Health Impacts of Coal

Should We Be Concerned?

Table 10 Main anthorpogenic emission sources of trace elements in Europe in 1979 (Pacyna and others, 1983, 1984)

Element	Main sources (% contribution to the total emission)			
As	metallurgical (82)	>**coal combustion (7)**		
Be	**coal combustion (almost 100)**			
Cd	metallurgical (83)	>**coal combustion (5)**	>oil combustion (4)	>refuse incinerators (3)
Co	oil combustion (58)	>**coal combustion (43)**		
Cr	metallurgical (80)	>**coal combustion (13)**		
Cu	metallurgical (61)	>**coal combustion (12)**	>wood combustion (11)	>oil combustion (10)
Mn	metallurgical (84)	>**coal combustion (11)**		
Mo	**coal combustion (70)**	>oil combustion (29)		
Ni	oil combustion (60)	>**coal combustion (17)**	>mining and refining (10)	
Pb	gasoline combustion (60)	>metallurgical (34)		
Sb	**coal combustion (74)**	>refuse incinerators (25)		
Se*	**coal combustion (50)**	>oil combustion (39)		
V	oil combustion (almost 100)			
Zn	metallurgical (73)	>refuse incinerators (17)	>wood combustion (6)	
Zr	**coal combustion (almost 100)**			

*Released w ith particles

Table 42 **Selected trace elements emitted by coal-fired power stations with known toxic responses in test systems and in humans** (US DOE, 1989)

Element	Health effects
As	anaemia, gastric disturbance, renal symptoms, ulceration; skin and lung carcinogen in humans; a suspected teratogen (birth defects).
Be	respiratory desease and lymphatic, liver, spleen, and kidney effects; and animal and probable human carcinogen.
Cd	emphysema and fibrosis of the lung, renal injury, possible cardiovascular effects; an animal and possible human carcinogen; testicular toxicity in mice and rats; teratogenic in rodents.
Hg	neural and renal damage, cardiovascular disease; methylmercury is teratogenic in humans.
Mn	respiratory and other effects.
Ni	dermatitis, intestinal disorders; Ni and nickel oxide dusts are carcinogenic to guinea pigs and rats; nickel refining is associated causally with cancer in humans.
Pb	anaemia, cardiovascular, neurological, growth retarding, and gastrointestinal effects; some compounds are animal and possible human carcinogens; foetotoxic and probably teratogenic to humans.
Se	gastrointestinal disturbance, liver and spleen damage, anaemia; a possible carcinogen, a suspected teratogen.
V	acute and chronic respirator dysfunction.

Is Coal an Important Source of Trace Elements in the Environment?

Potential Hazardous Air Pollutants

[1990 Clean Air Act Amendments]

	ppm in coal	Max Potential Annual Emissions(tons)
As	24	24,000
Be	2.2	2,200
Cd	0.5	500
Cl	600	600,000
Co	6	6,000
Cr	15	15,000
F	100	100,000

Potential Hazardous Air Pollutants

[1990 Clean Air Act Amendments]

	ppm in coal	Max Potential Annual Emissions(tons)
Hg	0.2	200
Mn	43	43,000
Ni	14	14,000
Pb	11	11,000
Sb	1.2	1,200
Se	2.8	2,800
U	2.1	2,100

TRACE ELEMENTS IN COAL
KNOWN HEALTH EFFECTS

- Arsenic – China – Skin Cancer
  Czechoslovakia – Impaired Hearing in Children
- Fluorine – Fluorosis Affects 10 Million in China!
- Selenium – Selenosis in China
  Fish Kills – Texas, N. Carolina
- Mercury – High Concentrations in Fish
  Source Questioned
- Beryllium – Increased Antibodies – Czech.
- Uranium – Allegations

Progressive trace element enrichment in a coal-fired power plant (ppm)

Sample	Cu	Zn	As	Mo	Sb	Pb	Se	Hg
Coal	9.6	7.3	--	0.99	--	--	1.9	0.07
Bottom ash	82	58	15	3.5	2.8	<5	7.7	0.14
Ppt ash (inlet)	230	250	120	41.0	14.0	66	27	0.31
Ppt ash (outlet)	320	370	150	60.0	18.0	130	62	--

TABLE 25 Effect of Fly-Ash Particle Size on the Concentration of Some Trace Elements (ppm) [a]

	Size Range (um)			
Element	>15	8-15	3-8	<3
As	13.7	56	87	132
Be	6.3	8.5	9.5	10.3
Cd	0.4	1.6	2.8	4.6
Co	8.9	16.3	19	21
Cr	28	49	59	63
Cu	56	89	107	137
Ga	43	116	140	178
Mn	207	231	261	317
Mo	9.1	28	40	50
Ni	25	37	44	40
Pb	73	169	226	278
Sb	2.6	8.3	13	20.6
Se	19	59	78	198
U	8.8	16	22	29
V	86	178	244	327
W	3.4	8.6	16	24
Zn	71	194	304	550

a Source: Ondov *et al*. (1979).

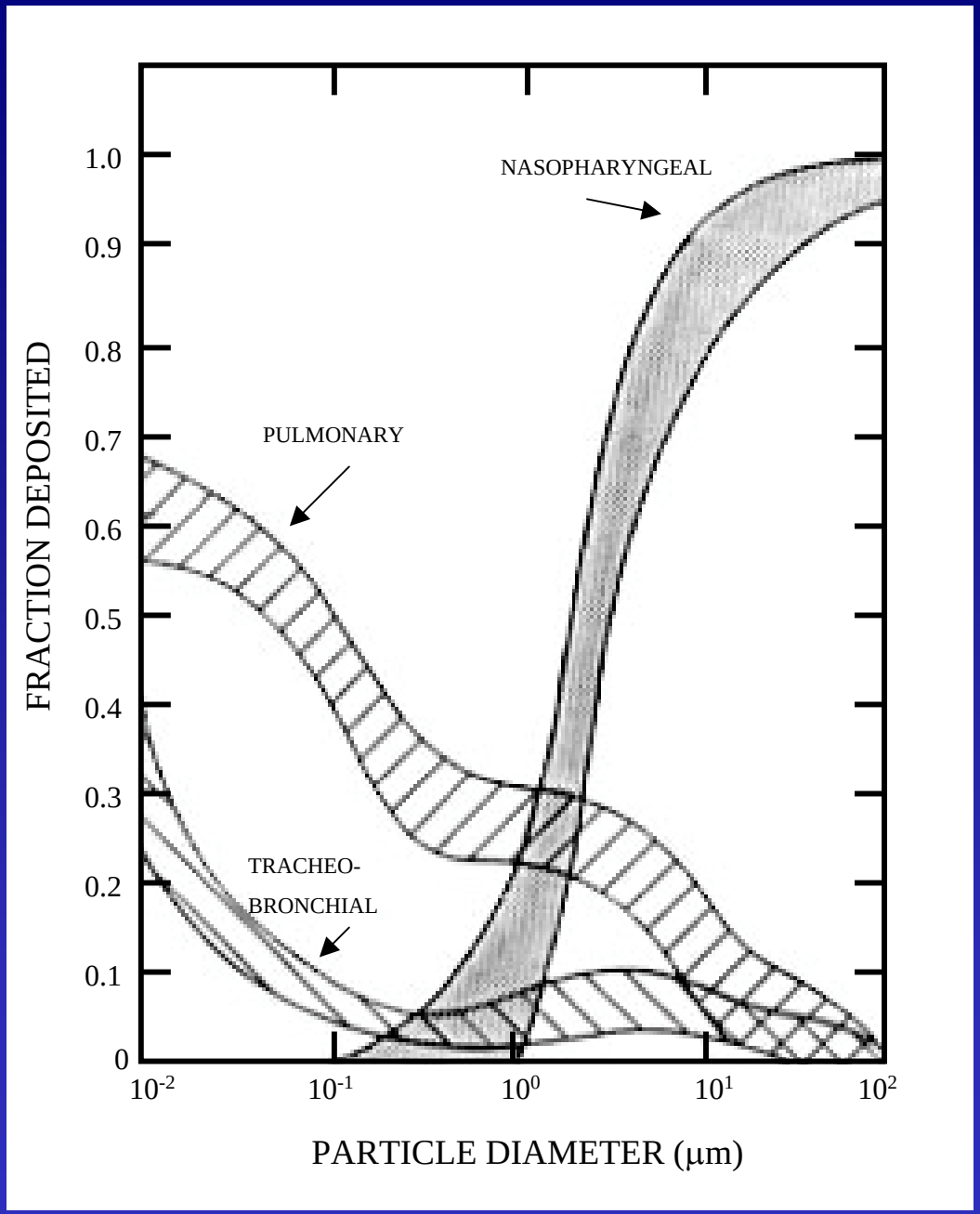


FIGURE 15 Respiratory deposition efficiencies for inhaled particles (U.S. Department of Health, Education, and Welfare, 1969)

Average Percent Removal

	Coal Cleaning	In Boiler	Post Combustion
As	45	43	97
Be	43	65	98
Cd	38	60	85
Cr	49	50	97
F	50	1,200	
Mn	2.8	56	98
Pb	55	52	93
Hg	21	8	
Ni	43		25

Percent of Atmospheric Emissions

(1990)

Pb	1.5
Ni	2.5
Cd	2.5
As	4
Cr	5
Hg	34
Se	37.5

Health Impacts of Coal

Should We Be Concerned?

It Depends!

Probably No, If

- High Quality Coal
- Coal Beneficiated
- Post Combustion Pollution Control
- Managed Disposal Practices

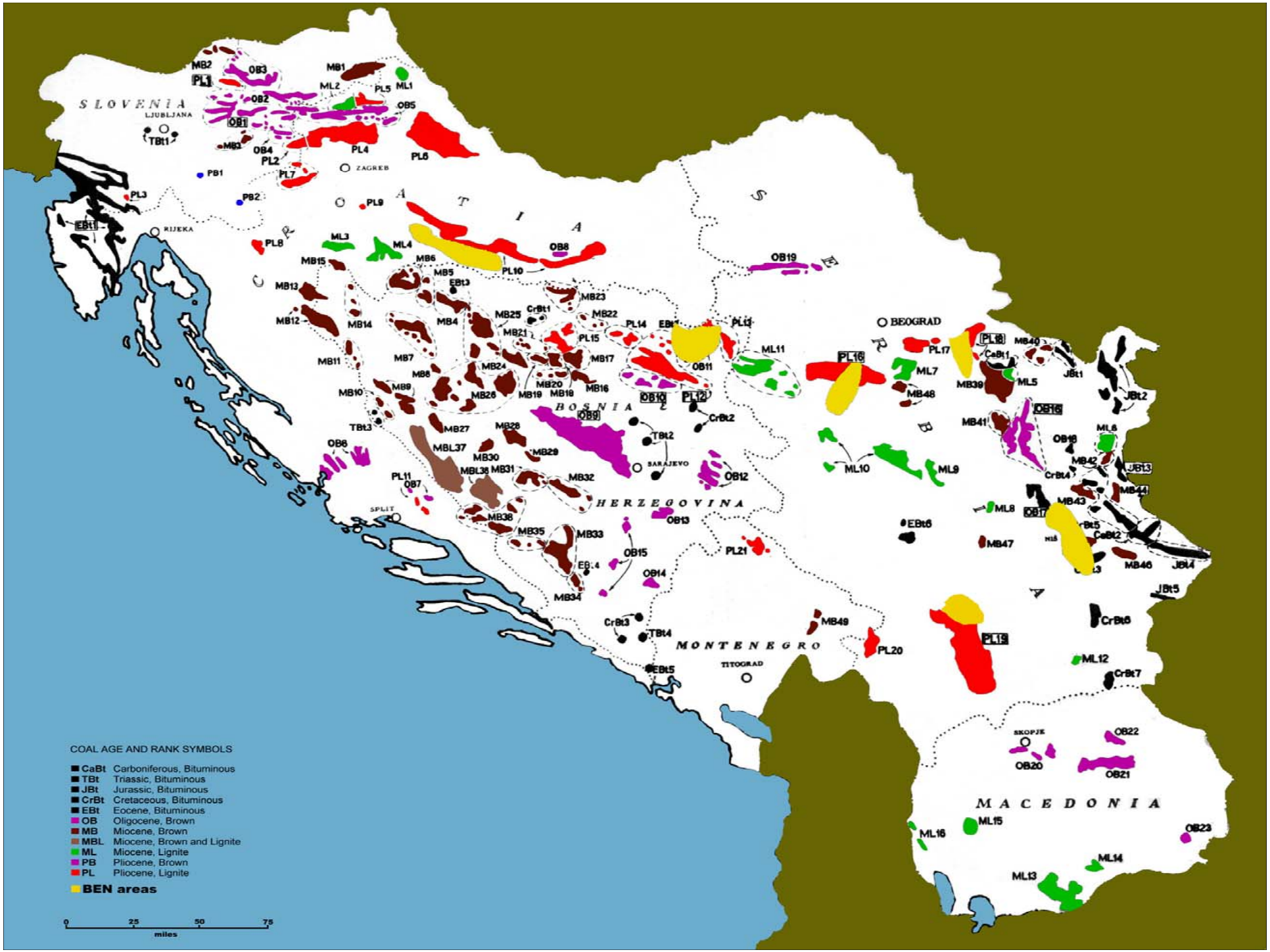
Probably Yes, If

- Poor Quality Coal
- No Beneficiation
- No Pollution Control
- Domestic Use

Health Impacts of Coal:

Facts and Fallacies

BALKAN ENDEMIC NEPHROPATHY (BEN)

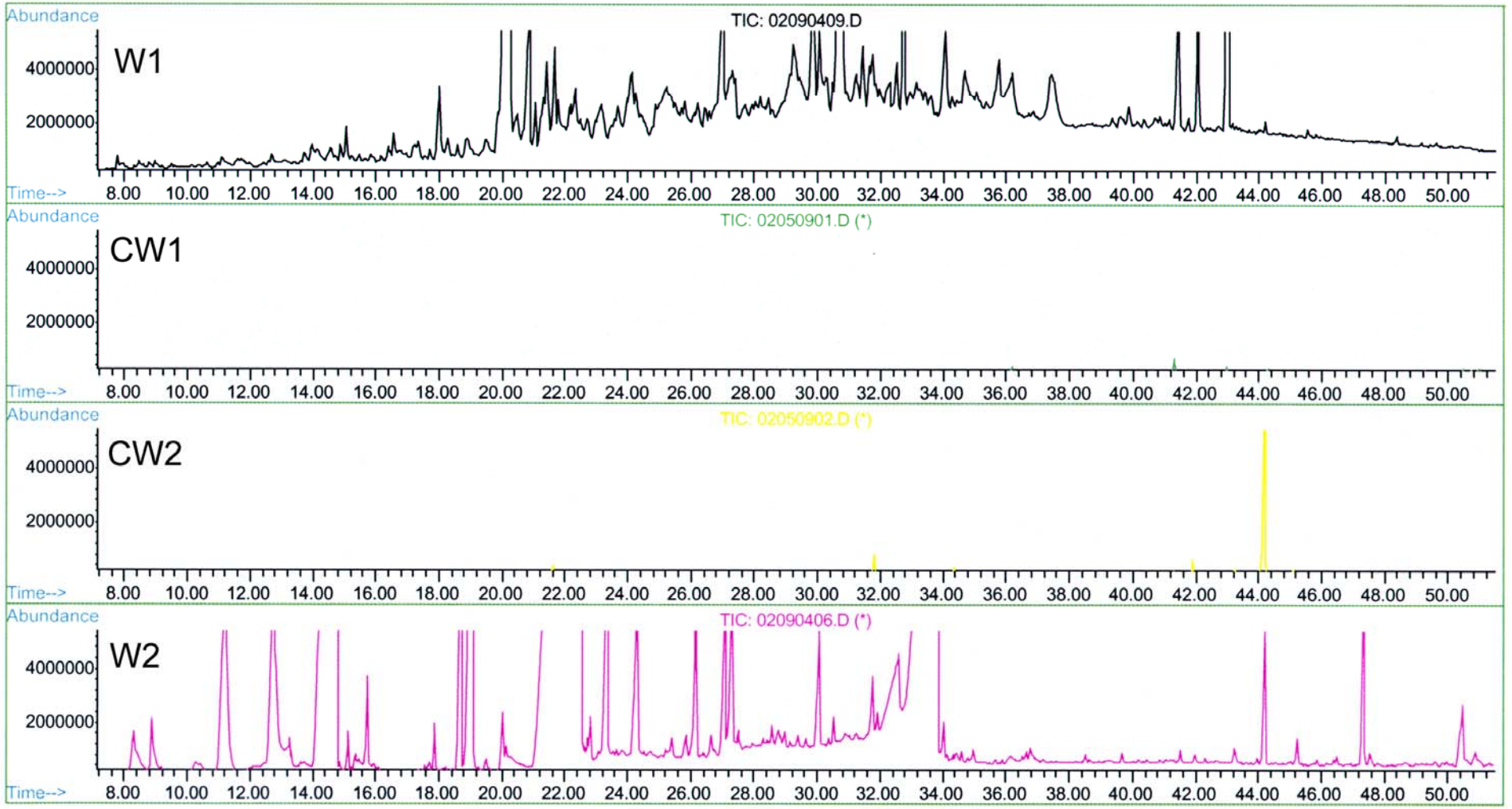

SLOVENIA
LJUBLJANA
ZAGREB
CROATIA
RIJEKA
SPLIT
BOSNIA
HERZEGOVINA
SARAJEVO
SERBIA
BEOGRAD
MONTENEGRO
TITOGRAD
MACEDONIA
SKOPJE
COAL AGE AND RANK SYMBOLS
CaBt Carboniferous, Bituminous
TBt Triassic, Bituminous
JBt Jurassic, Bituminous
CrBt Cretaceous, Bituminous
EBt Eocene, Bituminous
OB Oligocene, Brown
MB Miocene, Brown
MBL Miocene, Brown and Lignite
ML Miocene, Lignite
PB Pliocene, Brown
PL Pliocene, Lignite
BEN areas
0 25 50 75
miles

rural wells may supply tainted drinking water

groundwater percolates through coal seam

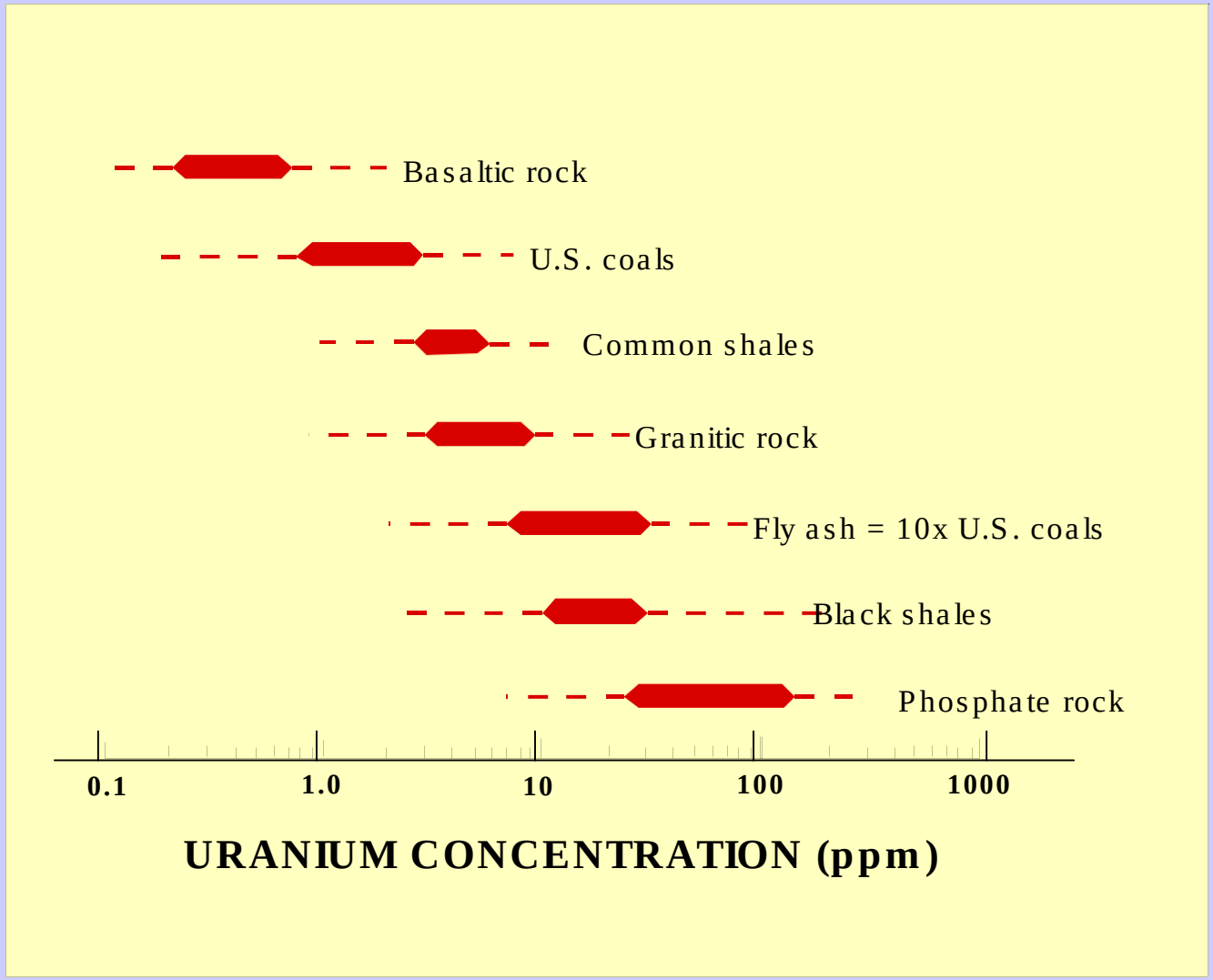
BEN patient being treated in dialysis clinic (Romania)

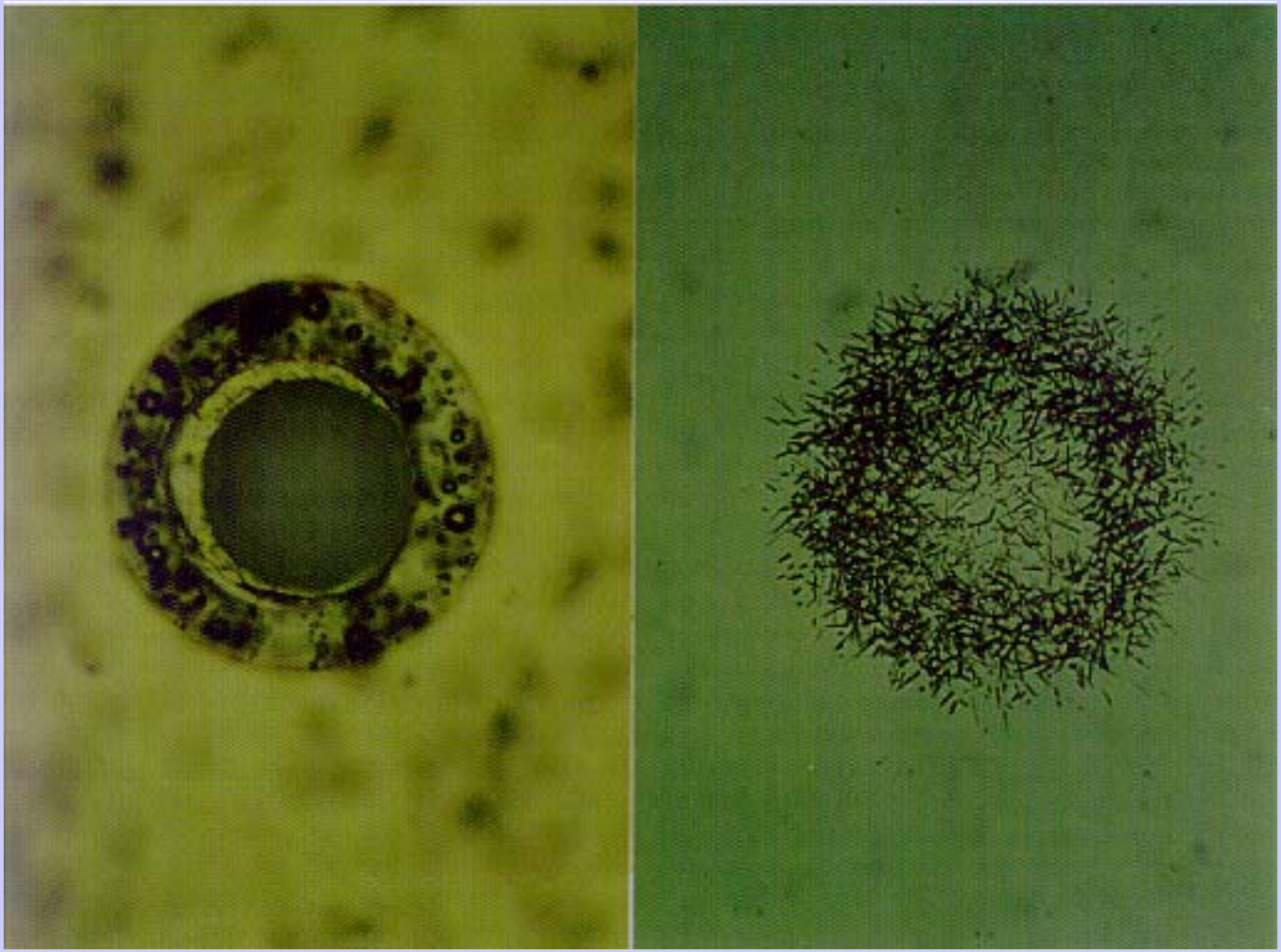
Water from wells in areas of Louisiana with high incidence of renal pelvic cancer and with lignite deposits (W1 and W2) have much higher levels of organic contaminants compared to control sites (CW1 and CW2)



Total ion currents (TICs) of Lousiana drinking well water samples collected from areas with high incidence of urinary tract cancer and underlying coal deposits (W1, W2) and control drinking well water samples from areas lacking coal deposits (CW1, CW2).

Typical Range of Uranium concentration in coal, fly ash, and a variety of common rocks





Photograph of hollow glassy fly ash particle (0.01 cm D)

Fission track radiograph of the same particle

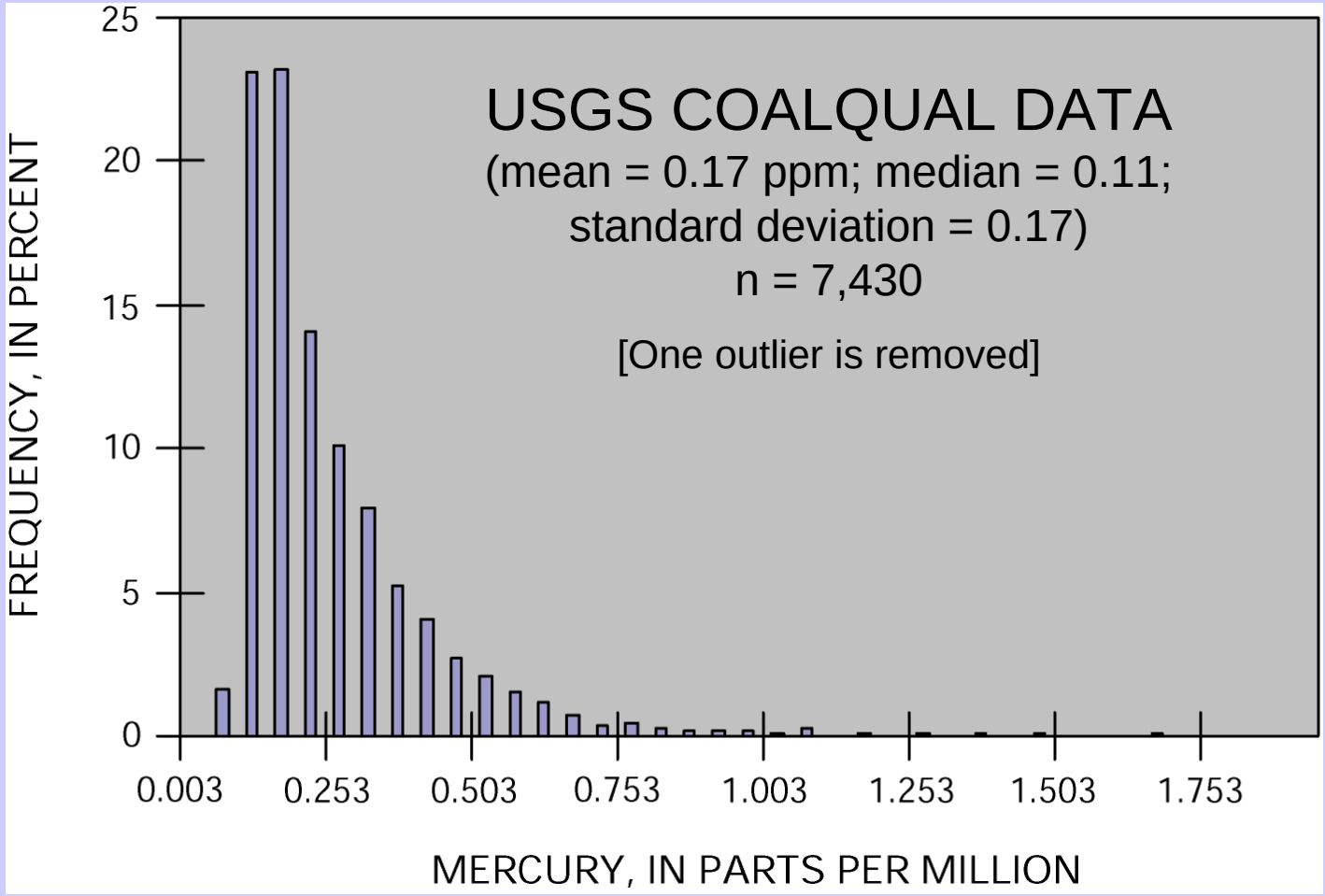
Nikitovka Hg Deposits

- *Abandoned Hg mines and Soviet-era processing plant.*
- *Hg-rich coal interbedded with sandstone Hg ores.*
- *Coal production ceased with mine closure.*
- *Hg-rich coal still collected for personal use or sale.*

2001 International Ash Utilization Symposium

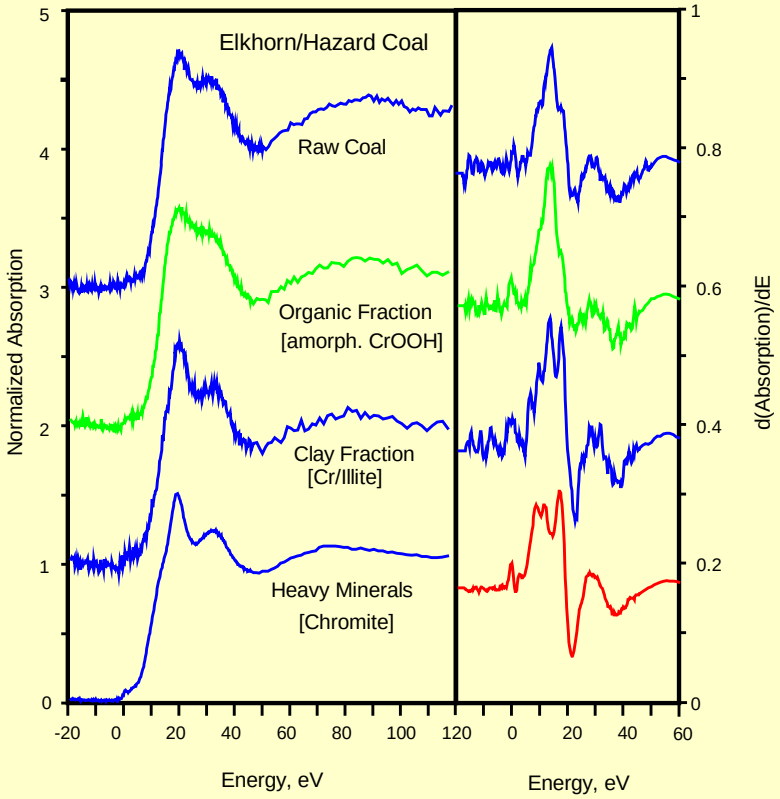
October 22-24, 2001

USGS
science for a changing world


USGS COALQUAL DATA
(mean = 0.17 ppm; median = 0.11;
standard deviation = 0.17)
n = 7,430
[One outlier is removed]
FREQUENCY, IN PERCENT
25
20
15
10
5
0
0.003
0.253
0.503
0.753
1.003
1.253
1.503
1.753
MERCURY, IN PARTS PER MILLION

Chromium in Coal: XAFS

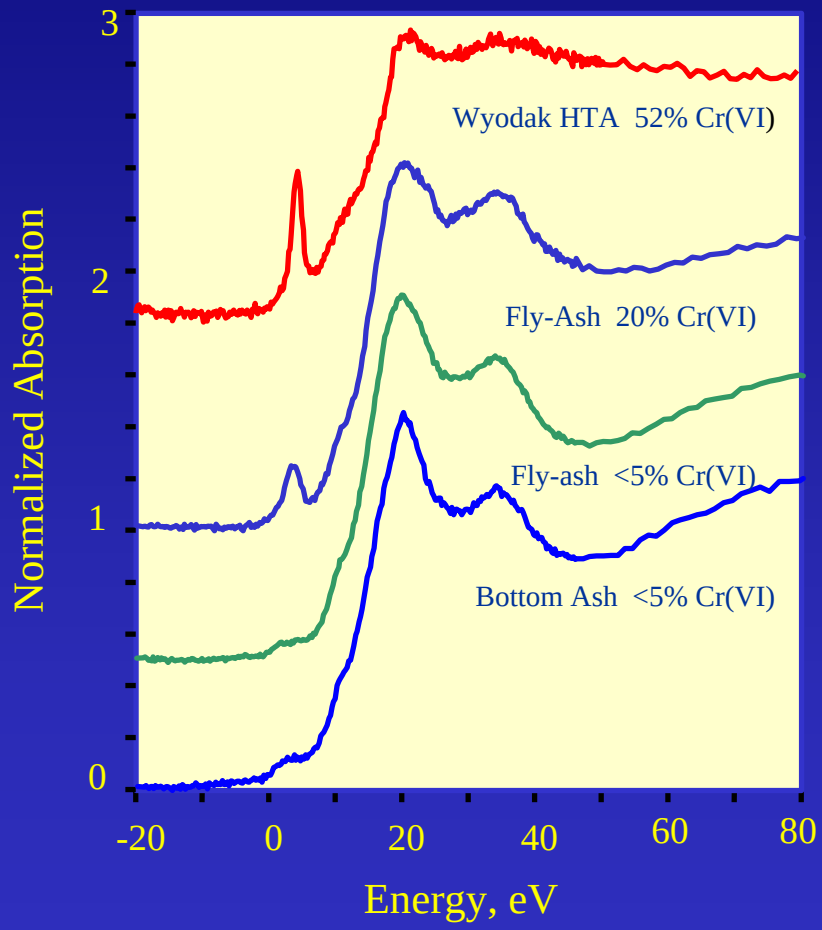
- *Two major forms identified:*
  - *Cr^{3+}/illite*
  - *Org. associated Cr (Amorph. CrOOH)*
- *Chromite- Common only in coals unusually rich in Cr*
- *Oxidation State- Always Cr^{3+}*



Chromium XANES spectra and derivatives for Elkhorn/Hazard coal and separated fractions. Note that a different spectrum is obtained for each fraction indicating that a different form of chromium dominates each fraction.

Cr in Ash: XAFS

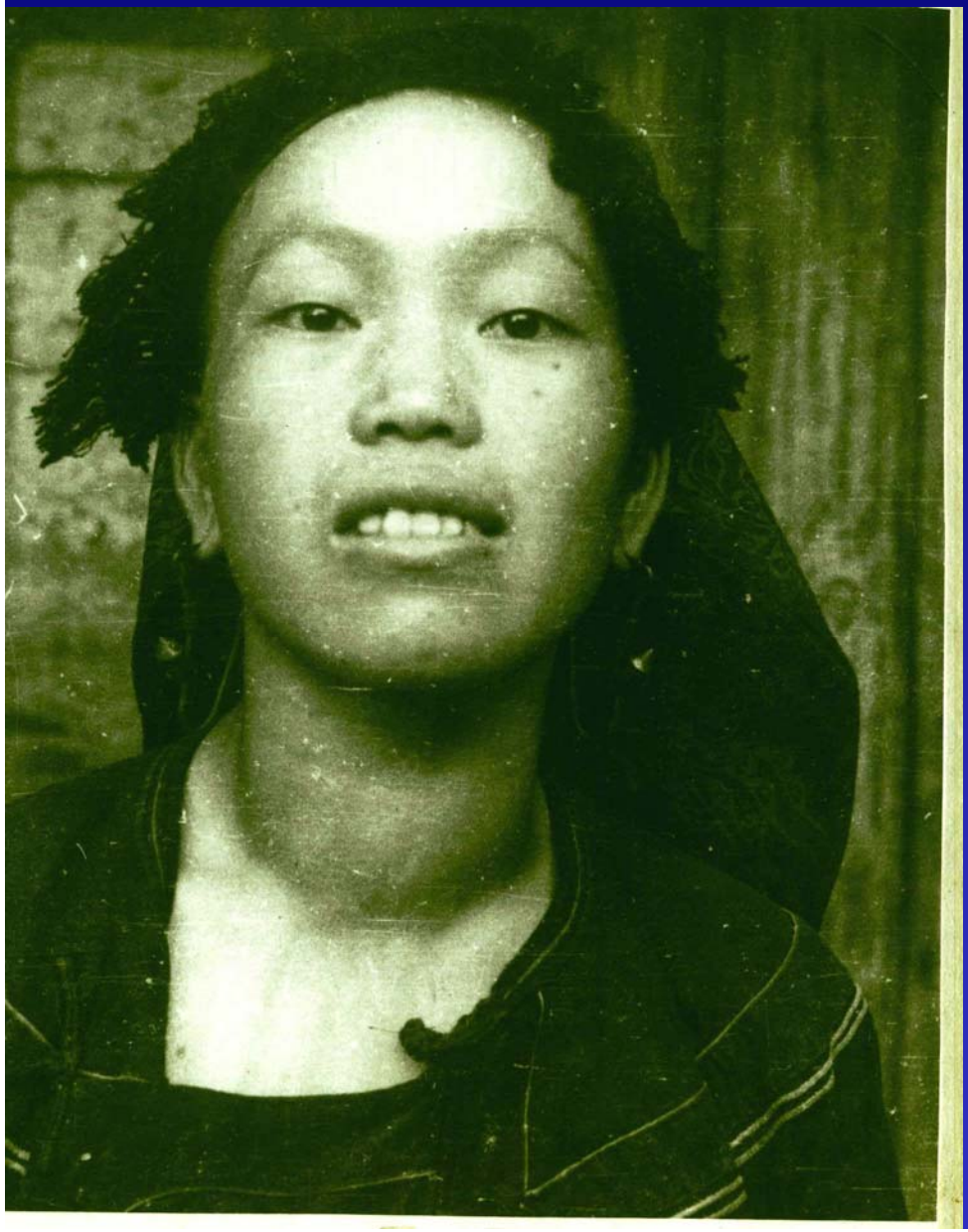
- Cr can be found as:
  - Cr/spinel associated with magnetic iron oxides.
  - Cr associated with alumino-silicate glass.
- Oxidation State of Cr
  - Often <5% Cr as Cr(VI) in bottom ash and fly-ash from bituminous coals.
  - Rarely up to 20% Cr as Cr(VI) in fly-ash from lower-rank coals.

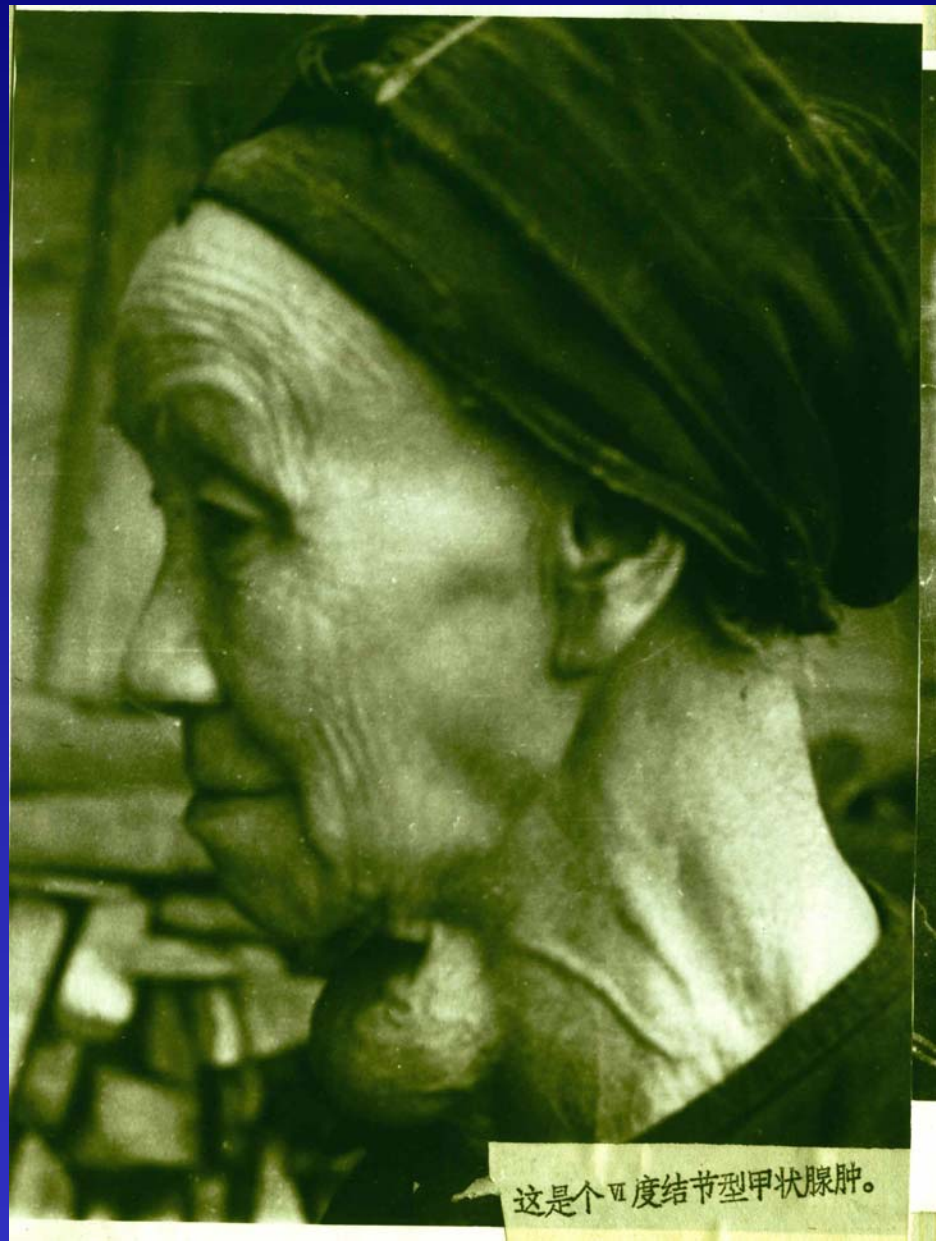


Coal Miners “Black Lung Disease”

National Museum of Health and Medicine, Washington, DC

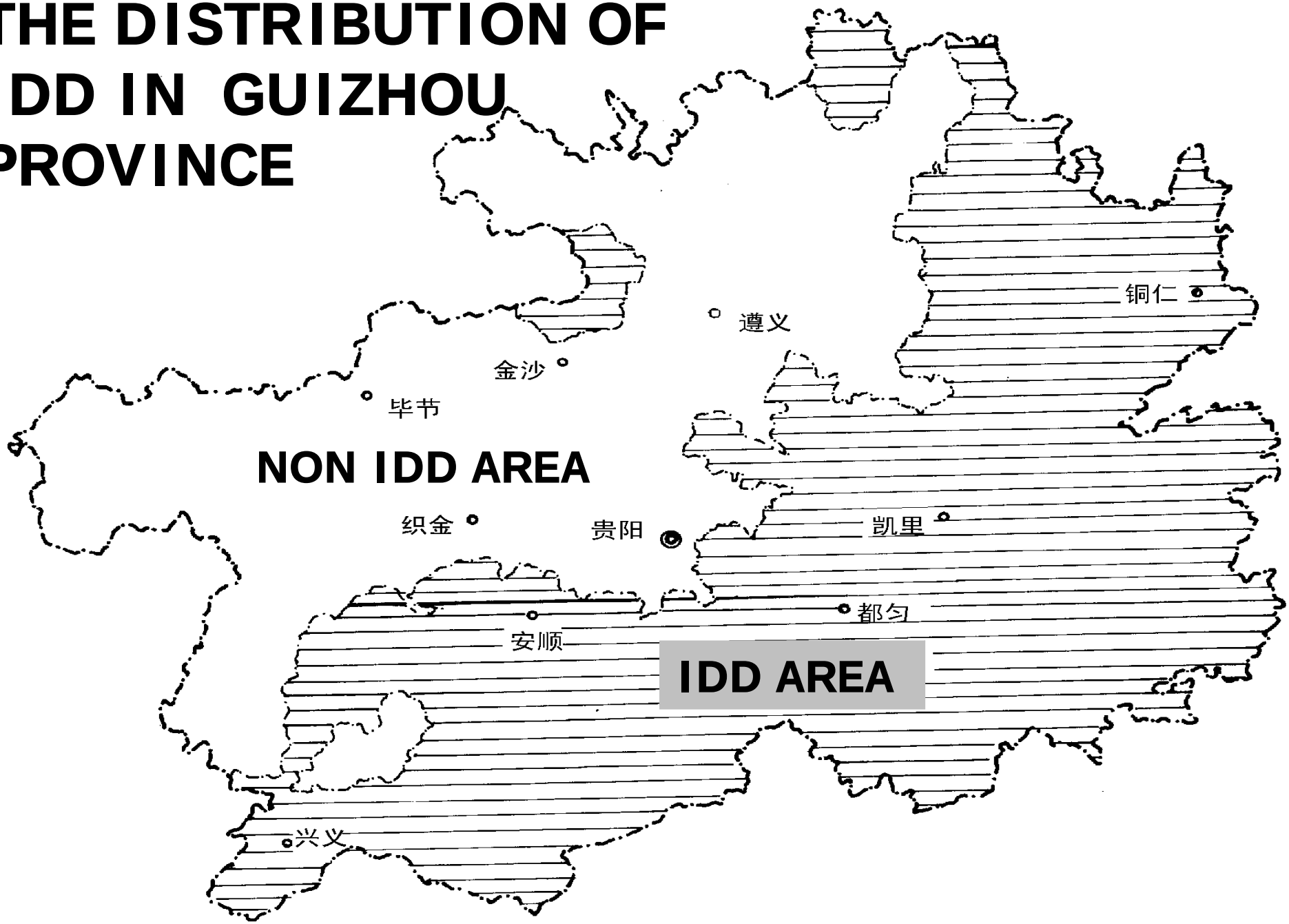
MINORITY PATIENTS IN GUIZHOU PROVINCE SUFFERING FROM IDD



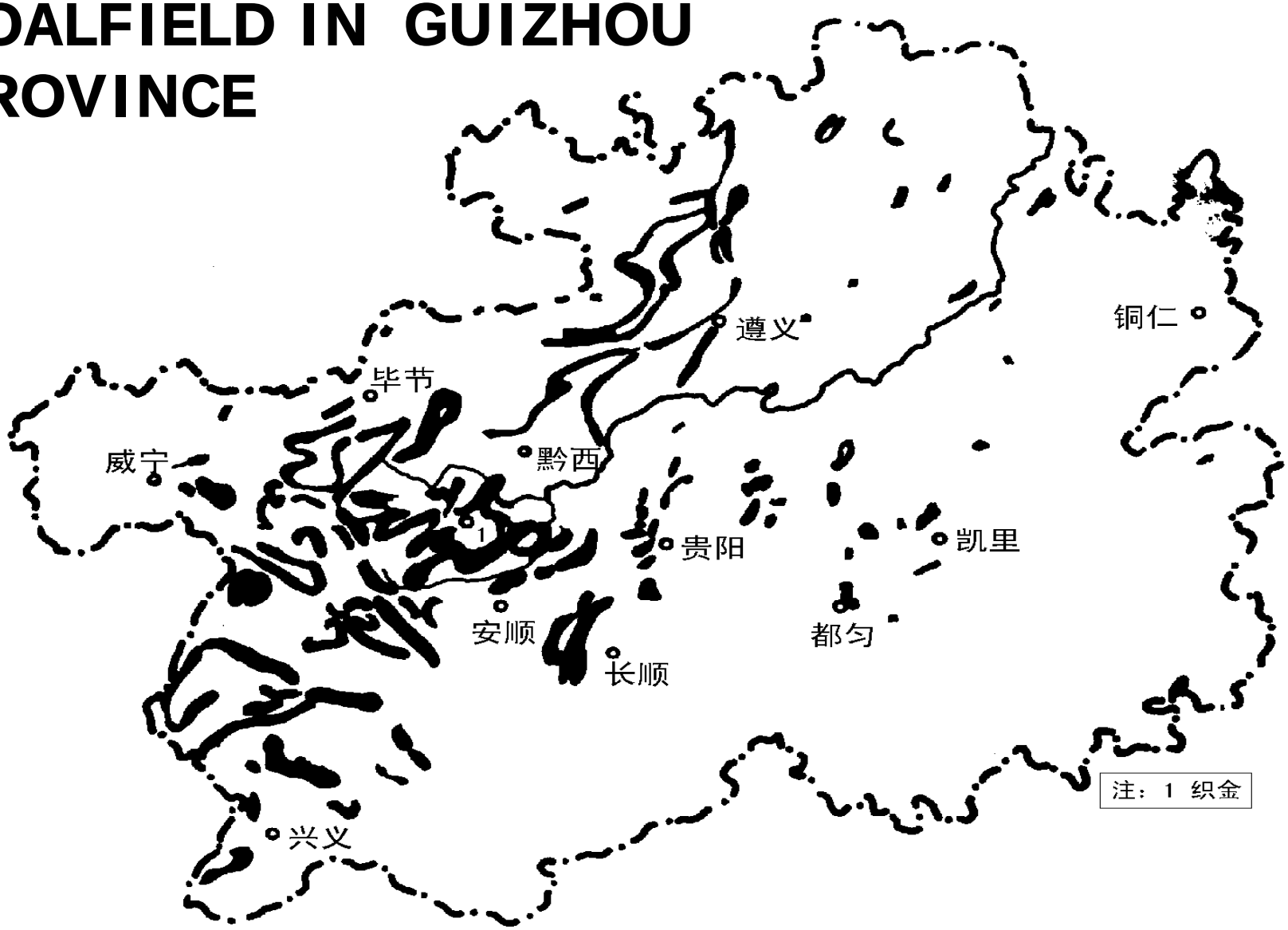


PATIENTS OF GUIZHOU PROVINCE SUFFERING FROM ENDEMIC CRETINISM IN 1980'S

THE DISTRIBUTION OF IDD IN GUIZHOU PROVINCE



THE DISTRIBUTION OF COALFIELD IN GUIZHOU PROVINCE



Iodine concentrations in coal (ppm)

Wyoming (subbit)	**0.56**	**(4)**
Colorado (bit)	**1.76**	**(3)**
Indiana (bit)	**1.12**	**(3)**
Louisiana (lig)	**0.5**	**(1)**
Penn & Tenn (bit)	**3.4**	**(8)**
U.S Ave.	**~ 1**	
World Ave.	**~ 1**	
Guizhou Prov.	**7.6**	**(~ 20; 0.9-28)**

We are part of the solution
not part of the problem