Soils and Health
A Medical Geology Perspective

Jose A. Centeno, PhD, FRSC

Email: jose.centeno@fda.hhs.gov

IMGA Website: http://www.medicalgeology.org

Disclaimer:

The opinions presented are the private views of the speaker, and should not be construed as official or representing the views of the U.S. Food and Drug Administration, the U.S. Department of Health and Human Services, or other U.S. Federal Government agencies.

Acknowledgements*

Olle Selinus – Sweden
Bob Finkelman – UTD – USA
Geoffrey Plumlee –USGS – USA
Fiona Fordyce – BGS – UK
Mark Cave – BGS – UK
Nelly Manay – Uruguay
Maria Aurora Armienta - Mexico
Ed Derbyshire - UK
Bao-shan Zheng – China
Toby Rossman – USA
Claudia Hopenhayn– USA
Andre Balla – USA
Gerald Combs – USDA – USA
Rufus Chaney – USDA – USA
Chien-Jen Chen – Taiwan
Jiin-Shuh Jean – Taiwan
Chin-Hsiao Tseng - Taiwan
Phil Weinstein - Australia
Angus Cook - Australia
Hassina Mouri – South Africa
Theo Davis – South Africa
Claire Howard - UK
Hector Rubio, Mexico
Bernardino Figuereido – Brazil
Eduardo Da Silva - Portugal
Paul Tchounwou - USA
Mark Lyles - USA
Diego Fridman - Argentina
Saverio Fiore – Italy
Elena Gimenez - Spain
Chasheng Zheng- Ireland
Brian Marker - UK
Laura Borgel - Chile

*presentation, research projects, course material

Medical Geology
A Working Definition

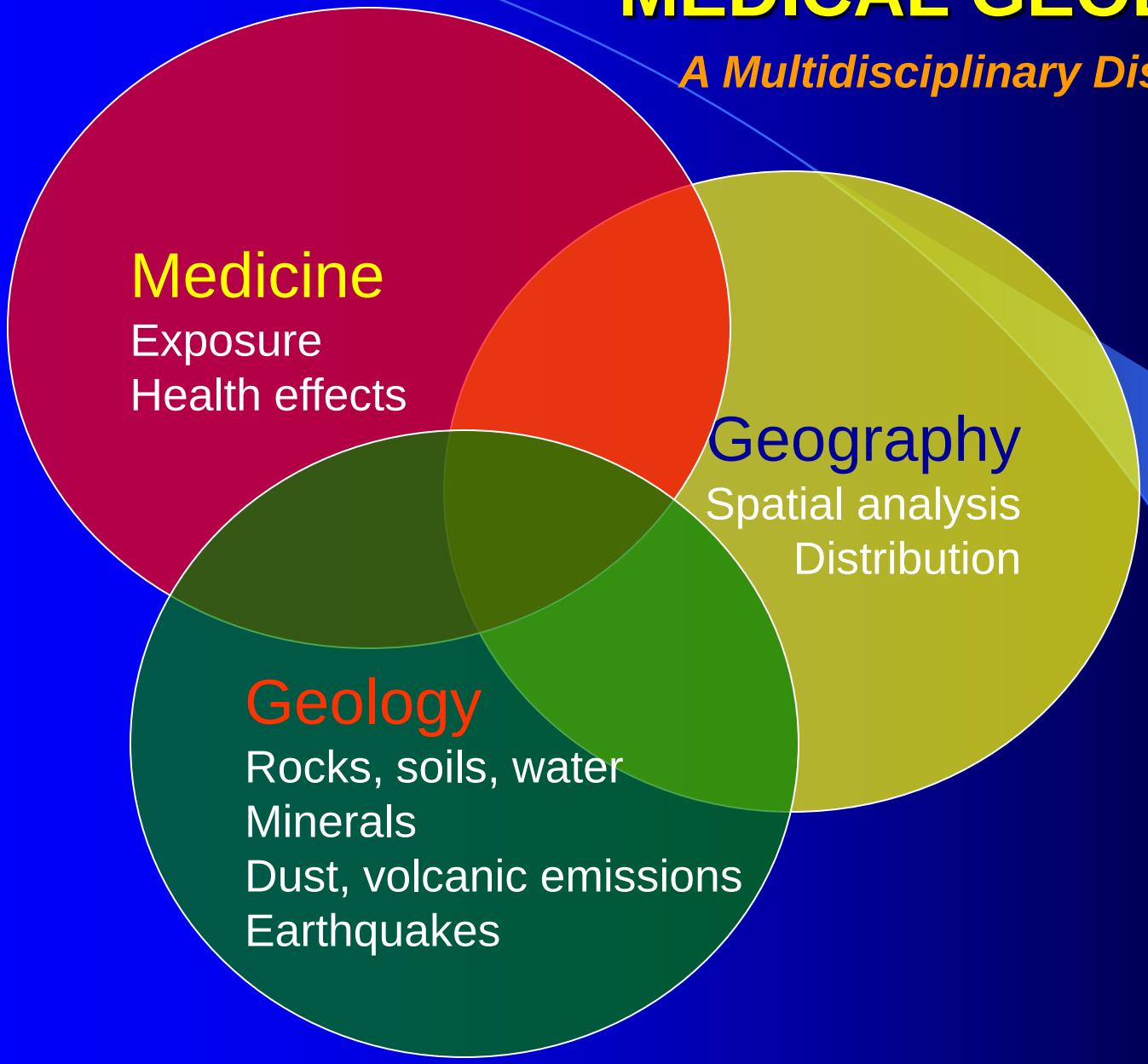
Medical Geology is **defined as the science dealing with the relationship between geological materials and geologic processes, and their impacts on health problems in human, animals (and plants).**

The scope and range of Medical Geology include:

- **identifying and characterizing natural sources of harmful materials in the natural environment;**
- **learning how to predict the movement and alteration of chemical, infectious, and other disease-causing agents;**
- **and understanding how people may be exposed to such materials.**

MEDICAL GEOLOGY

A Multidisciplinary Discipline



Why is Soil so Important to Medical Geology?

- The crops we eat are grown on soil
- The water we drink has been is contact with soil
- The animals we eat or provide us with milk graze on soil
- The dust we breath is largely soil
- Children, and some adults, eat soil
- Some medicines we use are derived from soil

Minerals and trace elements are important!

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

Examples of Soil Trace Element Health Impacts

- Trace Element Deficiency:

  Selenium (Se)
  Iodine (I)

- Soil-Generated Dust

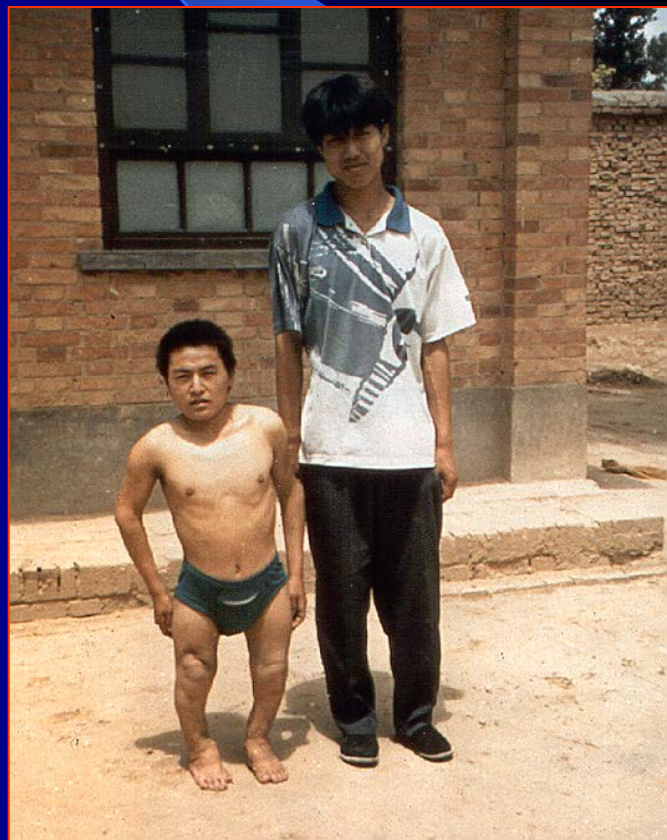
- Clays and Minerals

Selenium

- Essential trace elements in low concentrations
- Potential cancer protective agent and antioxidant
- Se deficiency
  - Deformations, dystrophy
  - Liver necrosis
- Excess Se may be associated with
  - Gastrointestinal disturbance
  - Liver and spleen damage

Toxicity : Selenosis
(loss of hair, nails)

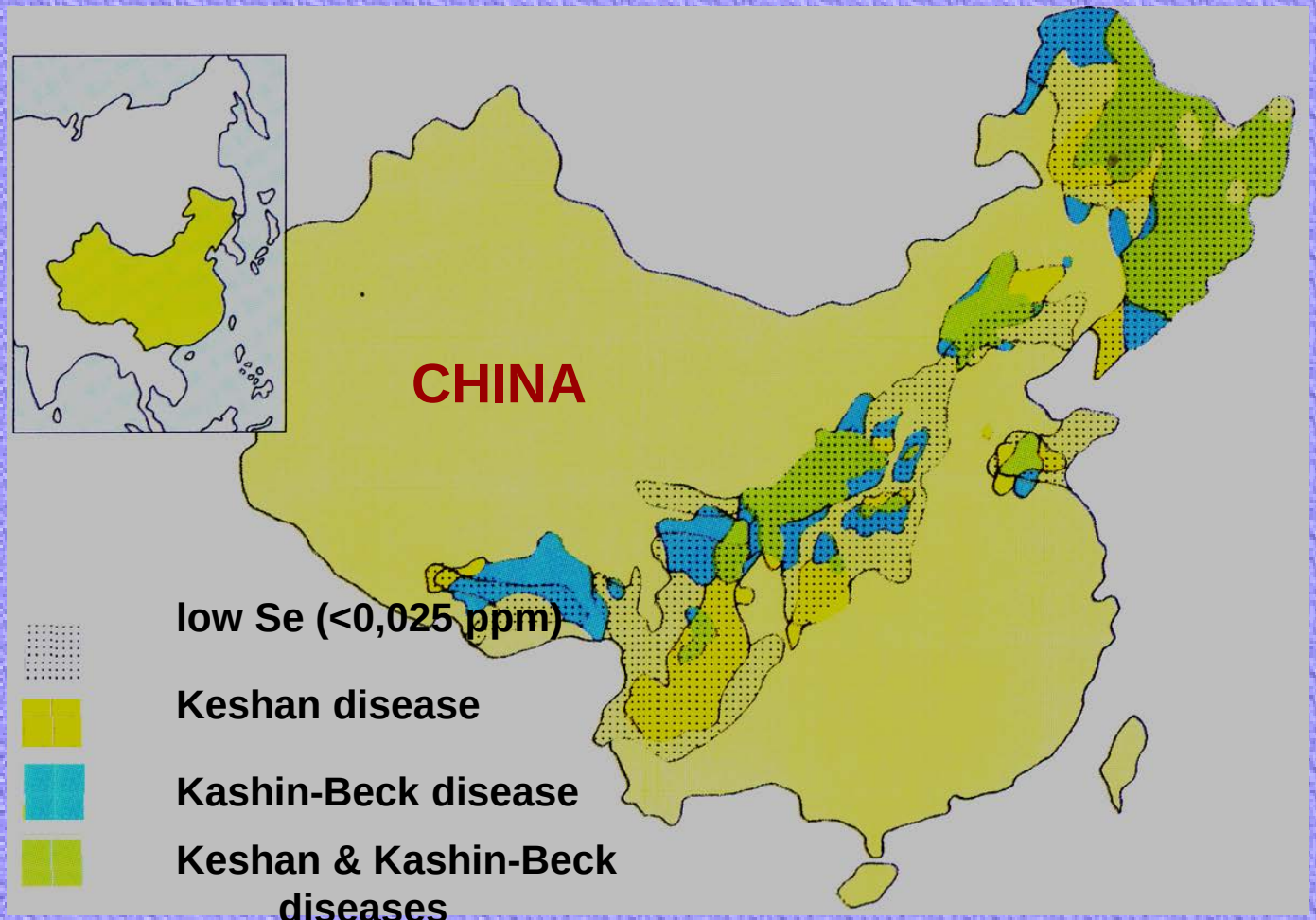
Selenium Deficiency:
Kashin-Beck Disease



Photos: Courtesy of Prof. Wang Zhilun

SELENIUM

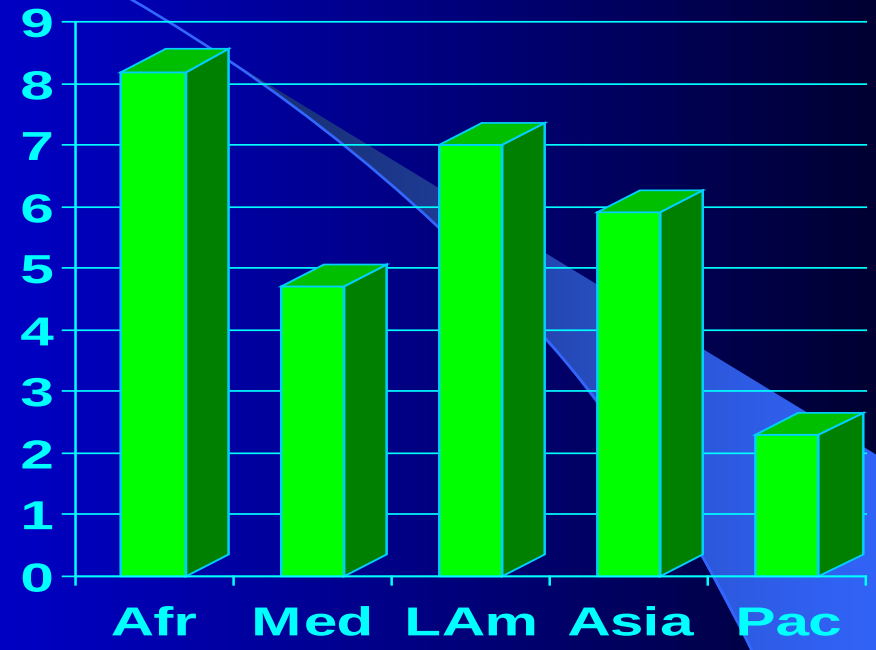
A belt of low-Se rocks influences millions of people.



Keshan disease – weakening of the heart muscle
Kashin-Beck disease – muscular pains, other effects

Global Prevalence of I Deficiency Diseases*

- >2 B at risk
- 740 M with goiter
- 20 M mentally retarded
- 6 M infants with cretinism (half in SE Asia)

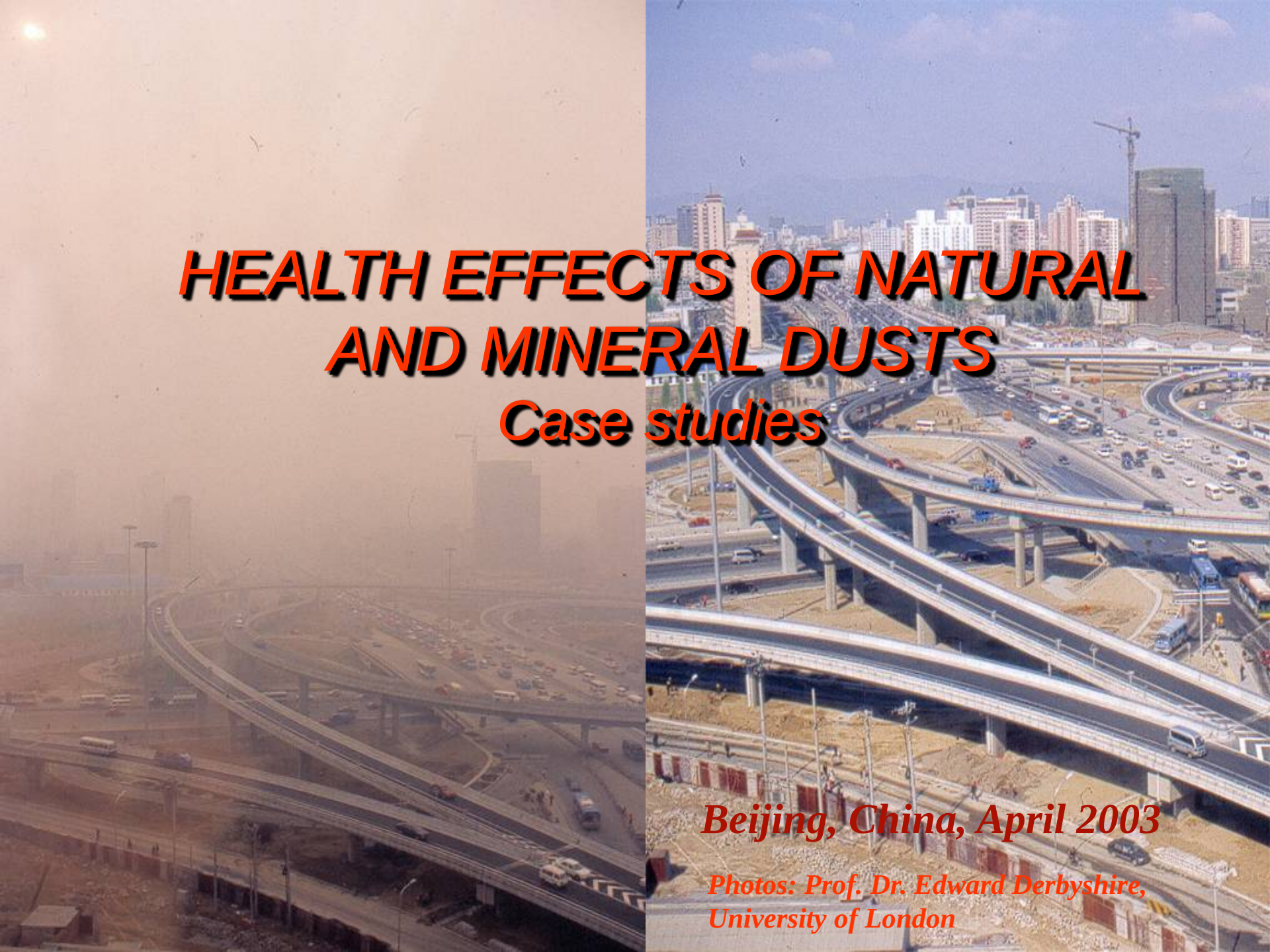


Iodine Deficiency Disorders (IDD) include: goiter (enlargement of the thyroid), cretinism (mental retardation with physical deformities), reduced IQ, miscarriages, birth defects.

Courtesy of Dr. Gerald Combs, USDA

HEALTH EFFECTS OF NATURAL AND MINERAL DUSTS

Case studies



Beijing, China, April 2003

Photos: Prof. Dr. Edward Derbyshire, University of London

Impacts of Soil-Generated Dust Related Materials


Mt Pinatubo from Clark AFB, 1991

Varied impacts:

- **impairment of visibility**
- **clogging of aircraft engines**
- **loss of fertility and habitats in areas of soil erosion**
- **smothering of crops**
- **physical (e.g. , irritant, radioactive, etc)**
- **chemical (e.g. , corrosive, toxic metals, etc)**
- **biological (e.g., allergogenic, pathogenic, microorganisms, etc)**

Therefore nuisance, economic loss, reduced quality of life, damage to health of humans, livestock, crops, wildlife and habitats.

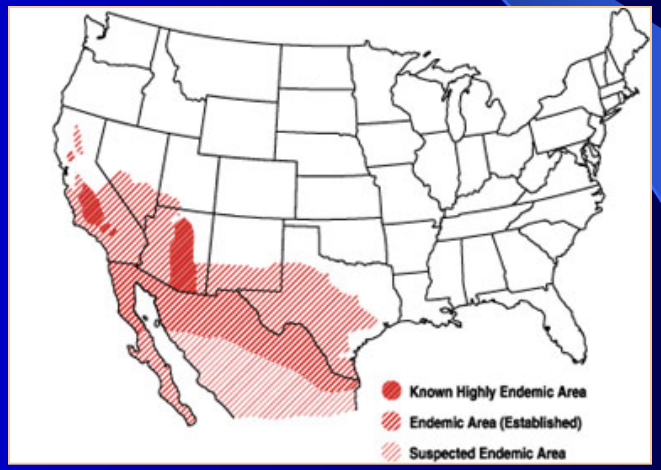
Significant costs, therefore control of dust and reduction of risks is of importance to society.

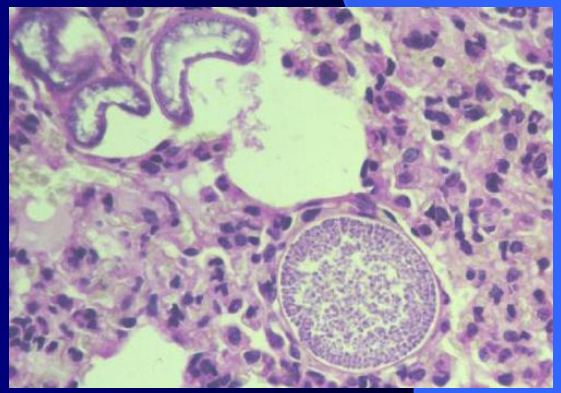
Dusts and the origin of Valley Fever (Coccidioidomycosis)

- Coccidioidomycosis is a reemerging infectious disease
- A systemic infection caused by the inhalation of airborne spores of *Coccidioides immitis*
- *C. immitis* is a soil inhabiting fungus found in North, Central, and South America.
- Given proper conditions, infectious spores are released when soil is disturbed
    - ie, storms, construction, earthquakes
- Dust storms have been shown to carry spore laden dirt as far as 700 km, causing outbreaks

*Courtesy of Dr. Geoffrey Plumlee, USGS and Dr, William Sprigg, University of Arizona

Tucson, Arizona
July 5, 2011





Valley Fever (Coccidioidomycosis)

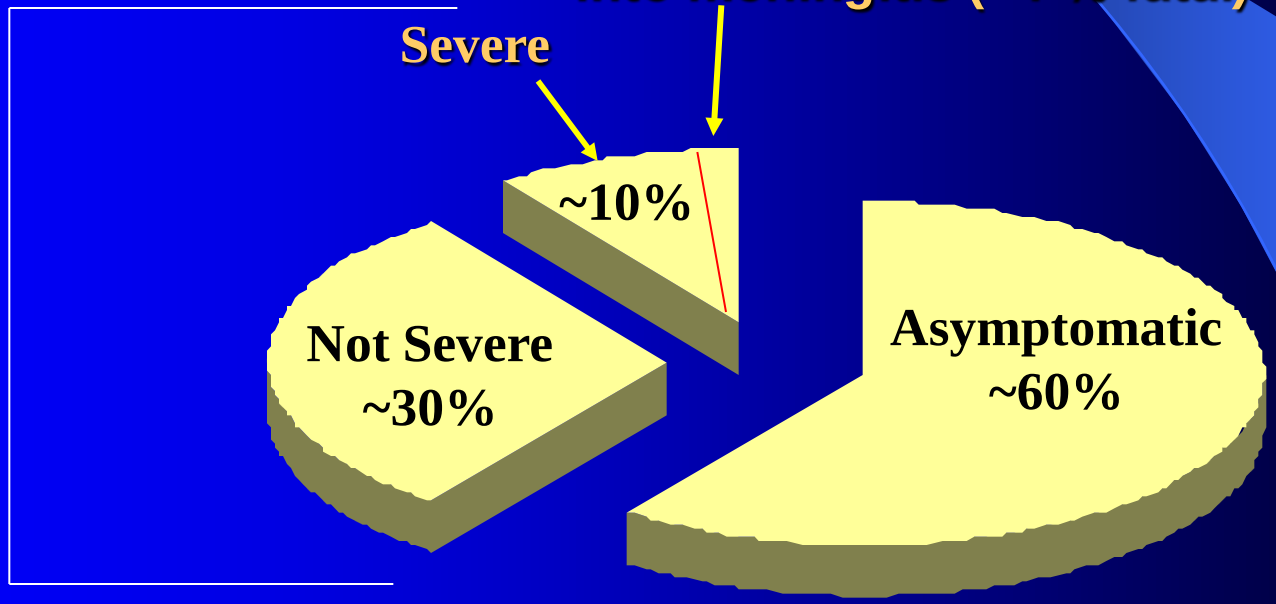


- Clinical manifestations occur in ~40% of infected persons

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



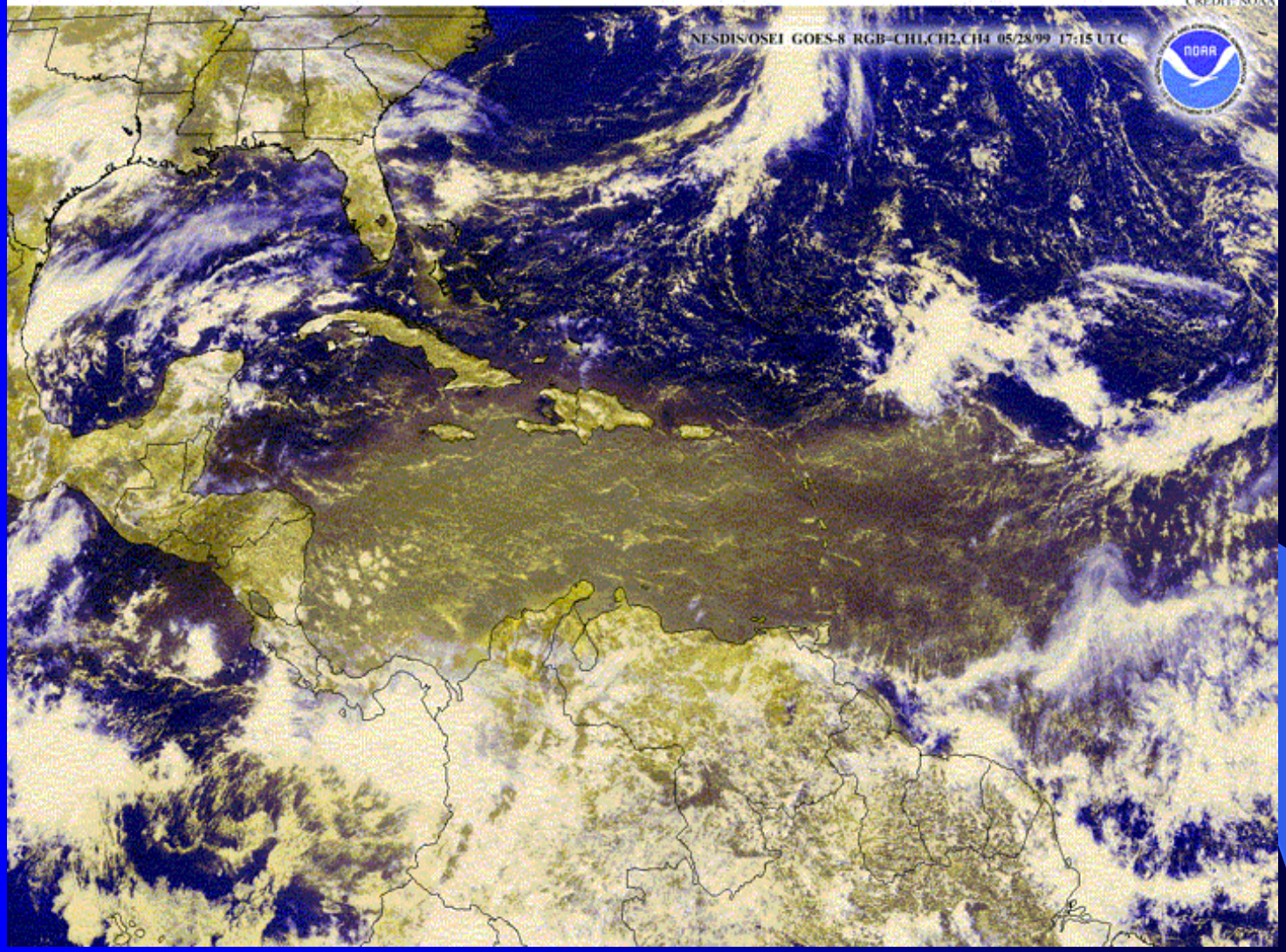
- 7,500 new cases of Valley Fever occur annually in the U.S.A, with a cost in excess of $60 million a year.

Dusts and the origin of Valley Fever (Coccidioidomycosis)

- Geologic links to Valley Fever
  - Boron-rich, alkaline soils?
  - Marine shale parent rocks?
  - Evaporative alkaline salts?
  - Slope, shape of topography

Airborne dust (brown haze) over the Caribbean Sea. This dust originated in the Sahara Desert of western Africa where it was lifted and carried off the coast by strong winds.

CREDIT: NOAA



- 100's of millions of tons of intercontinental dust is deposited annually.
- This 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.

Photo: Courtesy of NASA

Geophagia

The “dirt” [shown] is *kaolin*, a white clay mined in Georgia and South Carolina that is used for everything from making ceramics and textiles to diarrhea medicine.

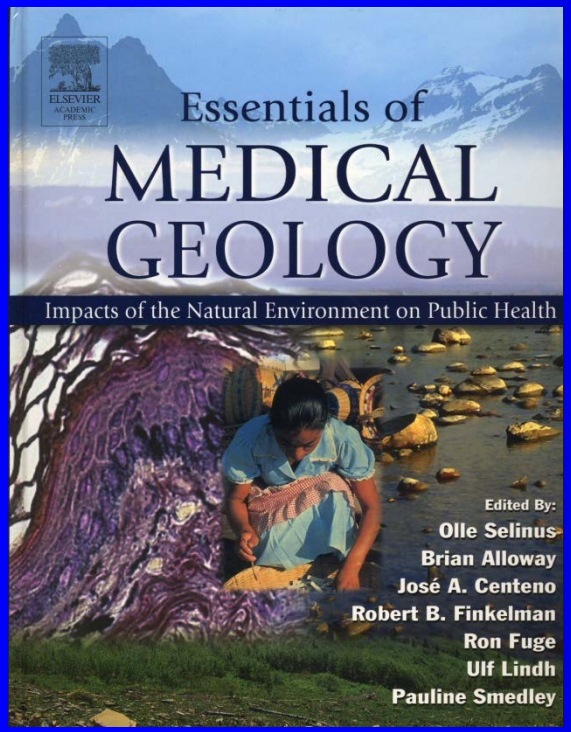
In this particular case, many pregnant women in rural southern Georgia, eat *kaolin* or a grayish native clay to Georgia commonly sold in Grocery stores. They crave the “dirt” and claim that it helps quite their pregnancy sickness and makes them feel better.

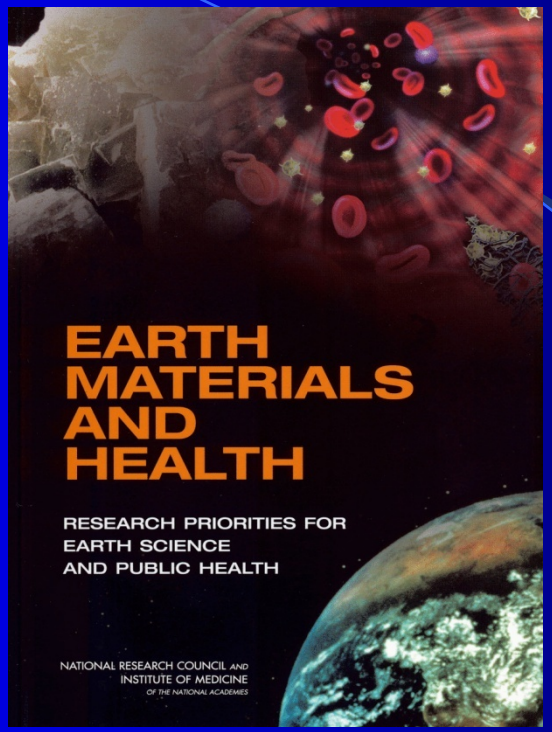
Source: http://www.augustachronicle.com/stories/031899/fea_clay.shtml

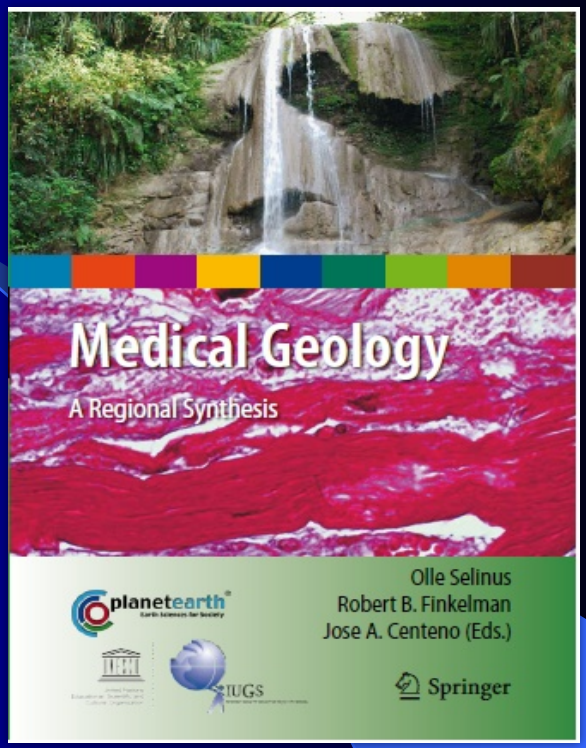
Soils, Clays and Minerals

Common places of extraction of “healing clays”: from the valleys and bottoms of stream gullies. Abuelo Vicente on the left photo and Abuela Emilia on the right photo (Colombia).

Useful References







1. Selinus O, Alloway B, Centeno JA, et al. "Essentials of Medical Geology Impacts of the Natural Environment on Human Health." Elseveir & Academic Press, 2005. ISBN: 0-12-636341-2.

2. "Earth Materials and Health – Research Priorities for Earth Science and Public Health". National Academies, National Research Council 2007. ISBN: 978-0-309-10470-8.

3. Selinus O, Centeno JA, Finkelman RB. Medical Geology – A Regional Synthesis. Springer, International Year of Planet Earth (UNESCO), 2010. ISBN: 978-3-642-05436-5


Geoscience
Public Health
Thank you!