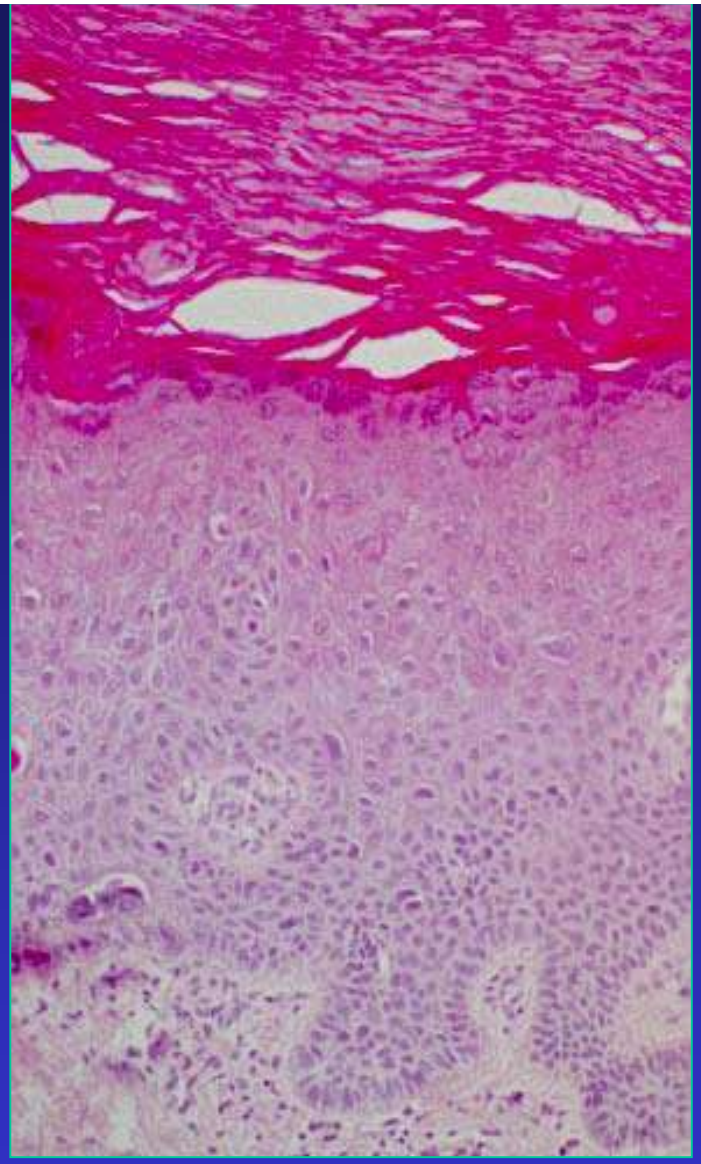
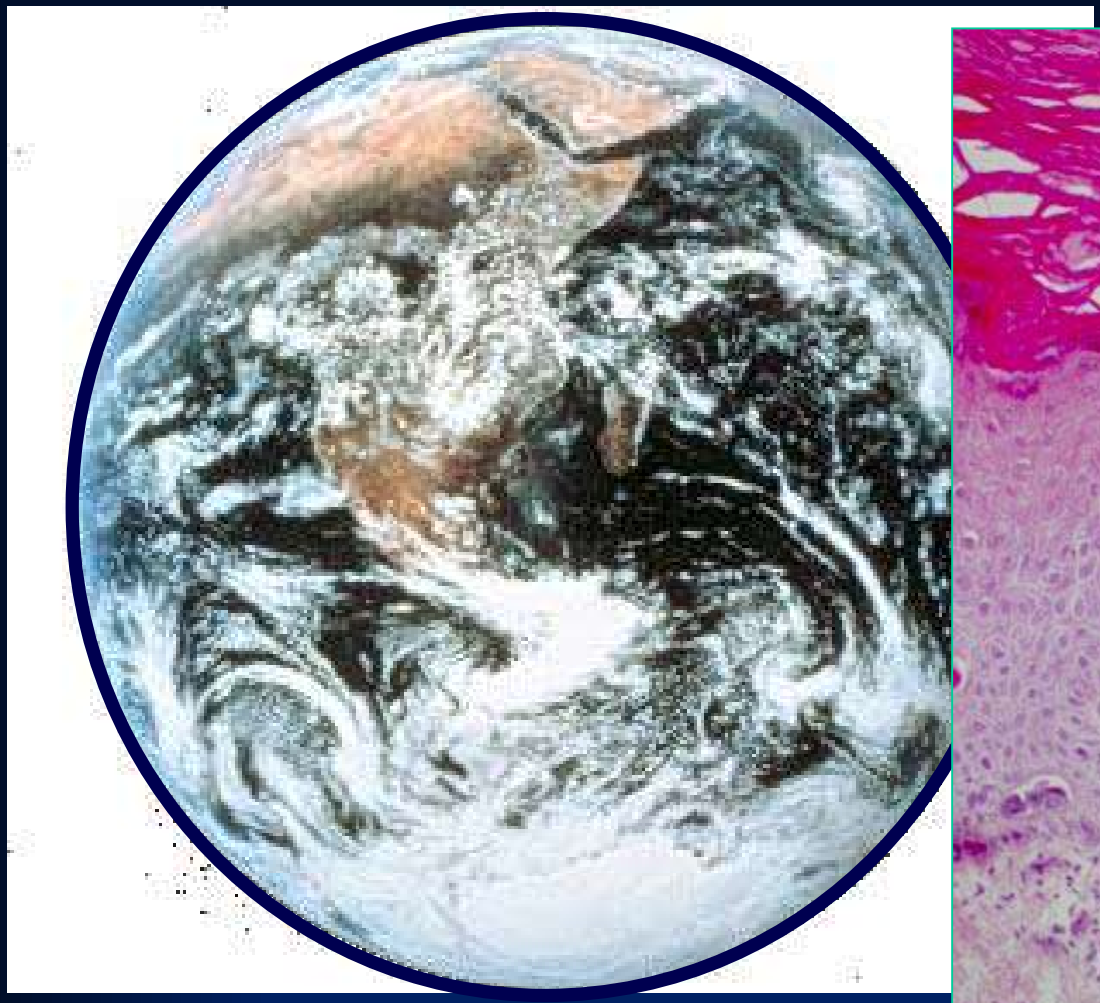
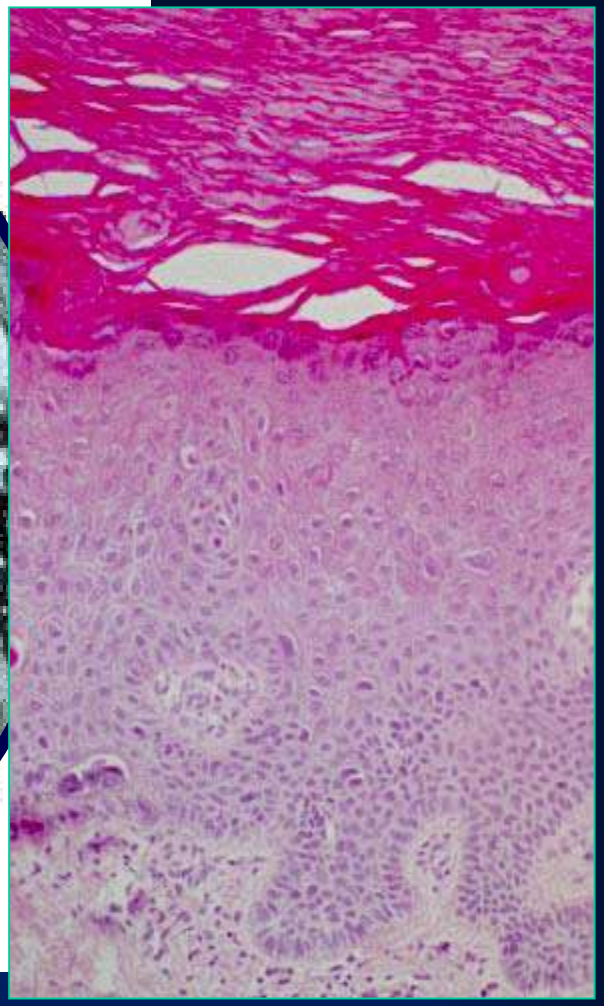


Environmental and health effects of toxic elements, metal ions, and minerals





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

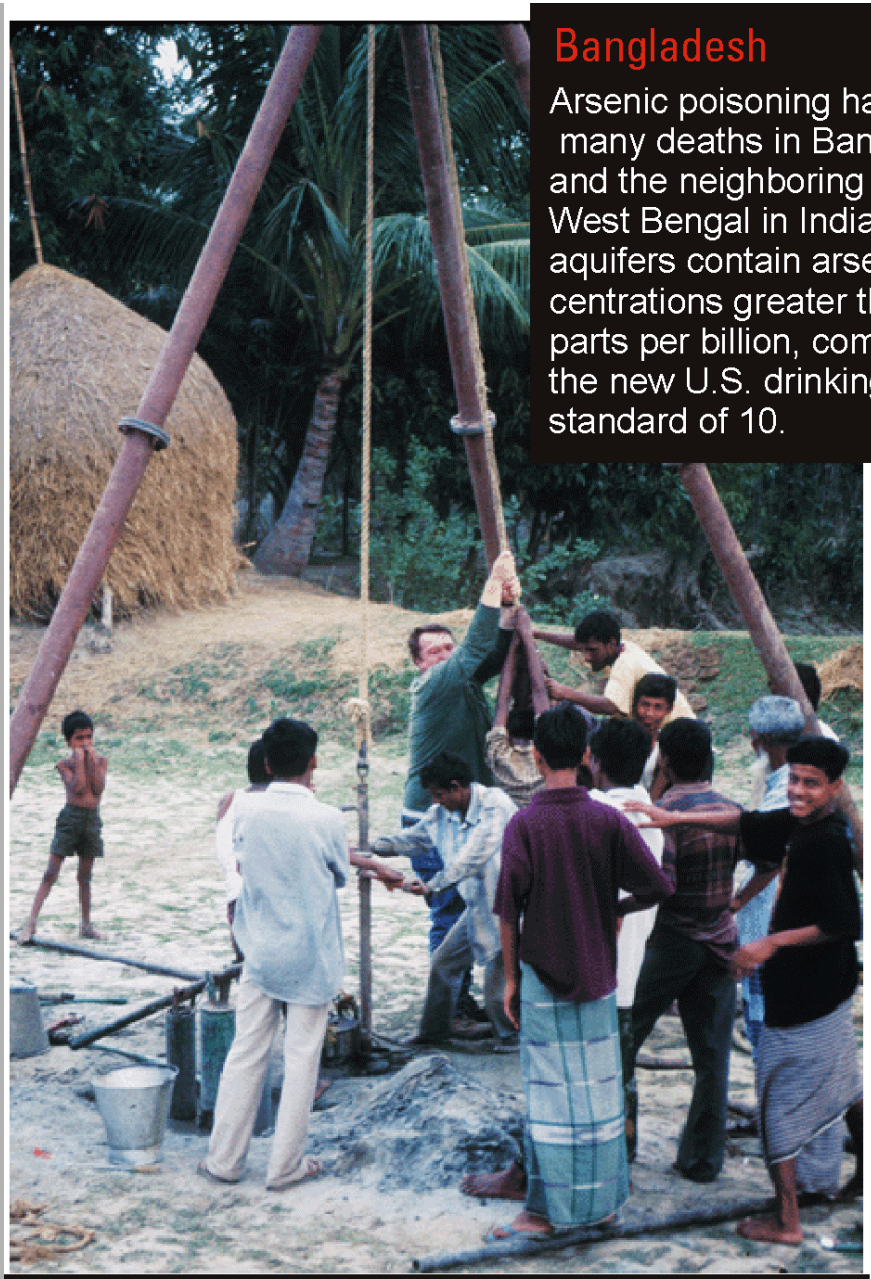
Medical Geology: A 10,000 Year Old Opportunity

Robert B. Finkelman
U.S. Geological Survey
rbf@usgs.gov

USGS

Bangladesh

Arsenic poisoning has led to many deaths in Bangladesh and the neighboring state of West Bengal in India. The Local aquifers contain arsenic concentrations greater than 1,000 parts per billion, compared with the new U.S. drinking water standard of 10.



Local sediment coring technology used by USGS and Geological Survey of Bangladesh to study arsenic contamination.

Medical Geology

(A Working Definition)

The Impacts of Geologic Materials and Geologic Processes on Animal and Human Health

USGS

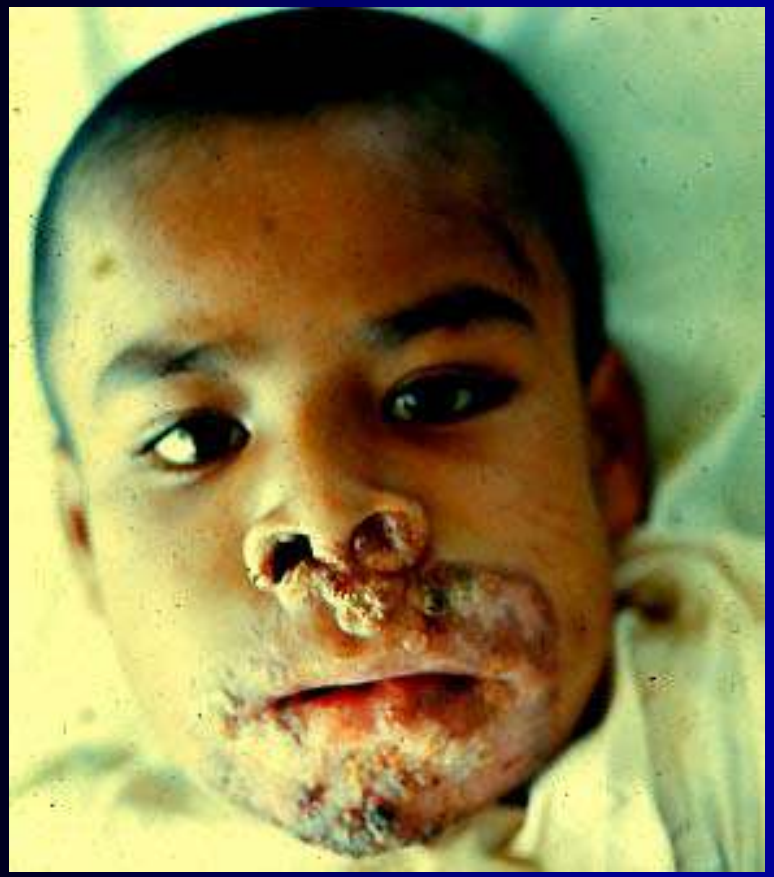
Medical Geology-Range of Issues

- Trace Element Exposure- As, Hg, F, Se, Zn, Al
- Dust- Asbestos, African, Valley Fever, Silicosis, CWP,VOG
- Organics- VOCs, MTBE,PAHs, Antibiotics, Pesticides
- Radionuclides,-Radon, Radium, Uranium
- Microbes, Pathogens-West Nile Encephalitis, LaCrosse Encephalitis, Plague, Hantavirus, Rift Valley Fever, Lyme disease, etc.
- Global Climate Change

USGS

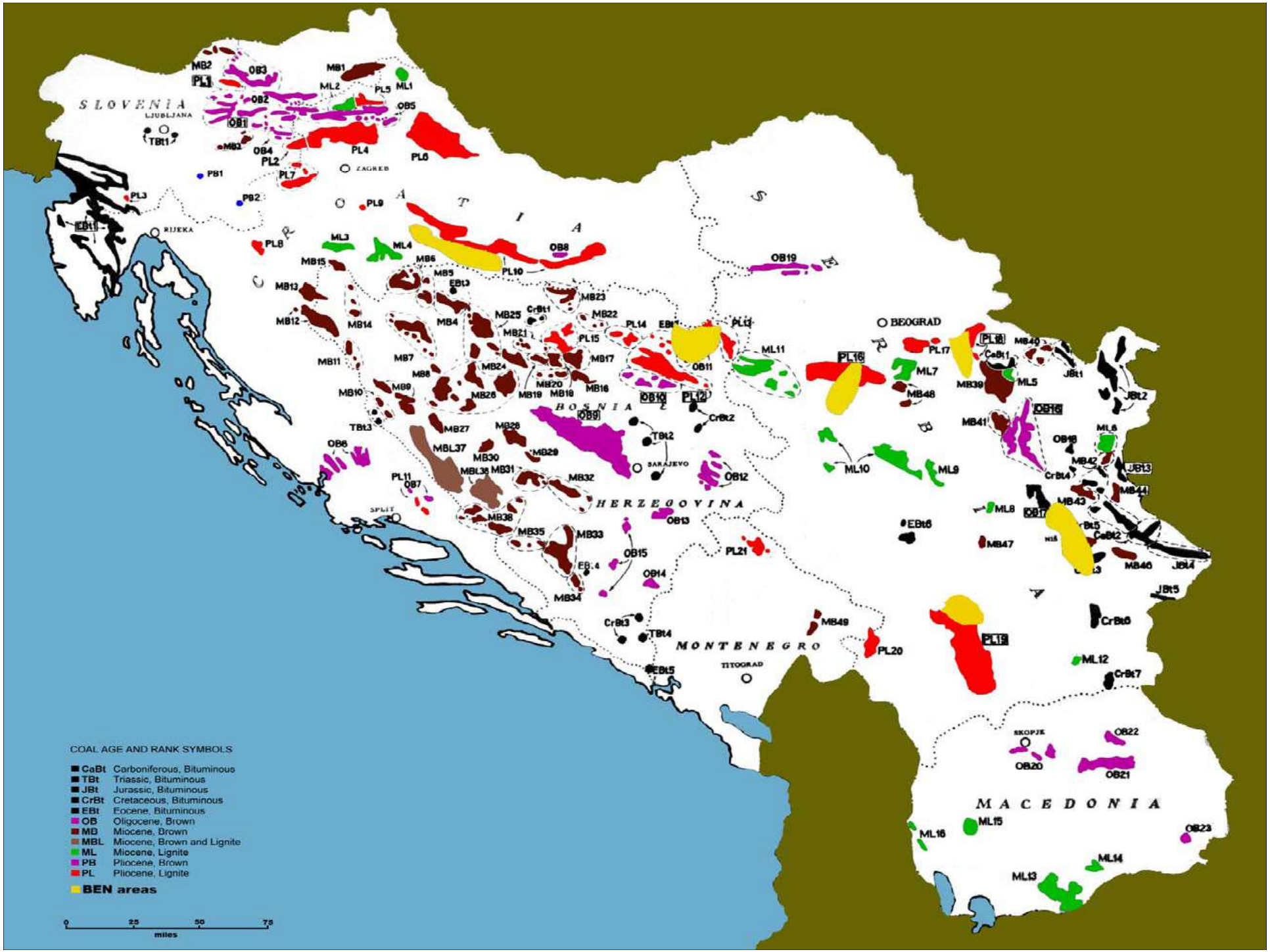
Disease Progression

Valley Fever-Clinical Presentation



- 7,500 new cases of Valley Fever occur annually in the U.S.A, with a cost in excess of $60 million a year.

BALKAN ENDEMIC NEPHROPATHY (BEN)


SLOVENIA
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ZAGREB
RIJEKA
SPLIT
SARAJEVO
BOSNIA
HERZEGOVINA
BEOGRAD
TITOGRAD
MONTENEGRO
SKOPJE
MACEDONIA
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
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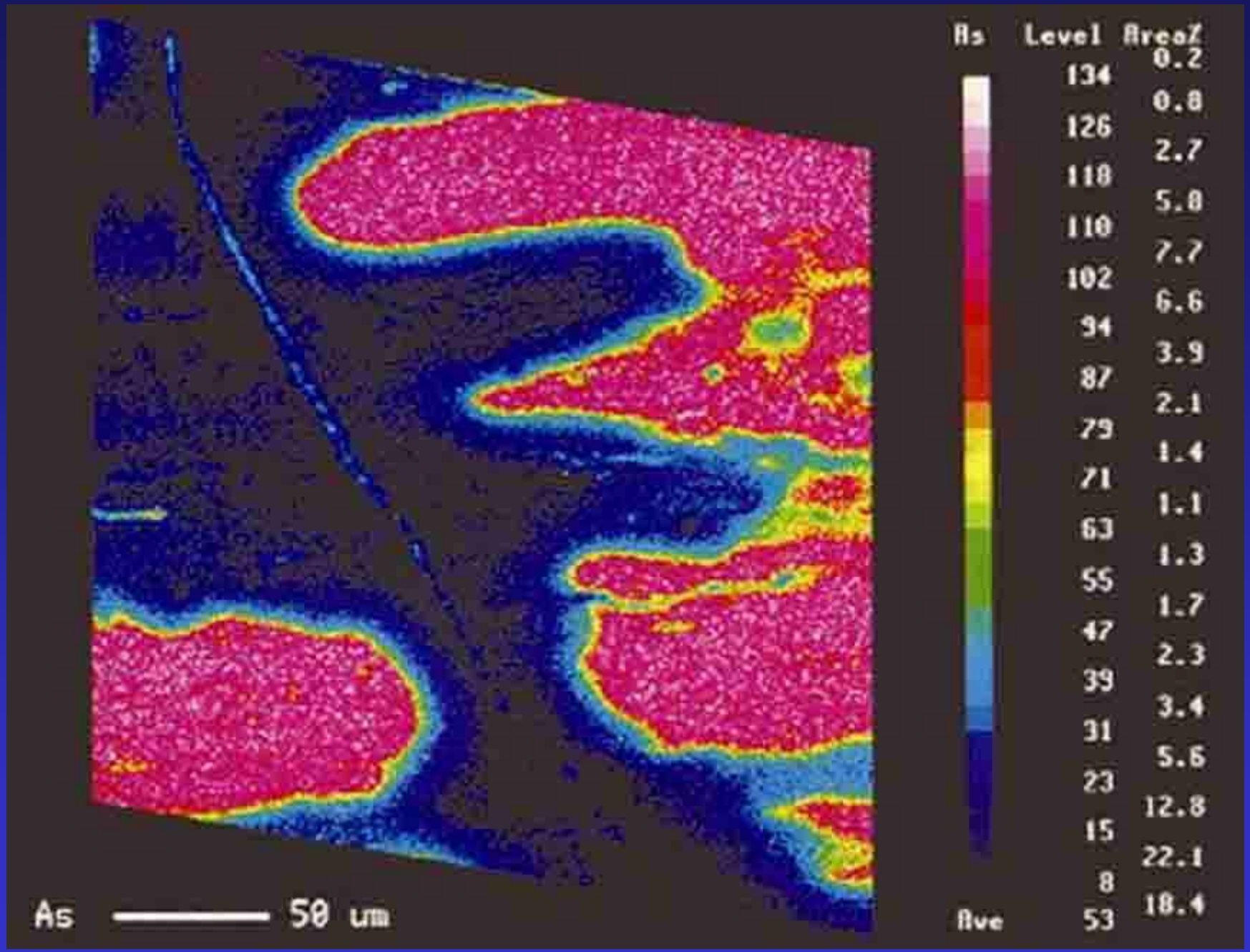
miles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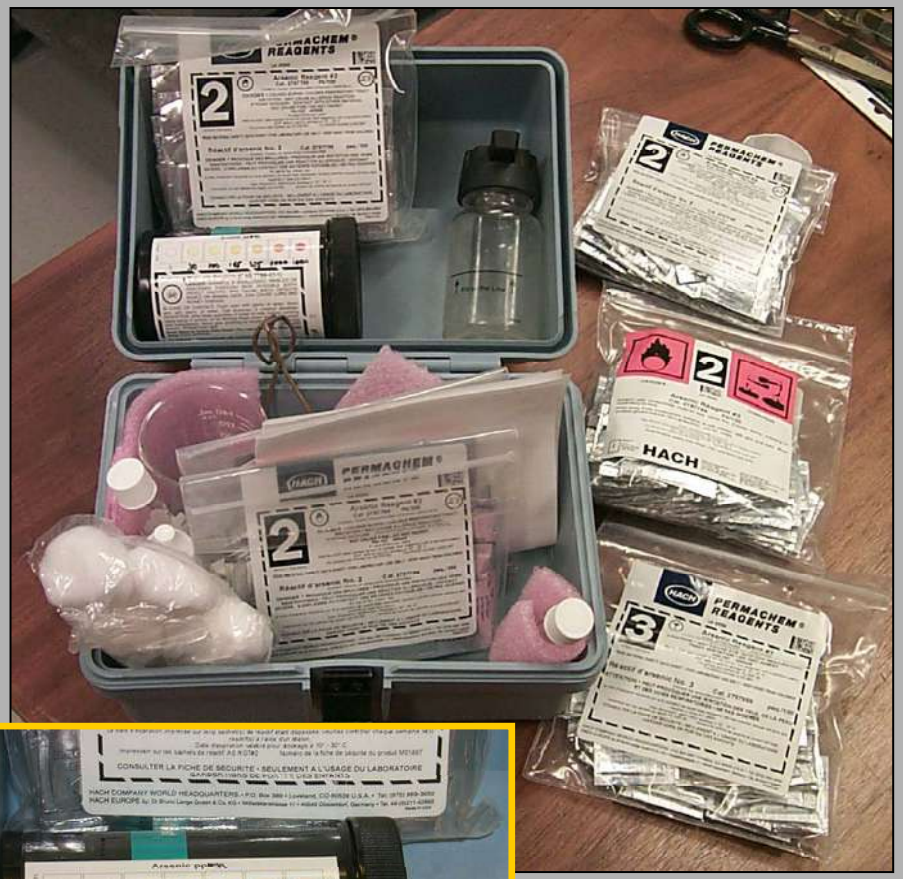

Arsenic Field Tests

- *Test kit developed in China to identify arsenic-rich coals in the field.*
- *Commercial version (left) being introduced by U.S. manufacturer.*
- *Testing has resulted in closure of "mines" with highest As coal.*

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MEDICAL GEOLOGY

Earth Science in Support of Public Health Protection

A new book to be published

"Medical Geology" is defined as the science dealing with the relationship between natural geological factors and health problems in man and animals, and understanding the influence of ordinary environmental factors on the geographical distribution of such health problems. Medical Geology is therefore a broad and complicated subject which requires interdisciplinary contributions from different scientific fields if the problems are to be understood, mitigated or resolved.

The International Working Group on Medical Geology has taken an initiative in publishing a book on Medical Geology. The book will be written by a very interdisciplinary team, geoscientists, medics, veterinarians, biologists, epidemiologists and pathologists.The book is planned to be published in 2003 by Academic Press, USA.

The readers of the *Medical Geology* will include undergraduate and graduate students, scientists and professionals in both geology and the health sciences, instructors and administrators at universities and observatories, and government and private agencies. The book will also be used as a reference book on the subject.

Overview of the chapters (responsible Associate Editors in blue):

Introduction, historical development

Section 1 (Background) Ulf Lindh

Geology, natural backgrounds, anthropogenic sources
Biology of the elements, Nutrition and diet, Biological responses

Section 2 (Pathways, exposures) Ron Fuge
Volcanic emissions
Water Pauline Smedley
Soils Brian Alloway
Animals and medical geology
Radon

Section 3 (Epidemiology, pathology) Jose Centeno
Epidemiology, Environmental medicine
Environmental pathology,
Environmental toxicology, Clinical assessment

Section 4 Bob Finkelman
Techniques and tools

Summary

Appendix (Reference values)

TIME SCHEDULE

- All authors make an outline and brief summary of contents (March 31, 2001)
- First draft from authors within 9 months (December 31, 2001)
- All manuscripts mailed for reviewing
- Deadline for reviews 6 weeks
- Revisions back within one month
- Compilation of all sections
- Manuscript to Academic Press (November 15, 2002)

Editor in Chief

- **Olle Selinus, Geological Survey of Sweden**
  olle.selinus@sgu.se

Associate editors:

- **Ulf Lindh, Centre for Metal Biology, Sweden**
  ulf.lindh@bmb.uu.se
- **Ron Fuge, University of Aberystwyth, UK**
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- **Brian Alloway, University of Reading, UK**
  b.j.alloway@reading.ac.uk
- **Pauline Smedley, British Geological Survey, UK**
  pls@bgs.ac.uk
- **Jose Centeno, US Armed Forces of Pathology, USA**
  centeno@aflp.osd.mil
- **Bob Finkelman, USGS, USA**
  rbf@usgs.gov

For additional information see http://home.swipnet.se/medicalgeology

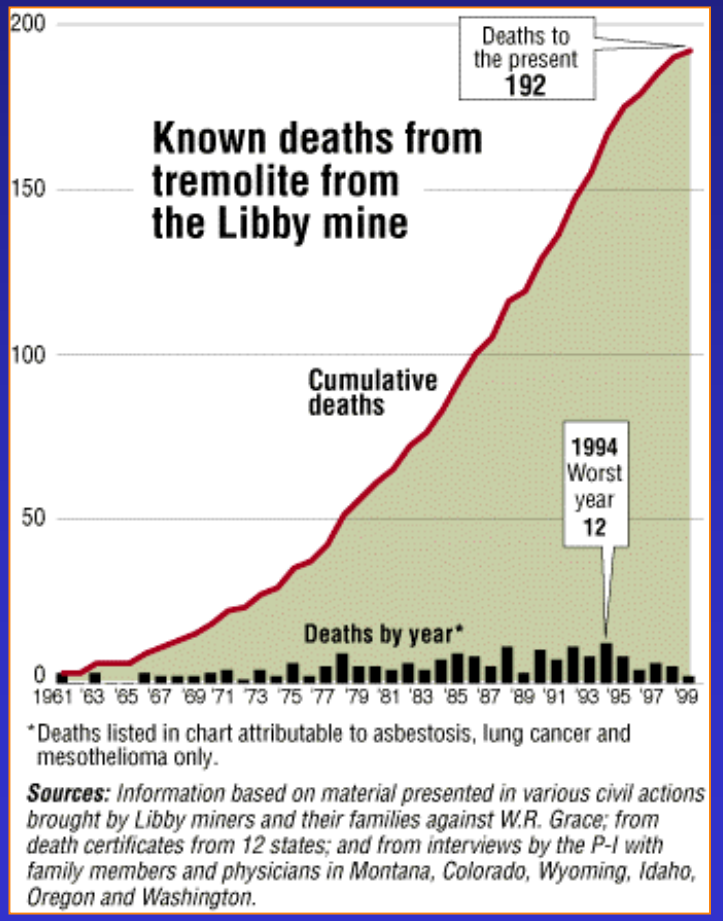
The Health Effects of Dusts

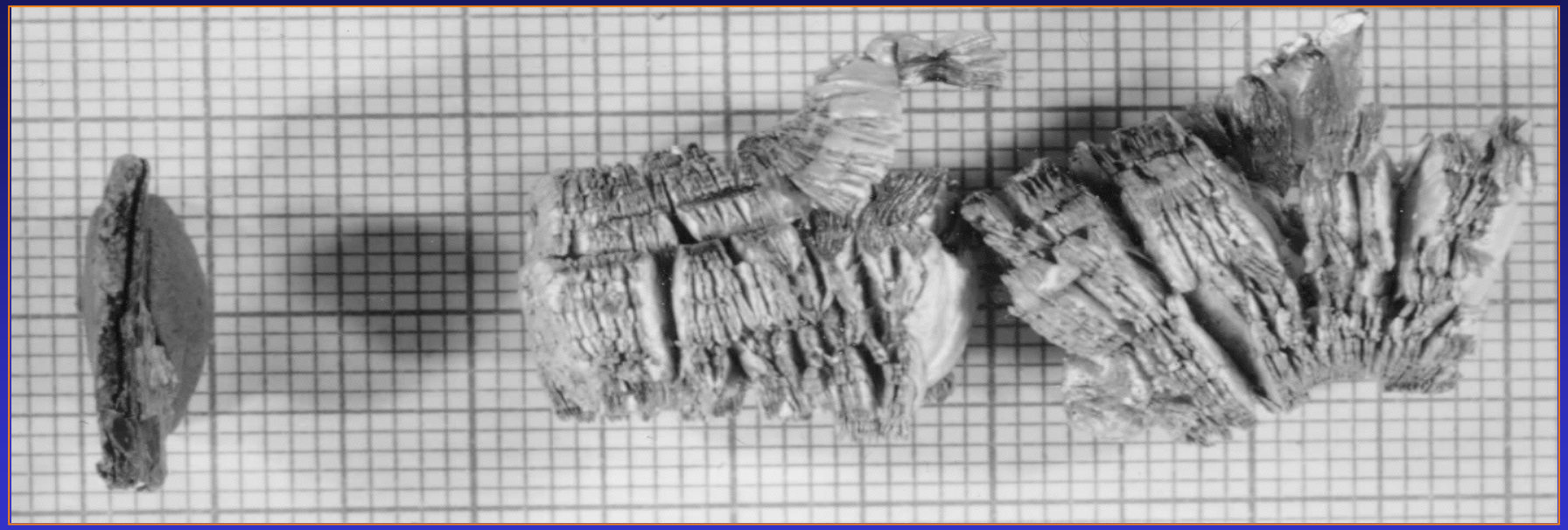
- Some aspects have been well known for decades
  - General effects of industrial / commercial asbestos
  - Silicosis (hard rock mining)
  - Black lung (coal mining)
- New issues and problems are arising
  - Effects of trace asbestos in other rocks, industrial products
  - Valley fever
  - Trans-oceanic dust transport

Libby, Montana

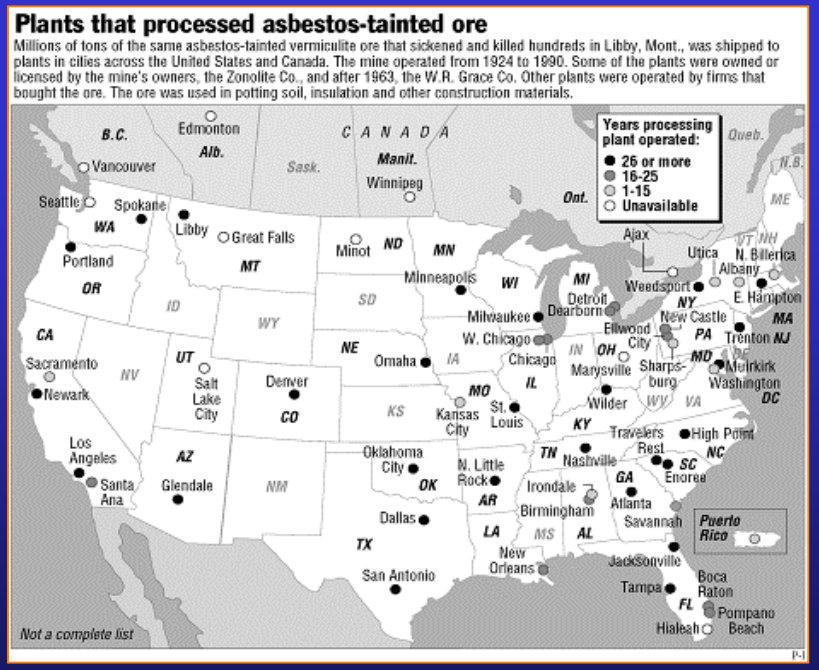
- In late 1999, the Seattle Post-Intelligencer (http://www.seattlep-i.com) ran a series of articles highlighting very high incidences of mesothemlioma, other cancers, and asbestosis among vermiculite miners and mill workers, their families, and the general public in Libby, Montana (pop. ~2500).
  - Nearly 200 deaths “attributable to asbestosis, lung cancer, and mesothelioma”
  - Reportedly another 300 residents currently have these diseases
- Fibrous tremolite, a potentially highly toxic form of asbestos, is a common trace mineral in the vermiculite mined at Libby.
- Although known for several decades, the growing health problems at Libby have recently become the focus of intense action by EPA and other regulatory agencies.

Images from Seattle Post-Intelligencer






10 micrometers
Fibrous Tremolite, SEM view


Plants that processed asbestos-tainted ore
Millions of tons of the same asbestos-tainted vermiculite ore that sickened and killed hundreds in Libby, Mont., was shipped to plants in cities across the United States and Canada. The mine operated from 1924 to 1990. Some of the plants were owned or licensed by the mine's owners, the Zonolite Co., and after 1963, the W.R. Grace Co. Other plants were operated by firms that bought the ore. The ore was used in potting soil, insulation and other construction materials.
Years processing plant operated:
26 or more
16-25
1-15
Unavailable
CANADA
B.C.
Alb.
Sask.
Manit.
Ont.
Queb.
N.B.
Vancouver
Edmonton
Winnipeg
Seattle
Spokane
Libby
Great Falls
Minot
Portland
Minneapolis
Milwaukee
Detroit
Dearborn
Ajax
Weedsport
Utica
N. Billerica
Albany
E. Hampton
New Castle
Ellwood City
Trenton
Sacramento
Newark
Omaha
W. Chicago
Chicago
Marysville
Sharps-burg
Melrkirk
Washington
Salt Lake City
Denver
Kansas City
St. Louis
Wilder
Travelers Rest
High Point
Los Angeles
Santa Ana
Glendale
Oklahoma City
N. Little Rock
Nashville
Enoree
Irondale
Birmingham
Atlanta
Savannah
Dallas
New Orleans
Jacksonville
Tampa
Boca Raton
Pompano Beach
Hialeah
Puerto Rico
San Antonio
Not a complete list

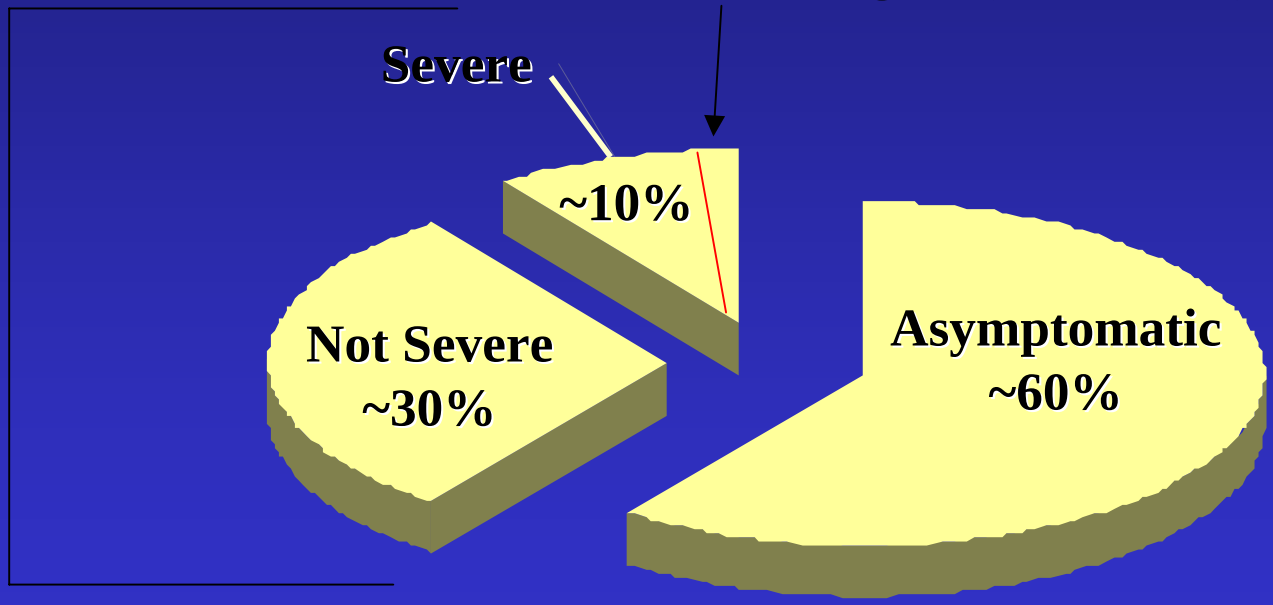
Valley Fever (Coccidioidomycosis)

- Clinical manifestations occur in ~40% of infected persons

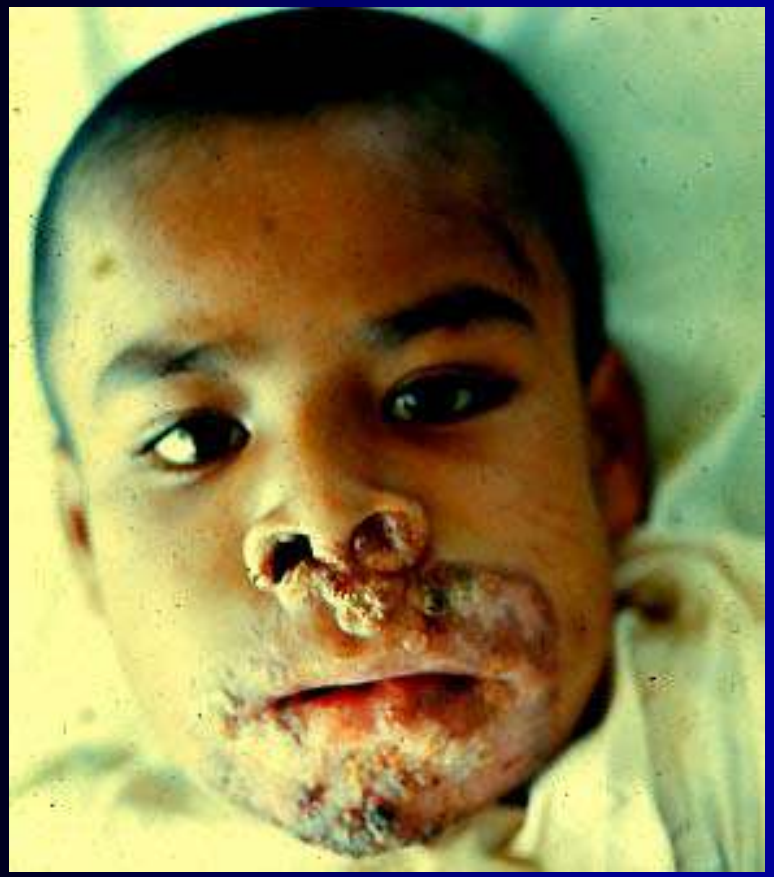
In ~1% to 2% of cases the disease becomes disseminated, and affects skin, bones, or joints, or develops into meningitis (<1 % fatal)

self -limited influenza-like illness to pneumonia

fatigue
cough
chest pain
fever
rash
headache
joint ache



Valley Fever-Clinical Presentation

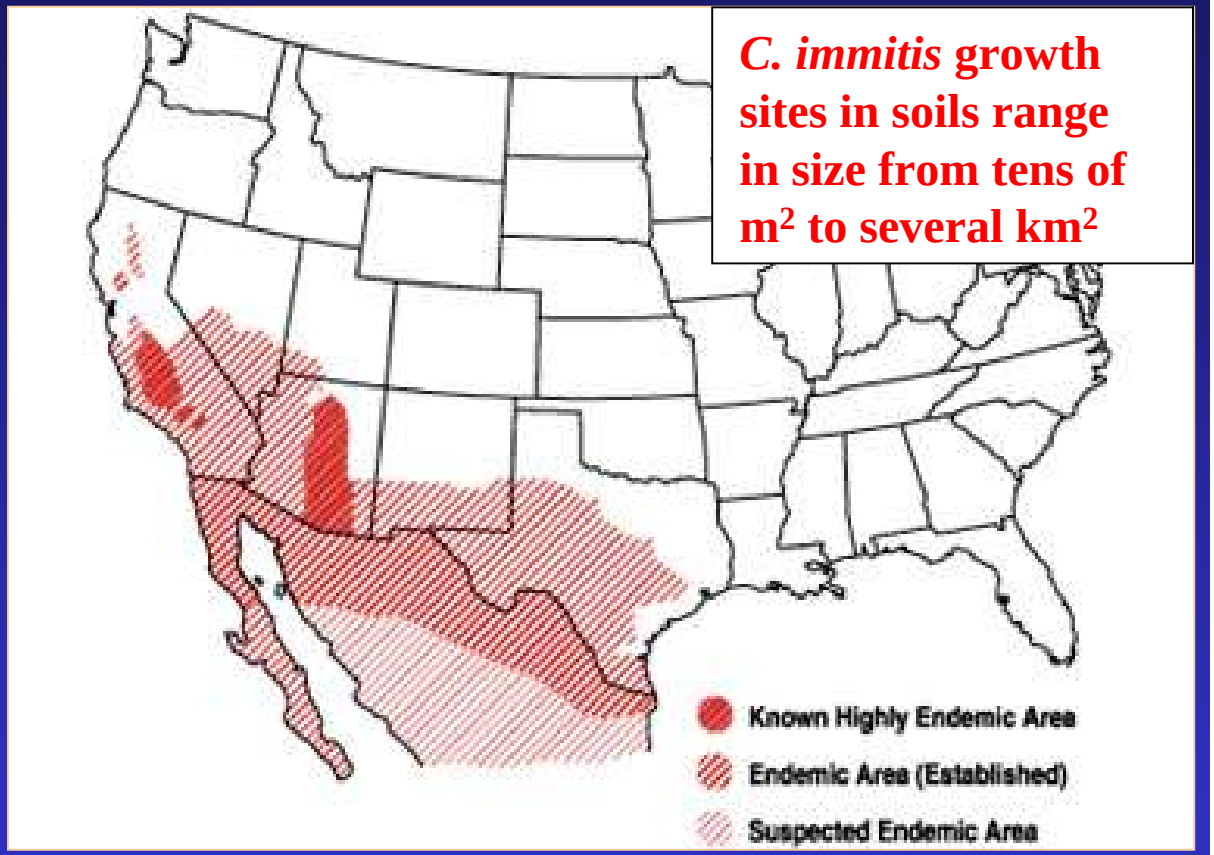


- 7,500 new cases of Valley Fever occur annually in the U.S.A, with a cost in excess of $60 million a year.

Dusts and the origin of Valley Fever (Coccidioidomycosis)

Coccidioidomycosis epidemiology

- Common in parts of desert southwest, but...
- Persons receiving packages and clothing from endemic regions have been infected by the aerosols created by handling
- Travelers passing even briefly through endemic areas can be infected and develop the illness well away from endemic areas



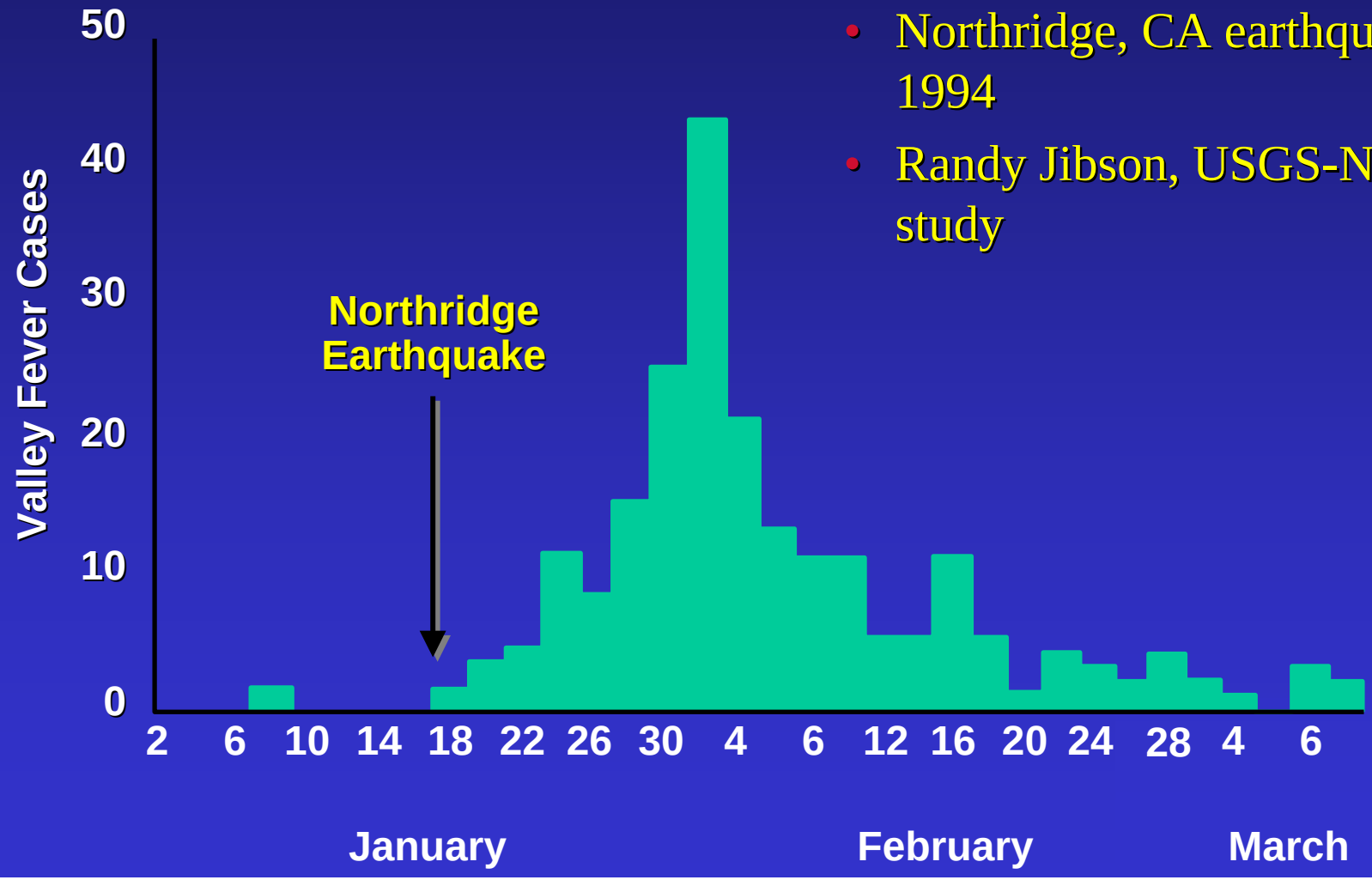
Dusts and the origin of Valley Fever (Coccidioidomycosis)

- Geologic links to Valley Fever
  - Boron-rich, alkaline soils?
  - Marine shale parent rocks?
  - Evaporative alkaline salts?
  - Slope, shape of topography
- Dust storms have been shown to carry spore laden dirt as far as 700 km, causing outbreaks

Geologic links to Valley Fever

Valley Fever cases after Northridge earthquake

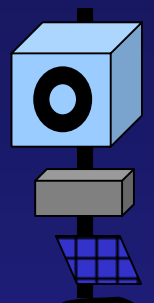
From Jibson et al., 1998

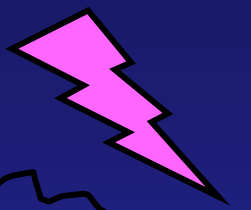


- Earthquakes can trigger VF epidemics by generating landslides and their resulting dust clouds
  - Northridge, CA earthquake, 1994
  - Randy Jibson, USGS-NIH study

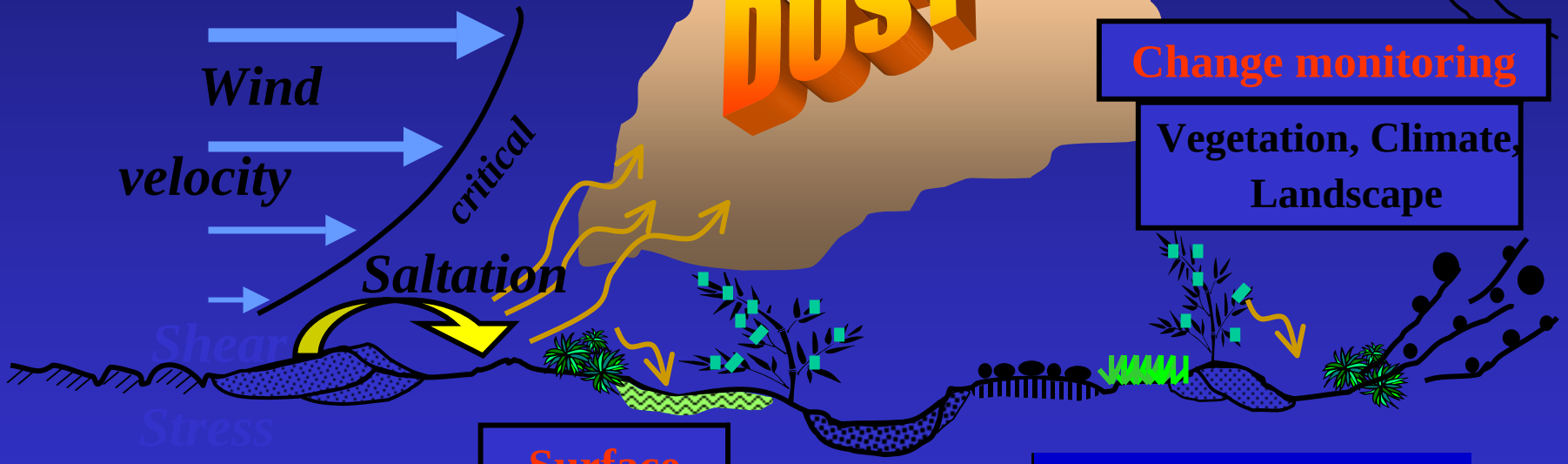
Development of Wind Erosion Model

Calibration
Dust event imaging





Atmospheric boundary layer



Change monitoring

Vegetation, Climate, Landscape

Surface

Armor, roughness RS extrapolation	Sediment availability Soil characteristics

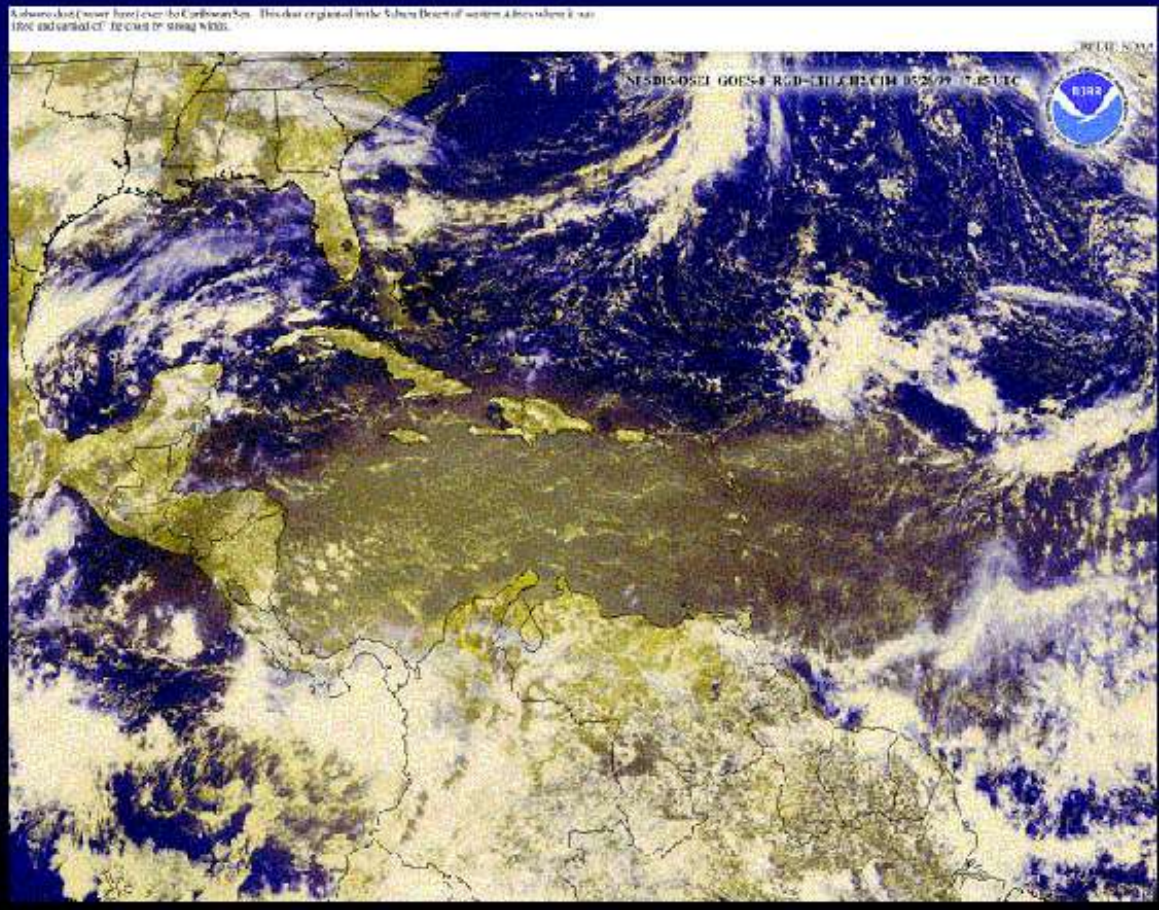
Surface response

USGS

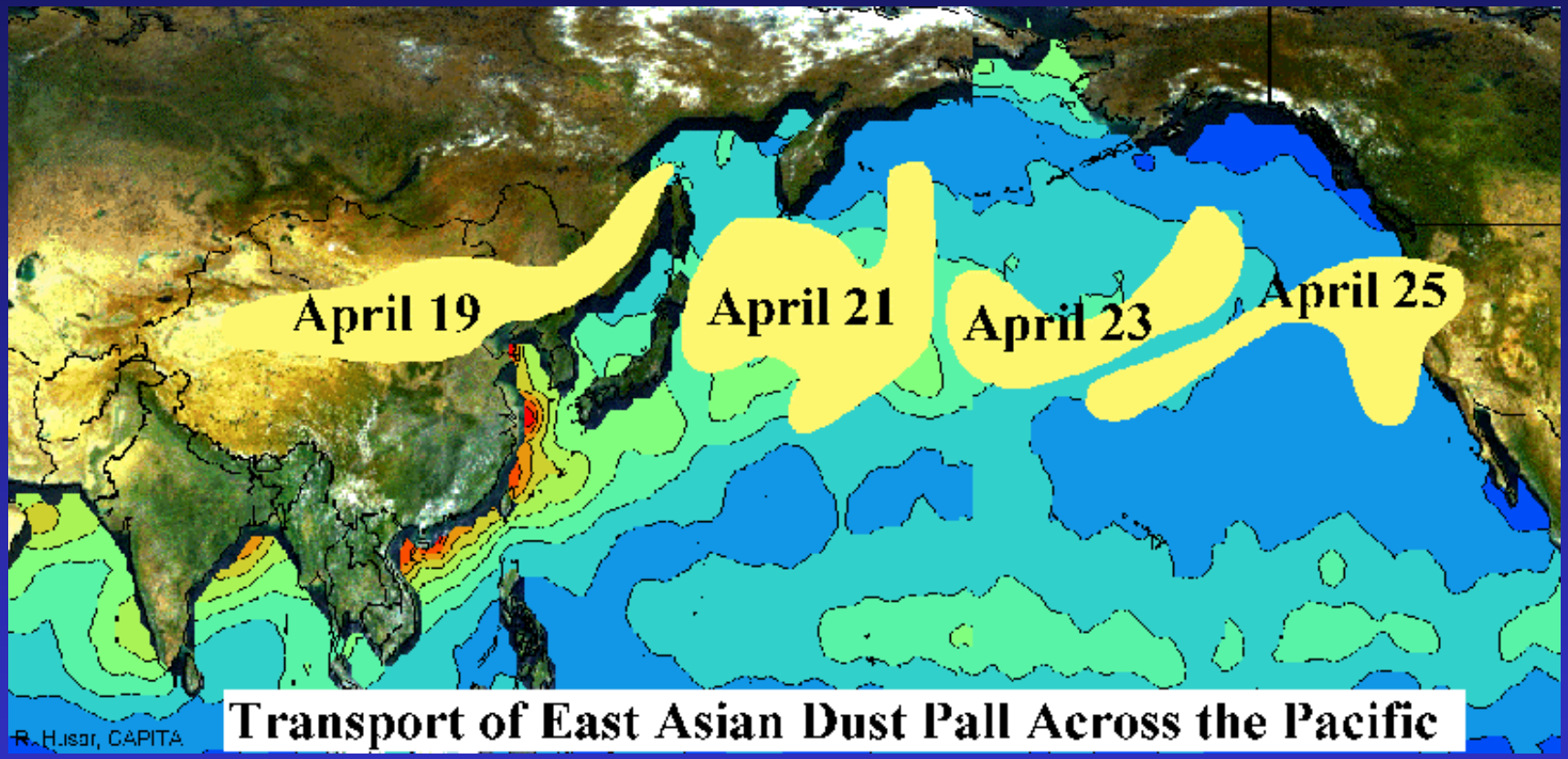
Intercontinental dust transport: Gene Shinn (eshinn@usgs.gov; http://coastal.er.usgs.gov/african_dust/)

- Increasing evidence from satelllite imagery and other means that signficant dust transport can occur between continents across large expanses of oceans
- This exotic dust is increasingly viewed as a key component of some terrestrial and marine ecosystems, as well as a potentially significant source of pathogens and environmental contaminants

- For example, atmospheric transport of dust from North Africa to the western Atlantic Ocean region has increased substantially in recent decades due to desertification of grasslands in the Sahara region
- 100's of millions of tons annually



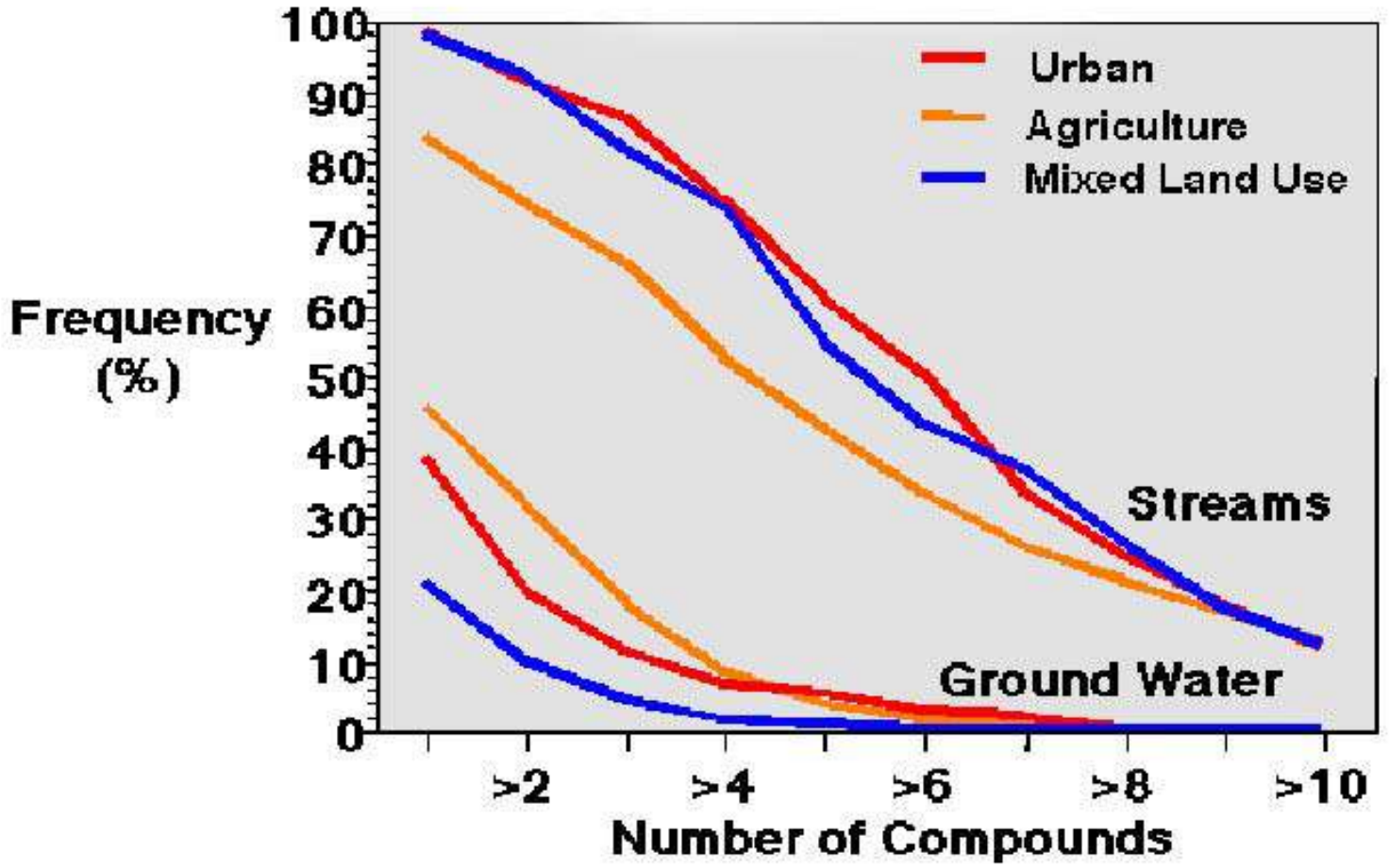
Location of 1998 dust cloud based on SeaWiFS, GMS5, GOES9, GOES10, TOMS satellite data



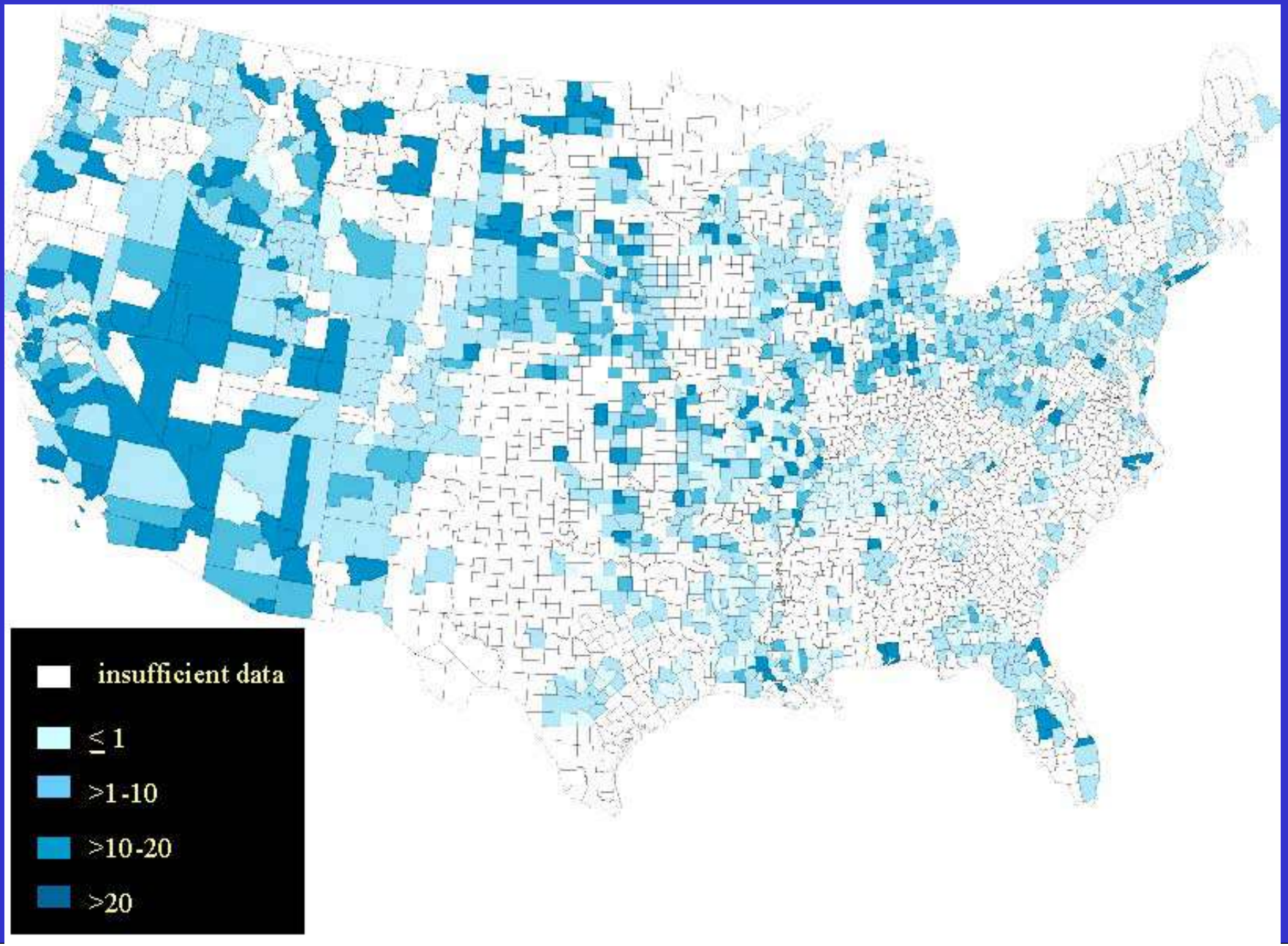
R.B. Husar and 28 others

USGS

Pesticides almost always occur as mixtures

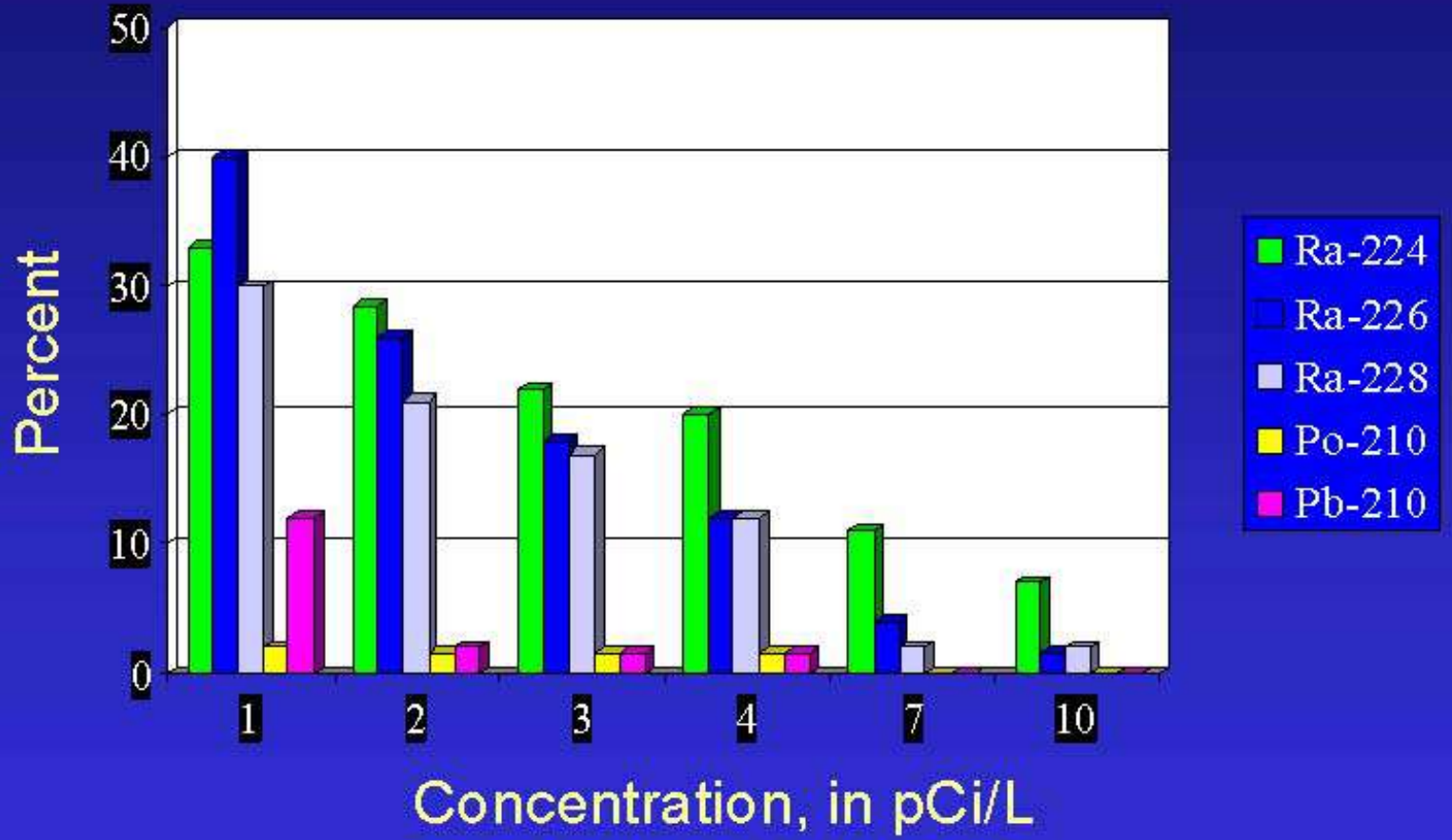


Arsenic in Ground Water in the U.S.



Radionuclide Samples Collected from Public Water Supplies

Percent of samples exceeding targeted concentrations



USGS

Geographic Analysis of Disease Risk

- Where are the potential areas of disease?
- Who are the populations at risk now and in the future?
- When might an outbreak occur?
- How can outbreaks be mitigated?

USGS
science for a changing world

Landscape Epidemiology

By knowing the ecological conditions necessary for the maintenance of specific pathogens in nature, one can use these characteristics to identify the spatial and temporal distribution of disease risk.

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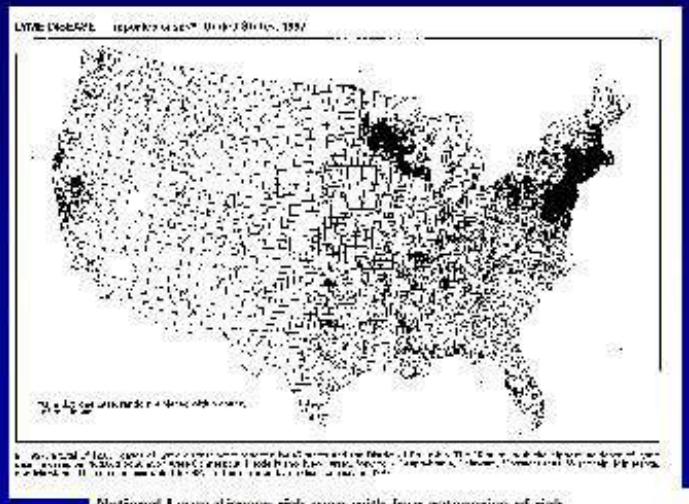
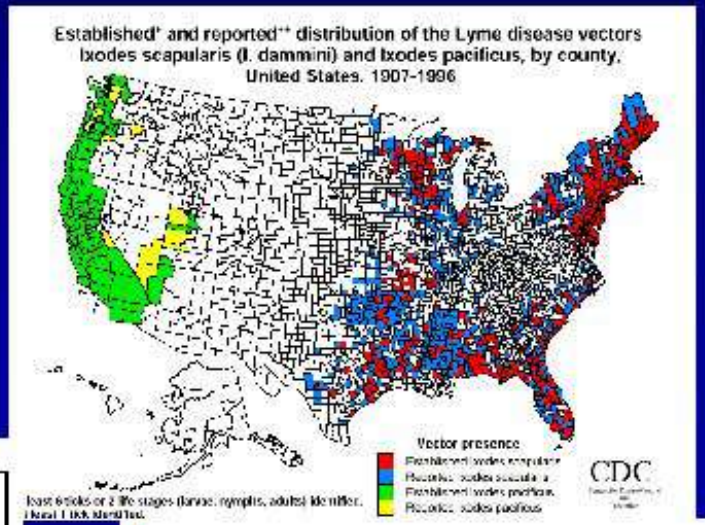
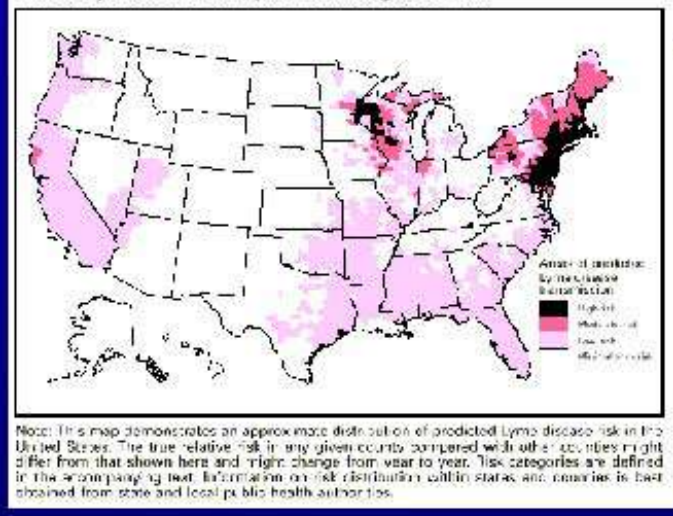
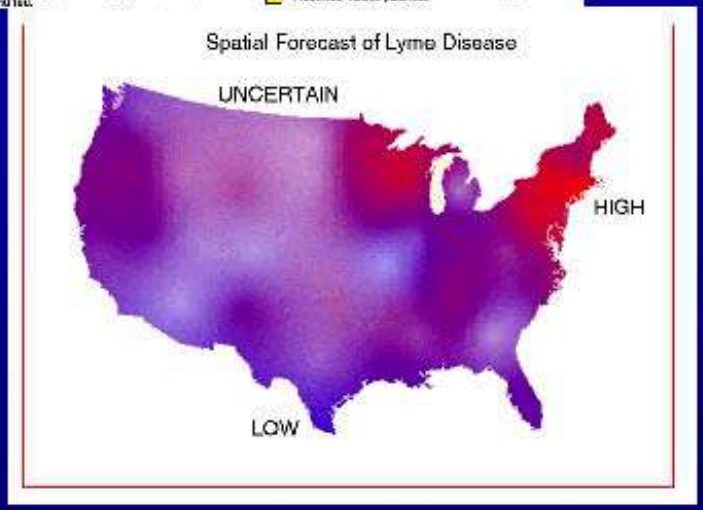
science for a changing world

Analysis of Lyme Disease









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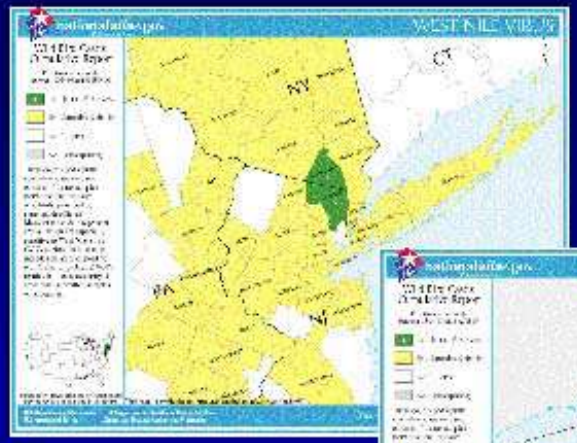
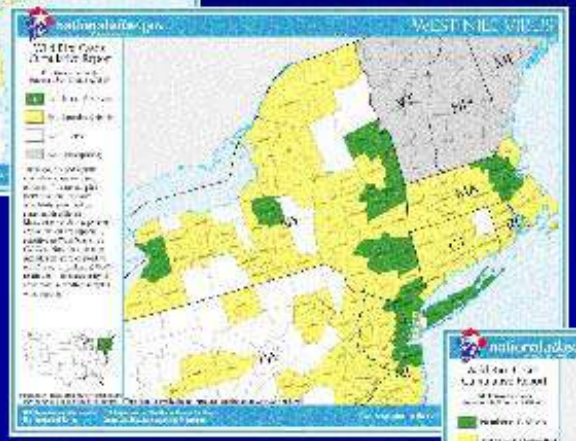
Spread of West Nile Virus - 2000

(avian mortality)



30 June



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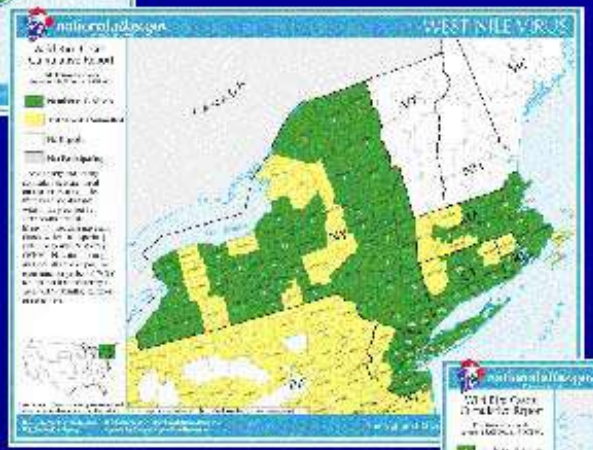
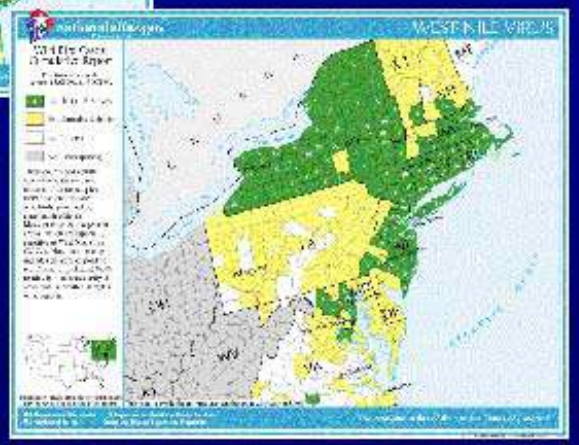


8 September



13 October

USGS
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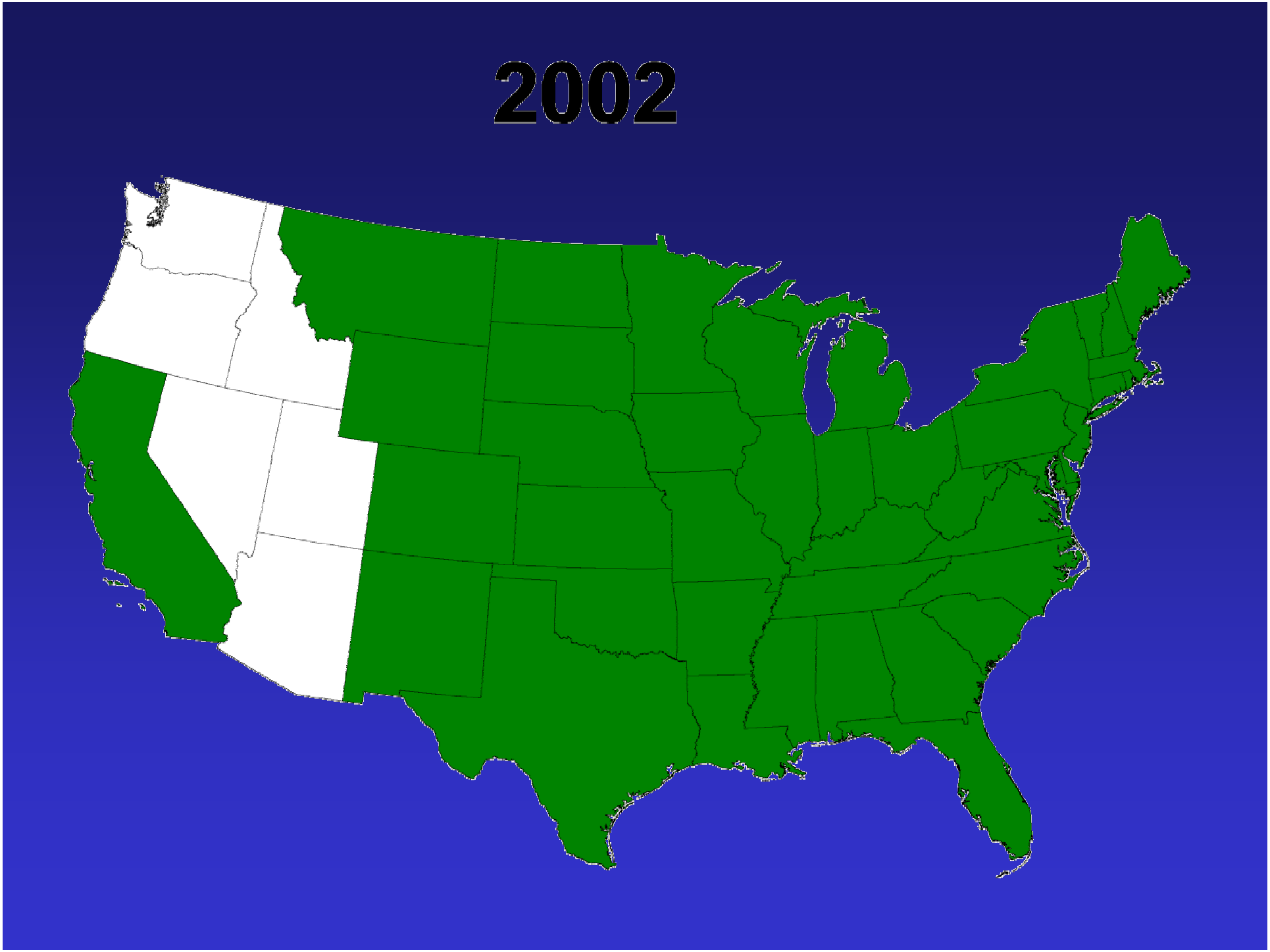
2002



Health Impacts of Biomass Fuels

Scale: Number of Peoples Affected.

>>>

AIDS

+

HEART DISEASE

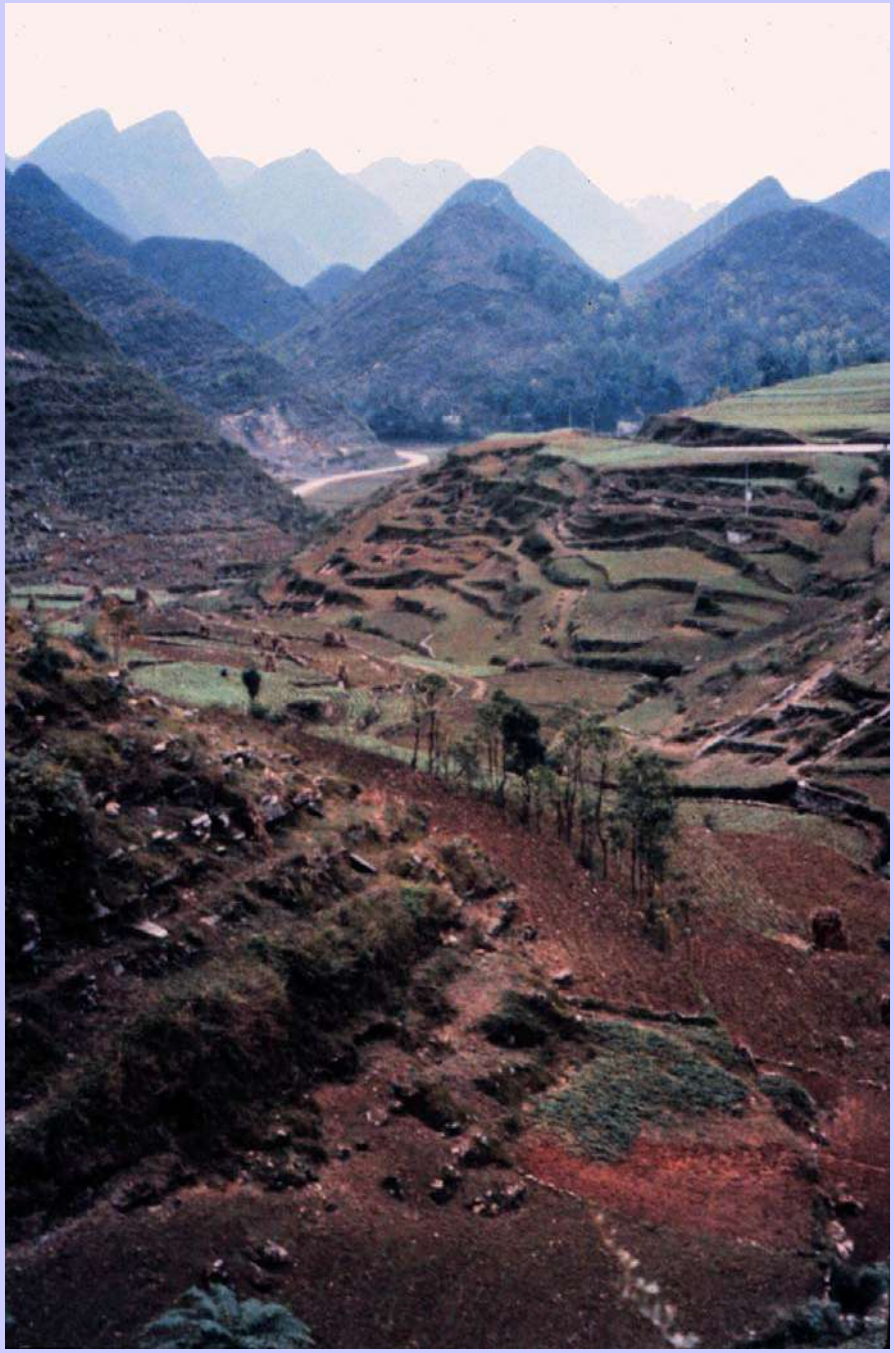
+

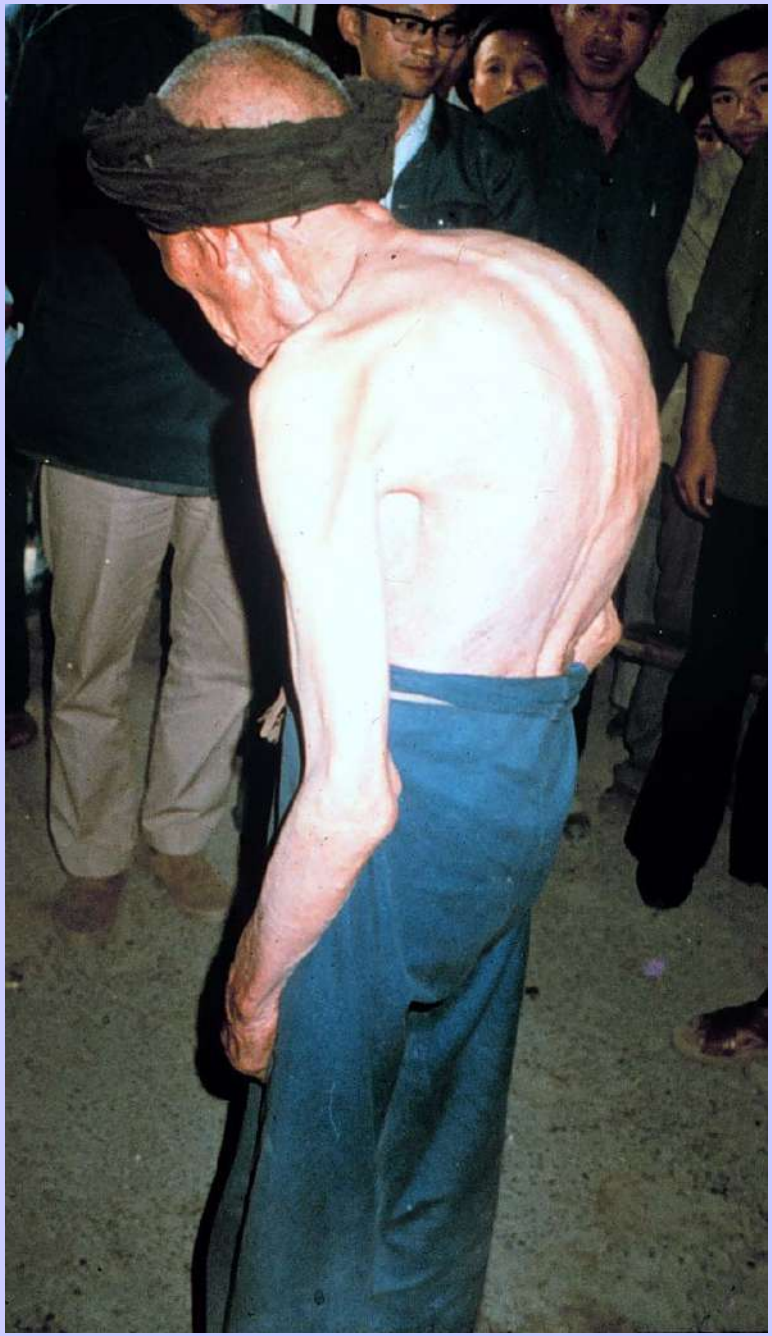
CANCER

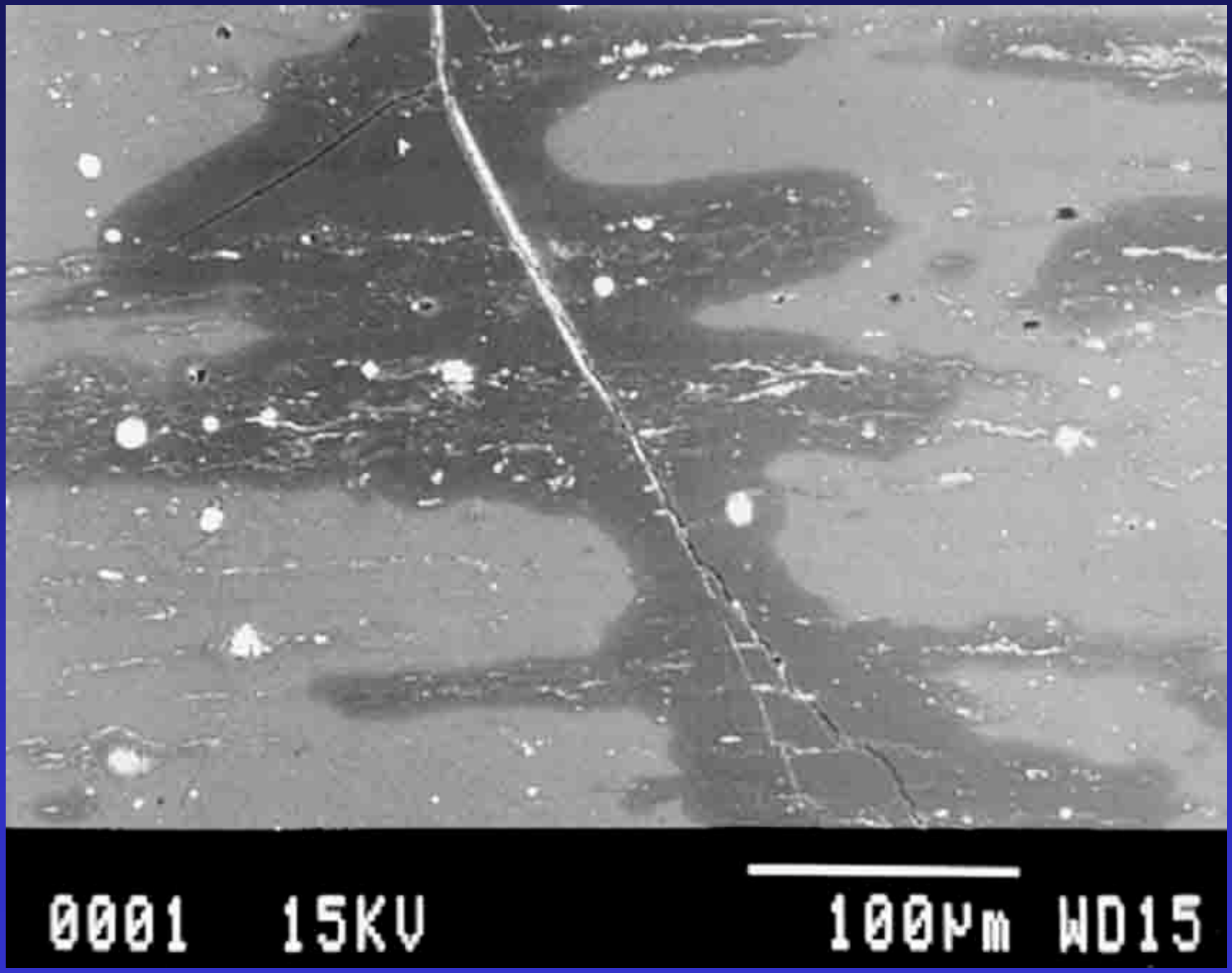
+++

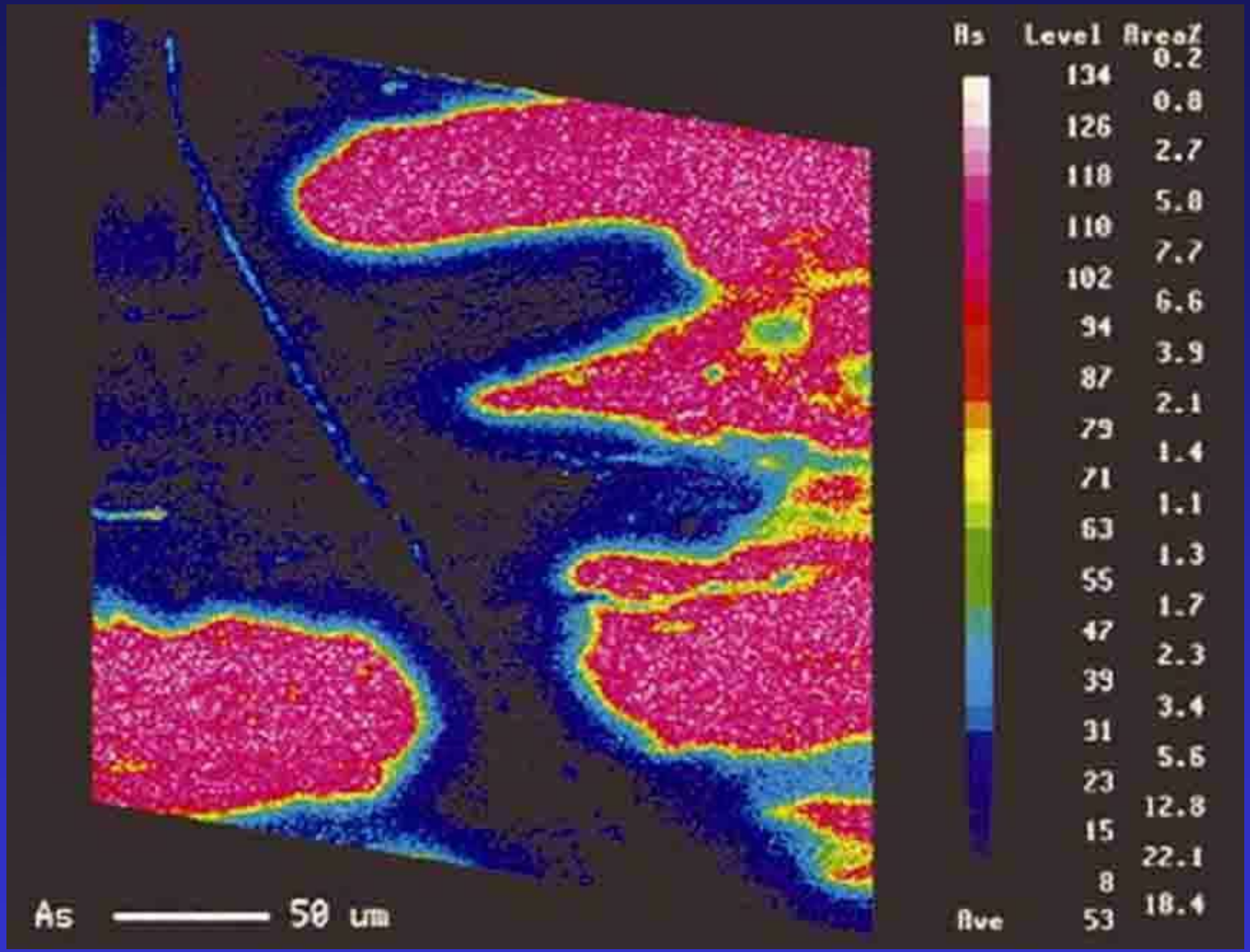
Severity: ~ 4 million deaths annually

USGS






0001 15KV
100µm WD15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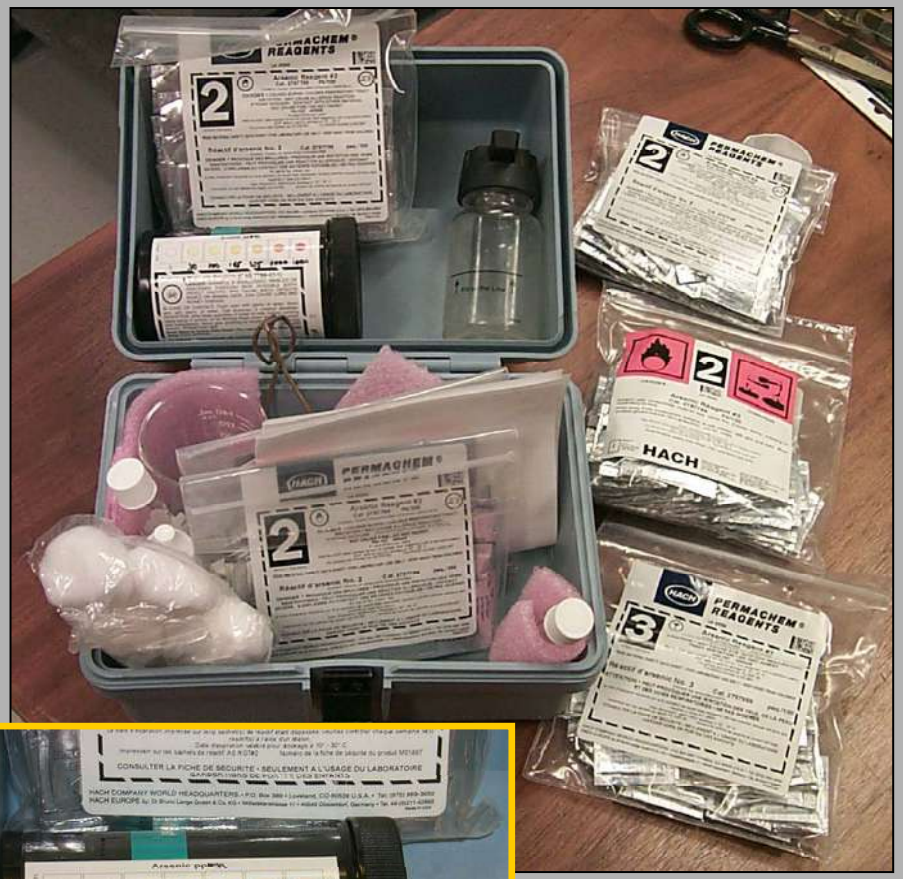
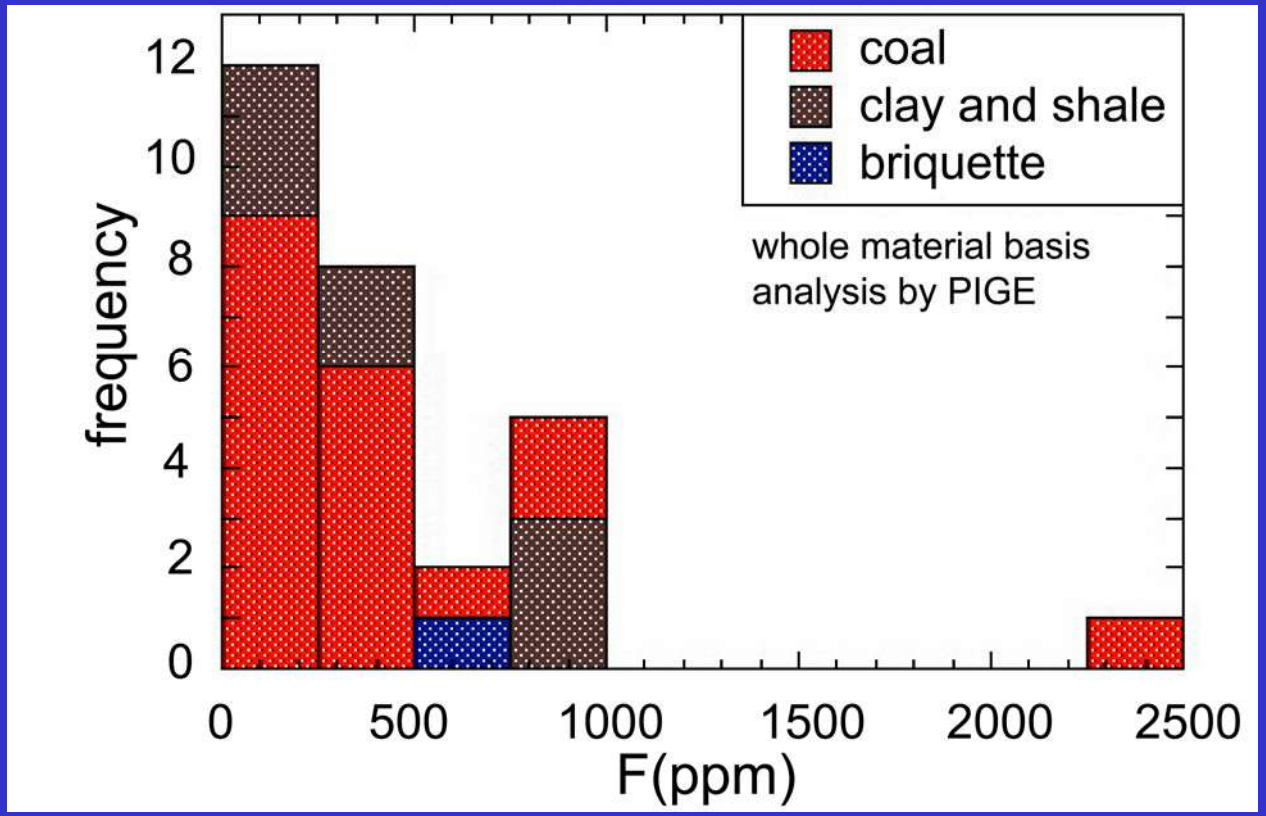
As
50 um

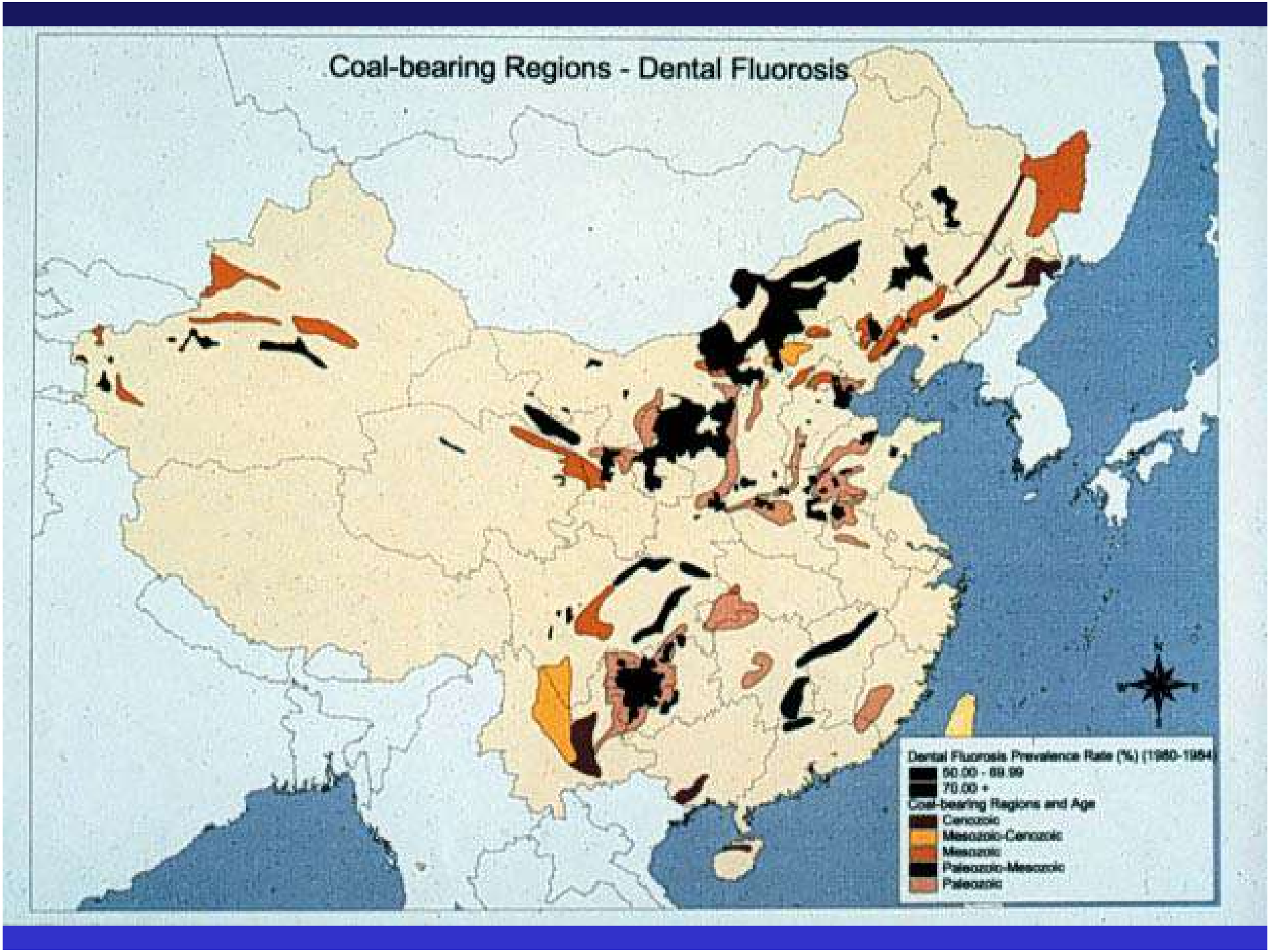


Arsenic Field Tests

- *Test kit developed in China to identify arsenic-rich coals in the field.*
- *Commercial version (left) being introduced by U.S. manufacturer.*
- *Testing has resulted in closure of "mines" with highest As coal.*

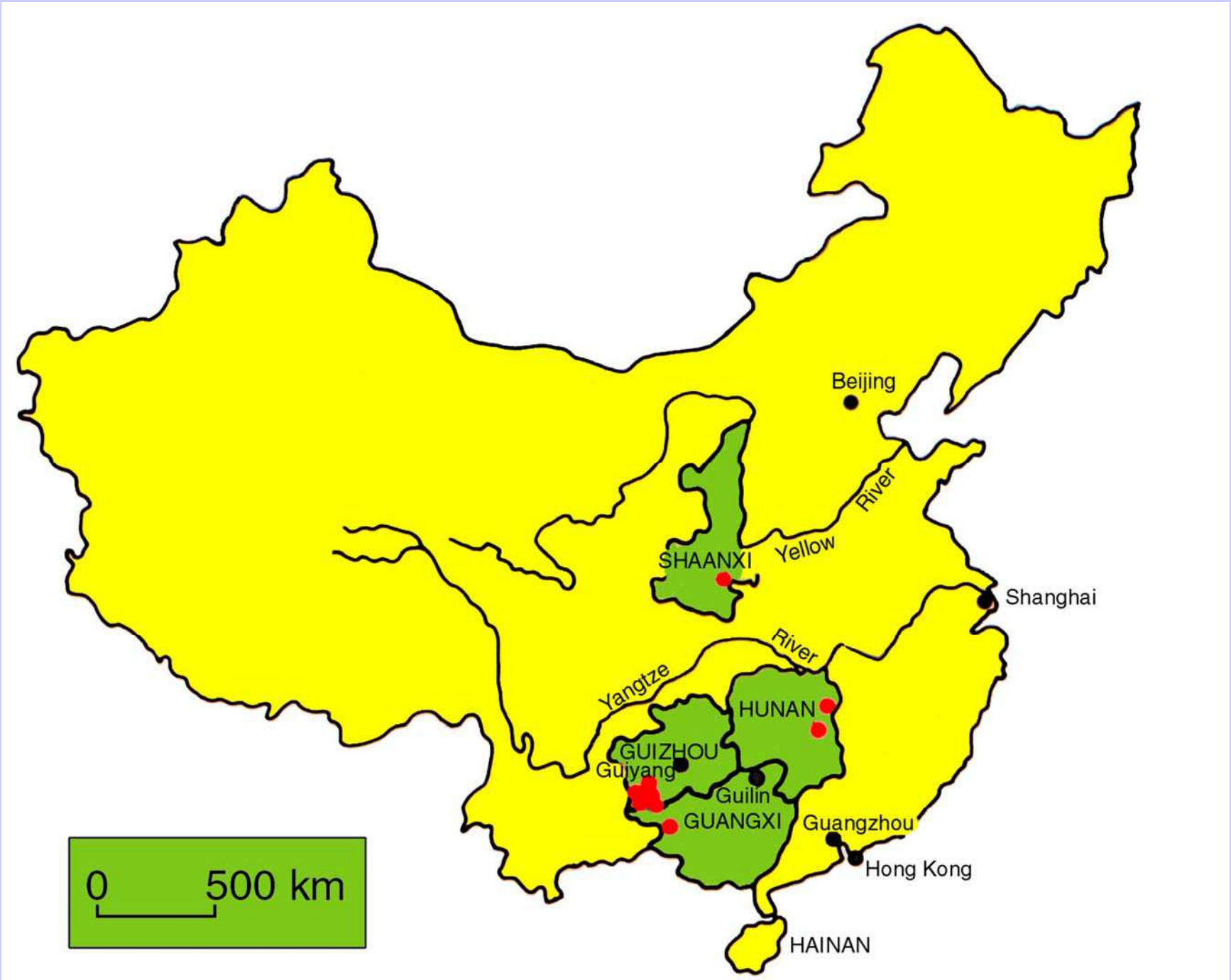
USGS
science for a changing world


coal
clay and shale
briquette
whole material basis
analysis by PIGE
frequency
0
2
4
6
8
10
12
0
500
1000
1500
2000
2500
F(ppm)


Coal-bearing Regions - Dental Fluorosis
Dental Fluorosis Prevalence Rate (%) (1980-1984)
60.00 - 69.99
70.00 +
Coal-bearing Regions and Age
Cenozoic
Mesozoic-Cenozoic
Mesozoic
Paleozoic-Mesozoic
Paleozoic

Coal Miners “Black Lung Disease”

National Museum of Health and Medicine, Washington, DC


Beijing
SHAANXI
Yellow
River
Shanghai
Yangtze
River
HUNAN
GUIZHOU
Guiyang
Guilin
GUANGXI
Guangzhou
Hong Kong
HAINAN
0
500 km