

FOSFOR

# FOSFOR

w litosferze

apatyty:



fluoroapatyty



hydroksyapatyty



chloroapatyty

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w litosferze

apatyty:



fluoroapatyty



hydroksyapatyty



chloroapatyty

w wodach:



# FOSFOR

w organizmach żywych:

kwasy nukleinowe

ATP

fosfokreatyna

związki strukturalne (fosfolipidy, fosforan  
wapnia)

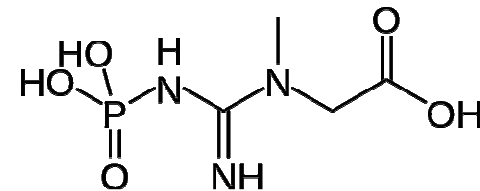
# FOSFOR

w organizmach żywych:

kwasy nukleinowe

ATP

fosfokreatyna



związki strukturalne (fosfolipidy, fosforan wapnia)

średnio 1,1% masy ciała człowieka

kości i zęby 7%

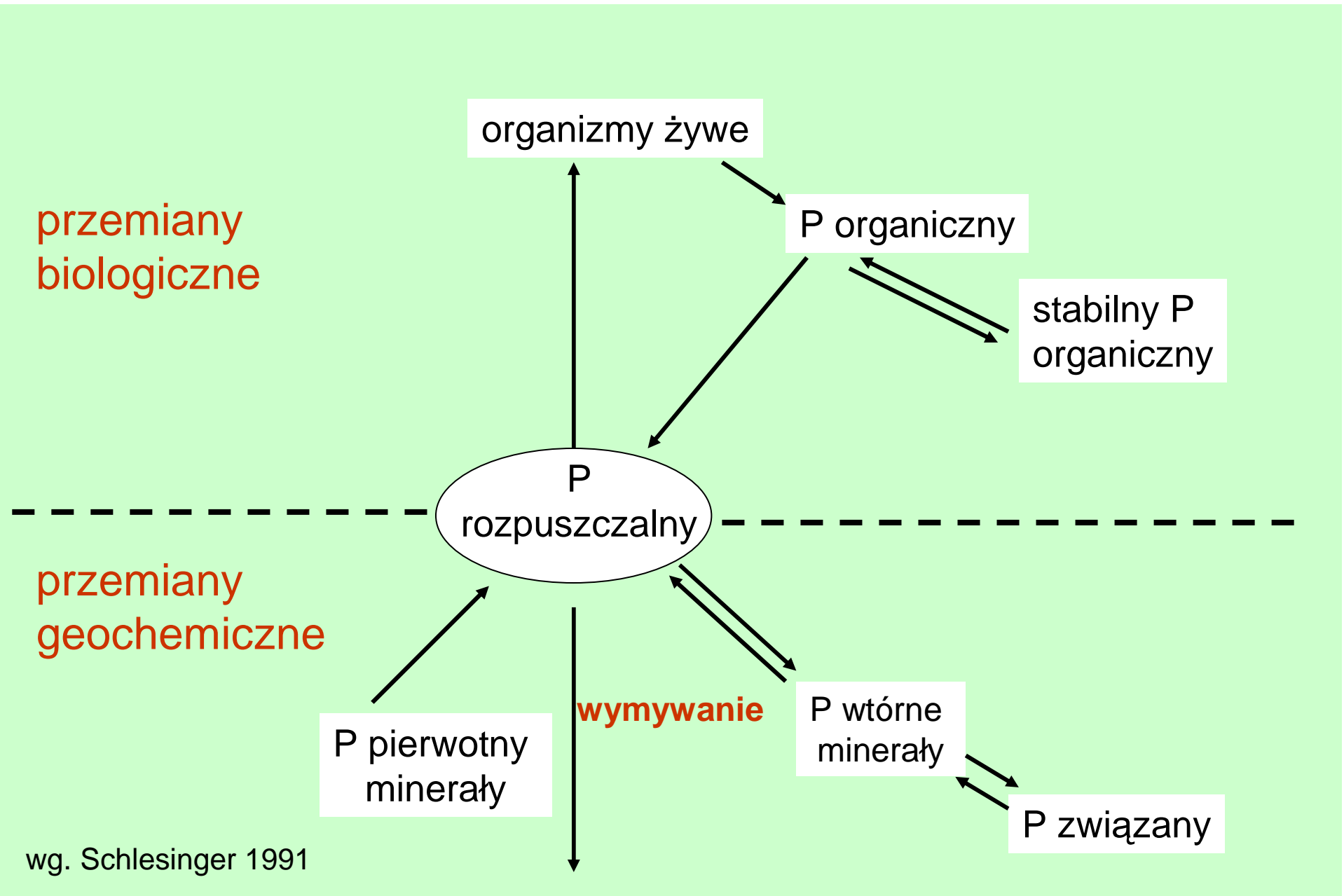
# FOSFOR

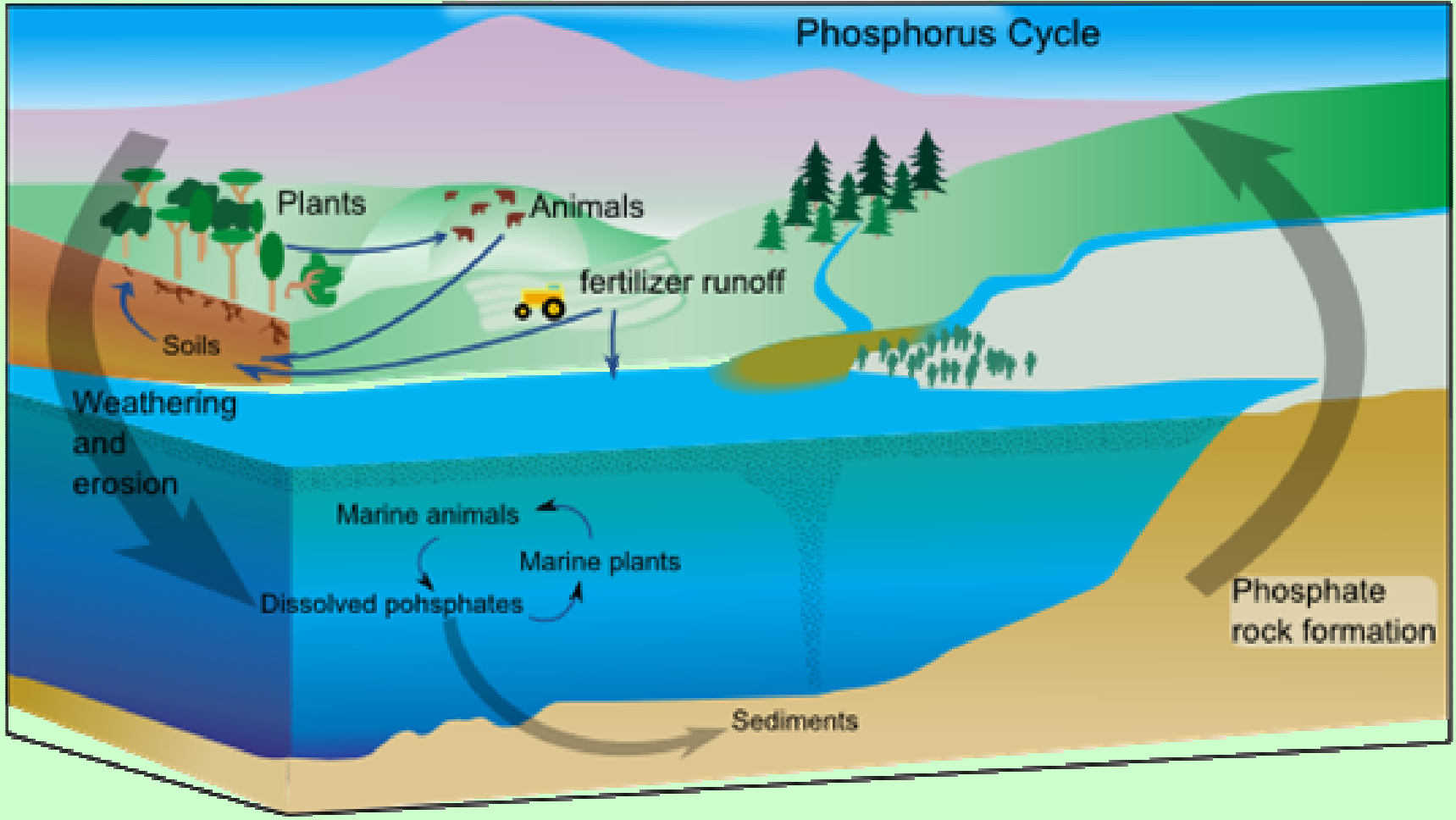
W glebach

- słaba rozpuszczalność
- mała mobilność

-MIKORYZA

# FOSFOR





Phosphorus Cycle

Plants

Animals

fertilizer runoff

Soils

Weathering and erosion

Marine animals

Marine plants

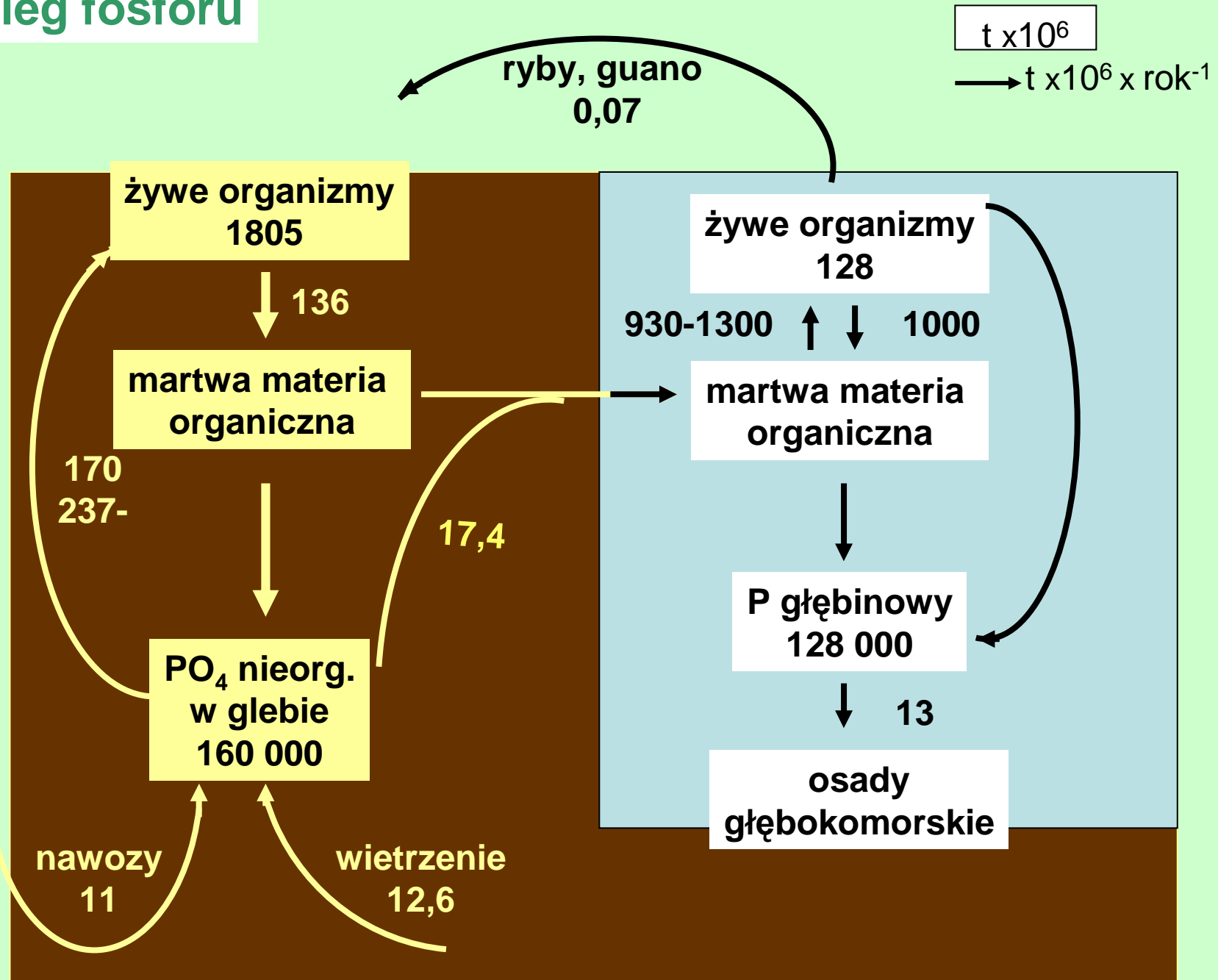
Dissolved phosphates

Phosphate rock formation

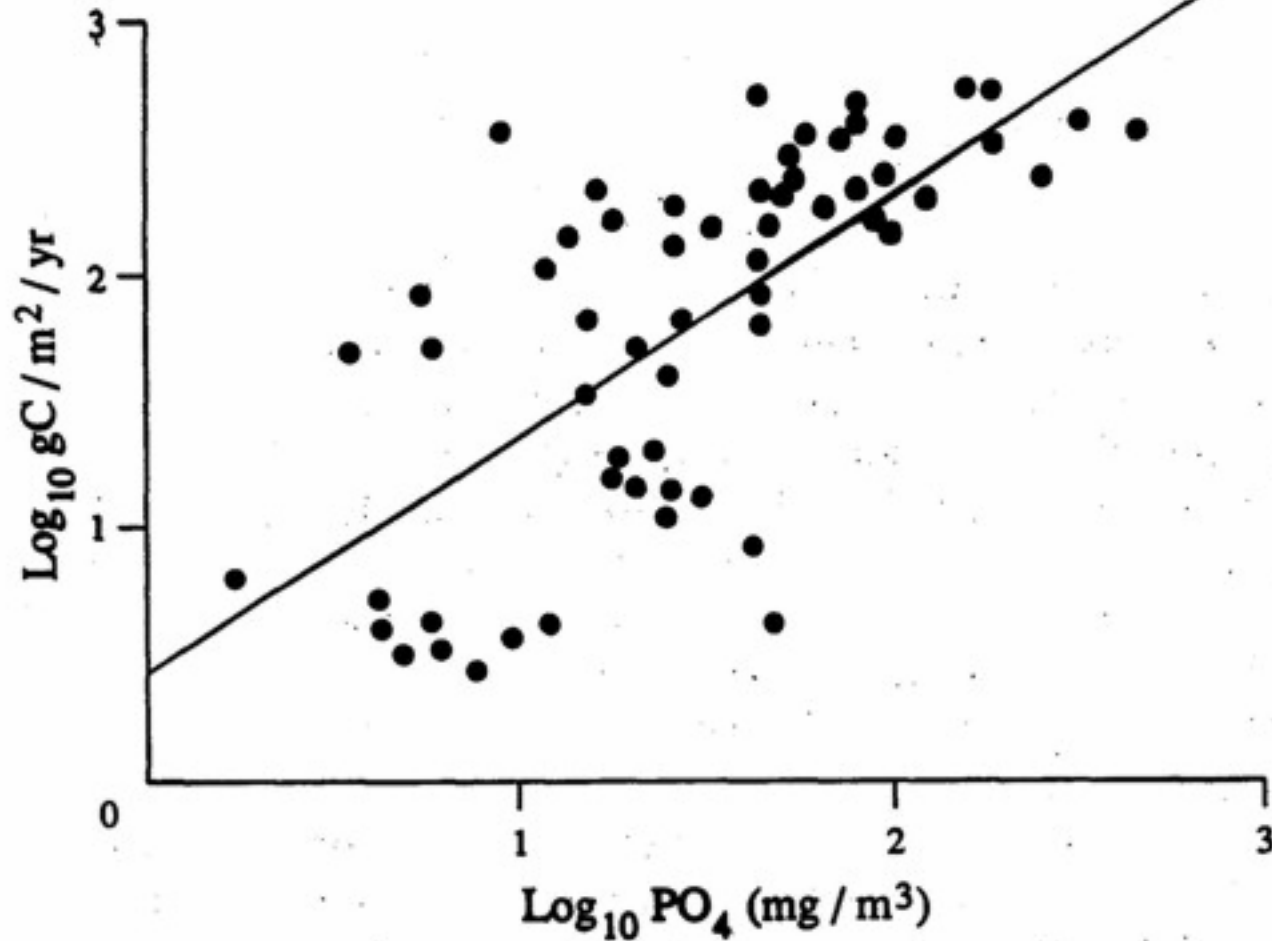
Sediments



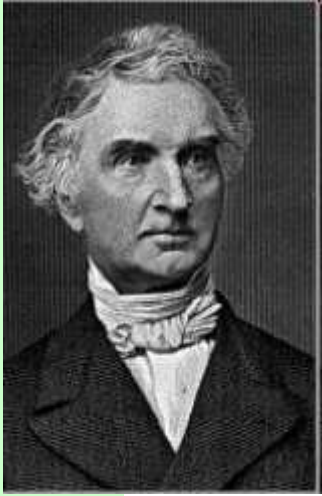
# Obieg fosforu



# FOSFOR



**Figure 7.8** Relationship between net primary production and the phosphorus concentration in lakes of the world. From Schindler (1978).



„prawo czynników ograniczających”  
Justus von Liebig

„... względne znaczenie jakiegoś czynnika ograniczającego jest tym większe, im bardziej dany czynnik, w porównaniu z innymi stanowi minimum.”

## Deficyty biogenów

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### **Nawozy:**

azotowe:

naturalne – np. saletra chilijska,  
sztuczne

siarkowe (rzadko)

potasowe (gleby piaszczyste i torfowe)

fosforowe

naturalne – źródło fosforyty i  
apatyty

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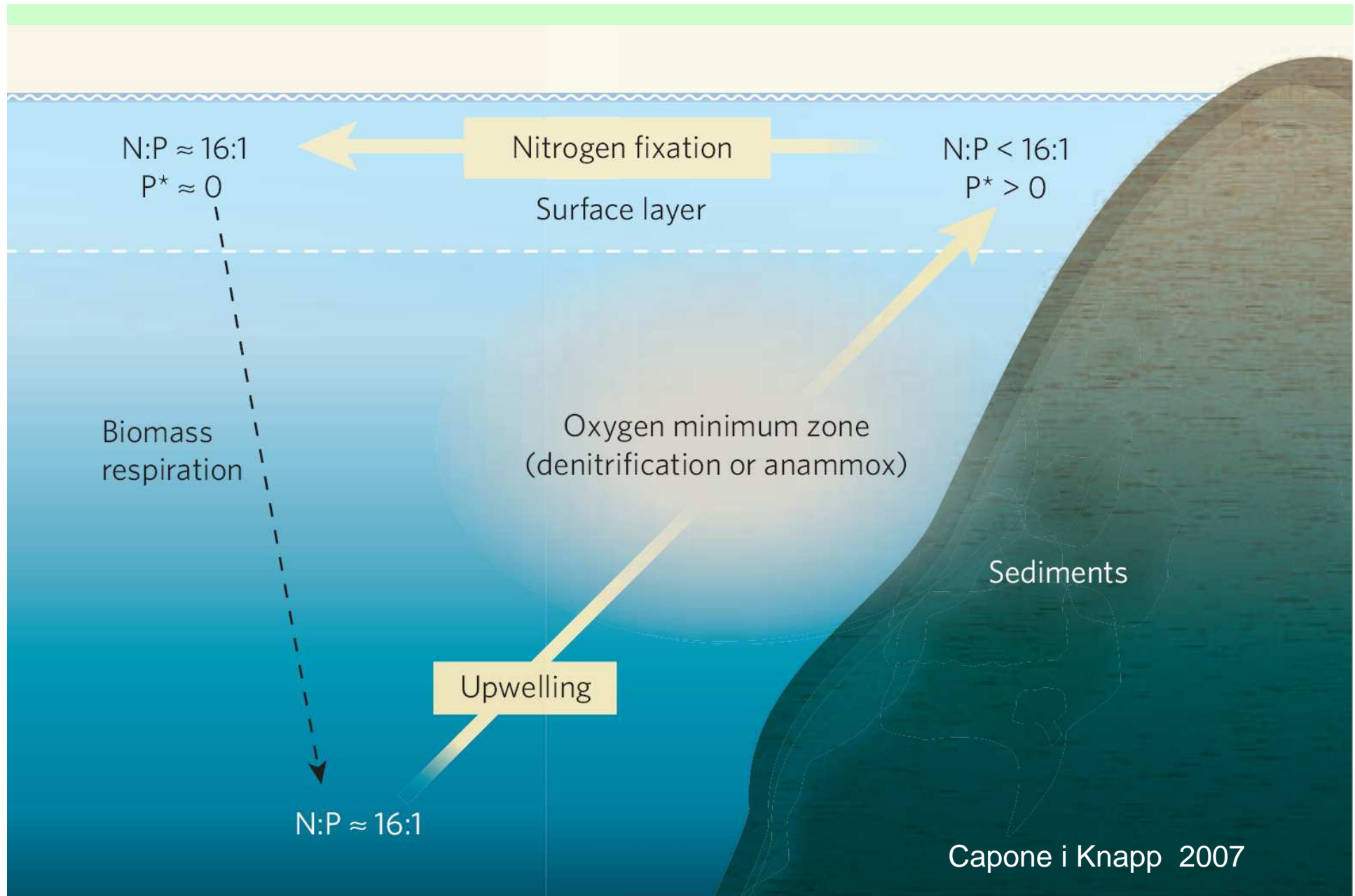
## Eutrofizacja - azot i fosfor

fosfor ( $>30 \mu\text{g/L}$ ), azot ( $>1500 \mu\text{g/L}$ ),

N:P 30:1 - ogranicza fosfor

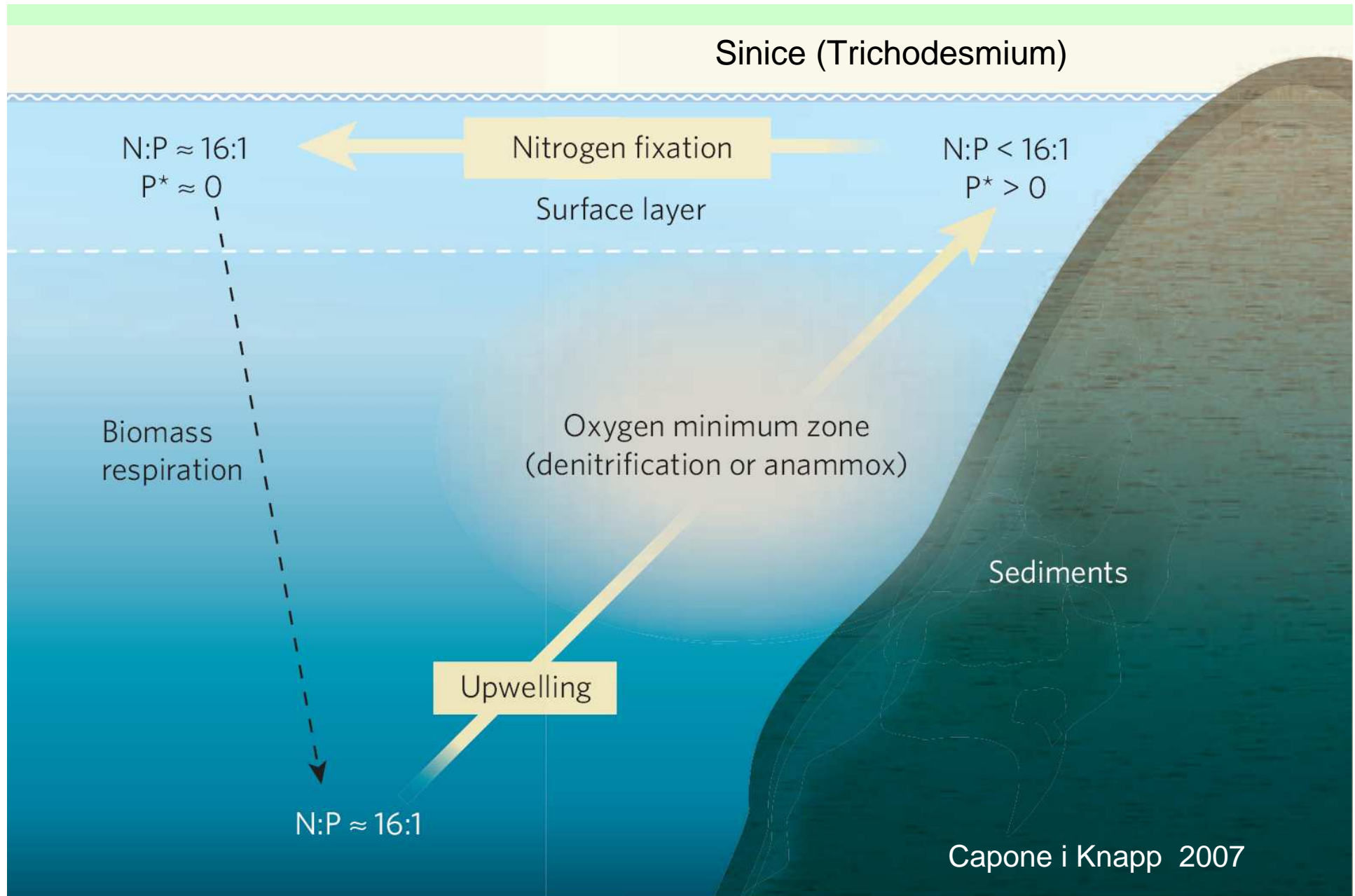
N:P 6:1 - ogranicza azot

# Fosfor w oceanie





# Fosfor w oceanie



# Eutrofizacja



ELA - Experimental Lakes Area (Kanada)

# Eutrofizacija



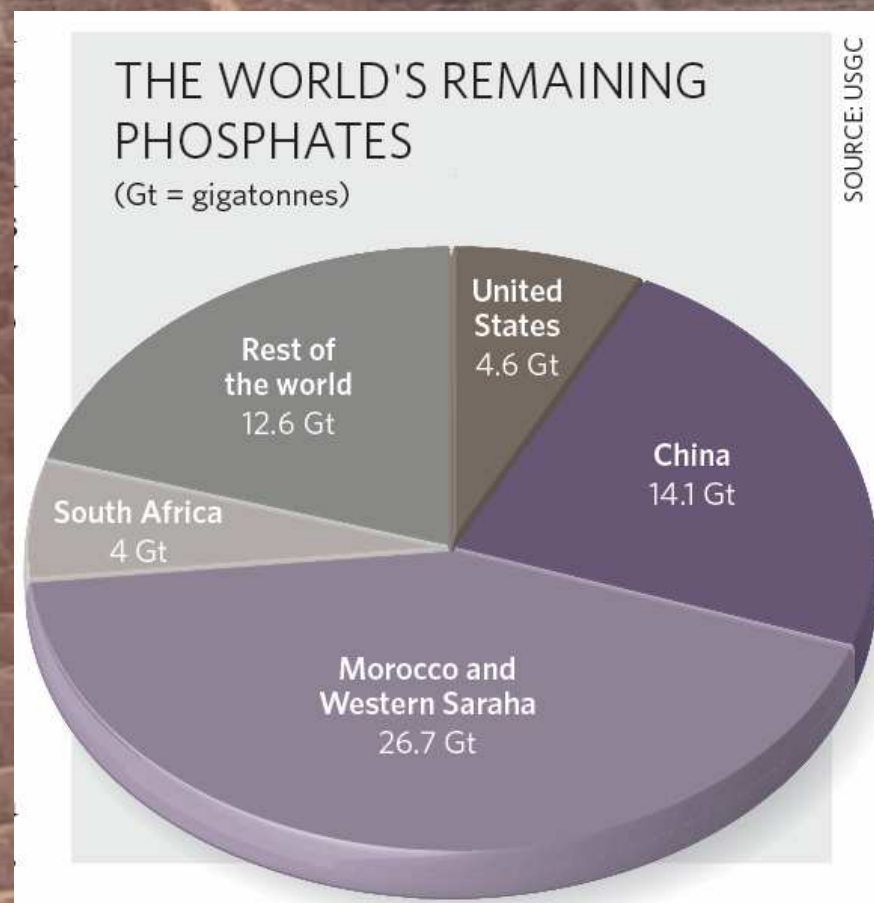
ELA - Experimental Lakes Area (Kanada)

An aerial photograph showing a vast, arid landscape with numerous terraced agricultural fields. The fields are arranged in a grid-like pattern, with two prominent, light-colored paths or roads running vertically through the center. The soil is a deep, reddish-brown color, and the overall scene suggests a dry, semi-arid environment. The terraces are closely spaced and follow the contours of the land, indicating a method of soil conservation or water management. In the bottom right corner, a small yellow tractor is visible on a dirt path.

# THE DISAPPEARING NUTRIENT

Nature vol. 461, 8 October 2009

**Eksploracja (2008):  
161 mln ton fosforów/rok**



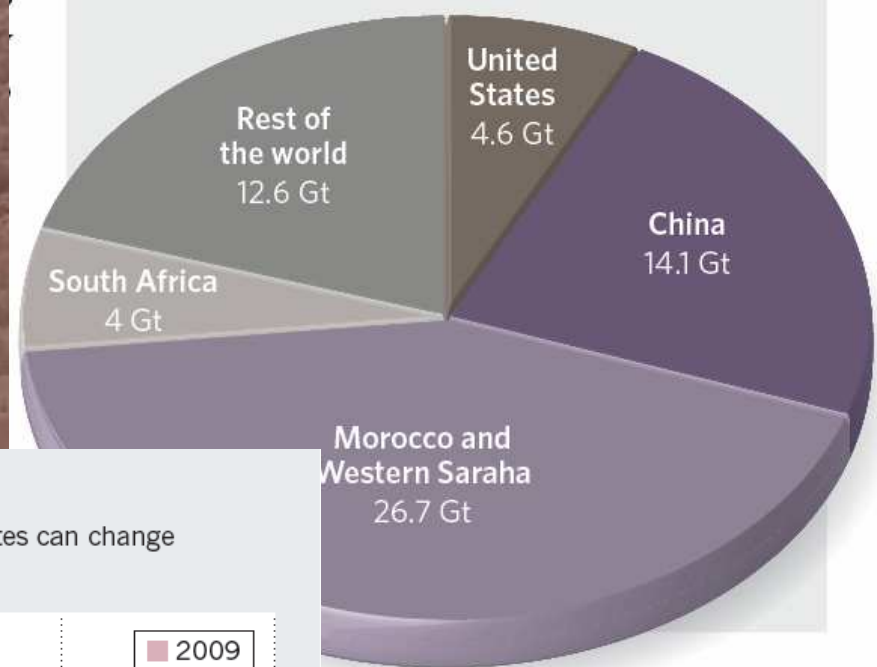
# THE DISAPPEARING NUTRIENT

**Eksploatacja (2008):  
161 mln ton fosforytów/rok**

**THE WORLD'S REMAINING PHOSPHATES**

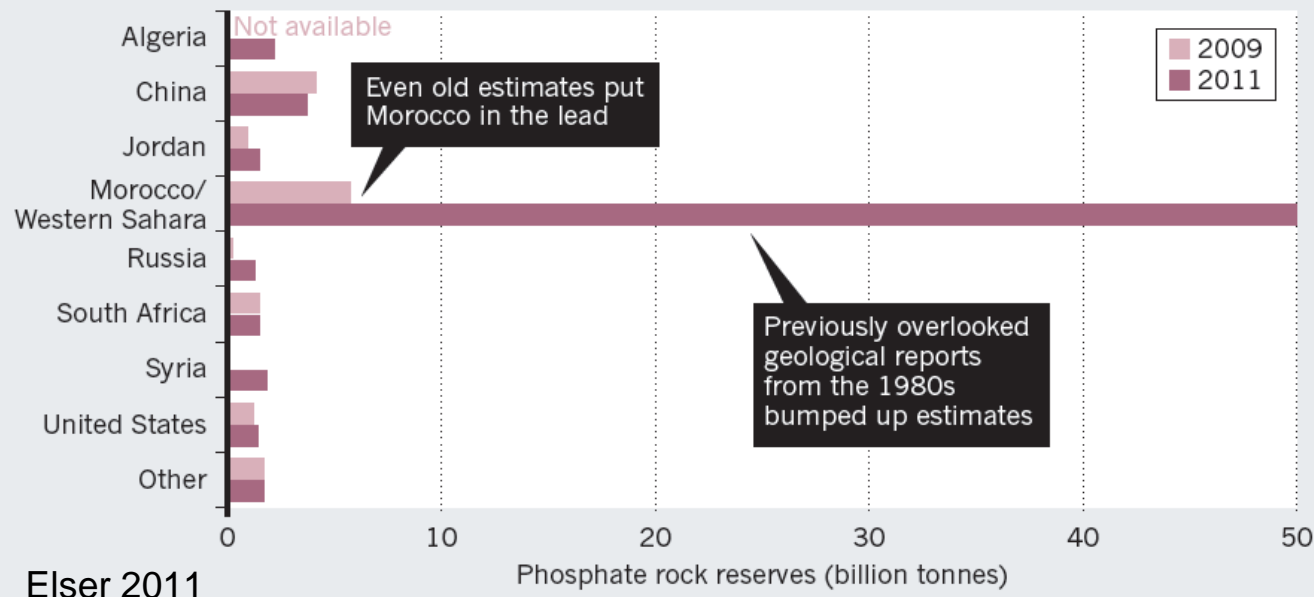
(Gt = gigatonnes)

SOURCE: USGC



**GLOBAL IMBALANCE**

Morocco holds the vast majority of global supplies of phosphorus; but these estimates can change disturbingly quickly.



Elser 2011



ure vol. 461, 8 October 2009

**ŽELAZO**

# ŽELAZO

$\text{Fe}^0$

$\text{Fe}^{2+}$

$\text{Fe}^{3+}$



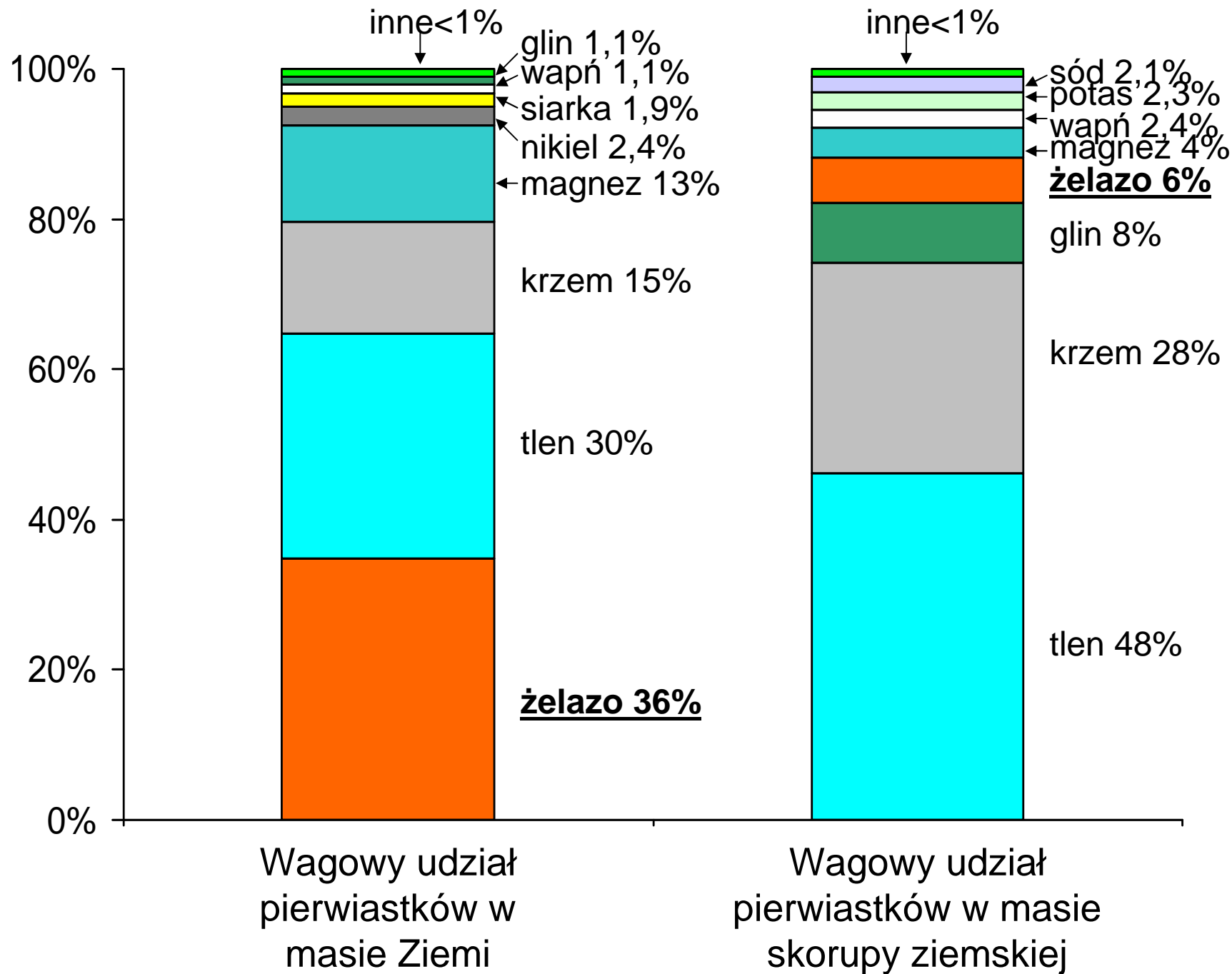
# ŽELAZO

$\text{Fe}^0$

$\text{Fe}^{2+}$

$\text{Fe}^{3+}$





# ŽELAZO

Litosfera:

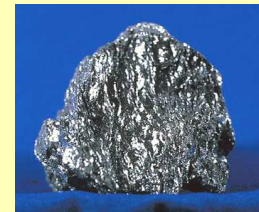
piryt ( $\text{FeS}_2$ )

hematyt ( $\text{Fe}_2\text{O}_3$ )

limonit ( $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ )

magnetyt ( $\text{Fe}_3\text{O}_4$ )

syderyt ( $\text{FeCO}_3$ )



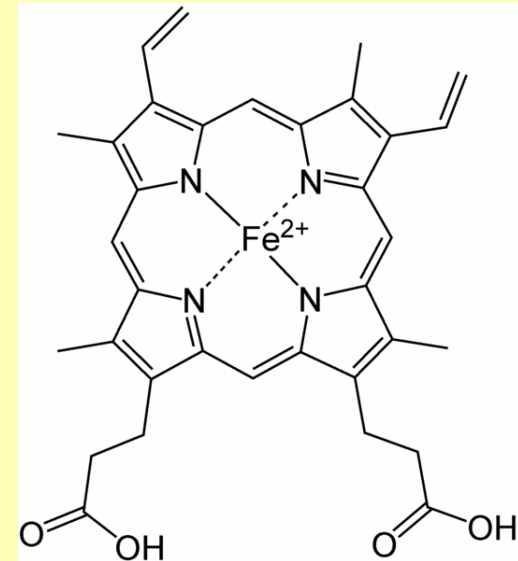
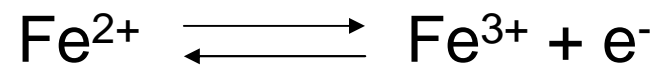
# ŽELAZO

## ORGANIZMY ŽYWE:

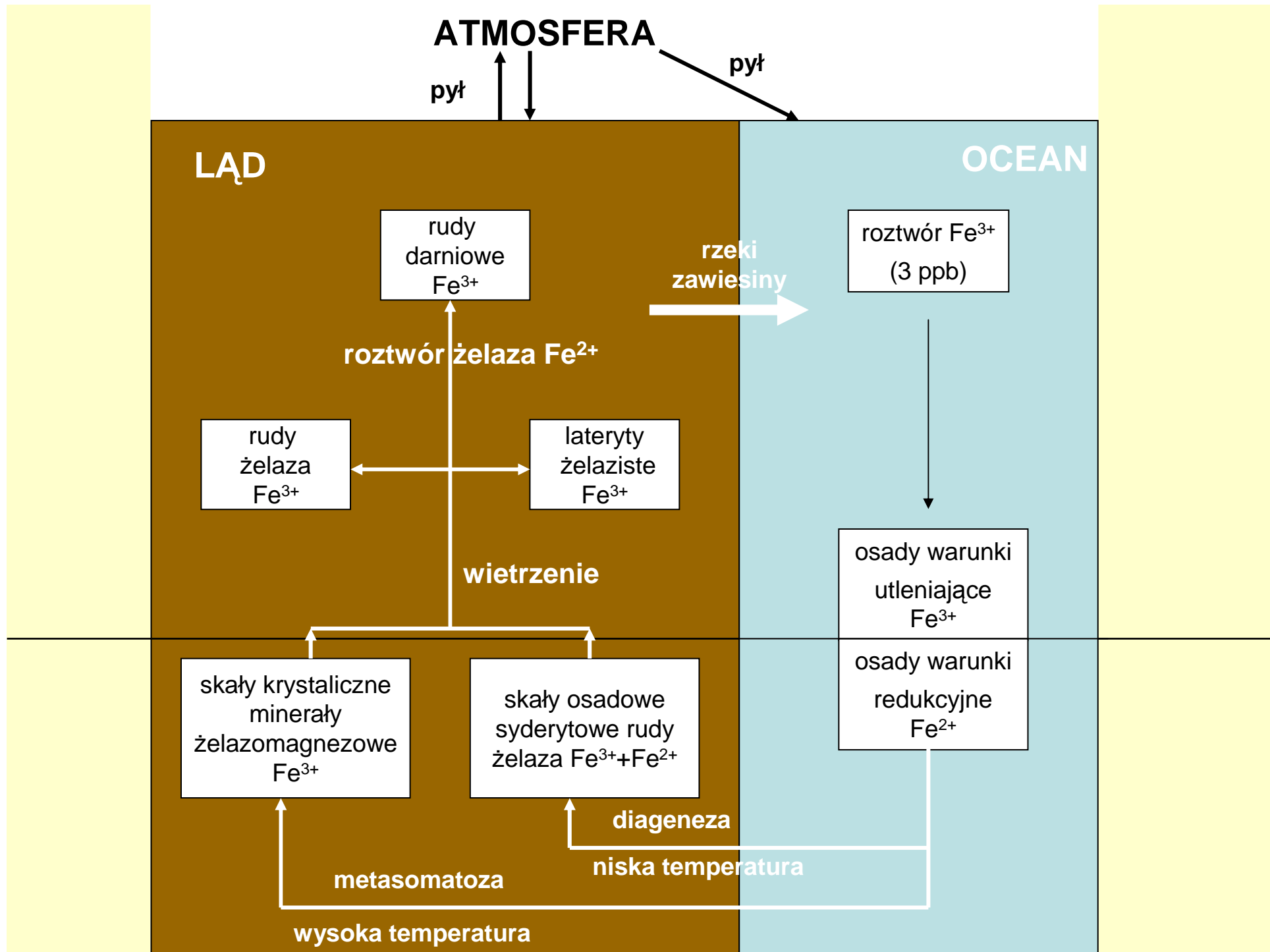
hemoglobina

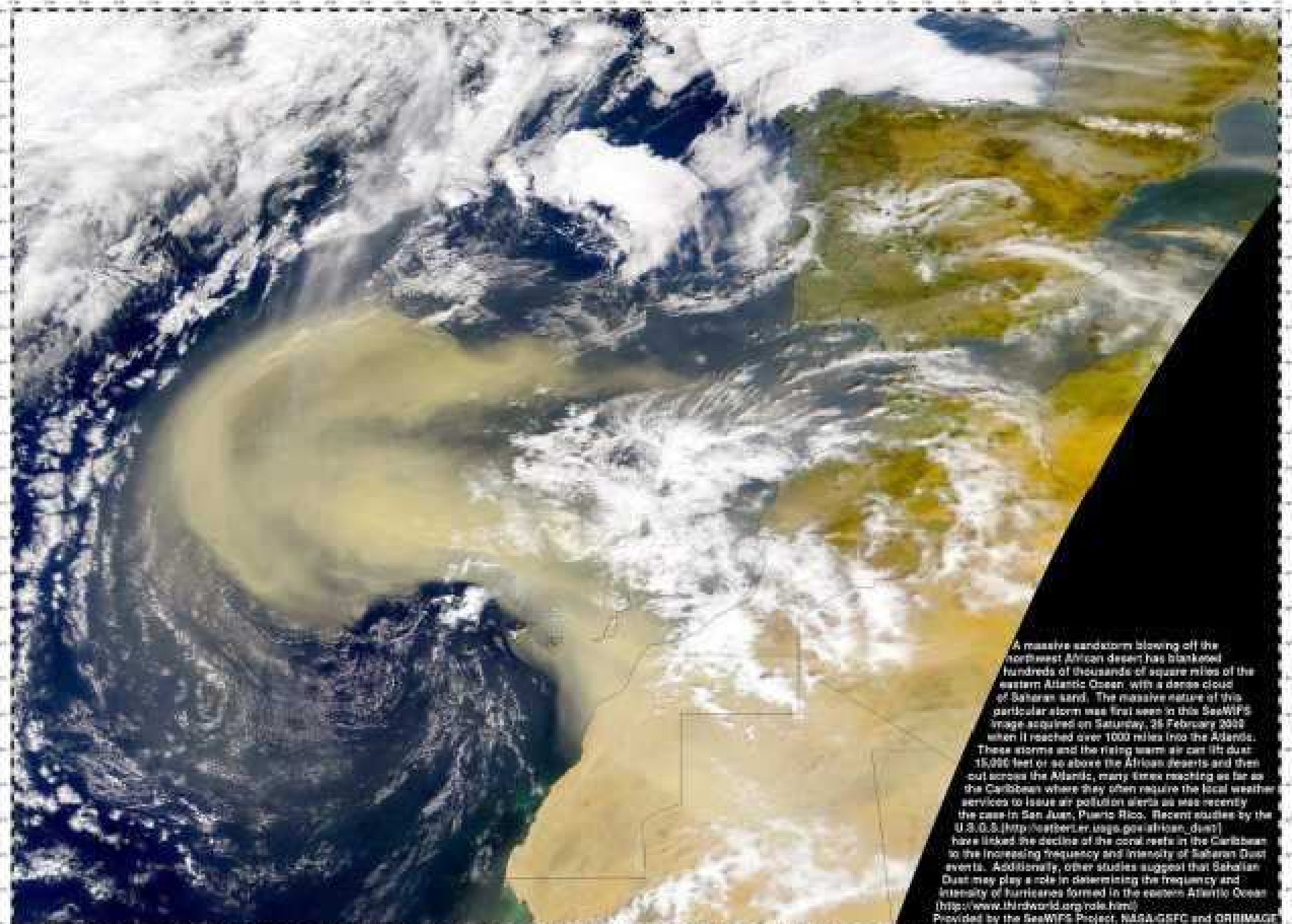
mioglobina

enzymy



Hem b



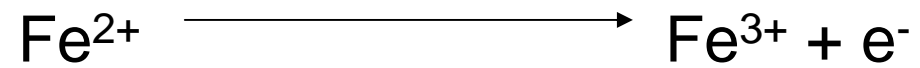


A massive sandstorm blowing off the northwest African desert has blanketed hundreds of thousands of square miles of the eastern Atlantic Ocean, with a dense cloud of Saharan sand. The massive nature of this particular storm was first seen in this SeaWiFS image acquired on Saturday, 26 February 2005 when it reached over 1000 miles into the Atlantic. These storms and the rising warm air can lift dust 15,000 feet or so above the African deserts and then out across the Atlantic, many times reaching as far as the Caribbean where they often require the local weather services to issue air pollution alerts as was recently the case in San Juan, Puerto Rico. Recent studies by the U.S.O.S. ([http://weather.usgs.gov/african\\_dust/](http://weather.usgs.gov/african_dust/)) have linked the decline of the coral reefs in the Caribbean to the increasing frequency and intensity of Saharan Dust events. Additionally, other studies suggest that Sahelian Dust may play a role in determining the frequency and intensity of hurricanes formed in the eastern Atlantic Ocean (<http://www.thirdworld.org/role.html>).  
Provided by the SeaWiFS Project, NASA/GSFC and ORRIMAGE

## Bakterie želazowe (Thiobacillus, Leptospirillum)

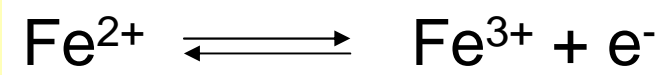


*Thiobacillus ferrooxidans*



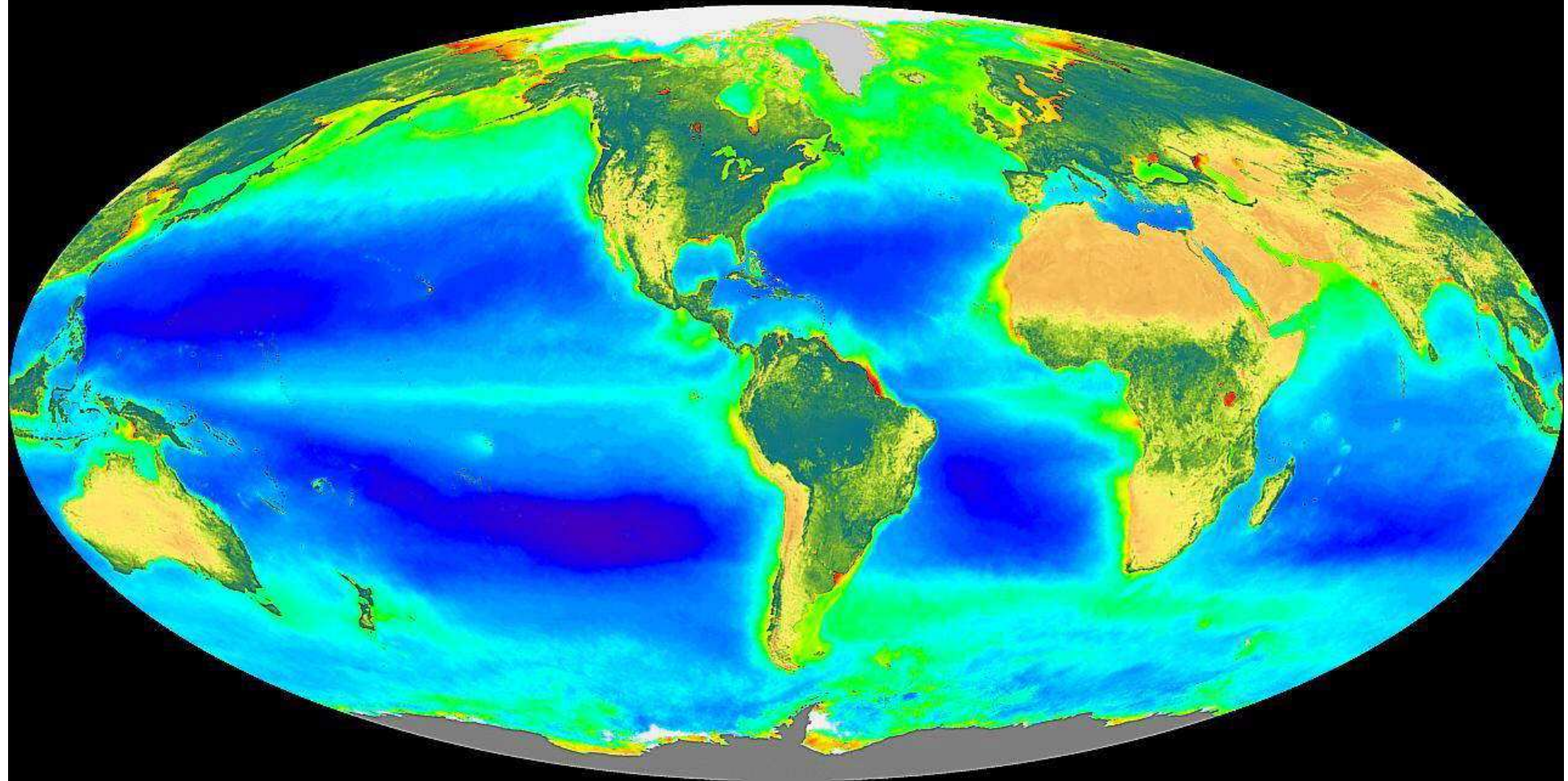
# ŽELAZO

BIF





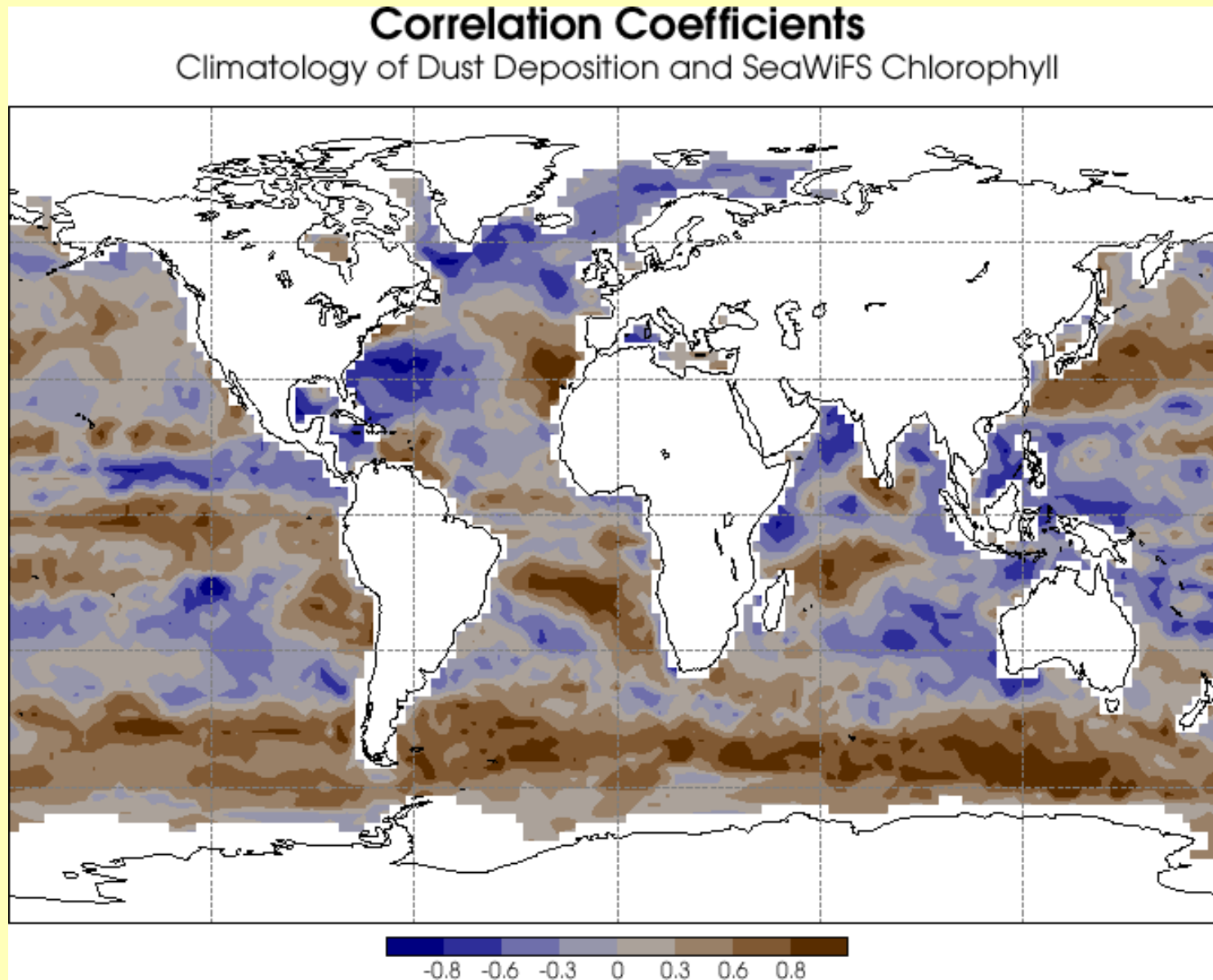
SeaWiFS Global Biosphere      September 1997 – August 2000  
Three Year Anniversary



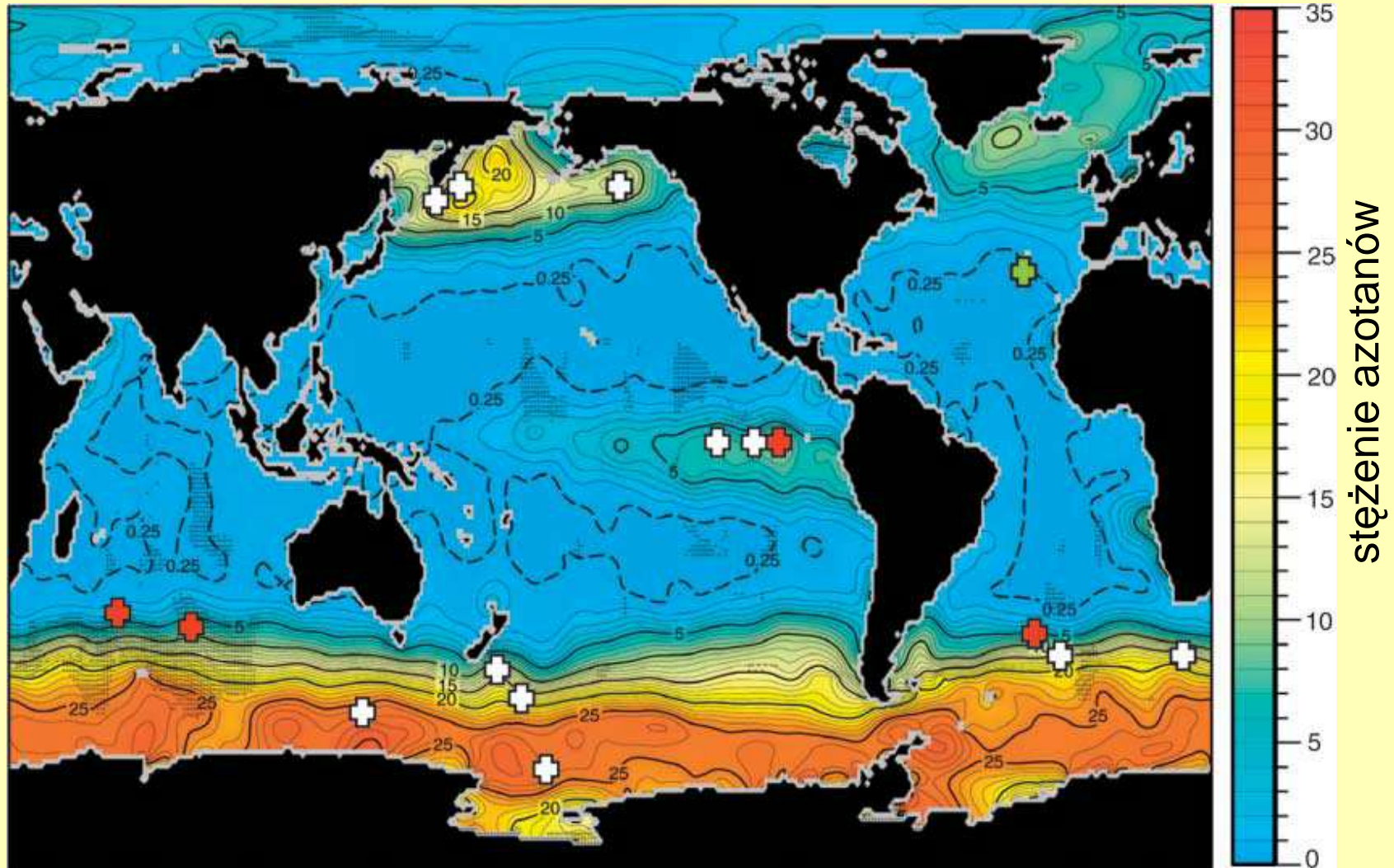
>01 .02 .03 .05 .1 .2 .3 .5 1 2 3 5 10 15 20 30 50  
Ocean: Chlorophyll  $a$  Concentration ( $\text{mg}/\text{m}^3$ )

Maximum Minimum  
Land: Normalized Difference Land Vegetation Index

# Korelacja opadu pyłu (Fe) i zawartości chlorofilu

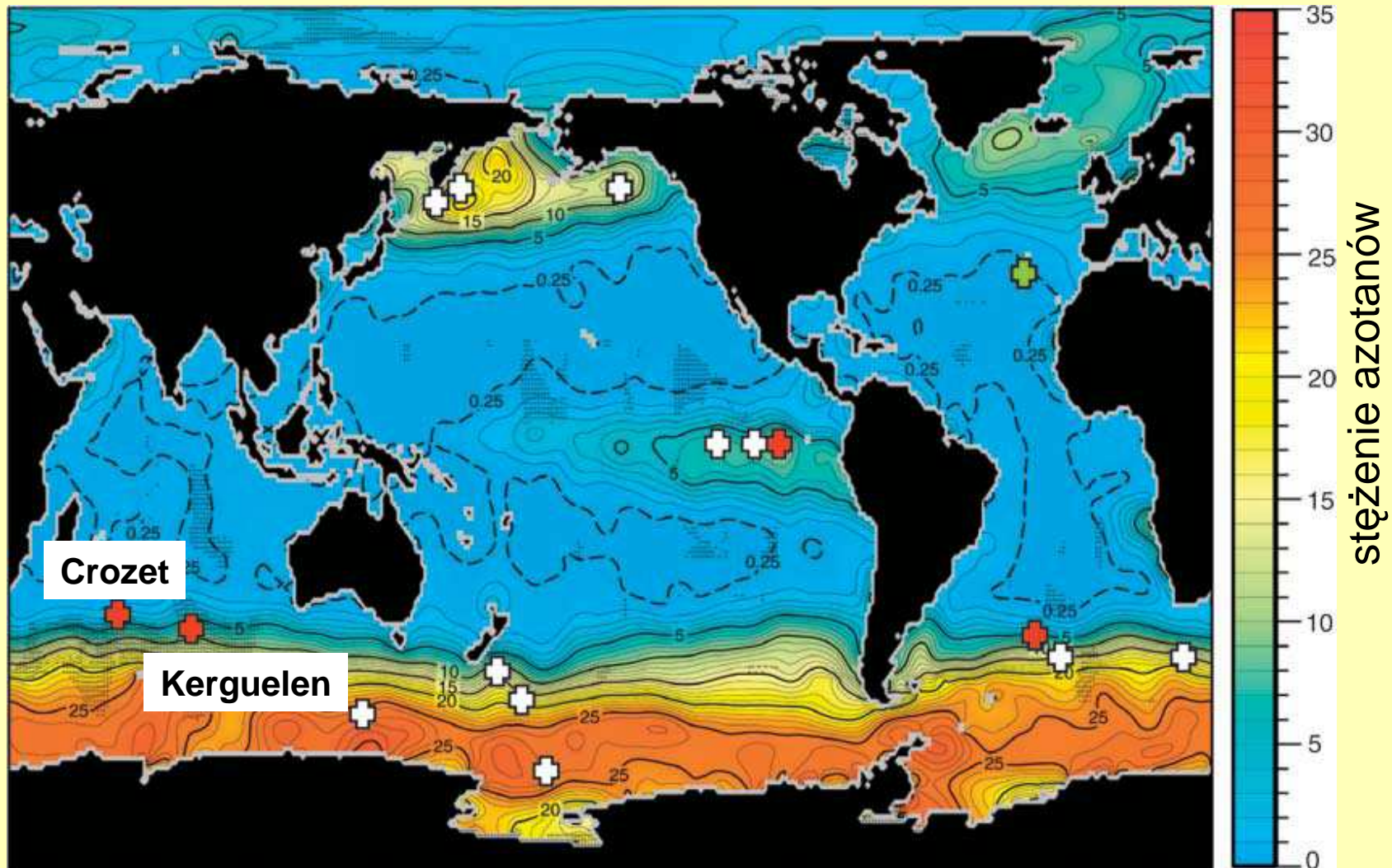


## Badania nad nawożeniem mórz żelazem (1993 – 2005)



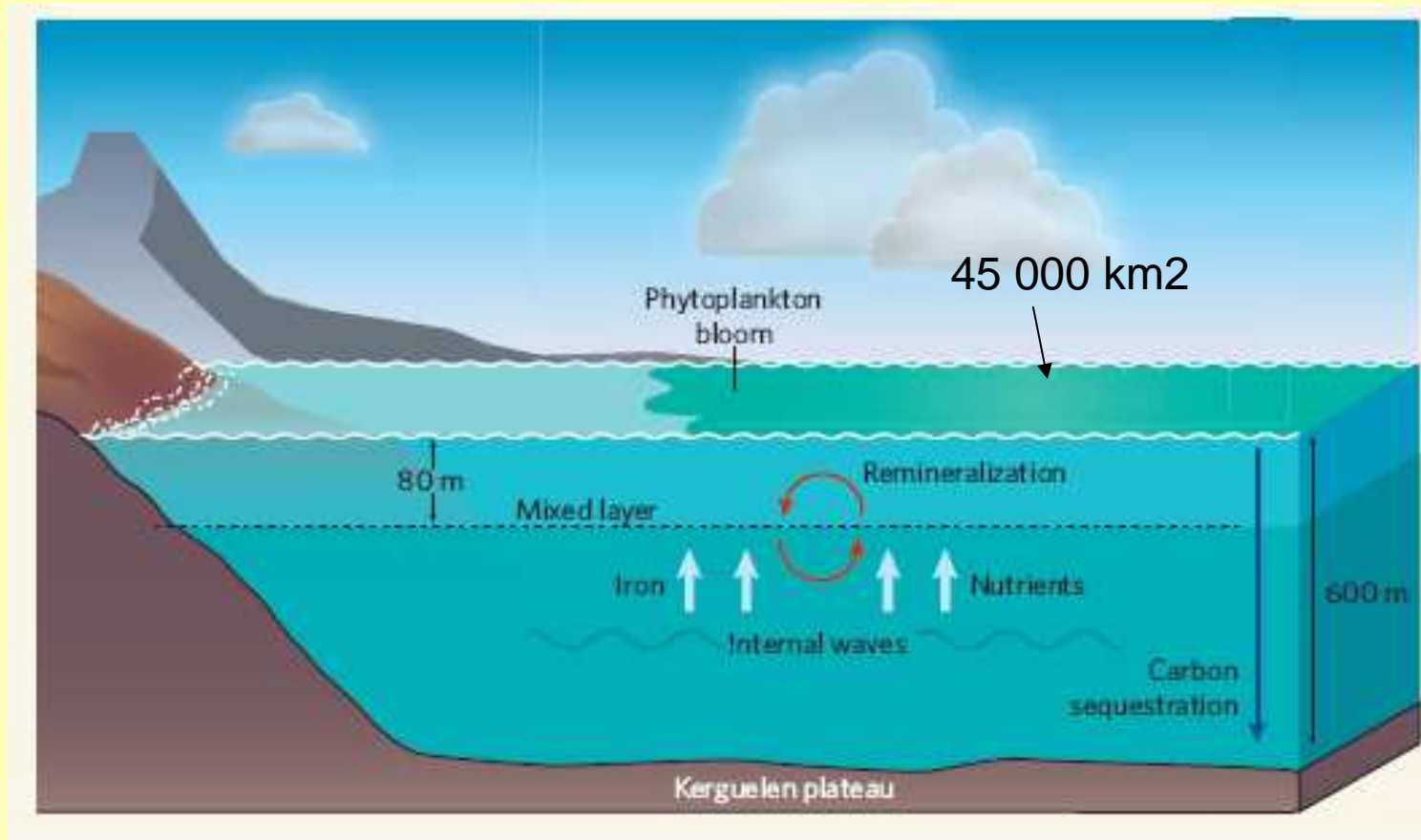
Boyd i in. 2007

## Badania nad nawożeniem mórz żelazem (1993 – 2005)



Boyd i in. 2007

## Zakwity glonów koło wysp Kerguelenów

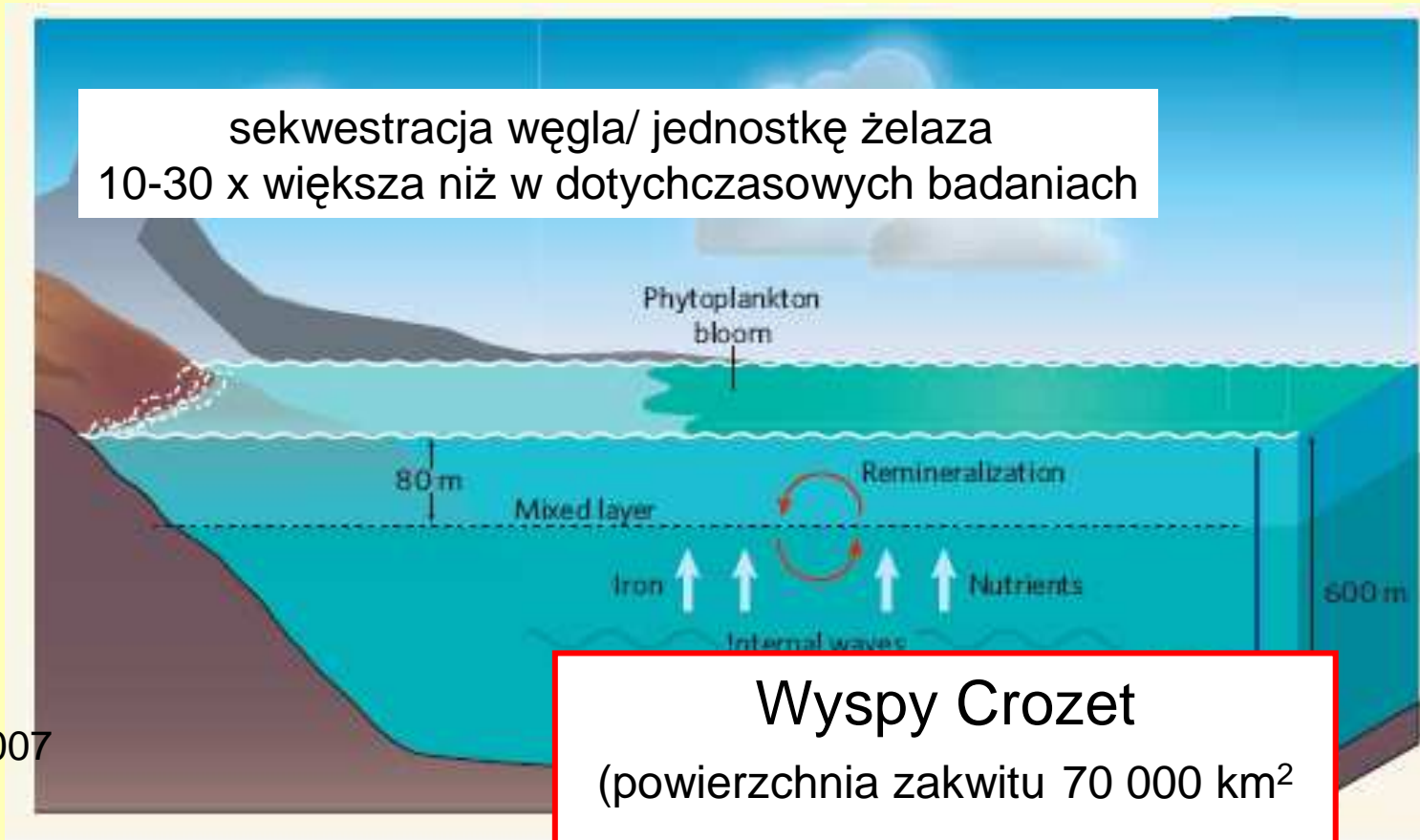


Blain i in. 2007

sekwestracja węgla/ jednostkę żelaza  
10-30 x większa niż w dotychczasowych badaniach

# Zakwity glonów koło wysp Kerguelenów

sekwestracja węgla/ jednostkę żelaza  
10-30 x większa niż w dotychczasowych badaniach



Blain i in. 2007

## Wyspy Crozet

(powierzchnia zakwitu 70 000 km<sup>2</sup>)

dopływ 270 t żelaza (pyły)



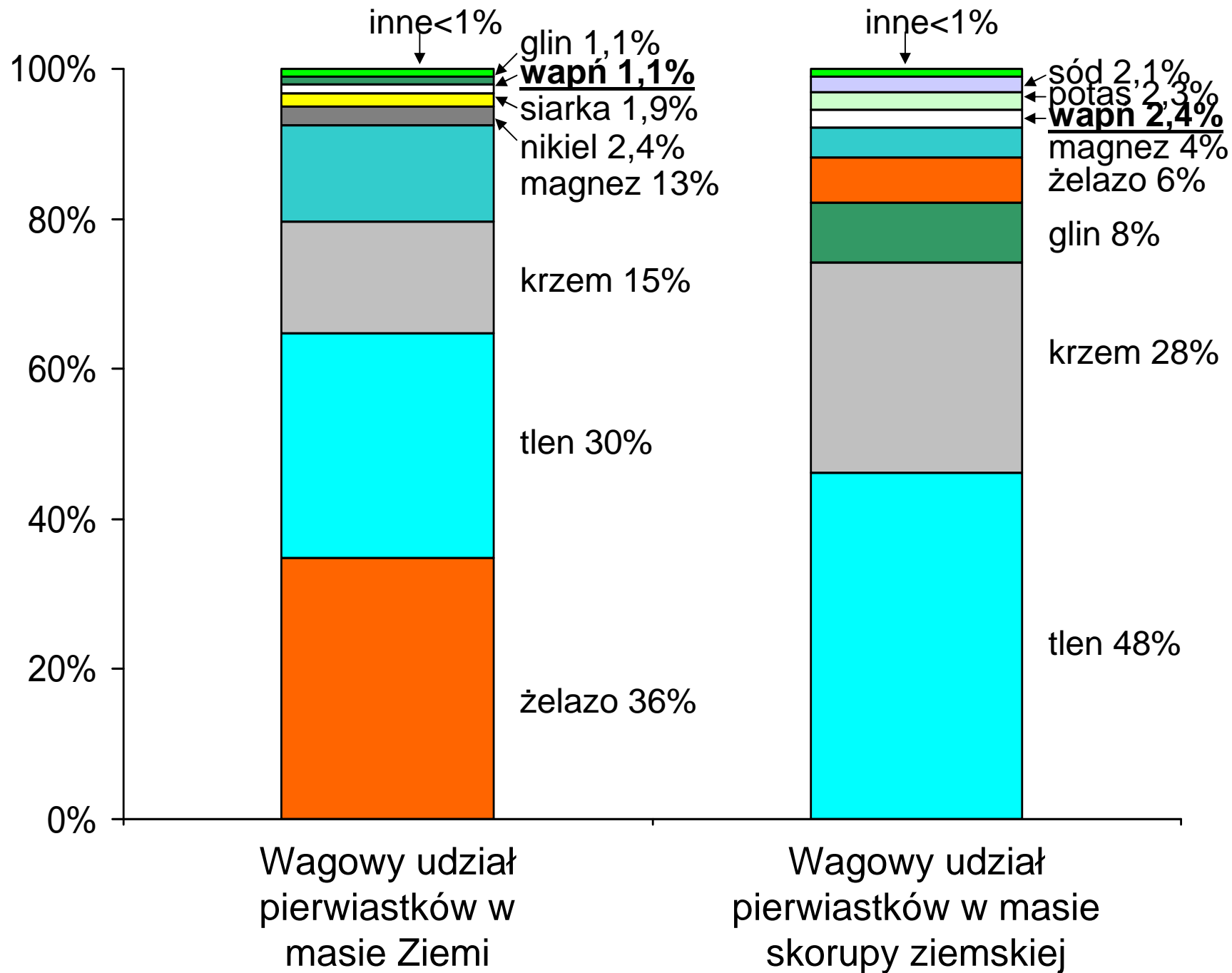
wzrost produktywności 3 x



słaba sekwestracja węgla

Pollard i in. 2009 (Nature)

WAPŃ





# WAPŃ

W skorupie ziemskiej 2,4%

minerały krzemianowe  $\text{CaSiO}_3$

węglany - wapień  $\text{CaCO}_3$

siarczany - gips  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

fosforany - apatyt  $\text{Ca}_3(\text{PO}_4)_2$

fluorki – fluoroapatyt  $\text{Ca}_3(\text{PO}_4)_3\text{F}$

# WAPŃ

W wodzie:

morskiej - 400 mg/kg

słodkiej – 15 mg/kg

# WAPŃ

## W ORGANIZMACH ŻYWYCH

- buduje szkielety i muszle
- udział w metabolizmie komórek (pompa wapniowa)
- zmienia konformację białek
- udział w mechanizmach regulacyjnych w komórkach
- udział w przekazywaniu bodźców

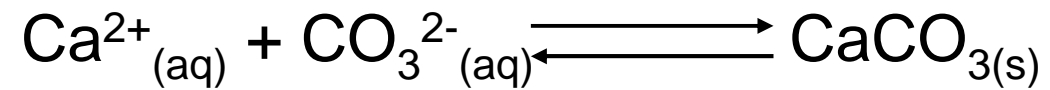
W organizmie człowieka średnio 1,4%

kości 17%

# WAPŃ

## TWORZENIE SKAŁ WAPIENNYCH

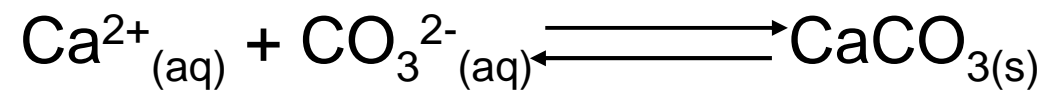
### 1. wytrącanie nieorganiczne



# WAPŃ

## TWORZENIE SKAŁ WAPIENNYCH

### 1. wytrącanie nieorganiczne



### 2. na drodze organicznej

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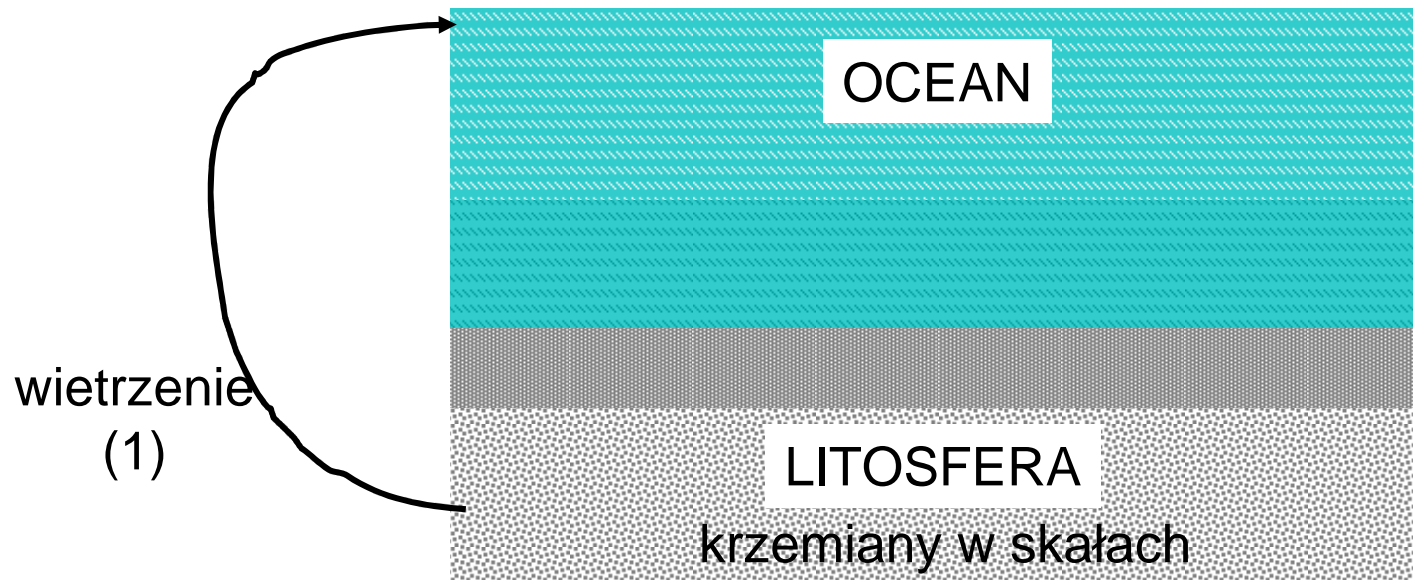
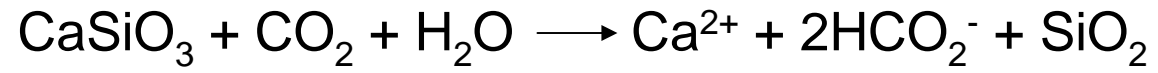
Wiciowce roślinne (Coccolithophores)

Otwornice (Foraminifera)

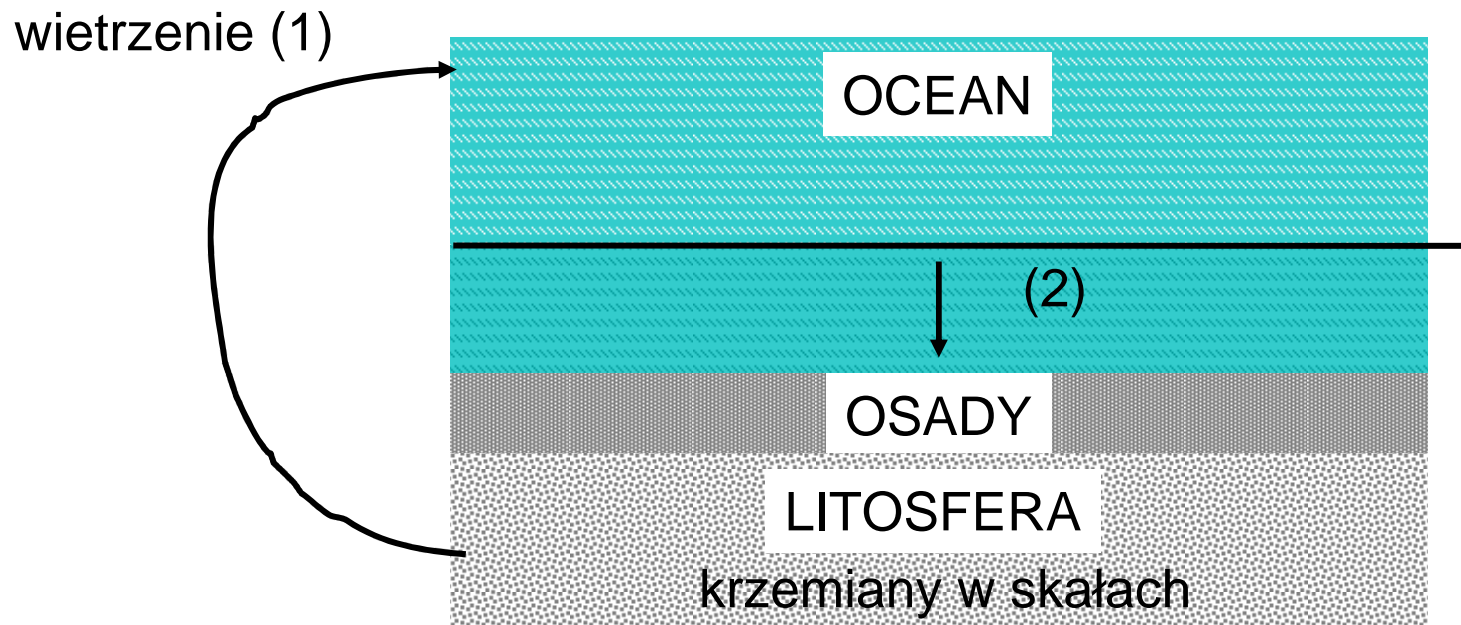
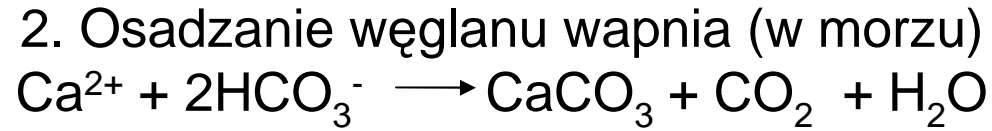
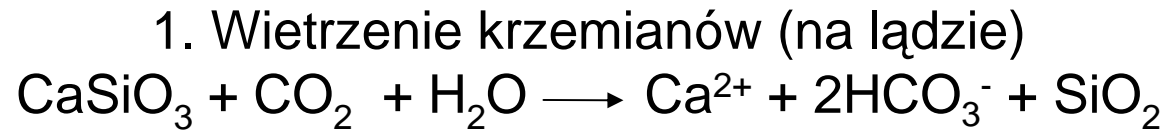


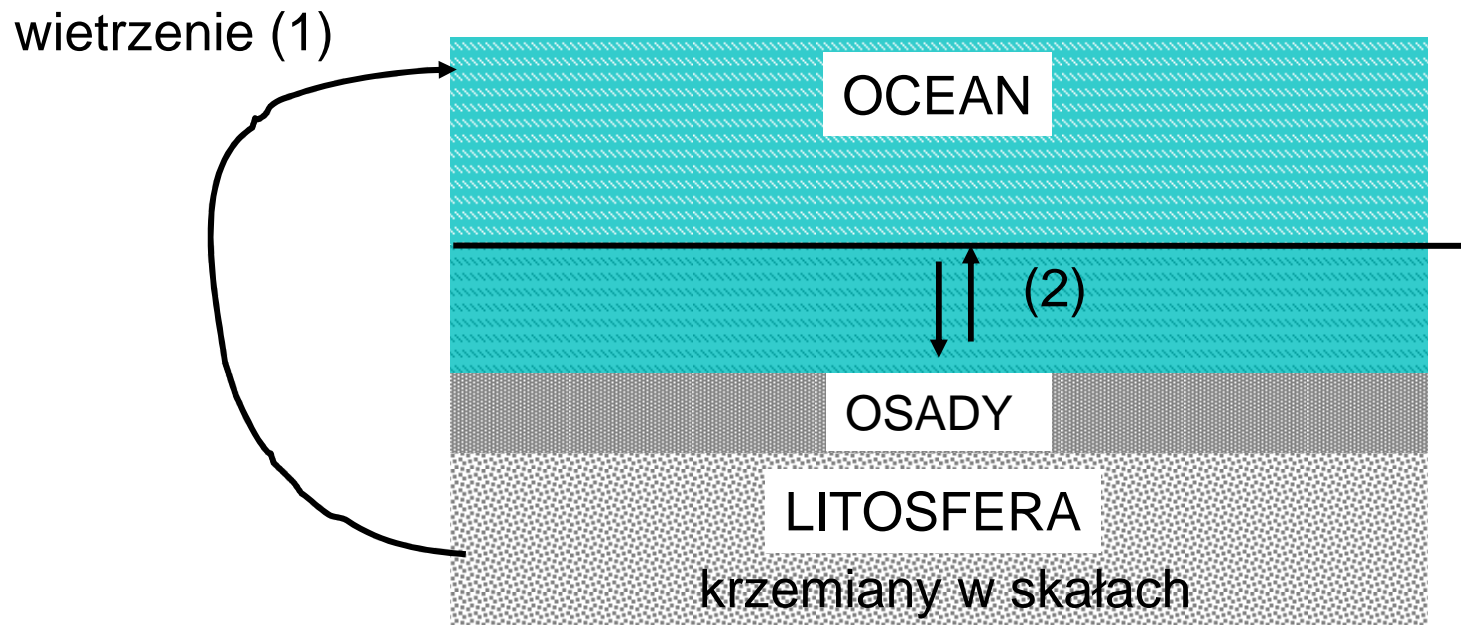
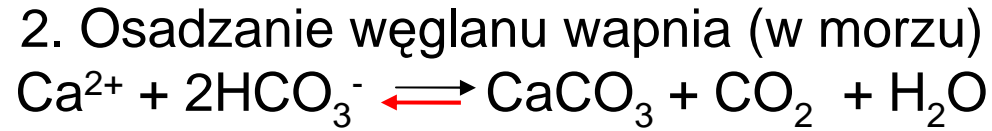
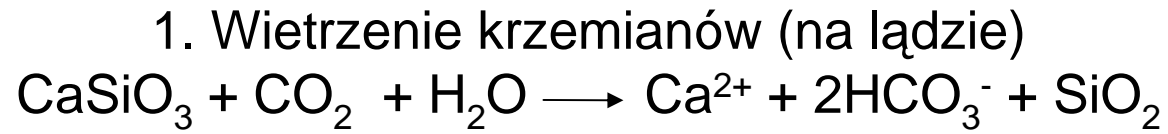
*Emiliana huxleyi*

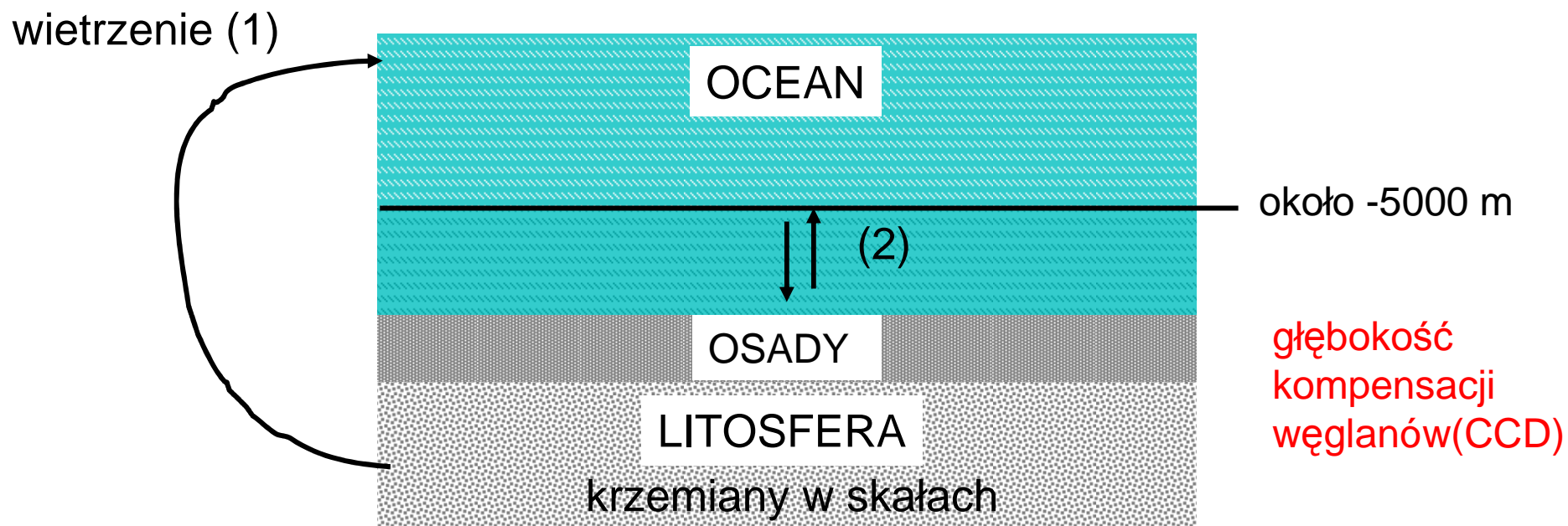
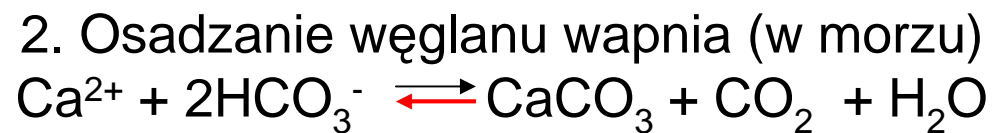
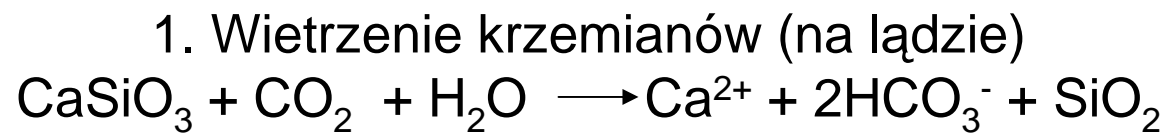
# 1. Wietrzenie krzemianów (na lądzie)

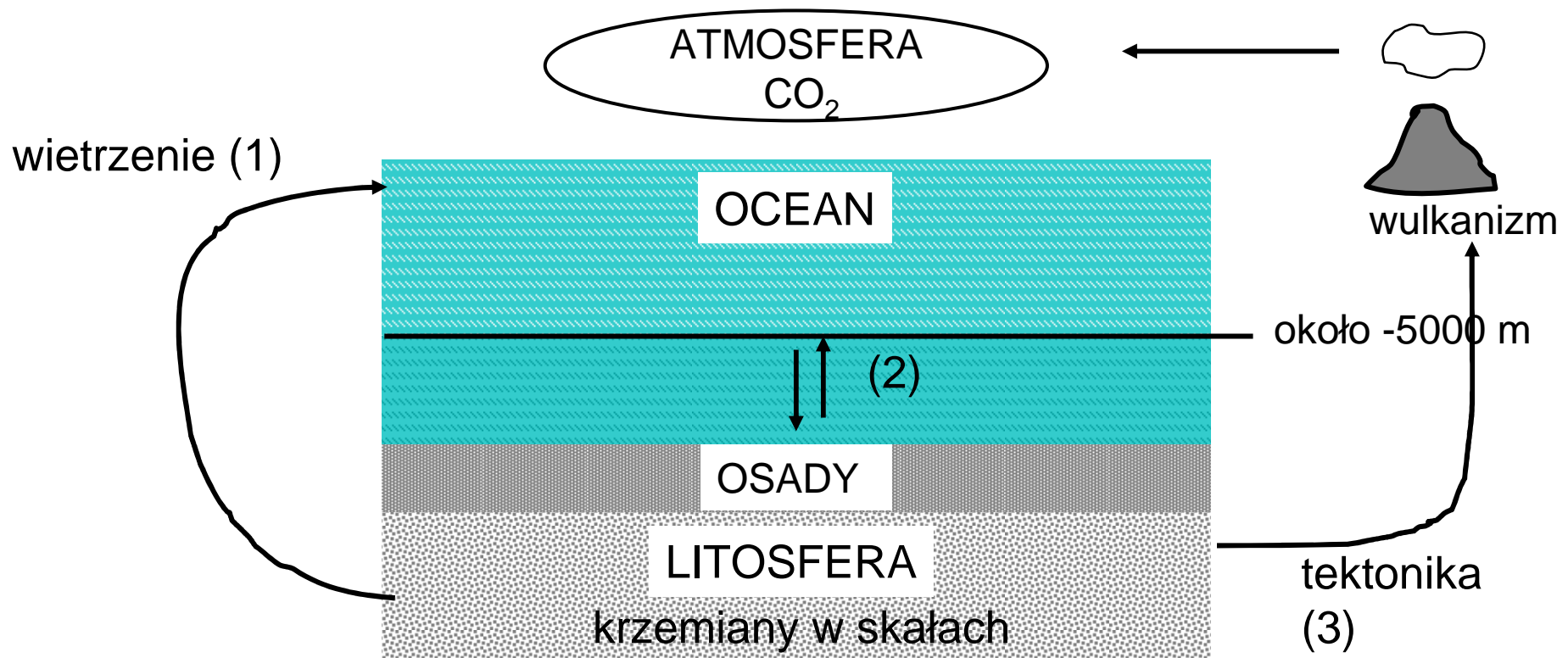
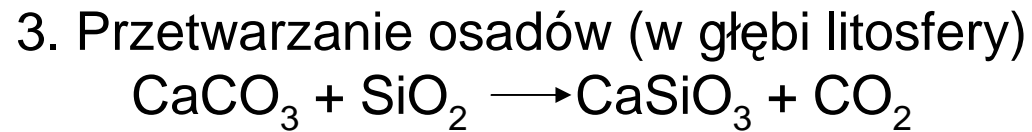
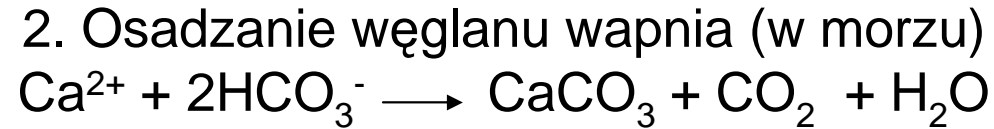
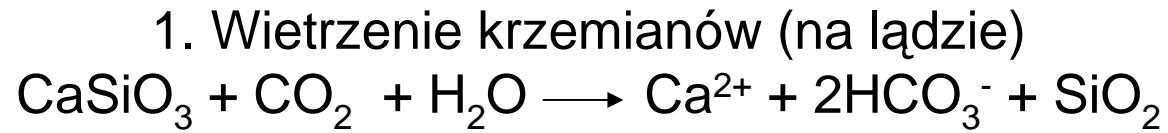


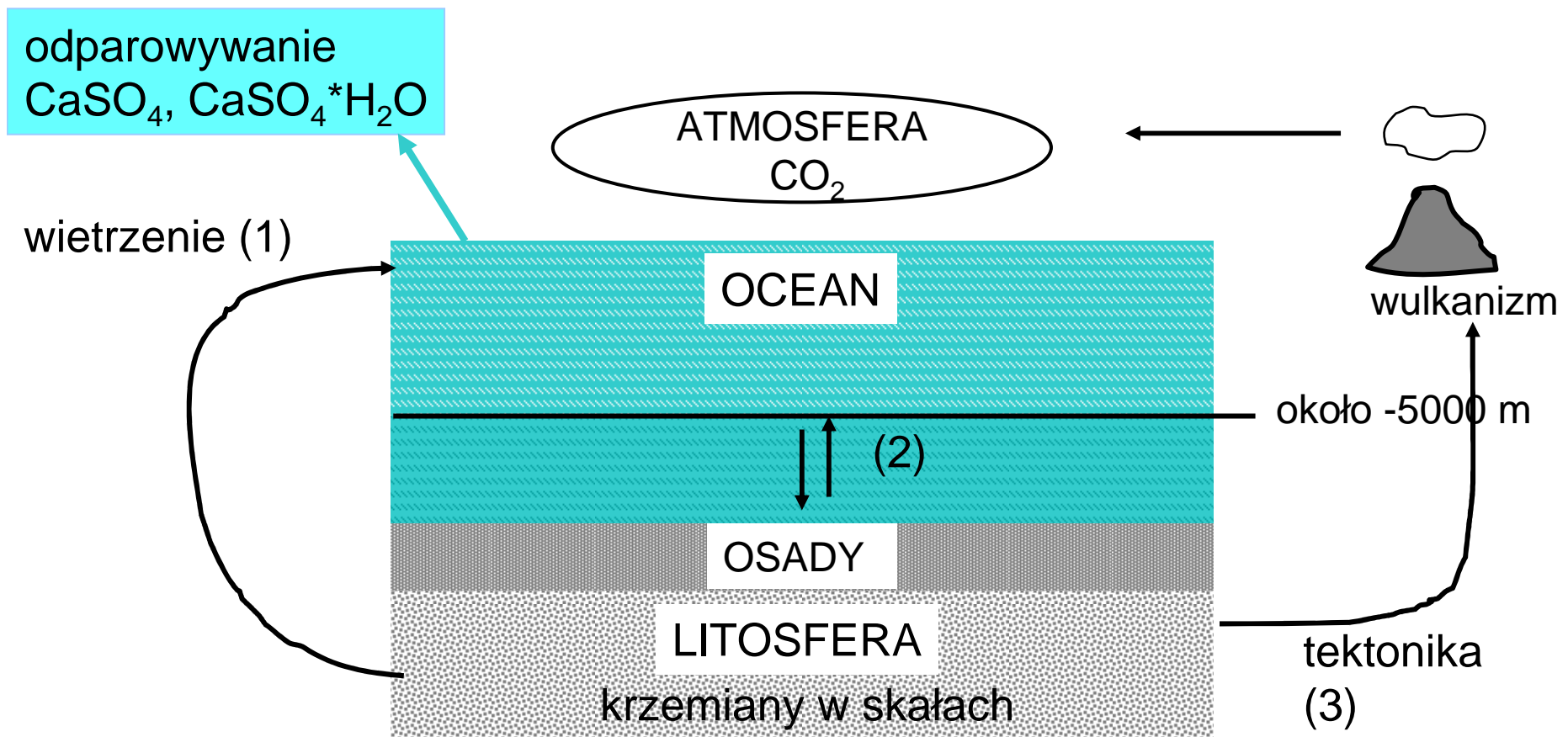
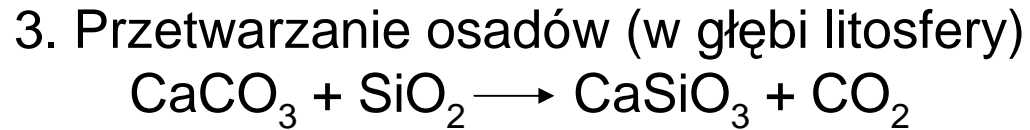
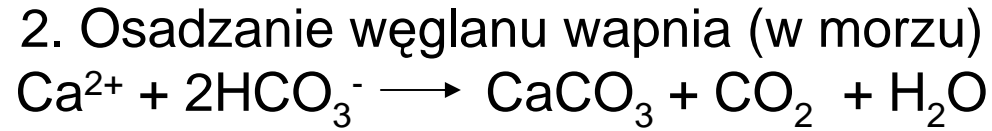
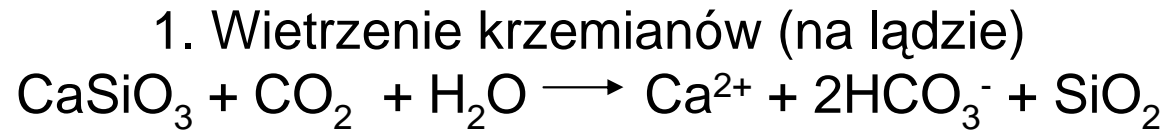






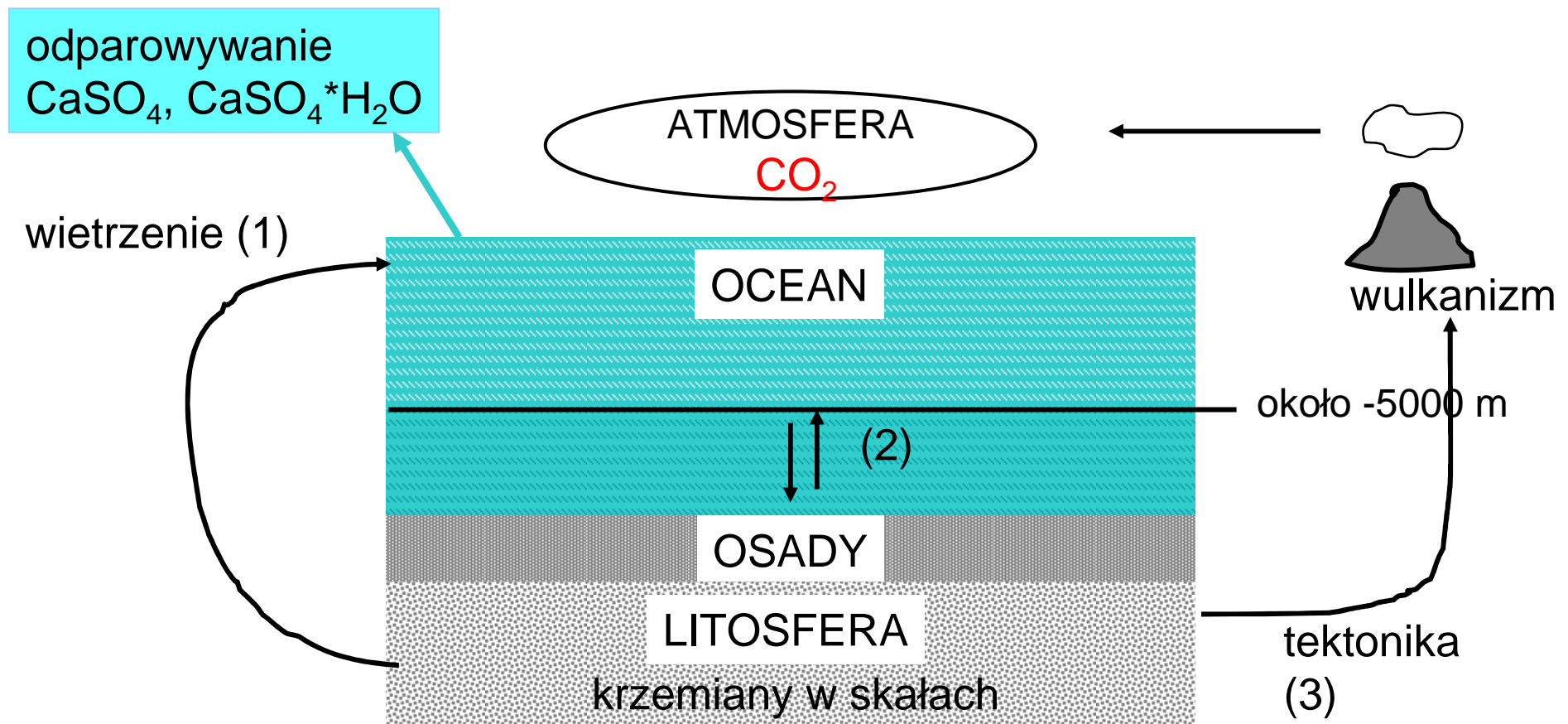






## CYKL WAPNIA POWIĄZANY Z CYKLEM WĘGLA

2. Osadzanie węglanu wapnia (w morzu)



## Wzrost stężenia CO<sub>2</sub> a organizmy planktoniczne



*Emiliana huxleyi*



*Gephyrocapsa oceanica*

Wiciowce roślinne (*Coccolithophores*)

Riebsell i in. 2000 (Nature)