic plates. The extreme heat from the mantle part of the lithosphere makes it easier for the plates to move; this is similar to how iron is bendable once it's heated. The movement of the lithosphere, called plate tectonics, is the reason behind a lot of Earth's most dramatic geologic events. When one plate moves beneath another, or when two plates rub together, they can create earthquakes and volcanoes.

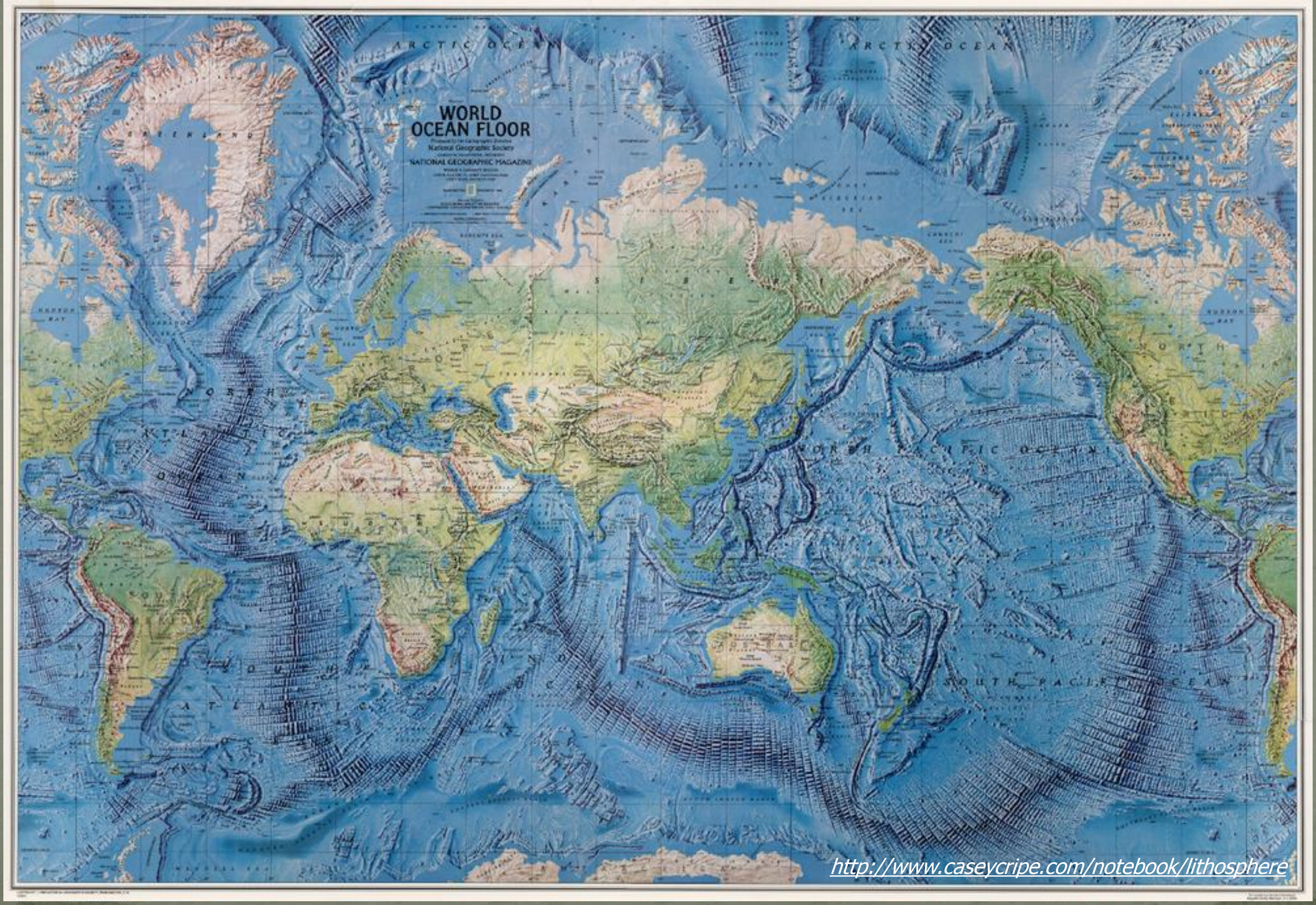

Convergent
Plate Boundary
Transform
Plate Boundary
Divergent
Plate Boundary
Convergent
Plate Boundary
Continental Rift Zone
(Young Plate Boundary)
Trench
Island Arc
Strato
Volcano
Shield
Volcano
Oceanic Spreading
Ridge
Trench
Continental Crust
Lithosphere
Oceanic Crust
Subducting
Plate
Asthenosphere
Hot Spot
http://www.msnucleus.org/membership/html/jh/earth/platetectonics/lesson4/platetec4a.html



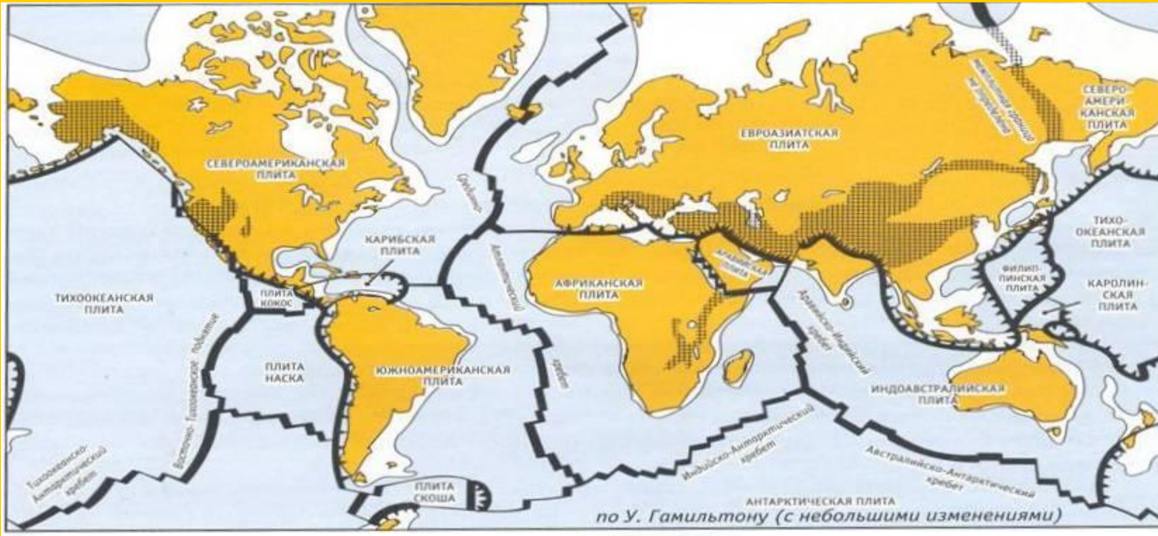
Epiplatform orogene
Platform
Border sea
Island arc
Ocean plate
Mid-ocean ridge
In-ocean arch
Deep-sea trench
Epigeo-synclinal orogene
Continent rift
KM
0
20
40
60
80
100
120
140
ASTHENOSPHERE
1
2
3
4
5
6
7
8
9
10
11



http://www.britannica.com/science/subduction-zone/images-videos

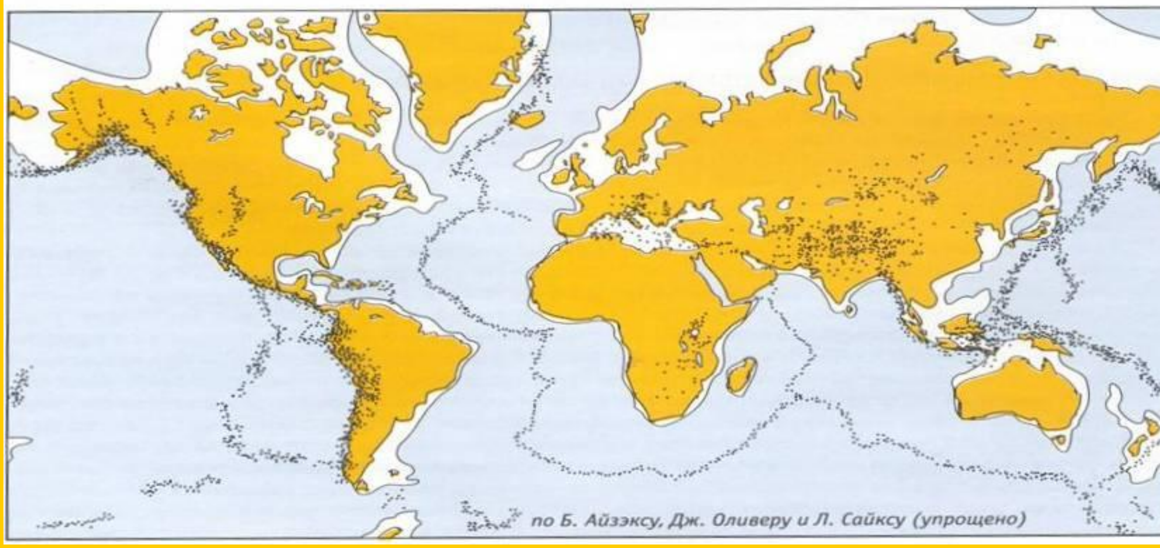


http://www.caseycripe.com/notebook/lithosphere



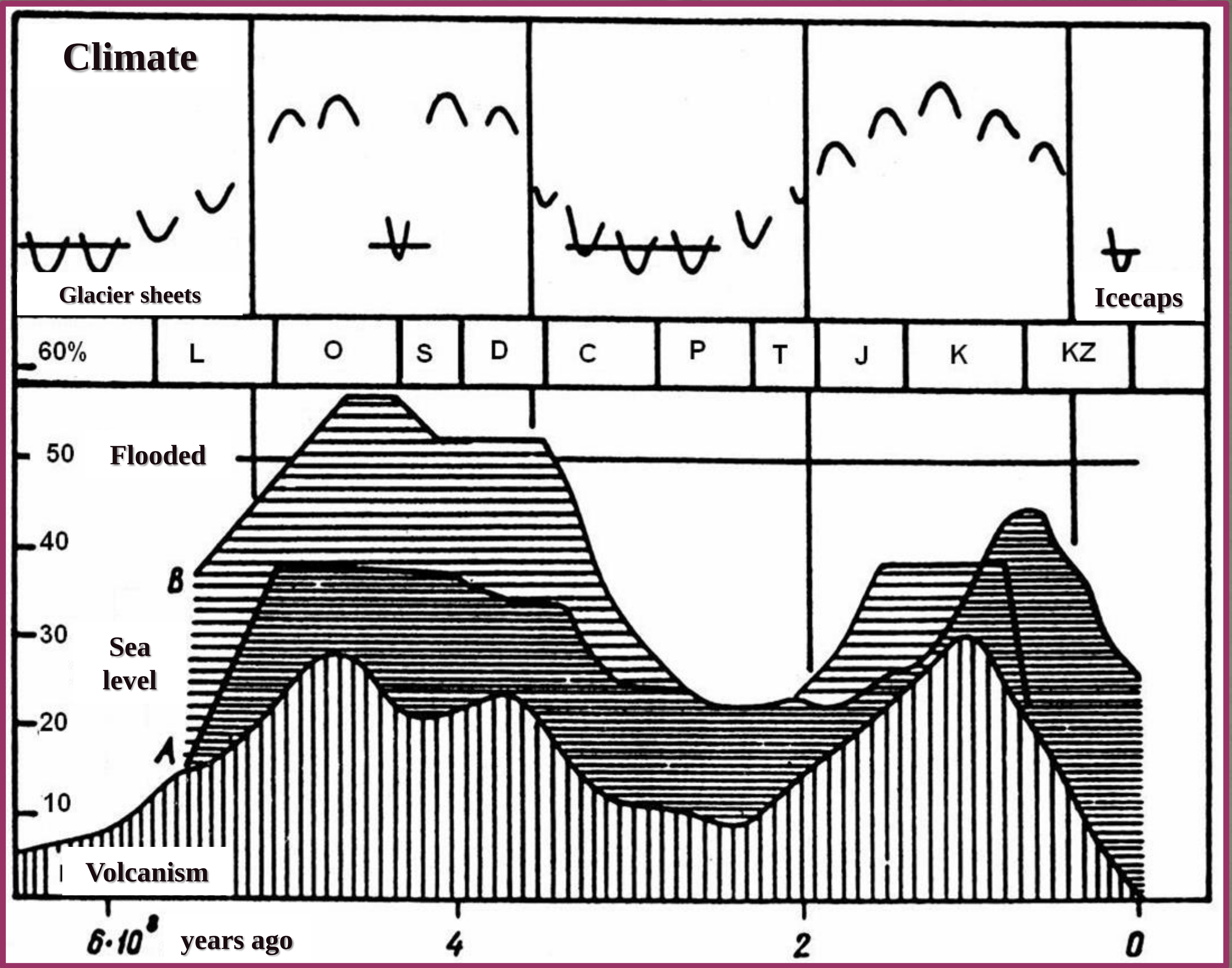
- Spreading zones (mid-ocean ridges);
- Intensive breakage zones in continental crust;
-Subduction zones (deep-sea trenches);
- Zones of continents collision;
- Transform boundary

а) б) -Continental crust (a-land; b- shelf);
- Ocean crust;



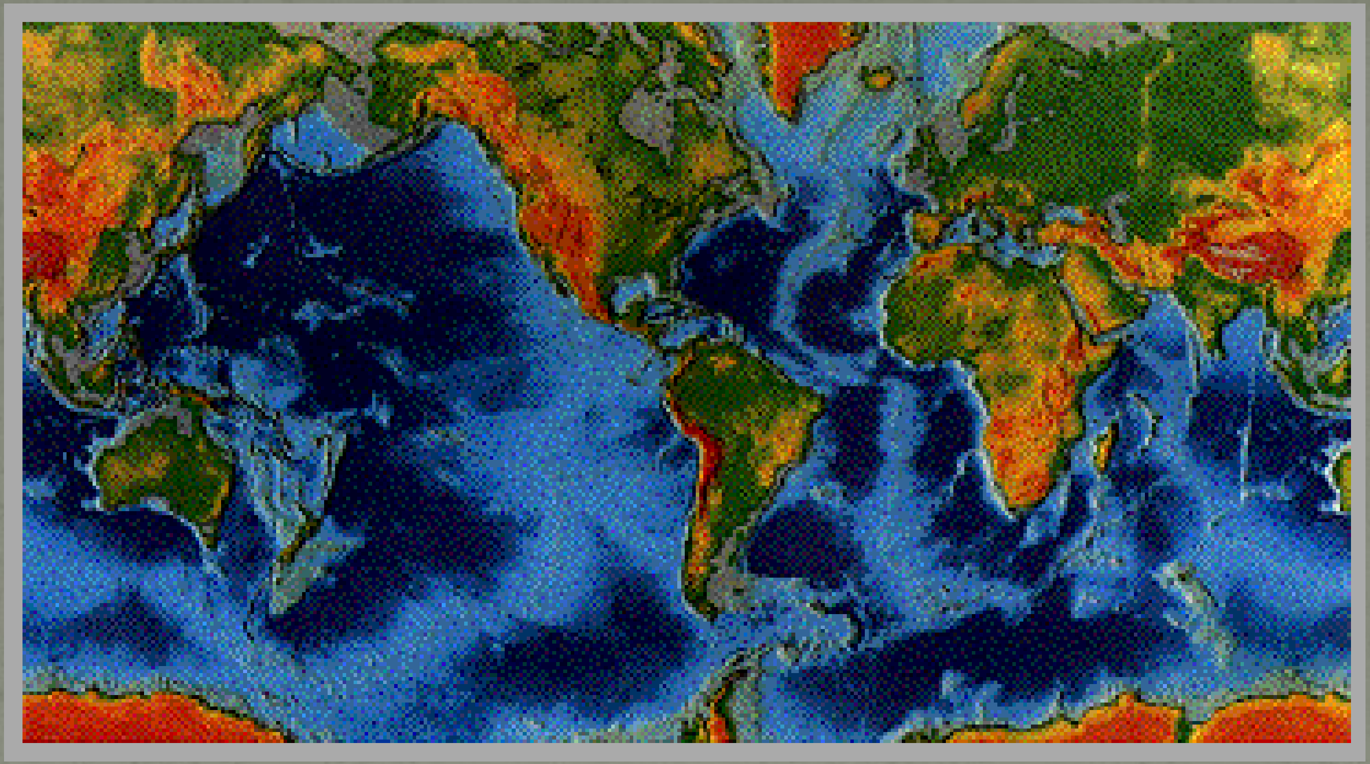
MAP - EARTHQUAKE EPICENTER DISTRIBUTION

This map shows that earthquake epicenters (dots) are distributed on the Earth surface nonuniformly. Usually they range in definite lines, which mark plate boundaries. Seismic activity is significantly higher in subduction zones than in spreading zones.



Climate
Glacier sheets
Icecaps
60%
L
O
S
D
C
P
T
J
K
KZ
50
Flooded
40
B
30
Sea
level
20
A
10
Volcanism
6·10⁸
years ago
4
2
0

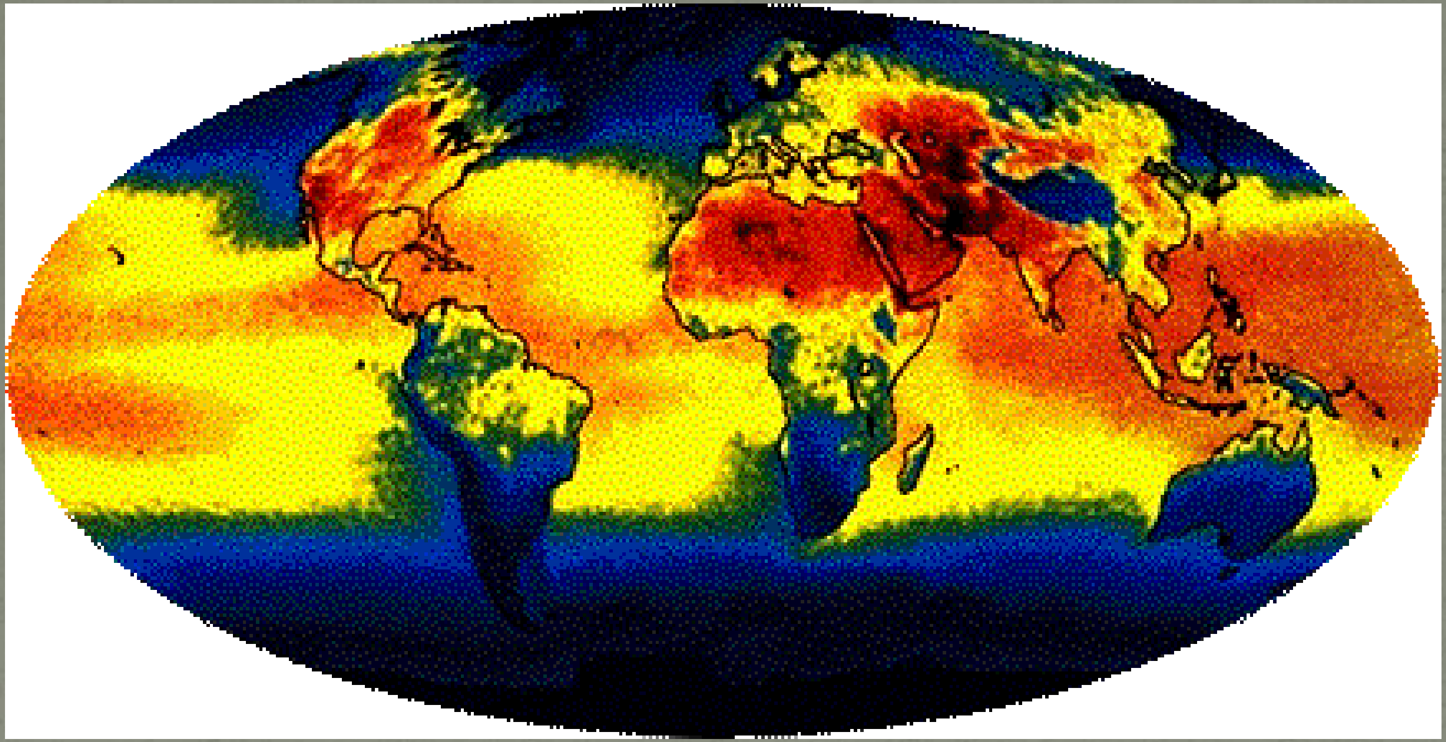
Topography



Different color hues and color density depends on the land elevation and depth. Colors indicate the depth according to the following:

- dark blue - deepest points;
- bright red - highest points;

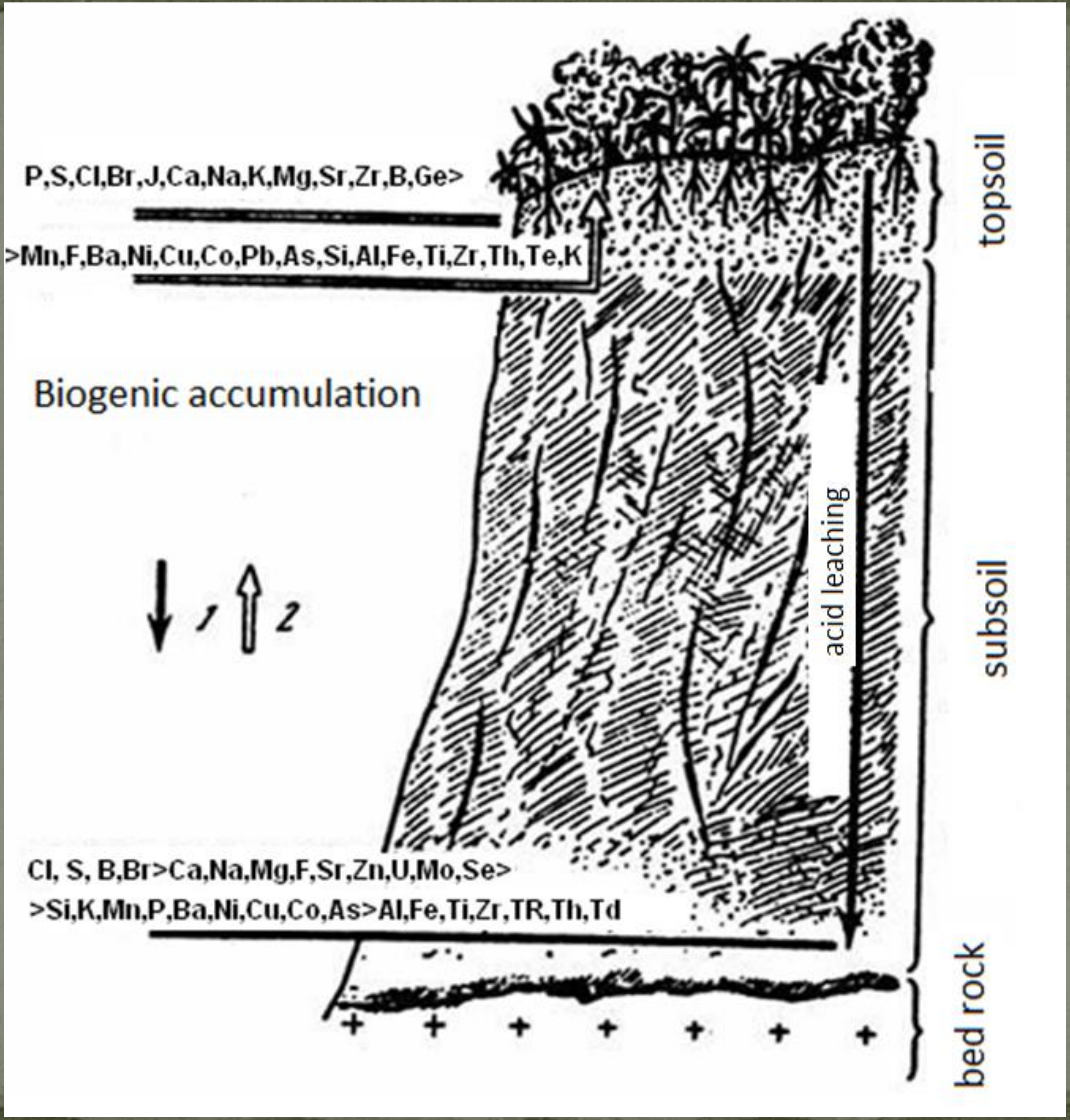
Surface Temperatures



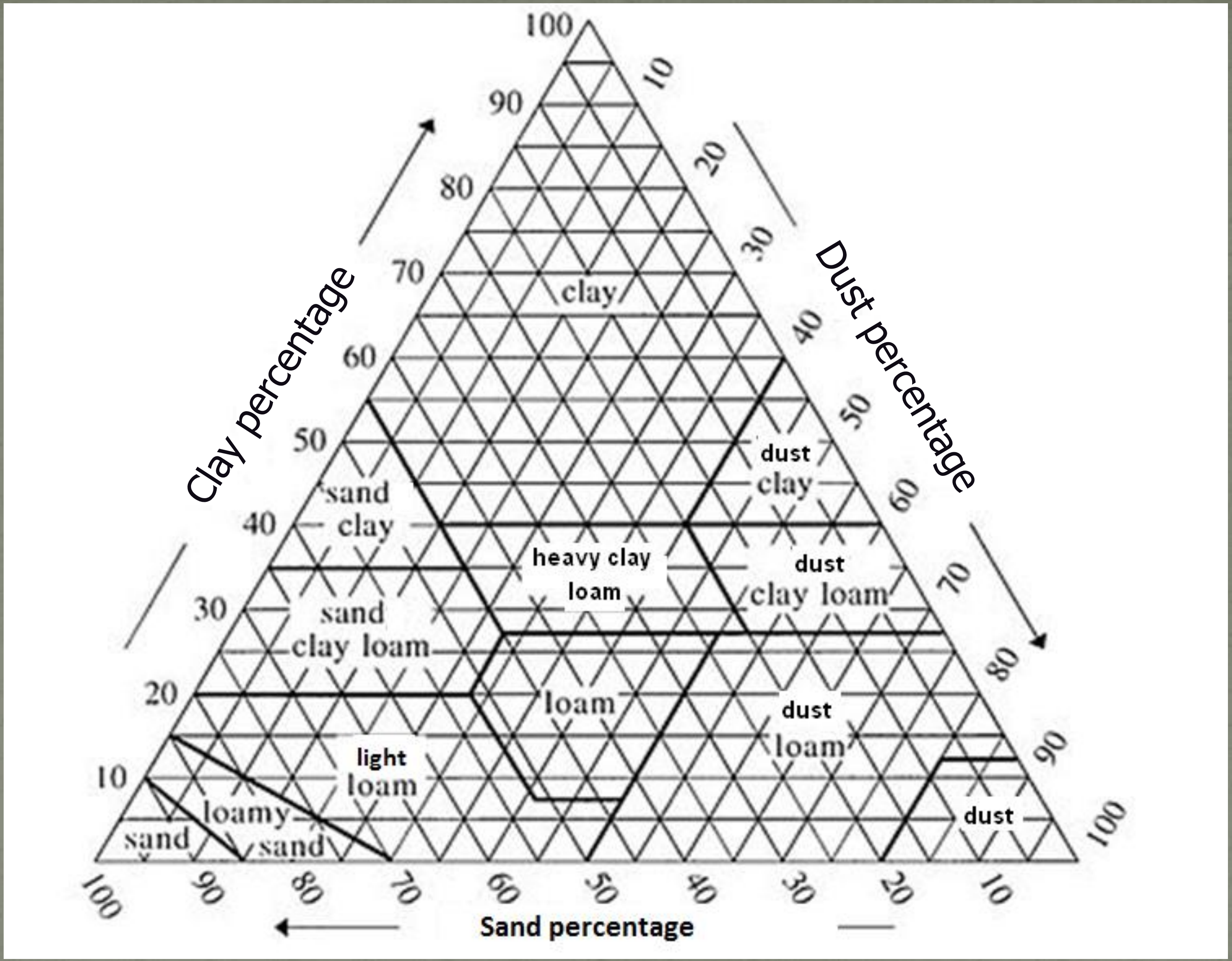
The highest temperature

The lowest temperature

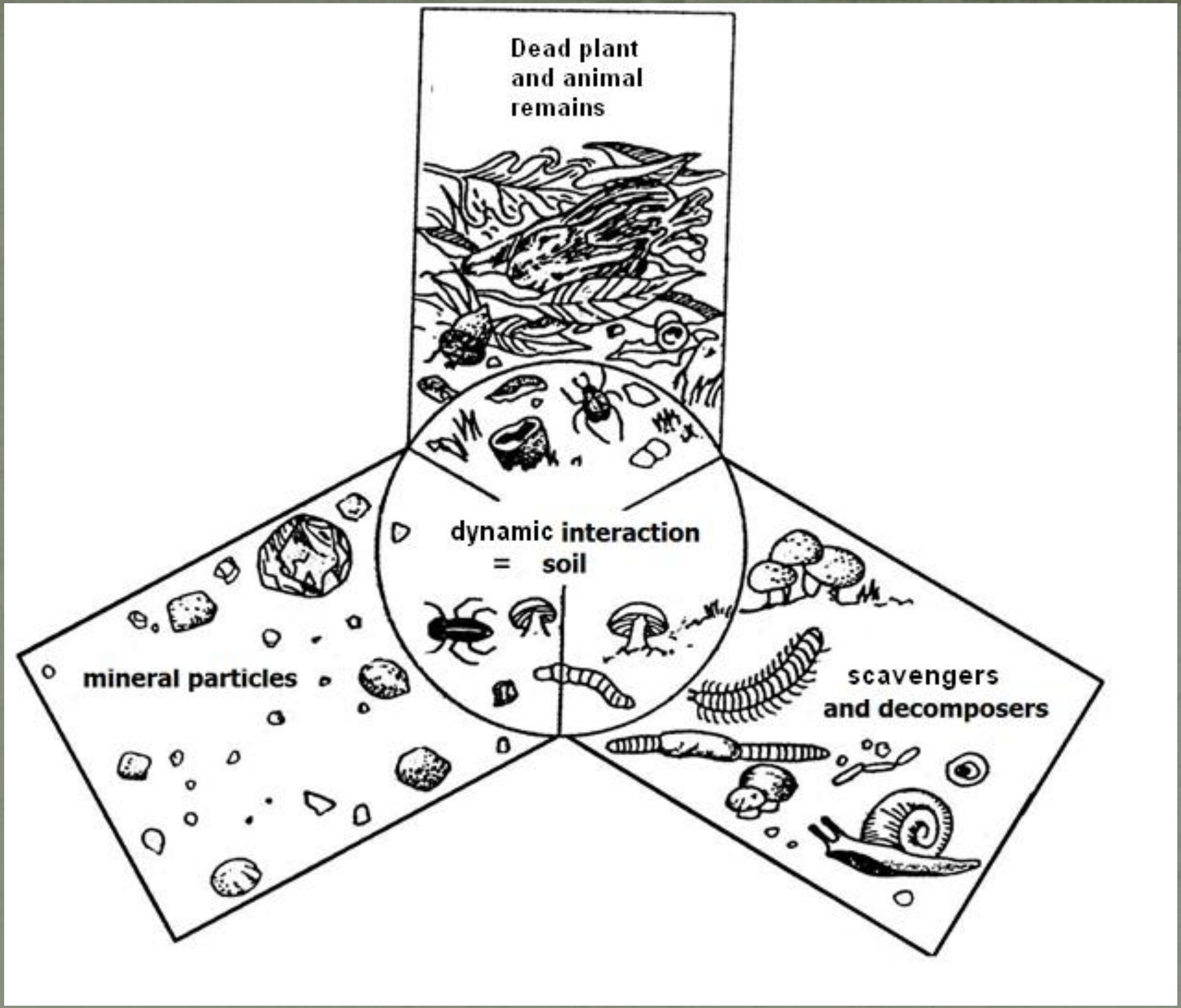
(June, 1988)



P,S,Cl,Br,J,Ca,Na,K,Mg,Sr,Zr,B,Ge>
>Mn,F,Ba,Ni,Cu,Co,Pb,As,Si,Al,Fe,Ti,Zr,Th,Te,K
Biogenic accumulation
1
2
acid leaching
Cl, S, B,Br>Ca,Na,Mg,F,Sr,Zn,U,Mo,Se>
>Si,K,Mn,P,Ba,Ni,Cu,Co,As>Al,Fe,Ti,Zr,TR,Th,Td
topsoil
subsoil
bed rock



Soil texture triangle

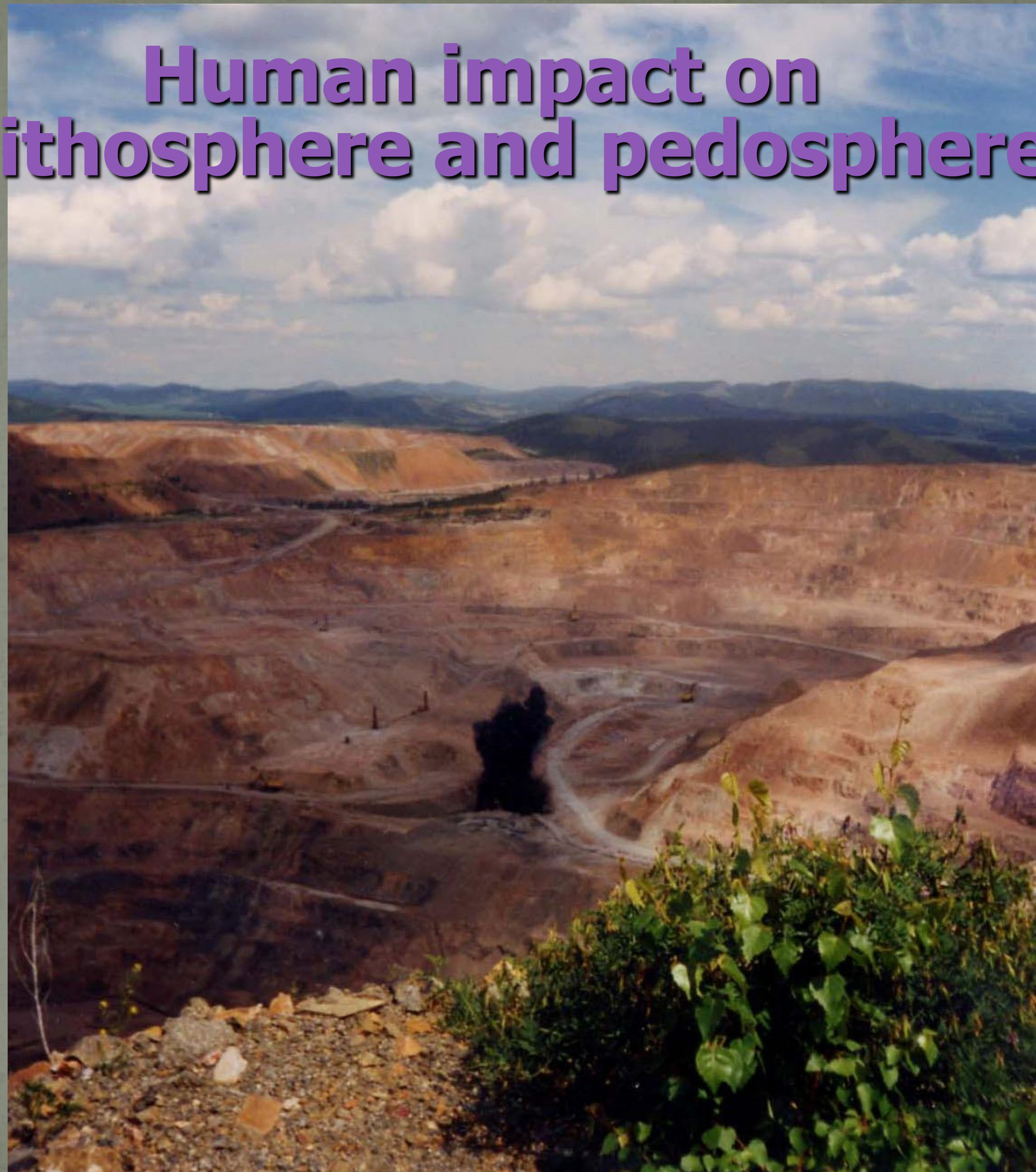


Fertile soil is the result of the dynamic interaction between the mineral particles, detritus, detritus feeder and decomposers. The lack of at least one of the three components can cause harmful consequences for soil.
(Nebel, 1993)

Relationships
between soil texture and its physico-chemical properties

Soil types	Water infiltration	Potential recharge	Ion-exchange capacity	Aeration	Cultivation
sand	good	low	low	free	good
silt	medium	medium	average	average	medium
clay	bad	high	high	poor	bad
clay loam	medium	medium	average	average	medium

Human impact on lithosphere and pedosphere

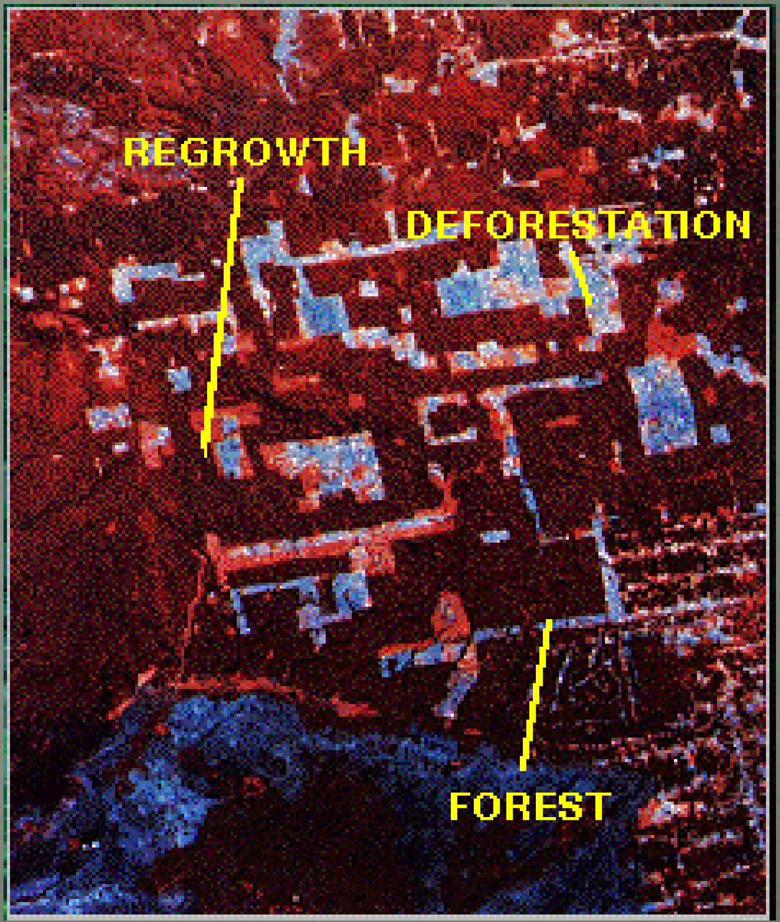



KOLCHAN.RU Personal site from Siberia

http://geoecograph.blogspot.ru/2015/04/ZAChEM-NUZhNO-IZUChAT-SUKCESSII.html

Soil erosion

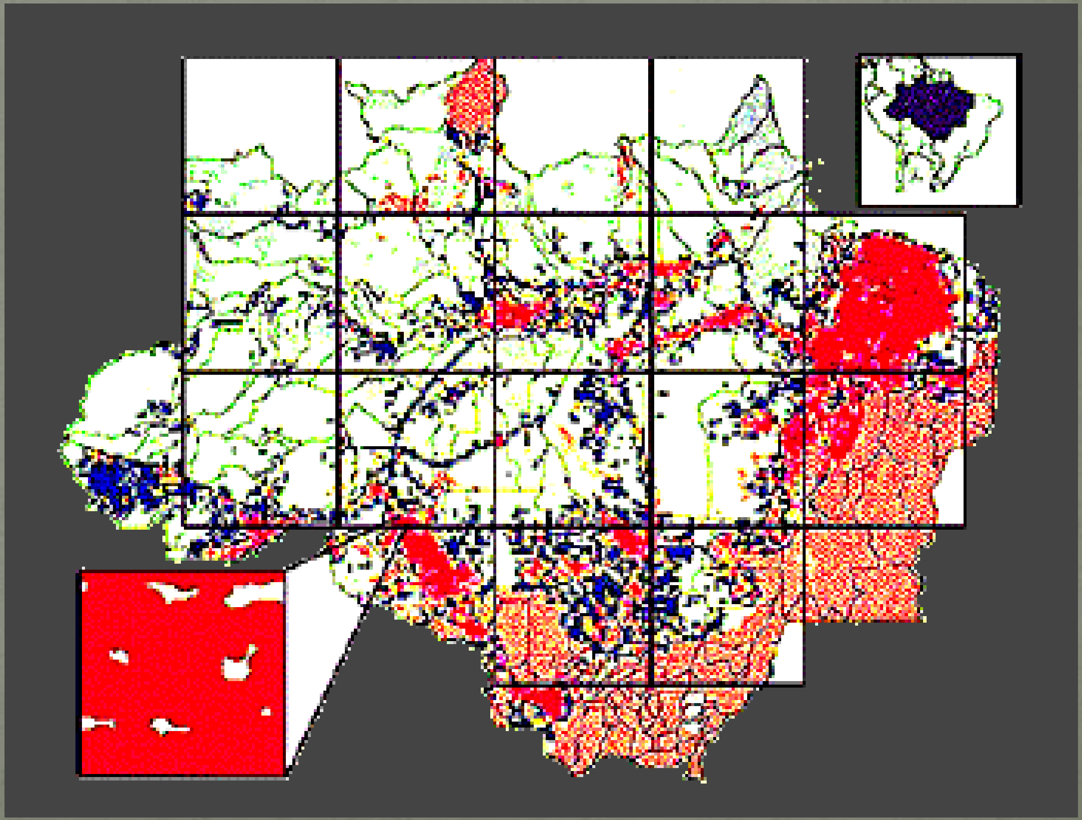
- Soil erosion as a result of deforestation in Madagascar (airborne survey , 1987) and Brazil (1988).

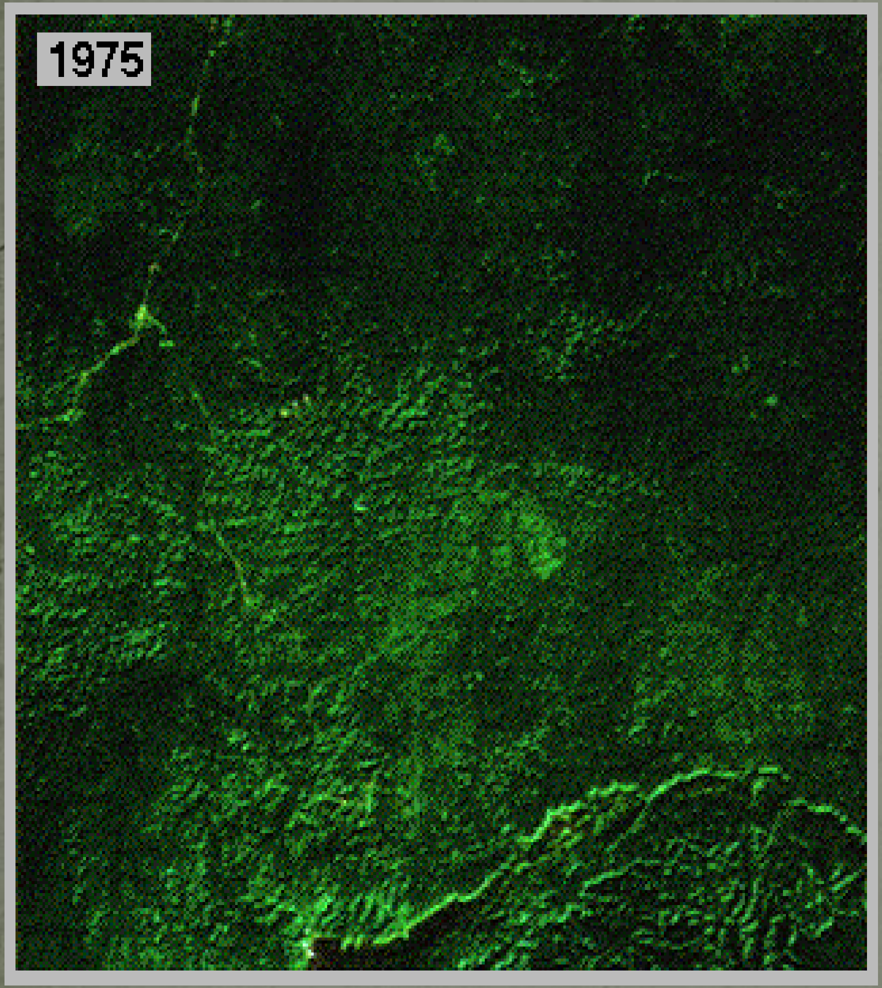


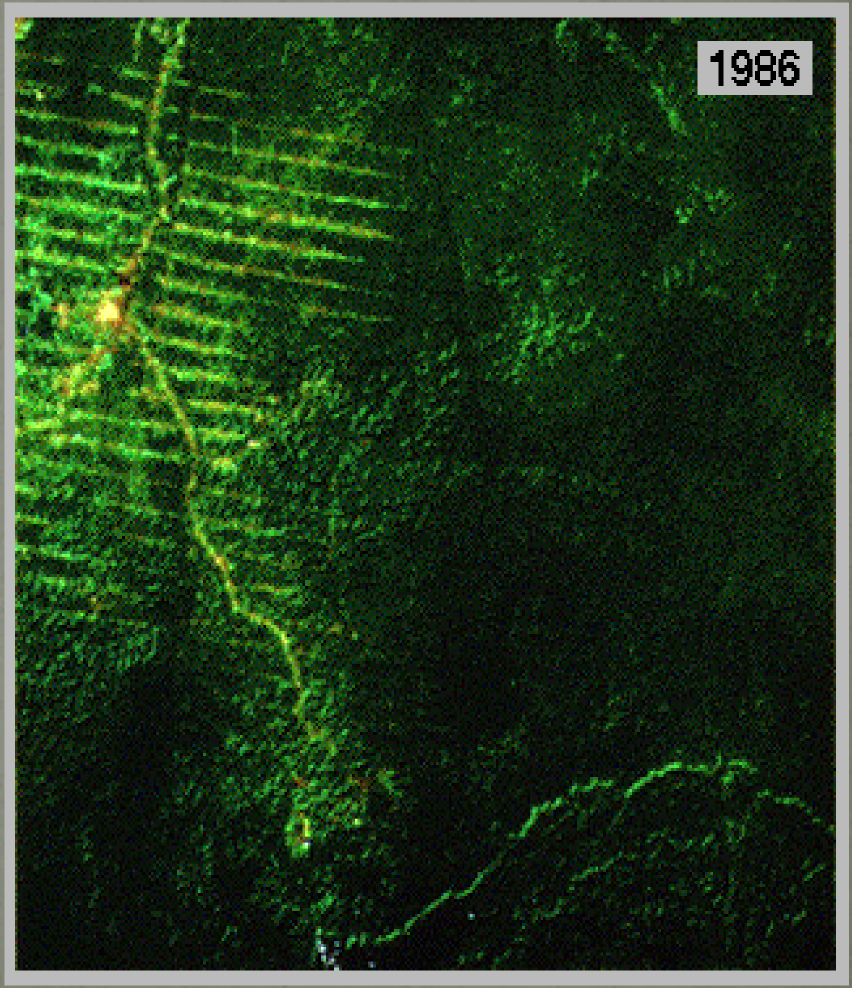
Deforestation consequences in Madagascar in 2016

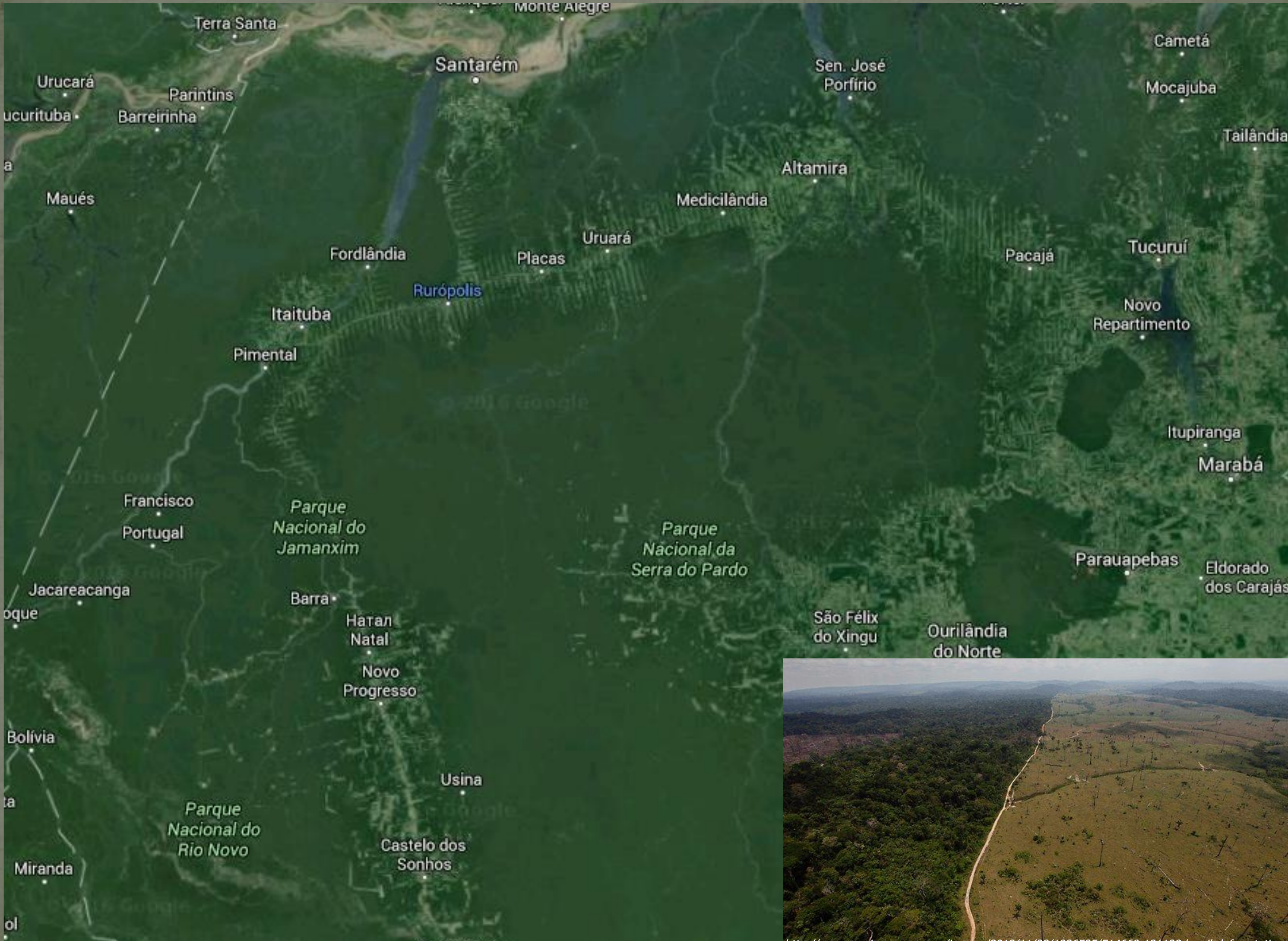
This figure shows areas in the Brazilian Amazon Basin where biological diversity was adversely affected by deforestation and isolation of forest in 1988, and the 1-kilometer long edge effect in consequence of adjacent areas deforestation.

Red color represents areas that were mostly affected.




1975

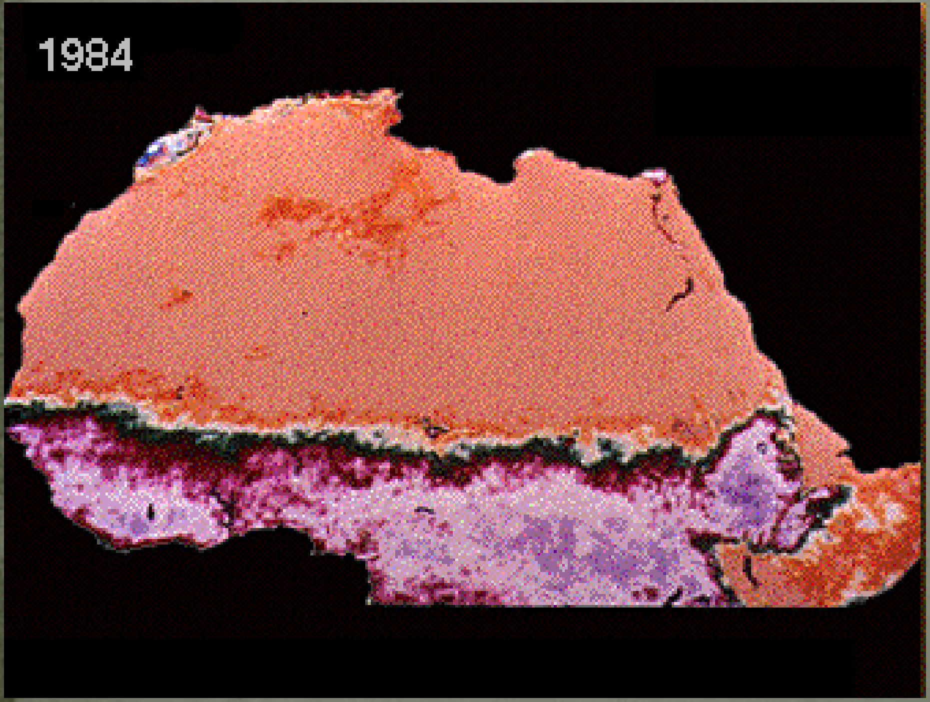

1986

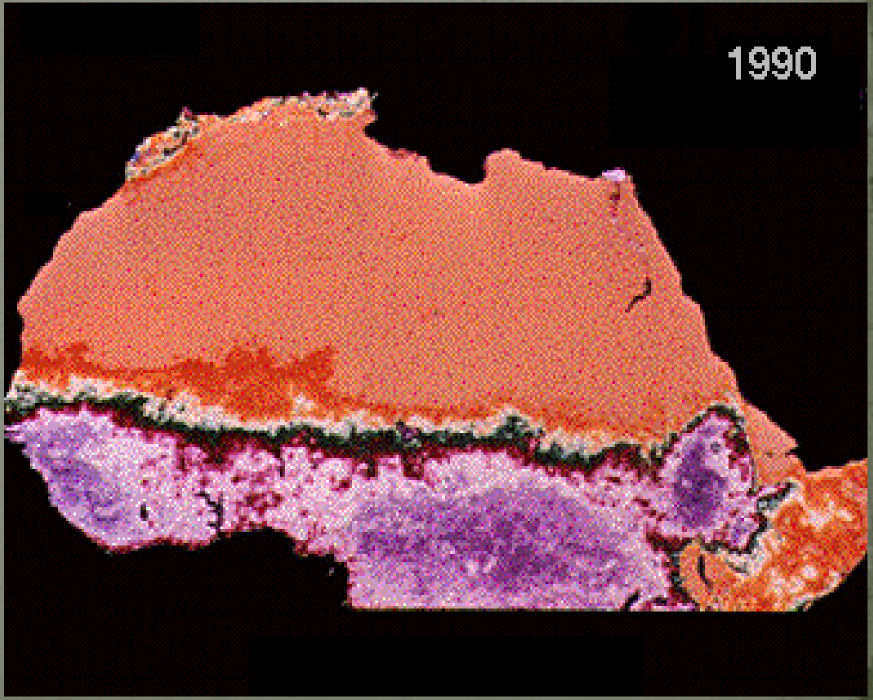


http://resources1.news.com.au/images/2012/11/28/1226525/514669-121128-brazil-deforestation.jpg

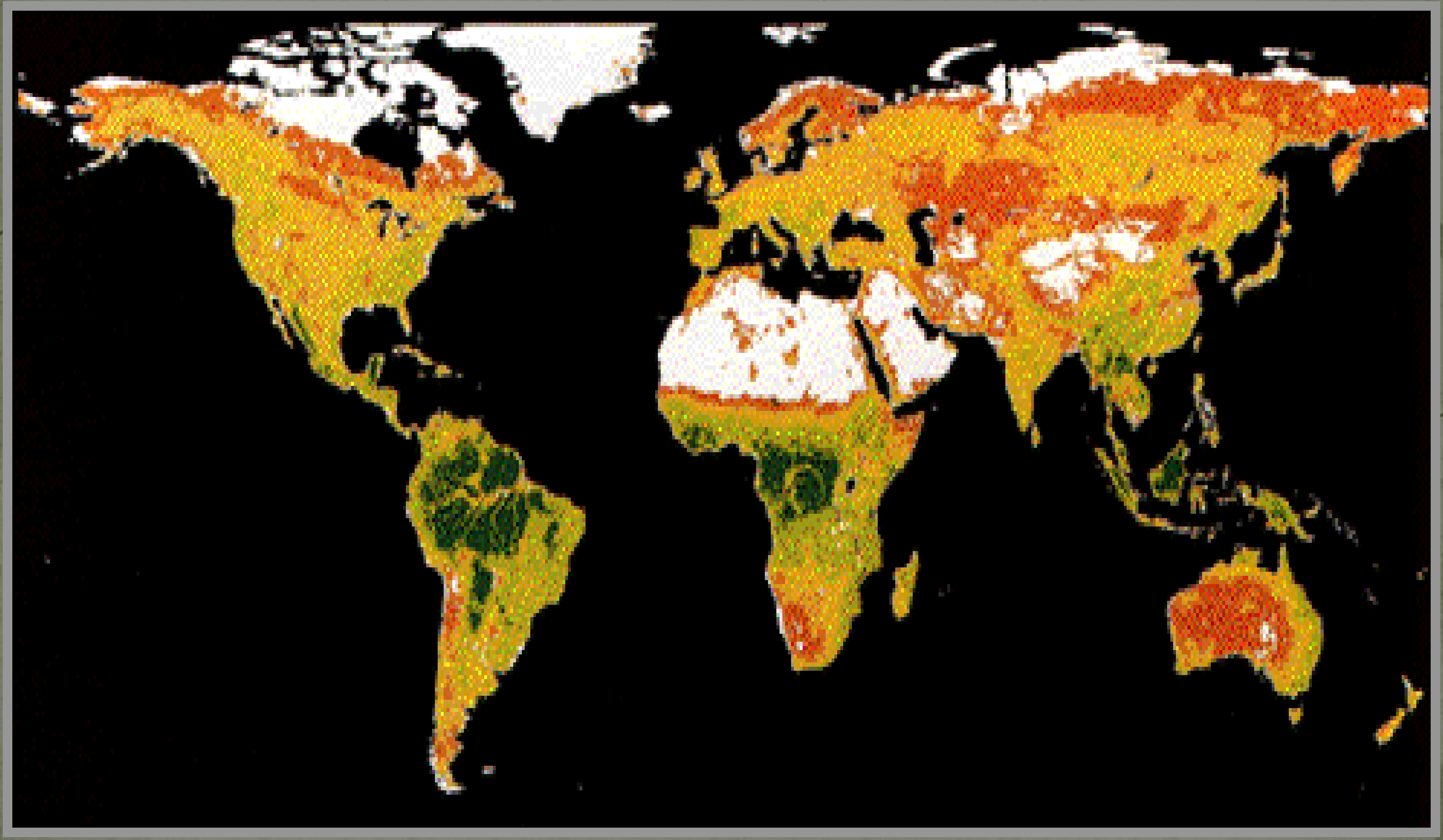
Desertification

- These comparative figures show that the Sahara Desert had contracted from 1984 to 1990, but it does not mean that Sahara has become smaller. Between 1980 and 1984, the Desert steadily expanded. During this 4-year period, the Sahara has spread southward up to 240 km.





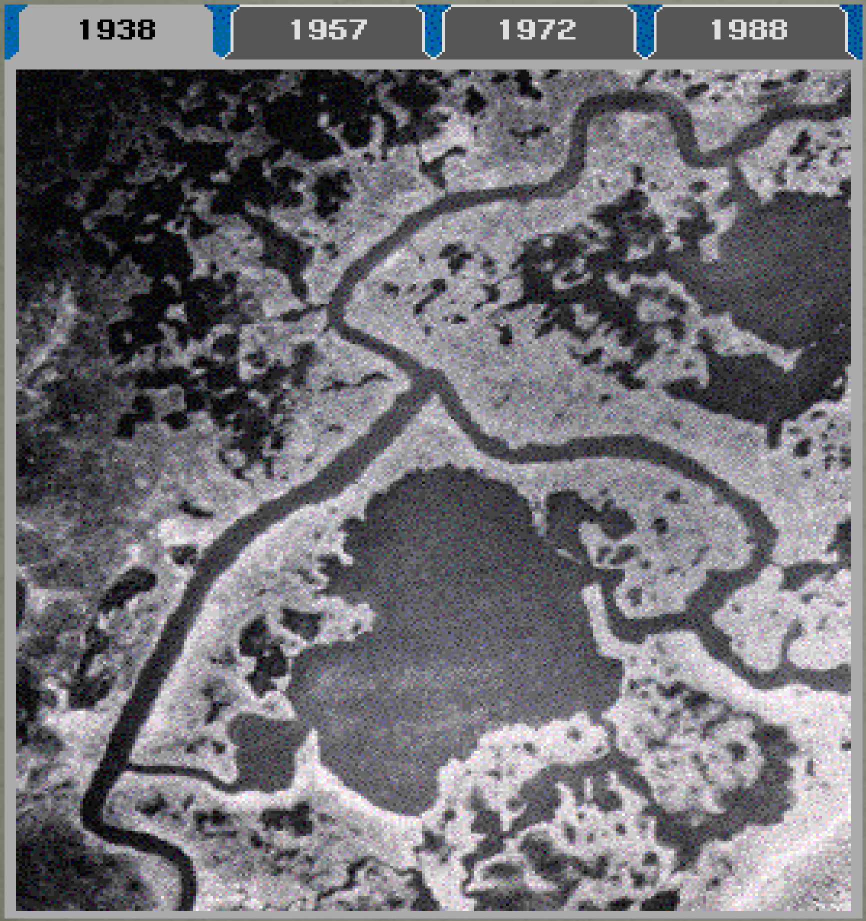

Средиземное
море
Ливан
Ирак
Тунис
Иордания
Марокко
Алжир
Ливия
Египет
Западная
Сахара
Красное
Мавритания
Мали
Нигер
Судан
Сенегал
Чад
Гамбия
Гвинея-Бисау
Буркина-Фасо
Гвинея
Бенин
Нигерия
Юж. Судан
Сьерра-Леоне
Того
Кот-д'Ивуар
Гана
Либерия
Камерун
Уганда

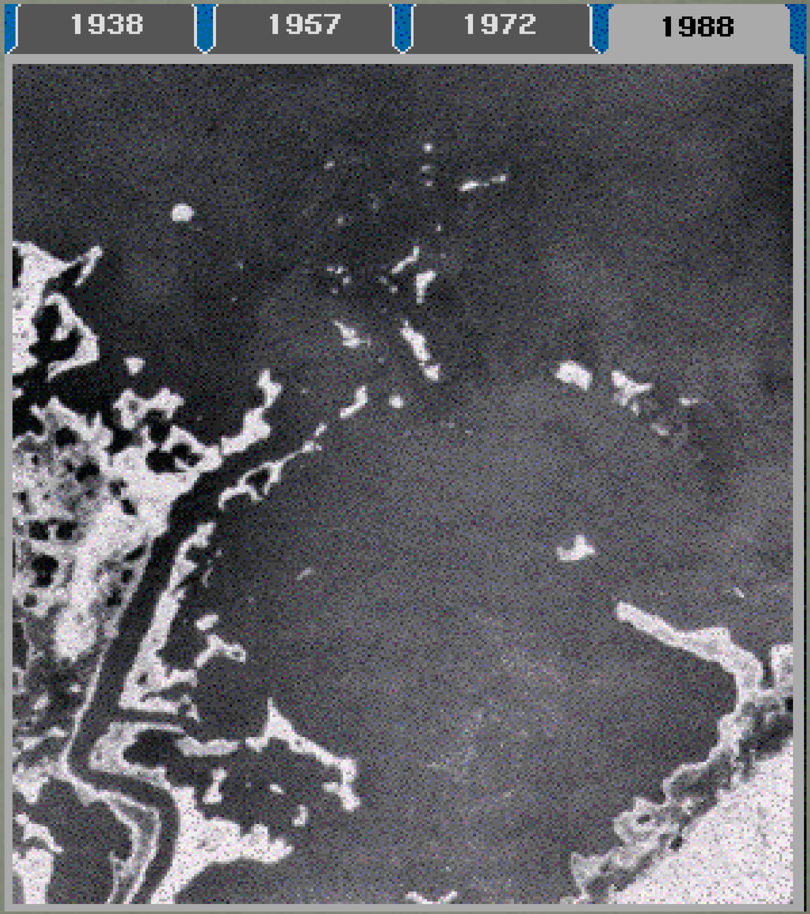


Desertification has impact on both the human habitat and global climate.

As you can see, desert sands are the bright surfaces that reflect solar radiation (mainly in Africa). An increase in the area of these bright surfaces would result in more solar energy reflected back to space and being less absorbed at the surface. This would tend to area drying up and further desertification.

- These vertical aerial photographs of the Big and Little Blackwater Rivers on the eastern shore of Maryland (USA) indicate the progressive formation of small swamps into big ones.





Swamping as a result of land restoration after oil spills

- https://www.youtube.com/watch?v=u6KxzGMF4co
- https://youtu.be/u6KxzGMF4co