MEDICAL GEOLOGY
(Geomedicine)

AN INTRODUCTION,
WITH BRAZILIAN EXAMPLES

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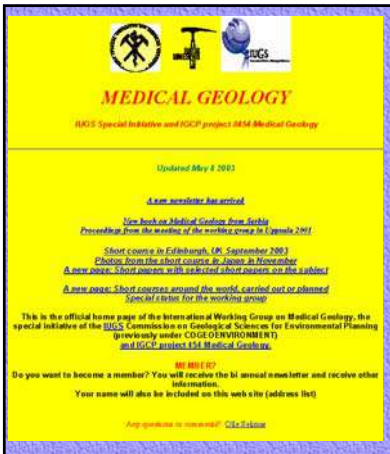
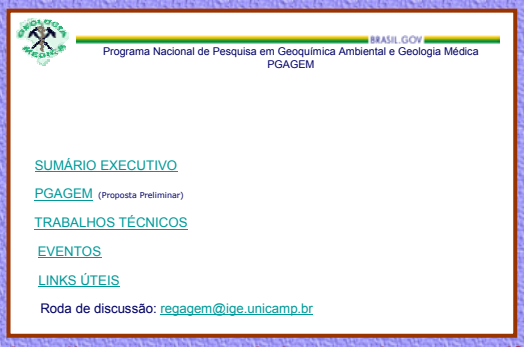
SOME OFFICIAL PROGRAMMES



Medical Geology
IGCP project #454
IUGS Special Initiative
http://home.swipnet.se/medicalgeology/



Brazilian Geological Services - CPRM
Programa Nacional de Pesquisa em Geoquímica Ambiental e Geologia Médica

http://www.cprm.gov.br/pgagem/pgagem.pdf

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MEDICAL GEOLOGY IS A *TEAM SCIENCE*

principal contribution from geologists:

GEOLOGY AND GEOCHEMISTRY OF TRACE ELEMENTS

- IRREGULARITIES IN THEIR REGIONAL DISTRIBUTION
- THEIR GEOLOGICAL AND GEOCHEMICAL CHARACTERISTICS
- NATURAL AND ARTIFICIAL CONTAMINATIONS
- INFLUENCE IN ANIMAL AND VEGETAL HEALTH DUE TO EXCESSES OR DEFICIENCIES

"You are what you eat"

Scarpelli

ESSENTIAL ELEMENTS TO ANIMALS AND VEGETATION

TO ALL	TO SEVERAL CLASSES	TO SOME CLASSES	TO SOME SPECIES	POSSIBLY ESSEN-TIAL
H, C, N	Si, V, Co	B, F, Cr	Li, Al, Ni	Rb, Sn
O, Na, Mg	Mo, I	Br	Sr, Ba	
P, S, Cl				
K, Ca, Mn				
Fe, Cu, Zn, Se				

MAJOR ELEMENTS — TRACE ELEMENTS

USGS - FAQ

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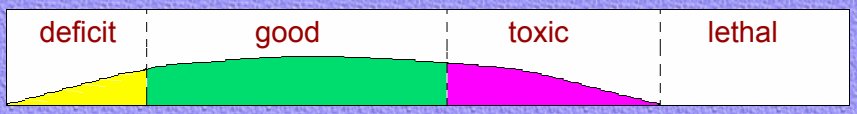
PATTERNS OF INFLUENCE OF THE ELEMENTS

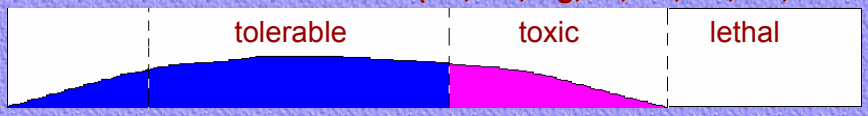
assimilation increase →

MACRONUTRIENTS (C, Ca, Cl, P, Mg, K, Na, S, O, H)

ESSENTIAL MICRONUTRIENTS (As, Co, Cr, Cu, Fe, Mn, Mo, Se, V, Zn, F, I, Si)



NON ESSENTIALS (Be, Cd, Hg, Ni, Pb, Sb, Sn, Ti etc.)



"Everything is poisonous, nothing is poisonous. It is just a question of dosage."

F.R.Siegel – "Environmental Geochemistry"

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ACTION OF MACRONUTRIENTS

Ca	Strengthening of bones and teeth; muscular activity; blood coagulation; cellular permeability. Excess may originate liver and bladder stones and renal insufficiency.
Cl	Maintenance of blood pressure; vital as acid constituent during digestion.
K	Maintenance of corporeal fluids; muscular contractions and nervous impulses.
Mg	In bones, together with Ca; activation of muscular contractions; body temperature control; component of several enzymes.
Na	Active in hydrosaline equilibrium; transmission of nervous impulses and transport of metabolites.
P	Bone constituent as apatite; participates of most body chemical reactions. Excess turns brittle hairs and bones.

G.Cortecci – "Geologia e Salute" and others
F.R. Siegel – "Environmental Geochemistry"
O.Selinus e A.Frank – "Medical Geology"

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ACTION OF MICRONUTRIENTS

Co	Active in vitamin B_{12} and in chemical reactions. Deficiency causes anemia. Excess causes hearth failures.
Cr	Needed for metabolism of sugar. Deficiency may cause diabetes, intolerance to glycose etc. Excess may result in renal failures. Excess of Cr^6 is cancerigenous.
Cu	Component of oxidizing enzymes during metabolism of energy sources; active in the synthesis of hemoglobin, in keratization and in skin and hair pigments. Deficiency leads to osteoporosis and low number of white blood cells.
F	Give strength to teeth and bones, avoiding dental caries and osteoporosis. Excess causes fluorosis of teeth and bones.
I	Required by thyroidal hormones, temperature control, body growth, reproduction etc. Deficiency causes abnormal growth of the thyroid.

G.Cortecci – "Geologia e Salute" and others
F.R. Siegel – "Environmental Geochemistry"
O.Selinus e A.Frank – "Medical Geology"

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FUNÇÃO DE MICRONUTRIENTES

Fe	Essential component of hemoglobin e enzymatic complexes required for energy generation and immunological system.
Mn	Promotion of growth and development; cellular functions; in bones and cartilages; takes part in metabolic reactions. Excess leads to excess of blood. May cause neurological diseases if inhaled to the lungs.
Se	Prevention of vascular and other diseases; neutralizes cells oxidation and aging actions of free radicals. Excess turns brittle nails and hair.
Zn	Occur in all tissues, mostly in bones, muscles and skin; active in the immunological system; regulates body growth; protects the liver. Deficiency reduces body growth.

G.Cortecci – "Geologia e Salute" and others
F.R. Siegel – "Environmental Geochemistry"
O.Selinus e A.Frank – "Medical Geology"

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OTHER ELEMENTS

Al	Non essential, albeit its crustal abundance. Interferes with and reduces assimilation of phosphorus and fluor, causing bone demineralization. Suspect of influencing Alzheimer disease.
As	Essential (?). Excess is carcinogenic.
Be	Non essential. Toxic when inhaled as dust.
Cd	Non essential. Toxic and carcinogenic. Interferes with Zn, inhibiting the normal assimilation of Zn.
Hg	Non essential. Poisonous.
Ni	Essential to vegetables, possibly also to animals.
Pb	Non essential and toxic.
Sb	Non essential.
Sn	Non essential.
Ti	Non essential.
V	Essential. Extends teeth life. Excess may cause lung diseases.

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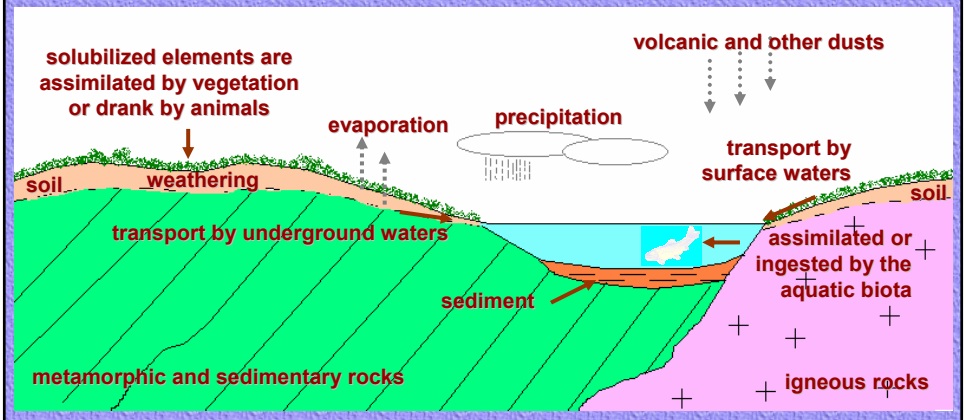
F.R.Siegel – "Environmental Geochemistry"

COMMON PATHWAYS OF THE ELEMENTS TO REACH THE FOOD CHAIN



Anthropomorphic actions not considered.

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WATER AND FOOD

Current waters reflect the chemical composition of underlying rocks.

Vegetation reflects the chemical composition of the soils where they growth.

The animals, for their water and food, reflect the chemical composition of the region where they live.

Population feeding exclusively of locally produced foods are more affected by geochemical anomalies.

There are classic cases of health problems due to abundance or lack of elements as I, As, Se, Zn and others.

IT SEEMS RECOMMENDABLE TO CONSUME TREATED WATER AND FOOD FROM VARIABLE SOURCES.

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POLLUTION AS SOURCE OF ANOMALIES

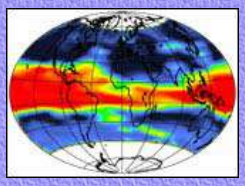
NATURAL

- Volcanism
- Dust storms

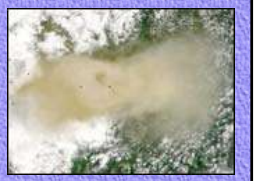
ANTHROPOMORPHIC

- Industrial rejects
- Mine rejects
- Insecticides
- Desertification
- Urban centers
- Others

VOLCANISM

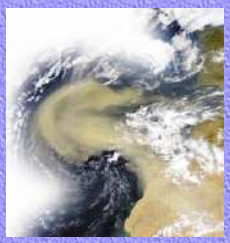


Pinatubo

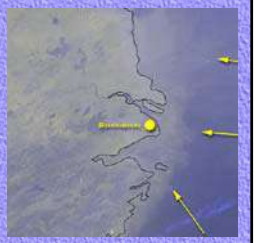


Quito, Ecuador

DUST STORMS



Africa



China

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GRADE OF GEOLOGICAL MATERIALS

TOTAL (the "in situ" grade of an element)

BIOAVAILABLE (fraction available for assimilation by live organisms)

ABSOLUTELY BIOAVAILABLE (fraction actually assimalable by a specific living organism)

(More frequently examined elements: Al, As, Be, Cd, Cr, Cu, Hg, NI, Pb, Se, and Sb; plus Ag, Ba, Co, Mn, Mo, Na, Tl, V and Zn)

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NATURAL AVAILABILITY

Weathering of mother rocks liberates metals and metalloids to soil, water, and atmosphere, as new minerals, residual minerals, in solution, adsorbed, as organic and/or inorganic complexes, and as vapors.

The weathering is strongly dependent of the local climate and the action of living organisms.

Carbonates and oxide-hydroxides of Fe and Mn predominate amongst the new crystalline forms of metals and metalloids.

Clay minerals are important for adsorption of metals and metalloids.

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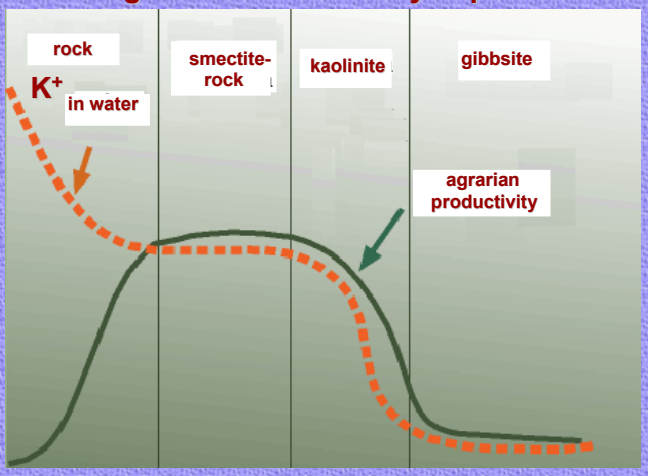
EXAMPLE OF BIOAVAILABILITY

The maximum agrarian productivity coincides with the greater bioavailability of potash.



In the soil profile, the peak concentration of K is were smectite predominates.

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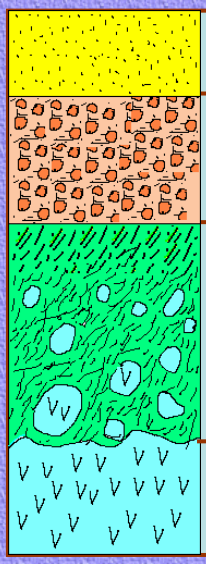
G.Cortecci – "Geologia e Salute"

LOW BIOAVAILABILITY, OR "METALS ESTERILIZATION", ON LATERIZATION



Zone A – yellow clays, rich in SiO_2. Leached of Mg, Ca, K, Na, Cu, Zn and others.
Zone B – clayous and concretional, rich in Al and Fe, with Mn, As, Co, Se, Zn, and Ni retained within limonite. Leached of Mg, Ca, K, Na and others.
Zone C – argillaceous saprolite, with gradual physical and chemical transition to the fresh rock below. Grades of Mg, Ca, K, Na, Cu, Ni and others increase towards the base. Water with dissolved metals accumulate towards the base.
Fresh rock.

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BIOAVAILABILITY

availability of the elements to the biota

It is influenced by climate, pH, oxidation potential, the biota (vegetation, microorganisms, etc.), mineralogy, temperature, speciation of the elements, interferences between the elements (>Cu when <Zn,Fe,Mo), etc.

Appearance of salts increase the bioavailability of the metals	greater ↑ smaller	Pb – oxalate Pb – carbonate Pb – acetate Pb – sulfate Pb – sulfide

Metals solubilized as cations are more bioavailable in acid waters.

Metals solubilized as oxi-anions (as As^{5}, Mo^{6-}, CrO^{6-}) are more bioavailable, essentially in basic waters.

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G.Cortecci – "Geologia e Salute"

CHEMICAL INTERFERENCES

Mo	Cu	Increase in soil pH increases the mobility of Mo in relation to the mobility of Cu, reducing the capacity of the vegetation to assimilate Cu, with bad results for animals and humans.
Cu	Fe	The presence of Cu, and possibly of Ni, is necessary for proper action of Fe in metabolism.
P_2O_5	Zn	Increase of P_2O_5 in soil reduces the capacity of vegetation to assimilate Zn, with detrimental results for animals and humans.
Zn	Cd	Increase of Zn reduces the capacity to assimilate Zn by vegetation, animals and humans.
S	Se	The use of S-rich fertilizers reduces the capacity of vegetation for assimilation of Se from soil, with bad effects for animals and humans.

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C.Montgomery, em "Environmental Geology"

TOXICITY – BRAZILIAN NORMS

SOLUBILIZATION TEST
NORM ABNT – NBR 10006

Test in neutral solution, ph 7.0.
Test in duplicate, each with 100 g of sample.
Permanence time of 7 days after strong initial agitation.
Final solutions diluted to 400 ml with deionized water.
Assaying for the grades of the solution.

LEACHING TEST
NORM ABNT – NBR 10005

Test in acid water, with acetic acid 0.5 N.
Continual agitation of 50 g sample, at pH 5.0 +/- 0,2.
Minimal period of 25 hours.
Acidity is maintained with additions of acetic acid.
Final solution is diluted to 800 ml with deionized water.
Assaying for the grades of the solution.

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BRAZILIAN NORMS FOR ARSENIC

WATER FOR HUMAN CONSUMPTION	< 0.010 mg/L (before 2000 was <0.050 mg/L)	Ministério da Saúde, Decree 1469/GM, Art. 14, of 29.12.2000
SUBSOIL WATER	there is no official limit	CETESB-SP uses grade of potable water
DISCHARGE IN NATURAL DRAINAGE	< 0.500 mg/L	CONAMA, Resolution20/1986

INERT PRODUCT	< 0.050 mg/L in solubilization test	ABNT, Norms NBR-10004 e 10006
NON INERT PRODUCT	< 5.000 mg/L in leaching test >0.050 mg/L in solubilization test	ABNT , Norms NBR-10004, 10005 e 10006
TOXIC PRODUCT	> 5.000 mg/L in leaching test	ABNT, Norms NBR-10004 e 10005

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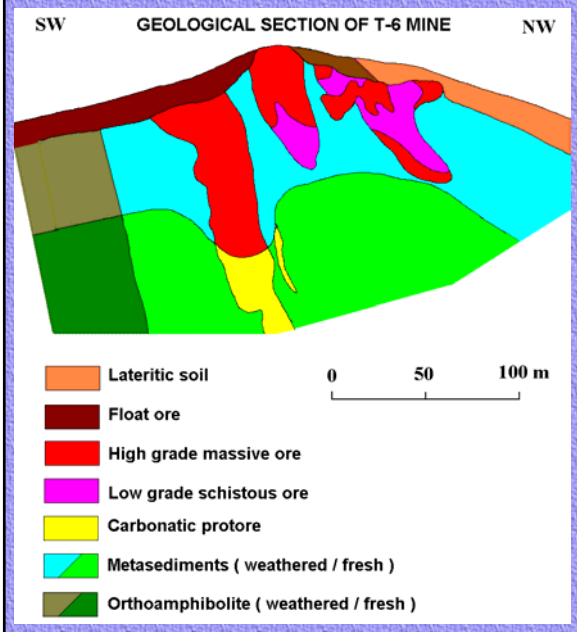
W.Scarpelli – "As em minério de manganês"



ARSENIC IN THE SERRA DO NAVIO MANGANESE ORES

The ore minerals, oxides and hydroxides of Mn, are product of weathering of protores constituted mostly of rhodochrosite and garnets, attacked by acid waters, with pH of about 5.5, typical of the Amazonian rain forest.

The As is retained within the oxides and hydroxides of Mn and Fe, with the resulting ores assaying about 0.17% As.

W.Scarpelli – "As em minério de manganês"

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ARSENIC SOLUBILITY

of the Serra do Navio manganese ore

Ore samples	Samples natural grades			LEACHING TESTS				SOLUBILIZATION TESTS			
				As		As leached		As		As leached	
	% Mn	% Fe	ppm As	Sample mg	solution mg/L	mg	%	Sample mg	solution mg/L	mg	%
G36	26	15	1,516	76	0.01	0.01	0.01	152	0.01	0.04	0.003
B30	29	15	1,364	68	0.01	0.01	0.01	136	0.01	0.04	0.003
M30	30	14	1,558	78	0.01	0.01	0.01	156	0.01	0.04	0.003
M28	29	13	1,499	75	0.01	0.01	0.01	150	0.01	0.04	0.003
M26	26	14	1,549	77	0.01	0.01	0.01	155	0.01	0.04	0.003
M20	25	13	1,356	68	0.01	0.01	0.01	136	0.01	0.04	0.003
Carb	17	5	1,415	71	0.07	0.06	0.08	142	0.47	0.19	0.133

Dissolution of As is smaller in the leaching tests, run under acid pH, reflecting that the ore was formed under acid conditions. Overall, less than 0.01% of the contained As is dissolved.

G36 e B30 – coarse ores (>0,8 cm diameter)
M30, M28, M26 e M20 – medium ores (<0,8 a >1 mm diameter)
Carb – fresh carbonatic protore

W.Scarpelli – "As em minério de manganês"

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EXAMPLES OF CHANGES OF TOXICITY LEVELS AS FUNCTION OF SPECIATION OF THE ELEMENTS

ELEMENT	LESS TOXIC	MORE TOXIC
As	As^3	As^5 (as arsenate)
	organic	inorganic
Cr	Cr^3	Cr^6 (as chromate)
Mo	Mo^2	Mo^6 (as molibdate)

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G.Cortecci – "Geologia e Salute"

SPECIFIC ABSOLUTE BIOAVAILABILITY

Corresponds to the actual percentage of an element effectively assimilated by a specific organism, animal or vegetal.

It is function of the form of occurrence of the elements, their speciation, interference with other elements, concentration, pH, Eh, temperature, climate, granulometry, etc.

Determined with analysis under a large number of conditional variables, not rarely including samples of vegetation and animals from the environment under study.

To replicate possible human ingestion, "in vitro" assays are made under pH of 1.5.

U.S. Naval Facilities Eng. Command; "Guide fo
Incorporating Bioavailability – UG-2041-ENV"

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EFFECTS OF NATURAL ANOMALOUS DISTRIBUTION OF TRACE ELEMENTS

IODINE - FLUORINE - ARSENIC - SELENIUM

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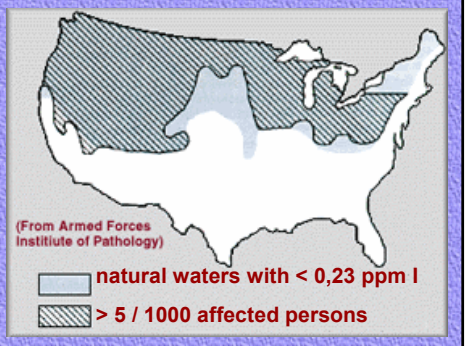
IODINE

Lack of iodine forces a hyperactivity of the thyroid gland.



The thyroid gland uses iodine to produce hormones to control the metabolism and the generation of corporal energy.

Before the regular addition of iodine to table salt, goiter was common in large areas with scarce iodine.

L.Chyi – "The Right Dose"
G.Cortecci – "Geologia e Salute"

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FLUORINE

Fluorine is an essential component of phosphates, as the hydroxi-fluor-apatite, a constituent of teethes and bones.

It is essential for healthy and strong teeths and bones, and to avoid osteoporosis.

The excess causes fluorosis, with mottled and harder teeth and bones calcifications.

Fluorosis is common where drainage water is high in fluor, and is consumed without adequate treatment, as in large areas of China, Ghana, Sri Lanka and other places.

More than 100,000,000 people have fluorosis.

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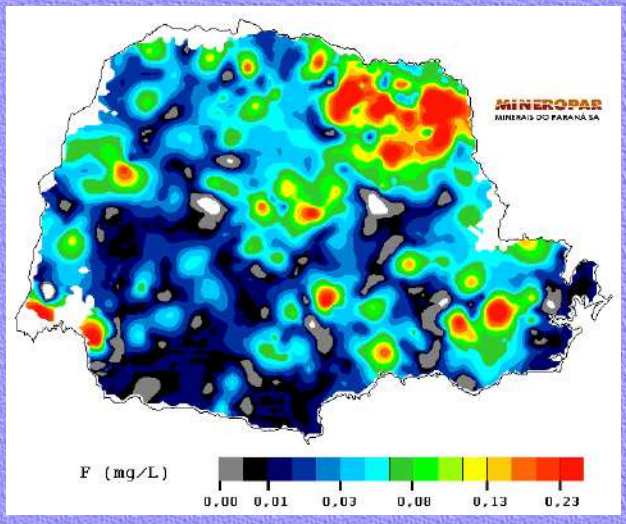
FLUORINE

IN SMALL DRAINAGE BASINS OF THE PARANÁ STATE, BRAZIL

(fluorine in drainage water, in mg/L)



O.A.B. Licht – "Atlas Geoquímico do Paraná", MINEROPAR

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ARSENIC

As^{5+} is more toxic than As^{3+} and inorganic (salt As) is more harmful than inorganic (methilated As).

When ingested in small doses, organic As is eliminated with urine. The excess could be fixed in vital organs, from where it could also be eliminated, as long as the excessive ingestion is not continued.

Inorganic As fixes itself easier in the organism than inorganic As, although part of it is transformed into inorganic by methilation.

Toxic effects appear when As is ingested in excess for long periods, resulting in cancer, cutaneous malignancies, etc.

In Chile, Argentine, Mexico, India, and other countries, where there are sites with anomalously high concentration of As in the water, the population that drinks that water presents high values of As in blood, hair, nails, and body organs.

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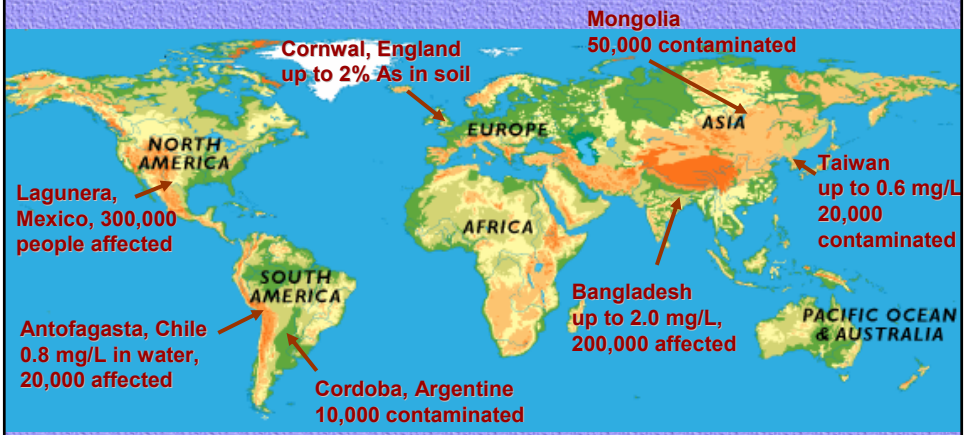
ARSENIC

PEOPLE AFFECTED BY NATURALLY CONTAMINATED WATER



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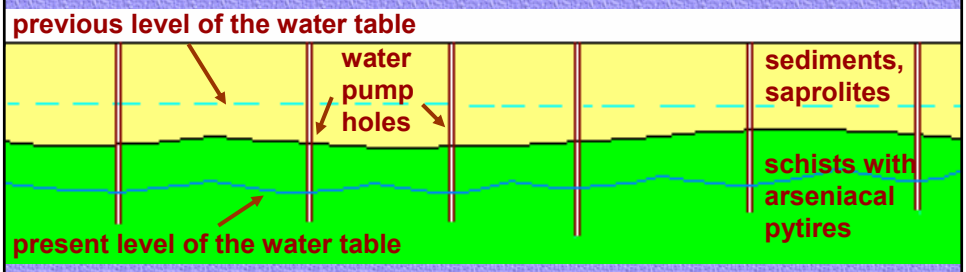
O.Selinus e A.Frank em "Medical Geology"

ARSENIC
THE PROBLEM OF BANGLADESH

(>200,000 people contaminated as the lowering of the water table by excessive pumping exposed arsenical pyrites to weathering)



MOST VISIBLE EFFECTS
due to excess of arsenic in the drink water

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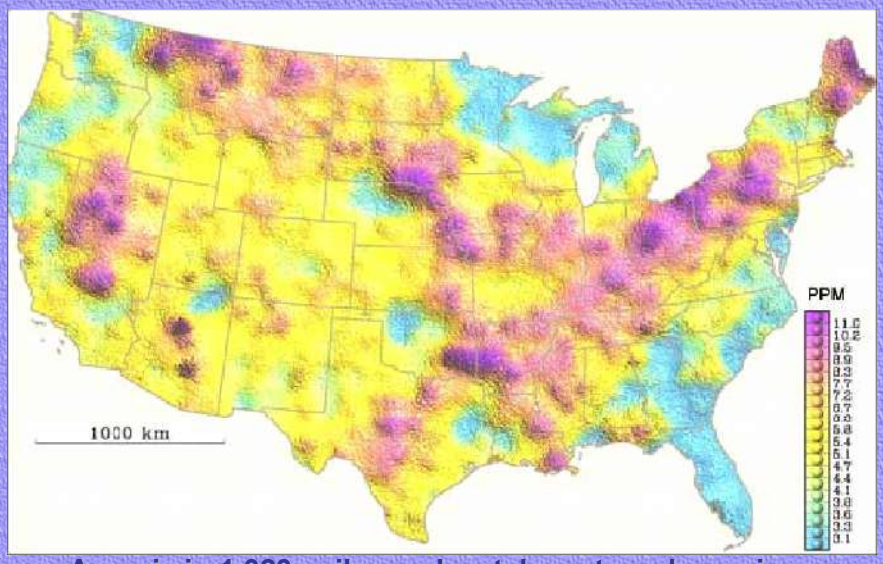
USA, ARSENIC IN SOIL



Arsenic in 1,323 soil samples, taken at road margins, at a spacing of 80 km, one sample at each 6,000 km^2.

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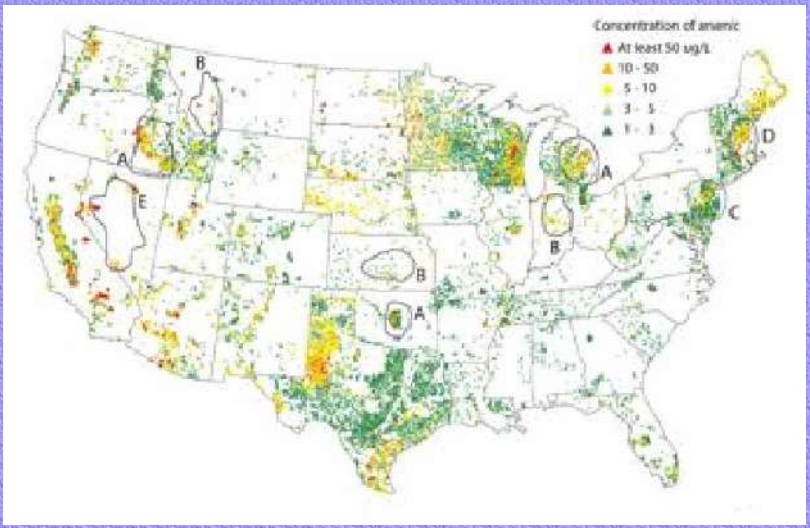
USGS, Prof. Paper 1648, "Geochemical Landscape"

USA, ARSENIC IN GROUNDWATER



Arsenic in 31,000 water wells and other sources of water used for human consumption, many requiring treatment.

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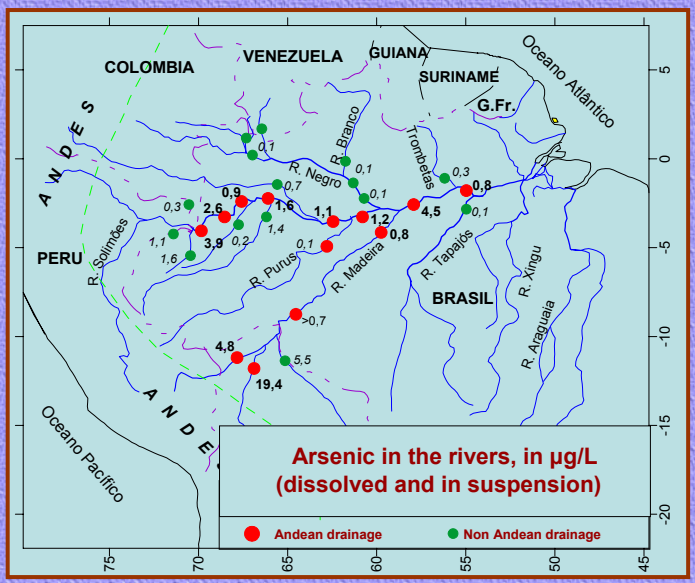
S.Ryker, em "Mapping As in Groundwater"

ARSENIC IN THE AMAZONIAN RIVERS



Rivers from the Andes shows higher content of As.

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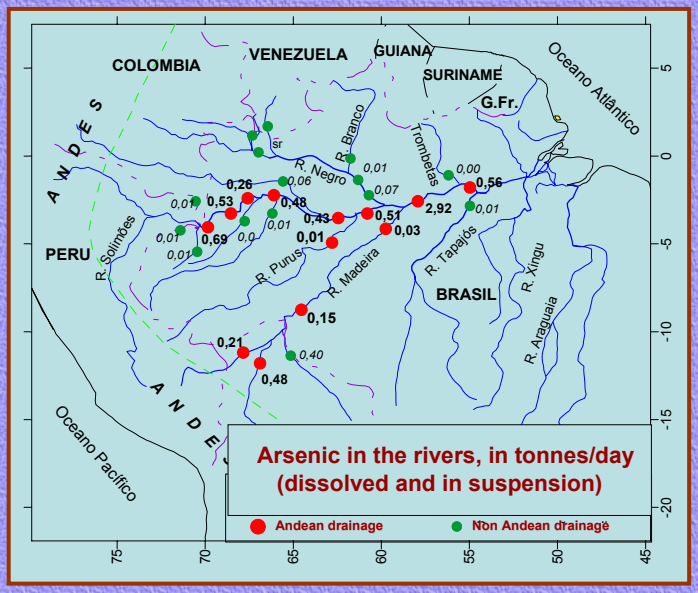
W.Scarpelli, with data from Projeto HIBAM

ARSENIC IN THE AMAZONIAN RIVERS



Roughly 0.6 tons of As are transported DAILY to the Atlantic.

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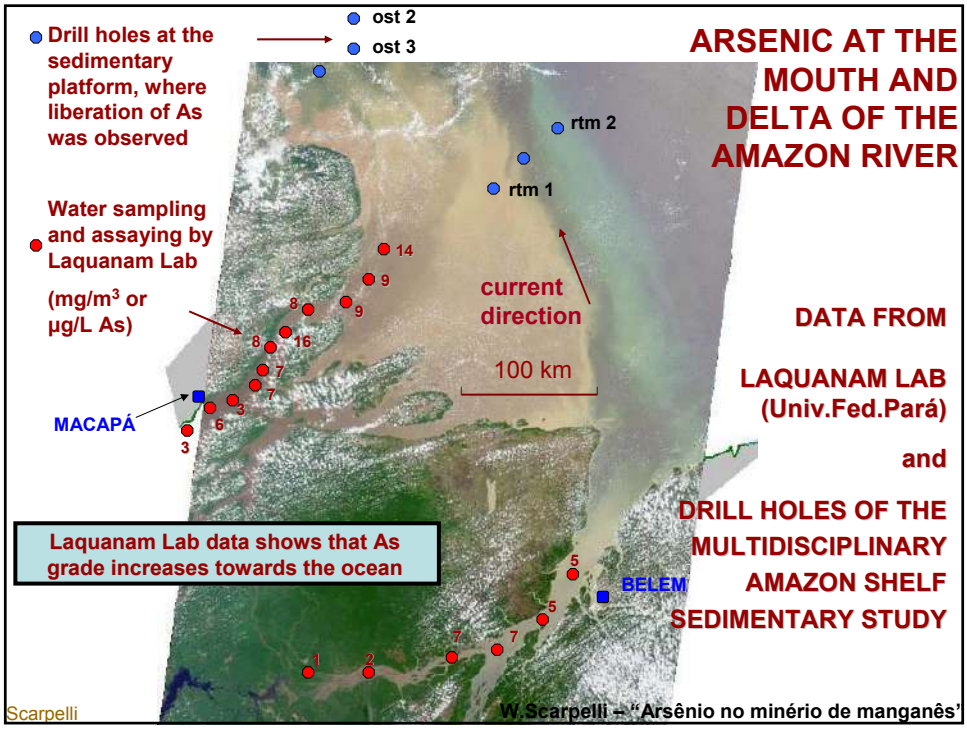

ARSENIC AT THE MOUTH AND DELTA OF THE AMAZON RIVER

DATA FROM

LAQUANAM LAB (Univ.Fed.Pará)

and

DRILL HOLES OF THE MULTIDISCIPLINARY AMAZON SHELF SEDIMENTARY STUDY

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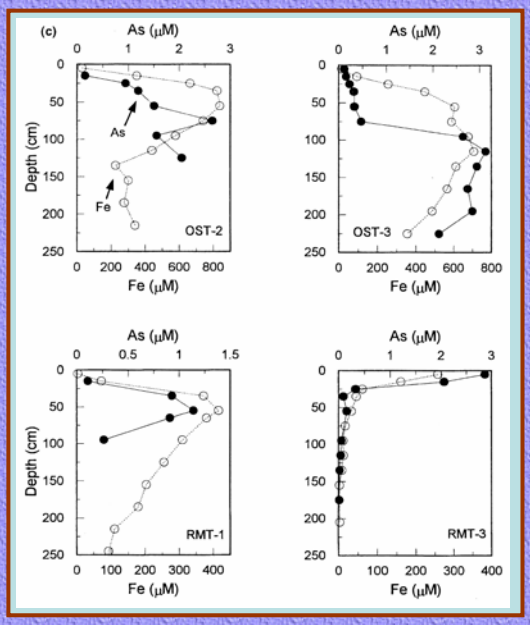
W.Scarpelli – "Arsênio no minério de manganês"



Soluble Fe and As in pore water of the 4 indicated holes drilled at the sedimentary platform.

ARSENIC LIBERATED AT THE DELTA OF THE AMAZON RIVER

The sediments of the platform get reduced at 1 to 1.5 m of depth, with crystallization of the iron hydroxides into sulfides and carbonates. Soluble Fe and As accumulate in the pore water. Turbulence of these sediments brings these elements to the ocean surface waters.

Sullivan & Allen in "Diagenetic cycling of arsenic in Amazon shelf sediments"; *Multidisciplinary Amazon Shelf Sediment Study*

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SELENIUM

Essential for metabolic reactions and for anti-oxidant enzymes, which delay aging.

Daily doses of less than 0.04 mg might be insufficient and greater than 0.10 mg could be toxic.

Sicknesses due to lack of Se occur in extensive areas of China, accompanying some geological structures.

Selenium occurs essentially in sulfides, and their chemical characteristics are similar to those of S.

Se^{6+} solubilizes easily than Se^{4+} and as such is more bioavailable. Se^{4+} stays mostly within Fe oxides and hydroxides.

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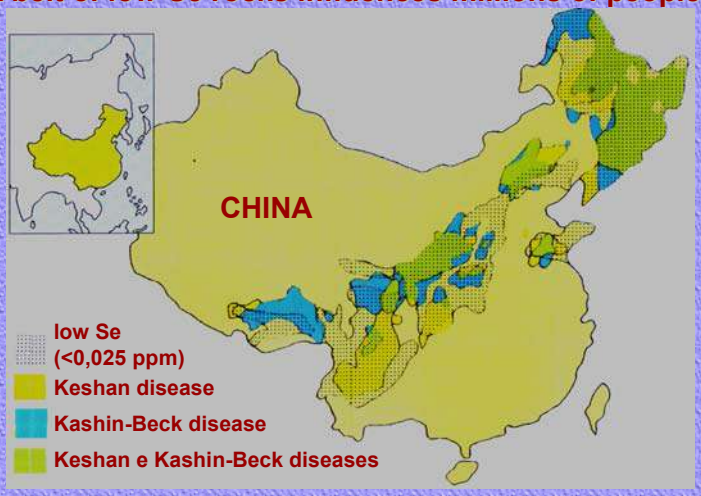
SELENIUM

A belt of low-Se rocks influences millions of peoples.



Keshan disease – weakening of the hearth
Kashin-Beck disease – muscular pains, others effects

O.Selinus e A.Frank in "Medical Geology",
in "Environmental Medicine", L.Moller

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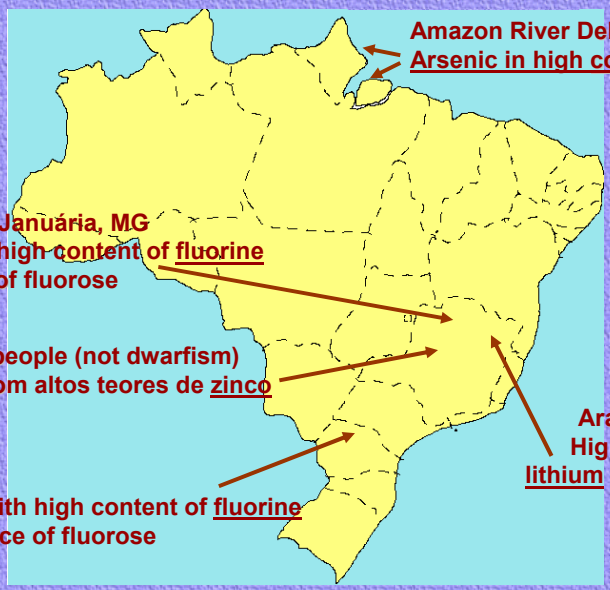
SOME NATURAL ANOMALIES IN BRAZIL



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HEAVY WATERS

In Europe, it was noted that the incidence of sudden earth failures is lower where people consumes heavy waters. These are waters rich in dissolved carbonates. The effect is greater where the ratio Mg:Ca is greater.

DELETERIOUS CHEMICAL ANOMALIES DUE TO HUMAN ACTIVITIES

ACID WATERS

MERCURY – ARSENIC – CADMIUM - LEAD

ACID WATERS

Waters turned excessively acid from sulfuric acid formed by oxidation and dissolution of of sulfides, mostly pyrites and pyrhotites.

They are also found near areas of sulfide ore mining and where the rejects of the mining and/or the tailings of the treatment plants are discarded without adequate care.

Besides their acidity, they might also be toxic due higher content of arsenic, lead, cadmium, copper, and other elements, liberated with the dissolution of sulfides and carbonates.

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EXAMPLES OF ANTROPOMORPHIC ANOMALIES

Santana, Amapá
Arsenic in tailings of pelotization

Santo Amaro, Bahia
Lead in tailings of a metal refinery

Iron Quadrangle
Arsenic in old gold tailings and in an area burnt by As-rich smokes

Extensive areas contaminated with mercury from garimpeiro gold works

Paraná – São Paulo
Tailings of lead mining also containing cadmium

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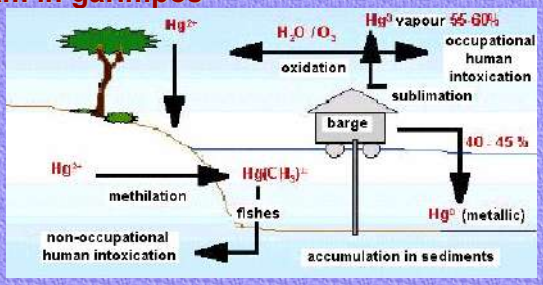
MERCURY

Almost inert as a metal, it is highly toxic as a gas or in an organic form. In acid environments rich in organic matter, it is slowly methilated, and then accumulates in the food chain, mostly in fishes.

carnivorous fishes concentrate methilated Hg

It is liberated by volcanism, weathering, and

- **Thermo-electric coal power plants**
- **Industries and their tailings**
- **Burning of Au-Hg amalgam in garimpos**
- **Dental amalgam**



Minamata disease – attacks brain and neurological system

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EXAMPLE OF MERCURY CONTAMINATION IN BRAZILIAN GARIMPEIRO AREAS

Normal values in hair, according to the OMS:	**1 to 2 ppb**
At Poconé, MT, outside the garimpo:	**0.3 to 3 ppb**
At Poconé, in the garimpo: (34 ppb after 16 years burning Au-Hg amalgam)	**1.3 to 34 ppb**
At Cumaru, PA, maximum observed:	**14 ppb**
At Madeira River, RO, maximum observed:	**97 ppb**
At Rainha, Tapajos River, maximum observed:	**34 ppb**
At São Luiz do Tapajós, maximum observed:	**48 ppb**
At Barreiras, Tapajós River, maximum observed:	**71 ppb**
At Paraná Mirim, Tapajós River, maximum observed:	**15 ppb**

F.Nogueira et alli. – "Mercúrio total em Poconé, MT"
R.C.Villas Boas et alli. – "Mercury in the Tapajós Basin"

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ARSENIC AT SANTANA, AMAPÁ, BRAZIL

Between 1973 and 1985, fines of the Serra do Navio manganese oxide ore were used to produce 1,275,000 tonnes of pellets, exported for steel plants. The heating of the ore, required for the pelletization, partially reconstituted the mineralogy of the protore, unstable under surface conditons. During the operation, 75,600 tonnes of rejects were deposited in a water-filled basin built near the plant.

Submersed in the water, the As situated near the surface of the particles were liberated, contaminating the underground water around the artificial basil.

The removal of the rejects from the basin interrupted the contamination, and was followed by immediate reduction of soluble As in the underground water.

The decrease was due to precipitation of As with oxides and hydroxides of Mn and Fe, in the acid waters, as it happened during the genesis of the ore.

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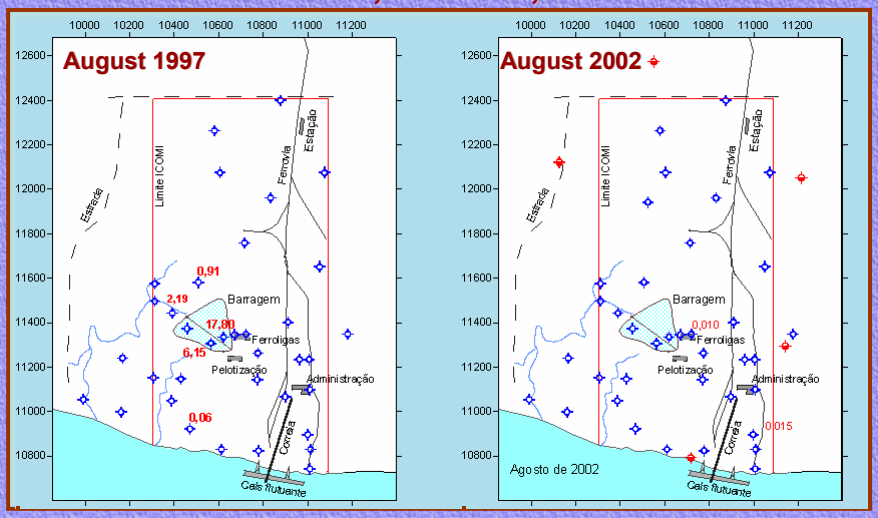
W.Scarpelli – "As em minério de manganês"

ARSENIC IN MONITORING WATER WELLS SANTANA, AMAPÁ, BRAZIL



As in the monitoring wells without values: from 1997, < 0,05 mg/L
from 2002, < 0,01 mg/L

(all values in mg/L)

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CADMIUM AND LEAD

Cadmium is present in soil, vegetation and water
usually originates from Pb, Zn, and Cu sulfides
disseminates via water and air
concentrates in vegetation and animals
liberated from tailings, rejects and industries
batteries, burning of coal and cigarettes
causes softening and weakening of bones
causes osteoporosis (competing with calcium)

Lead industry and mining rejects
very wide dispersion, due to intensive use
quite disseminated near cities
causes saturnism and other brain diseases

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DELETERIOUS PHYSICAL INFLUENCE FROM GEOLOGICAL MATERIALS

- **Silica dust** in the lungs - silicosis

  (occur essentially where there is a large quantity of fresh angular fragments of silica, recently formed)

- **Manganese dust** – attack to the nervous system

  (it is rare, but possible, where there is abundance of manganese dust and no ventilation)

- **Asbestos**
- **Radon** – radioactive gas
- **Other radioactive elements**

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ASBESTOS

The material seems attractive to the industry as it is

reducible to fibers, used as a raw material for several purposes

resistant to high temperatures

resistant to attack by chemical agents

As sources of industrial asbestos:

SERPENTINES (crisotile)

crisotile

AMPHIBOLES (riebeckite/crocidolite, grunerite (amosite), anthophyllite, tremolite e actinolite)

tremolite

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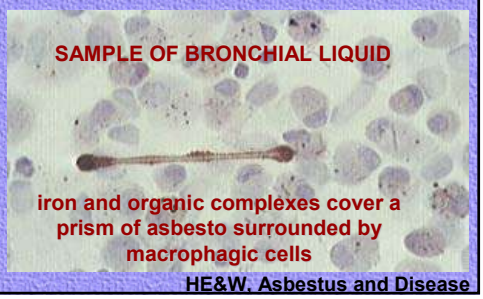
ASBESTOS

The human body has resources to return back fragments inhaled with the respiration, before they reach the lungs.

Fragments that reach the lung, usually of <10 μ, are enveloped by macrophagic cells, originating small globular masses that are expelled with small coughs.

The process is not efficient with prismatic particles, as those of asbestos, which are not easily coughed out. Reactions with macrophagic cells, mainly if the mineral has Fe, initiate chemical and physical reactions which might result in cancer in the lungs.

dust, prisms of asbesto and macrophages



iron and organic complexes cover a prism of asbesto surrounded by macrophagic cells

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HE&W, Asbestus and Disease

ASBESTOS

Serpentines are less aggressive than amphiboles, possibly because they contain less iron and are more flexible.

The incidence of asbestosis is perceptible essentially with workers of mines and industries which manipulate with large quantities of asbestos, mainly where they are smokers.

Cancer appears years after the ingestion of the fibers in the lungs, mainly with smokers.

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		Uranium	238U	4.5*10.9 years
		↓		
α	+	Radium	226Ra	1,602 years
		↓		
α	+	Radon	222Rn	3.8 days
		↓		
α	+	Polonium	218Po	3 minutes
		↓		
α	+	Lead	214Pb	27 minutes
		↓		
βγ	+	Bismuth	214Bi	20 minutes
		↓		
βγ	+	Polonium	214Po	<1 seconds
		↓		
α	+	Lead	210Pb	21 years
		↓		
β	+	Bismuth	210Bi	5 days
		↓		
β	+	Polonium	210Po	138 days
		↓		
α	+	Lead	206Pb	stable

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RADON

Chain of the radio-isotopes formed with the transformation of U^{238} to Pb^{206}, with the intermediate elements and their half-lifes.

The capacity of penetration increase from the α to the γ particles.

The ionization of the α particles is greater than that of the γ particles.

M.Svartengren – "Radon, a great health risk", in Environmental Medicine, L.Moller

RADON

Radioactive gas, intermediate in the transformation of U^{238} into Pb^{206}, during which there are solid radioactive phases and intense emission of alfa, beta and gamma rays.

It is found in soil, and in surface and underground waters, in areas of granites, gneisses, alkaline rocks, shales and other silicatic rocks, essentially those that contain phosphates.

The gas form of radon allows for its inhalation with the respiration and ingestion with drinking water.

It represents a substantial risk in underground mines where there is uranium, in this case requiring strong ventilation.

In cold areas, where the houses are closed to preserve the heat, radon might penetrate from beneath through small cracks in the floor. That justifies the building of a open basement under the house floors. The risk is smaller in well ventilated environments.

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BIOREMEDIATION

Stimulated use of natural micro-organisms to consume and neutralize toxic products in soil and water.

The action of the micro-organisms might be accelerated with addition of nutrients.

It requires continued monitoring of the evolution of the process.

It is being used by the USGS for organic contaminants (oils, sludge, pesticides, solvents, fertilizers, etc.)

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USGS – "Biogradation: Nature's Way to a Cleaner Environment"

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