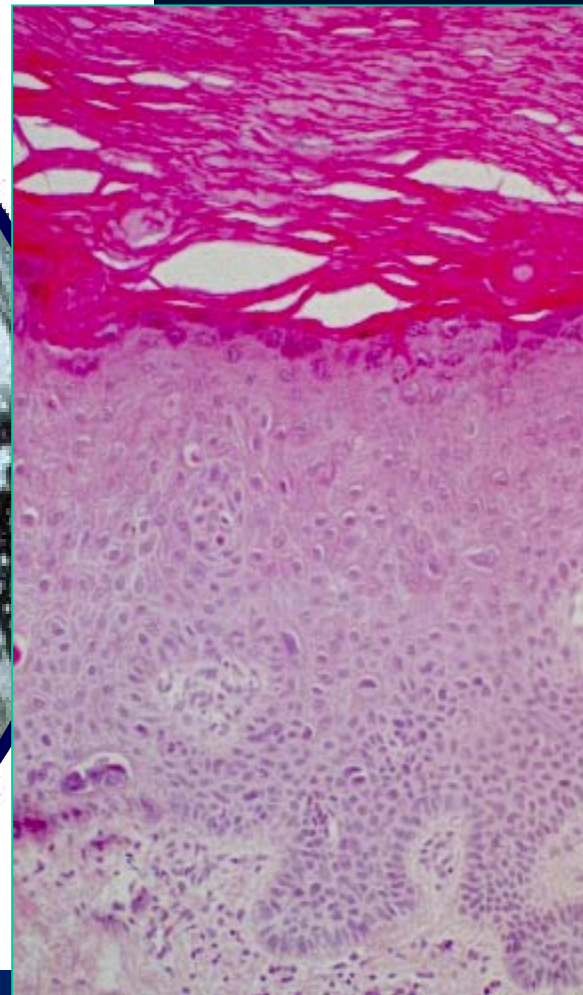


Environmental and health effects of  
toxic elements, metal ions, and minerals



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](mailto:rbf@usgs.gov)









## 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

# 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







# Disease Progression

---



# Valley Fever-Clinical Presentation



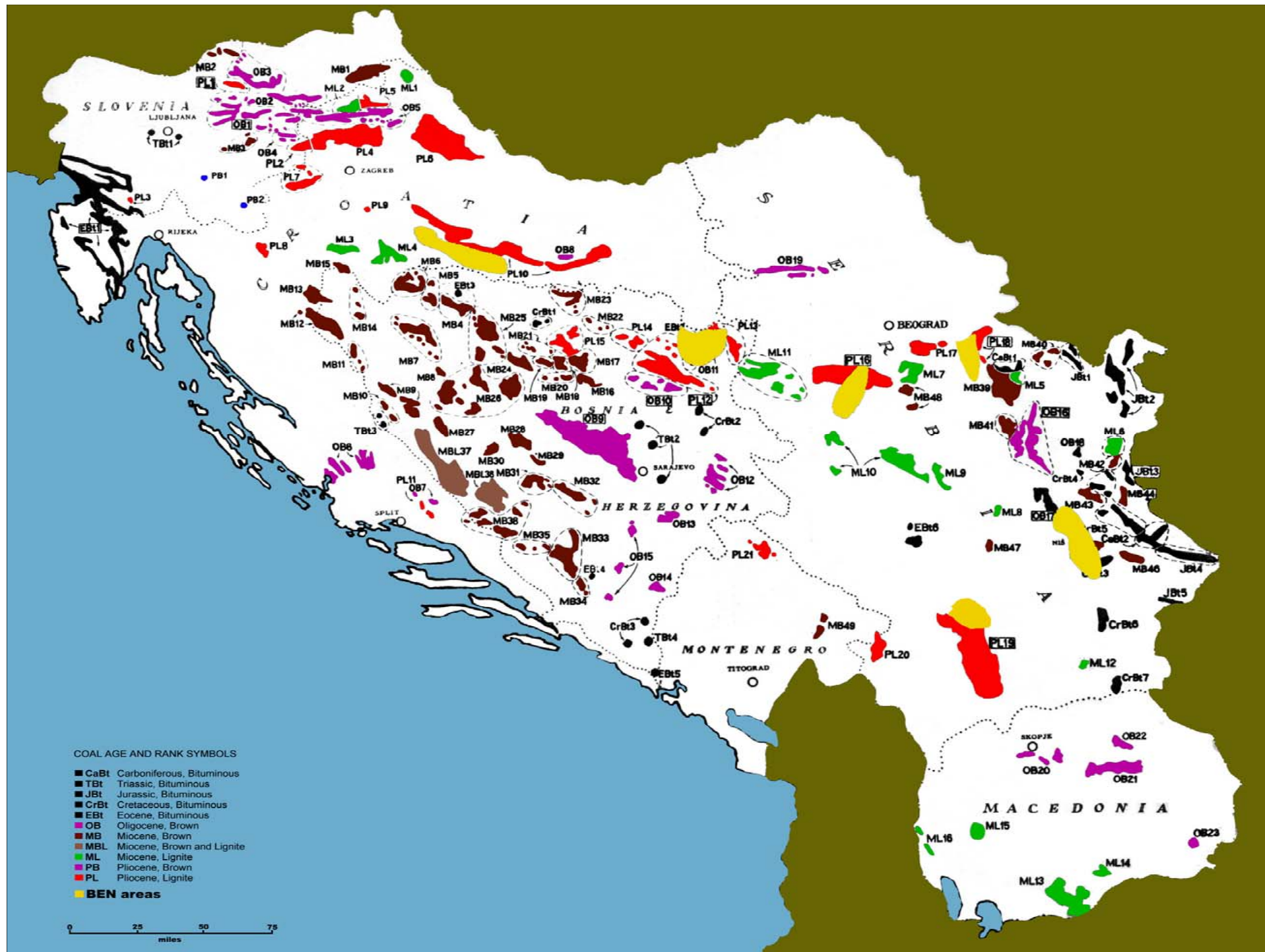
◆ 7,500 new cases of Valley Fever occur annually in the U.S.A, with a cost in excess of \$60 million a year.



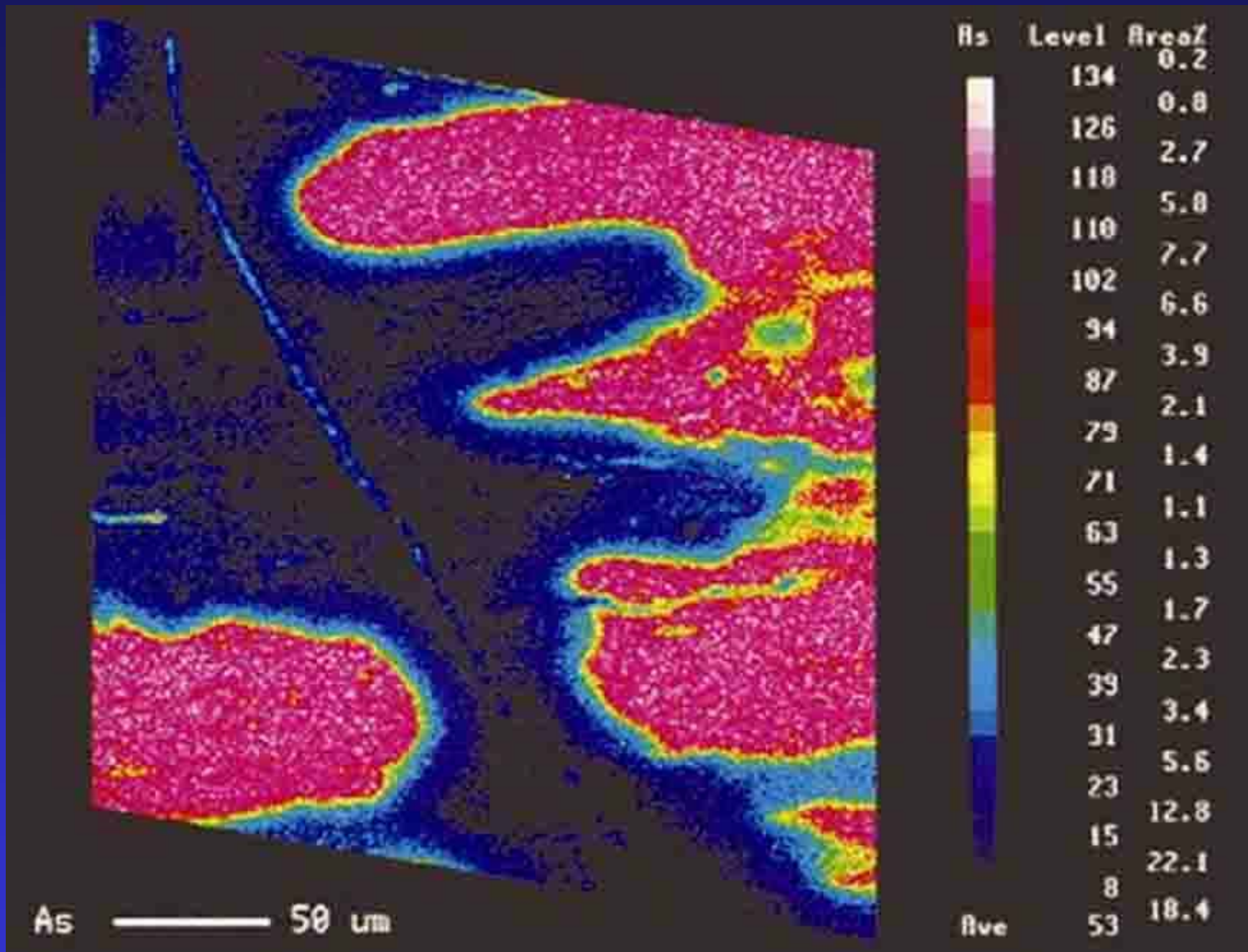


# BALKAN ENDEMIC NEPHROPATHY (BEN)



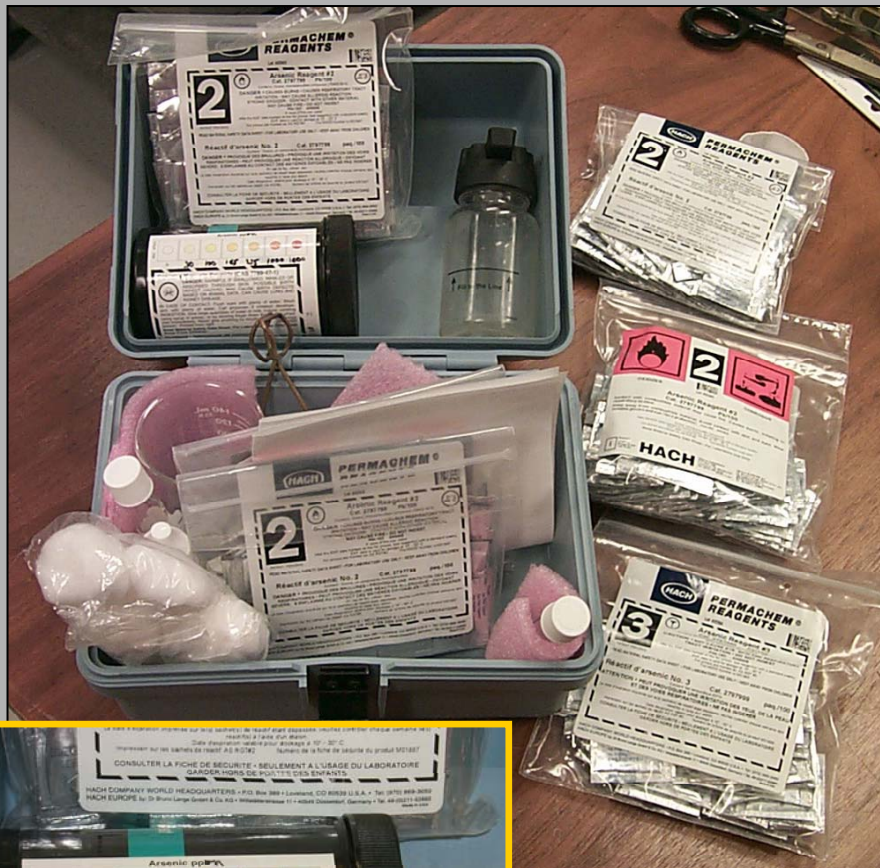






# Arsenic Field Tests

- *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.*





## **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@bms.uu.se*
- **Ron Fuge, University of Aberystwyth, UK**  
*rrf@aber.ac.uk*
- **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@afip.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



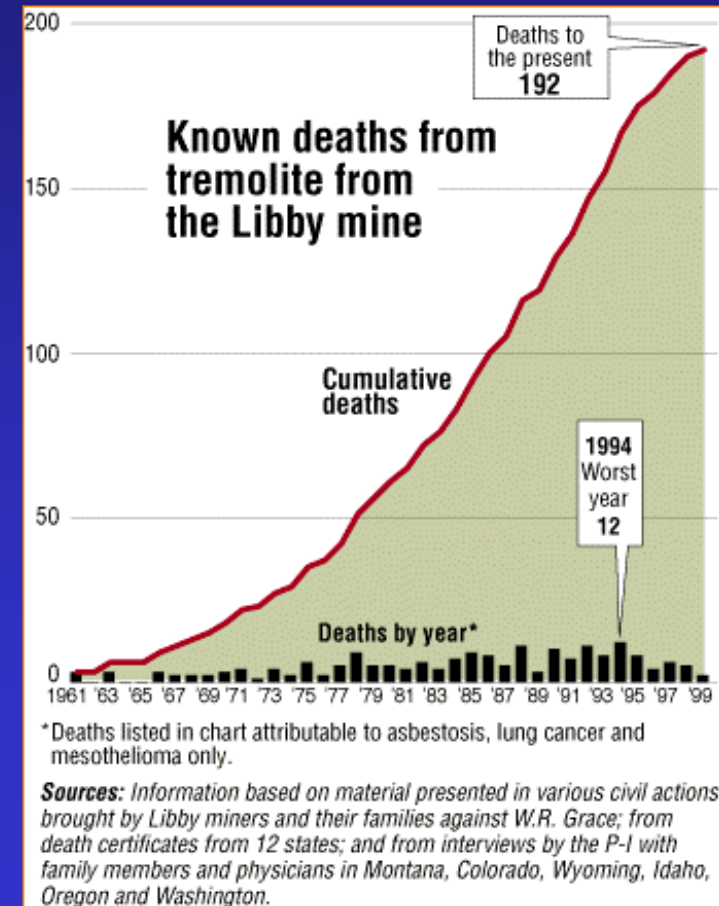


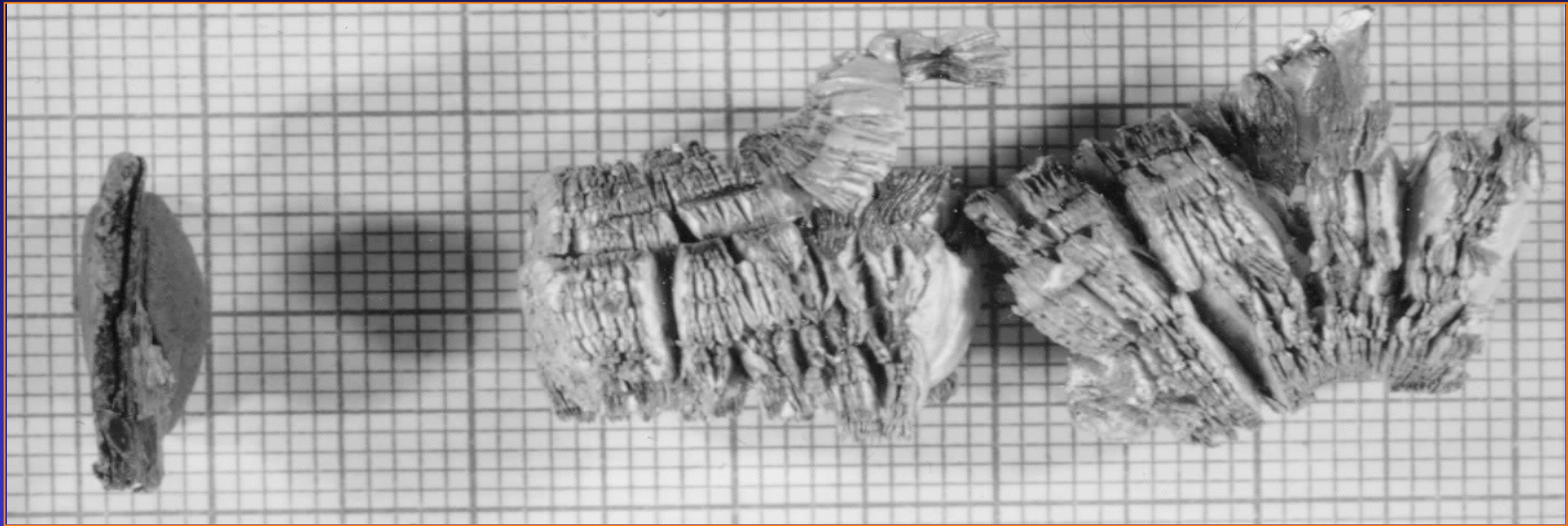
# Libby, Montana

- In late 1999, the Seattle Post-Intelligencer (<http://www.seattlep-i.com>) ran a series of articles highlighting very high incidences of mesothelioma, 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.



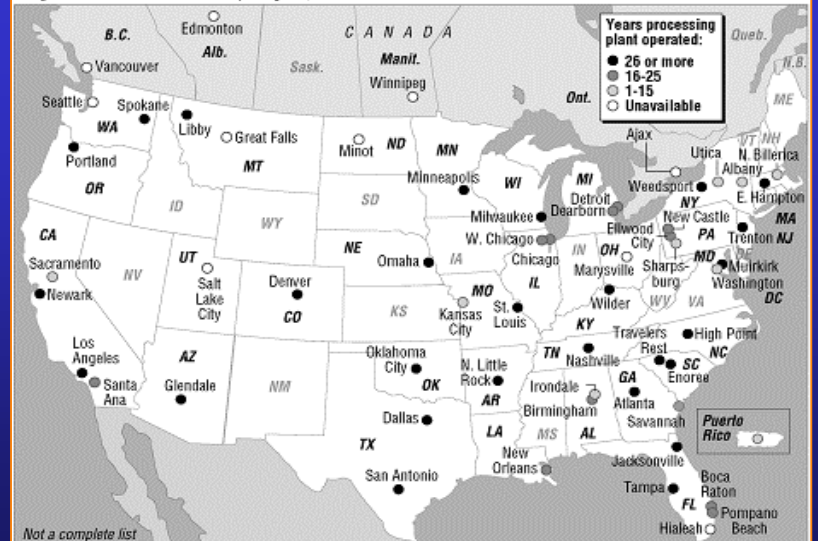
Images from Seattle Post-Intelligencer





### 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.



# Valley Fever (Coccidioidomycosis)

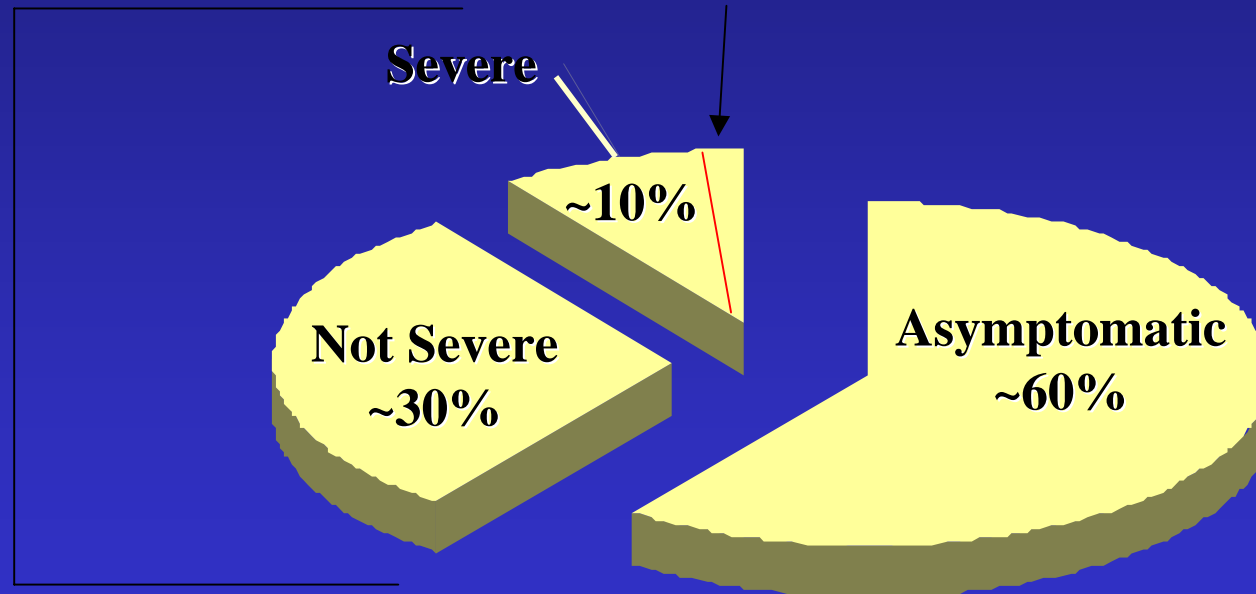
- Clinical manifestations occur in ~40% of infected persons



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

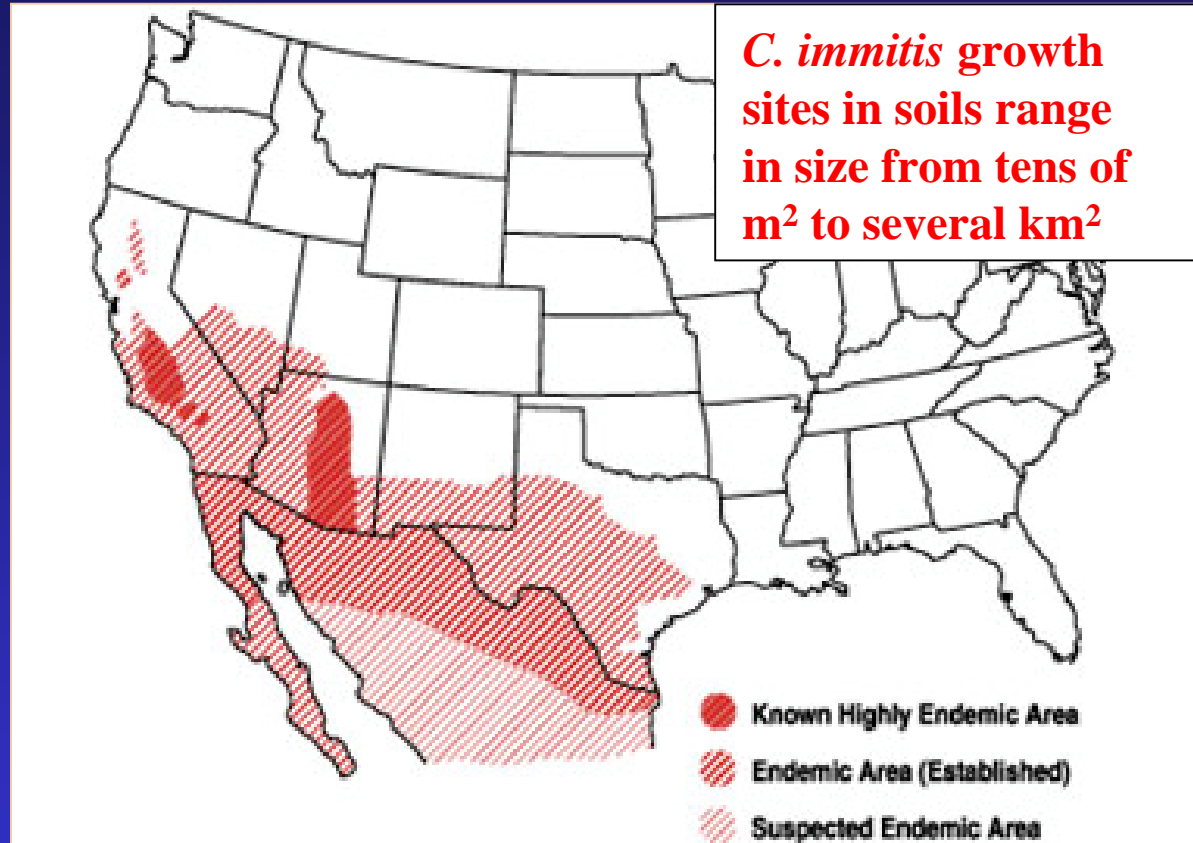


◆ 7,500 new cases of Valley Fever occur annually in the U.S.A, with a cost in excess of \$60 million a year.

# 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



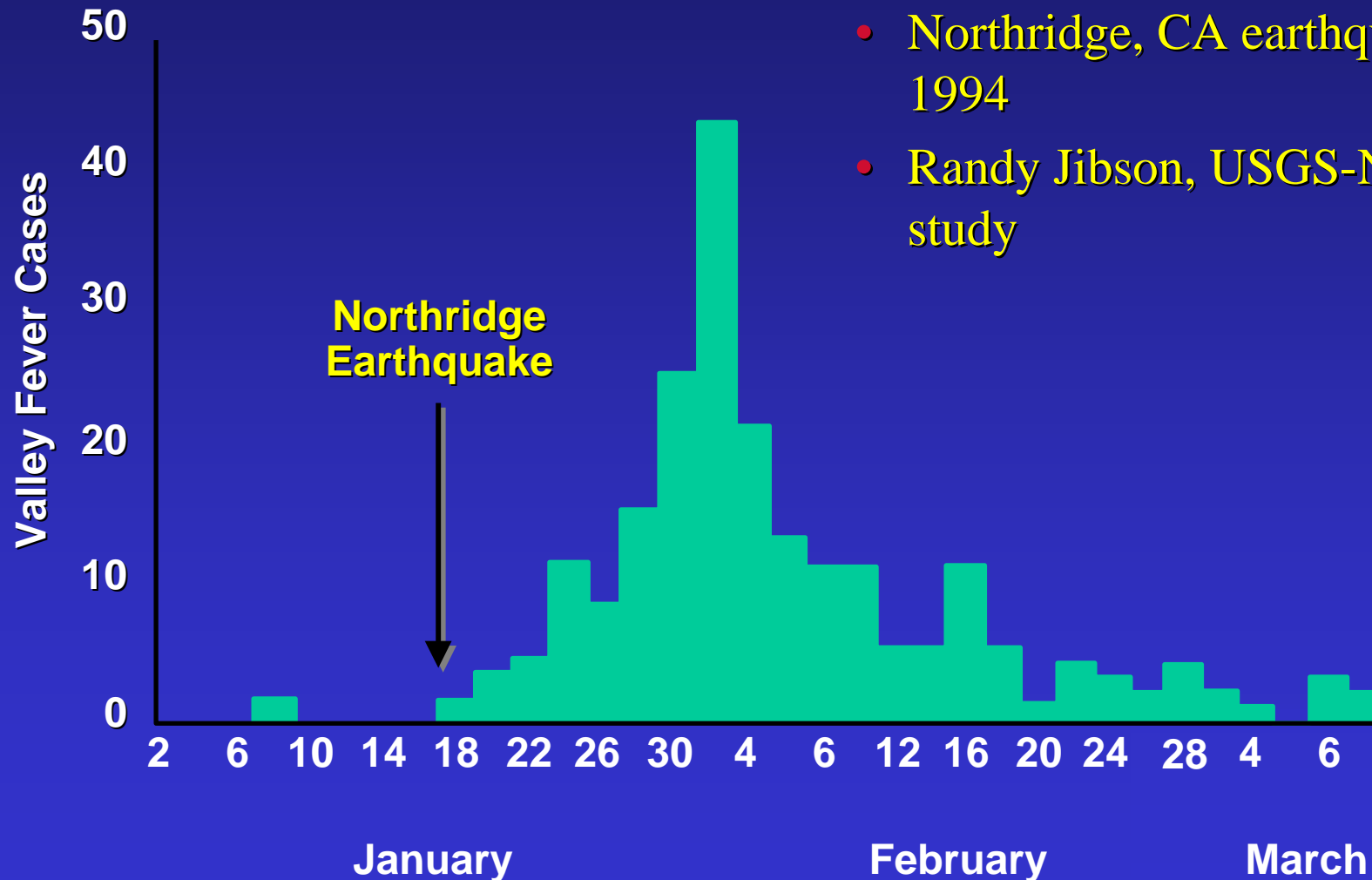
# Geologic links to Valley Fever

## Valley Fever cases after Northridge earthquake

From Jibson et al., 1998

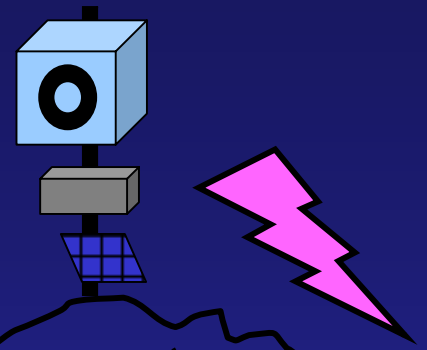
- Earthquakes can trigger VF epidemics by generating landslides and their resulting dust clouds

- Northridge, CA earthquake, 1994
- Randy Jibson, USGS-NIH study

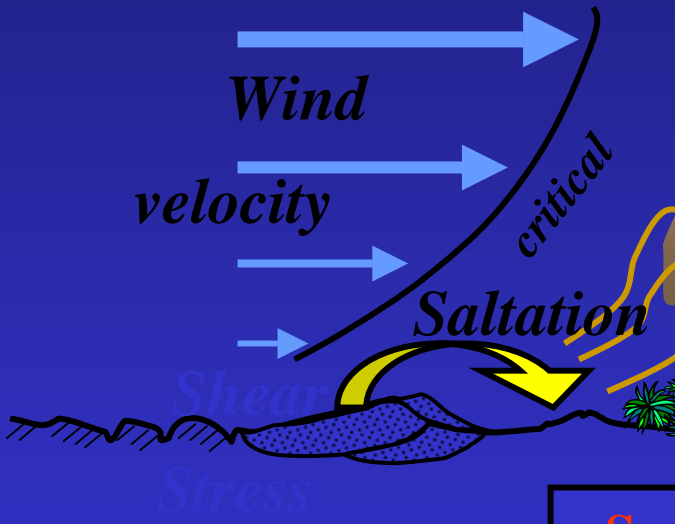


# Development of Wind Erosion Model

Calibration  
Dust event imaging



Atmospheric boundary layer



# DUST

Change monitoring  
Vegetation, Climate,  
Landscape

Surface

Surface response

Armor, roughness RS extrapolation	Sediment availability Soil characteristics
--------------------------------------	---

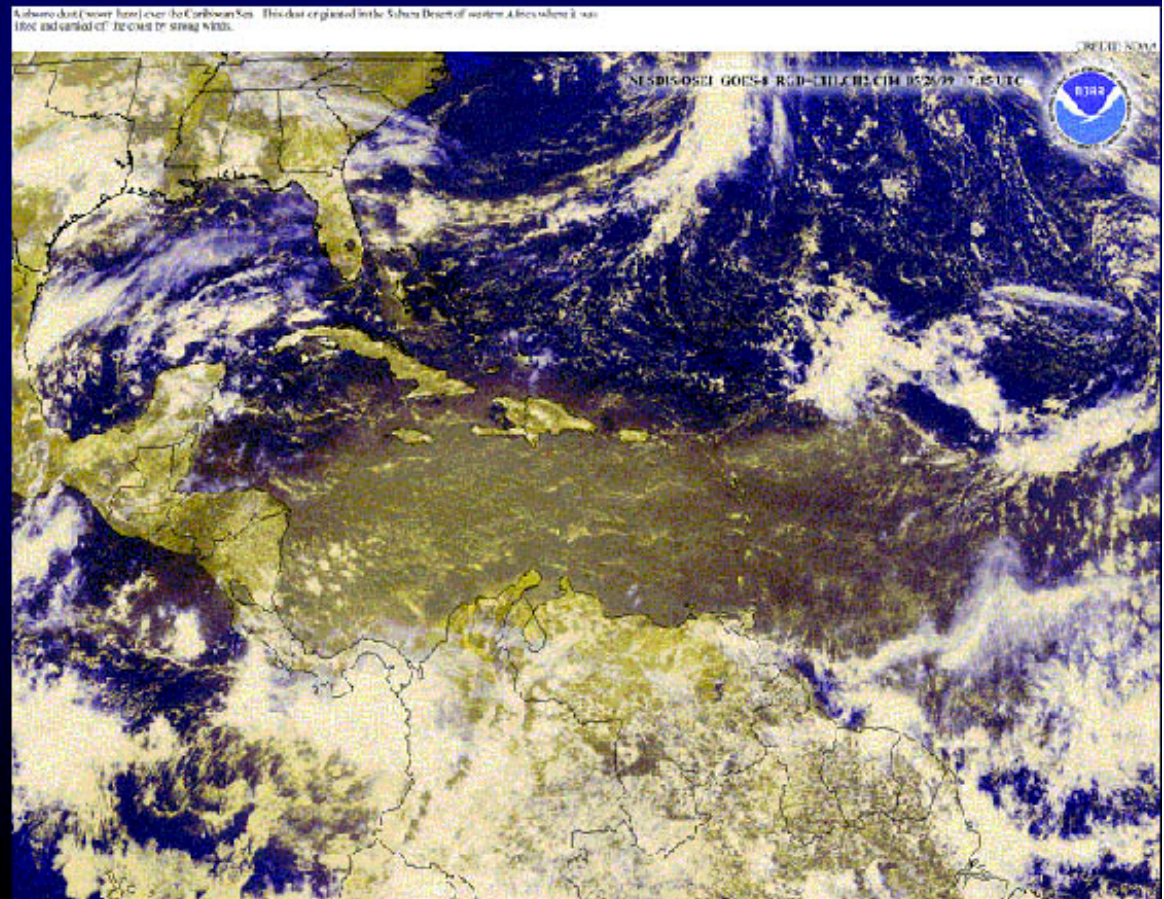




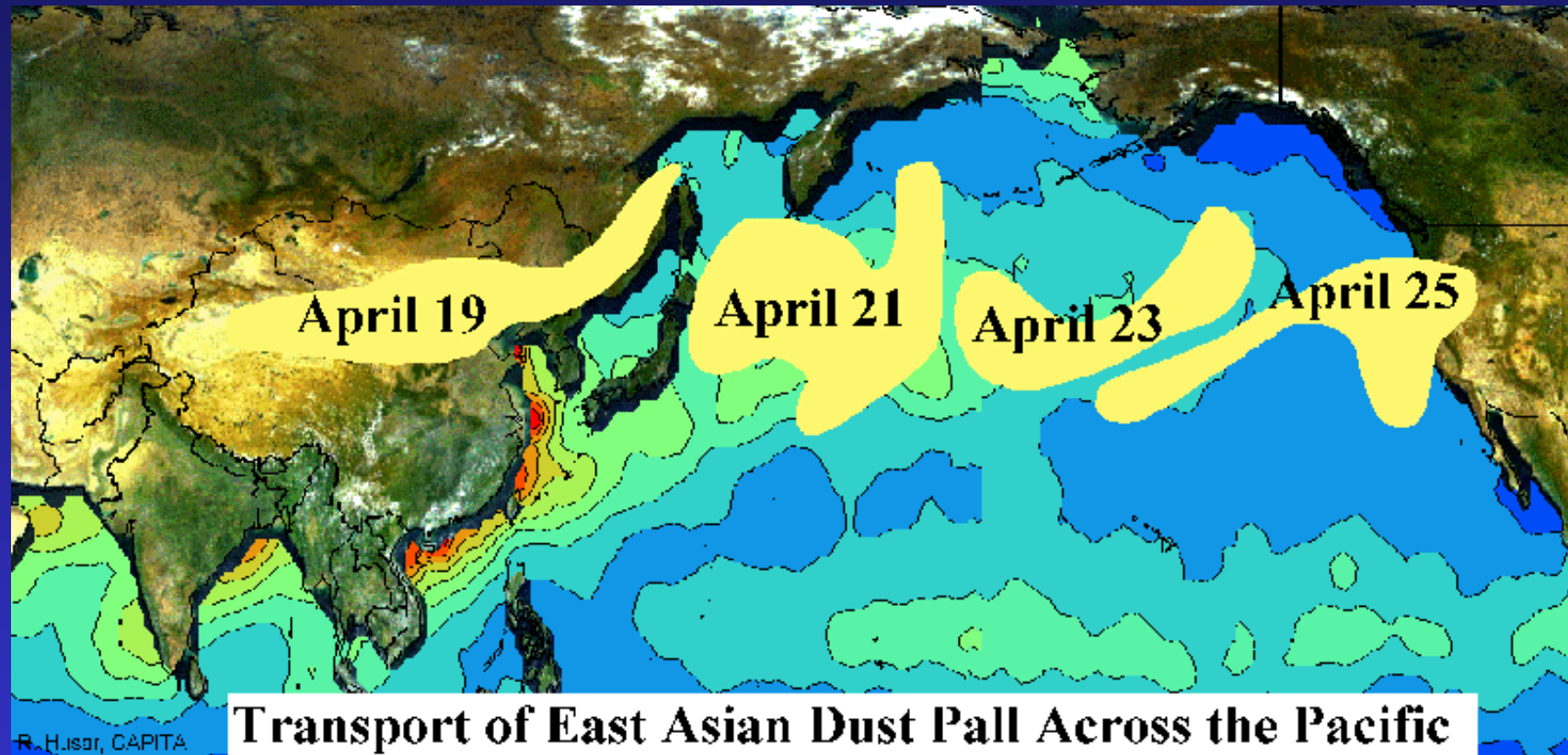
**Intercontinental dust transport:** Gene Shinn (eshinn@usgs.gov;  
[http://coastal.er.usgs.gov/african\\_dust/](http://coastal.er.usgs.gov/african_dust/))

- Increasing evidence from satellite imagery and other means that significant 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**

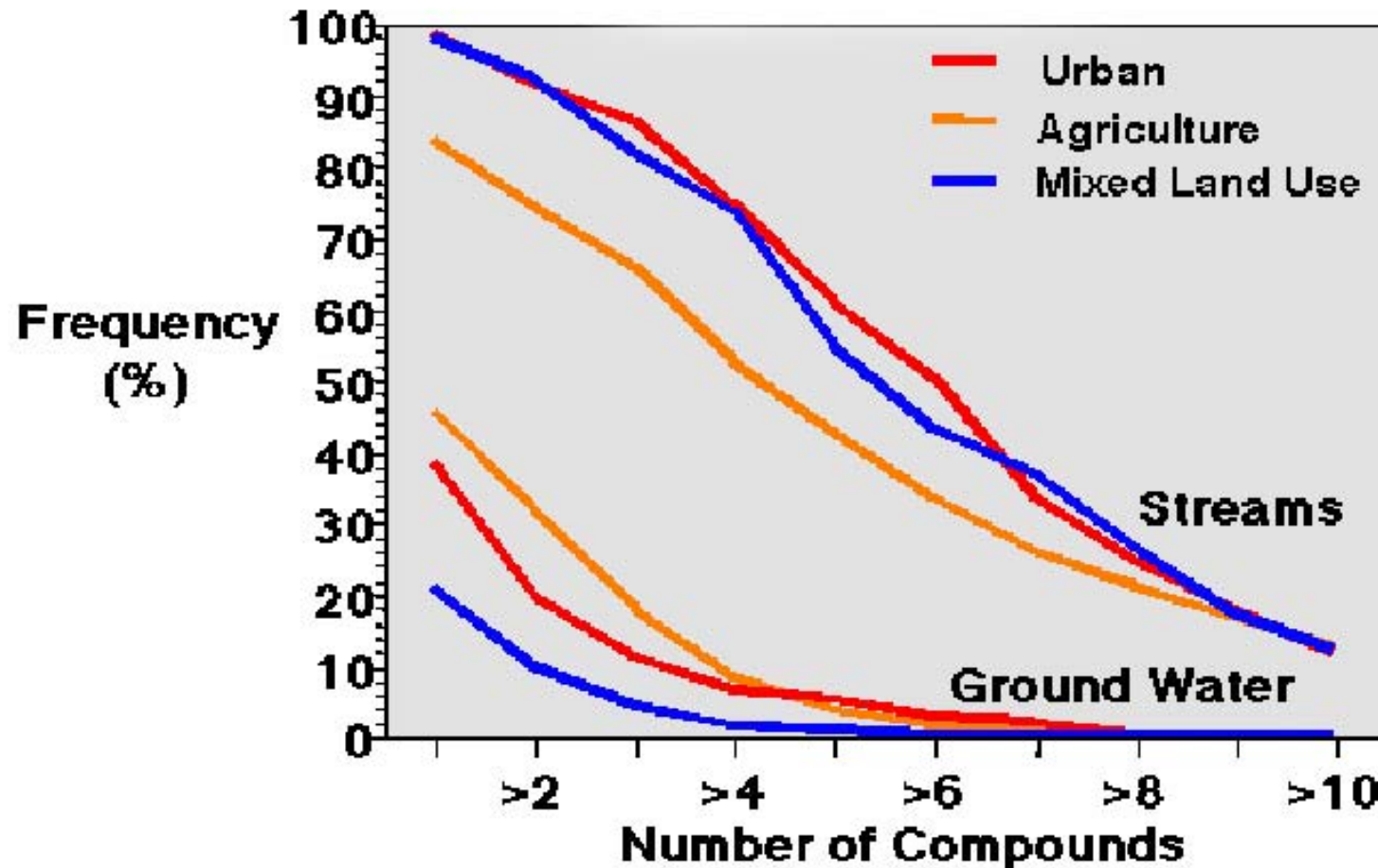


**R.B. Husar and 28 others**

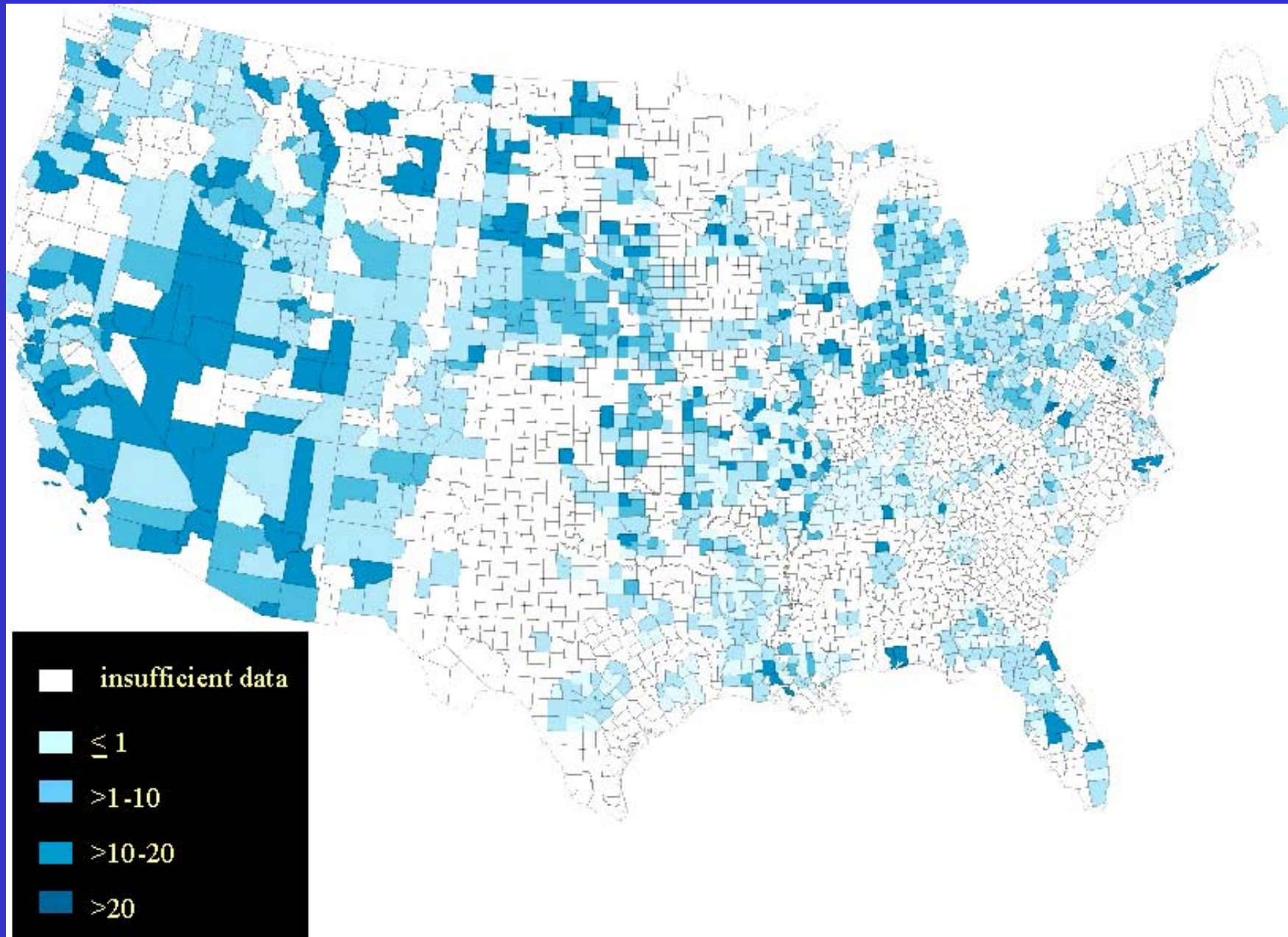




# Pesticides almost always occur as mixtures

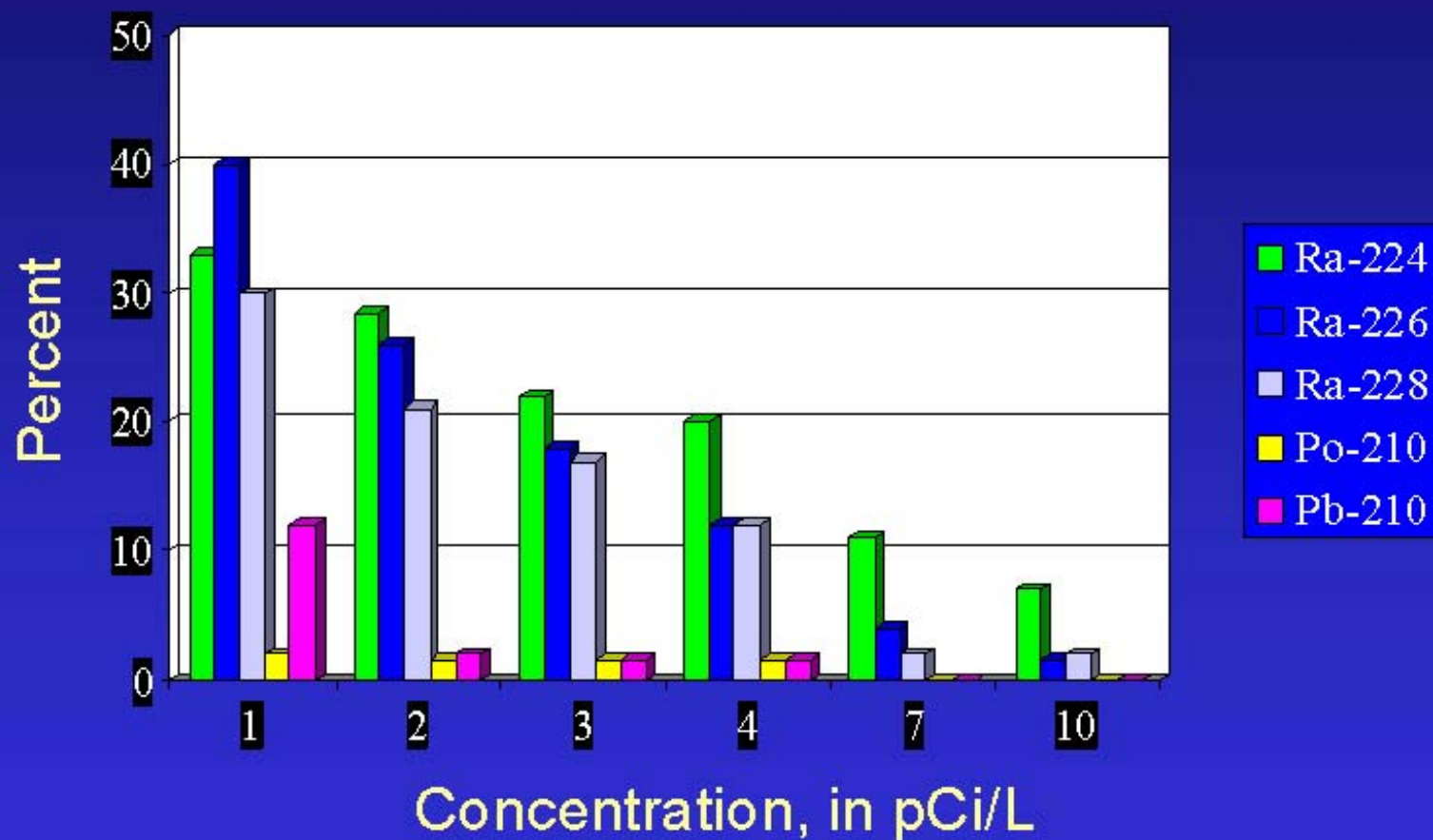


# Arsenic in Ground Water in the U.S.



# Radionuclide Samples Collected from Public Water Supplies

Percent of samples exceeding targeted concentrations



# 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?



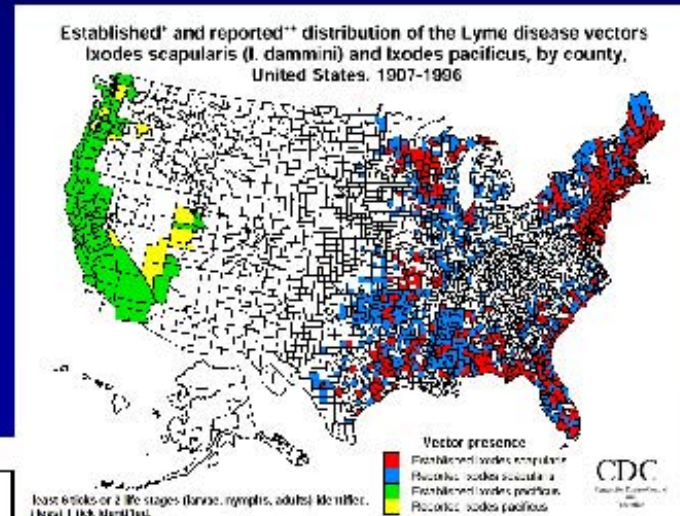
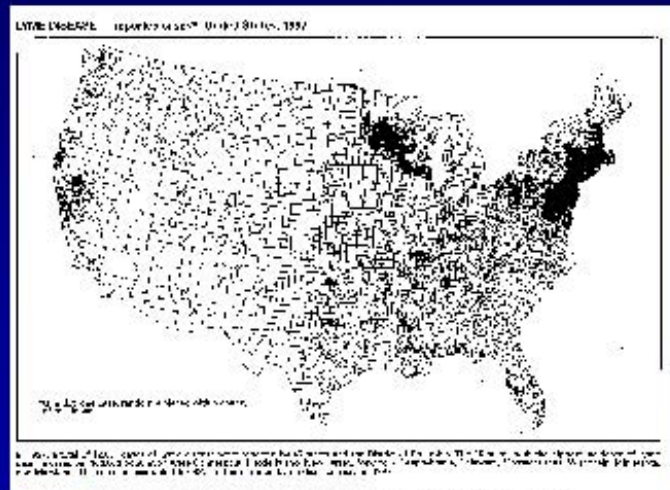


# Landscape Epidemiology

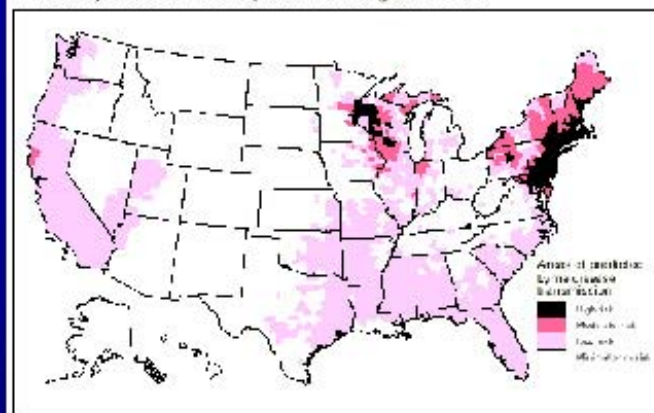
By knowing the ecological conditions necessary for the maintenance of specific pathogens in nature, one can use these characteristics to identify the spatial and temporal distribution of disease risk.



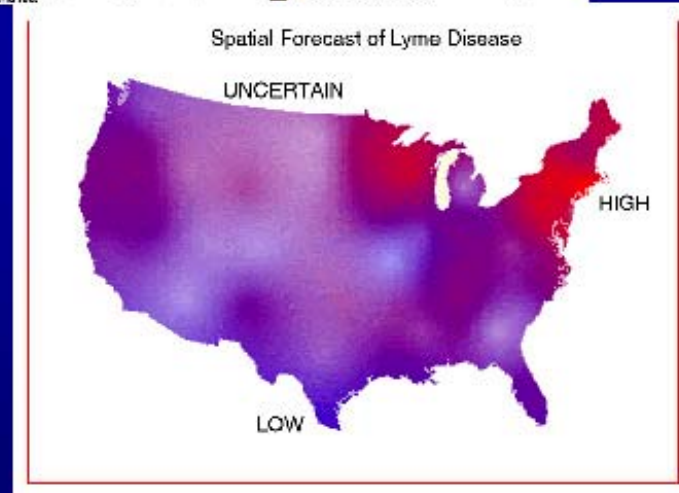
# Analysis of Lyme Disease



National Lyme disease risk map with four categories of risk



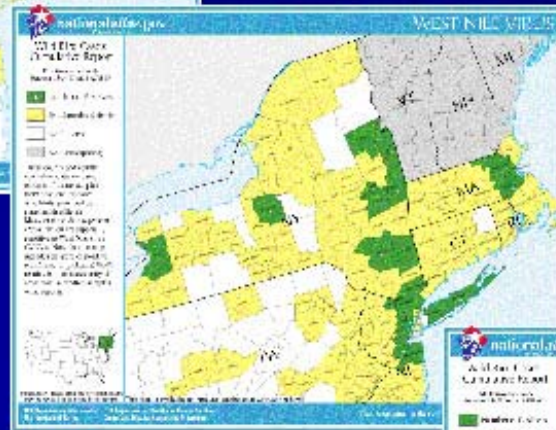
Note: This map demonstrates an approximate distribution of predicted Lyme disease risk in the United States. The true relative risk in any given county compared with other counties might differ from that shown here and might change from year to year. Risk categories are defined in the accompanying text. Information on risk distribution within states and counties is best obtained from state and local public health authorities.



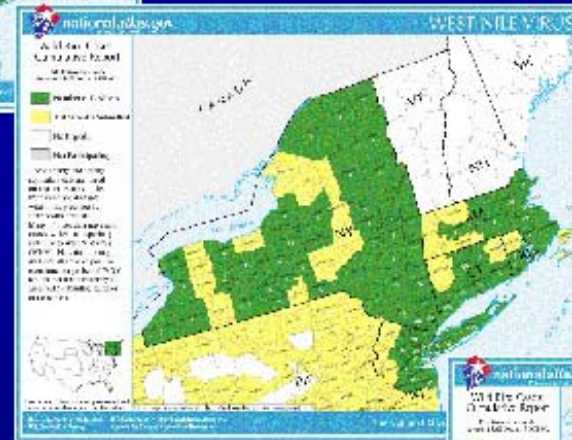
# Spread of West Nile Virus - 2000 (avian mortality)



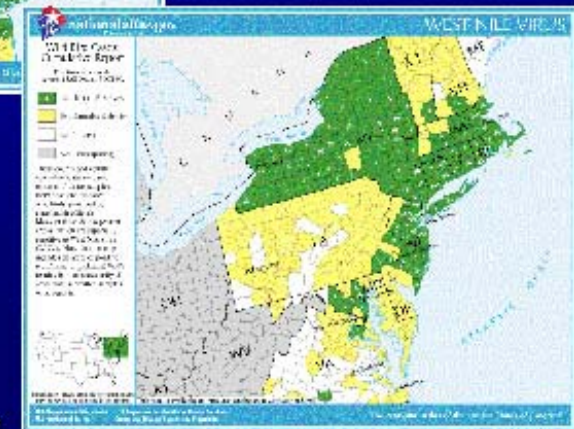
30 June



4 August

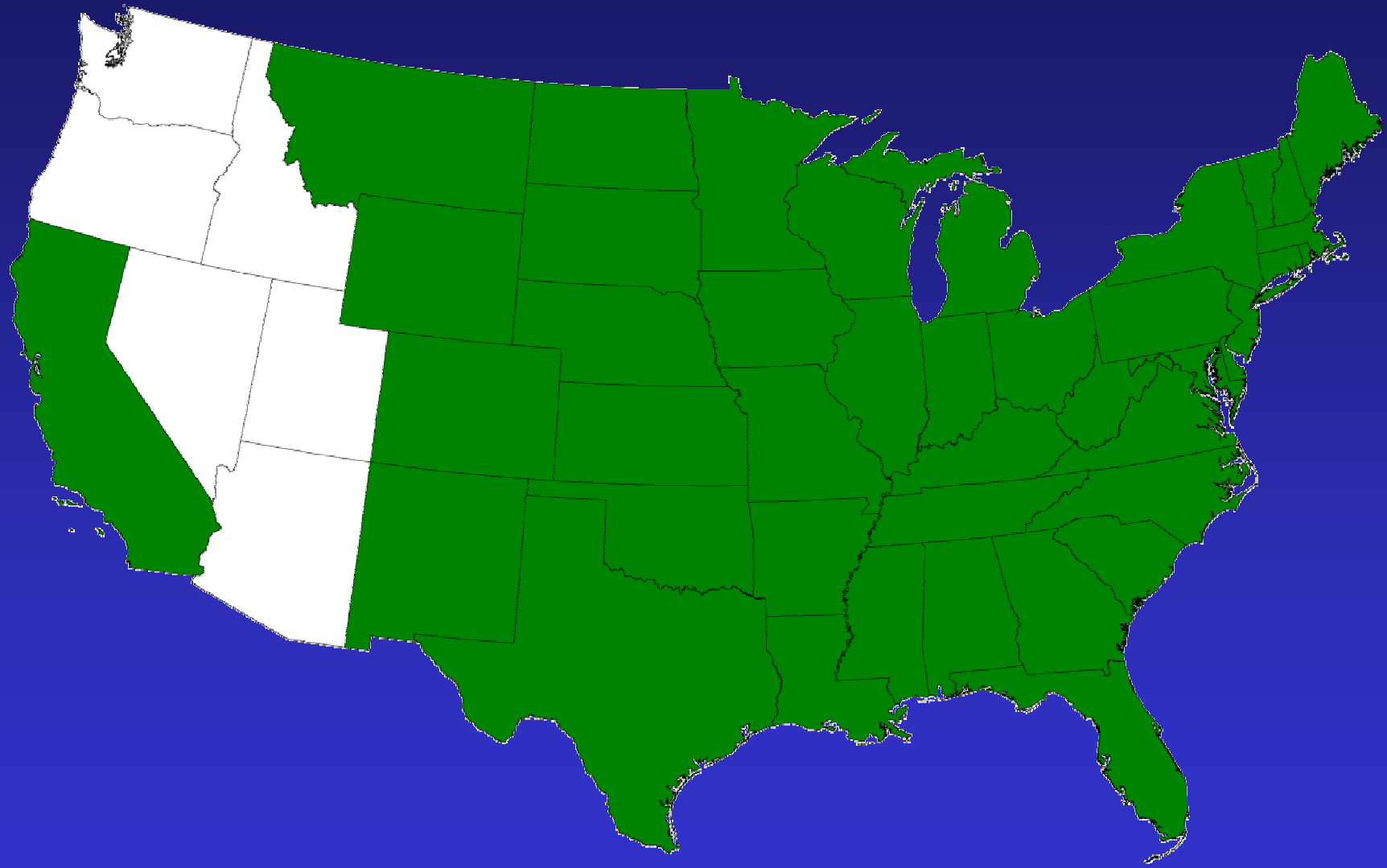


8 September



13 October

**2002**



# Health Impacts of Biomass Fuels

**Scale: Number of Peoples Affected.**

>>>

**AIDS**

+

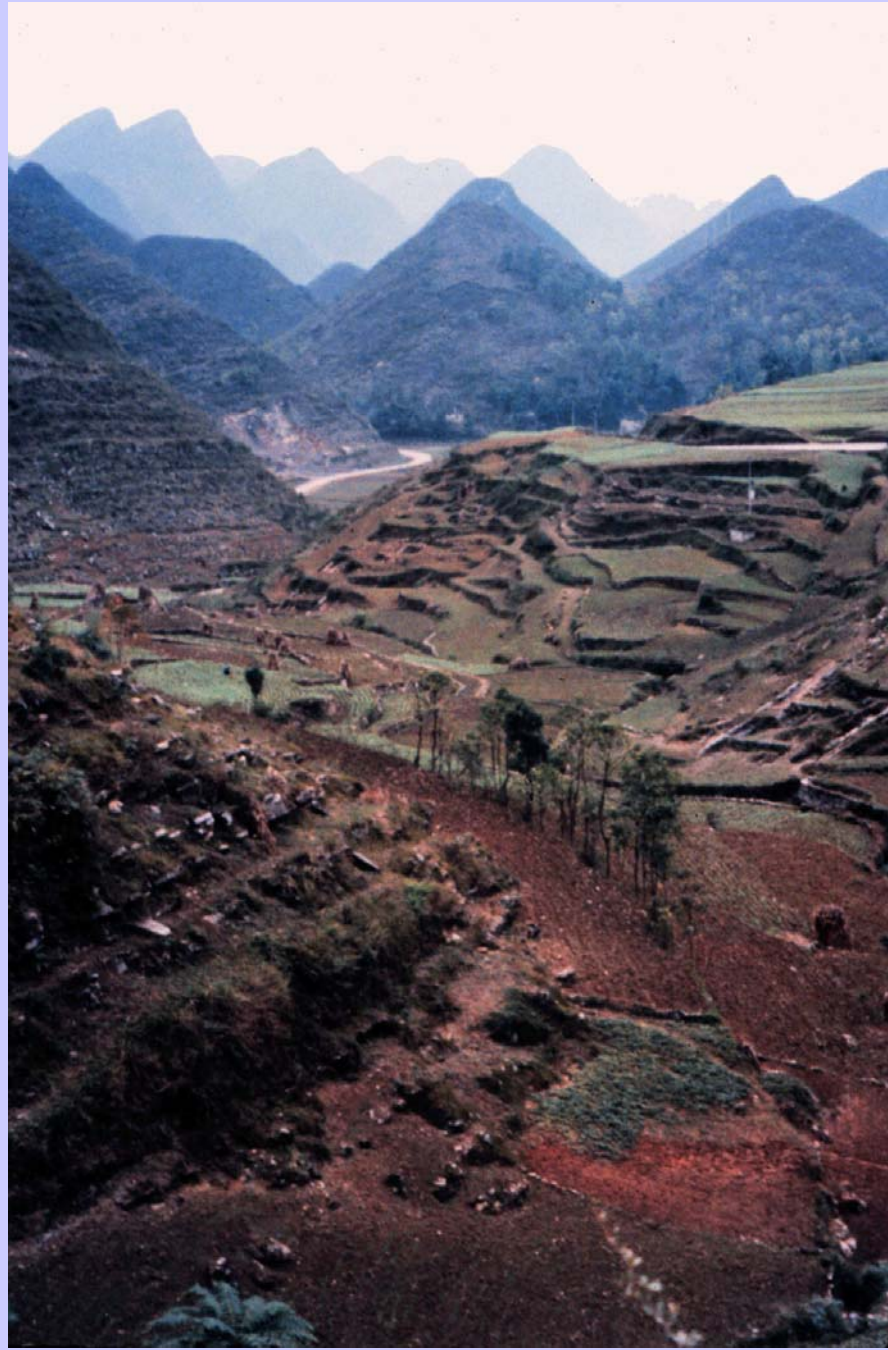
**HEART DISEASE**

+

**CANCER**

+++

**Severity: ~ 4 million deaths annually**





















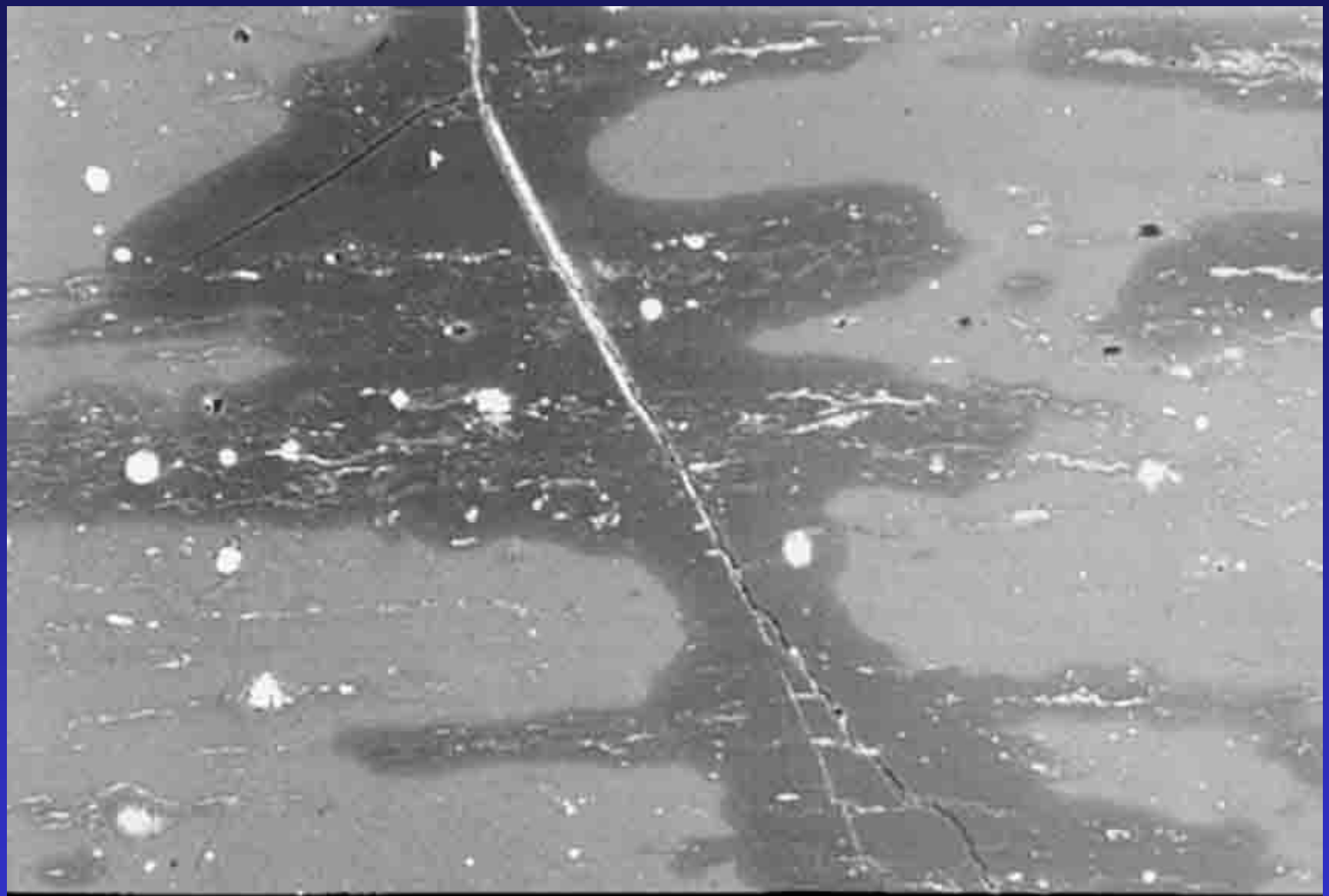






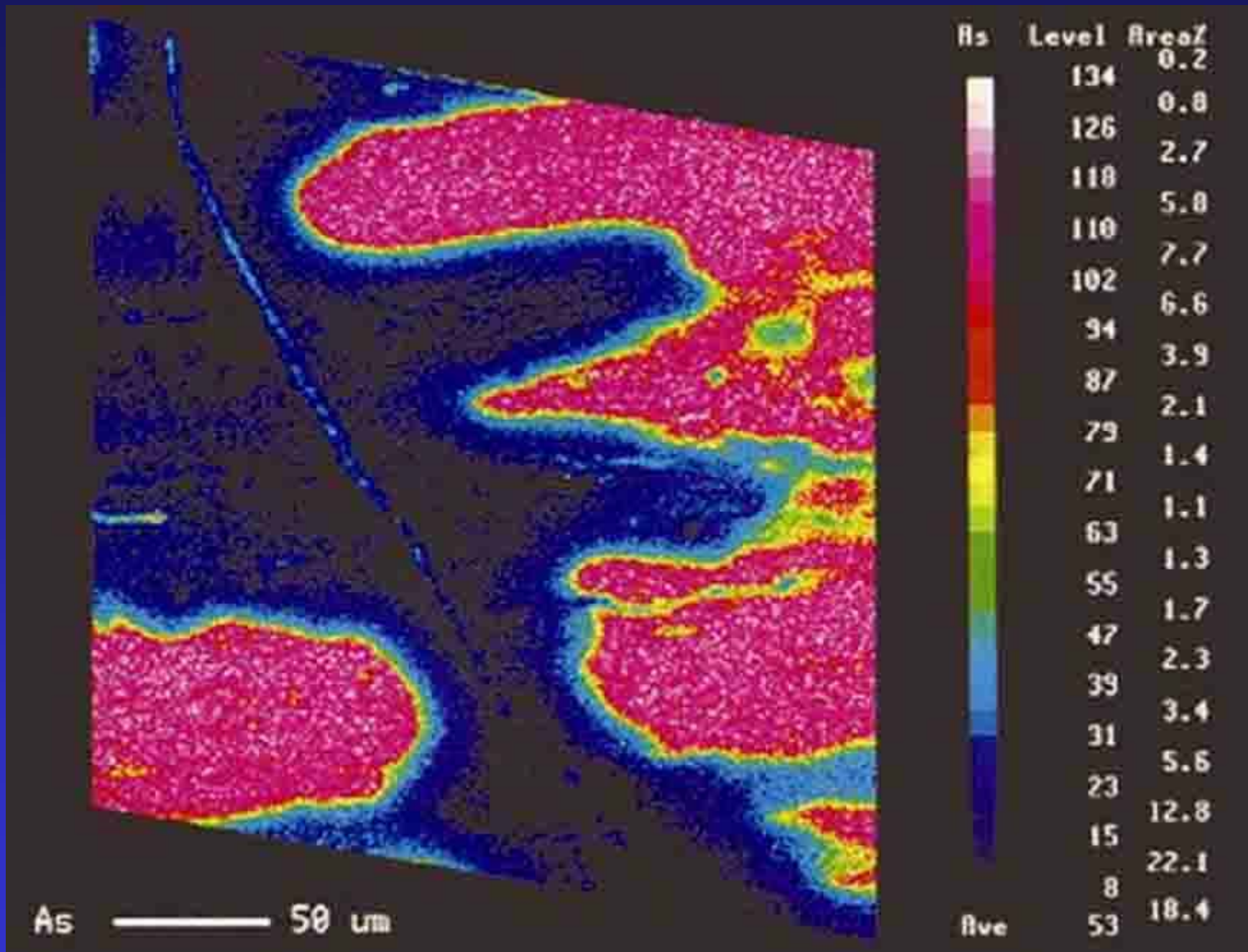






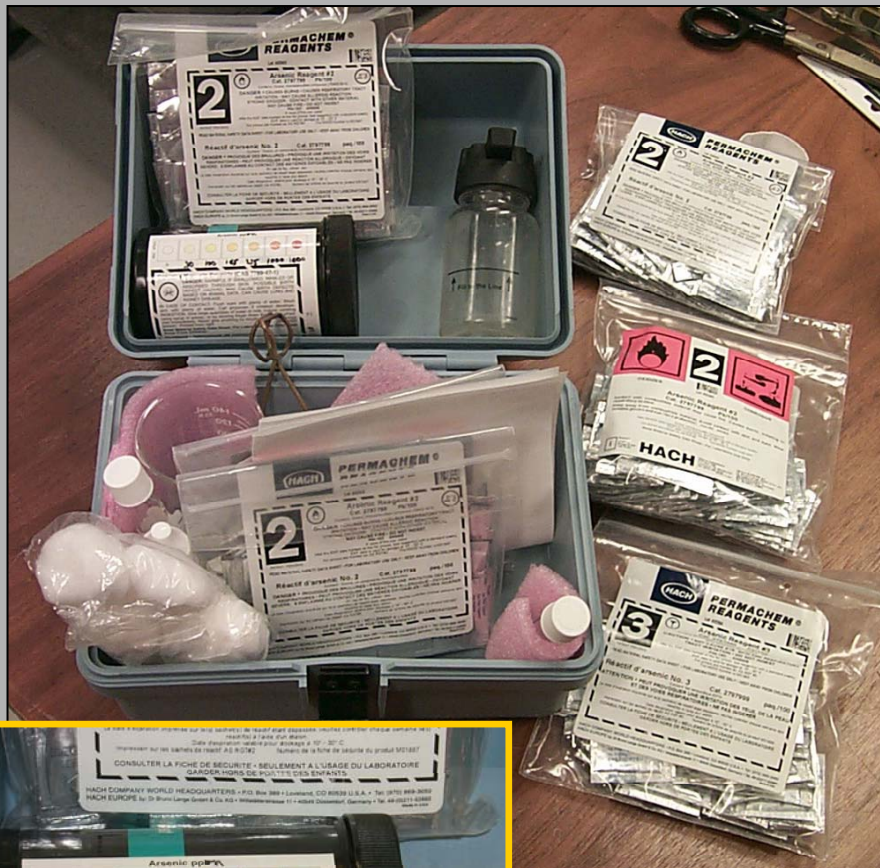
0001 15KV

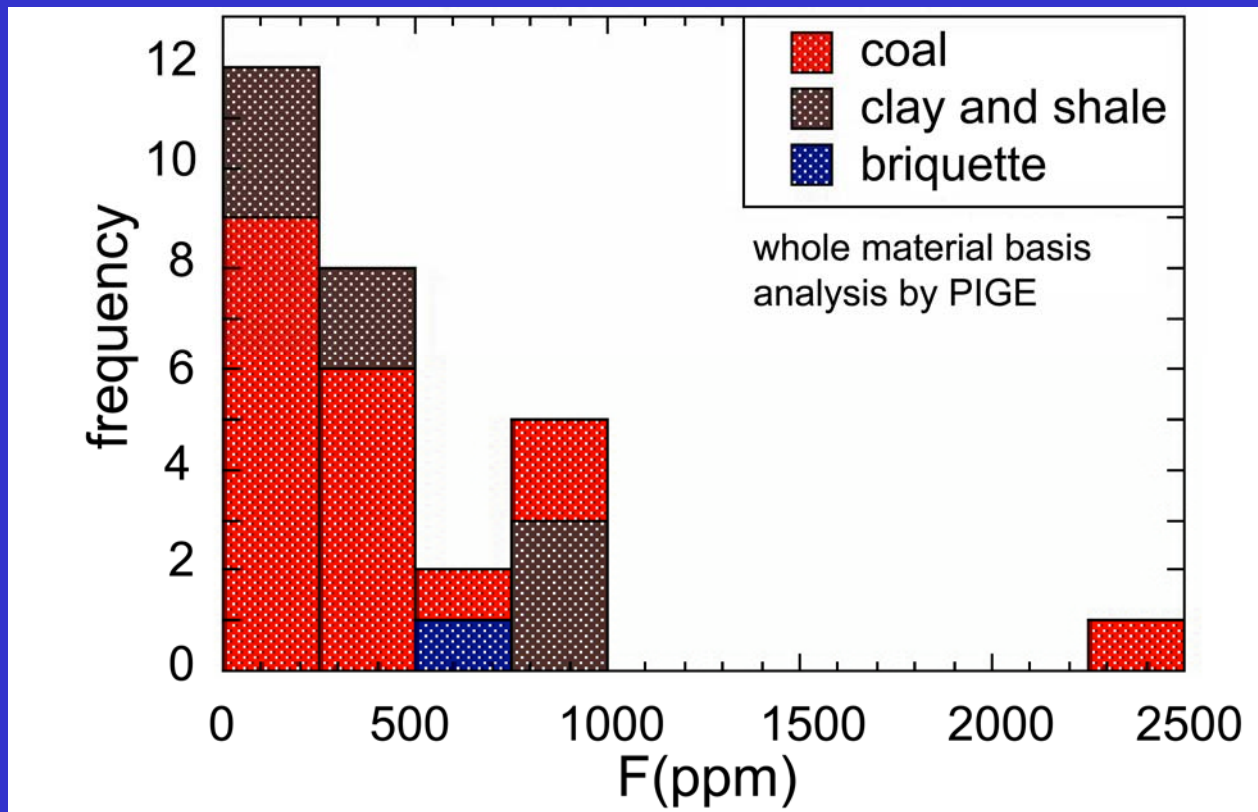
100µm WD15



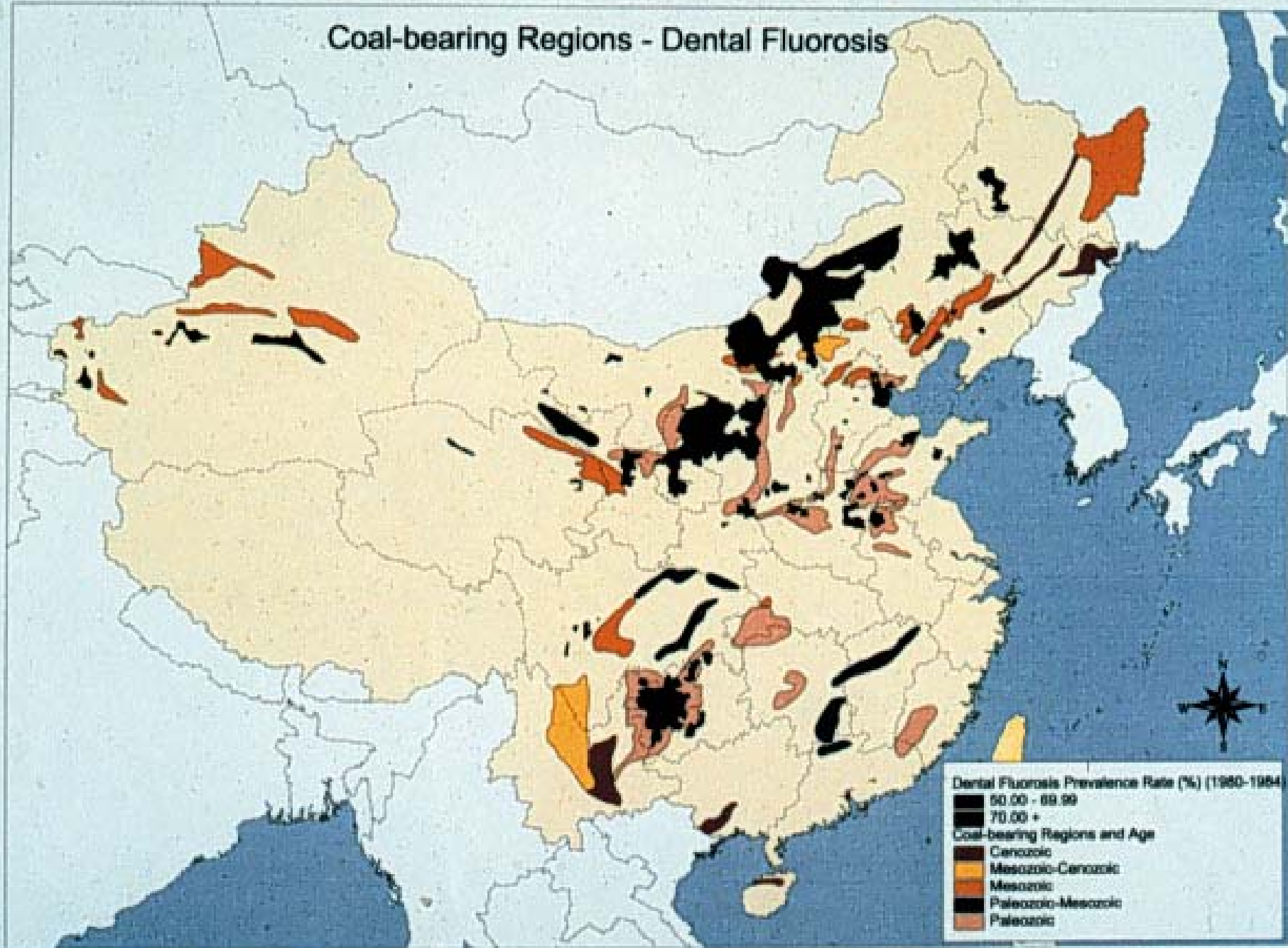
# Arsenic Field Tests

- *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.*





# Coal-bearing Regions - Dental Fluorosis







# Coal Miners “Black Lung Disease”



*National Museum of Health and Medicine, Washington, DC*

