MEDICAL GEOLOGY IN BRAZIL

STATE OF ART

Cassio Roberto da Silva cassio@rj.cprm.gov.br
Geological Survey of Brazil–CPRM
Workshop and Hemispherical Conference on Medical Geology
Gurabo – Puerto Rico November 14 – 18, 2005

CPRM Serviço Geológico do Brasil
Secretaria de Geologia, Mineração e Transformação Mineral
Ministério de Minas e Energia
BRASIL UM PAÍS DE TODOS

Medical Geology Research begin:

In 1996 F in Paraná State: stream sediment, soil and water

In 1996 Pb and Cd in Bahia State: stream sediment and soil

In 1998 Pb in Ribeira Valle – São Paulo and Parana states : stream sediment, soil and water

In 1998 As in Iron Quadrangle Minas Gerais State: stream sediment

In 2002 - 2003

ENVIRONMENTAL GEOCHEMISTRY AND MEDICAL GEOLOGY NETWORK - REGAGEM

regagem@ige.unicamp.br

NATIONAL RESEARCH PROGRAM OF ENVIRONMENTAL GEOCHEMISTRY AND MEDICAL GEOLOGY - PGAGEM

www.cprm.gov.br/pgagem

Enviromental and Health Effects
of Toxic Elements, Metal Ions, and Minerals

2003 INTERNATIONAL WORKSHOP

October 14 – 16, 2003 Campinas -SP

MEDICAL GEOLOGY

METALS, HEALTH AND THE ENVIRONMENT

GEOLOGIA MÉDICA BRASIL

110 participants

SYMPOSIUM ON MEDICAL GEOLOGY

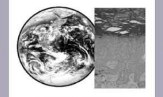
32nd IGC – Florence

2004

Total: 33 presentations

Brazilian papers:
04 presentations

2005 WORKSHOP INTERNACIONAL



Environmental and health effects of toxic elements, metal ions, and minerals

PÚBLICO ALVO

O workshop destina-se a geólogos, geoquímicos, ecologistas, químicos, biólogos, médicos, toxicologistas, epidemiologistas, patologistas, dentistas, veterinários, bioestatísticos e muitos outros profissionais da saúde, do meio ambiente e das geociências com interesse em geologia médica, em particular no efeito dos íons dos metais tóxicos no meio ambiente e na saúde humana e animal. O mais importante do evento é possibilitar contatos e o desenvolvimento de redes de pesquisa e discussão entre profissionais que trabalham em diferentes áreas do meio ambiente e da saúde.

APOIO

PATROCÍNIO

GEOLOGIA MÉDICA

METAIS, SAÚDE E AMBIENTE

Uma emergente disciplina que estuda a influência dos fatores geológicos ambientais sobre a saúde humana e dos animais

02-04 Junho · 2005 · Rio de Janeiro · Brasil

TEMAS

- Saúde Ambiental: Fontes de Exposição e Efeitos na Saúde dos Elementos Traço, Metais Tóxicos e Metalóides
- Toxicologia Ambiental, Estudos Geoquímicos e Efeitos na Saúde Humana
- Toxicologia Analítica: Especiação dos Elementos Traço, Métodos Analíticos
- Tópicos Especiais em Pesquisa sobre Geologia Médica e Saúde Humana
- Palestras Nacionais: Uso Seguro de Bens Minerais, Vigilância em Saúde Ambiental, Epidemiologia/Geoquímica Ambiental e Geologia Médica; Arsênio: Exposição Humana, Câncer e Elementos Traços, Fluorose Dentária, Geoquímica dos Solos, Biofortificação na Prevenção de Deficiência de Micronutrientes

MINI-CURSO

Dr. Olle Selinus (Serviço Geológico da Suécia)
Dr. Robert Finkelman (Serviço Geológico dos Estados Unidos)
Dr. José Centeno (Instituto de Patologia das Forças Armadas dos Estados Unidos)

PALESTRAS NACIONAIS PARA CONVIDADOS / SESSÃO POSTER ABERTA A INTERESSADOS

CPRM · Serviço Geológico do Brasil

Auditório "Salão Nobre"
Avenida Pasteur, 404, 3° andar - Urca
Rio de Janeiro · RJ · BRASIL

INFORMAÇÕES E INSCRIÇÕES ATÉ 15/5/2005

www.cprm.gov.br/pgagem

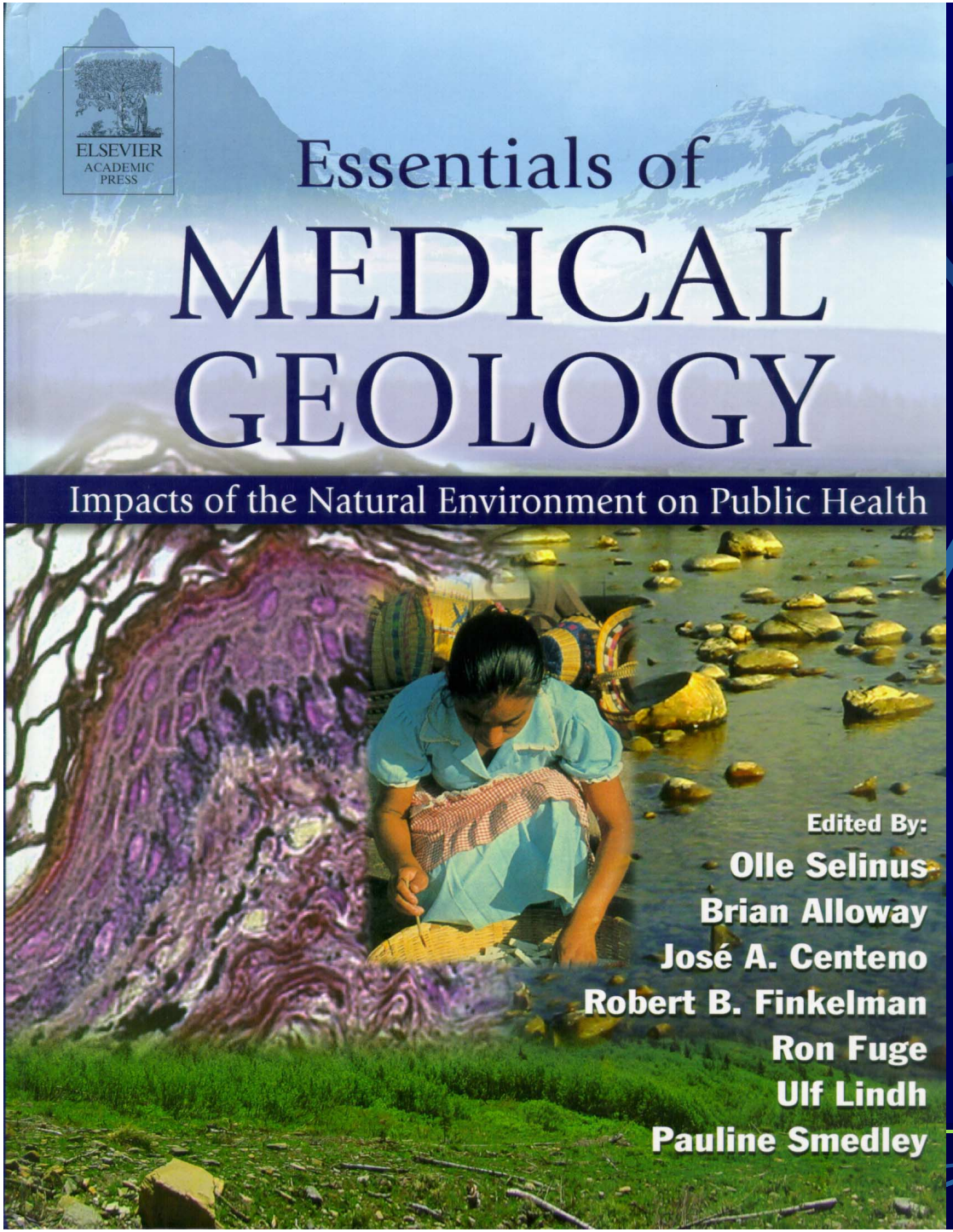
Tradução simultânea inglês/português/inglês
Taxa de inscrição: R$ 300,00 para profissionais e R$ 50,00 para estudantes.
Informações: Fátima Maria Nascimento SGB / Rosa Maria Pires SGB
e-mail: derid@rj.cprm.gov.br tel: (21) 2295-0734, fax (21) 2295-5804

GEOLOGIA MÉDICA
BRASIL

210 Participants

55 Brazilian presentations

(11 lectures, 41 posters)



Acquisition of 36 books after the workshop

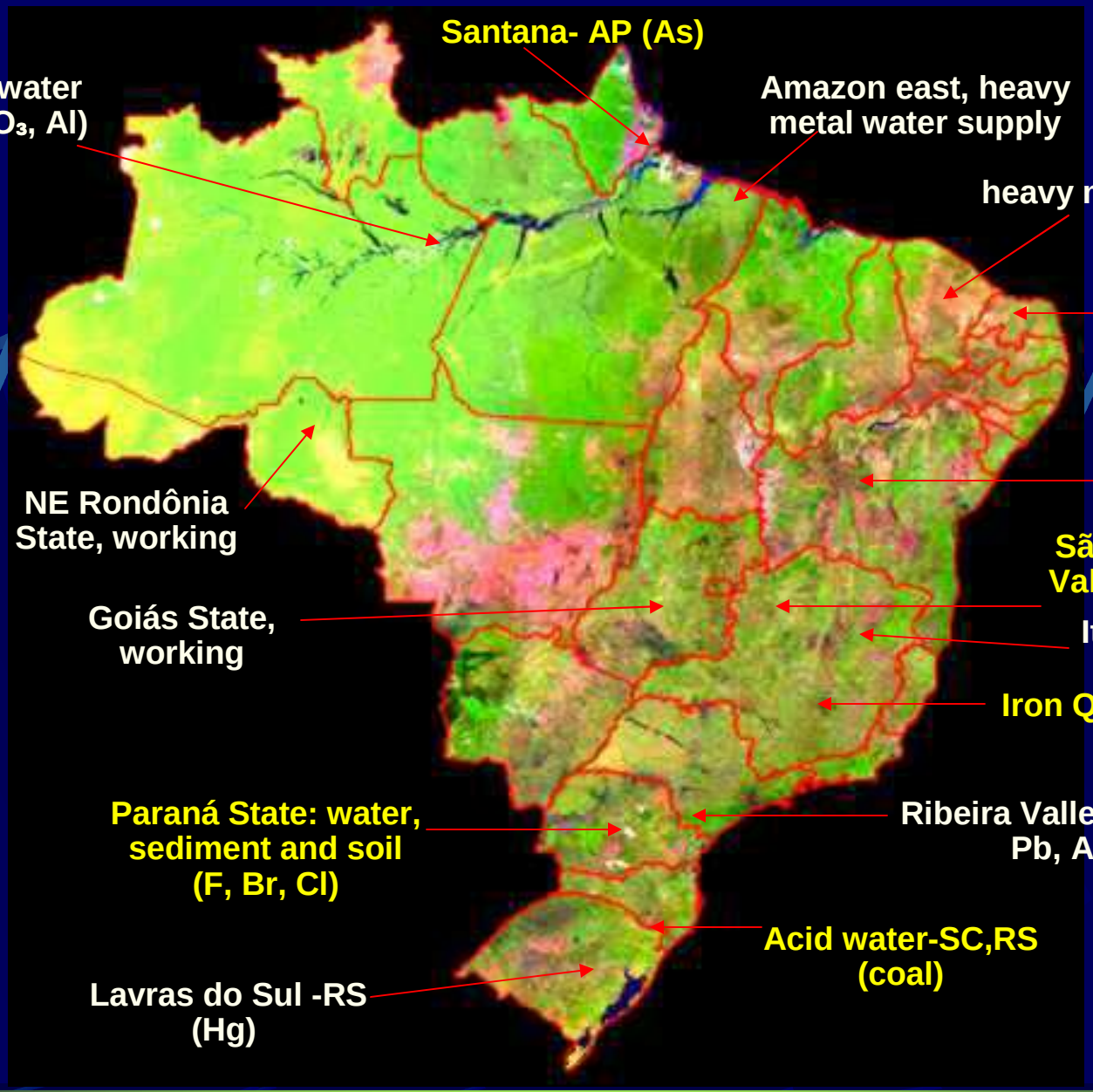
16 to Geological Survey

20 to other researchers

DISSEMINATION ACTIVITIES – 2003/2005

- Medical Geology Workshop (Jun/03) – SGB/CPRM – RJ
- International Workshop on Medical Geology (Oct/03) – Campinas- SP
- Geology Week (Nov/03) – Rural Federal University of Rio de Janeiro-R.
- Brazilian Congress of Geochemistry (Nov/03) – Belem - PA
- Amazon Geological Symposium (Dec/03) – Manaus – AM
- Environment and Mining Congress (Mar/04) – Salvador - BA
- Geology Week (Jun/04) – Federal University of Rio de Janeiro
- 32 IGC (Aug/04) – Florence – Italia
- Brazilian Geological Congress (Oct/04) – Araxa – MG
- Distribution of PGAGEM folder
- International Workshop On Medical Geology (Jun/05) – Rio de Janeiro
- Hydric Resources Seminary of Rondonia (Oct/05)
- Short Course Geochemistry Congress (Nov/05) – P.Galinhas - PE

DISSEMINATION ACTIVITIES 2003/2005 - LOCATION



Main areas of research on medical geology

NATIONAL RESEARCH PROGRAM ON ENVIRONMENTAL GEOCHEMISTRY and MEDICAL GEOLOGY "PGAGEM"- BRAZIL

NATIONAL PARTNERSHIP:

- ***Serviço Geológico do Brasil – CPRM***
- ***Universidade de Campinas – UNICAMP***
- ***Minerais do Paraná – MINEROPAR***
- ***Universidade do Estado de São Paulo – USP***
- ***Universidade Federal do Estado do Pará – UFPA***
- ***Universidade Estadual de Londrina – UEL***
- ***Universidade Federal Fluminense – UFF***
- ***Comissão Nacional de Energia Nuclear – CNEN***
- ***Instituto Evandro Chagas (Health Institute)***
- ***Instituto Adolfo Lutz (Health Institute)***
- ***Escola Nacional de Saúde Pública – ENSP (Health School)***
- ***Fundação Nacional de Saúde – FUNASA (Ministry of Health)***
- ***Empresa Brasileira de Agropecuária – EMBRAPA (Soil)***

INTERNATIONAL PARTNERSHIP:

- ***U.S. Geological Survey (USGS)***
- ***U.S. Armed Forces Institute of Pathology (AFIP)***
- ***Geological Survey of Sweden (SGU)***
- ***International Union of Geological Sciences (IUGS)***
- ***International Medical Geology Association (IMGA)***

OBJETIVES

- Identification of elements: essential and/or toxic compounds;
- Public health support;
- Mineral exploration;
- Identification sources of contamination: industry, agricultural, mining and domestic – rural and urban;

OBJETIVES

- Surface and underground water contamination;
- Regional assessment of environmental degradation
- Environmental impacts;

OBJETIVES

Give support to:

- National Agency of Water, Hydrographic Basin Committee,
- Federal, state and county environmental institutions,
- EEZ, GEO Brazil/IBAMA/PNUMA.

METHODOLOGY

- Environmental geochemistry survey in the whole country
- Establishment of partnerships
- Water samples, soil and rivers and lakes bottom sediments
- On line data base

Hydrographic basin and sampling of sediment

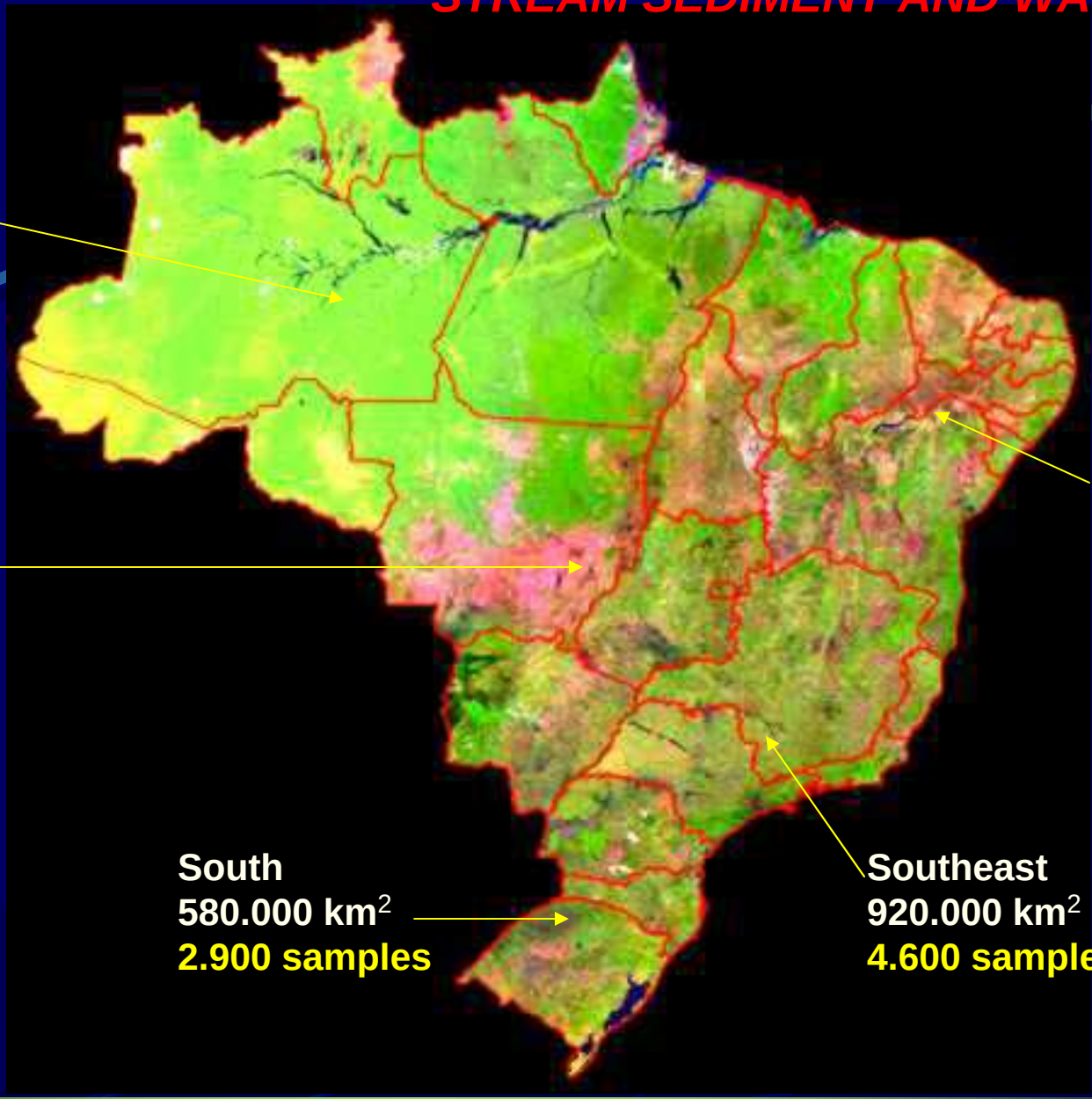
STREAM SEDIMENT AND WATER

Brazil was divided in two areas, according to the access:

AREA I: 1 sample/2.000 Km^2 basin – the remaining territory, areas with remote access (eg. Amazon)

AREA II: density of 1 sample/100 Km^2 basin – larger and most developed country areas, with good access

STREAM SEDIMENT AND WATER



North
3.800.000 km^2
8.250 samples

West Center
1.614.000 km^2
6.200 samples

Northeast
1.600.00 km^2
7.750samples

South
580.000 km^2
2.900 samples

Southeast
920.000 km^2
4.600 samples

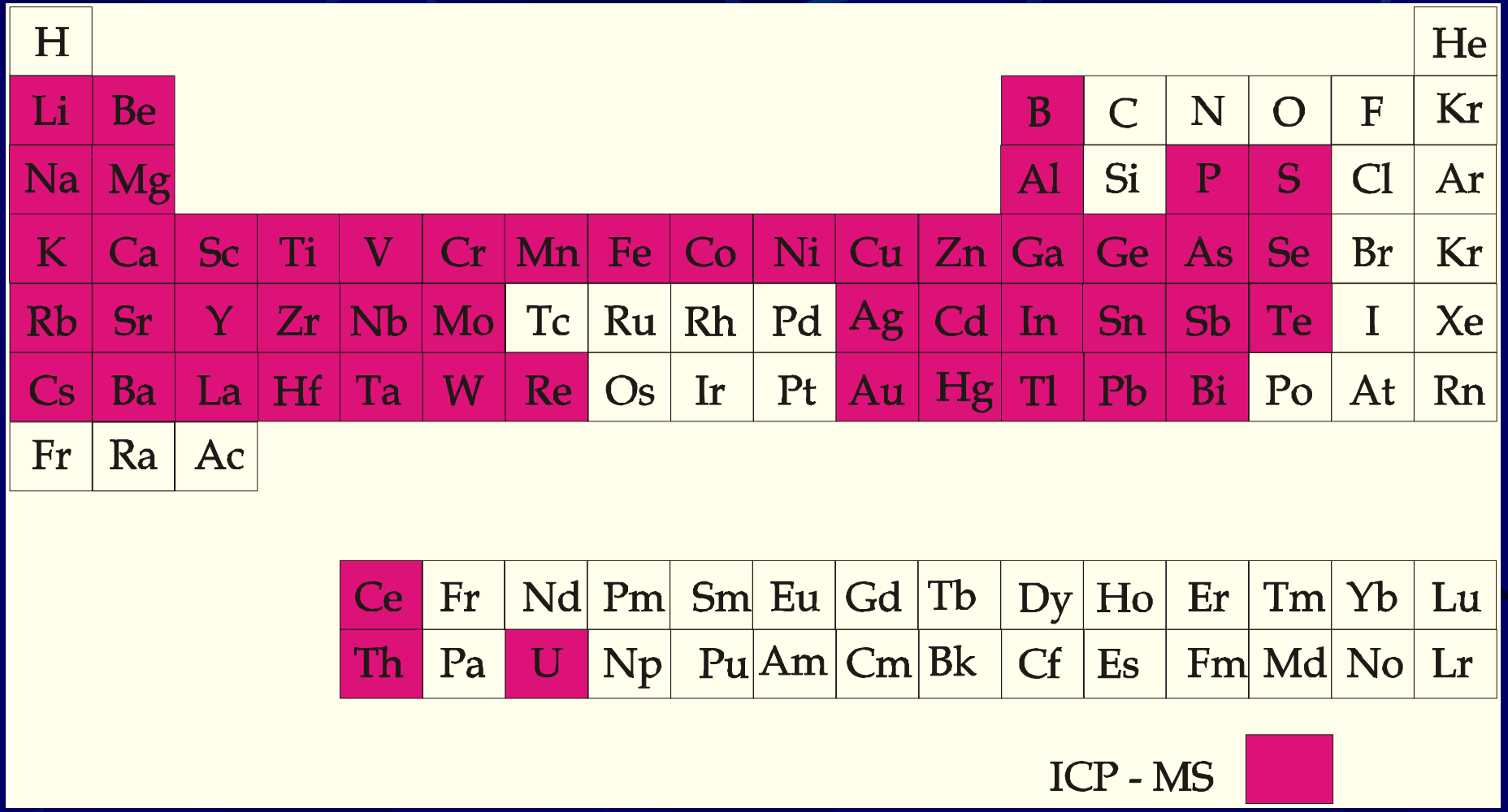
Total
8.514.000 km^2
29.700 samples

- **Water supply:**

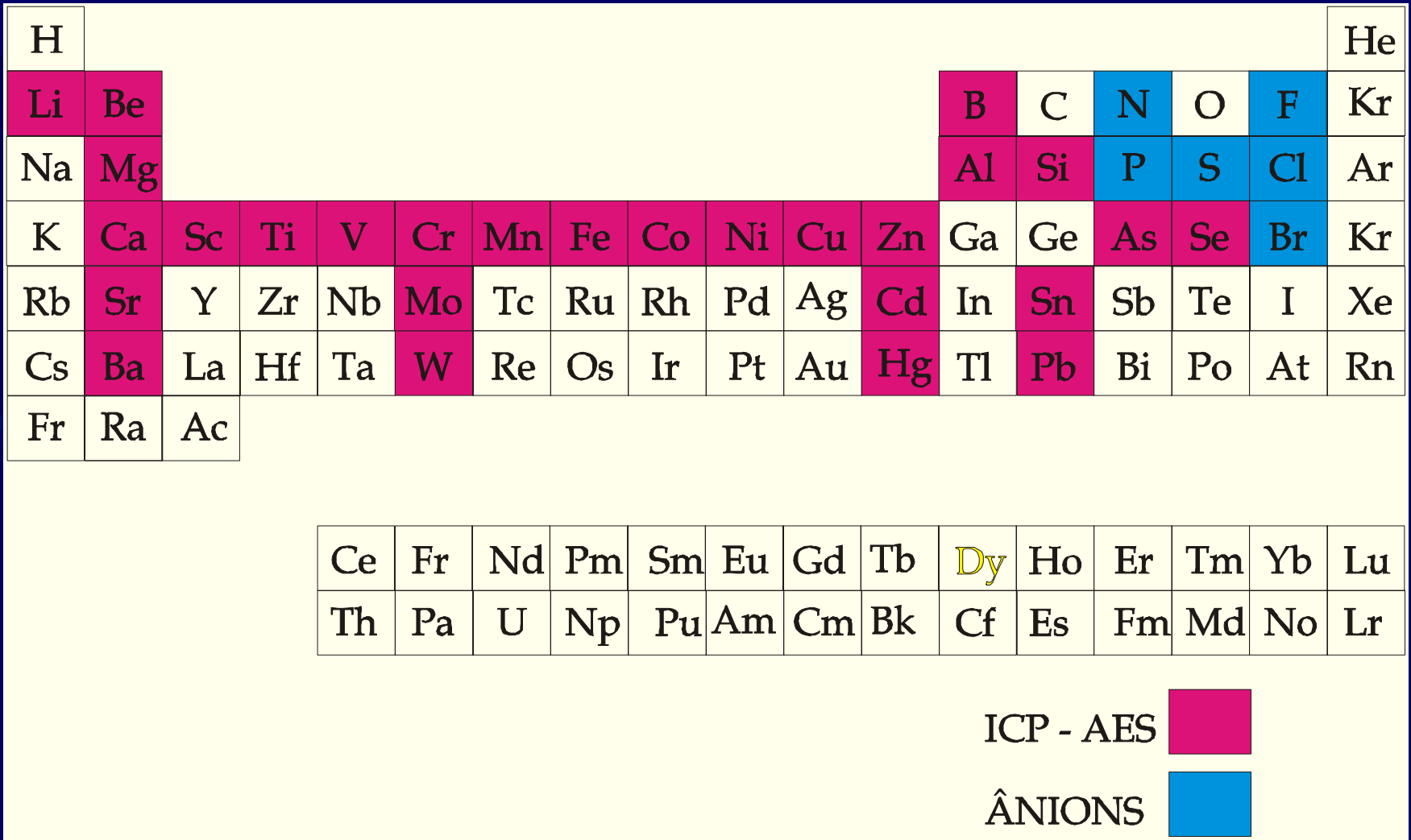
In counties where there is no treated water – 1 water sample will be collected.

- **Soil:**

In counties where the main agricultural products or subsistence farming (soy, bean, cotton, rice, coffee, corn) cultivated areas – 3 soil samples will be collected.



Sediment and soil analysis



WATER QUALITY PHYSICAL PARAMETERS (IN FIELD): Ph, Eh, Conductivity, Dissolved Oxygen, Temperature.

Water (cations and anions) analysis

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ARSENIC OCCURRENCE IN BRAZIL AND HUMAN EXPOSURE

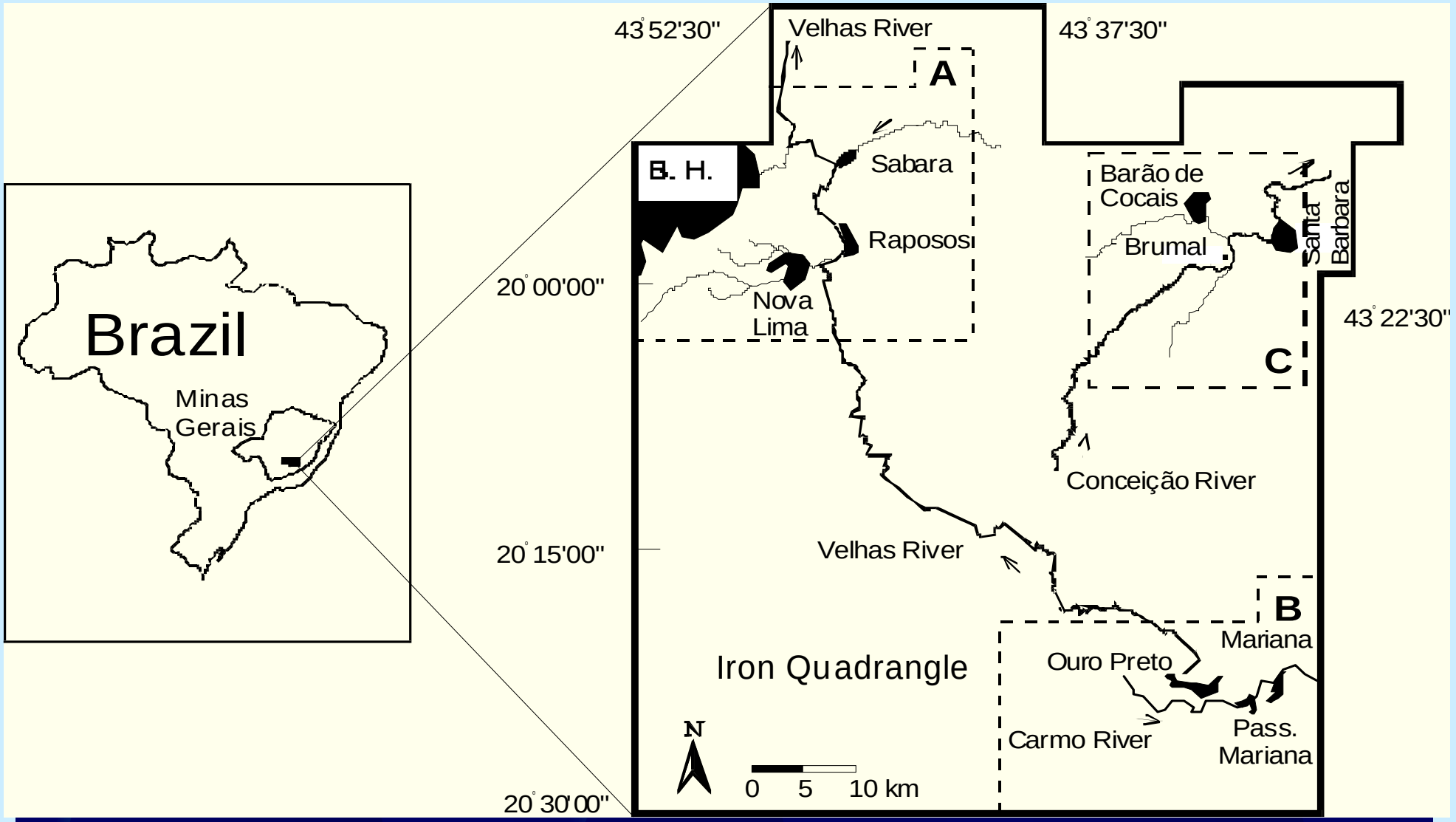
Bernardino R. Figueiredo,

Ricardo P. Borba & Rômulo S. Angélica

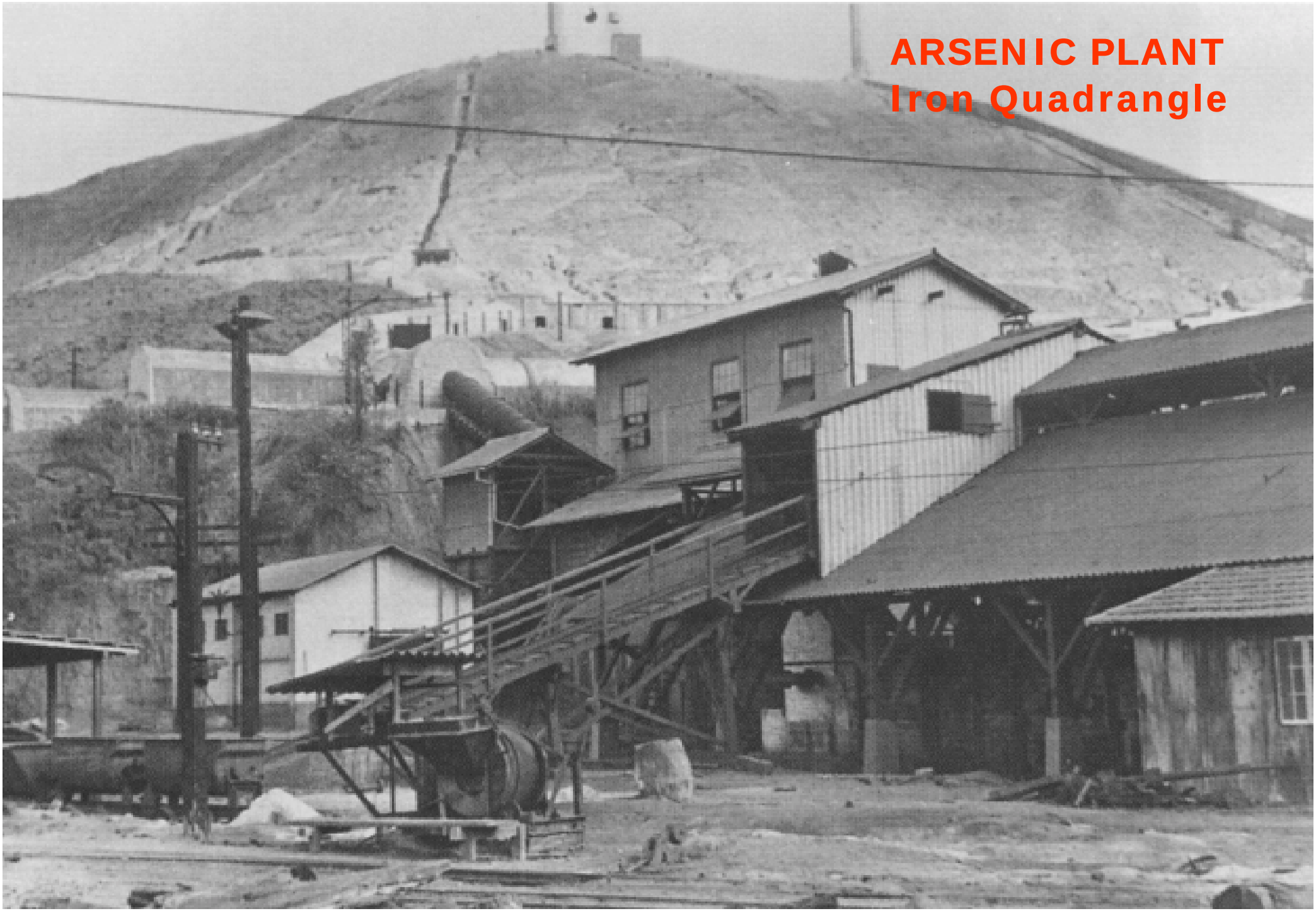
Santana
Amapá

The Iron
Quadrangle

Ribeira
Valley



The Iron Quadrangle, Minas Gerais State


ARSENIC PLANT
Iron Quadrangle

ARSENIC DISTRIBUTION IN THE IRON QUADRANGLE

Sediments

<4,000 mg/Kg As

Surface waters

<350 µg/L As

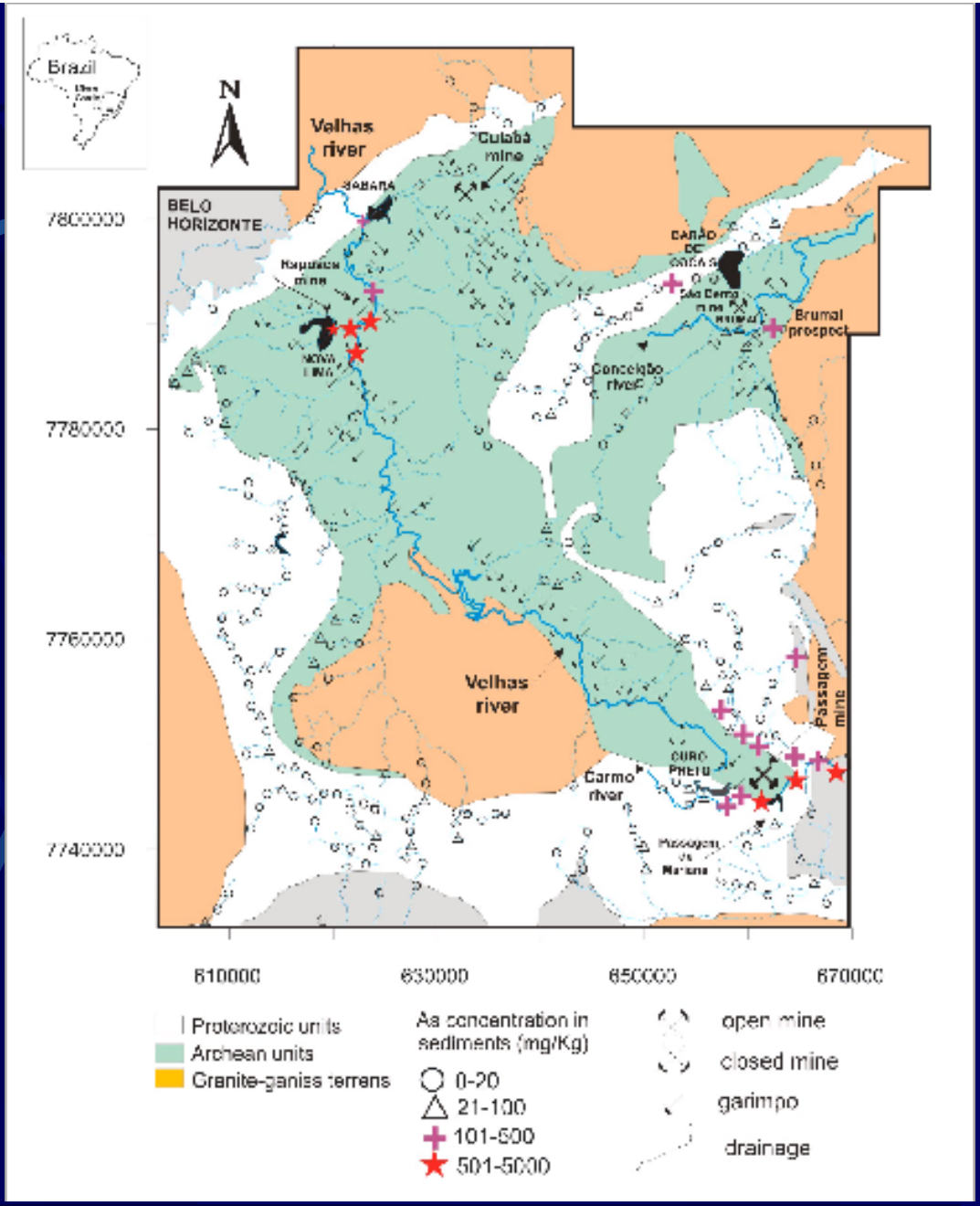
Groundwater

<10 µg/L As

Mine waters

<2980 µg/L As_{total}

<86 µg/L As^{3+}



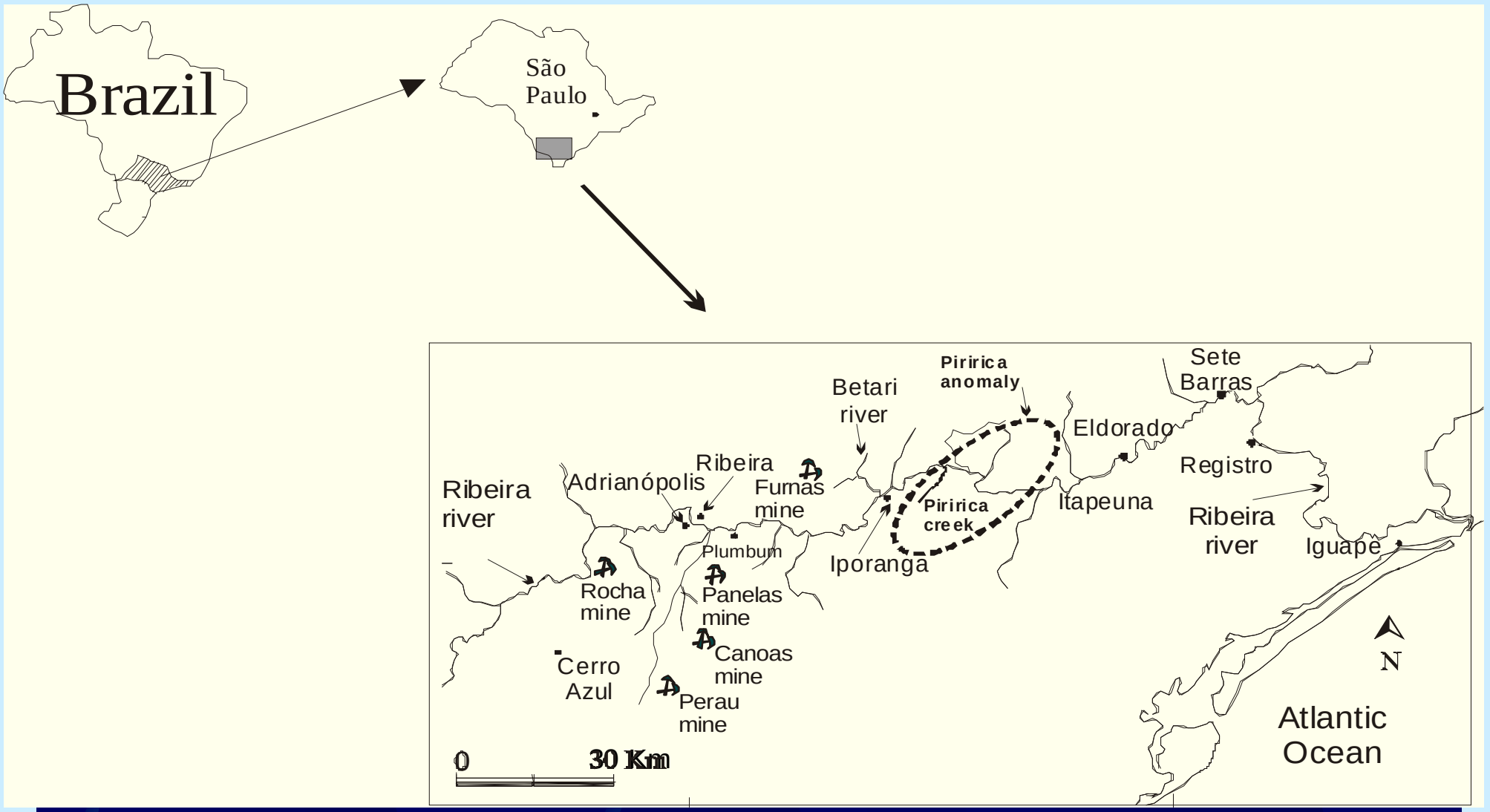
ARSENIC IN URINE – IRON QUADRANGLE 1998 (µg/L As)

Locality	n	mean	boys	girls
Galo		30.2	31.3	29.3
Mingu		18.5	21.4	13.5
Brumal		25.3	27.0	23.8
TOTAL	126	25.7	27.1	24.3

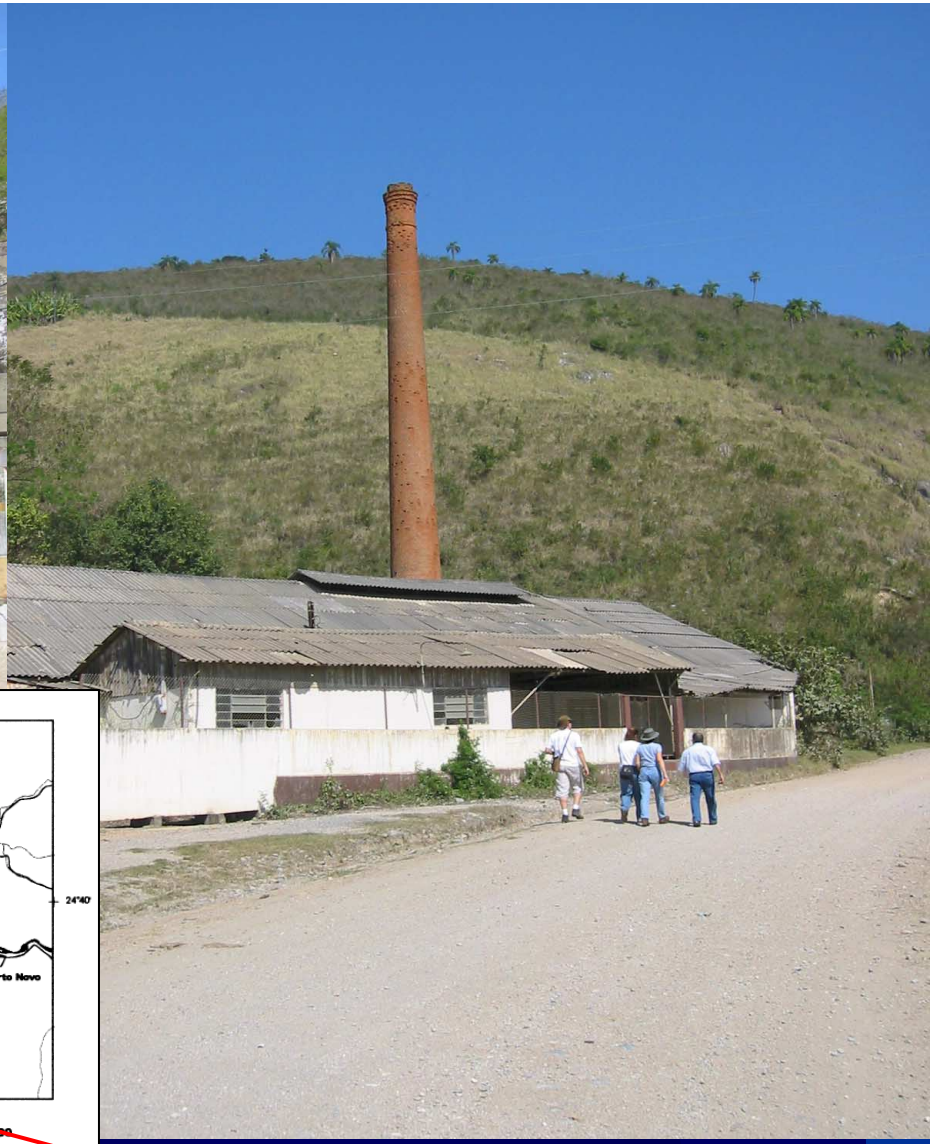
19 % of children > 40 µg/L As

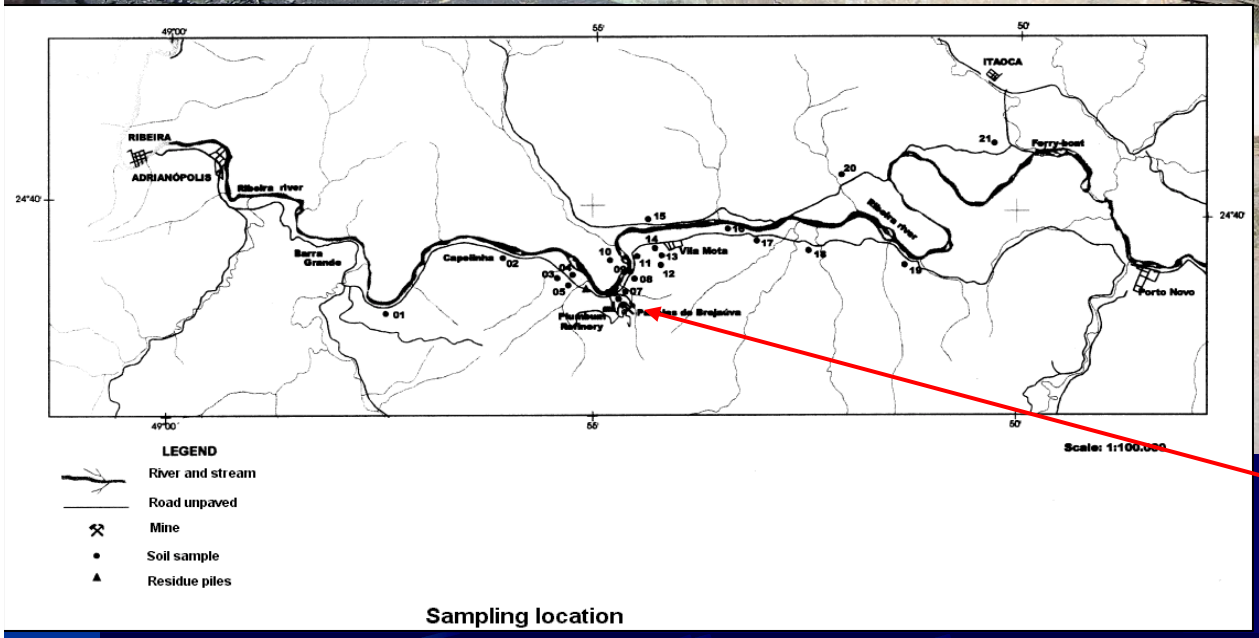
(5% - 2003)

Source: Matschullat et al. (2000, 2004)



Ribeira Valley, Southeastern Brazil





Sampling location

Plumbum Smelter
Ribeira Valley

Middle Ribeira Valley – Natural arsenic anomaly

As contents

Sediments
<355 mg/Kg

Surface water
<9 µg/L

Soils (0-30 cm)
<2,000 mg/Kg

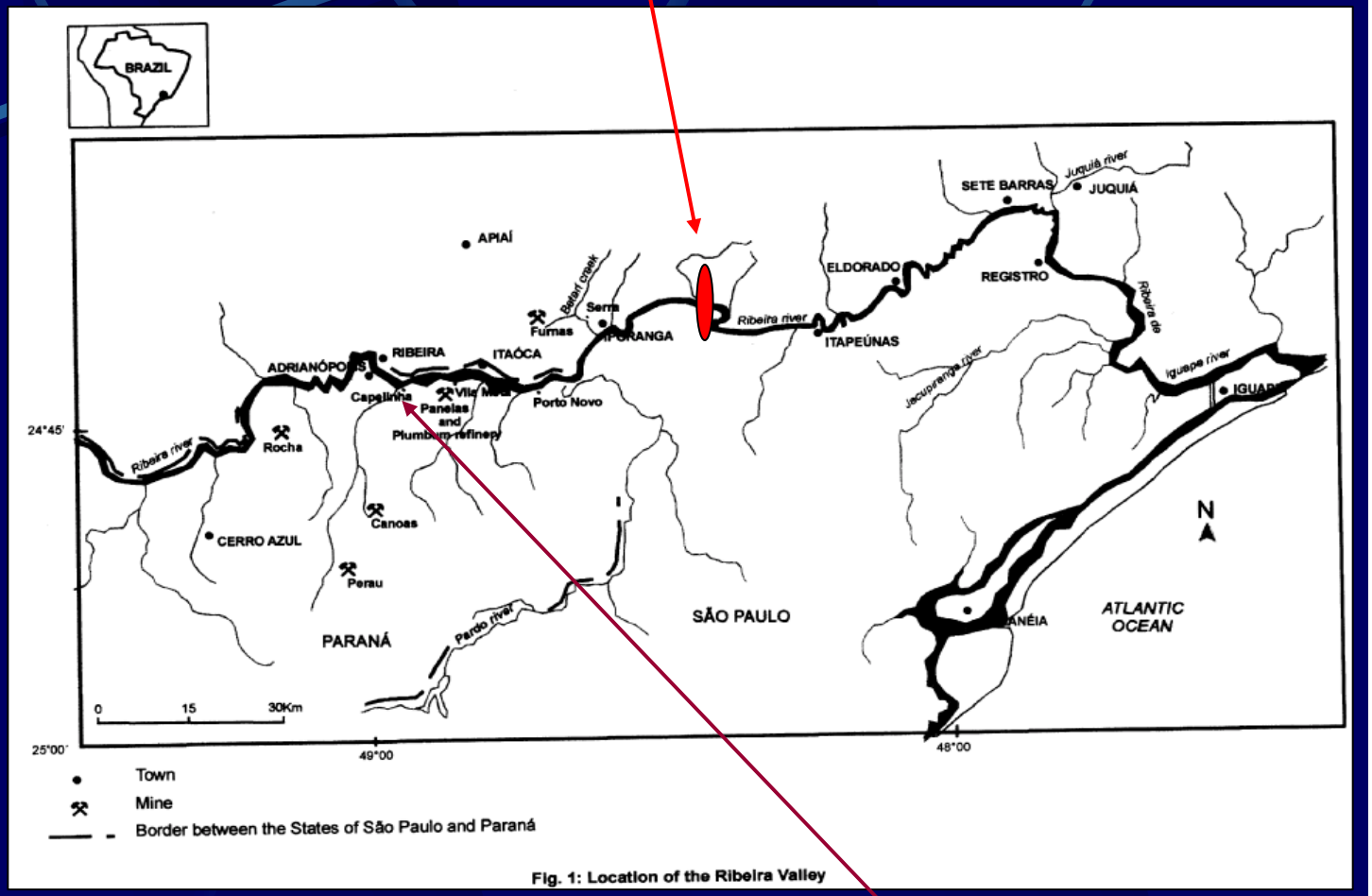


Fig. 1: Location of the Ribeira Valley

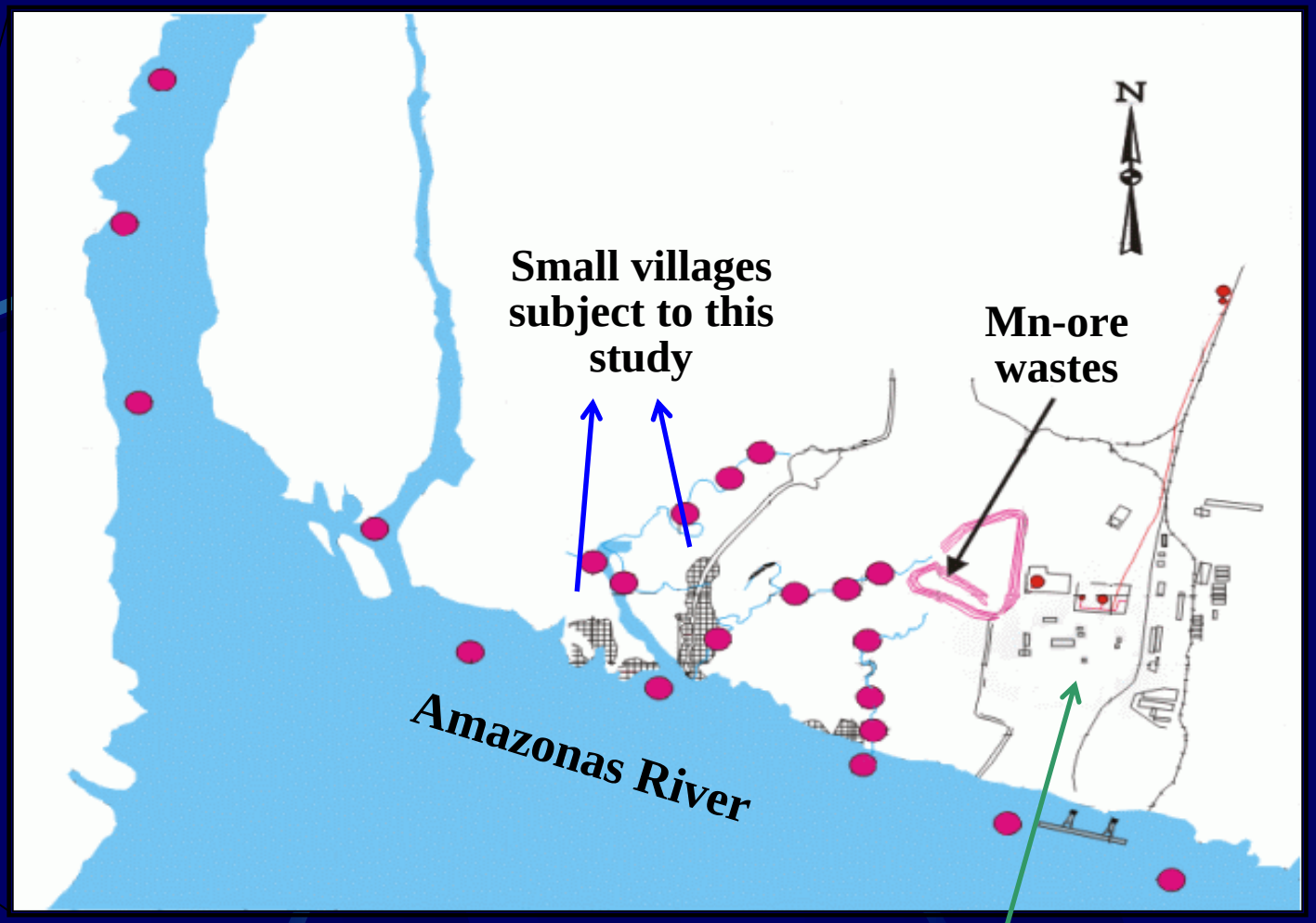
Upper Ribeira Valley – Pb-Zn mining and refinery

ARSENIC IN URINE – RIBEIRA VALLEY – 2002-2003 (µg/L As)

Locality	n	Mean	Min	Max
Cerro Azul	156	3.86	1	34.12
Serra	175	8.90	1	62.54
Iporanga	108	8.35	1	33.49
Pilões	49	4.63	1	68.92
Castelhanos	54	9.48	1	60.32
São Pedro	51	11.35	1	76.19
Maria Rosa	26	2.24	1	24.34
Nhungara	22	6.98	1	36.55
TOTAL	641			

Source: Sakuma et al. (2003, 2005)

SANTANA-AMAPÁ AREA



● Surface water and sediment samples

Beneficiation plant

ARSENIC IN HAIR – SANTANA 2001-2002 (µg/g)

Population	n	Mean	Min	Max
MEN	182	0.200	0.074	1.936
WOMEN	330	0.200	0.063	1.855
TOTAL	512	0.200	0.063	1.936

Source: Santos et al. (2003)

CONCLUDING REMARKS

Only point pollution sources known so far

- High As concentrations in river sediments and soils
- Deep chemical weathering favors As retention in soils and sediments
- Very low As concentrations in surface waters (dilution phenomena)
- Low levels of human exposure for As
- Population less dependent on groundwater supply (except in NE region)

FINAL REMARK

Non-point pollution sources still unknown

- **studies on As-bearing geological formations and major aquifers in Brazil where As-anomalies have been indicated are still to be done**

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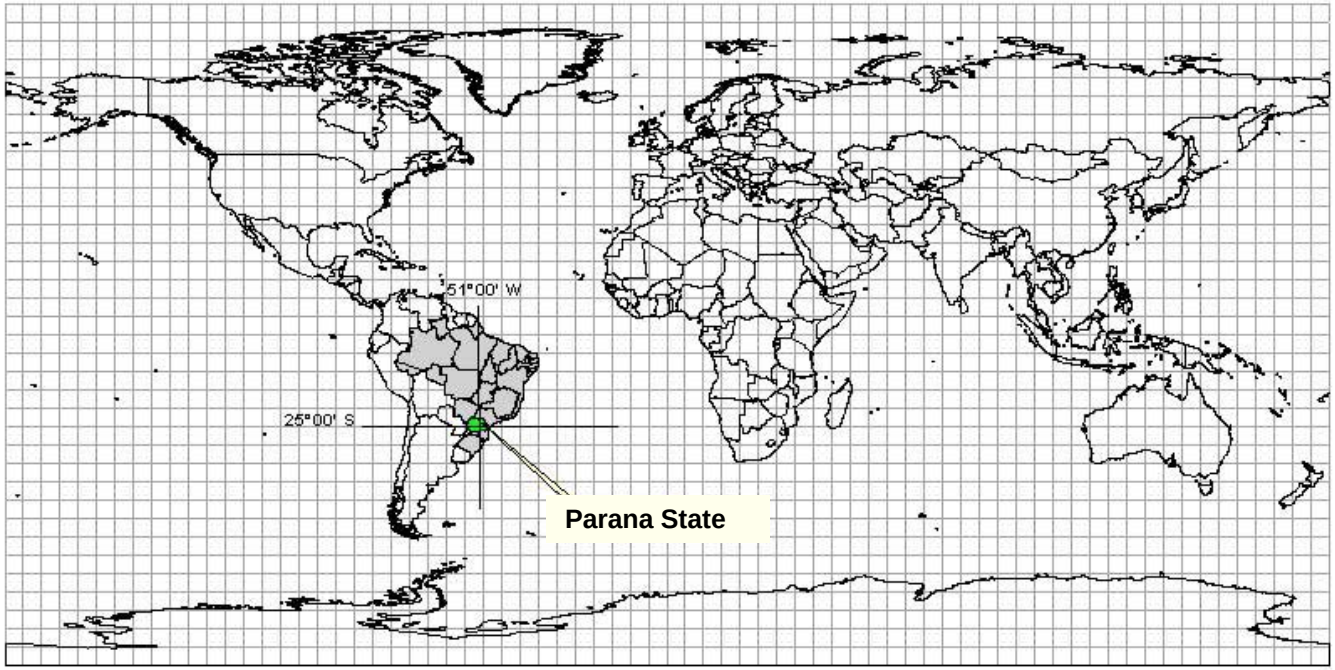
UNICAMP

MULTIELEMENT GEOCHEMICAL OF SURFACE TO DELIMIT ENVIRONMENTAL RISKS AND IMPACTS, PARANÁ STATE, BRAZIL

LICHT, O.A.B., **Otavio@pr.gov.br**

Minerais do Paraná S.A. - MINEROPAR



Low Density Sampling

Area: 200.000 Km²

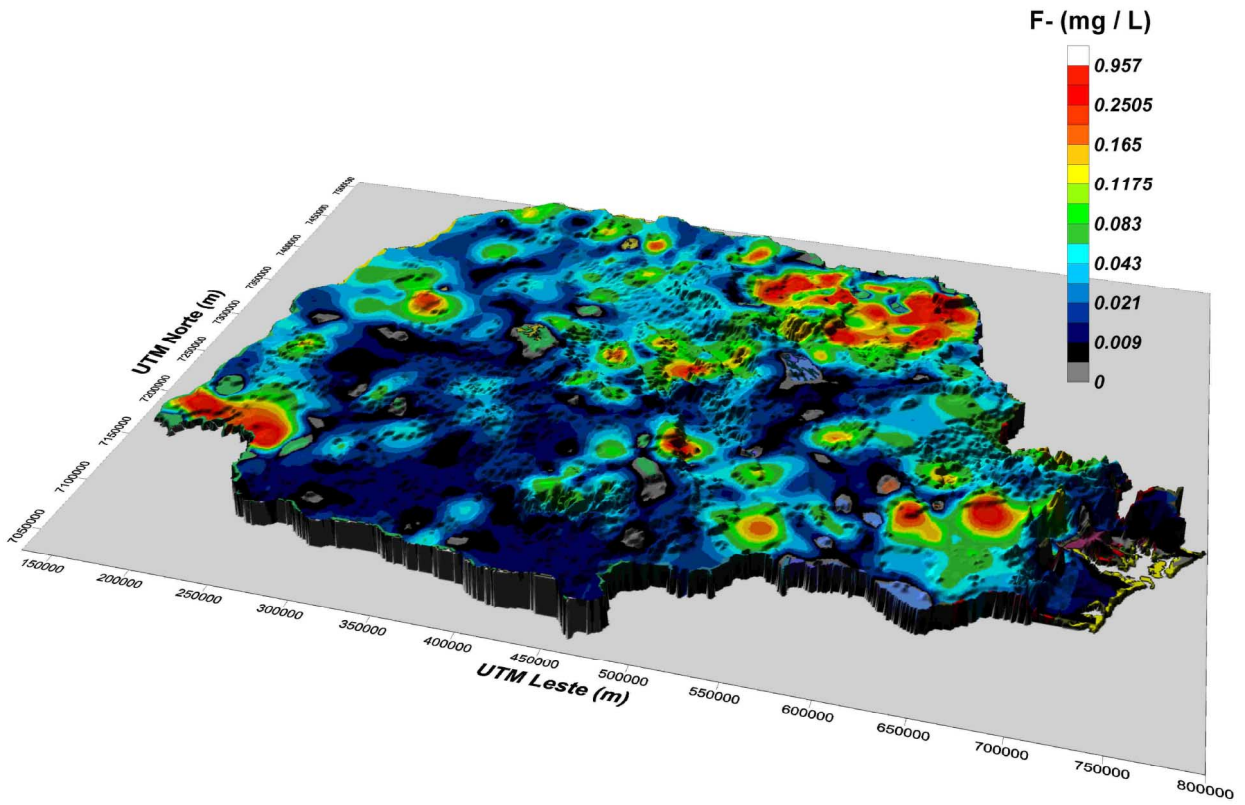
water sample: 696

sediment sample: 696

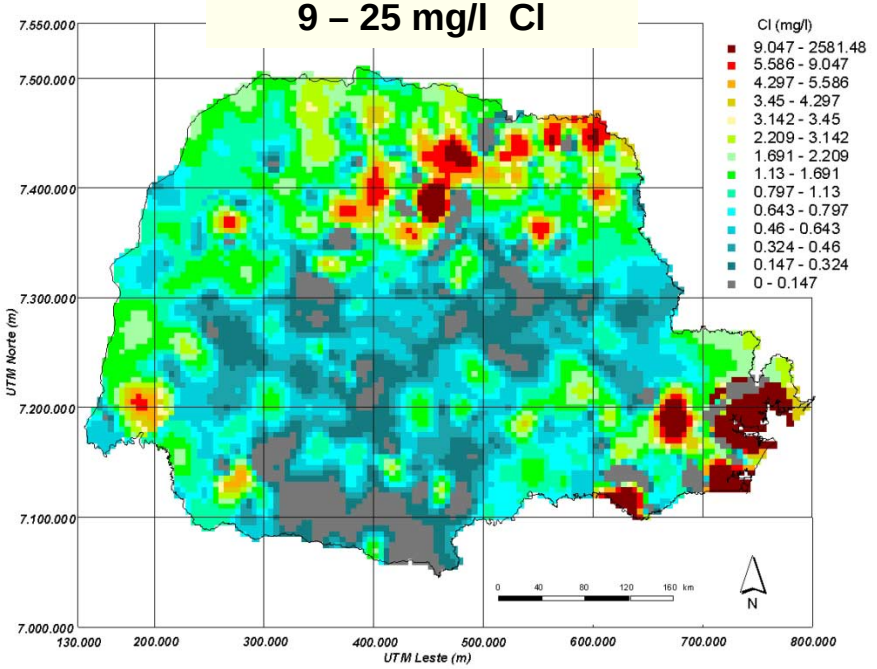
soil sample: 307

2,2 mg/l F

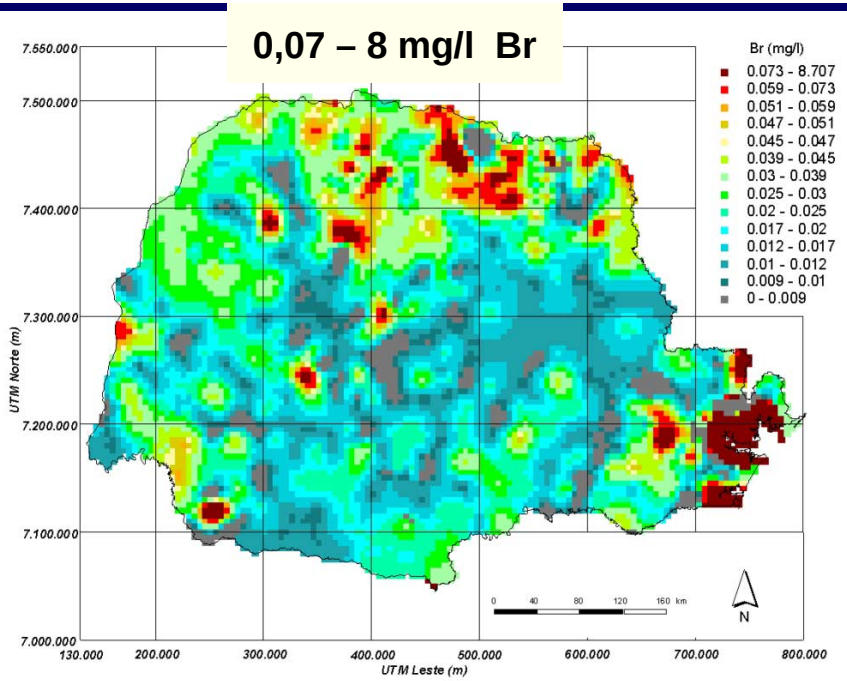
Groundwater

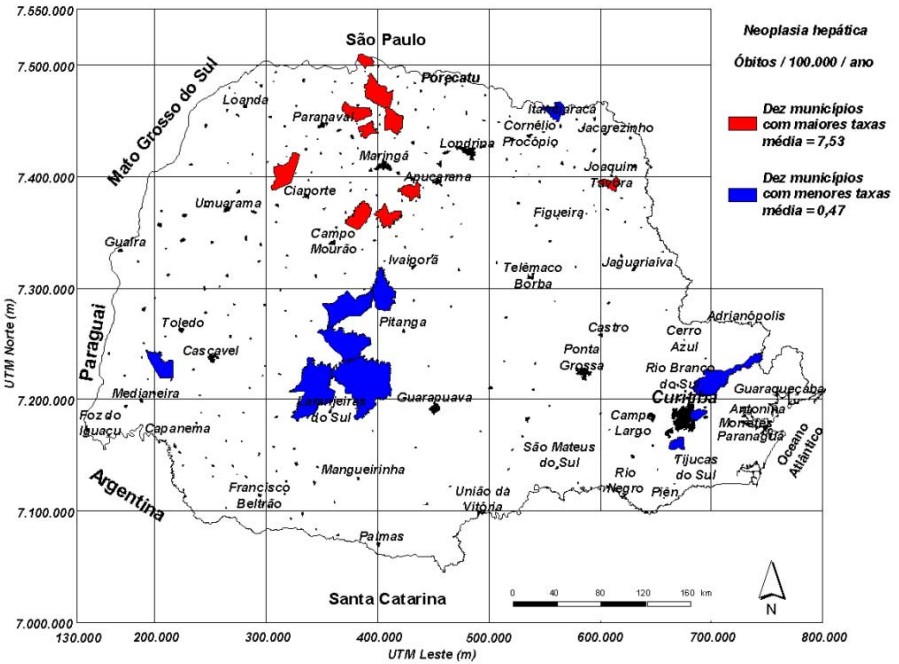


9 – 25 mg/l Cl



0,07 – 8 mg/l Br

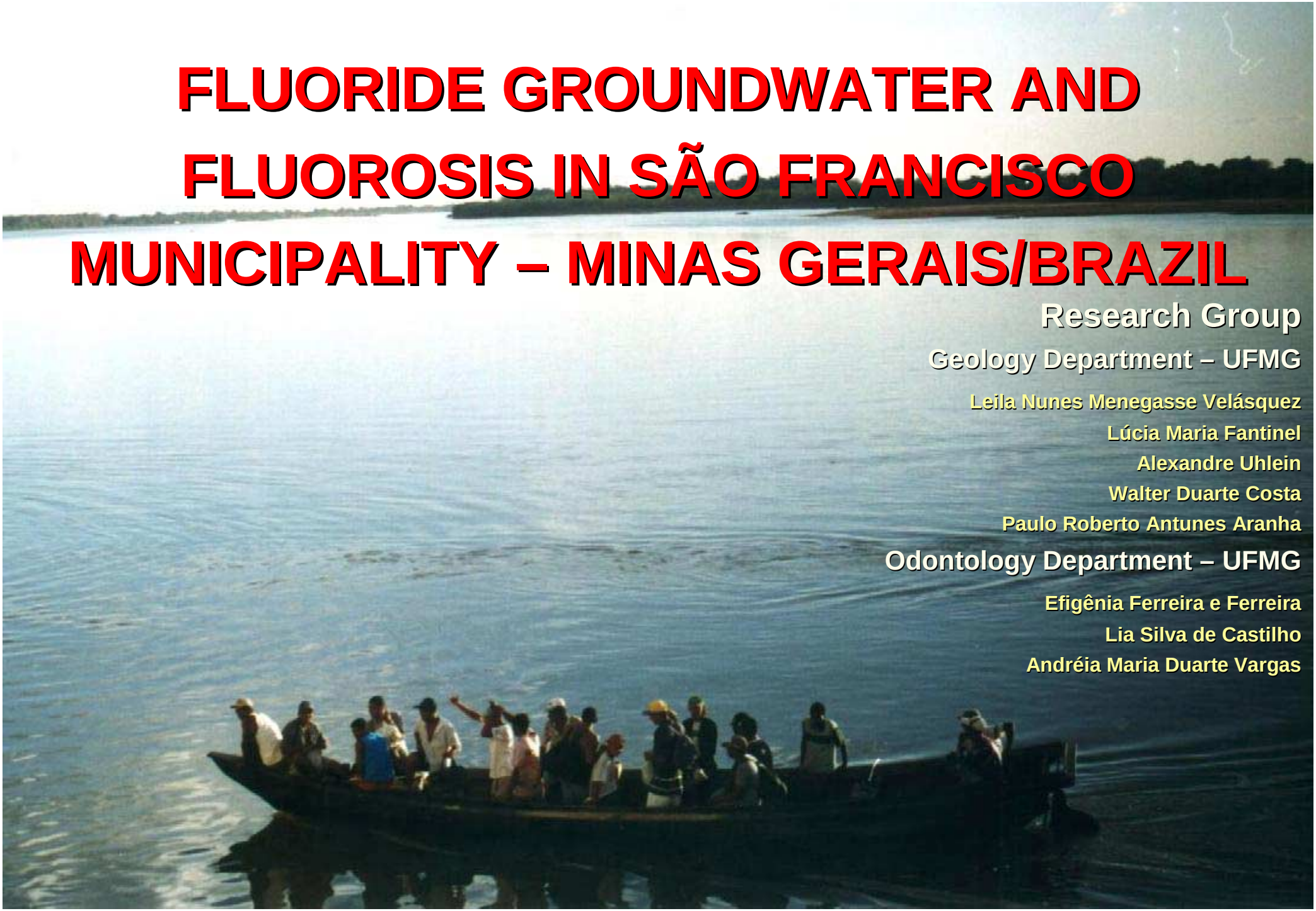




Death: 10 municipality > rate 7.5/100.000 inhabitants cancer of liver

10 municipality < rate 0.47/100.000 inhabitants

FLUORIDE GROUNDWATER AND FLUOROSIS IN SÃO FRANCISCO MUNICIPALITY – MINAS GERAIS/BRAZIL



Research Group

Geology Department – UFMG

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Walter Duarte Costa

Paulo Roberto Antunes Aranha

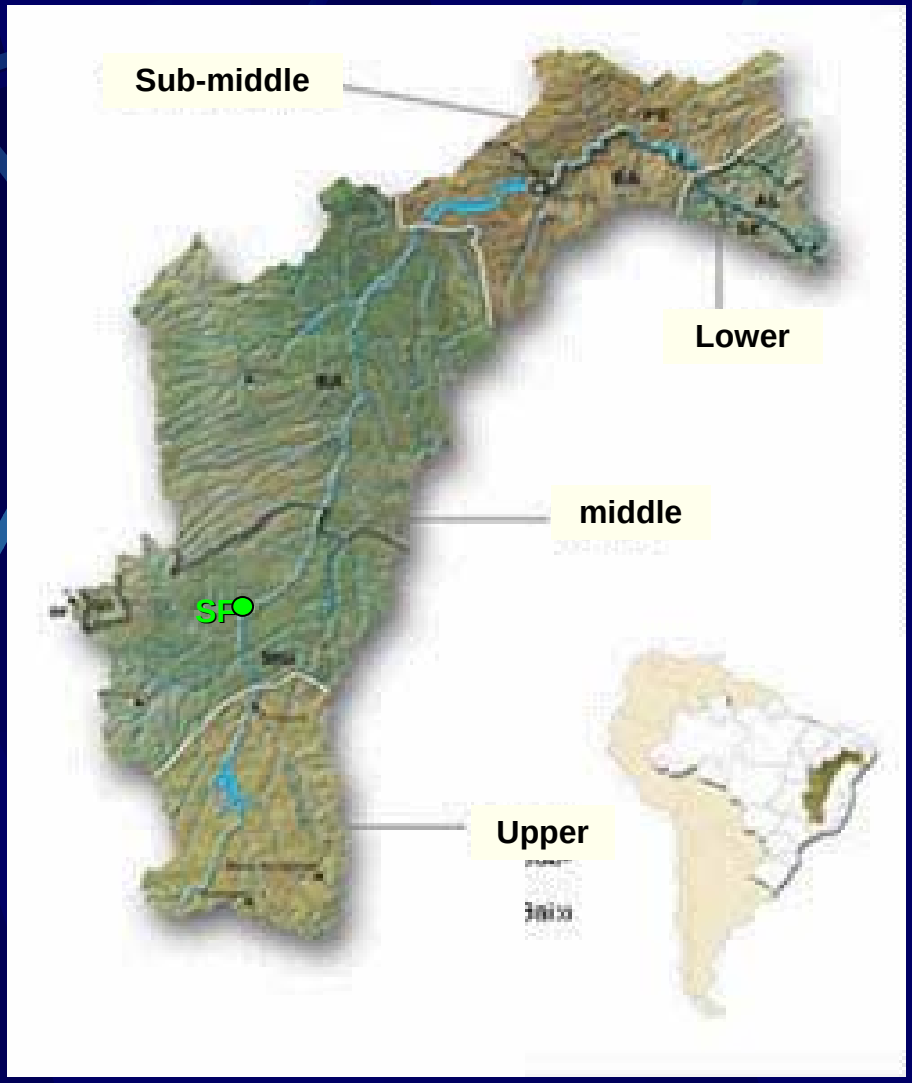
Odontology Department – UFMG

Efigênia Ferreira e Ferreira

Lia Silva de Castilho

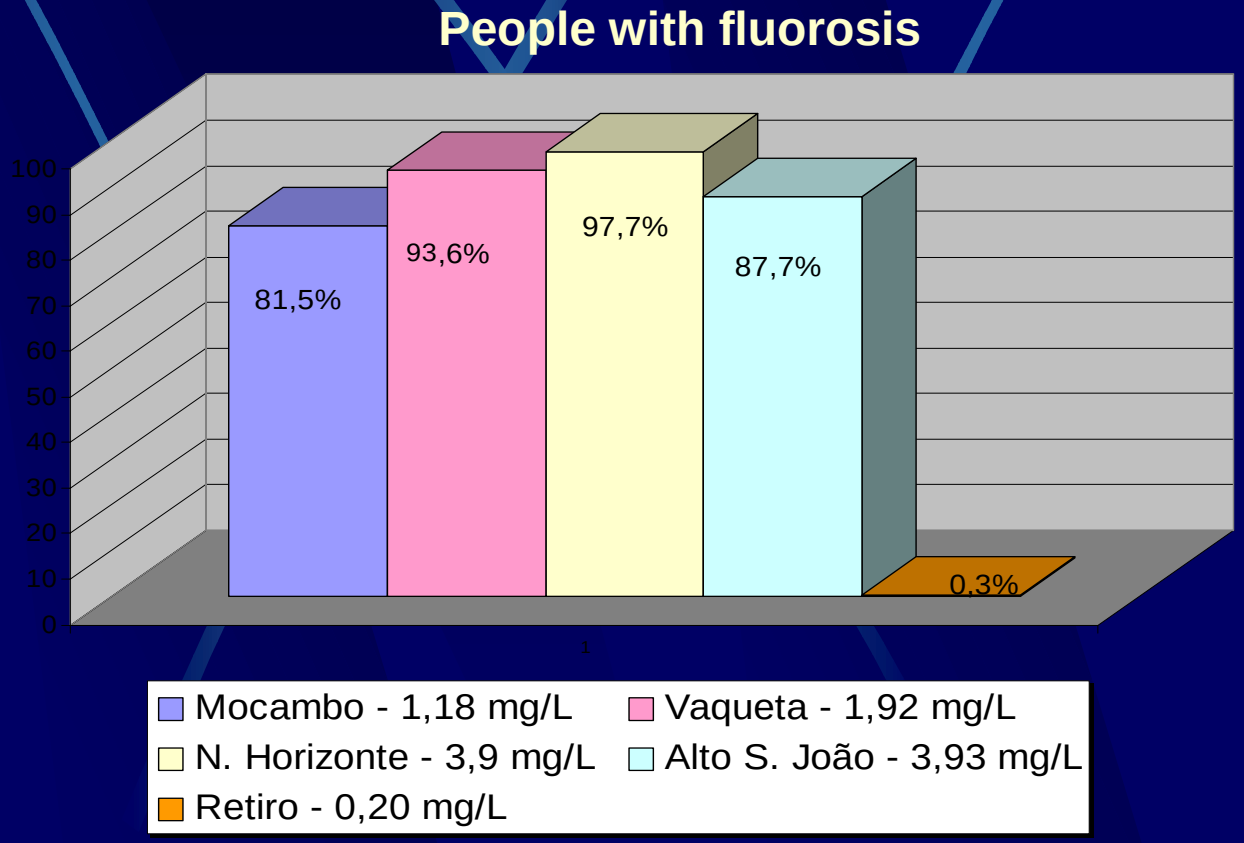
Andréia Maria Duarte Vargas

Location: São Francisco river basin



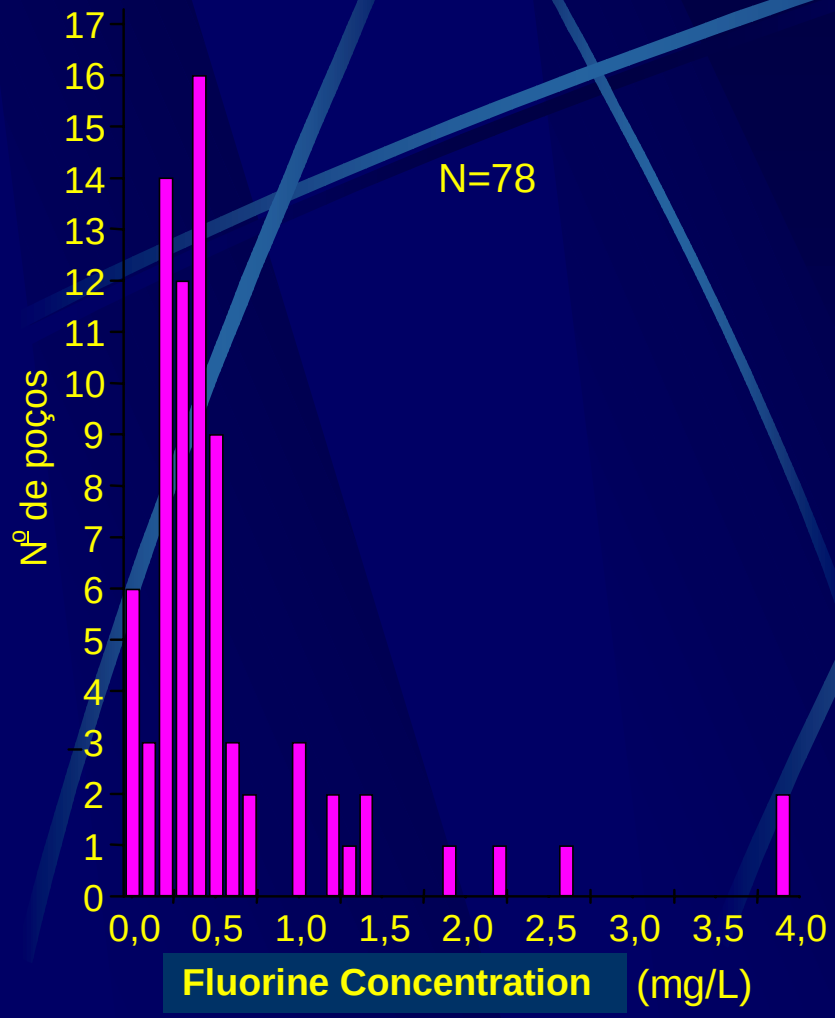
Epidemiological Research

Fluorosis - Mocambo



65,4% high level

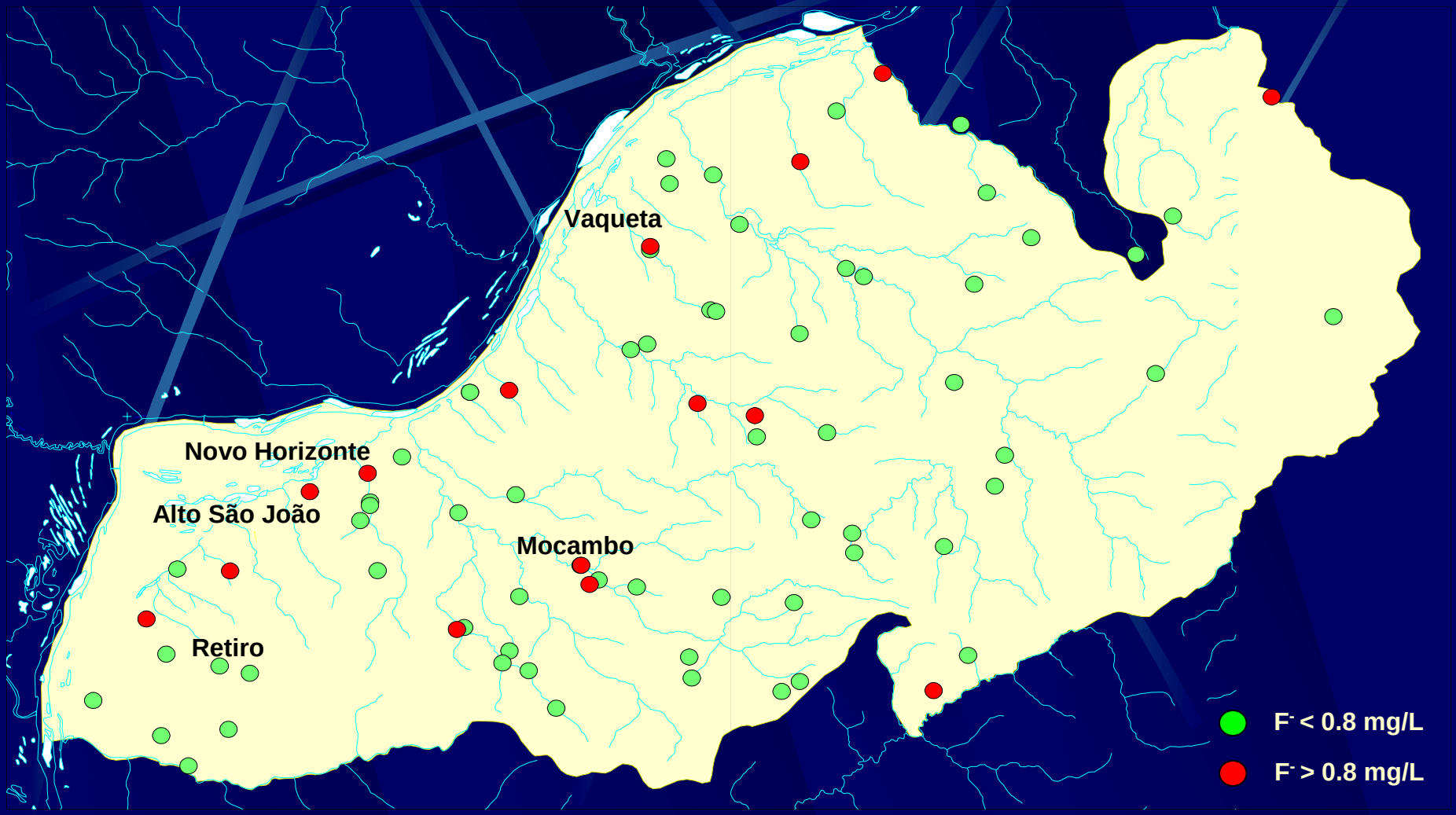
Fluorine concentration in groundwater



- *Background*: 0,45mg/L
- 27 samples above BG (34.6%)
- 13 samples above MVP (16.7%)

MVP =	T ºC	Good (mg/L)	Max (mg/L)	
	26.4 – 32.5	0.7	0.8	Source: MS/1976

Fluorine distribution in groundwater



Conclusions

- High endemic tooth fluorosis in São Francisco municipality;
- The cause of the tooth fluorosis is the long consumption of groundwaters rich in F^- (> 0.8 ppm) ;
- Fluoride disseminated in calcitic veins, in limestone, is the main source of contamination;
- The anomalous of F^- has hard association with fractures and with the stratigraphy;
- It is necessary to expand the research to other areas, north and east of Bambuí Supergroup (limestone).

The biofortification as a tool to prevent micronutrients deficiency

Marilia Regini Nutti

Embrapa Agroindustry of Aliments

Research network

1 - Embrapa Acre
2 - Embrapa Agrobiology
3 - Embrapa Food Technology
4 - Embrapa Tropical Agroindustry
5 - Embrapa Agriculture West
6 - Embrapa Cotton
7 - Embrapa Amapá
8 - Embrapa Western Amazon
9 - Embrapa Eastern Amazon
10 - **Embrapa Rice and Beans**
11 - Embrapa Goats
12 - Embrapa Cerrados
13 - Embrapa Temperate Climate
14 - Embrapa Forests
15 - Embrapa Beef Cattle
16 - Embrapa Dairy Cattle
17 **- Embrapa Vegetables**
18 - Embrapa Agricultural Information
19 - Embrapa Agricultural Instrumentation
20 **- Embrapa Cassava & Fruits**
21 - Embrapa Environment
22 - Embrapa Mid-North
23- **Embrapa Maize & Sorghum**
28- Embrapa Genetic Resources & Biotechnology

Agricultural Ministry

BRASIL UM PAÍS DE TODOS GOVERNO FEDERAL

Situation in Brazil - Micronutrients

- ✓ **Epidemiologic Data :**

  Iron Deficiency

  Vitamin A Deficiency

  Iodine Deficiency (fortification with kitchen salt)

- ✓ **Isolated studies show:**

  Problem related to Zn and Se

  Ca (low swallow)

  Other ??

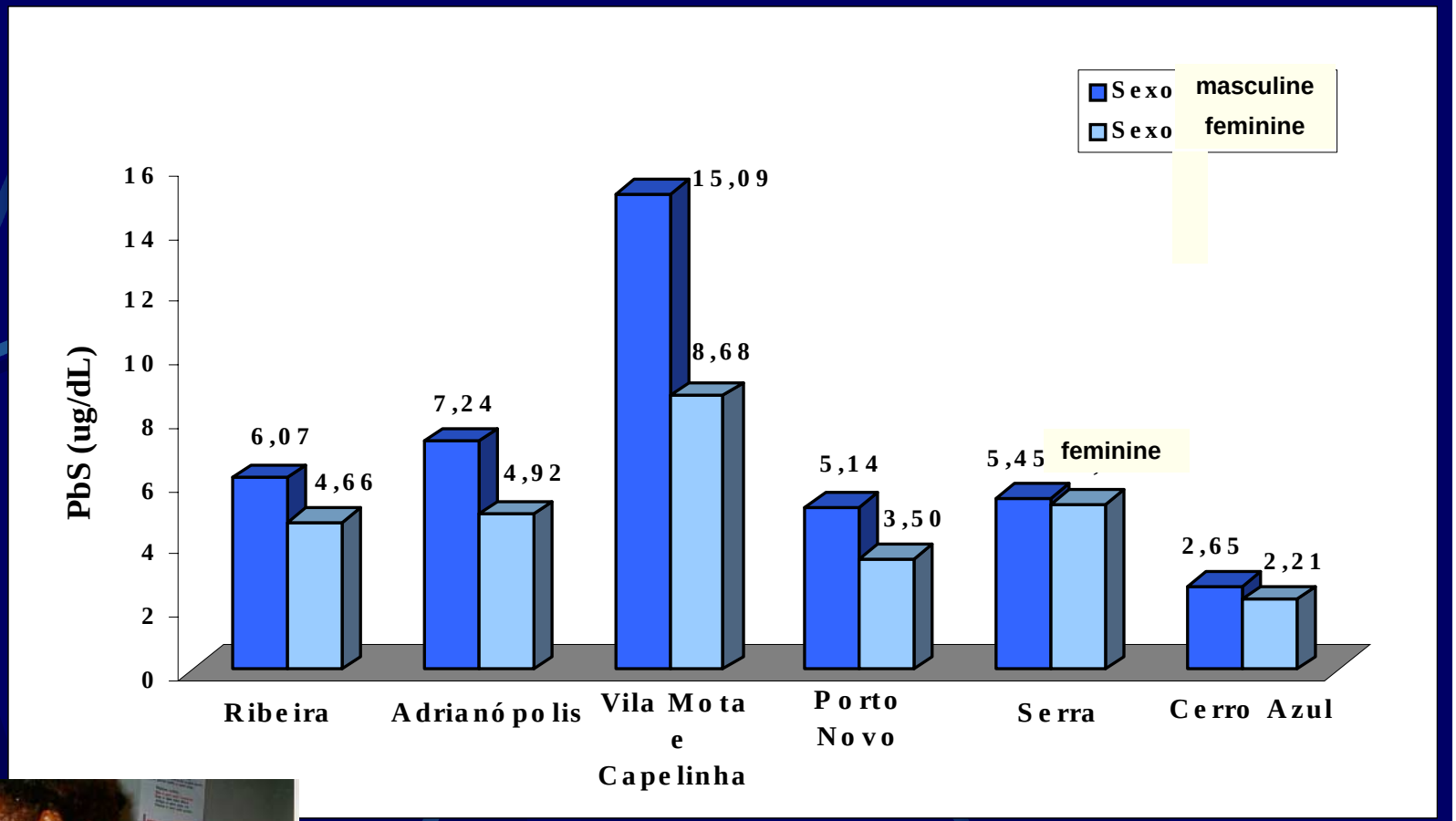
CONCLUSIONS

- **1)** The swallow of some minerals (Fe, Ca, Zn , Se) is lower than recommended or is faintly bio-available in diet.
- 2) Biochemical parameters lower than reference values: population risk groups, confirm the necessity of intervention
- 3) Solution to the problem depends on integrated efforts of scientific community, industries and government, searching for best alternatives

Pb HUMAN AND ENVIRONMENTAL CONTAMINATION IN ADRIANÓPOLIS, PARANÁ STATE, BRAZIL

Fernanda Gonçalves da Cunha[1], Bernardino Ribeiro de Figueiredo[2], Mônica Maria Bastos Paoliello[3], Eduardo Mello De Capitani[4], Alice Sakuma[5]

[1]Serviço Geológico do Brasil, [2]Instituto de Geociências/UNICAMP, [3]Departamento de Patologia Aplicada, Legislação e Deontologia/Universidade estadual de Londrina, [4]Faculdade de Ciências Médicas/UNICAMP, [5]Instituto Adolfo Lutz,



Middle concentrations of Pb in children's blood (335), per sex

Conclusion

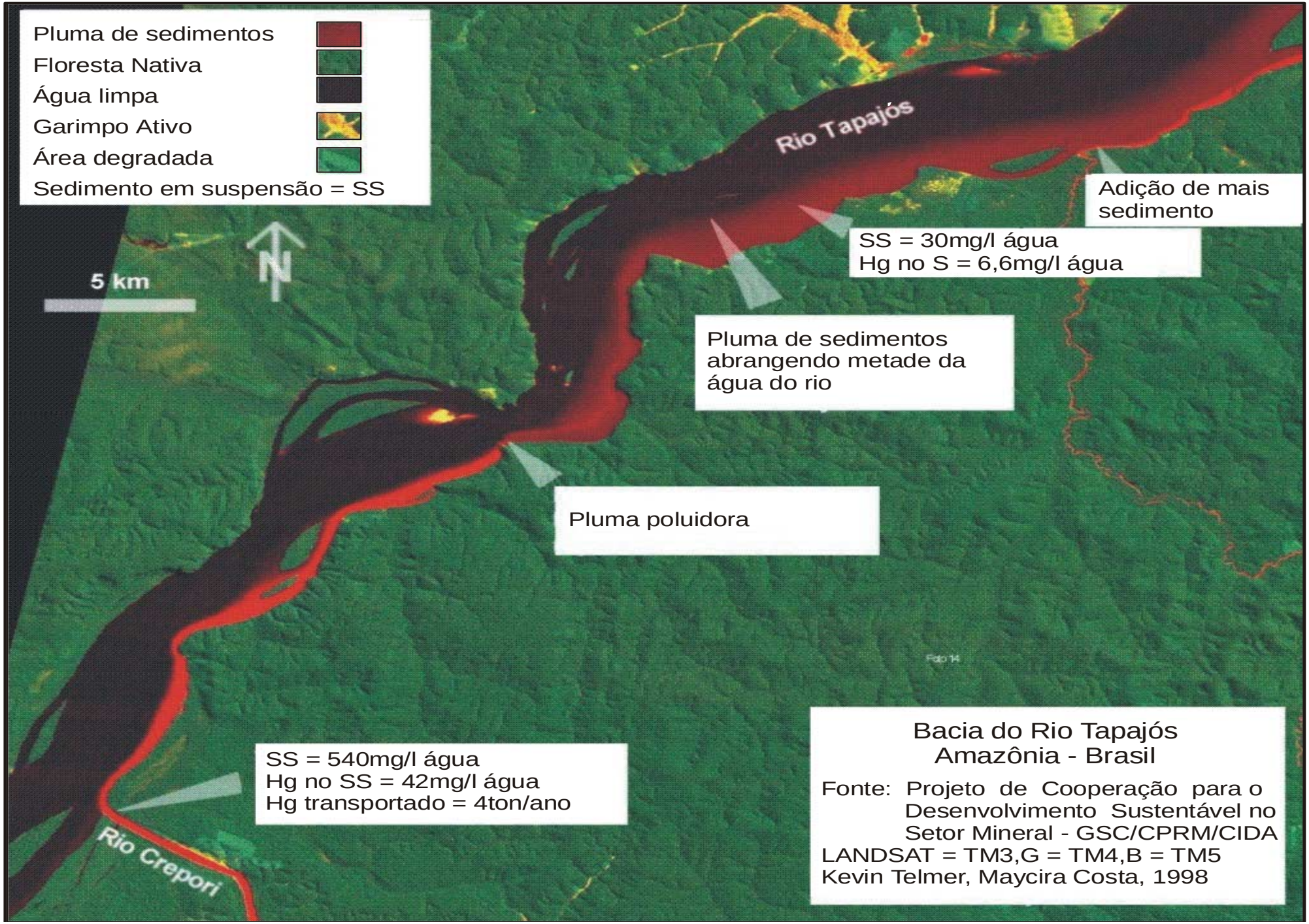
Area 4 Km^2 surroundings of the metallurgy (soil with 21-916 µg/g)

20 children of Capelinha and Mota Village with more than 10 µg/dL (60% of the analysed children)

Contamined mainly by dust and food (local vegetable)

Garimpos Areas

Extensive areas contaminated with Hg in Au "garimpos"


Pluma de sedimentos
Floresta Nativa
Água limpa
Garimpo Ativo
Área degradada
Sedimento em suspensão = SS
Rio Tapajós
Adição de mais sedimento
SS = 30mg/l água
Hg no S = 6,6mg/l água
5 km
N
Pluma de sedimentos abrangendo metade da água do rio
Pluma poluidora
SS = 540mg/l água
Hg no SS = 42mg/l água
Hg transportado = 4ton/ano
Rio Crepori
Bacia do Rio Tapajós
Amazônia - Brasil
Fonte: Projeto de Cooperação para o Desenvolvimento Sustentável no Setor Mineral - GSC/CPRM/CIDA
LANDSAT = TM3,G = TM4,B = TM5
Kevin Telmer, Maycira Costa, 1998

Hg garimpeiro's hair on Amazon Brazil 1996

Poconé, MT, out garimpo	0,3 a 3 ppb
Poconé, in garimpo area : (34 ppb after amálgama burn by 16 years)	1,3 a 34 ppb
Cumaru, PA, max	14 ppb
Rio Madeira, RO, max	97 ppb
Rainha, Rio Tapajós, max	34 ppb
São Luiz do Tapajós, max	48 ppb
Barreiras, Rio Tapajós, max	71 ppb
Paraná Mirim, Rio Tapajós, max	15 ppb

- **Reference hair, WHO, 1 – 2 ppb**

GEOCHEMISTRY IN PUBLIC SUPPLY WATER, EAST AMAZON

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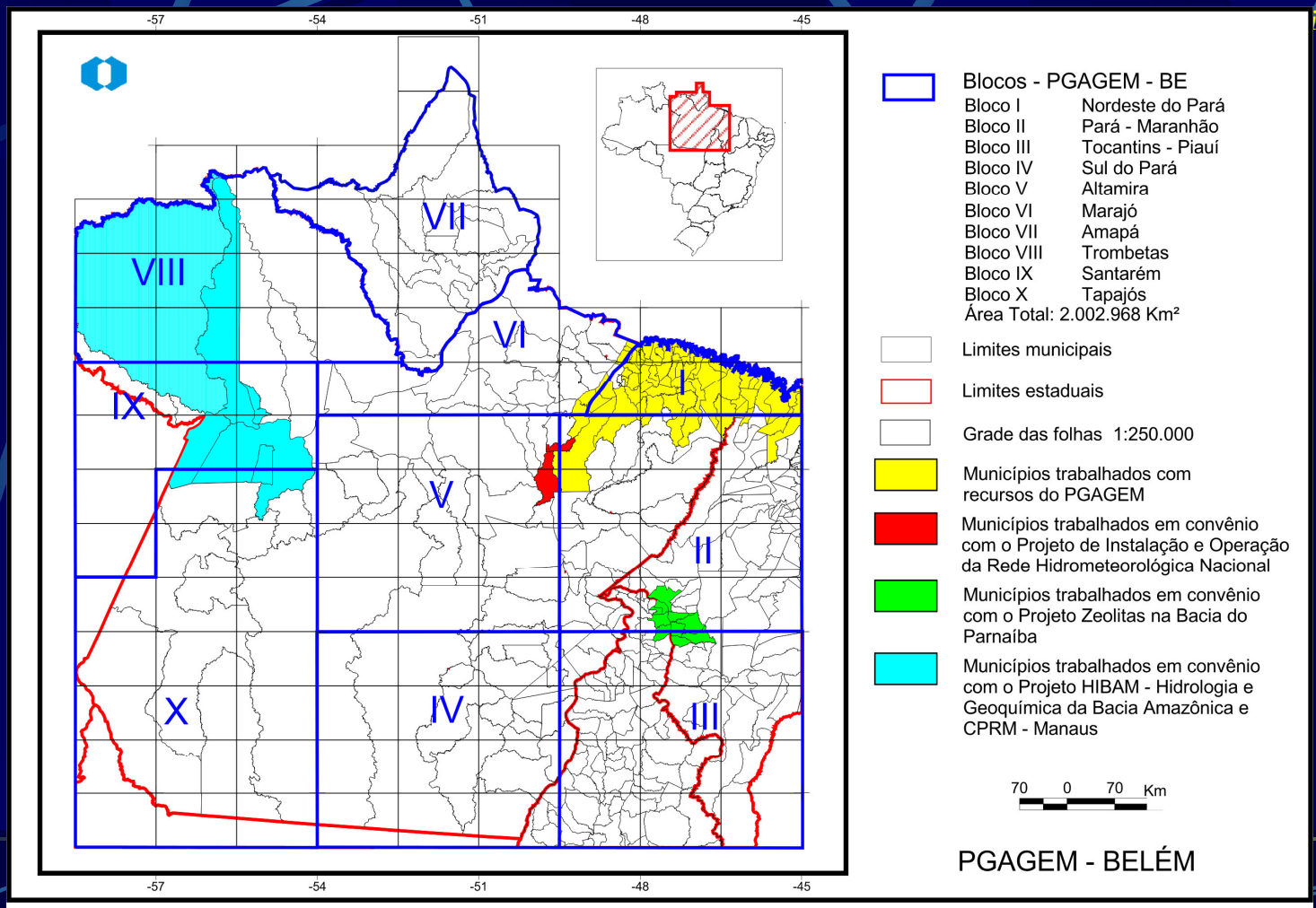
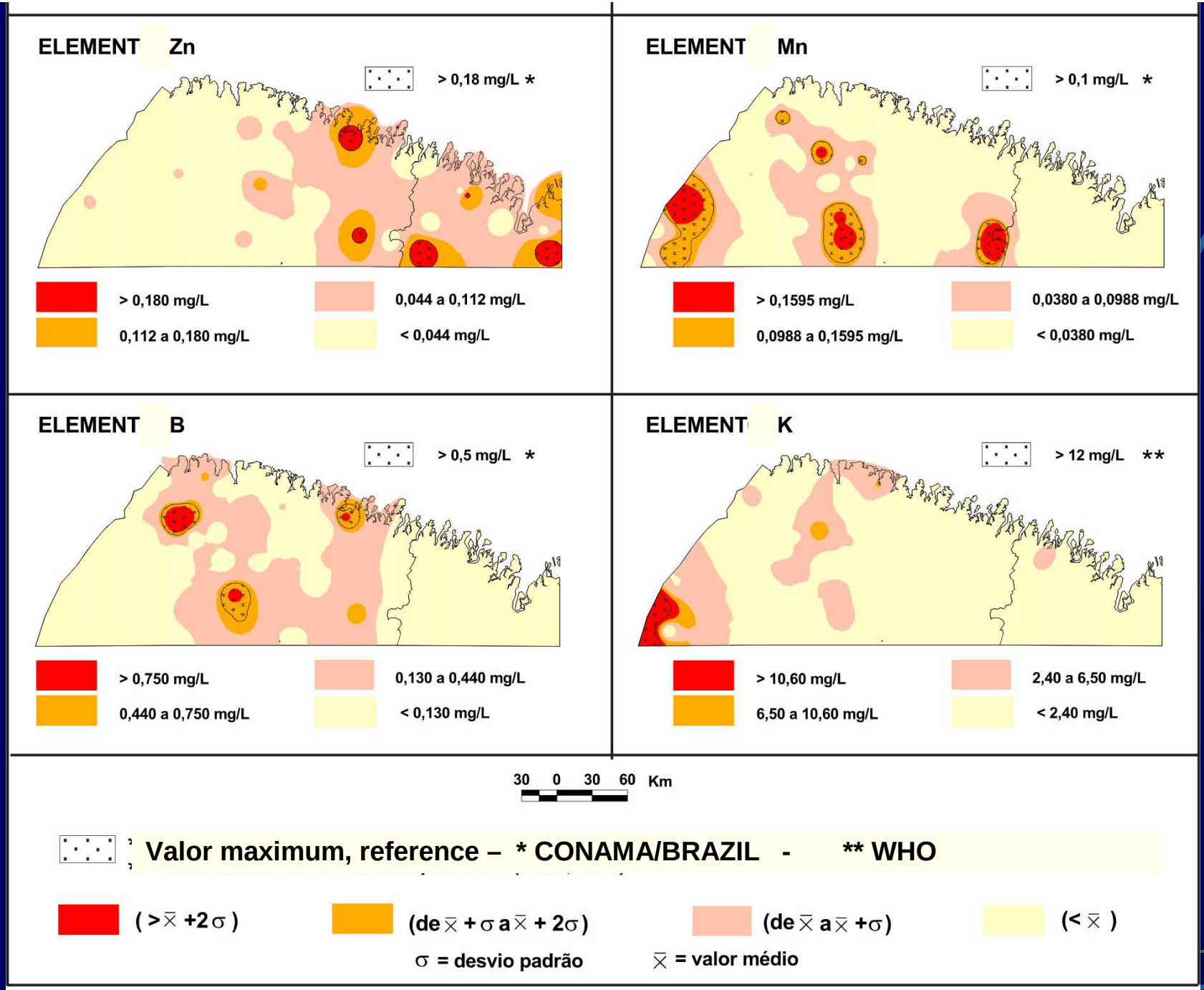
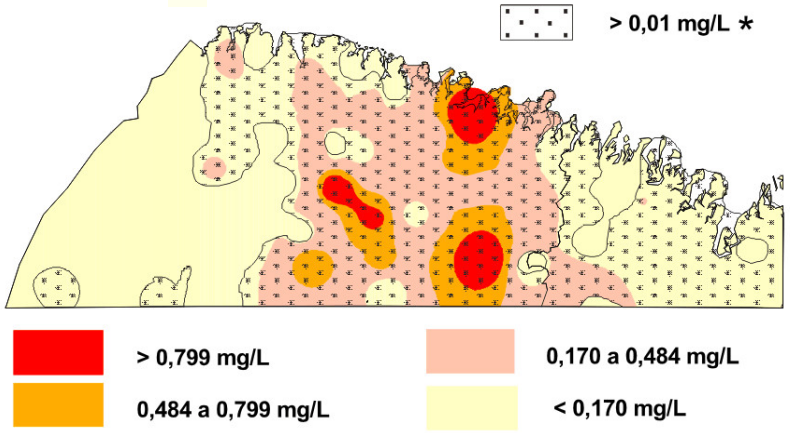


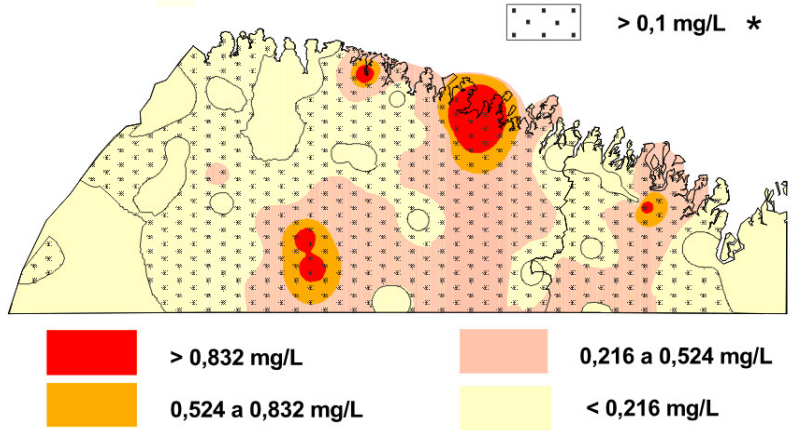
Fig 1: Mapa de localização dos trabalhos executados pelo PGAGEM-Belém na coleta de água de abastecimento público


ELEMENT Zn
> 0,18 mg/L *
> 0,180 mg/L
0,112 a 0,180 mg/L
0,044 a 0,112 mg/L
< 0,044 mg/L
ELEMENT Mn
> 0,1 mg/L *
> 0,1595 mg/L
0,0988 a 0,1595 mg/L
0,0380 a 0,0988 mg/L
< 0,0380 mg/L
ELEMENT B
> 0,5 mg/L *
> 0,750 mg/L
0,440 a 0,750 mg/L
0,130 a 0,440 mg/L
< 0,130 mg/L
ELEMENT K
> 12 mg/L **
> 10,60 mg/L
6,50 a 10,60 mg/L
2,40 a 6,50 mg/L
< 2,40 mg/L
30 0 30 60 Km
Valor maximum, reference – * CONAMA/BRAZIL - ** WHO
(> $\bar{x}$ +2 σ)
(de $\bar{x}$ + σ a $\bar{x}$ + 2σ)
(de $\bar{x}$ a $\bar{x}$ +σ)
(< $\bar{x}$)
σ = desvio padrão
$\bar{x}$ = valor médio

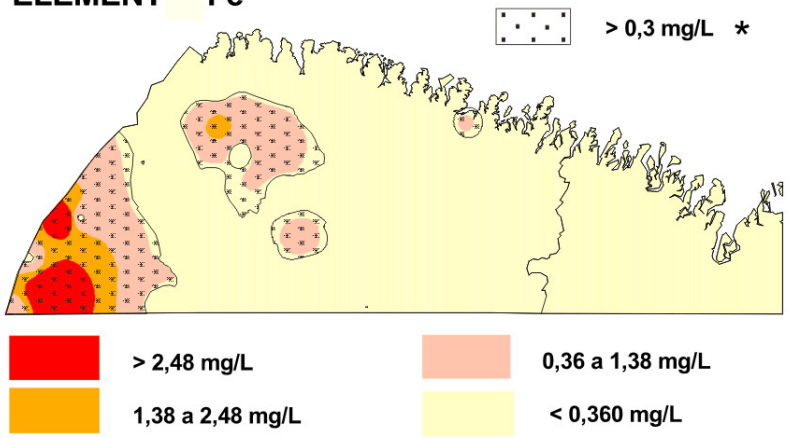
ELEMENT Pb



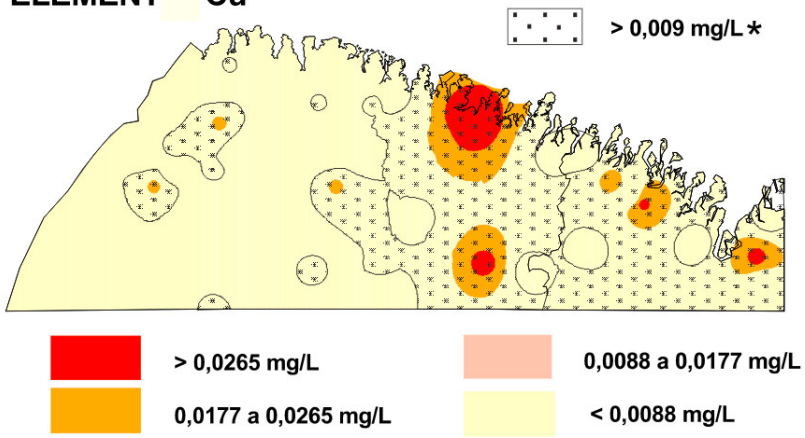
ELEMENT Al



ELEMENT Fe



ELEMENT Cu



maximum value, reference

*** CONAMA/BRAZIL**

**** WHO**

Water Supply Northeast Para State: East Amazon

Pb (145 x); Al (18 x); Fe (8 x); Cu (3 x): above WHO - natural source

pH 4-6 in 90% area - organic source

High disease rates by water (worm, hepatitis, diarrhea, etc)

Pará State / highest rate stomach cancer in Brazil

There isn't any study relating the diseases with these results

HEAVY METAL IN PUBLIC SUPPLY WATER, CEARA STATE, NORTHEAST-BRAZIL

Sergio Frizzo, frizzo@fo.cprm.gov.br
Geological Survey of Brazil – CPRMFO

CEARÁ (146.000 Km^2 - 7.430.000 **inhabitants**)

Urban population 5.300.000 **inhabitants** (71%)

760 **district in** 184 **municipalities**

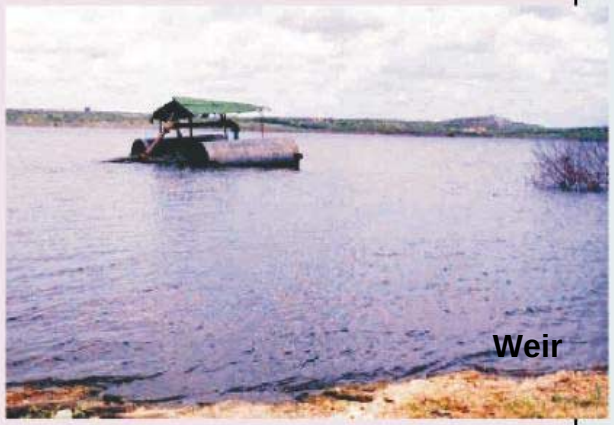
470 (62%) **Districts with regular supply; 154 of them without water treatment**

290 (38%) **Districts with other types of supply**

(fountain, private well, cask truck)

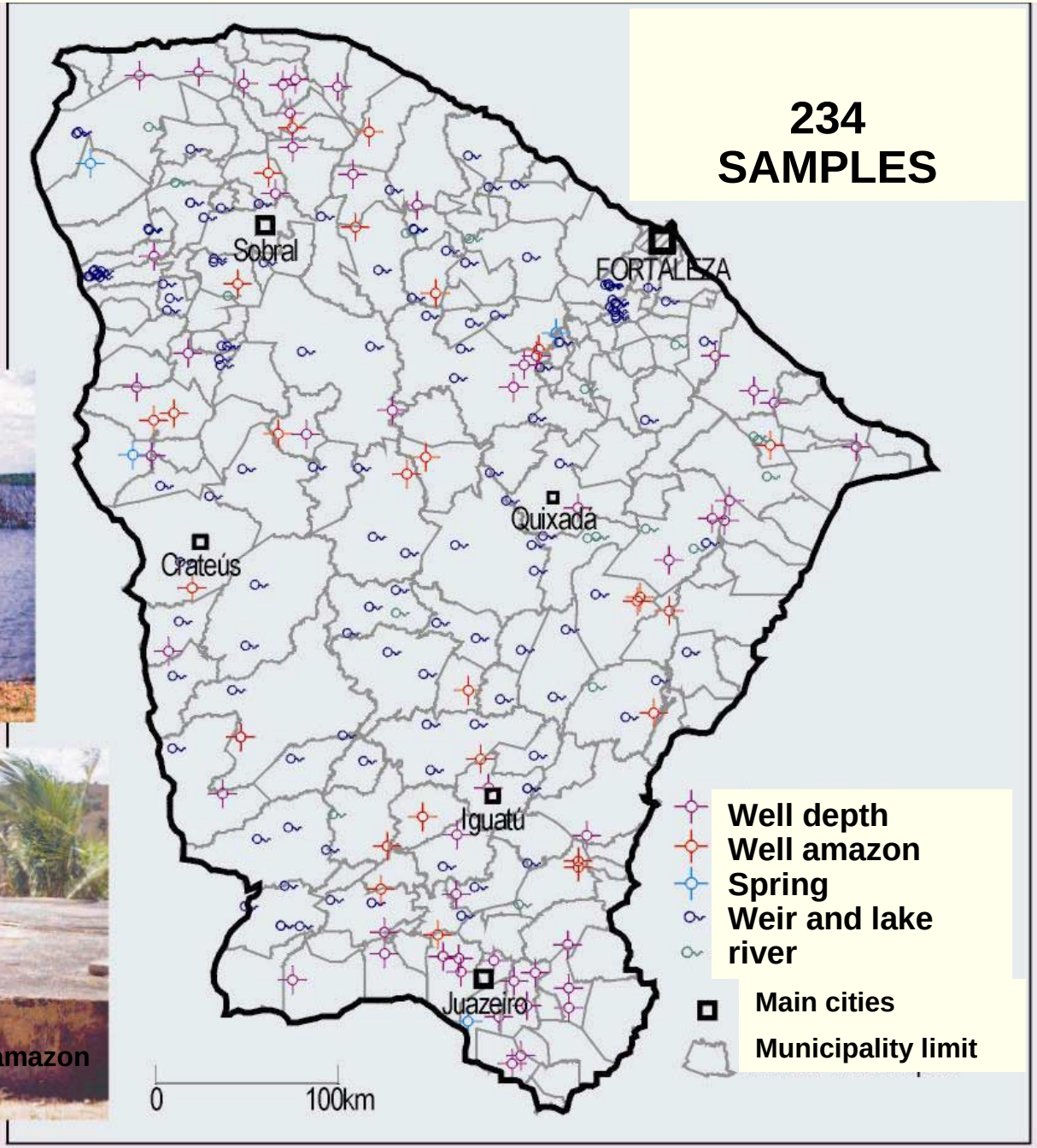
SAMPLING WATER STATION

Well depth



Weir

Well amazon

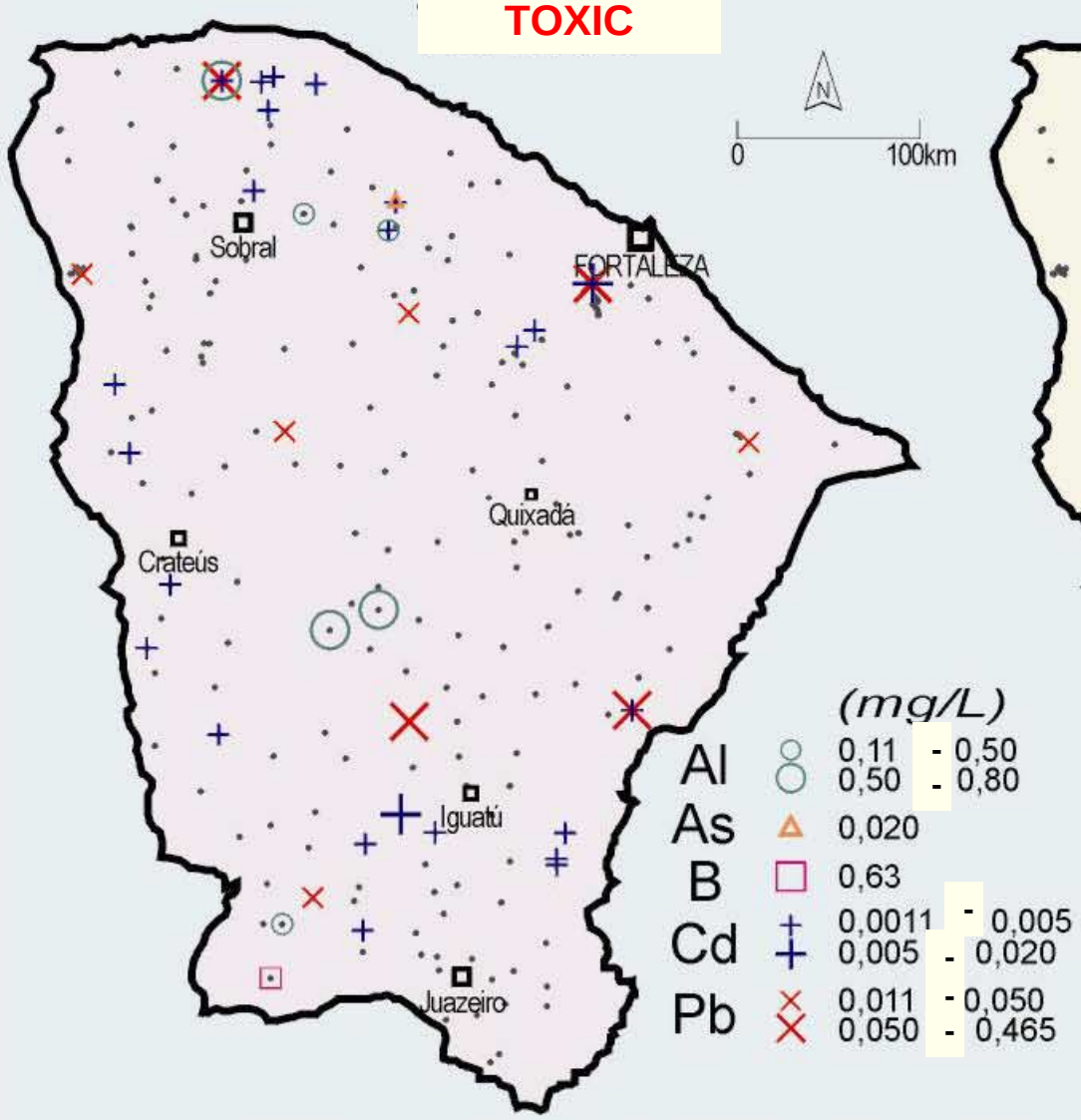


METAL CONCENTRATION ABOVE CONAMA/BRAZIL REFERENCE

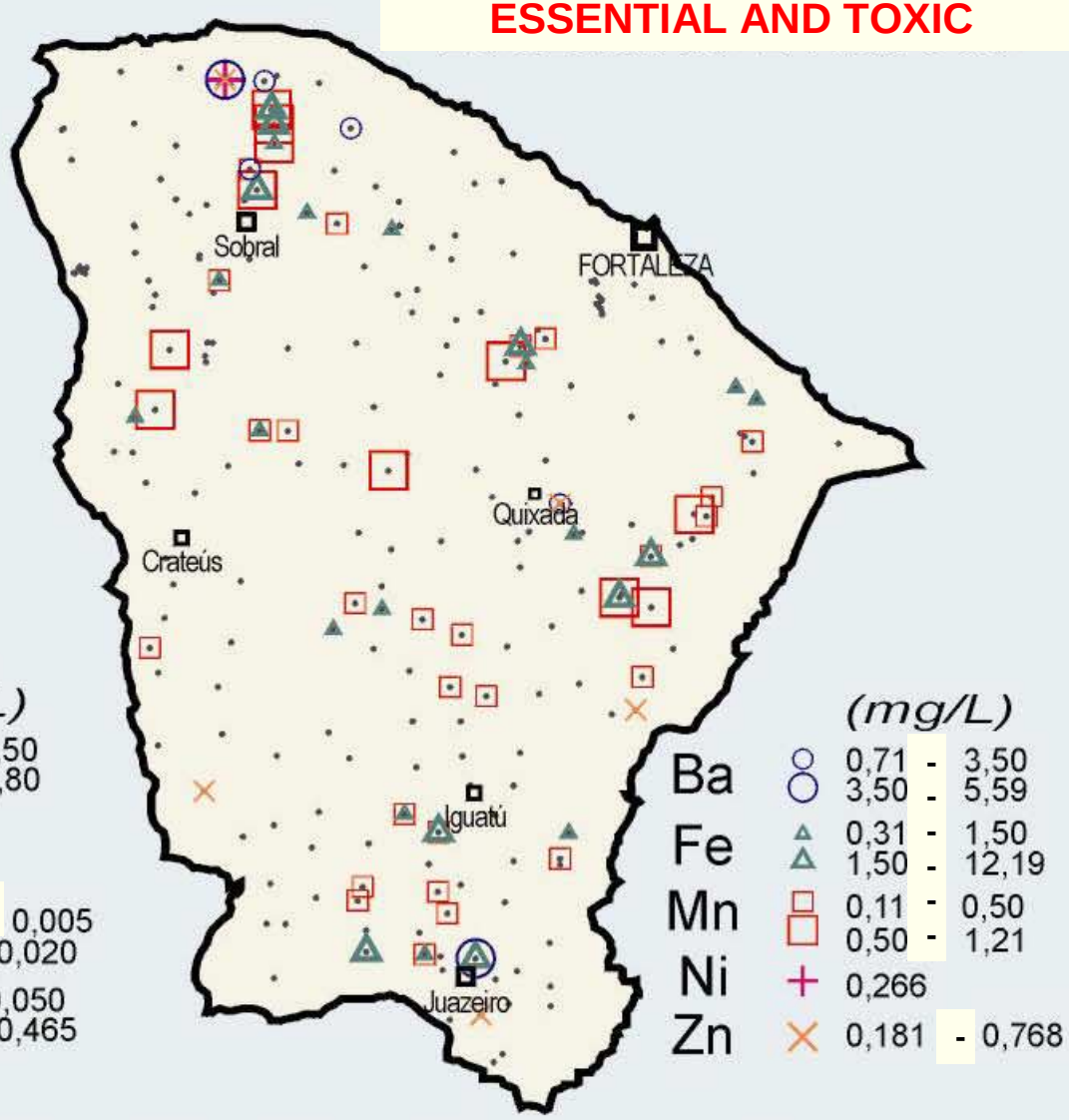
until 5 X the reference value

from 5 X until the highest result

TOXIC



ESSENTIAL AND TOXIC



100 samples (43%) with excess in one or more metals

CONCLUSION

⇒ **Medical Geology has grown very fast in Brazil in the last 3 years**

⇒ **International short courses held in Brazil have helped this growth**

⇒ **Today there are more than 300 researchers on medical geology in the network**

⇒ **It's estimated that there are about 80 researchers working on medical geology**

⇒ **Important work contribution to people's well-being and environmental policy**

⇒ ***The need for introducing Medical Geology to Medicine and Geology courses***

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