

# Ciclos biogeoquímicos dos nutrientes nos oceanos

Ciclos Biogeoquímicos I

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Resenha 2

**Nome:** Carbono  
**Número Atômico:** 6  
**Símbolo Químico:** C  
**Configuração Electrónica:** [He]2s 2p<sup>2</sup>  
**Abundância:**  
*Terra:* 480 ppm  
*Sistema Solar:* 4.17x 10<sup>8</sup> (rel. a [H]=1x10<sup>12</sup>)

# Ciclo Biogeoquímico do CARBONO



6	12.011
3820 K	3.25
5100 K	
3513 kg m <sup>-3</sup>	C
[He]2s <sup>2</sup> 2p <sup>2</sup>	
Carbono	

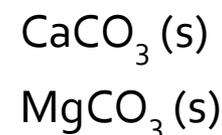
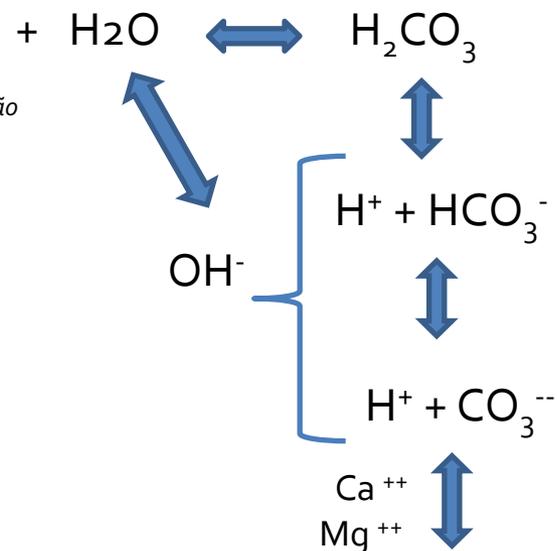
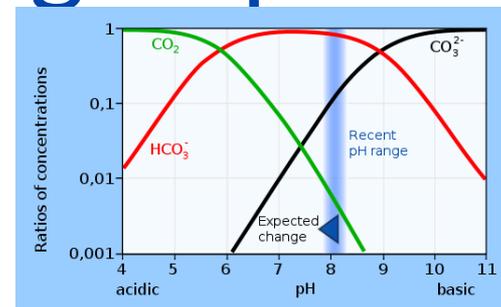
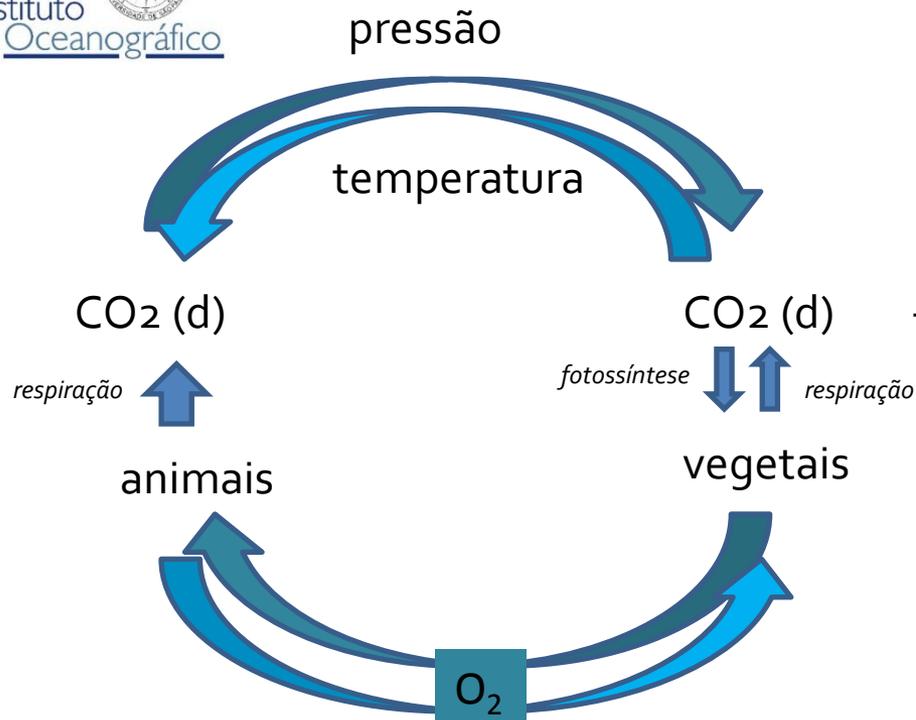


Átomo de carbono

O átomo de carbono (não metal)  
é um elemento neutro de número  
atômico Z=6 com distribuição eletrônica  
K=2 L=4

Profa Dra Elisabete de Santis Braga

# Bomba Biogeoquímica



Os oceanos se comportam como sistemas tampões, matam seu pH mesmo com adições de pequenas quantidade de “agentes” ácidos e básicos. Assim há apenas uma pequena alteração que deve ser acompanhada para que não saia do limite de tamponamento, o que pode acontecer com a adição do CO<sub>2</sub> em excesso no sistema.

$$C_1 = (\text{H}^+) (\text{OH}^-) / (\text{H}_2\text{O})$$

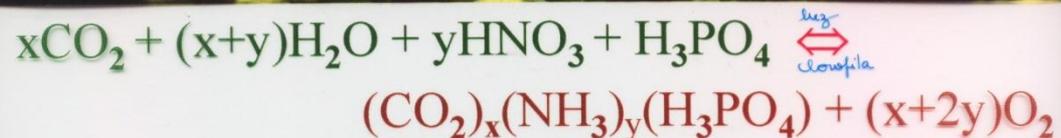
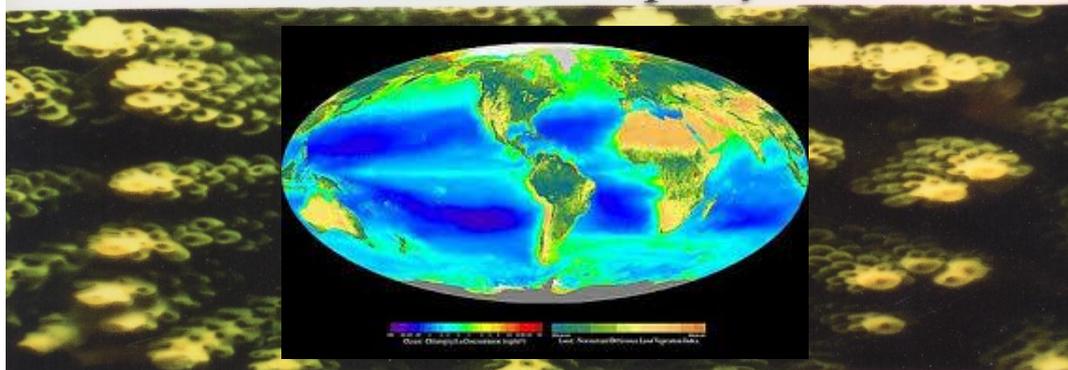
$$C_2 = (\text{CO}_2) (\text{H}_2\text{O}) / (\text{H}_2\text{CO}_3)$$

$$C_3 = (\text{H}^+) (\text{HCO}_3^-) / (\text{H}_2\text{CO}_3)$$

$$C_4 = (\text{H}^+) (\text{CO}_3^{2-}) / (\text{H}_2\text{CO}_3)$$

$$C_5 = (\text{Ca}^{++}) (\text{CO}_3^{2-}) / (\text{CaCO}_3)$$

## Fotossíntese/respiração



onde: x e y são coeficientes de Redfield

relações O/C/N/P

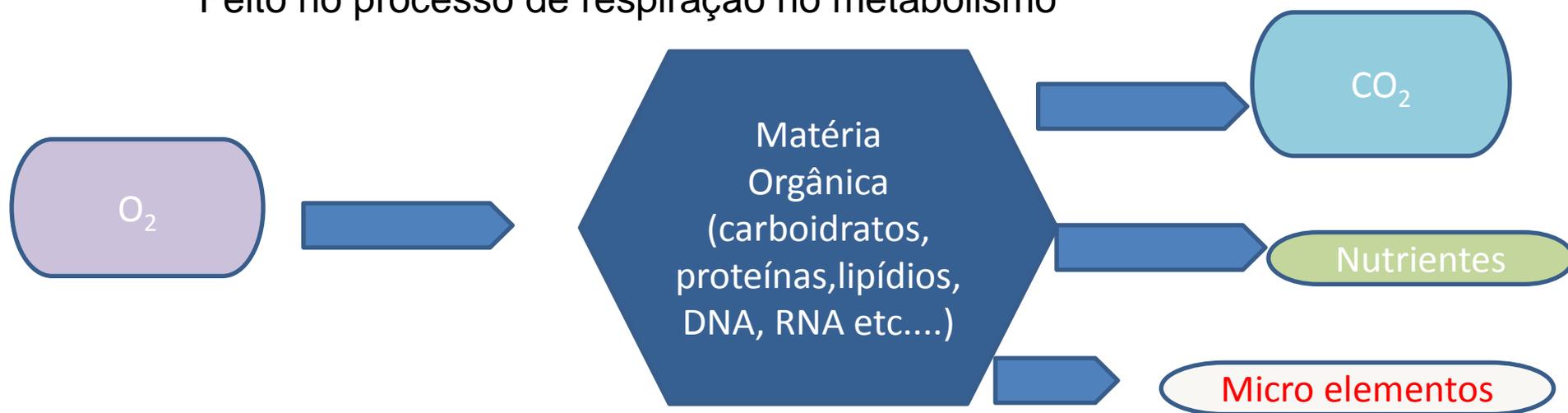
-276/106/16/1 Redfield et al., 1963

-276/106/15/1 Goldman, 1980

# Decomposição da matéria orgânica = oxidação da MO



Consome oxigênio e transforma MO em componentes inorgânicos  
Feito por microorganismos sobre detritos orgânicos  
Feito no processo de respiração no metabolismo



# Carbono encontrado no mar

Carbono Particulado – retido no filtro de 0,45  $\mu\text{m}$   
Carbono Dissolvido – atravessa o filtro de 0,45  $\mu\text{m}$

## Carbono Particulado

**Inorgânico** – carbonatos, esqueletos e frústulas de diatomáceas.  
**Orgânico (COP)** – fitoplâncton, zooplâncton, detritos de fito e zooplâncton e de organismos maiores

## Carbono Dissolvido

**Inorgânico** - carbonato, bicarbonato e gás carbônico (97,5%)

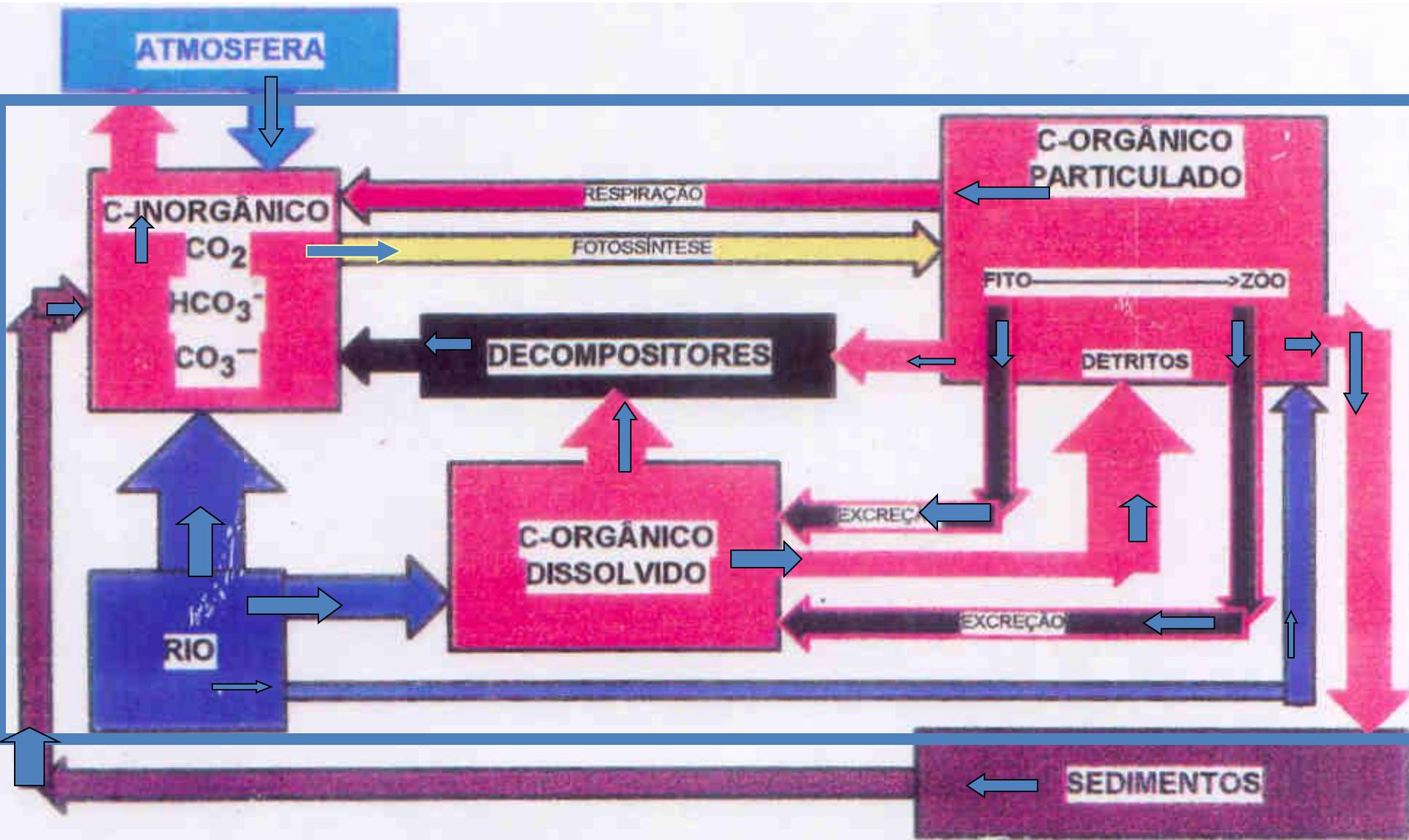
$\text{HCO}_3^-$  87%

$\text{CO}_3^{2-}$  9,5%

$\text{CO}_2$  1%

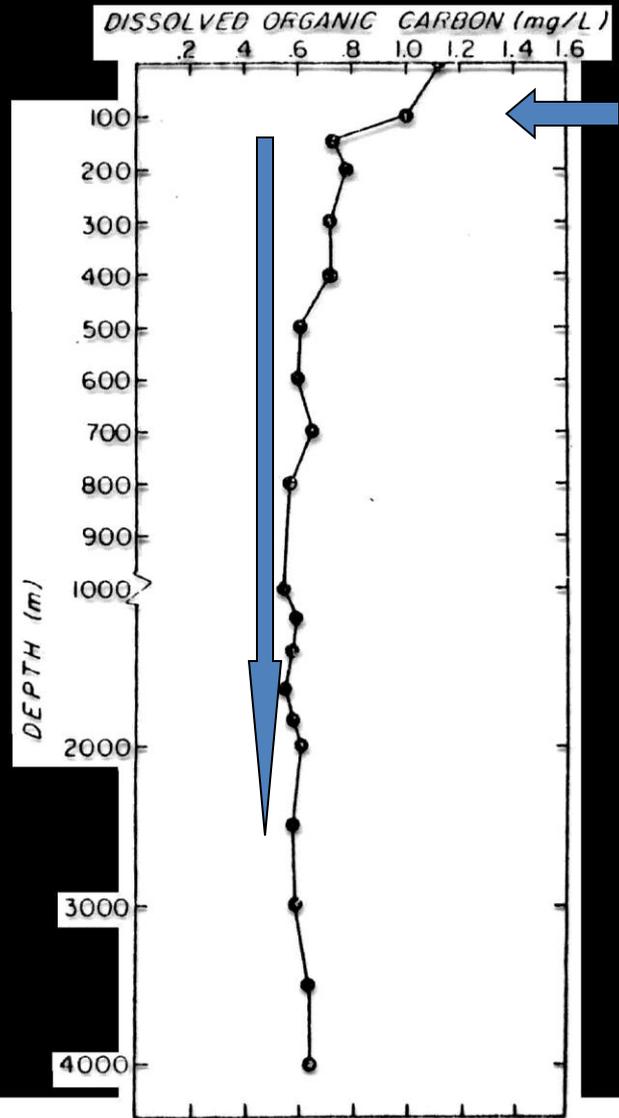
} CID ( carbono inorg. Dissolv.)

**Orgânico** – carboidratos, aminoácidos, hidrocarbonetos, lipídios, etc. (2,5%)-COD



**CICLO DO CARBONO**

DAVID W. MENZEL



Distribuição do Carbono orgânico dissolvido (COD)

S 4

FIG. 8.8  
fac  
por  
tur  
eau

The vertical distribution of dissolved organic carbon in the tropical Atlantic between 5-20°N and 60-70°W. Values are the average of 10 stations. R.V. *Atlantis II*, Cruise 14,

# Composição média da MO microplâncton marinho

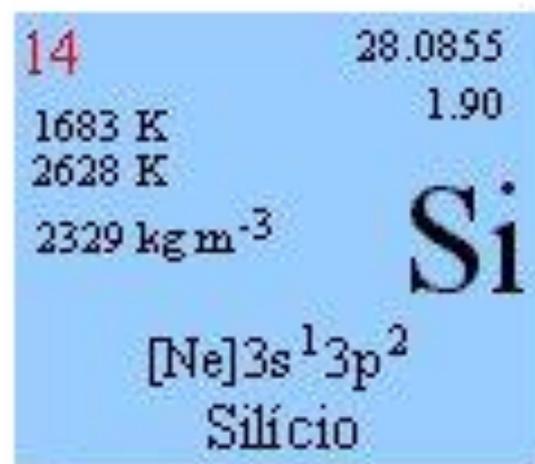


Redifield et al. 1963  
Goldman, 1980

- Aportes
- Assimilação e cadeia trófica
- Decomposição e remineralização
- Regeneração
- Bomba biológica

# Ciclo Biogeoquímico do SILÍCIO

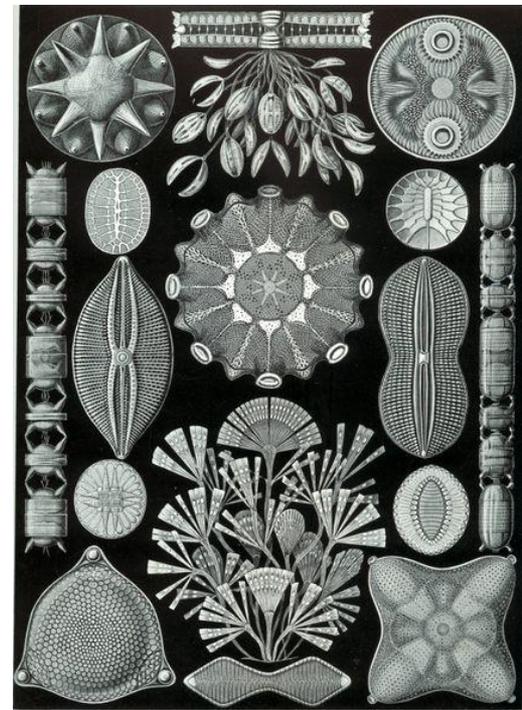
Profa Dra Elisabete de Santis Braga

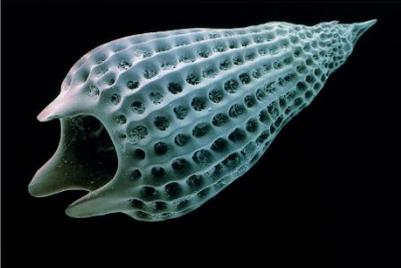


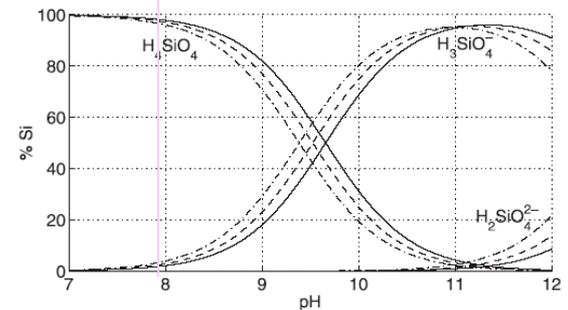
# SILÍCIO

- Si dissolvido – inorgânico e orgânico
- Si particulado – inorgânico e orgânico
- SILÍCIO DISSOLVIDO INORGÂNICO
- Principal forma – ácido ortosilícico

»  $\text{Si}(\text{OH})_4$

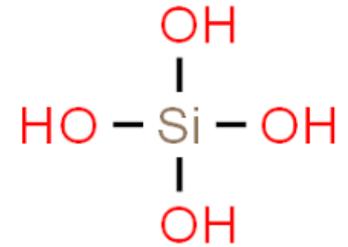


$\text{H}_4\text{SiO}_4$	Ácido ortoSilícico	$\text{H}_3\text{SiO}_4^-$	Tri-Idrogeno-Silicato
		$\text{H}_2\text{SiO}_4^{2-}$	Di-Idrogeno-Silicato
		$\text{HSiO}_4^{3-}$	Idrogeno-Silicato
		$\text{SiO}_4^{4-}$	Silicato



# SILÍCIO

- Si dissolvido – inorgânico e orgânico
- Si particulado – inorgânico e orgânico

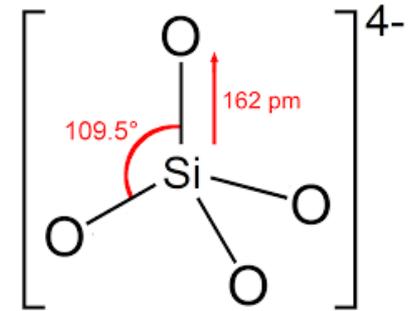


Ácido ortosilícico

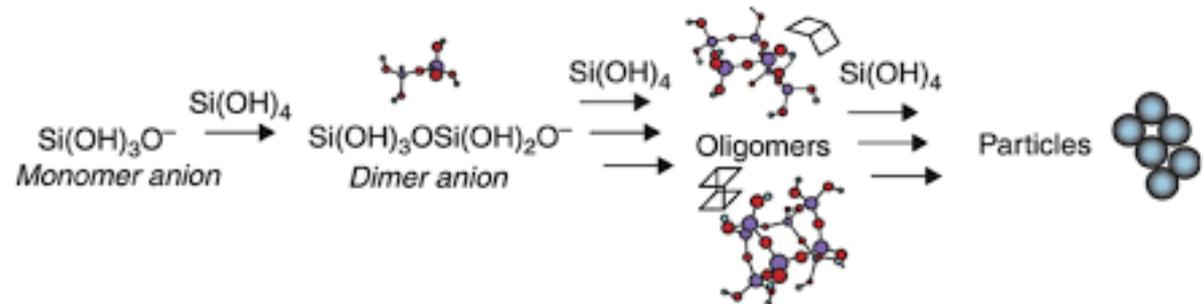
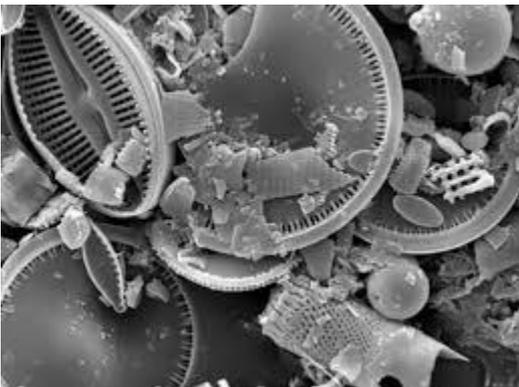
- SILÍCIO DISSOLVIDO INORGÂNICO
- Principal forma – ácido ortosilícico



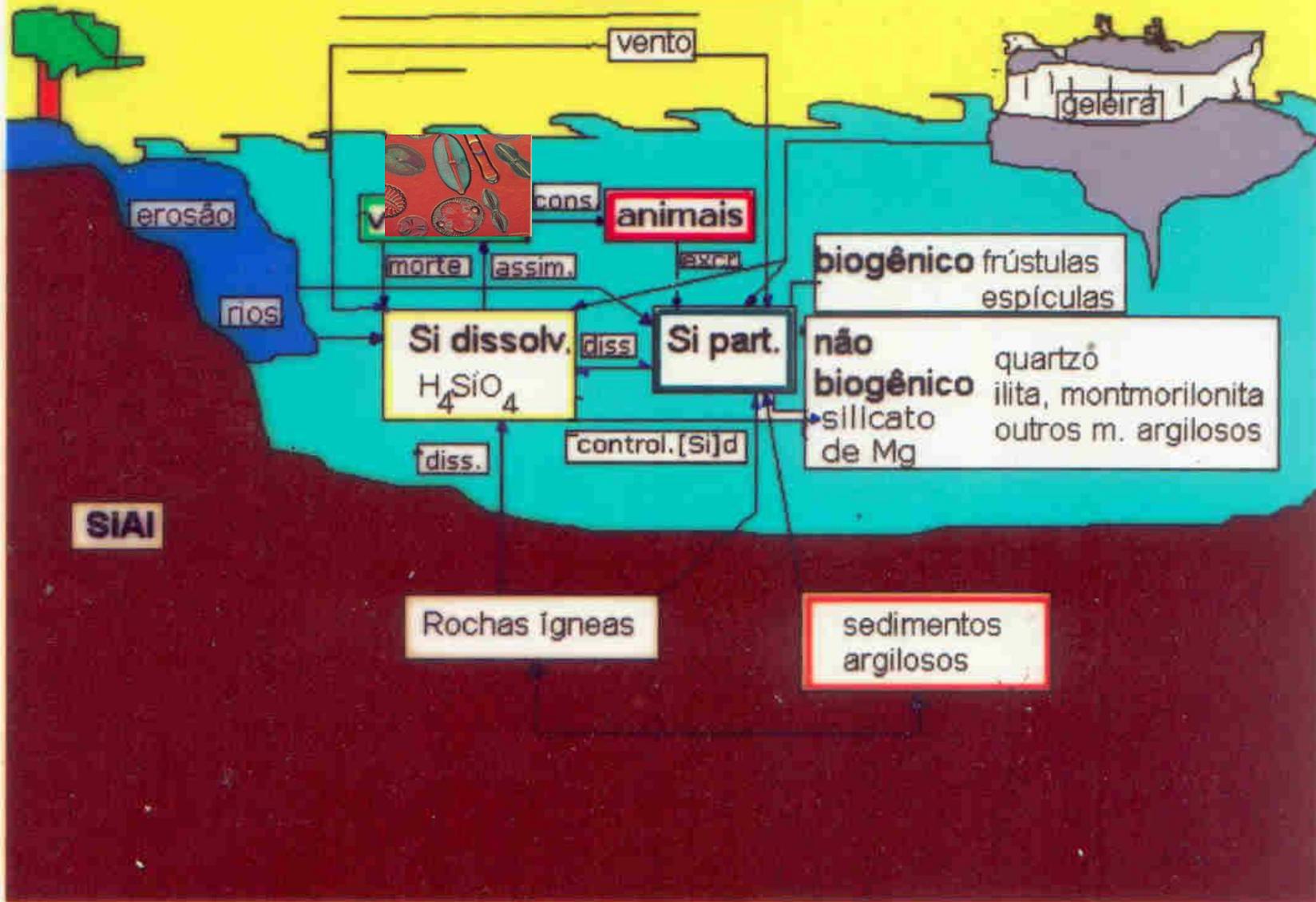
- Obs. Se o pH aumenta (>8,0) a solubilidade do Si aumenta
- Se a Temperatura aumenta, a solubilidade do Si aumenta

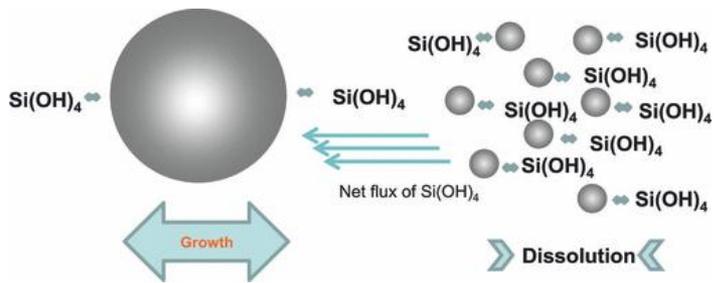


ortosilicato



# Ciclo do Silício

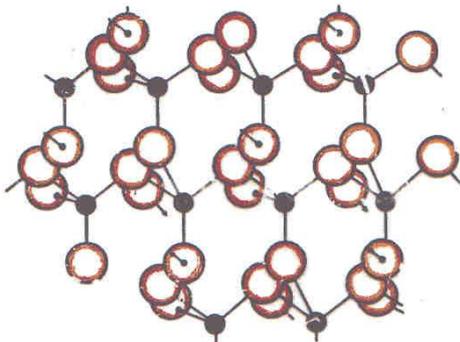




**TABLE 16.1**  
Geochemical Balance of Dissolved Silicon in the Modern Ocean  
Shown in Units of  $10^{14}$  g  $\text{SiO}_2/\text{y}$

Input		Removal	
Process	Amount	Process	Amount
Dissolved in rivers	4.3	Burial of opaline tests	10.4
Submarine weathering	0.9	Inorganic adsorption at river mouths	0.4
Diffusion out of the seafloor	5.7		
	10.9		10.8

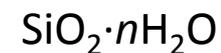
Source: From *Marine Geology*, J. Kennett, copyright © 1982 by Prentice Hall, Englewood Cliffs, NJ, p. 479 and D. J. DeMaster, 1979, unpublished doctoral dissertation, Yale University, New Haven, CT, p. 165. After *Studies in Paleocyanography*, G. R. Heath (ed.: W. W. Hay), copyright © 1974 by the Society for Economic Petroleum Mineralogists, Tulsa, OK, p. 88. Reprinted by permission.



**FIGURE 16.1** Three-dimensional crystal structure of quartz.

entrada	$\times 10^{16}$ g/ano	saída	$\times 10^{16}$ g/ano
Processo	Quant.	Processo	Quant.
Dissolvido em rios	4,3	soterramento	10,4
Intemperismo submarino	0,9	Adsorção do Si inorgânico junto a boca de rios	0,4
Difusão pelo leito marinho	5,7		
total	10,9		10,8

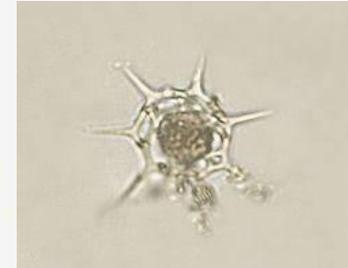
Opalina – sílica hidratada amorfa



# Silício



espongiários



silicoflagelados

- Silício
- apenas 1 estado de oxidação
- Compõem as frústulas das diatomáceas, espículas de esponjas, silicoflagelados e radiolários
- Presente em formas minerais como: quartzos, feldspatos, olivinas, piroxenos, amphibolos, micas ( muscovita, biotitas) etc.
- sílica amorfa - polímero de Si e pode ter origem artificial.
- Input via rios é acentuado do silício particulado
- Presença de ácidos húmicos dificulta a solubilidade da sílica, metais traços como: Al, Be e Fe dificultam a solubilização das carapaças das diatomáceas
- Participação no sistema de tamponamento da água
- Silício particulado não biogênico: ilita, montmorilonita, clorita, kaolinita.
- Subsaturação devido a formação de silicato de magnésio hidroxilado



radiolários

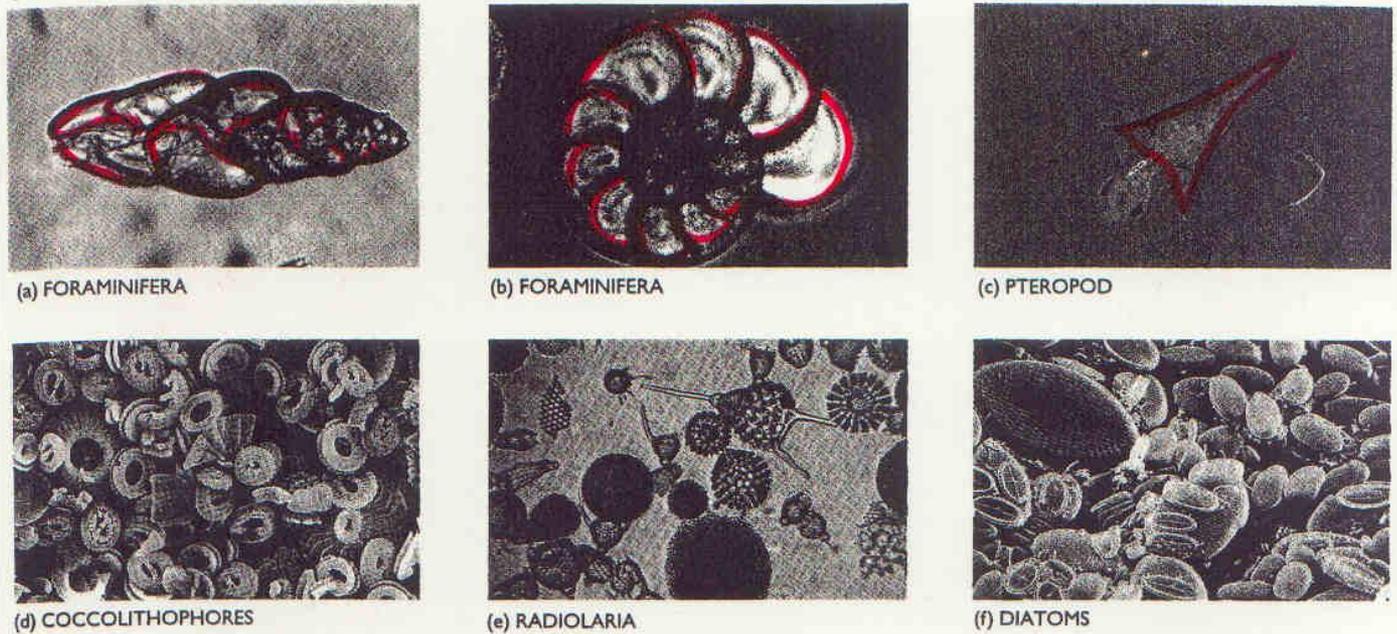


FIGURE 4-14  
Common microfossils in biogenic oozes.

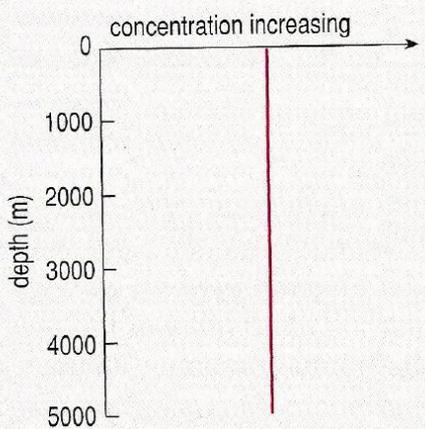
TABLE 4-2  
Distribution of pelagic sediment

Type	Composition	Atlantic (%)	Pacific (%)	Indian (%)	Global (%)
Foraminiferal ooze	Carbonate	65	36	54	47
Pteropod ooze	Carbonate	2	0.1	—	0.5
Diatom ooze	Silica	7	10	20	12
Radiolarian ooze	Silica	—	5	0.5	3
Red clay	Aluminum silicate	26	49	25	38

Source: Adapted from W. H. Berger, Biogenous deep sea sediments: production, preservation and interpretation in *Chemical Oceanography*, vol. 5, J.P. Riley and R. Chester, eds. (New York: Academic Press, 1976), 265-388; and J. Kennett, *Marine Geology* (Englewood Cliffs, N.J.: Prentice-Hall, 1982).

**CONSERVATIVE ELEMENTS**  
(bio-unlimited)

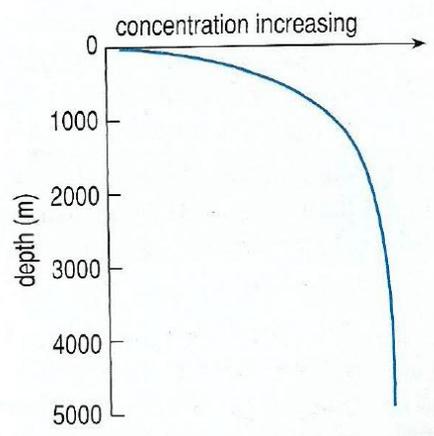
- |    |    |
|----|----|
| B  | Mg |
| Br | Mo |
| Cl | Na |
| Cs | Rb |
| F  | S  |
| K  | Tl |
| Li | U  |



(a)  $\approx 1$

**RECYCLED ELEMENTS**  
(nutrient-type profiles)

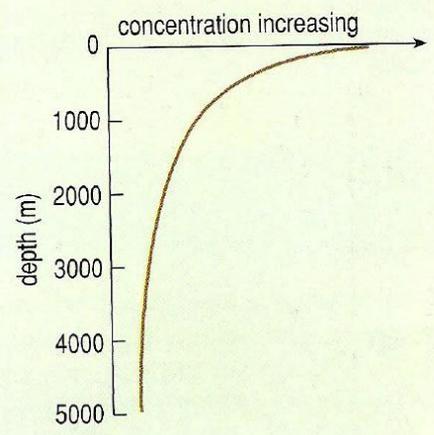
- |    |    |    |    |    |
|----|----|----|----|----|
| Ag | Cu | I  | Pr | Tb |
| As | Dy | La | Pt | Tm |
| Ba | Er | Lu | Ra | V  |
| Be | Eu | N  | Sc | Yb |
| C  | Fe | Nd | Se | Zn |
| Ca | Gd | Ni | Si |    |
| Cd | Ge | P  | Sm |    |
| Cr | Ho | Pd | Sr |    |



(b)  $>1$

**SCAVENGED ELEMENTS**

- |    |    |
|----|----|
| Al | Mn |
| Bi | Pb |
| Ce | Sn |
| Co | Te |
| Hg | Th |



(c)  $<1$

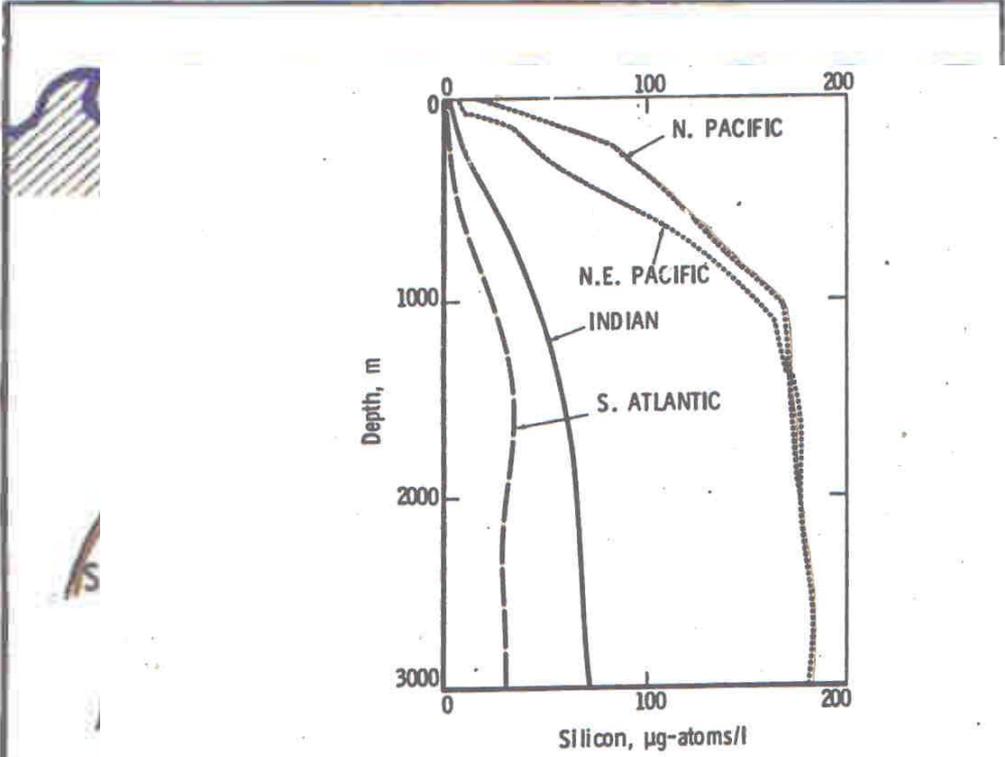


Figure 8.7 Silicate Profiles in the North Pacific, Indian, and South Atlantic Oceans. From Sverdrup, Johnson, and Fleming (1942), with permission of Prentice-Hall, Inc.

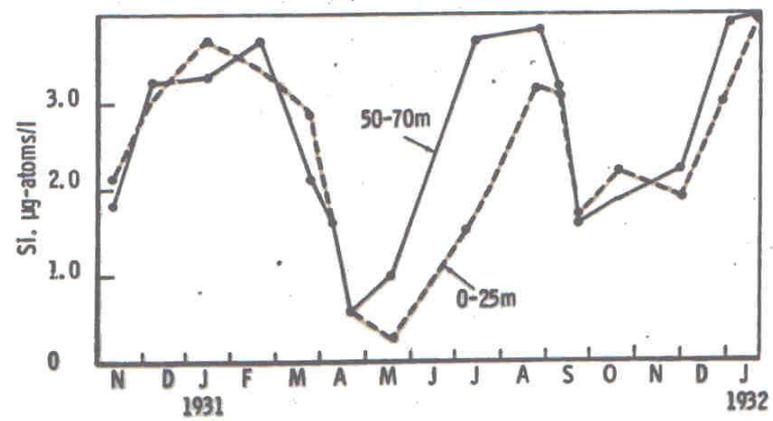
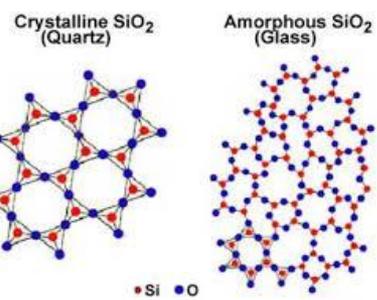
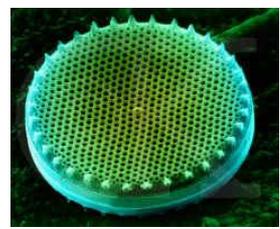


Figure 3 Silicon Cycle in the Sea.

