¿Que es un metal traza (o metal pesado)?

1. Químicamente corresponden a los elementos de transición, pero también se incluyen elementos no metálicos i.e., Al (III); Pb(IV); As(V), Se(VI)
2. Tienen con una densidad > 5 g/cm^3
3. Su concentración en sedimentos es muy baja (< 0,1%)
4. Son escenciales y tóxicos

Periodic Table

Periodic Table of the Elements

1 — Atomic number
H — Symbol of element
1.0080 — Atomic weight
Hydrogen — Name of element

🟥 Inert Gas
🟦 Gas
🟨 Liquid

Light Metals (I A – II A) · **Transitional Elements** · **Heavy Metals** (III B – II B) · **Nonmetals** (III A – VII A)

	I A	II A	III B	IV B	V B	VI B	VII B	VIII B			I B	II B	III A	IV A	V A	VI A	VII A	VIII A
1	🟦 1 **H** 1.0080 Hydrogen																	🟥 2 **He** 4.003 Helium
2	3 **Li** 6.939 Lithium	4 **Be** 9.012 Berylium											5 **B** 10.81 Boron	6 **C** 12.011 Carbon	🟦 7 **N** 14.007 Nitrogen	🟦 8 **O** 15.994 Oxygen	🟦 9 **F** 18.998 Fluorine	🟥 10 **Ne** 20.1863 Neon
3	11 **Na** 22.990 Sodium	12 **Mg** 24.31 Magnesium											13 **Al** 26.98 Aluminum	14 **Si** 28.09 Silicon	15 **P** 30.974 Phosphorus	16 **S** 32.064 Sulphur	🟦 17 **Cl** 35.453 Chlorine	🟥 18 **Ar** 39.948 Argon
4	19 **K** 39.102 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.90 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.71 Nickel	29 **Cu** 63.54 Copper	30 **Zn** 65.37 Zinc	🟨 31 **Ga** 69.72 Gallium	32 **Ge** 72.59 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	🟨 35 **Br** 79.909 Bromine	🟥 36 **Kr** 83.80 Krypton
5	37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** (99) Technetium	44 **Ru** 101.1 Ruthenium	45 **Rh** 102.90 Rhodium	46 **Pd** 106.4 Palladium	47 **Ag** 107.870 Silver	48 **Cd** 112.40 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.69 Tin	51 **Sb** 121.75 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	🟥 54 **Xe** 131.30 Xenon
6	🟨 55 **Cs** 132.91 Cesium	56 **Ba** 137.34 Barium	57 TO 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.85 Tungsten	75 **Re** 186.2 Rhenium	76 **Os** 190.2 Osmium	77 **Ir** 192.2 Iridium	78 **Pt** 195.09 Platinum	79 **Au** 197.0 Gold	🟨 80 **Hg** 200.59 Mercury	81 **Tl** 204.37 Thallium	82 **Pb** 207.19 Lead	83 **Bi** 208.98 Bismuth	84 **Po** (210) Polonium	85 **At** (210) Astatine	🟥 86 **Ra** (222) Radon
7	🟨 87 **Fr** (223) Francium	88 **Ra** 226.05 Radium	89 TO 103															

Lanthanide series	57 **LA** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** (147) Promethium	62 **Sm** 150.35 Samarium	63 **Eu** 157.25 Europium	64 **Gd** 158.92 Gadolinium	65 **Tb** 158.92 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thullium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
Actinide series	89 **Ac** (227) Actinium	90 **Th** 232.04 Thorium	91 **Pa** (231) Protactinium	92 **U** 238.03 Uranium	93 **Np** (237) Neptunium	94 **Pu** (242) Plutonium	95 **Am** (243) Americium	96 **Cm** (247) Curium	97 **Bk** (249) Berkelium	98 **Cf** (251) Californium	99 **Es** (254) Einsteinium	100 **Fm** (253) Fermium	101 **Md** (256) Mendelevium	102 **No** (256) Nobelium	103 **Lw** (257) Lawrencium

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Upper Saddle River, NJ 07458

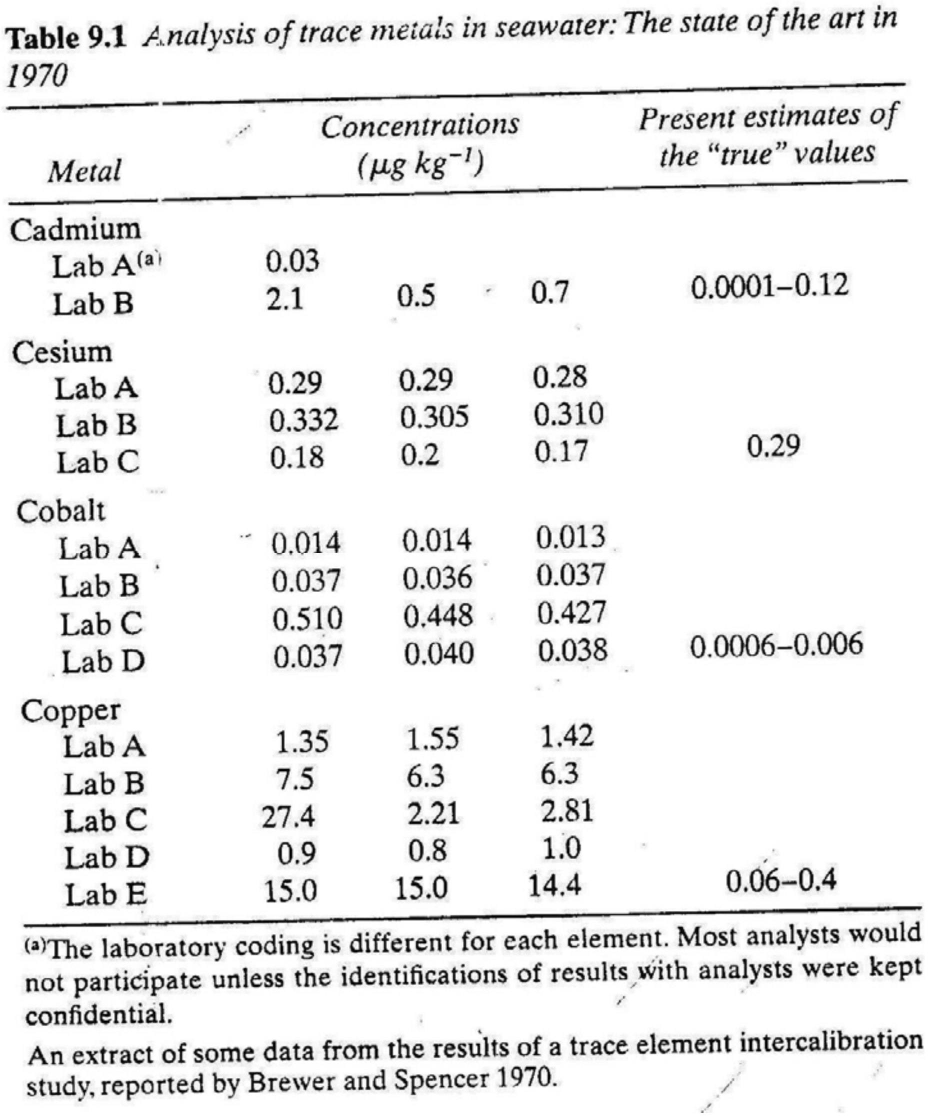


Table 9.1 *Analysis of trace metals in seawater: The state of the art in 1970*

Metal	*Concentrations ($\mu g\ kg^{-1}$)*			*Present estimates of the "true" values*
Cadmium				0.0001–0.12
Lab A[a]	0.03			
Lab B	2.1	0.5	0.7	
Cesium				0.29
Lab A	0.29	0.29	0.28	
Lab B	0.332	0.305	0.310	
Lab C	0.18	0.2	0.17	
Cobalt				0.0006–0.006
Lab A	0.014	0.014	0.013	
Lab B	0.037	0.036	0.037	
Lab C	0.510	0.448	0.427	
Lab D	0.037	0.040	0.038	
Copper				0.06–0.4
Lab A	1.35	1.55	1.42	
Lab B	7.5	6.3	6.3	
Lab C	27.4	2.21	2.81	
Lab D	0.9	0.8	1.0	
Lab E	15.0	15.0	14.4	

(a)The laboratory coding is different for each element. Most analysts would not participate unless the identifications of results with analysts were kept confidential.

An extract of some data from the results of a trace element intercalibration study, reported by Brewer and Spencer 1970.

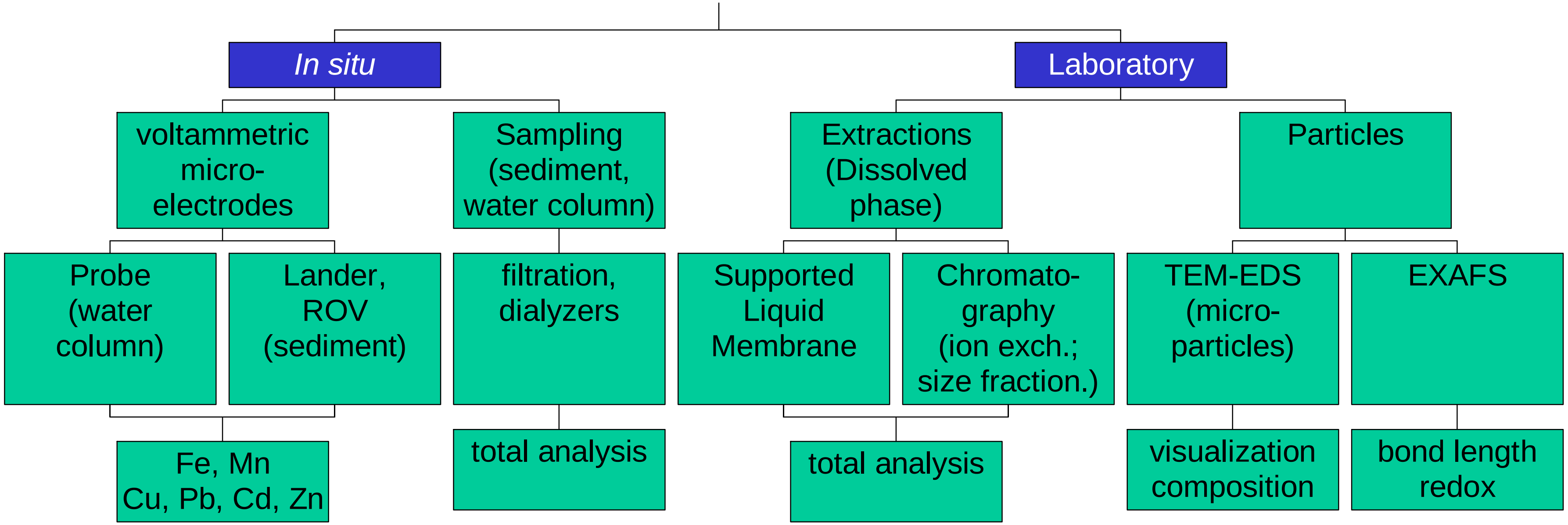
The Problem of Metals

- Metals are potentially dangerous because they can affect enzymatic functions and the nervous system
- Anthropogenic activities contribute to their accumulation in the environment
- Metals are not biodegradable

=> What is the toxic species and how much?

=> What is the residence time?

Analytical Speciation
(multi-techniques)



In situ

voltammetric micro-electrodes

Probe (water column)

Lander, ROV (sediment)

Fe, Mn
Cu, Pb, Cd, Zn

Sampling (sediment, water column)

filtration, dialyzers

total analysis

Laboratory

Extractions (Dissolved phase)

Supported Liquid Membrane

Chromato-graphy (ion exch.; size fraction.)

total analysis

Particles

TEM-EDS (micro-particles)

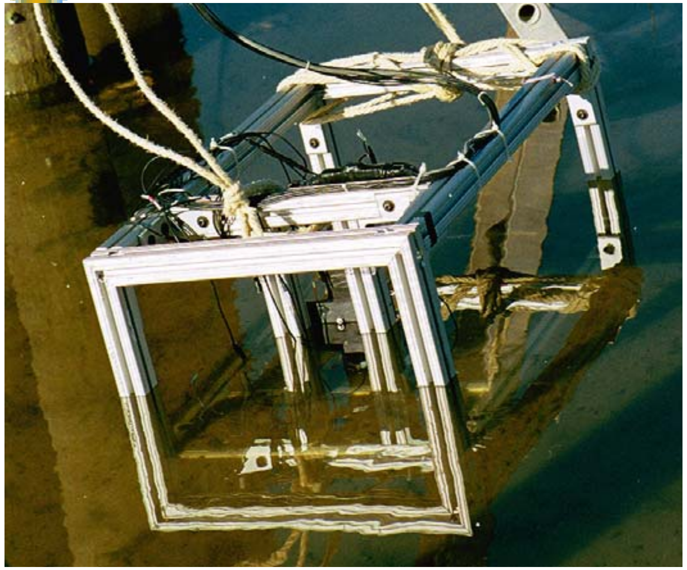
visualization composition

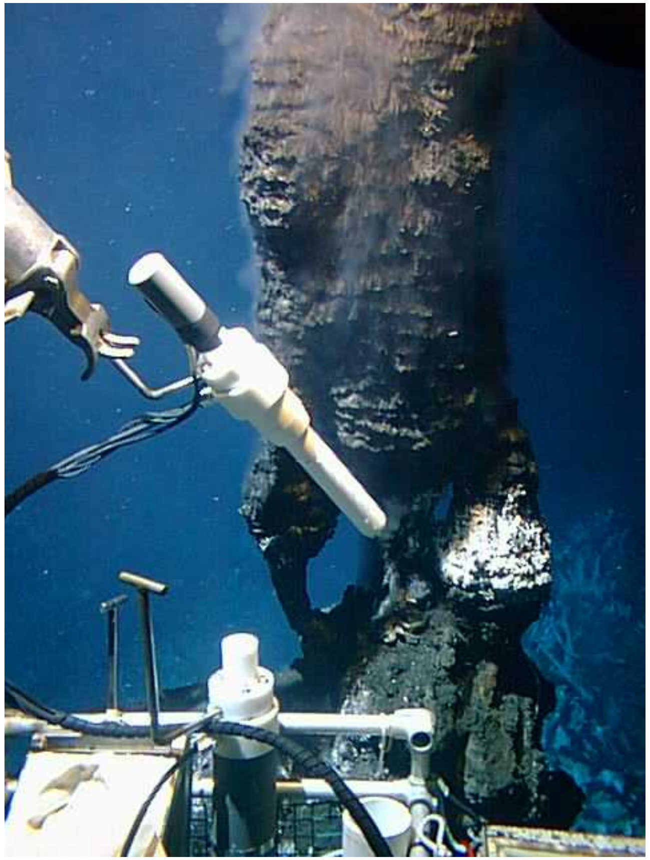
EXAFS

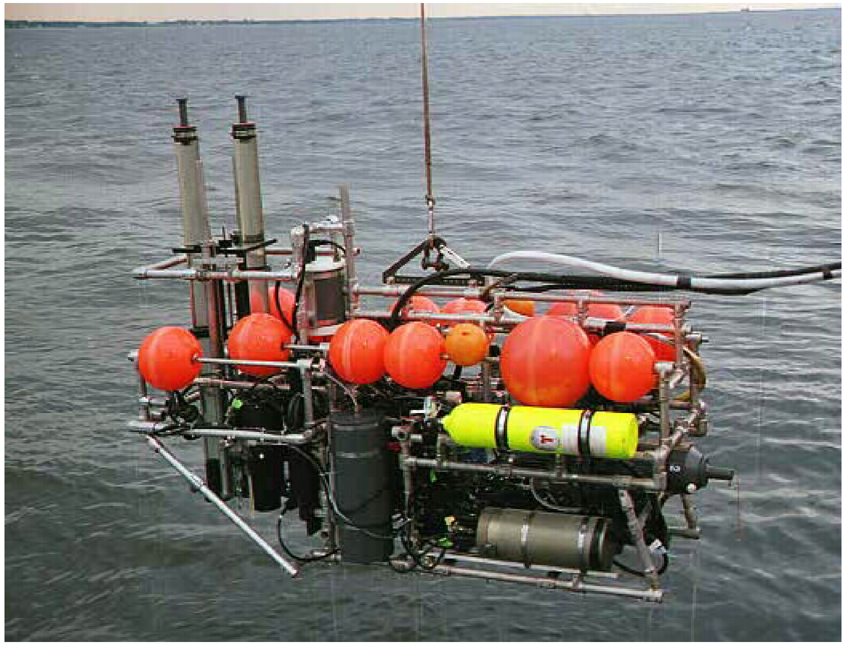
bond length redox

- – few techniques available
- – speciation is operationally defined
- – artifacts due to sampling and handling

In Situ Voltammetric Measurements

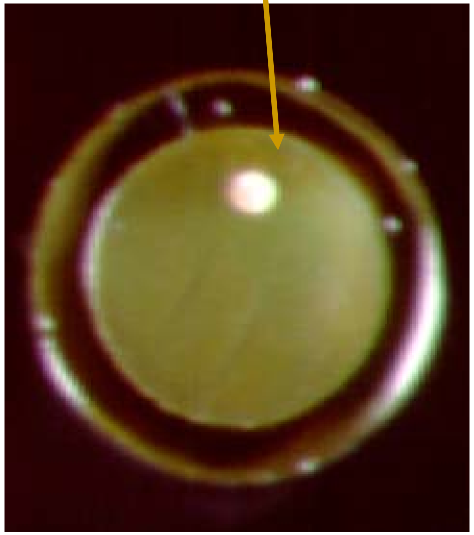




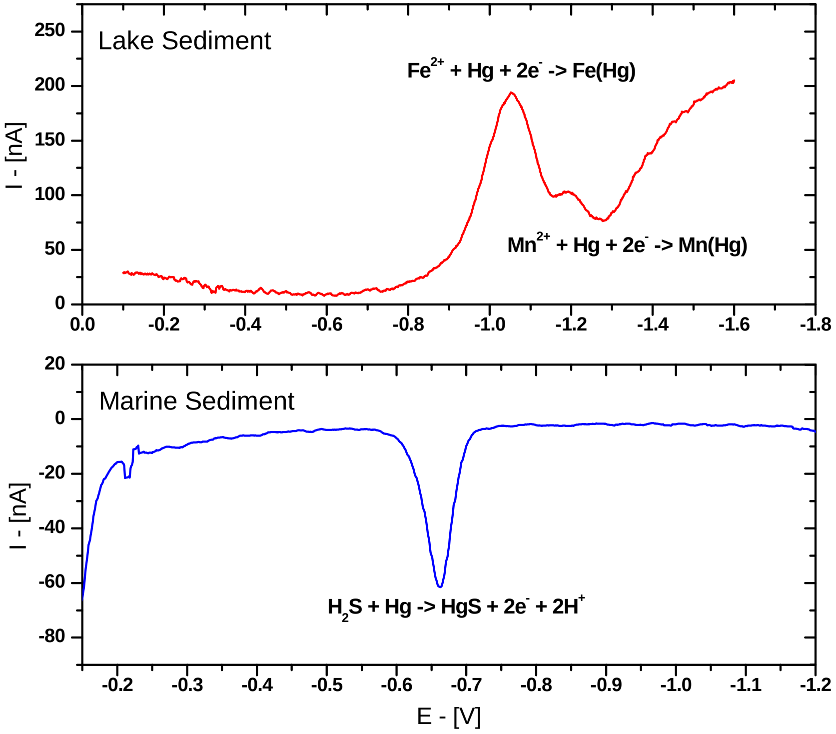


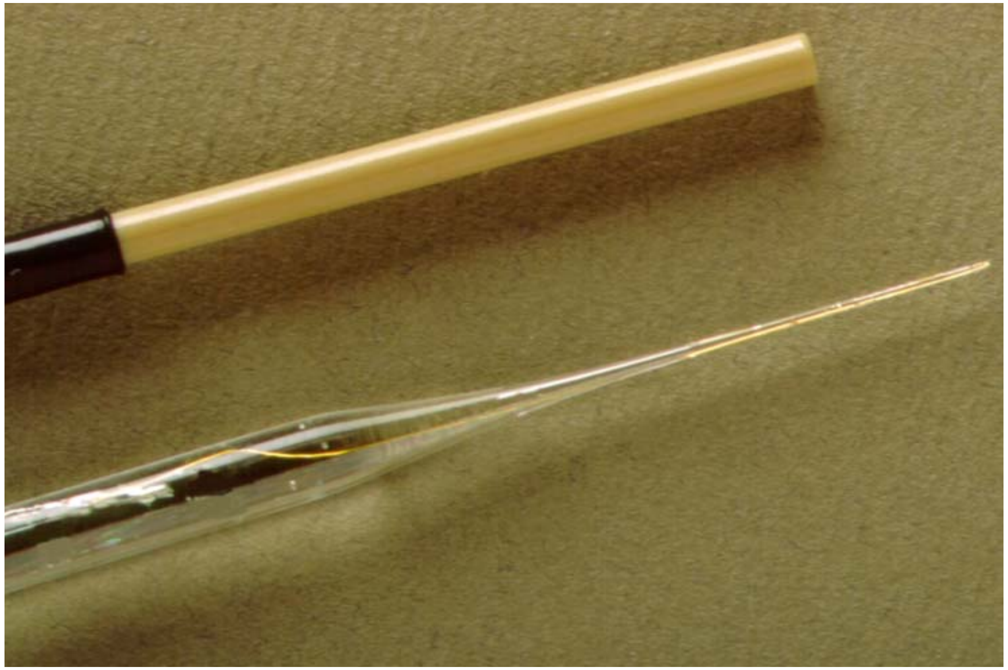
Design of *in situ* sensors

- Reliable, automatic measurements
- Simple, compact, low-cost
- Minimization of artifacts
- Multi-element analysis
- High sensitivity (1 pM to 100 nM)
- Speciation capabilities
- Microsensors

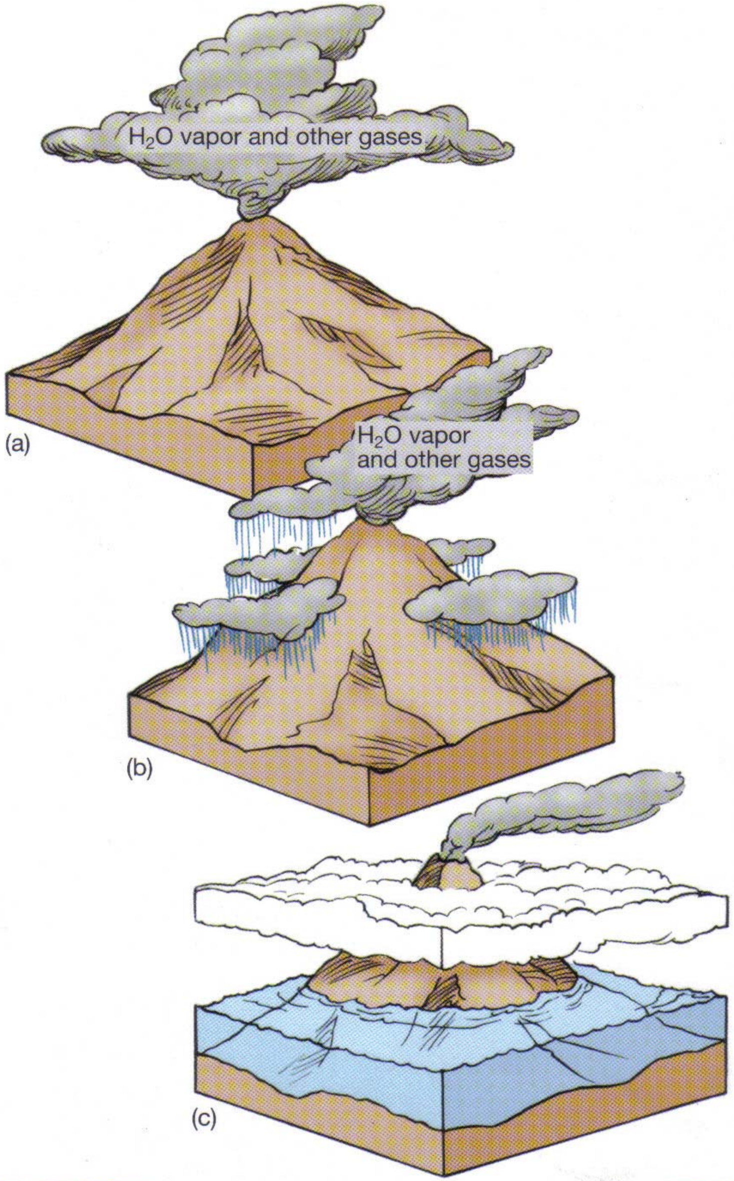


100 μm diameter Au





T-14 Fig. 1-14 Formation of Earth's oceans



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Area: **361,100,000 square kilometers (139,400,000 square miles)**

Volume: **1,370,000,000 cubic kilometers (329,000,000 cubic miles)**

Average depth: **3,796 meters (12,451 feet)**

Average temperature: **3.9°C (39.0°F)**

Average salinity: **34,482 grams per kilogram (0.56 ounce per pound), 3.4%**

Average land elevation: **840 meters (2,772 feet)**

Most abundant elements (by mass):

Oxygen	**(86%)**
Hydrogen	**(11%)**
Chlorine	**(1.9%)**
Sodium	**(1.1%)**
Magnesium	**(0.1%)**

Age: **About 4 billion years**

Future: **Uncertain**

Characteristics of the ocean world

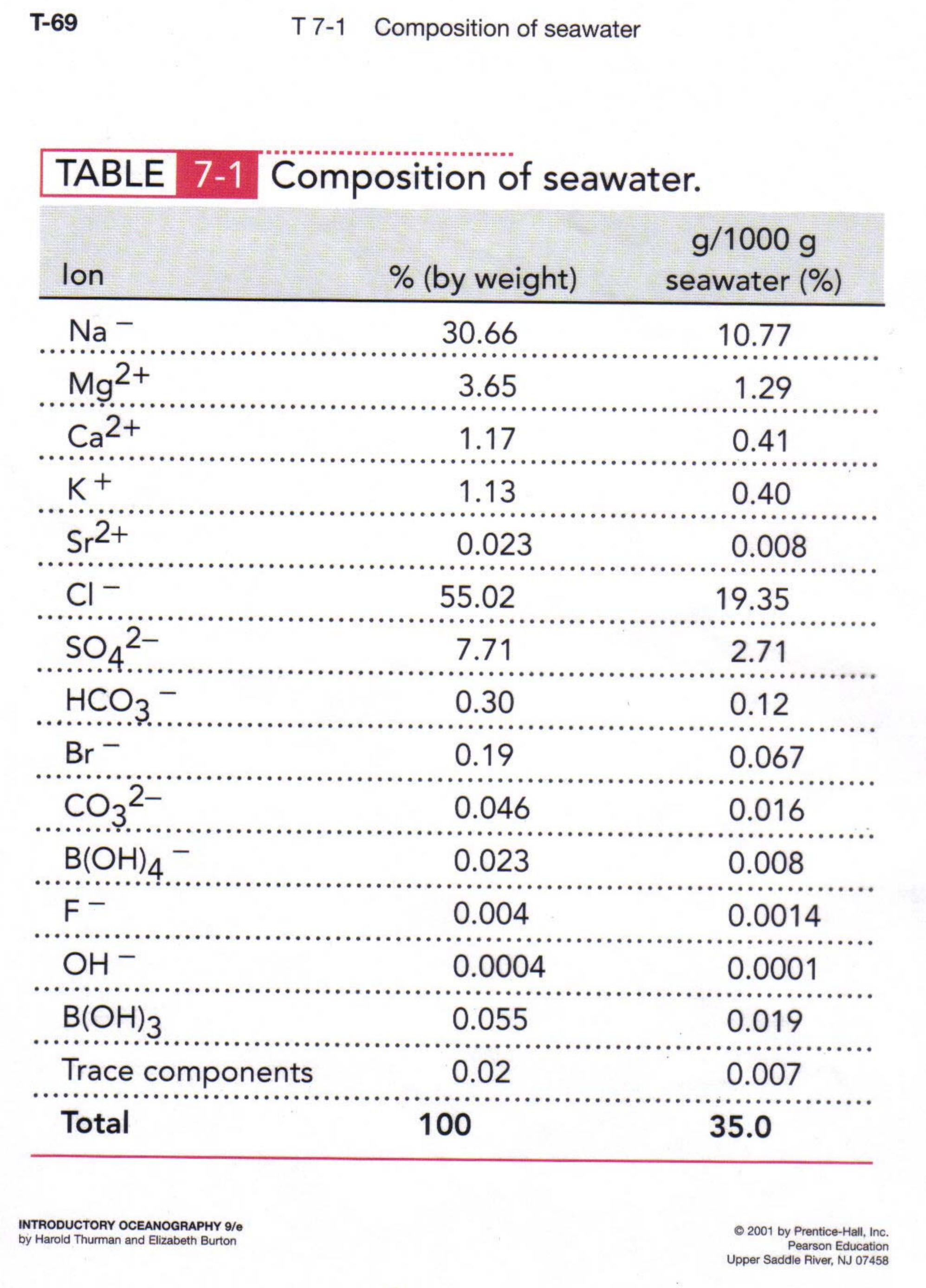

TABLE 7-1 Composition of seawater.

Ion	% (by weight)	g/1000 g seawater (%)
Na^-	30.66	10.77
Mg^{2+}	3.65	1.29
Ca^{2+}	1.17	0.41
K^+	1.13	0.40
Sr^{2+}	0.023	0.008
Cl^-	55.02	19.35
SO_4^{2-}	7.71	2.71
HCO_3^-	0.30	0.12
Br^-	0.19	0.067
CO_3^{2-}	0.046	0.016
$B(OH)_4^-$	0.023	0.008
F^-	0.004	0.0014
OH^-	0.0004	0.0001
$B(OH)_3$	0.055	0.019
Trace components	0.02	0.007
Total	**100**	**35.0**

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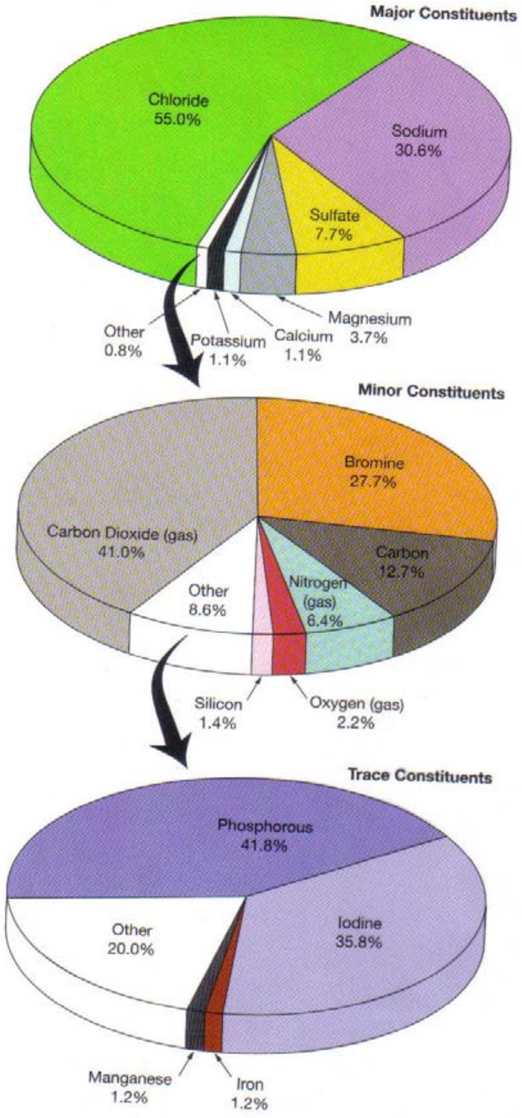
T-104 Fig. 5-14 **Major dissolved materials in seawater**



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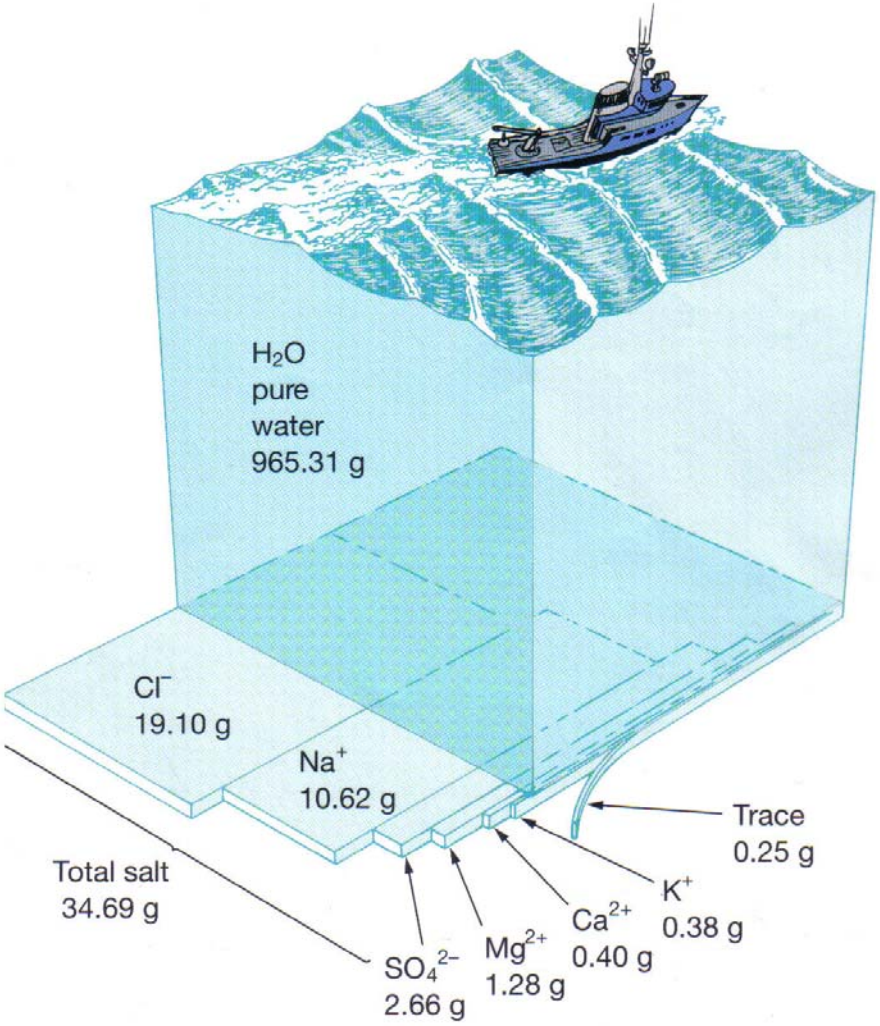
T-103 Fig. 5-13 Constituents of ocean salinity



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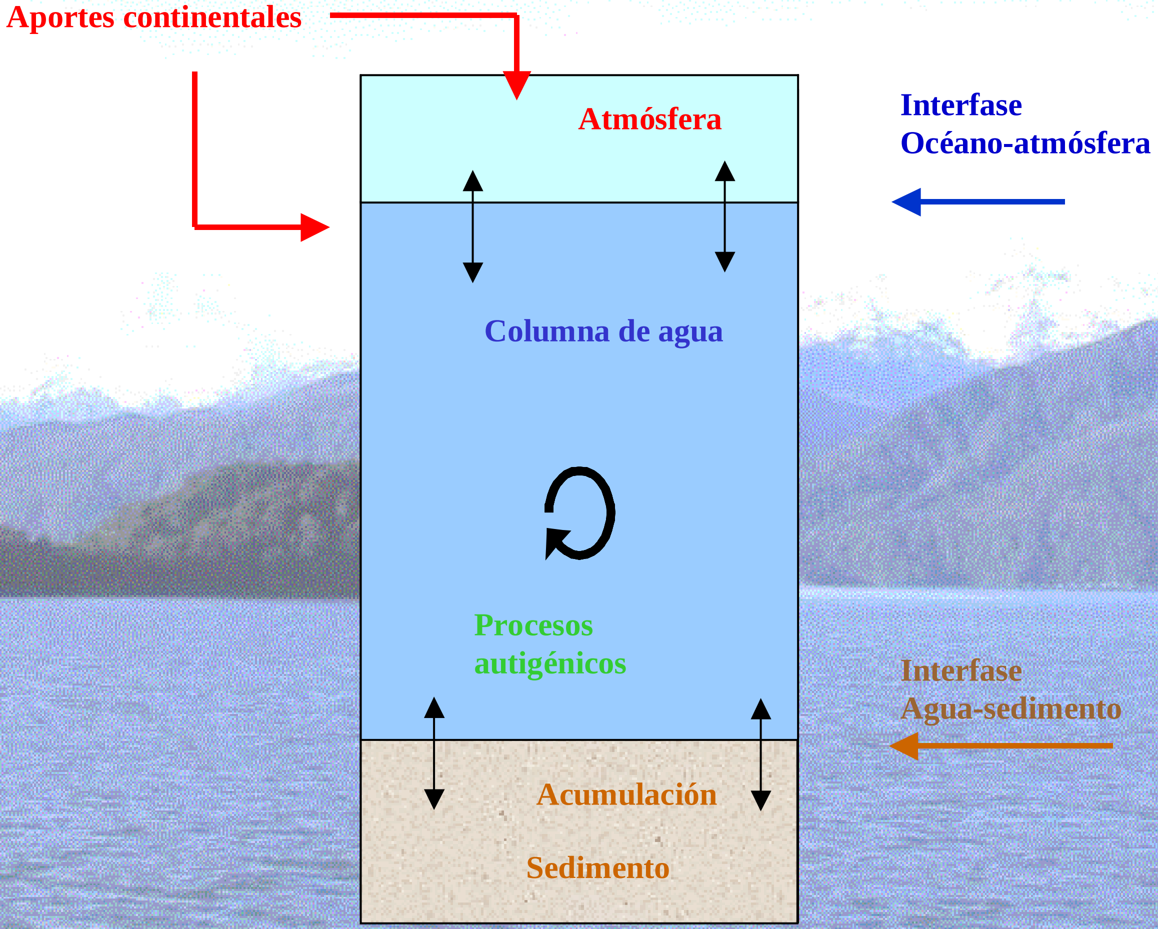
SISTEMA MARINO COMO AMBIENTE



Aportes continentales

Atmósfera

Interfase
Océano-atmósfera

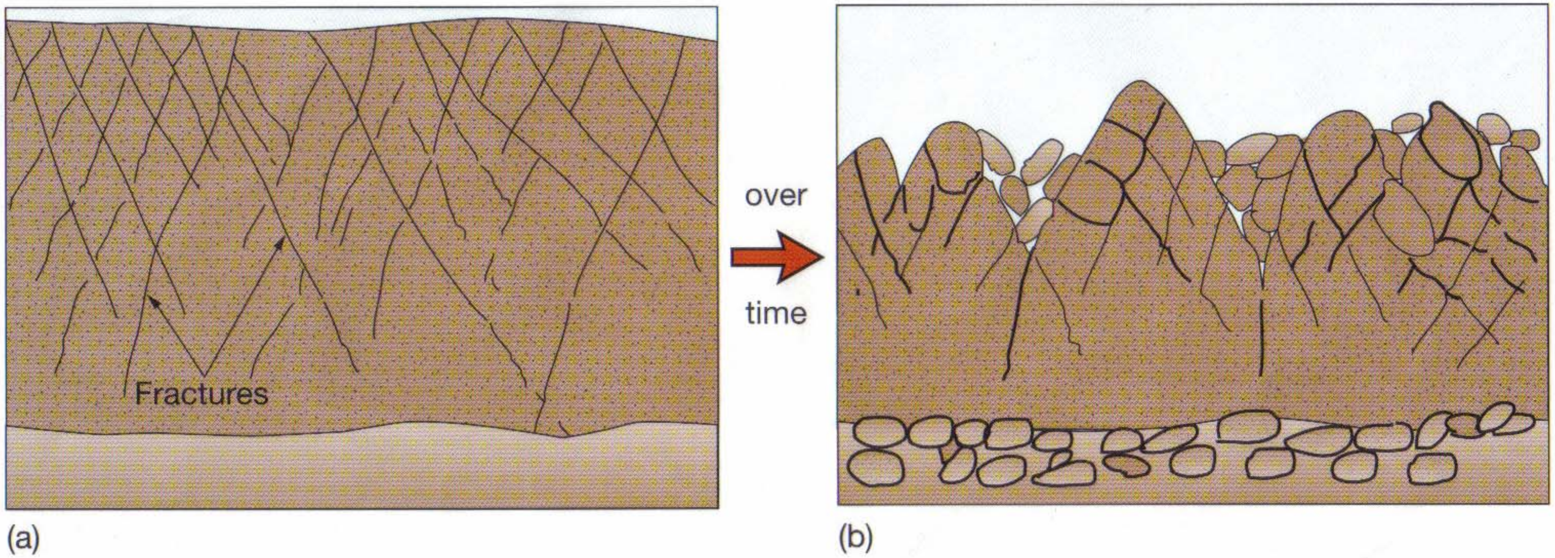
Columna de agua

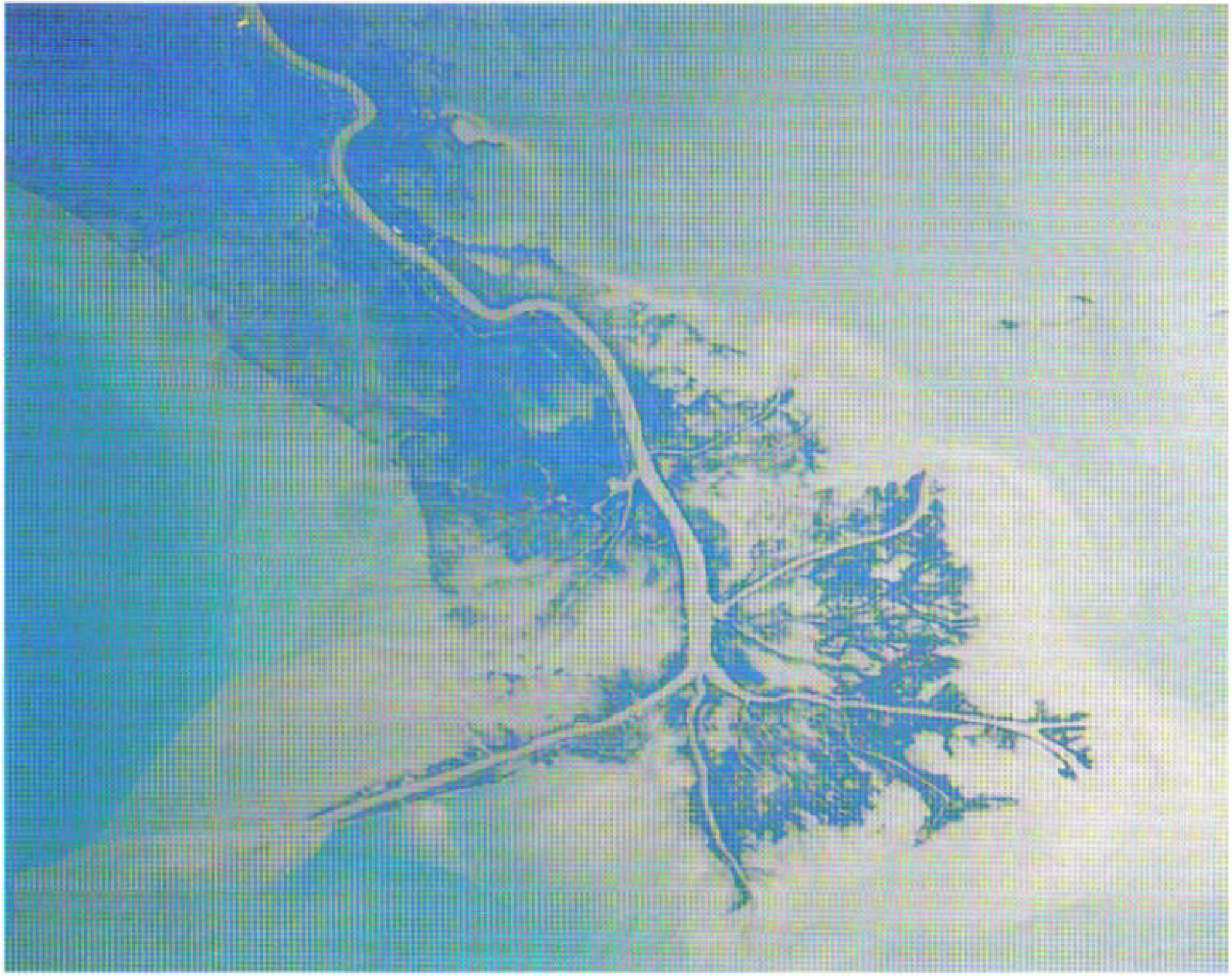
Procesos
autigénicos

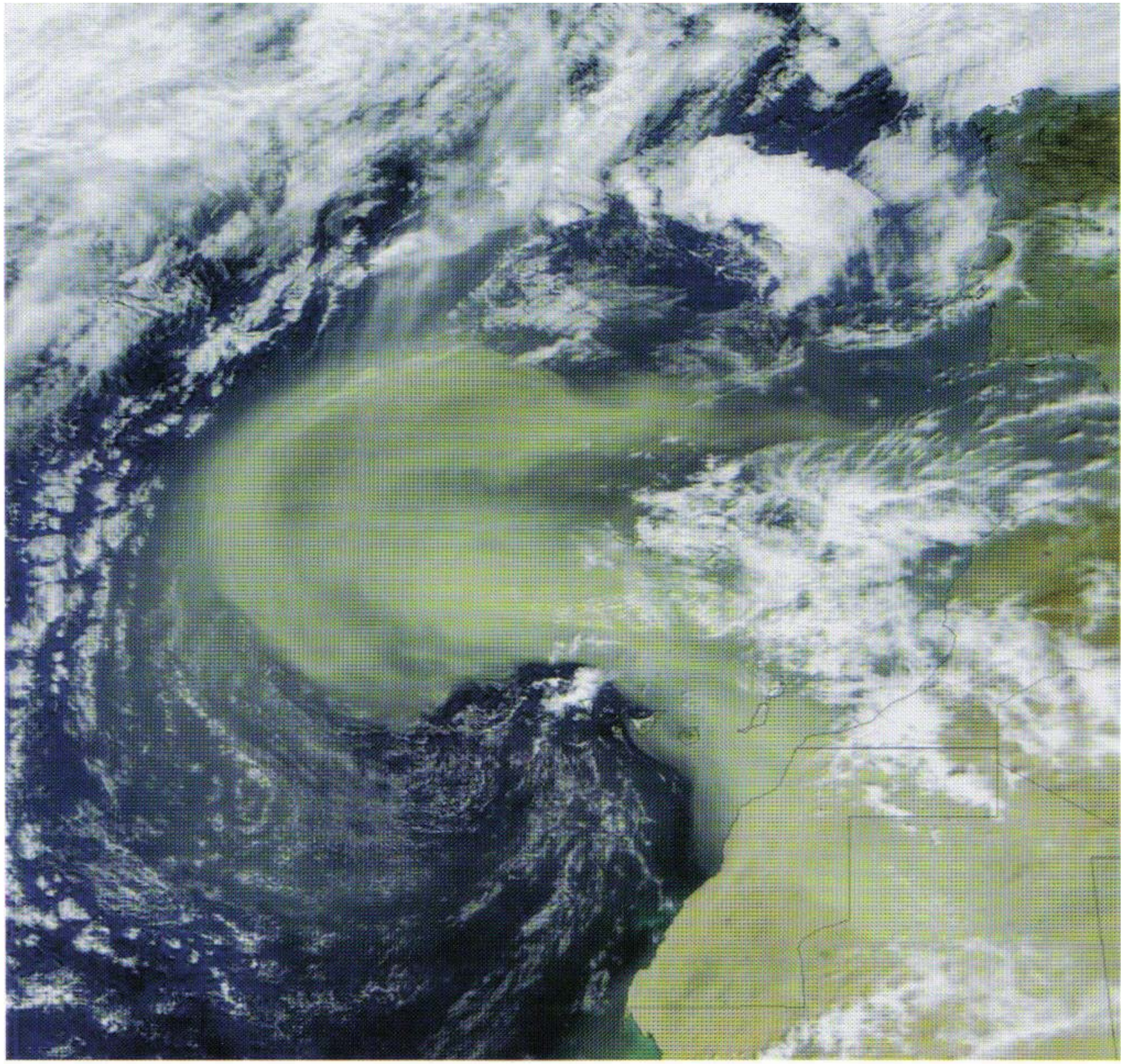
Interfase
Agua-sedimento

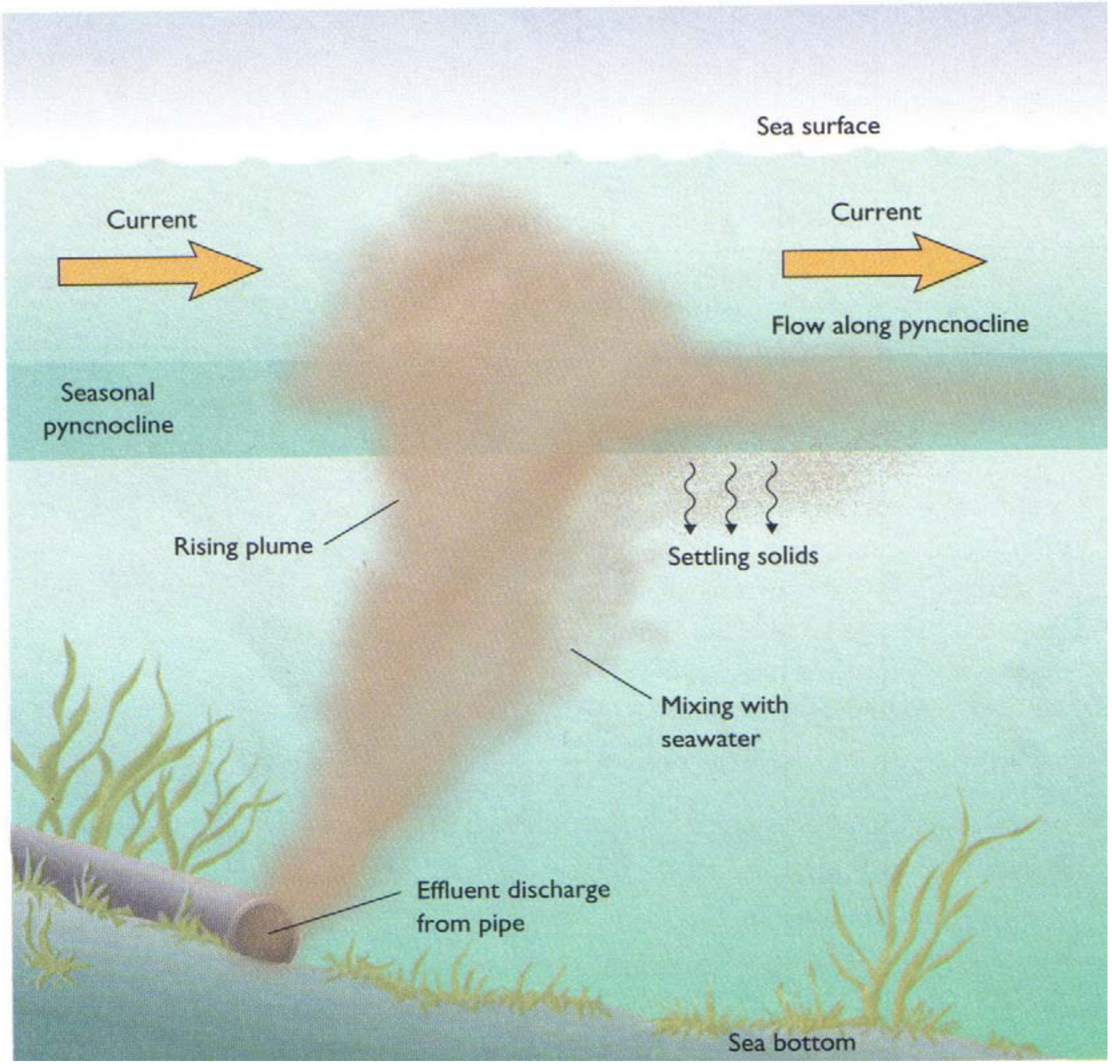
Acumulación

Sedimento

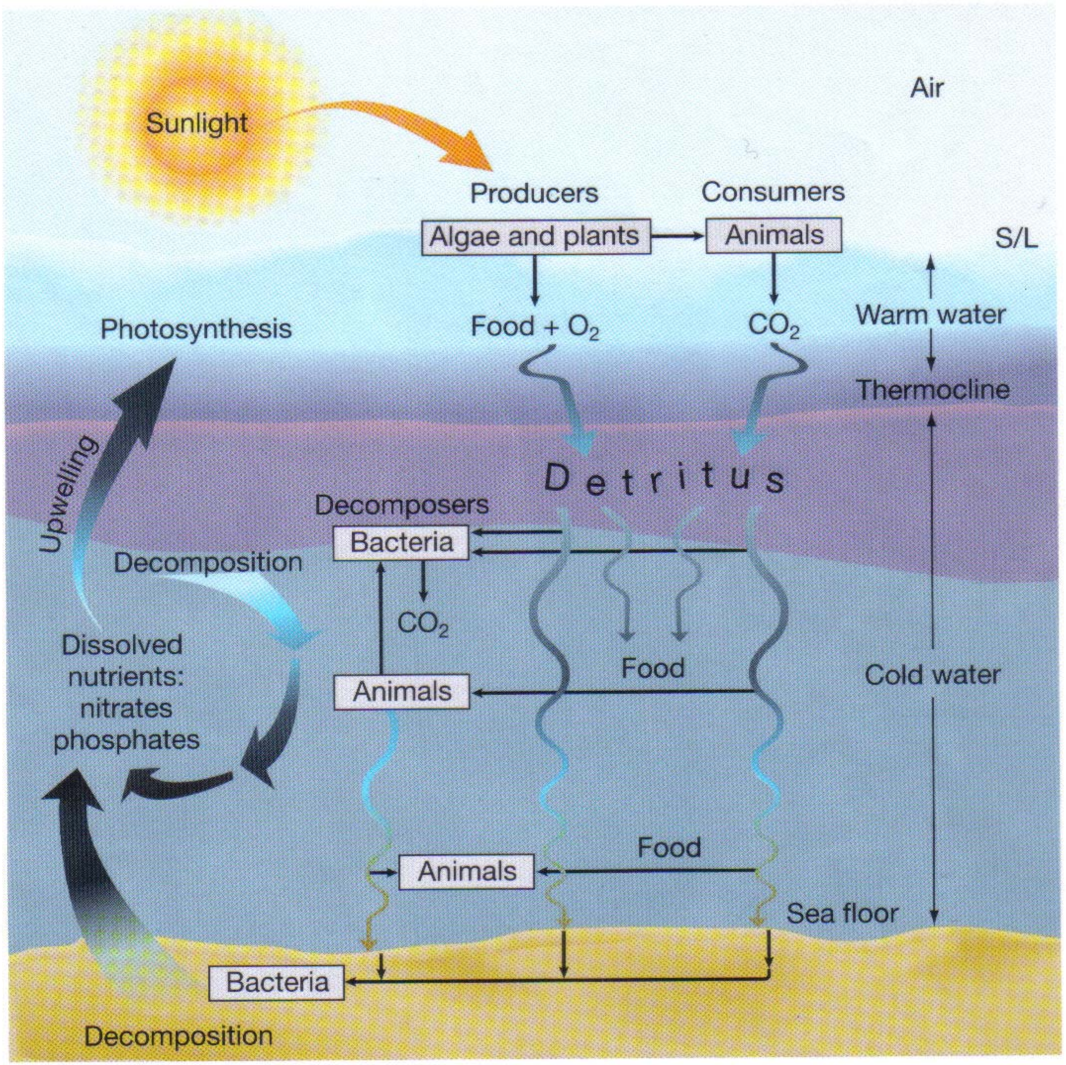

Fractures
over
time
(a)
(b)





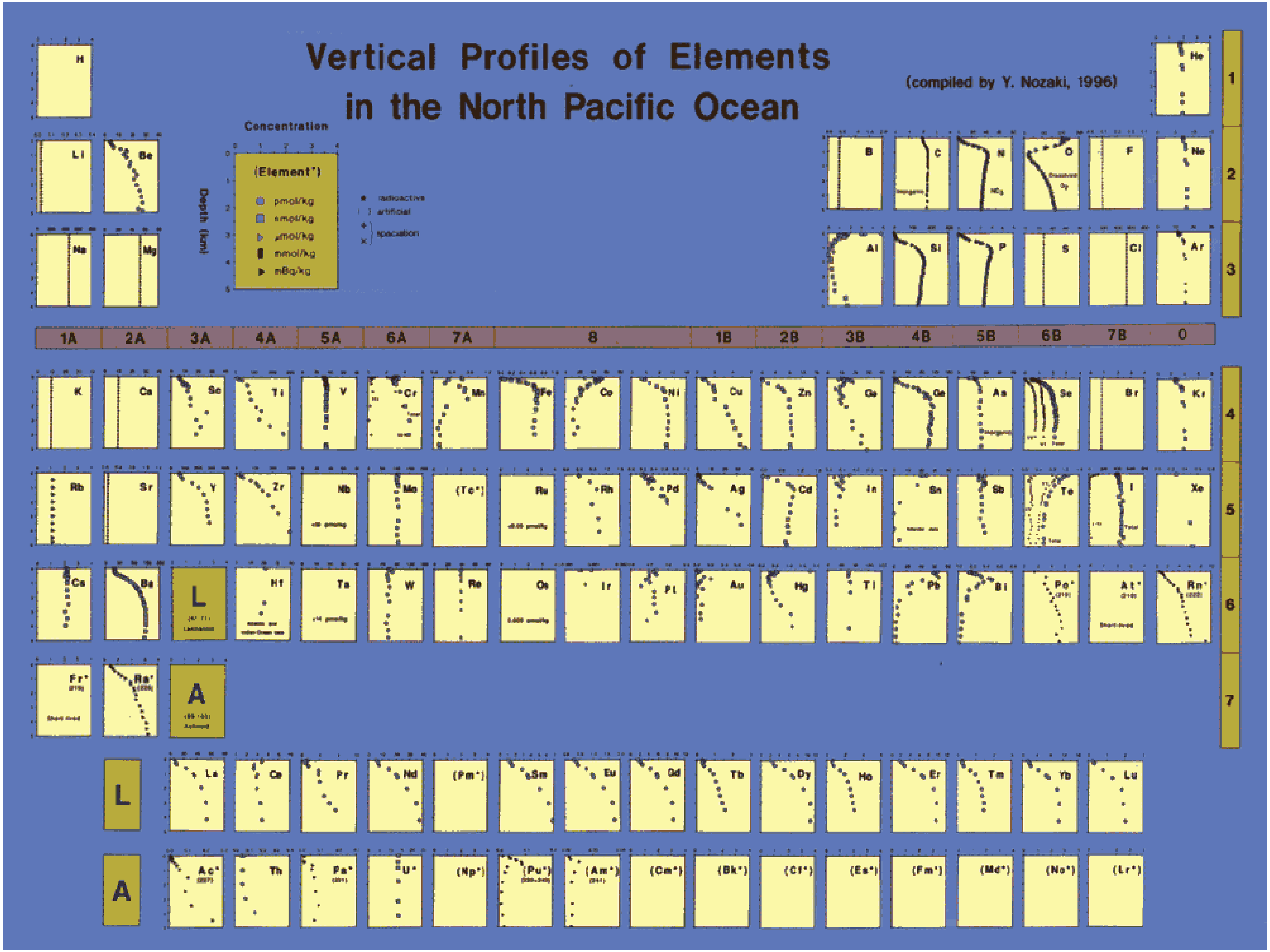

Sea surface
Current
Current
Flow along pyncnocline
Seasonal pyncnocline
Rising plume
Settling solids
Mixing with seawater
Effluent discharge from pipe
Sea bottom

T-284 Fig. 13-16 Biogeochemical cycling of matter

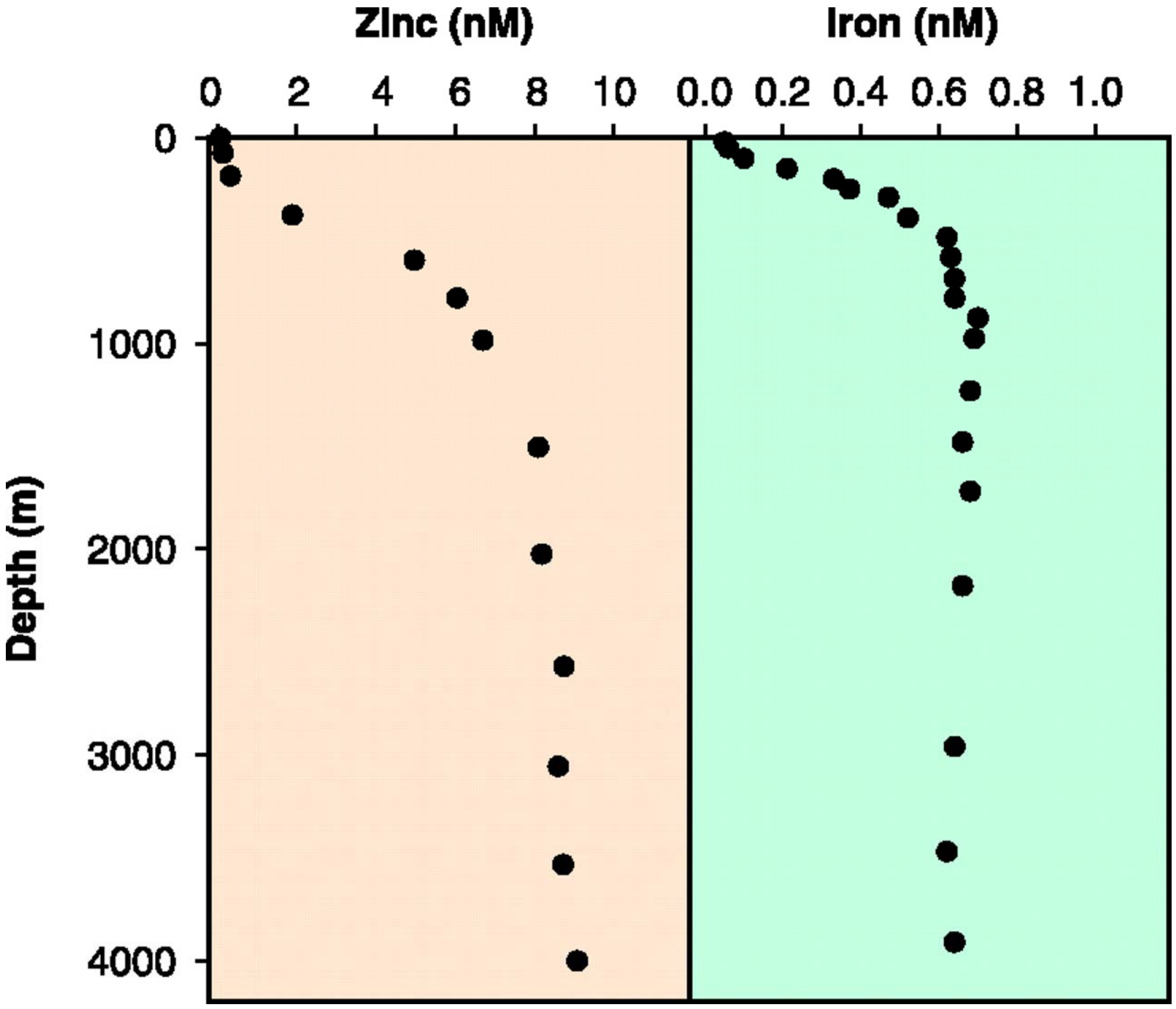


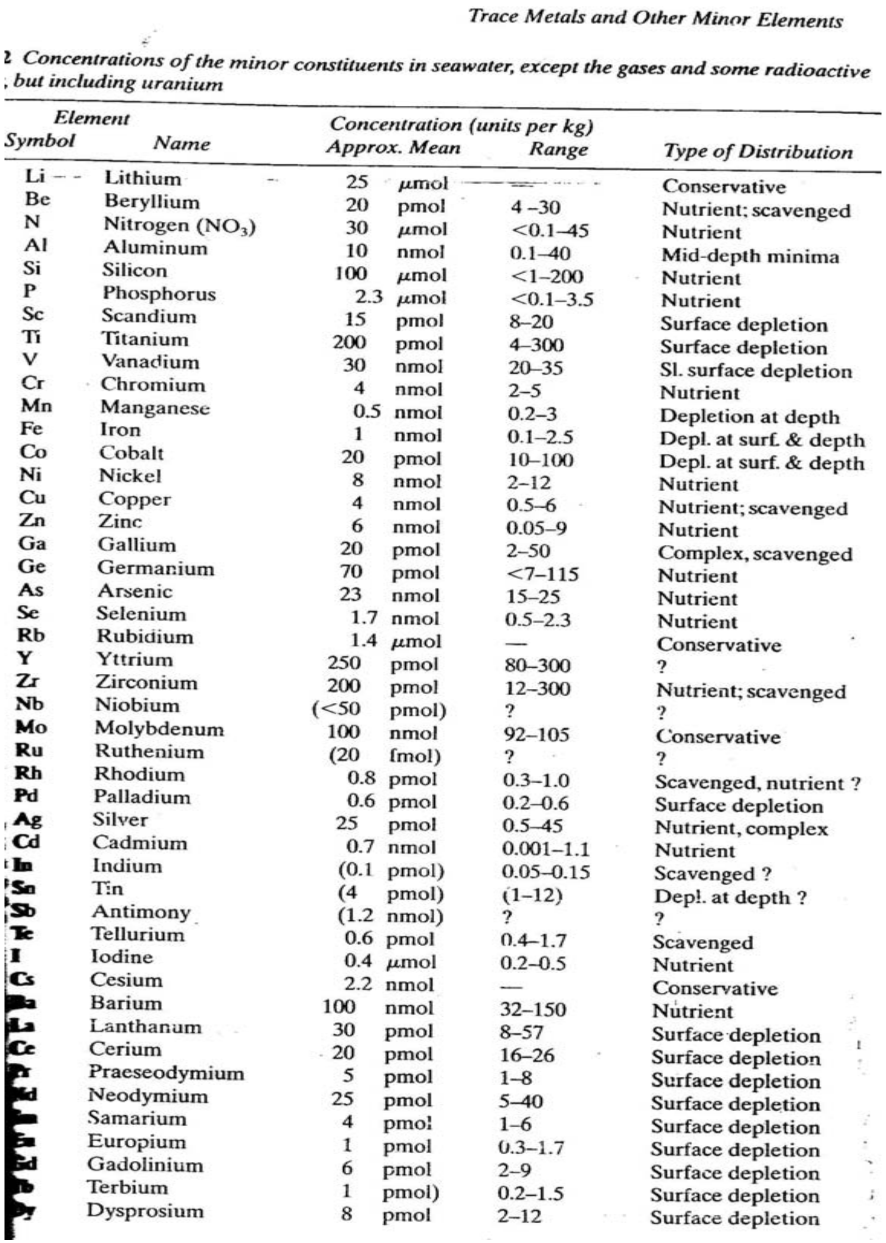
Vertical Profiles of Elements in the North Pacific Ocean

(compiled by Y. Nozaki, 1996)



Vertical profiles of dissolved zinc (43) and iron (44) concentrations in the north Pacific Ocean





2 Concentrations of the minor constituents in seawater, except the gases and some radioactive
, but including uranium

Element		*Concentration (units per kg)*			
Symbol	*Name*	*Approx. Mean*		*Range*	*Type of Distribution*
Li	Lithium	25	μmol		Conservative
Be	Beryllium	20	pmol	4–30	Nutrient; scavenged
N	Nitrogen (NO_3)	30	μmol	<0.1–45	Nutrient
Al	Aluminum	10	nmol	0.1–40	Mid-depth minima
Si	Silicon	100	μmol	<1–200	Nutrient
P	Phosphorus	2.3	μmol	<0.1–3.5	Nutrient
Sc	Scandium	15	pmol	8–20	Surface depletion
Ti	Titanium	200	pmol	4–300	Surface depletion
V	Vanadium	30	nmol	20–35	Sl. surface depletion
Cr	Chromium	4	nmol	2–5	Nutrient
Mn	Manganese	0.5	nmol	0.2–3	Depletion at depth
Fe	Iron	1	nmol	0.1–2.5	Depl. at surf. & depth
Co	Cobalt	20	pmol	10–100	Depl. at surf. & depth
Ni	Nickel	8	nmol	2–12	Nutrient
Cu	Copper	4	nmol	0.5–6	Nutrient; scavenged
Zn	Zinc	6	nmol	0.05–9	Nutrient
Ga	Gallium	20	pmol	2–50	Complex, scavenged
Ge	Germanium	70	pmol	<7–115	Nutrient
As	Arsenic	23	nmol	15–25	Nutrient
Se	Selenium	1.7	nmol	0.5–2.3	Nutrient
Rb	Rubidium	1.4	μmol	—	Conservative
Y	Yttrium	250	pmol	80–300	?
Zr	Zirconium	200	pmol	12–300	Nutrient; scavenged
Nb	Niobium	(<50	pmol)	?	?
Mo	Molybdenum	100	nmol	92–105	Conservative
Ru	Ruthenium	(20	fmol)	?	?
Rh	Rhodium	0.8	pmol	0.3–1.0	Scavenged, nutrient ?
Pd	Palladium	0.6	pmol	0.2–0.6	Surface depletion
Ag	Silver	25	pmol	0.5–45	Nutrient, complex
Cd	Cadmium	0.7	nmol	0.001–1.1	Nutrient
In	Indium	(0.1	pmol)	0.05–0.15	Scavenged ?
Sn	Tin	(4	pmol)	(1–12)	Depl. at depth ?
Sb	Antimony	(1.2	nmol)	?	?
Te	Tellurium	0.6	pmol	0.4–1.7	Scavenged
I	Iodine	0.4	μmol	0.2–0.5	Nutrient
Cs	Cesium	2.2	nmol	—	Conservative
[illegible]	Barium	100	nmol	32–150	Nutrient
La	Lanthanum	30	pmol	8–57	Surface depletion
Ce	Cerium	20	pmol	16–26	Surface depletion
[illegible]	Praeseodymium	5	pmol	1–8	Surface depletion
[illegible]	Neodymium	25	pmol	5–40	Surface depletion
[illegible]	Samarium	4	pmol	1–6	Surface depletion
[illegible]	Europium	1	pmol	0.3–1.7	Surface depletion
[illegible]	Gadolinium	6	pmol	2–9	Surface depletion
[illegible]	Terbium	1	pmol)	0.2–1.5	Surface depletion
[illegible]	Dysprosium	8	pmol	2–12	Surface depletion

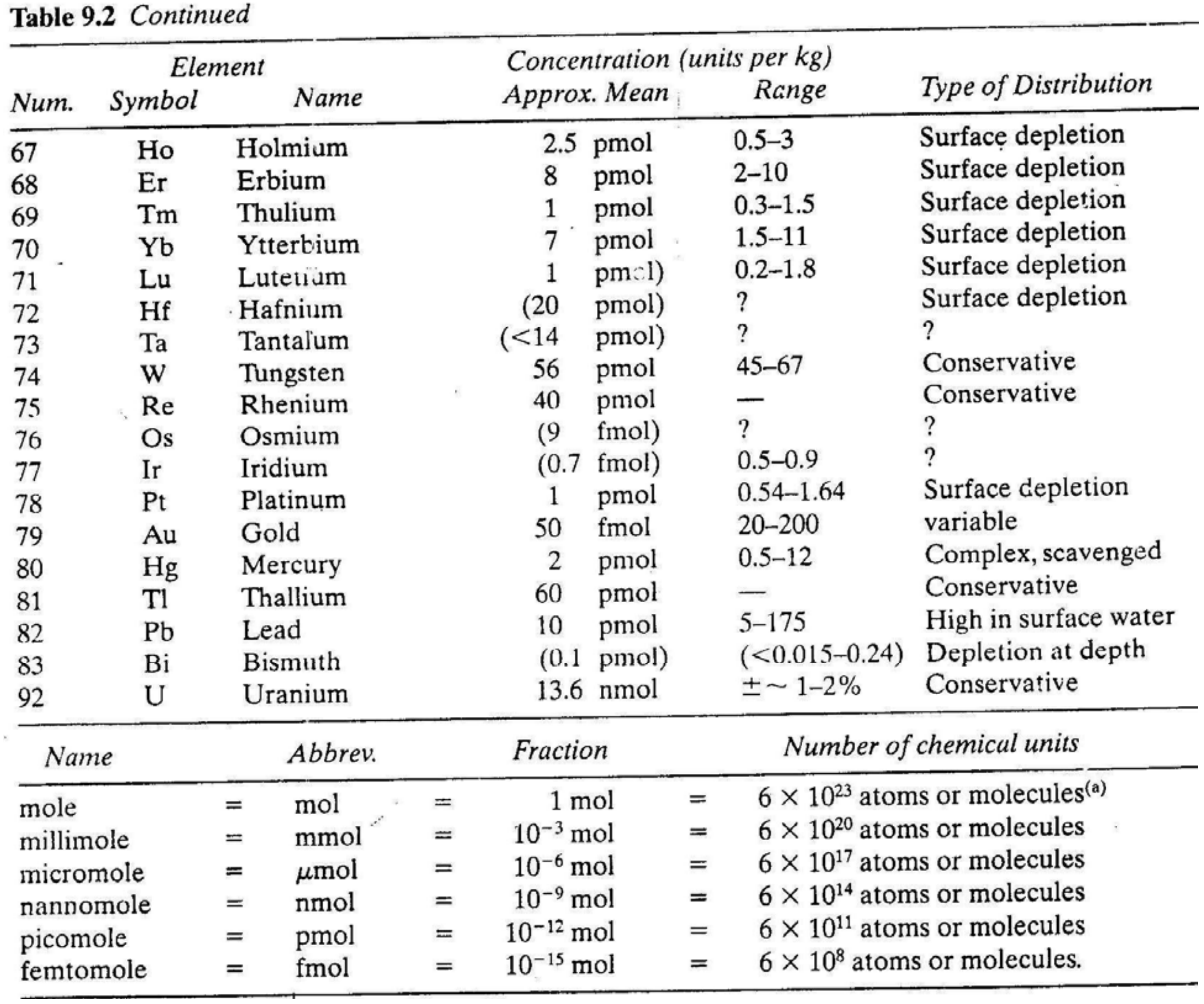


Table 9.2 *Continued*

	Element		*Concentration (units per kg)*		
Num.	*Symbol*	*Name*	*Approx. Mean*	*Range*	*Type of Distribution*
67	Ho	Holmium	2.5 pmol	0.5–3	Surface depletion
68	Er	Erbium	8 pmol	2–10	Surface depletion
69	Tm	Thulium	1 pmol	0.3–1.5	Surface depletion
70	Yb	Ytterbium	7 pmol	1.5–11	Surface depletion
71	Lu	Lutetium	1 pmol)	0.2–1.8	Surface depletion
72	Hf	Hafnium	(20 pmol)	?	Surface depletion
73	Ta	Tantalum	(<14 pmol)	?	?
74	W	Tungsten	56 pmol	45–67	Conservative
75	Re	Rhenium	40 pmol	—	Conservative
76	Os	Osmium	(9 fmol)	?	?
77	Ir	Iridium	(0.7 fmol)	0.5–0.9	?
78	Pt	Platinum	1 pmol	0.54–1.64	Surface depletion
79	Au	Gold	50 fmol	20–200	variable
80	Hg	Mercury	2 pmol	0.5–12	Complex, scavenged
81	Tl	Thallium	60 pmol	—	Conservative
82	Pb	Lead	10 pmol	5–175	High in surface water
83	Bi	Bismuth	(0.1 pmol)	(<0.015–0.24)	Depletion at depth
92	U	Uranium	13.6 nmol	±~ 1–2%	Conservative

Name		*Abbrev.*		*Fraction*		*Number of chemical units*
mole	=	mol	=	1 mol	=	6 × 10^{23} atoms or molecules$^{(a)}$
millimole	=	mmol	=	10^{-3} mol	=	6 × 10^{20} atoms or molecules
micromole	=	μmol	=	10^{-6} mol	=	6 × 10^{17} atoms or molecules
nannomole	=	nmol	=	10^{-9} mol	=	6 × 10^{14} atoms or molecules
picomole	=	pmol	=	10^{-12} mol	=	6 × 10^{11} atoms or molecules
femtomole	=	fmol	=	10^{-15} mol	=	6 × 10^{8} atoms or molecules.

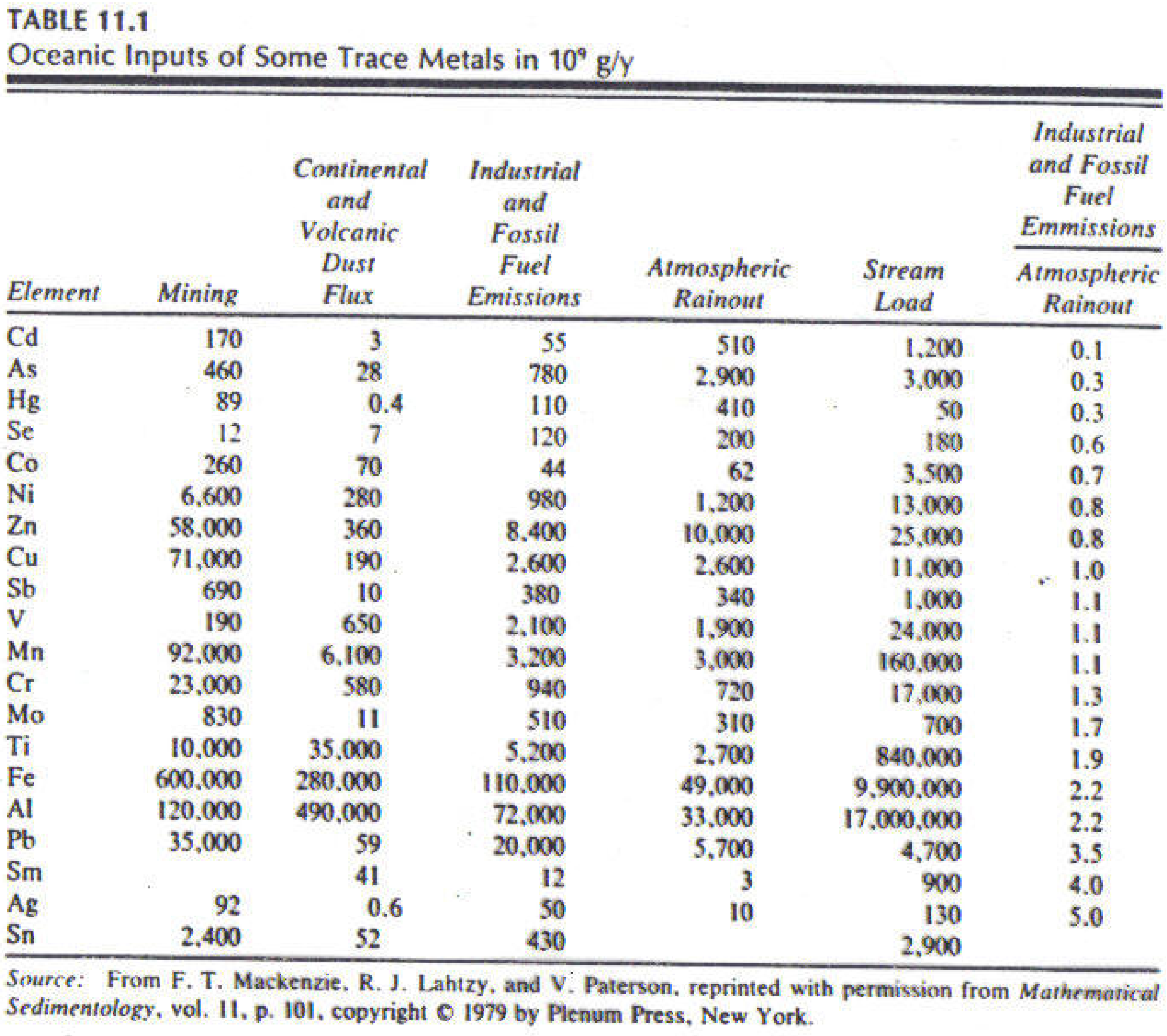


TABLE 11.1

Oceanic Inputs of Some Trace Metals in 10^9 g/y

						Industrial and Fossil Fuel Emmissions
Element	*Mining*	*Continental and Volcanic Dust Flux*	*Industrial and Fossil Fuel Emissions*	*Atmospheric Rainout*	*Stream Load*	*Atmospheric Rainout*
Cd	170	3	55	510	1,200	0.1
As	460	28	780	2,900	3,000	0.3
Hg	89	0.4	110	410	50	0.3
Se	12	7	120	200	180	0.6
Co	260	70	44	62	3,500	0.7
Ni	6,600	280	980	1,200	13,000	0.8
Zn	58,000	360	8,400	10,000	25,000	0.8
Cu	71,000	190	2,600	2,600	11,000	1.0
Sb	690	10	380	340	1,000	1.1
V	190	650	2,100	1,900	24,000	1.1
Mn	92,000	6,100	3,200	3,000	160,000	1.1
Cr	23,000	580	940	720	17,000	1.3
Mo	830	11	510	310	700	1.7
Ti	10,000	35,000	5,200	2,700	840,000	1.9
Fe	600,000	280,000	110,000	49,000	9,900,000	2.2
Al	120,000	490,000	72,000	33,000	17,000,000	2.2
Pb	35,000	59	20,000	5,700	4,700	3.5
Sm		41	12	3	900	4.0
Ag	92	0.6	50	10	130	5.0
Sn	2,400	52	430		2,900	

Source: From F. T. Mackenzie, R. J. Lahtzy, and V. Paterson, reprinted with permission from *Mathematical Sedimentology*, vol. 11, p. 101, copyright © 1979 by Plenum Press, New York.

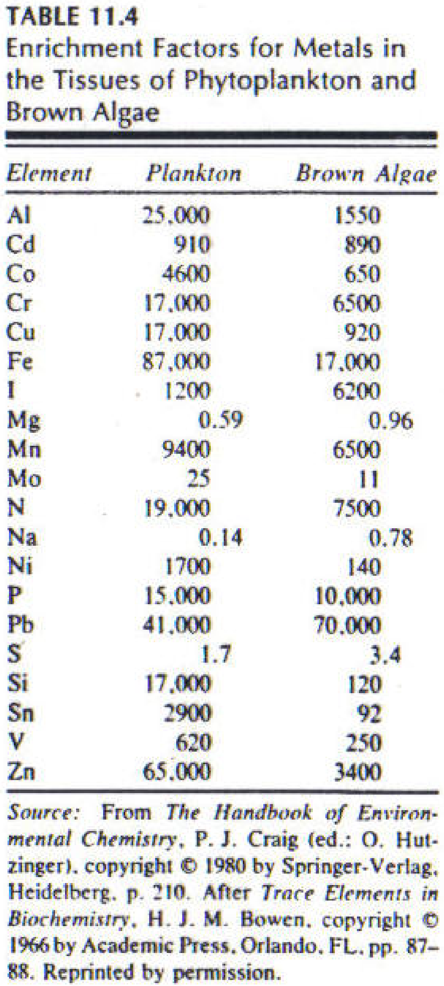


TABLE 11.4

Enrichment Factors for Metals in the Tissues of Phytoplankton and Brown Algae

Element	*Plankton*	*Brown Algae*
Al	25,000	1550
Cd	910	890
Co	4600	650
Cr	17,000	6500
Cu	17,000	920
Fe	87,000	17,000
I	1200	6200
Mg	0.59	0.96
Mn	9400	6500
Mo	25	11
N	19,000	7500
Na	0.14	0.78
Ni	1700	140
P	15,000	10,000
Pb	41,000	70,000
S	1.7	3.4
Si	17,000	120
Sn	2900	92
V	620	250
Zn	65,000	3400

Source: From *The Handbook of Environmental Chemistry*, P. J. Craig (ed.: O. Hutzinger), copyright © 1980 by Springer-Verlag, Heidelberg, p. 210. After *Trace Elements in Biochemistry*, H. J. M. Bowen, copyright © 1966 by Academic Press, Orlando, FL, pp. 87–88. Reprinted by permission.

Fig. 2. (A) Examples of release of complexing agents and metal ligand complexes from marine plankton: CdX, phytochelatin-Cd complex released by diatoms (25); CuY, peptide complexes of Cu released by coccolithophorids (26); CuZ, unidentified Cu ligand complex released by Synechococcus (27, 28); sid, siderophore released by heterotrophic bacteria and cyanobacteria (17); L, unidentified Co complexing agent released by Prochlorococcus (29); C, Cys; E, Glu; G, Gly; Q, Gln; and R, Arg

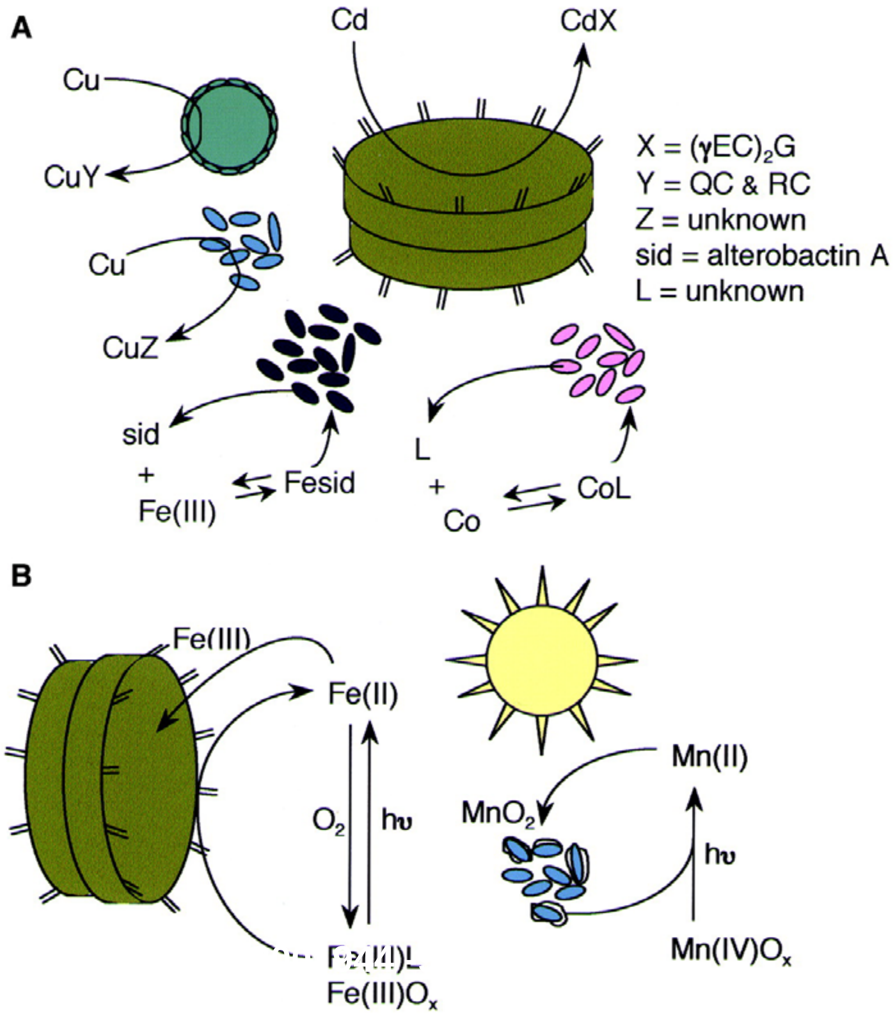
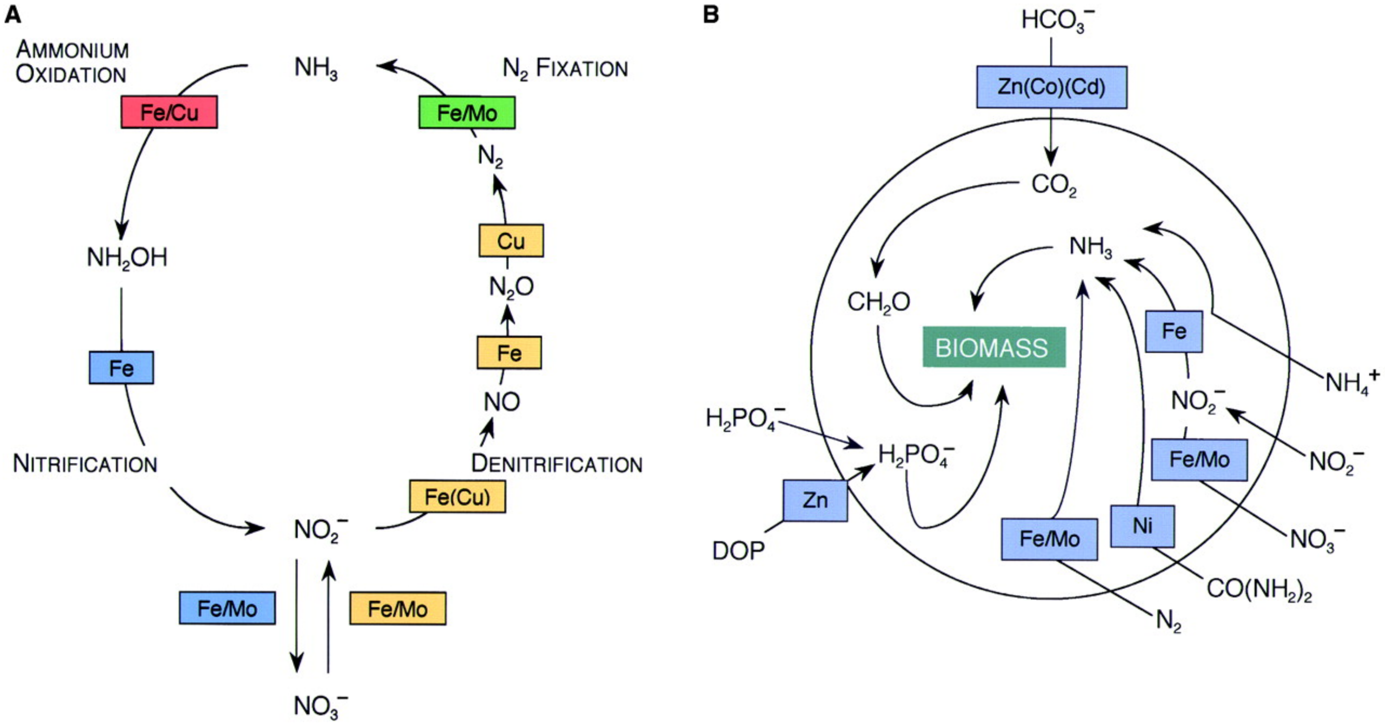
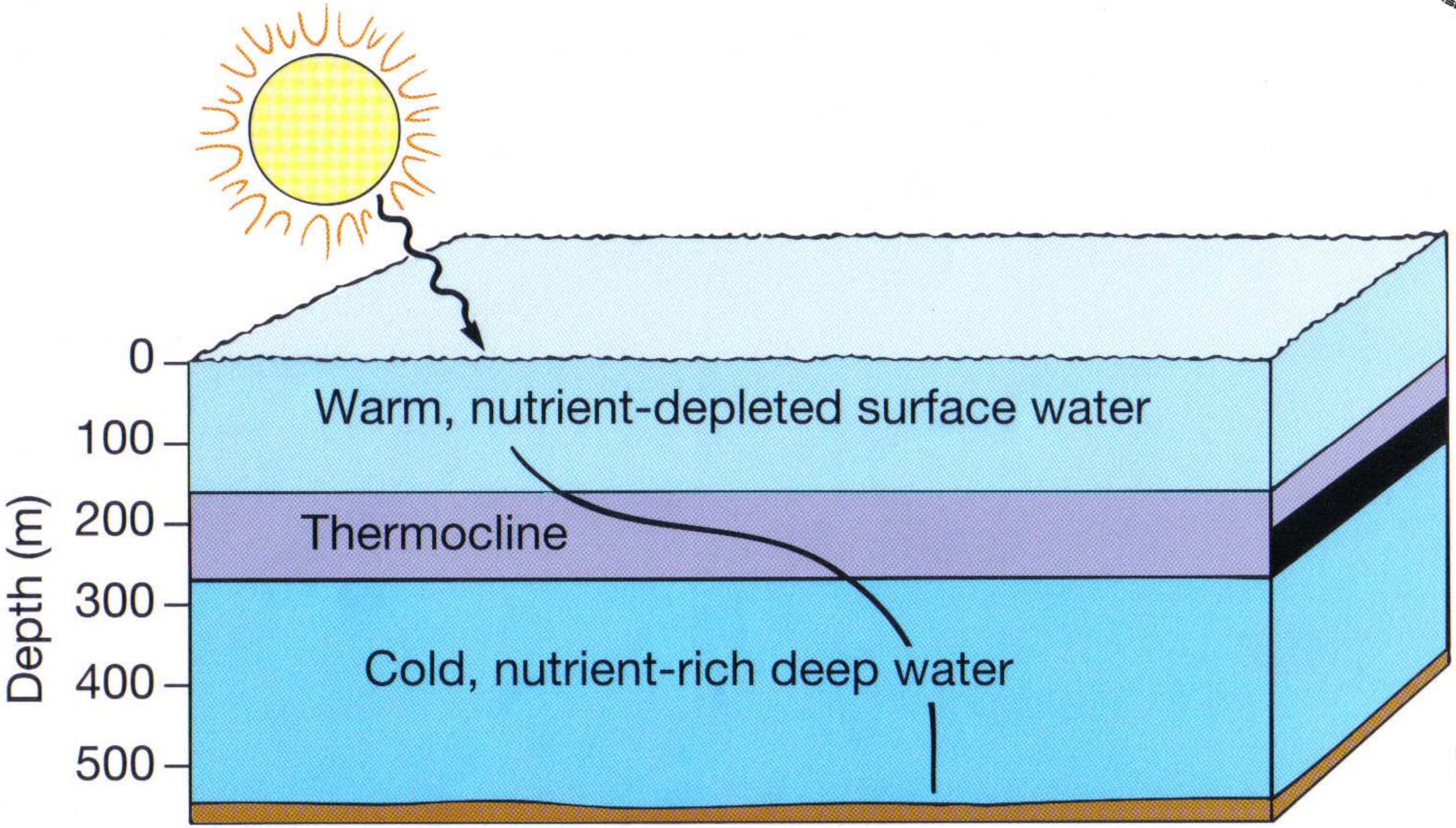


Fig. 3. (A) A diagram of the nitrogen cycle, illustrating the metal cofactors in each enzymatically catalyzed step



T-279 Fig. 13-11

Productivity in tropical oceans



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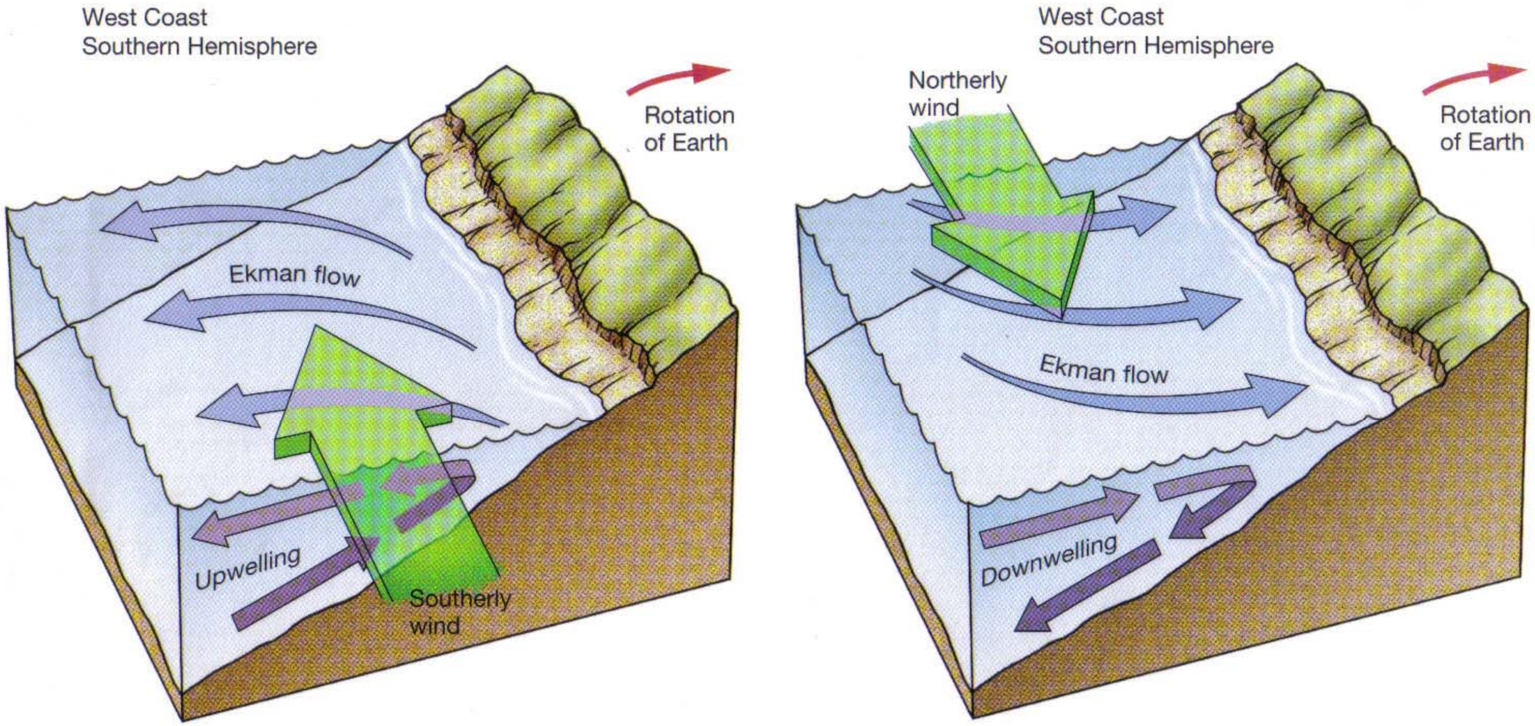
T-155 Fig. 7-11

Coastal upwelling and downwelling



(a) (b)

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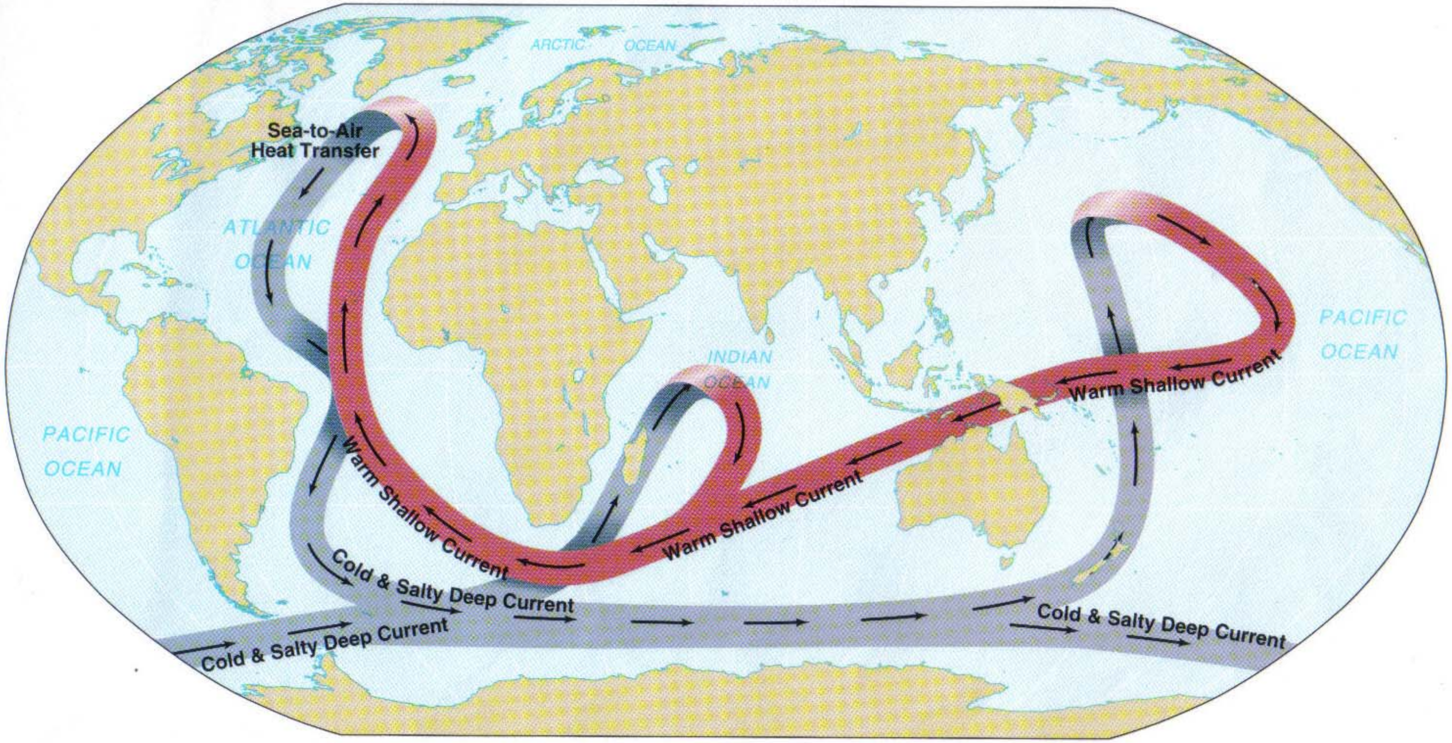
T-168 **Fig. 7-27**

Conveyer-belt circulation



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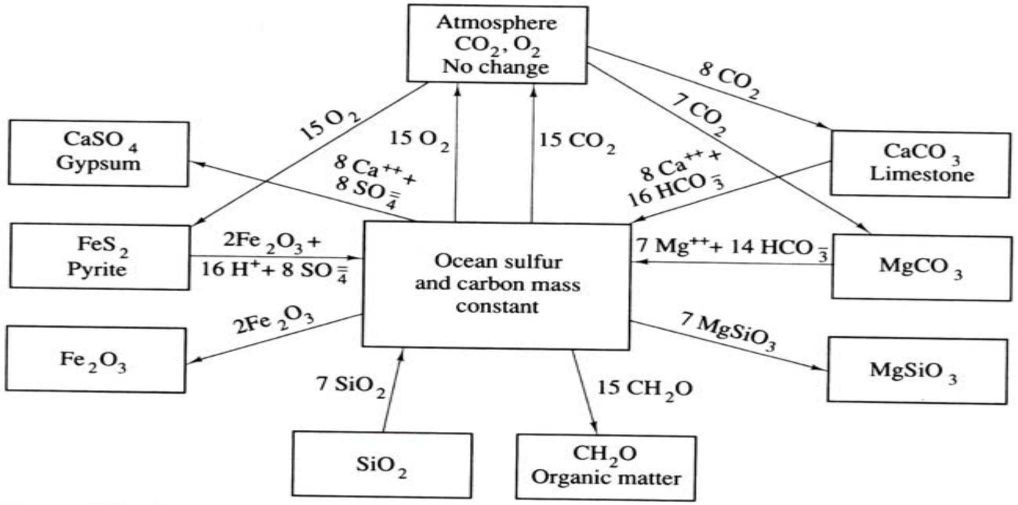
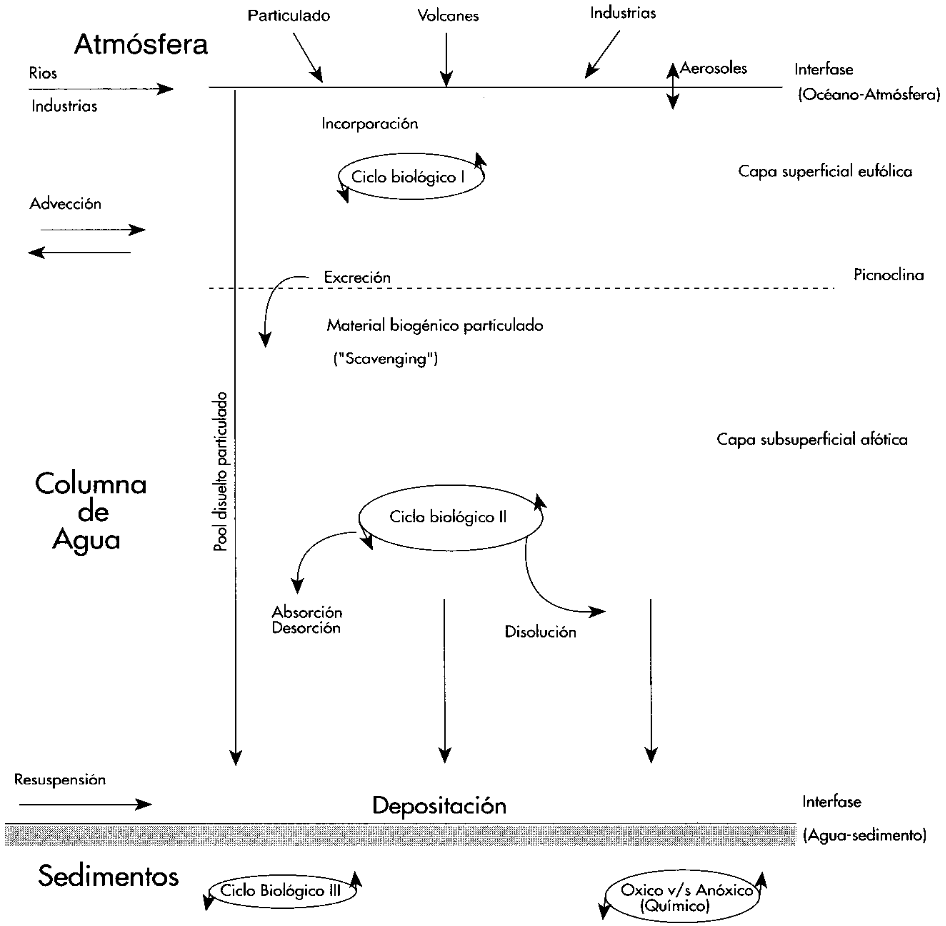


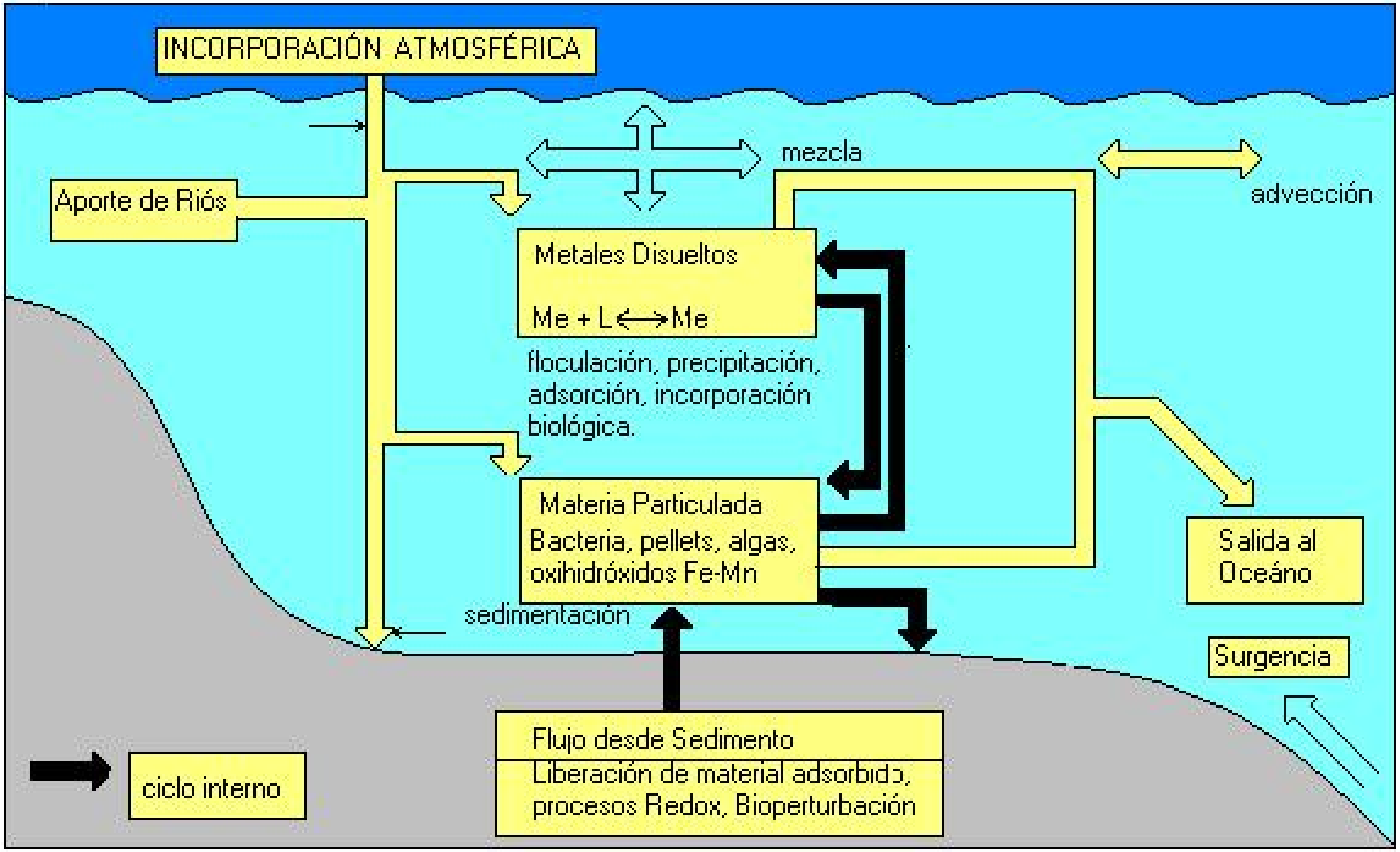
Figure 1.1 A model of major sedimentary reservoirs and the transfers between them that are associated with an increase in the mass of the biosphere by 15 moles. From Garrels and Lerman (1981).



Ciclo Biológico I : Producción/Consumo (Incorporación/Excreción)
Ciclo Biológico II : Degradación materia orgánica (Regeneración)
Ciclo Biológico III : Bioperturbación (Incorporación)

Figura 3. Esquema de los principales procesos que determinan la abundancia de un metal partícula-reactivo marino costero.

Figure 3. Diagram of main processes that determine abundance of a metal particle-coastal marine reactive.



INCORPORACIÓN ATMOSFÉRICA

Aporte de Riós

mezcla

advección

Metales Disueltos

Me + L ⟷ Me

floculación, precipitación, adsorción, incorporación biológica.

Materia Particulada

Bacteria, pellets, algas, oxihidróxidos Fe-Mn

Salida al Oceáno

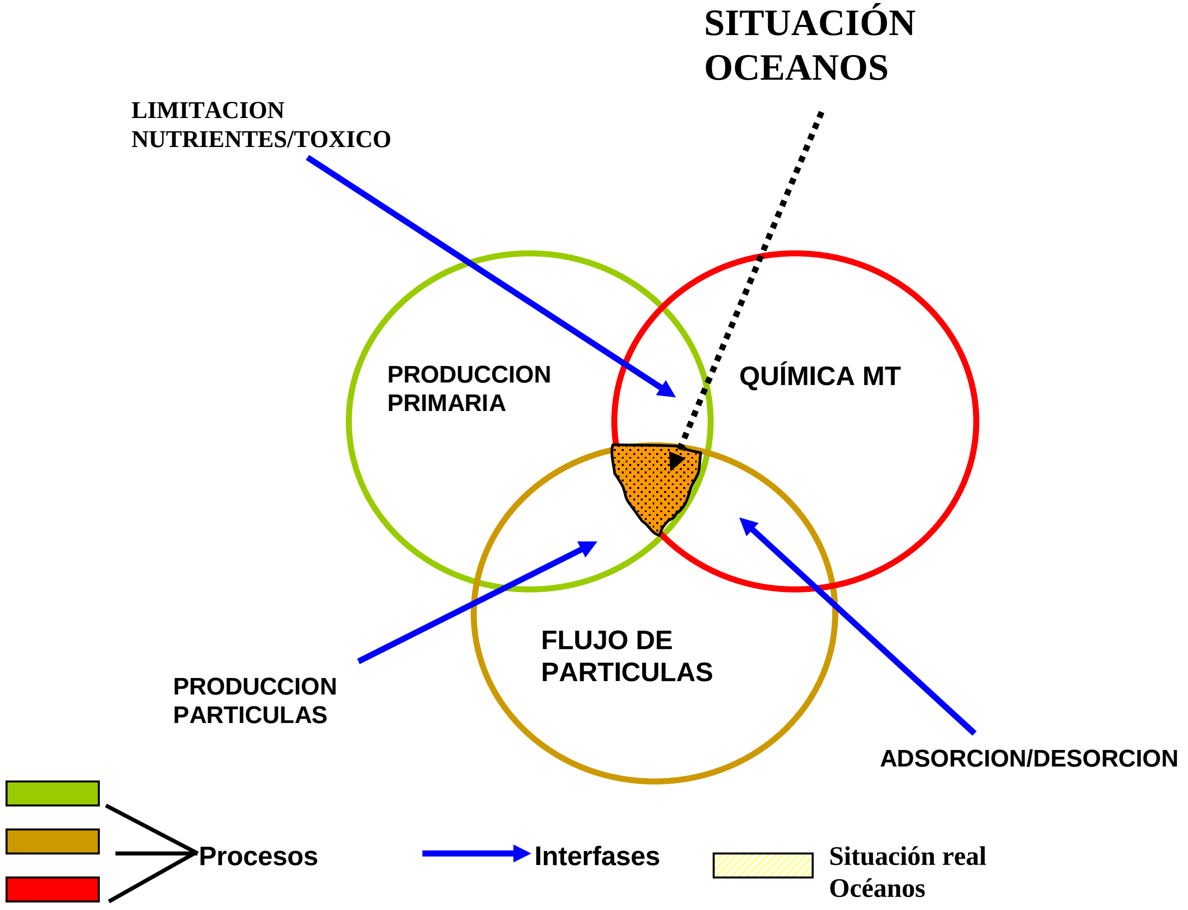
sedimentación

Surgencia

Flujo desde Sedimento

Liberación de material adsorbido, procesos Redox, Bioperturbación

ciclo interno



SITUACIÓN OCEANOS

LIMITACION NUTRIENTES/TOXICO

PRODUCCION PRIMARIA

QUÍMICA MT

FLUJO DE PARTICULAS

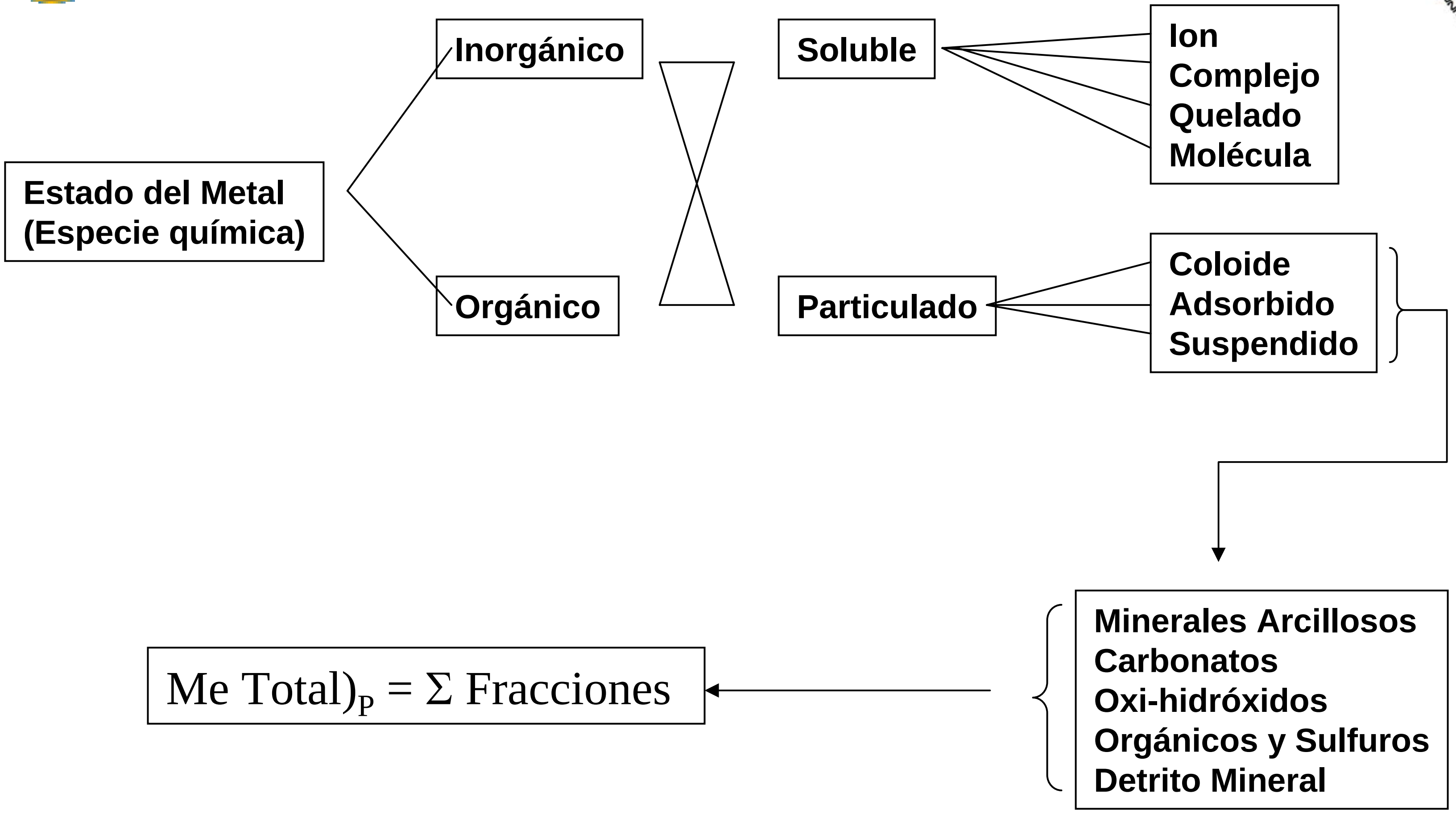
PRODUCCION PARTICULAS

ADSORCION/DESORCION

🟩 🟫 🟥 Procesos

→ Interfases

▨ Situación real Océanos



Estado del Metal (Especie química)

Inorgánico

Orgánico

Soluble

- **Ion**
- **Complejo**
- **Quelado**
- **Molécula**

Particulado

- **Coloide**
- **Adsorbido**
- **Suspendido**

- **Minerales Arcillosos**
- **Carbonatos**
- **Oxi-hidróxidos**
- **Orgánicos y Sulfuros**
- **Detrito Mineral**

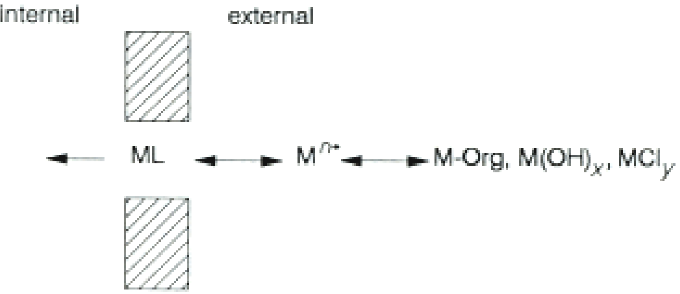
$\text{Me Total})_P = \Sigma$ Fracciones

Uptake of Dissolved Metals

Uptake rate Membrane permeable M complex

(a) Nutrient metal uptake systems

- Ligand associated with facilitated tranport system (L), complexes metal for tranport.
- M^{n+}can be "mistaken" for nutrient metals, e.g. Zn, Mn.

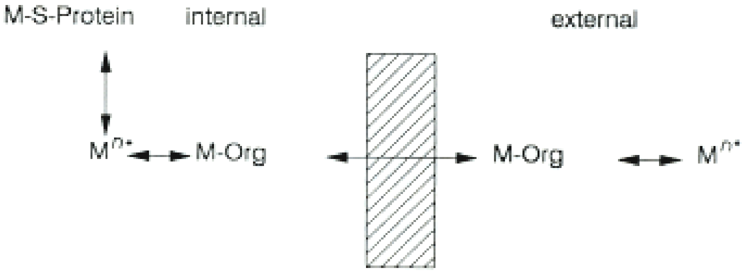


internal external

← ML ↔ M^{n+} ↔ M-Org, $M(OH)_x$, MCl_y

(b) Passive diffusion through membrane

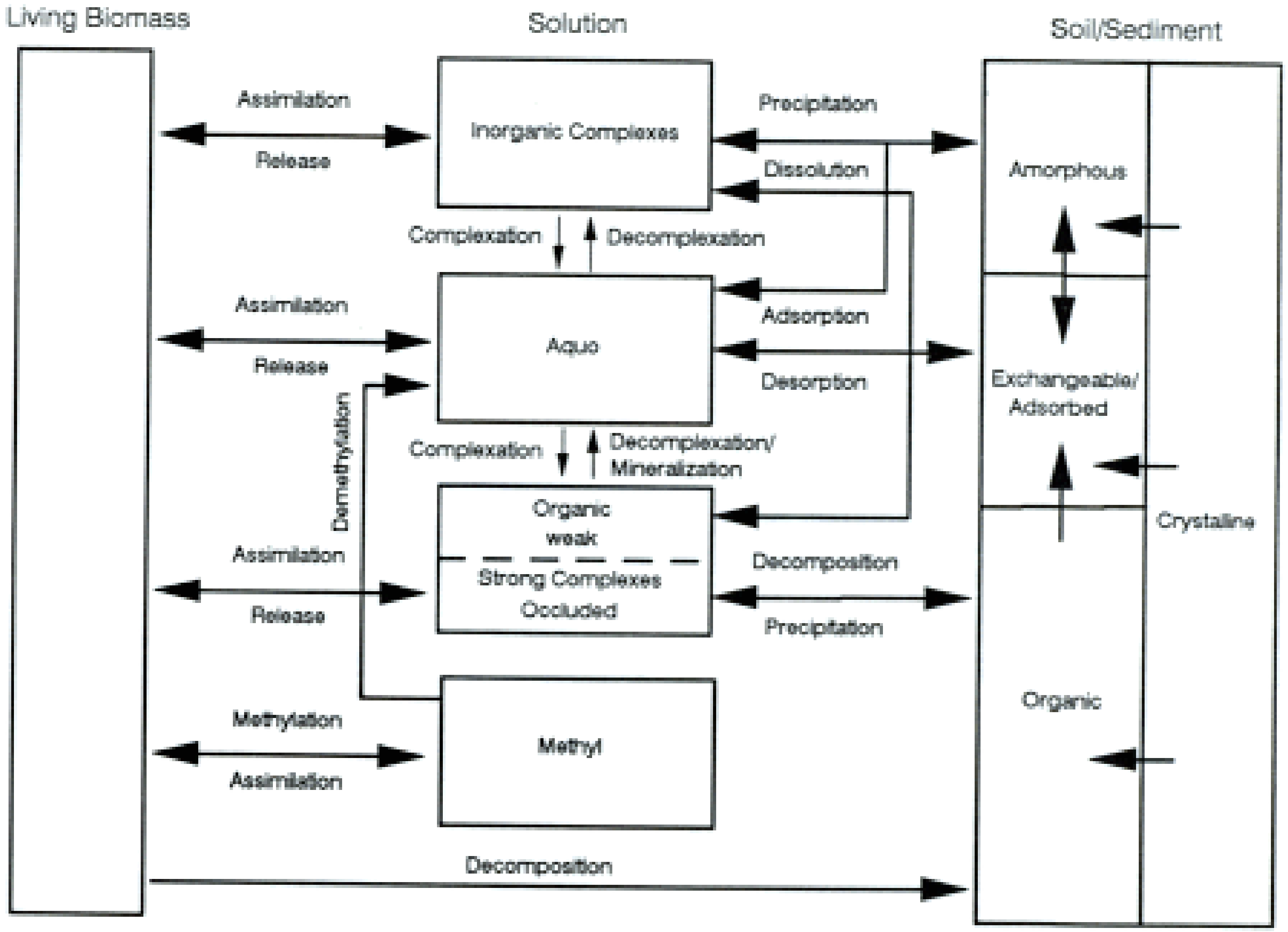
- Membrane permeable species diffuse passively through plasma membrane.
- Neutral species (e.g. M-Org) may be most permeable.



M-S-Protein internal external

↕

M^{n+} ↔ M-Org ↔ M-Org ↔ M^{n+}


Living Biomass
Solution
Soil/Sediment
Assimilation
Release
Inorganic Complexes
Precipitation
Dissolution
Amorphous
Complexation
Decomplexation
Assimilation
Release
Aquo
Adsorption
Desorption
Exchangeable/
Adsorbed
Demethylation
Complexation
Decomplexation/
Mineralization
Organic
weak
Strong Complexes
Occluded
Crystalline
Assimilation
Release
Decomposition
Precipitation
Methyl
Organic
Methylation
Assimilation
Decomposition

LA FASE “TRANSPORTADORA”

Fases orgánicas : ácidos húmicos y fúlvicos

Material orgánico sólido

Fases carbonatadas

Fases Fe y Mn

Fases detríticas/no detríticas

Fases autigénicas/litogénica

Adsorción e intercambio iónico

MEDIO

ORGANISMO

EXPOSICIÓN

Organos y
Celulas

AGUA O
SEDIMENTO

INTERFASE

DISPONIBILIDAD
AMBIENTAL

METABOLISMO
HOMEOSTASIS

BIODISPONIBILIDAD
AMBIENTAL

BIODISPONIBILIDAD
TOXICOLOGICA/
FARMACOLOGICA

- Forma Química
- Concentración (Actividad)
- Compartimiento
- Tiempo Residencia

- Incorporación
- Tasa de Encuentro
- Eficiencia

Función al nivel de Órganos o Celular.

Distribución y acumulación de plomo en sedimentos de los fiordos de la XI región

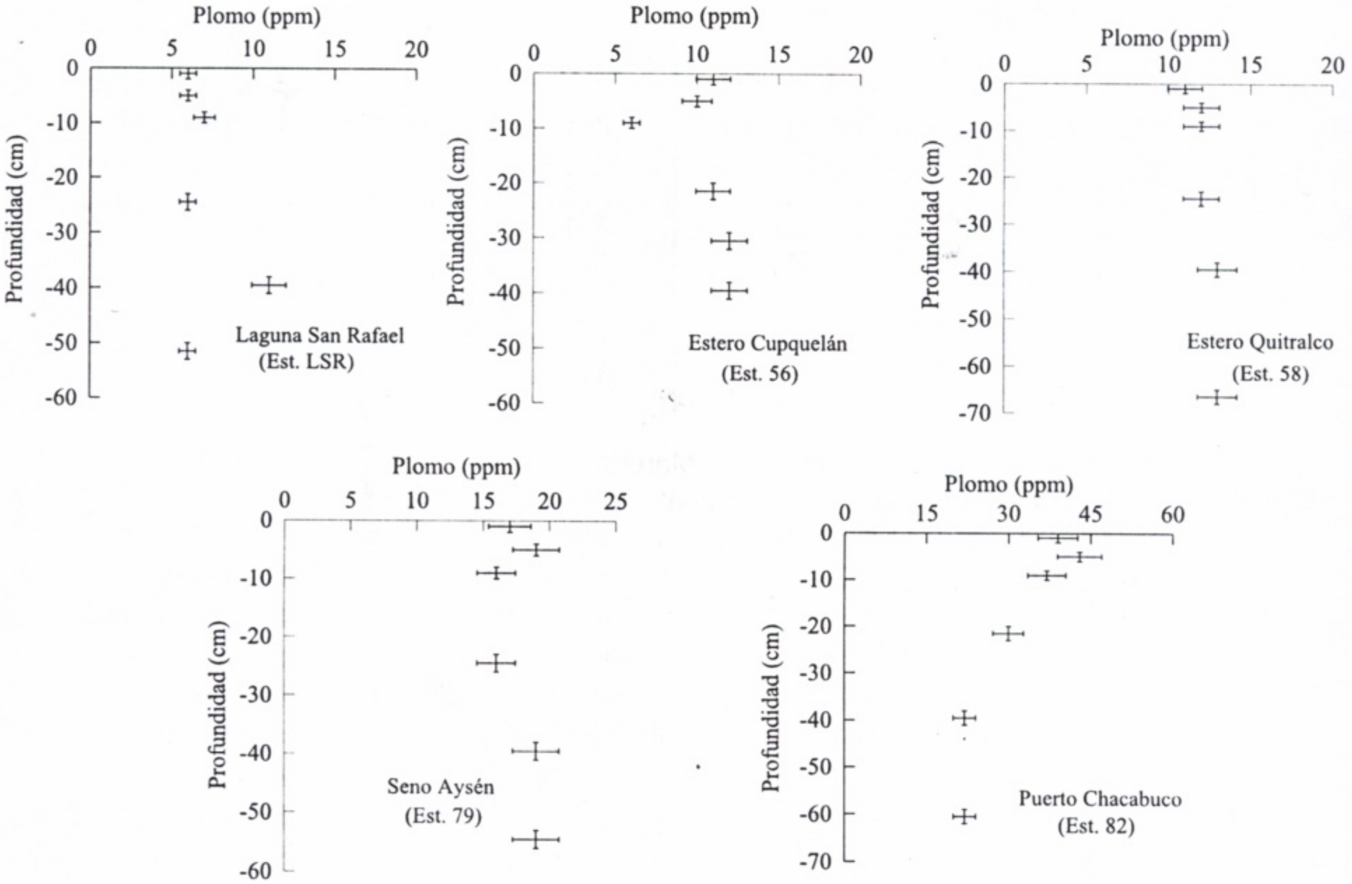


Fig. 3: Distribución vertical de Pb en los sedimentos de las localidades estudiadas.

Fig. 3: Vertical distribution of Pb in the sediments of studied locations.

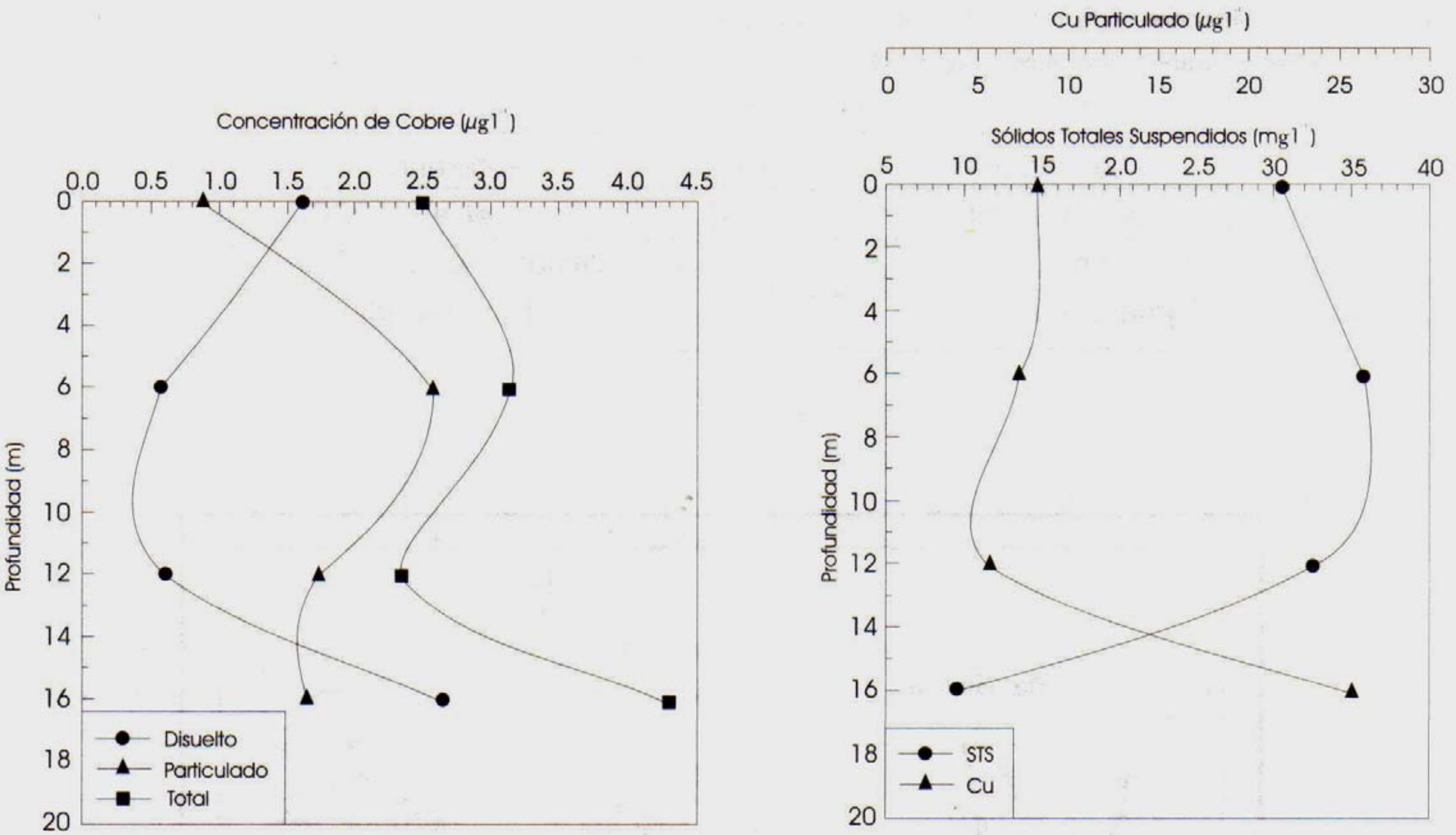


Fig. 2: a) Perfiles de cobre disuelto, particulado, total, b) Perfiles de STS y cobre particulado en la columna de agua.

Fig. 2: a) Vertical profile of total, dissolved and particulate copper , b) Vertical profile of TSS and particulate copper in the water column.

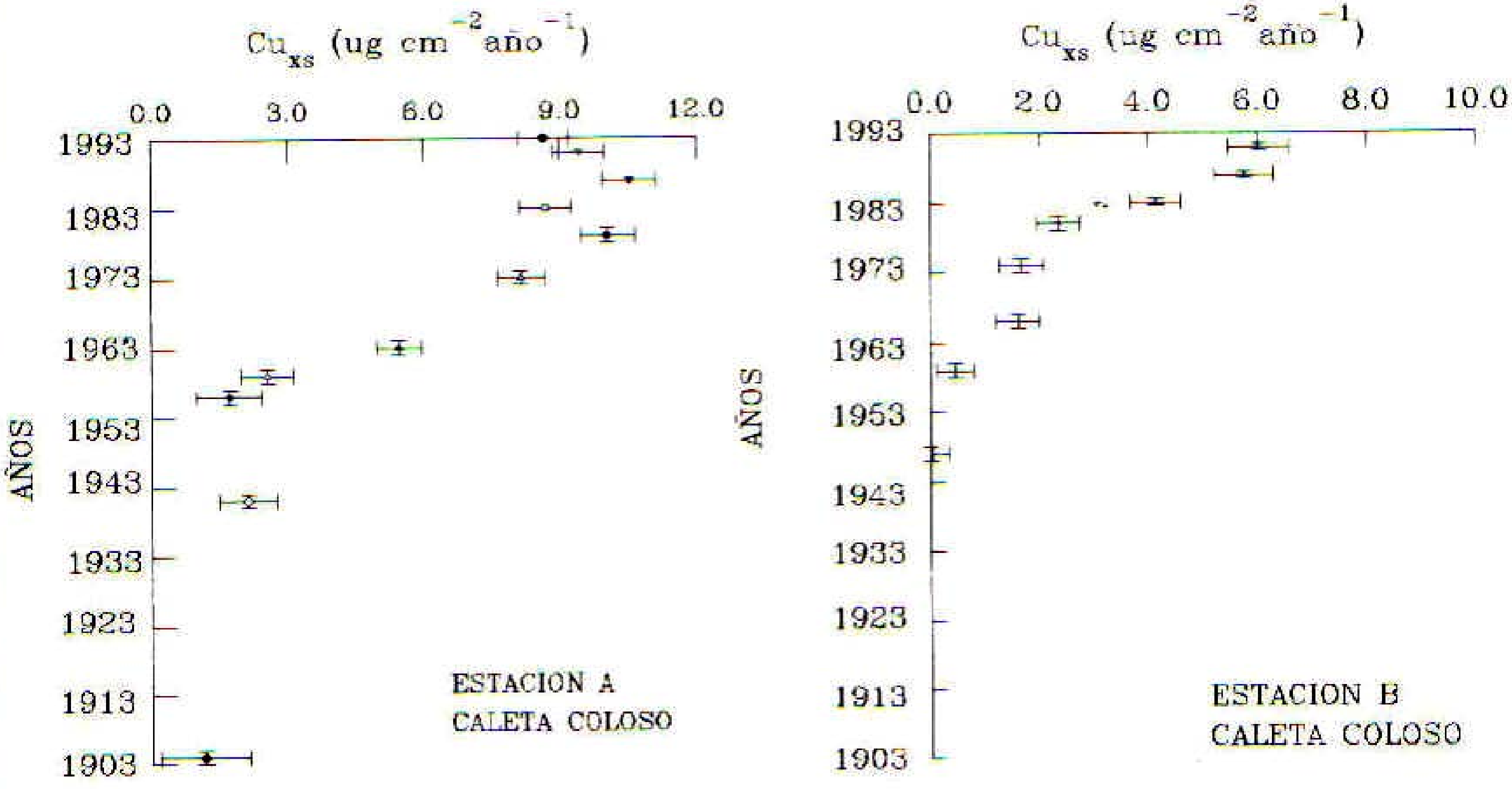
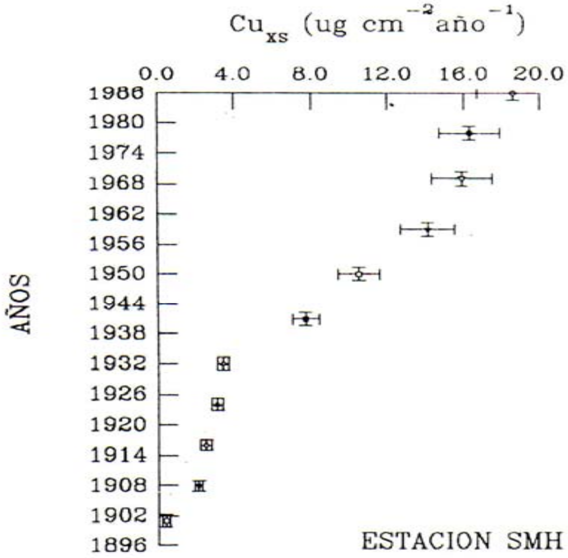
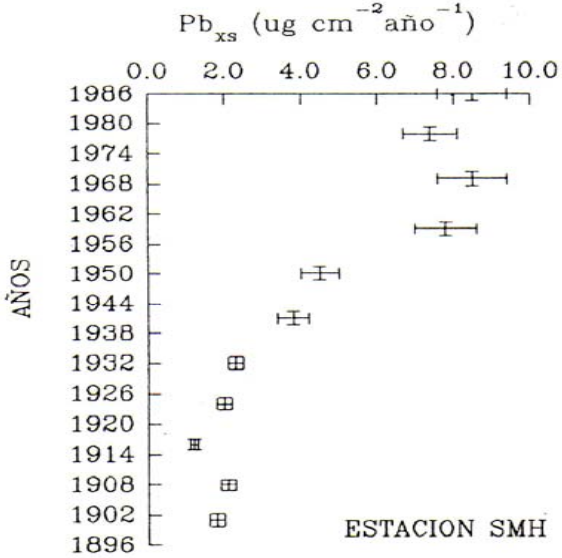
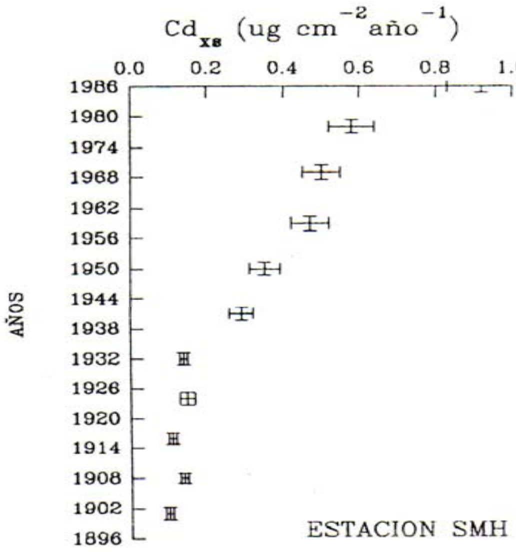
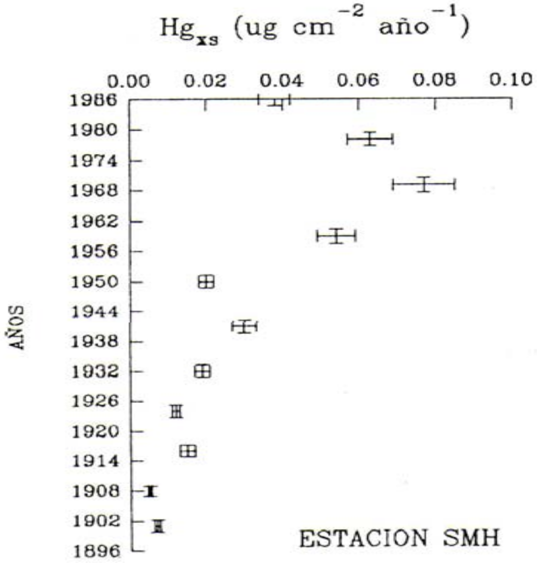


FIGURA 6. Flujo de exceso de Cu con respecto al tiempo en Caleta Coloso.


Cu_xs (ug cm^-2 año^-1)
0.0 4.0 8.0 12.0 16.0 20.0
1986 1980 1974 1968 1962 1956 1950 1944 1938 1932 1926 1920 1914 1908 1902 1896
AÑOS
ESTACION SMH


Pb_xs (ug cm^-2 año^-1)
0.0 2.0 4.0 6.0 8.0 10.0
1986 1980 1974 1968 1962 1956 1950 1944 1938 1932 1926 1920 1914 1908 1902 1896
AÑOS
ESTACION SMH


Cd_xs (ug cm^-2 año^-1)
0.0 0.2 0.4 0.6 0.8 1.0
1986 1980 1974 1968 1962 1956 1950 1944 1938 1932 1926 1920 1914 1908 1902 1896
AÑOS
ESTACION SMH


Hg_xs (ug cm^-2 año^-1)
0.00 0.02 0.04 0.06 0.08 0.10
1986 1980 1974 1968 1962 1956 1950 1944 1938 1932 1926 1920 1914 1908 1902 1896
AÑOS
ESTACION SMH

	Inventario (mg Cu cm^{-2})	Inventario (mg Pb cm^{-2})
Entradas		
Advección(1)	0,004	0,02
Transporte atmosférico(2)	0,210	0,05
Aporte Antropogénico(3)	0,410	0,09
	0,624	0,16
Salidas		
Acumulación en sedimentos	0,624	0,16

(1): Asume 100% de remoción de Cu y Pb desde columna de agua

(2): Estimado a partir del nivel pre-industrial

(3). Estimado por diferencia (ver texto)