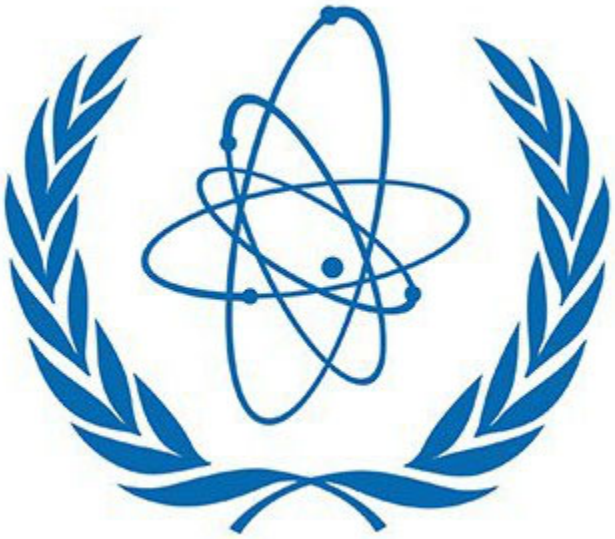
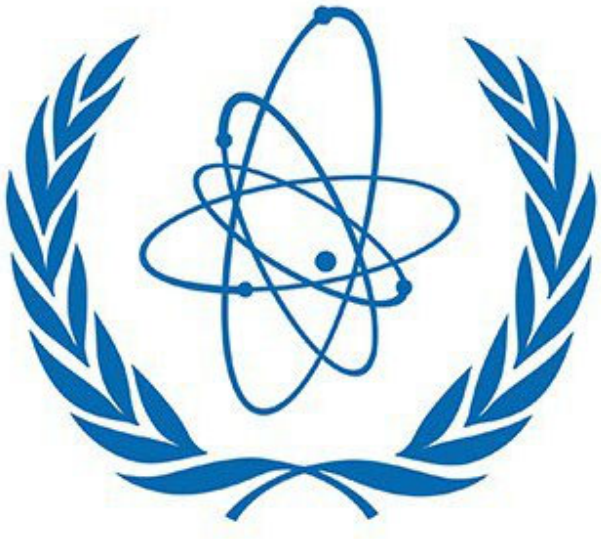
Intro to Global WMD Issues

Margaret E. Kosal, PhD

Intro to Global WMD Issues



Intro to Global WMD Issues



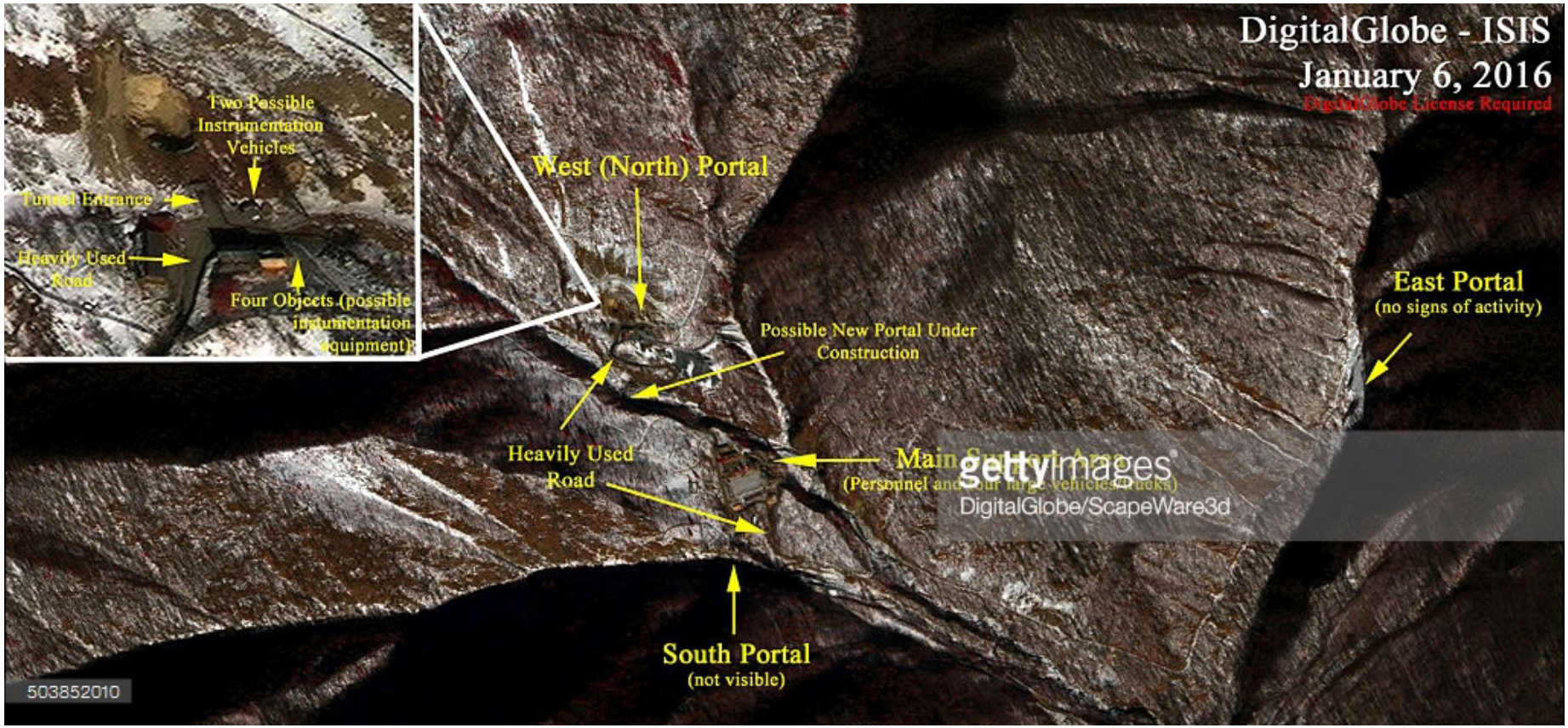
North Korea nuclear blast

Pyongyang says it tested a hydrogen bomb Wednesday

Source: Johns Hopkins University/38North.org

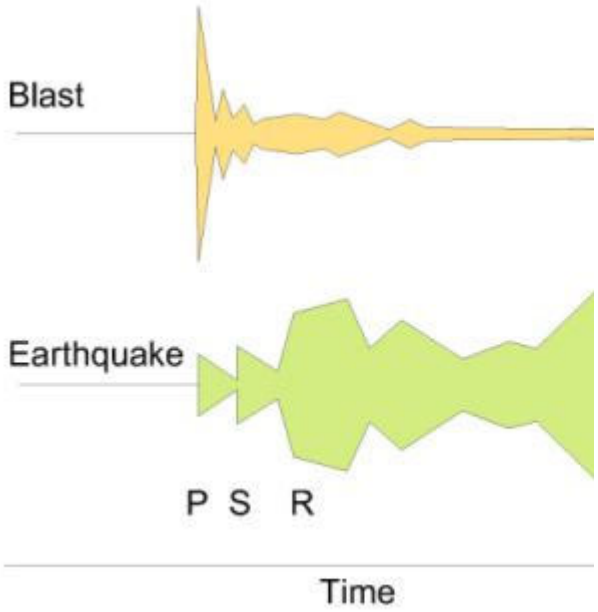
AFP

January 2016
Nuclear Test



DigitalGlobe image was taken shortly after the underground Nuclear Test at North Korea's Punngye-ri Nuclear test Site on January 6th, 2016.
Analysis by the Institute for Science and International Security (ISIS).

Nuclear Test or Earthquake?



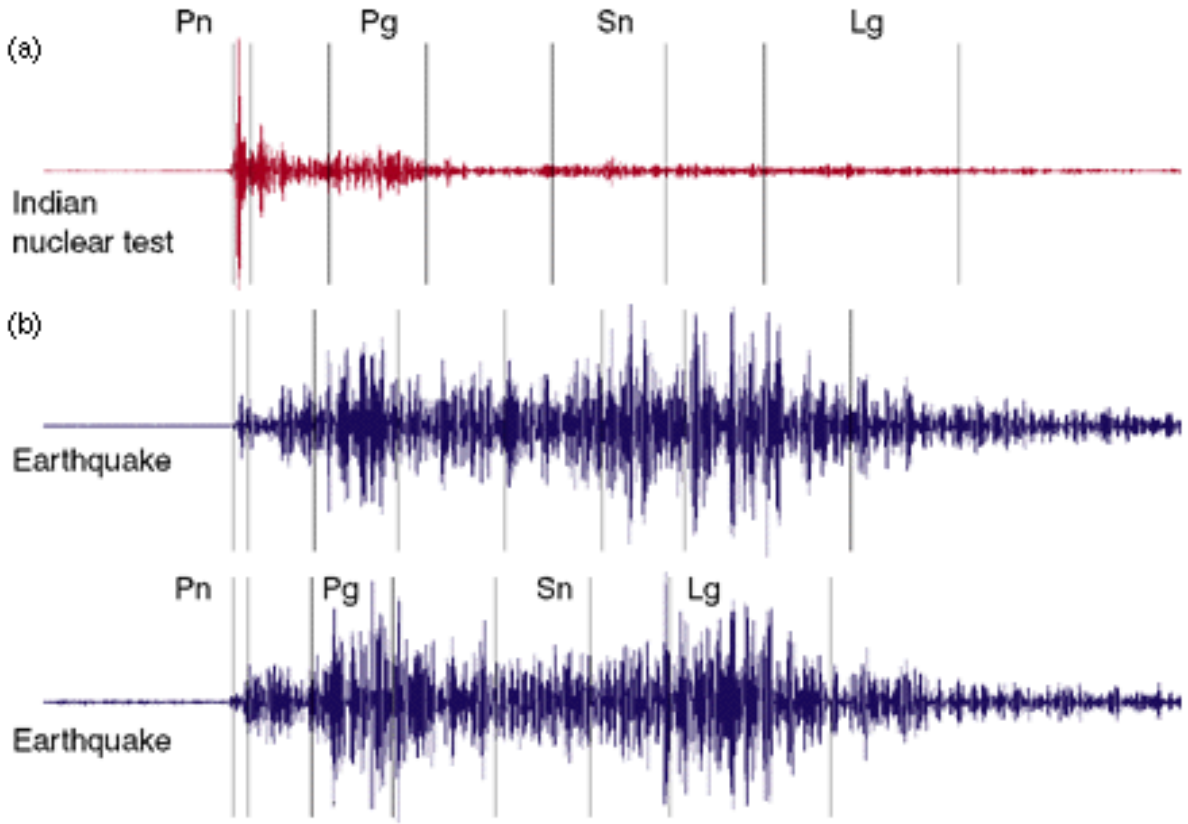
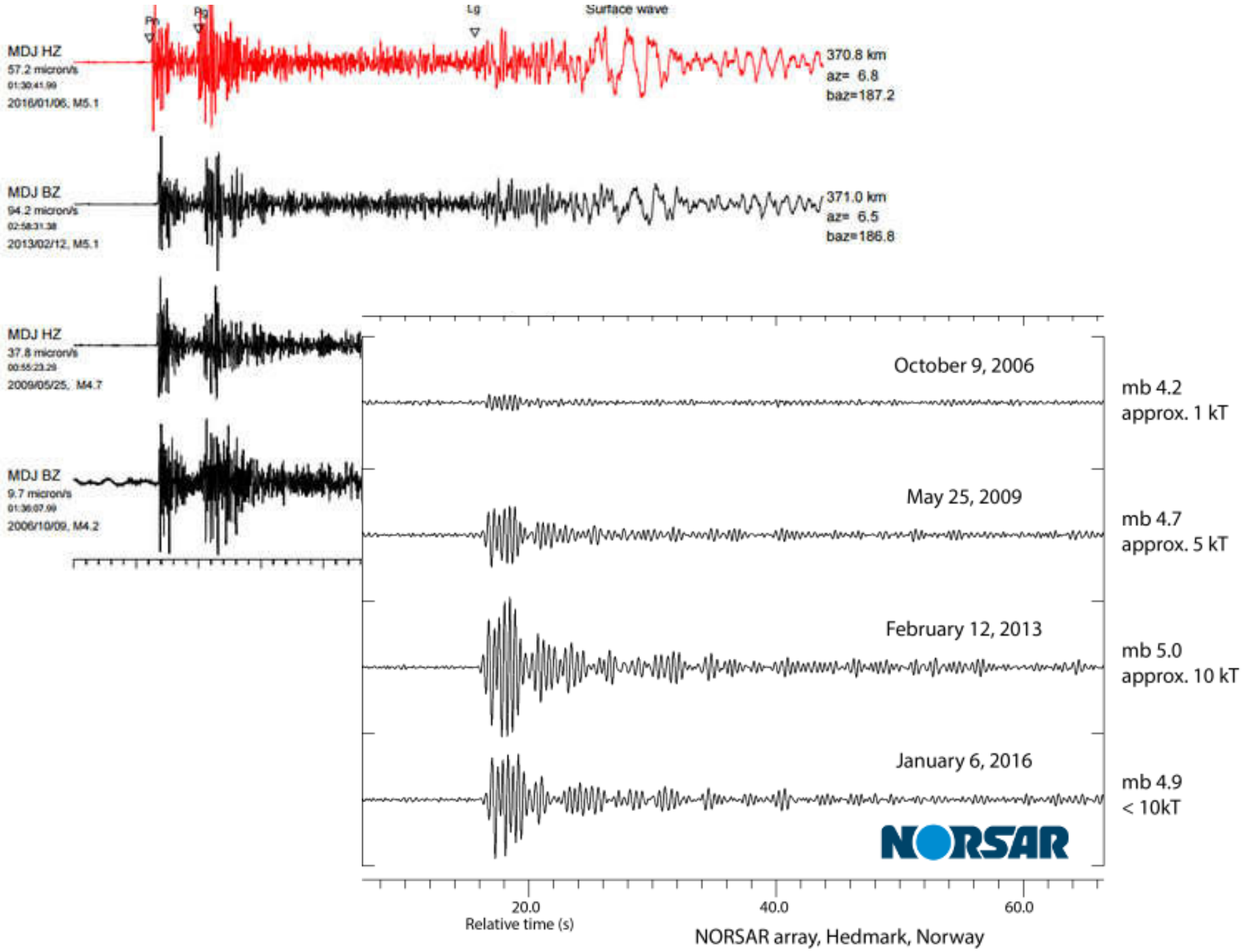
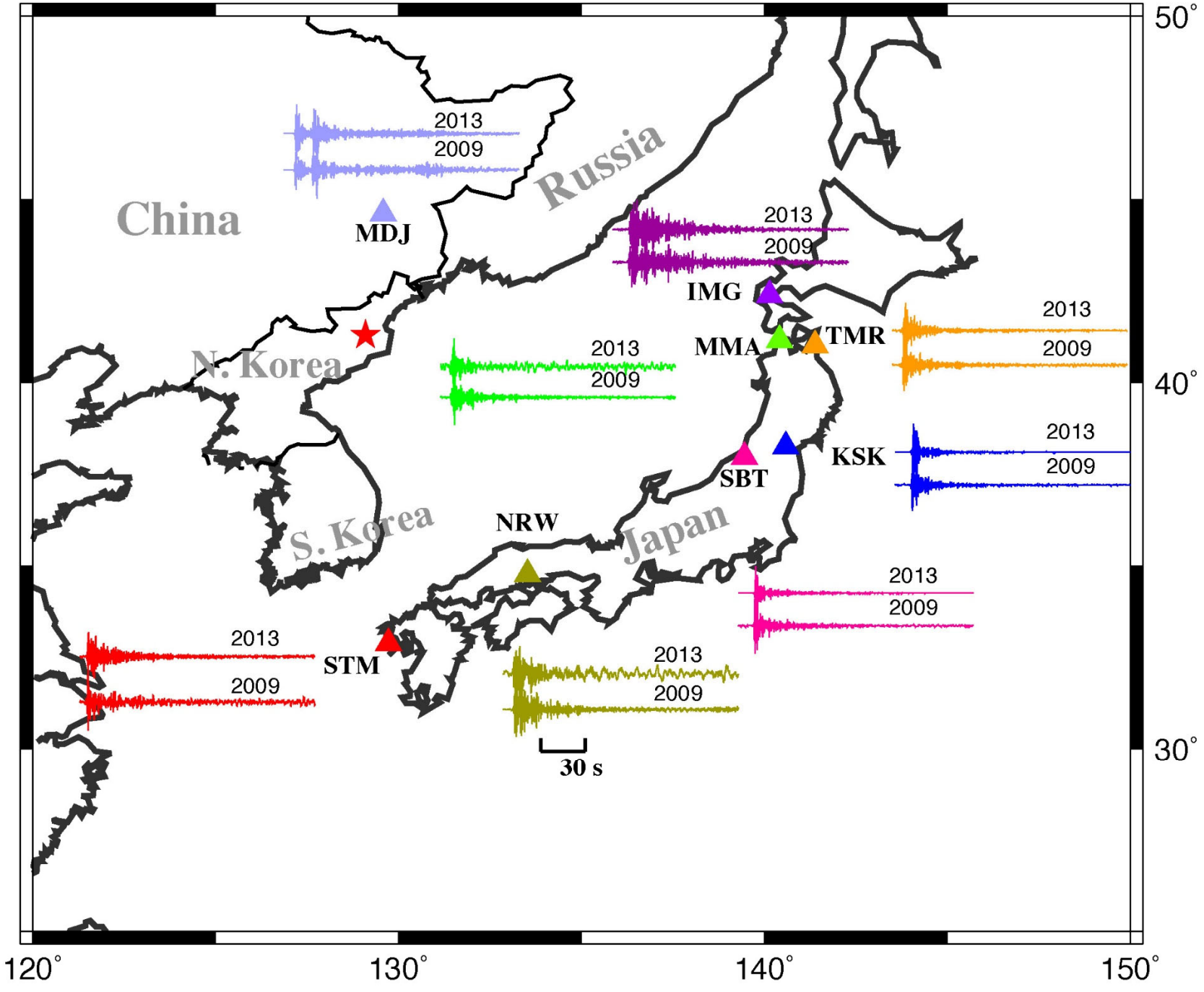


Figure 5. An international monitoring station in Pakistan detected the Indian nuclear test of May 11, 1998, about 740 kilometers away. (a) Analysis of the seismogram showed a P-wave-to-S-wave ratio strongly indicative of an explosion and not (b) nearby earthquakes.


Pn
Pg
Lg
Surface wave
MDJ HZ
57.2 micron/s
01:30:41.99
2016/01/06, M5.1
370.8 km
az= 6.8
baz=187.2
MDJ BZ
94.2 micron/s
02:58:31.38
2013/02/12, M5.1
371.0 km
az= 6.5
baz=186.8
MDJ HZ
37.8 micron/s
00:55:23.29
2009/05/25, M4.7
MDJ BZ
9.7 micron/s
01:36:07.99
2006/10/09, M4.2
October 9, 2006
mb 4.2
approx. 1 kT
May 25, 2009
mb 4.7
approx. 5 kT
February 12, 2013
mb 5.0
approx. 10 kT
January 6, 2016
mb 4.9
< 10kT
NORSAR
20.0
40.0
60.0
Relative time (s)
NORSAR array, Hedmark, Norway

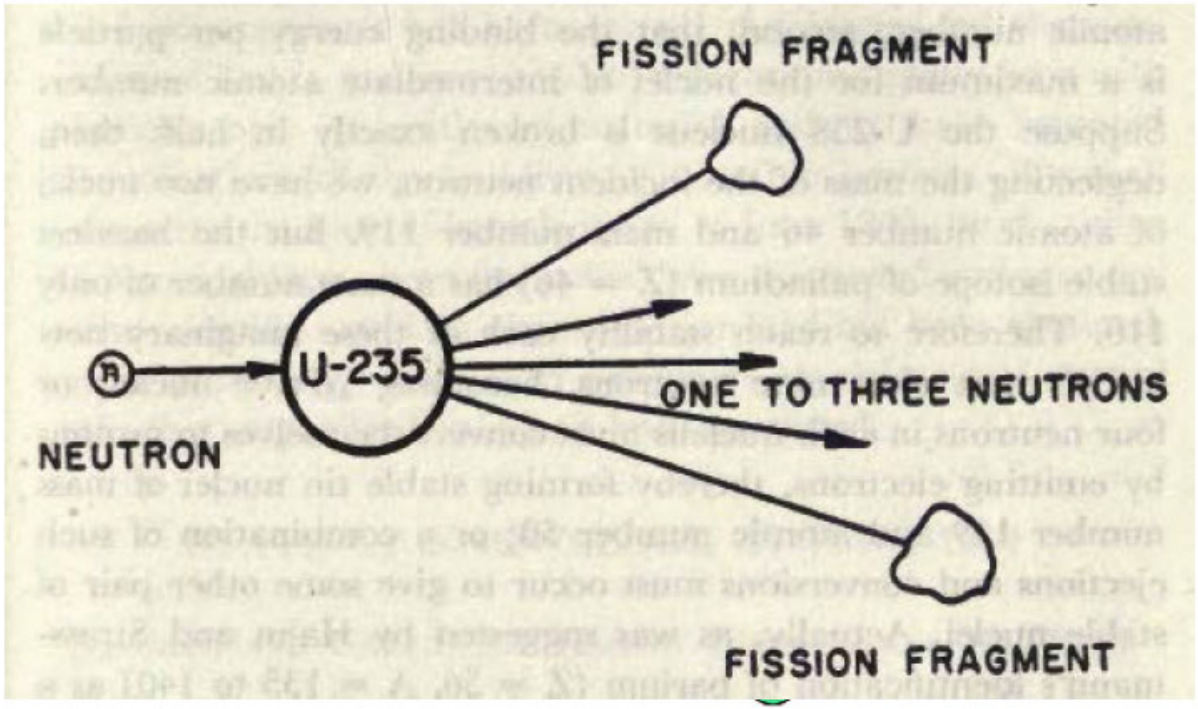

China
Russia
N. Korea
S. Korea
Japan
MDJ
IMG
MMA
TMR
KSK
SBT
NRW
STM
2013
2009
30 s
50°
40°
30°
120°
130°
140°
150°

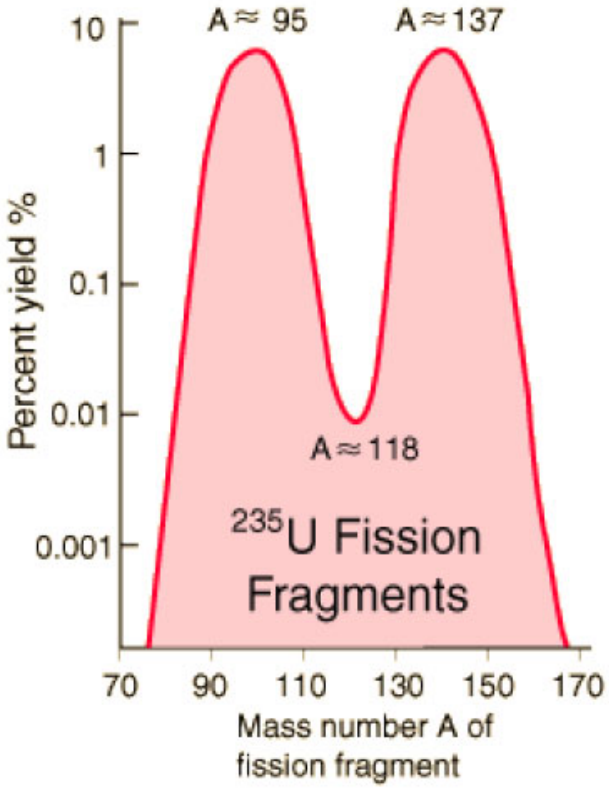
How do we know if it's a nuclear test

or

if it's not just a big conventional explosion underground?

The Nuclear Fission Yield Curve



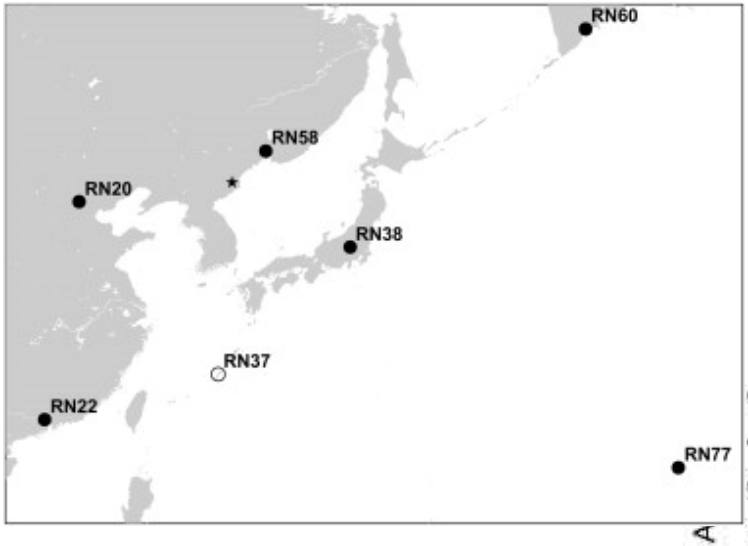


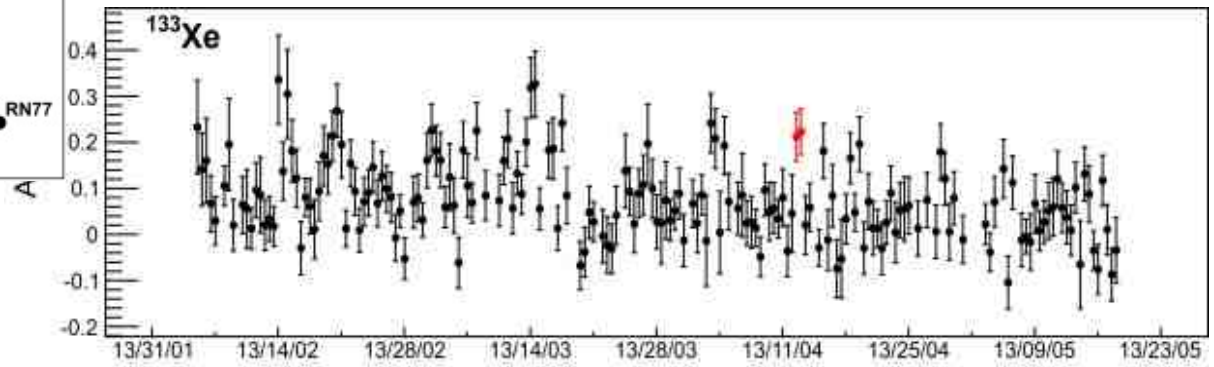
- Fission of uranium produces two new atoms
- About one out of five winds up as xenon

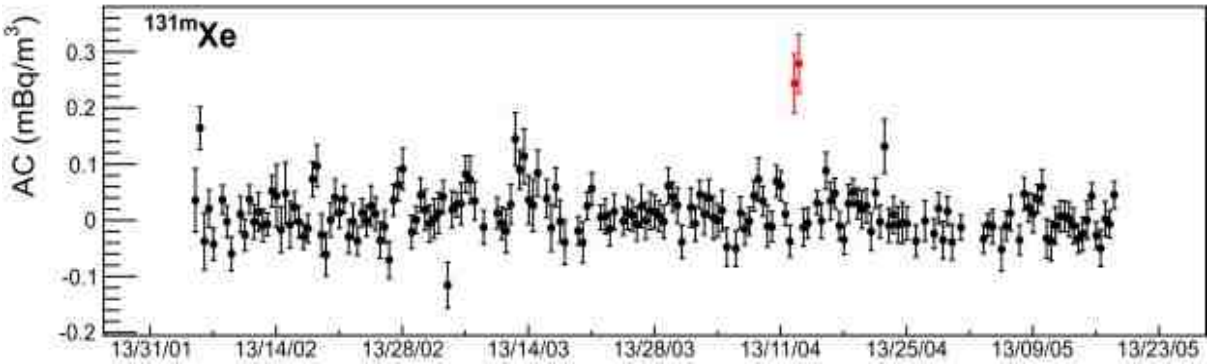
Image courtesy of Harry Miley, PNNL

Radionuclide Monitoring

^{133}Xe Isotopes

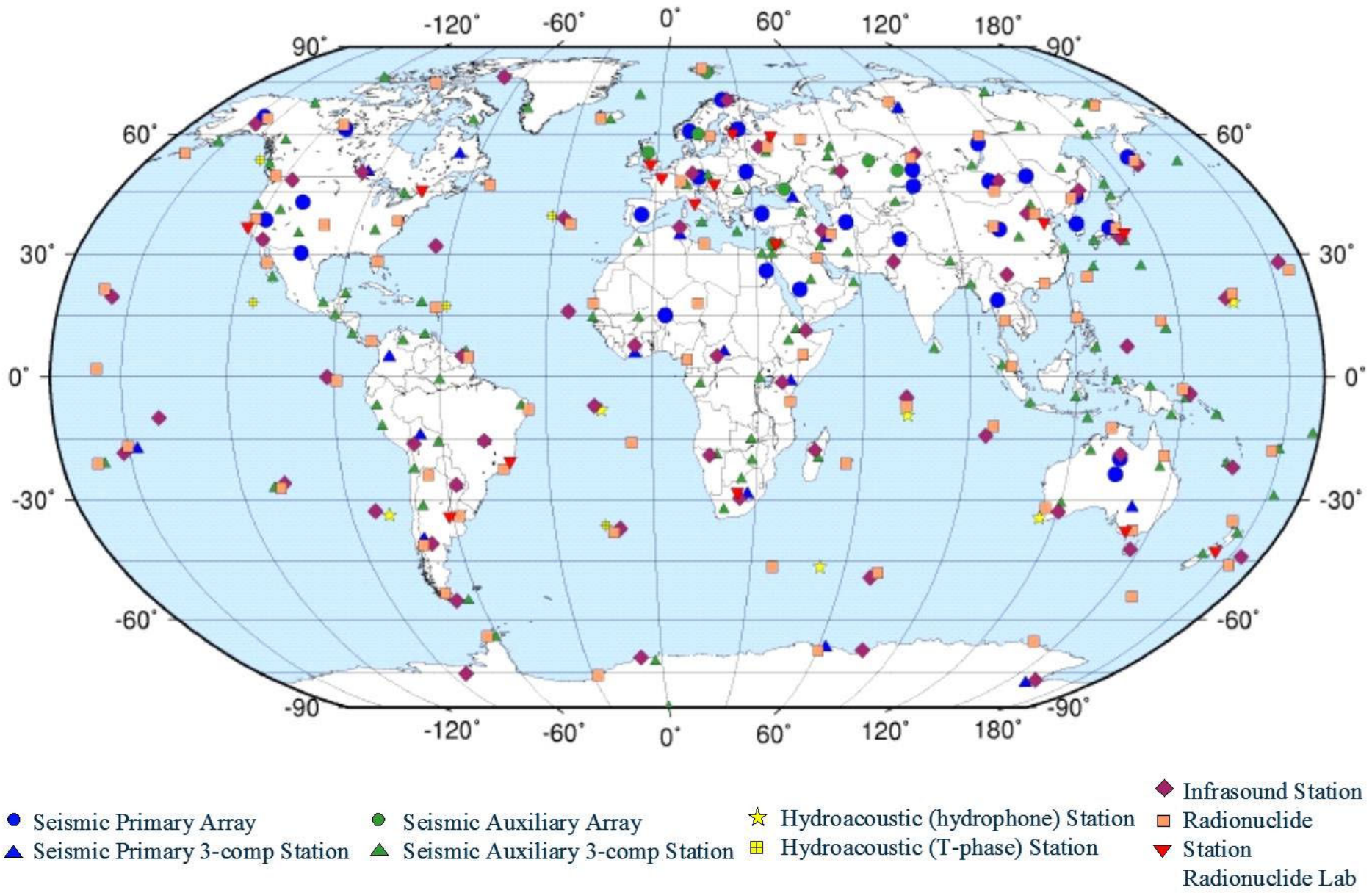




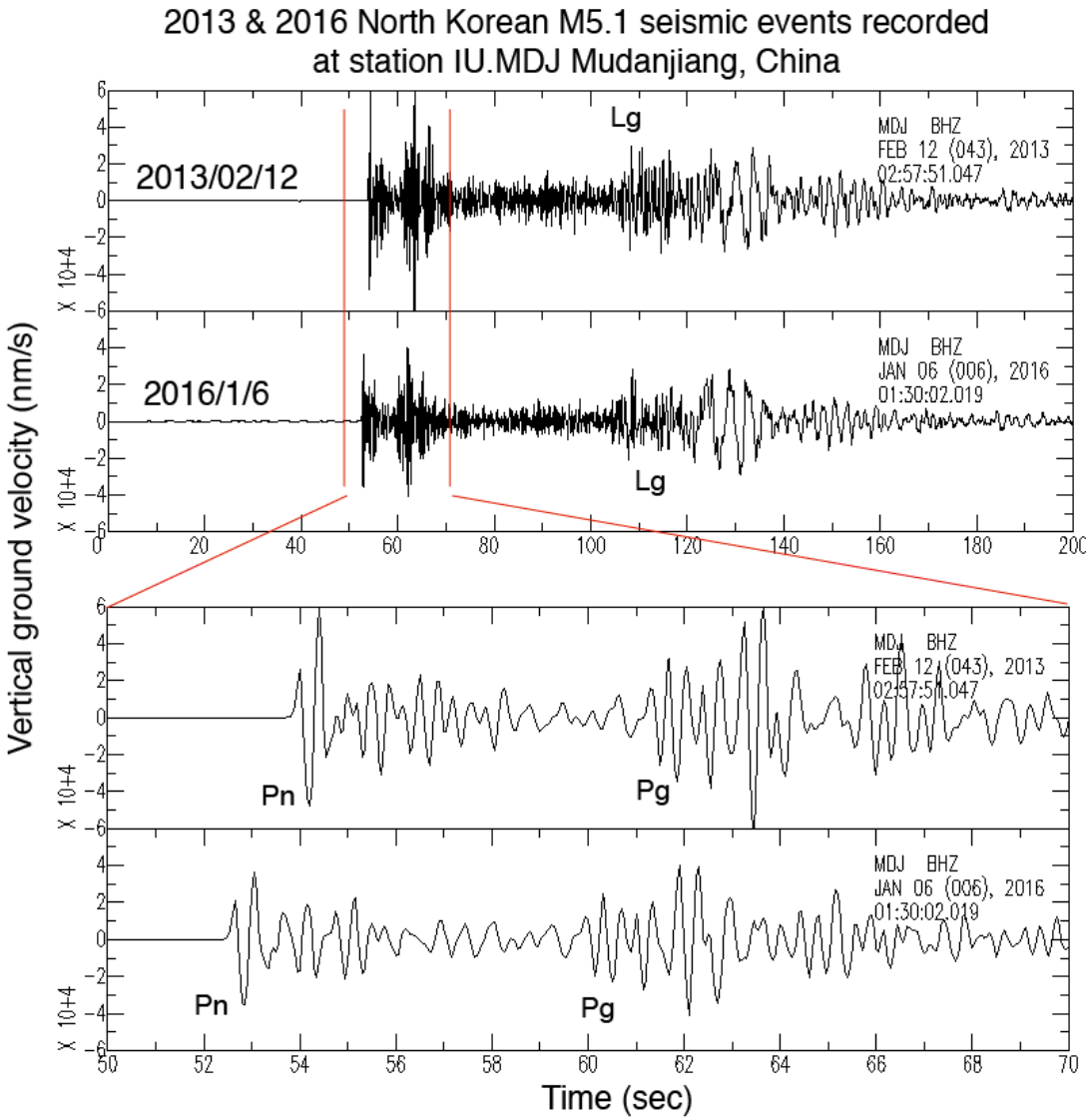


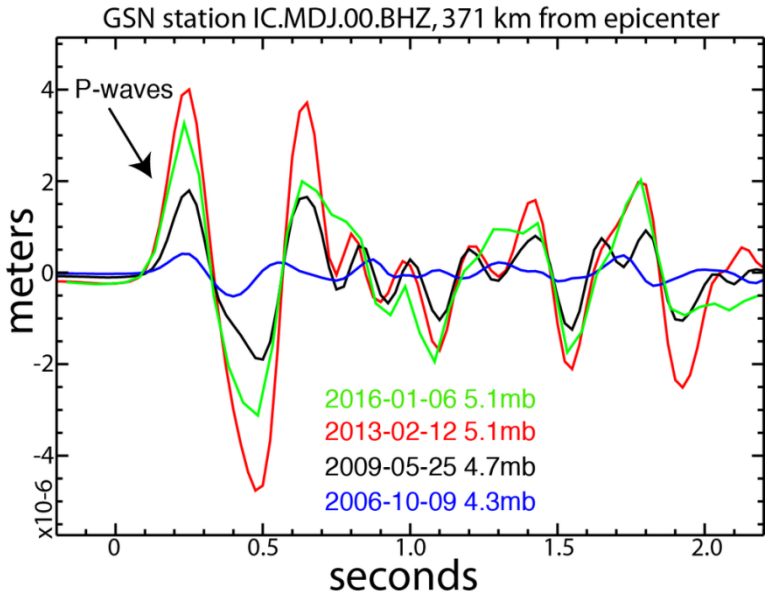
A Ringbom, et al., "Radioxenon detections in the CTBT international monitoring system likely related to the announced nuclear test in North Korea on February 12, 2013," *Journal of Environmental Radioactivity,* November 2013, 128C, pp 47-63.

CTBTO Monitoring Stations



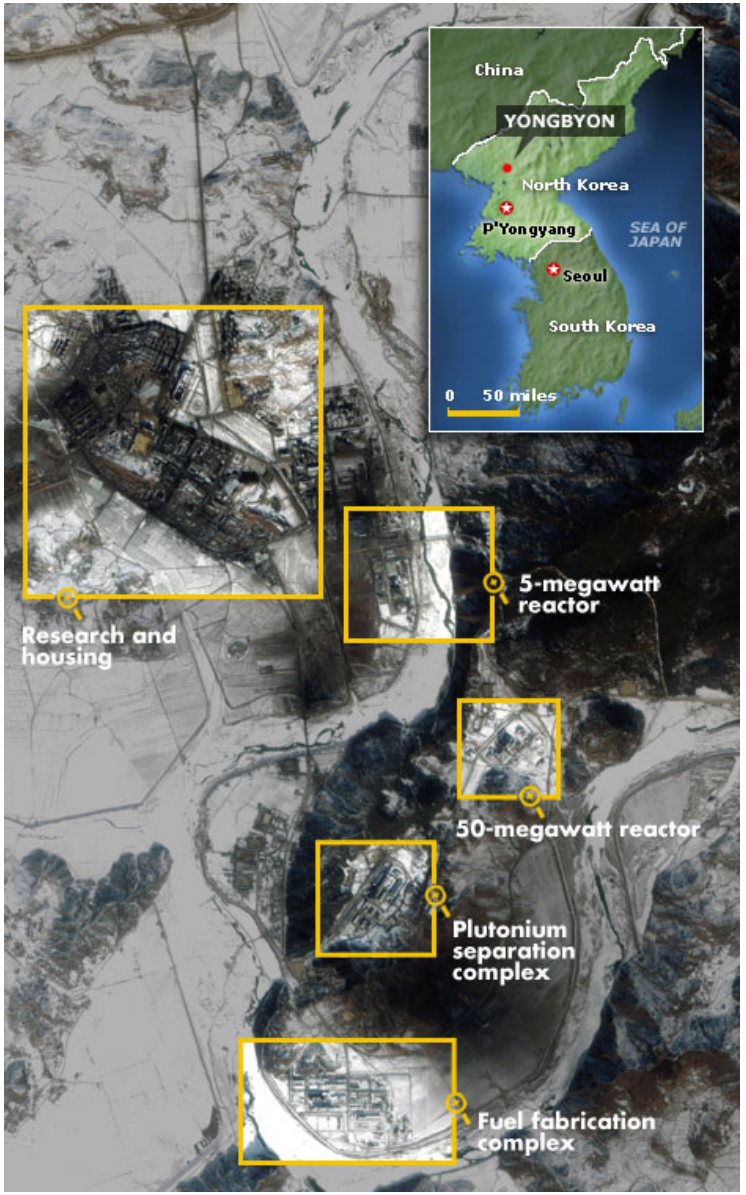
Atomic or Hydrogen Bomb?



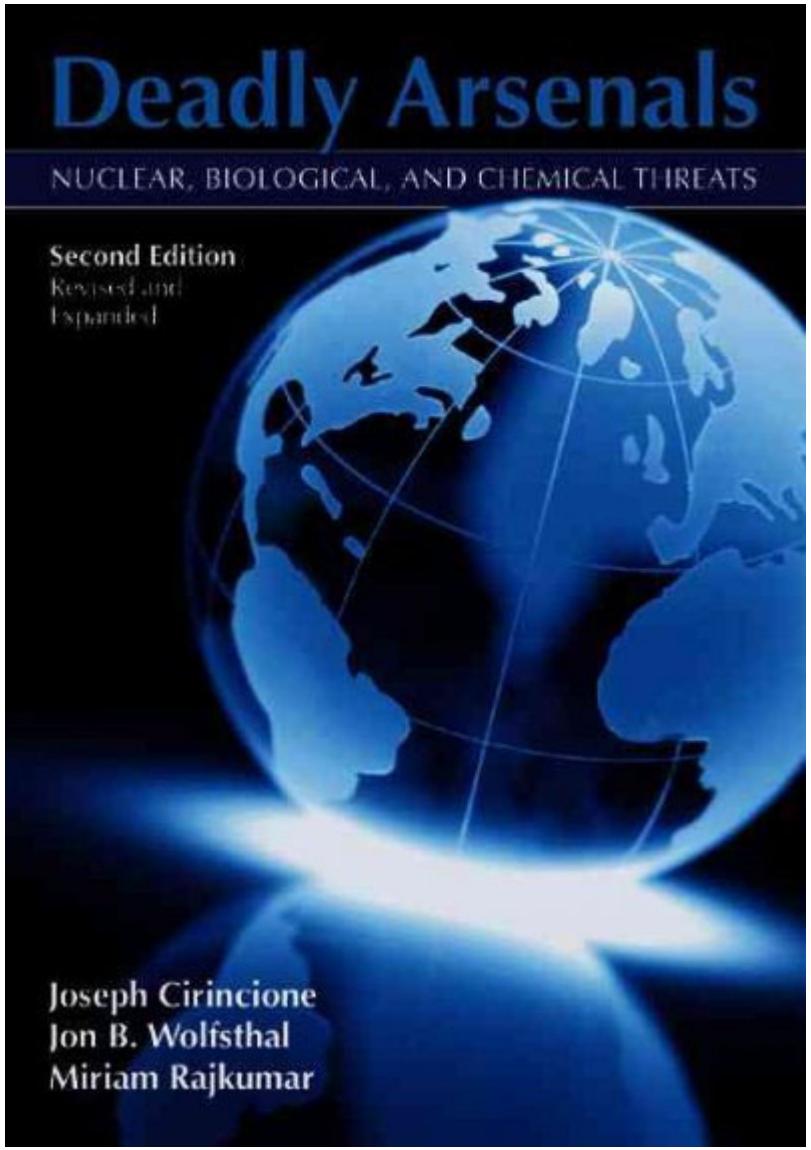


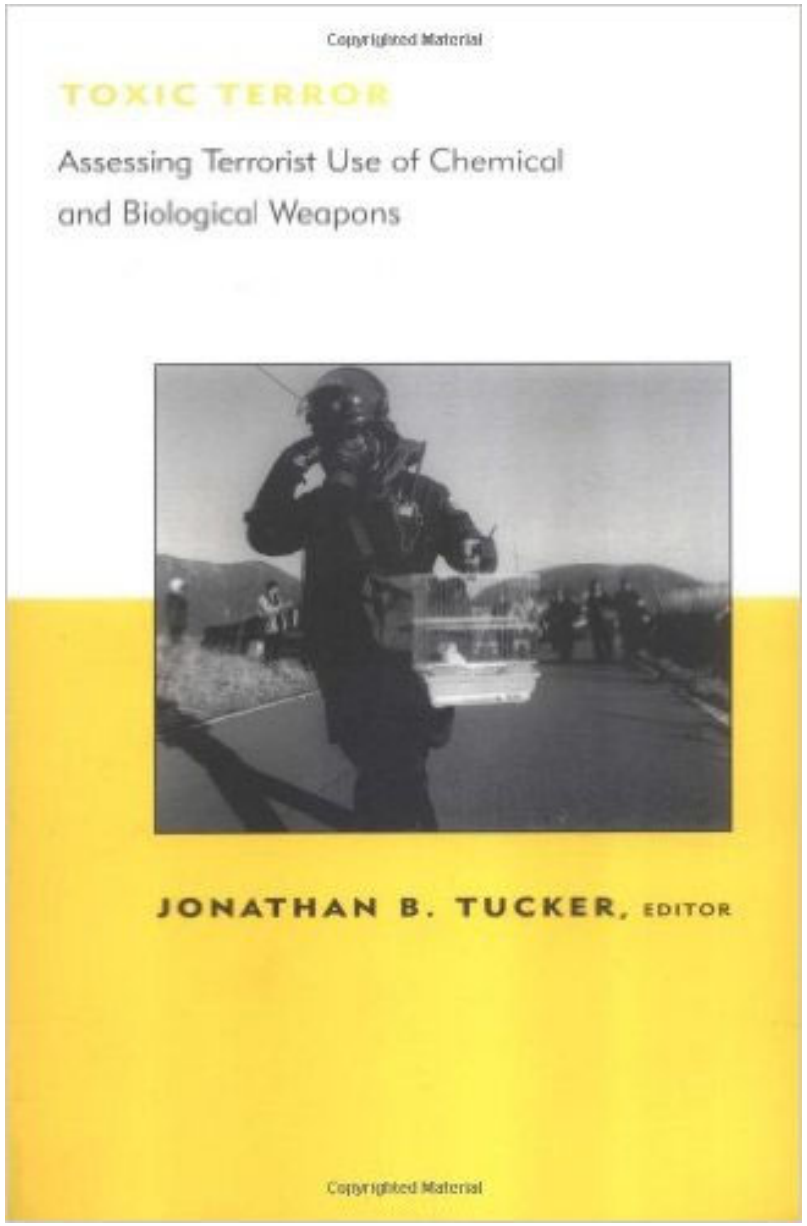
What does it all mean? Geopolitics

- Uncertainty
- Regime stability
- Intent
- Nuclear transfer/sale
- Withdrawal from NPT/international law



Texts


Deadly Arsenals
NUCLEAR, BIOLOGICAL, AND CHEMICAL THREATS
Second Edition
Revised and
Expanded
Joseph Cirincione
Jon B. Wolfsthal
Miriam Rajkumar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TOXIC TERROR
Assessing Terrorist Use of Chemical
and Biological Weapons
JONATHAN B. TUCKER, EDITOR
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S&T and Nuclear Weapons

"The concept of nuclear deterrence is historically and substantively at the heart of the whole nuclear issue. I used it way back in 1939 as the rationale for starting the work on the atom bomb (but soon realized its fallacy); it was the rationale for nearly all the scientists in the pre-Manhattan years. Deterrence - in its various forms - was the reason for the build-up of huge arsenals during the Cold War period, and it is being used now to justify the retention of nuclear weapons."

"The problem of deterrence has of course been frequently debated …. But the arguments have usually been on the political, strategic or military aspects; little attention has been paid to the ethical aspect. The reason for this is the one mentioned earlier: **ethical issues have no place on the agenda of the cynics**."

"Above all, remember your humanity."

– Sir Joseph Rotblat, Manhattan Project Physicist & 1995 Nobel Peace Prize Winner

"I call on all scientists in all countries to cease and desist from work creating, developing, improving and manufacturing further nuclear weapons - and, for that matter - other weapons of potential mass destruction such as chemical and biological weapons."

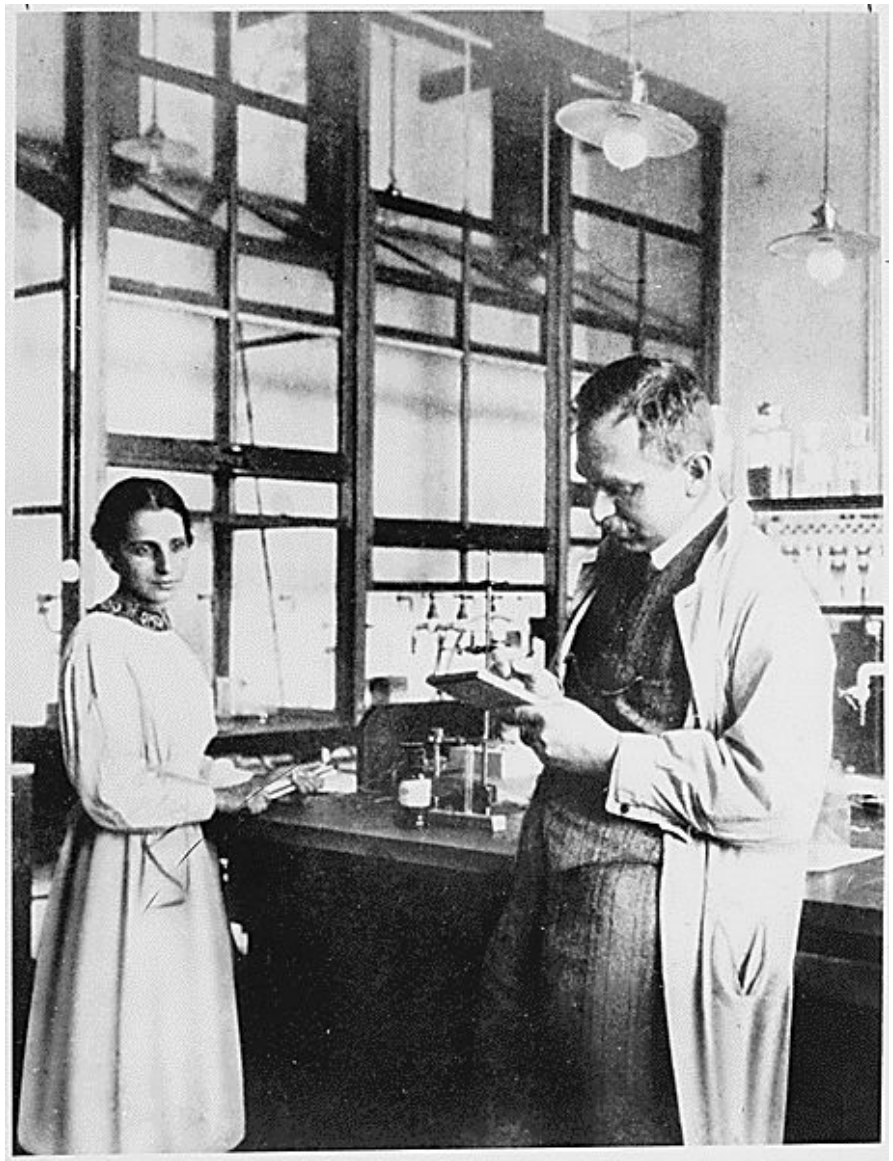
– Prof Hans Bethe, Manhattan Project Physicist, August 1995

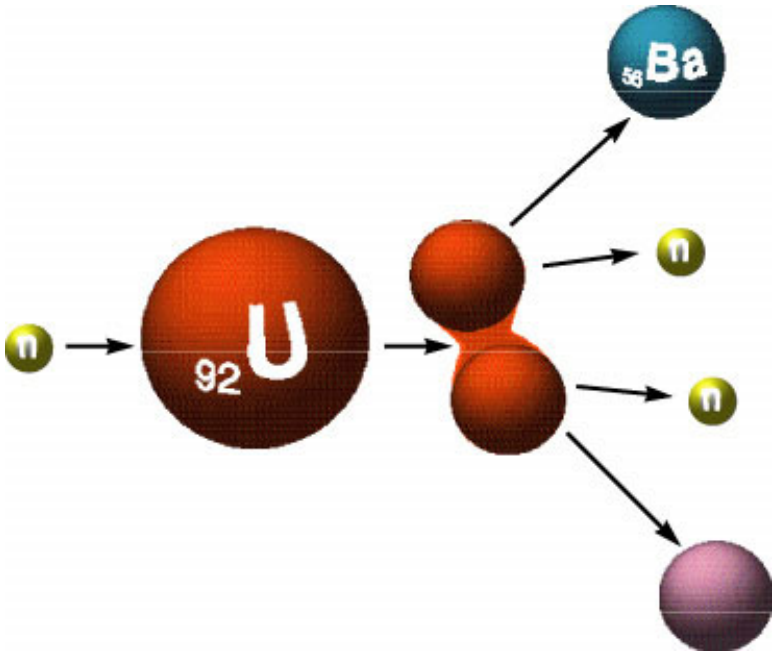
At the end of the 19th century, many scientists did not realize they were on the edge of a revolution in physics…

"The most important fundamental laws and facts of physical science have all been discovered, and these are now so firmly established that the possibility of their ever being supplanted in consequence of new discoveries is exceedingly remote… Our future discoveries must be looked for in the sixth place of the decimals."

— *Albert Michelson, 1894*

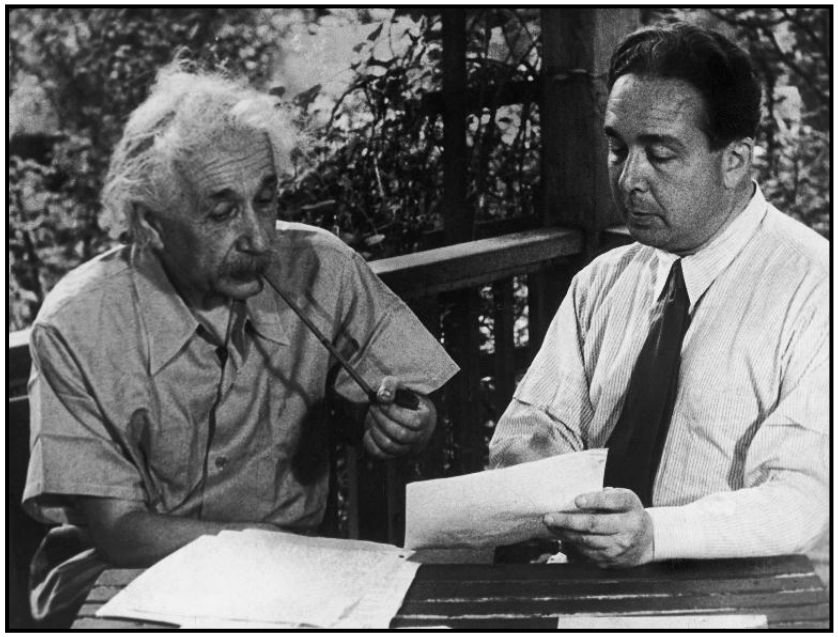
Meitner & Hahn





$E=mc^2$

US Government Involvement



- 2 August 1939: Einstein signs a letter alerting Pres FD Roosevelt to possibility of an atomic bomb
  - Warned that Germany might be developing such a weapon
  - Leo Szilard wrote the letter for Einstein to sign
- 1 September 1939: Germany invades Poland and WWII begins
- Pres Roosevelt established an Advisory Committee on Uranium
  - Provided funds for research to universities
- 7 December 1941: Japan attacks Pearl Harbor and US enters WWII

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium,by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an inofficial capacity. His task might comprise the following:

a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

b) to speed up the experimental work,which is at precent being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,

A. Einstein

(Albert Einstein)

Franck Report

"If no international agreement is concluded immediately after the first demonstration, this will mean a flying start of an unlimited armaments race.

"We believe that these considerations make the use of nuclear bombs for an early, unannounced attack against Japan inadvisable. If the United States would be the first to release this new means of indiscriminate destruction upon mankind, she would sacrifice public support throughout the world, precipitate the race of armaments, and prejudice the possibility of reaching an international agreement on the future control of such weapons."

– Report of the Committee on Political and Social Problems
Manhattan Project "Metallurgical Laboratory," University of Chicago, 11 June 1945

"Not until we drop two bombs on Japan." – Leslie R. Groves

"Well, I have my doubts, General Groves" – R. Oppenheimer

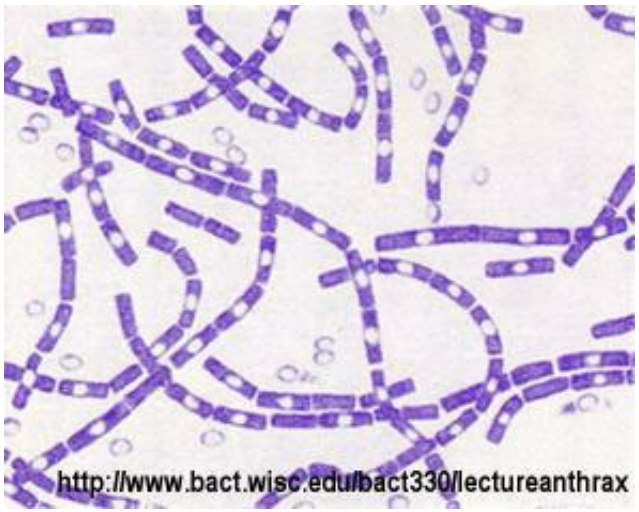
"Now we're all sons of bitches." – Kenneth Bainbridge

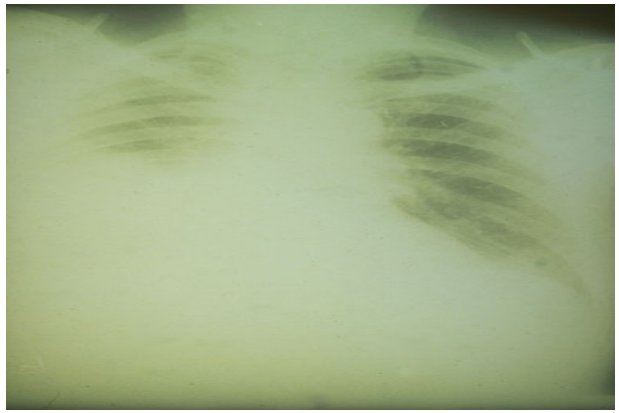
"In 1945, when we ceased worrying about what the Germans would do to us, we began to worry about what the government of the United States would do to other countries." – Leo Szilard

Biological Weapons Overview

Anthrax

- Caused by *Bacillus anthracis* bacteria
  - "Woolsorter's disease"
- Routes of entry
  - cutaneous (natural)
  - ingested
  - **inhalation**
- Incubation 1-6 days
- Symptoms resemble flu
  - cutaneous highly treatable with antibiotics *(untreated less than 20% fatality)*
  - inhalation 60-70% death rate with treatment
    - death within 24-36h onset severe inhalation symptoms destroys membranes of lung and intestines
- Non-contagious
- Extremely environmentally robust (as spores)





Courtesy of USMRMC

Lung X-ray showing widened mediastinum

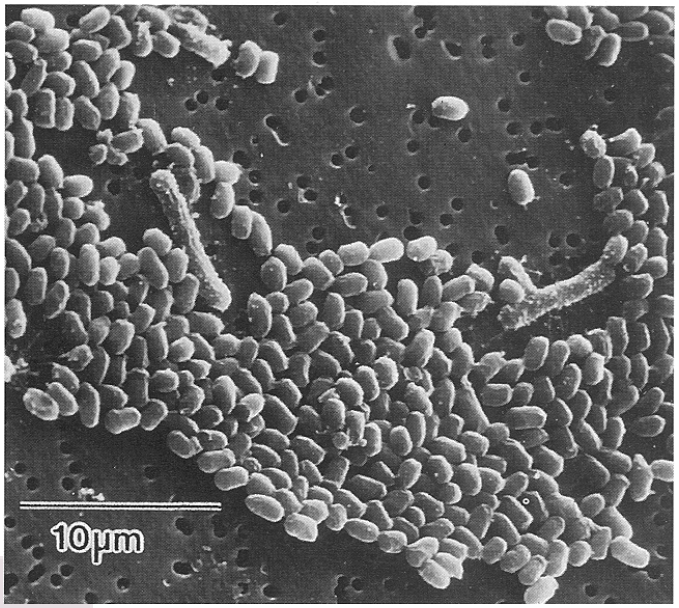
BW History of *B. anthracis*

- WWI Germans attempt to infect horses, mules & reindeer
- Unit 731 Japanese in northeast China in 1930's
  - tested on POWs
  - fatality estimates vary widely >1000
- "Agent N" 1940's designation by Allies
  - Gruinard Island (off Scottish coast) contaminated until 1986
- Allegedly during Rhodesian Civil War 1979-1980
  - outbreak largely confined to black-held Tribal Trust Lands
  - >10,700 casualties, 182 deaths
- US and Soviet BW stockpile
- Aum Shinrikyo
  - used vaccine strain
- 2001 mailings of 5-6 spore-containing letters
  - 22 casualties
  - 5 deaths

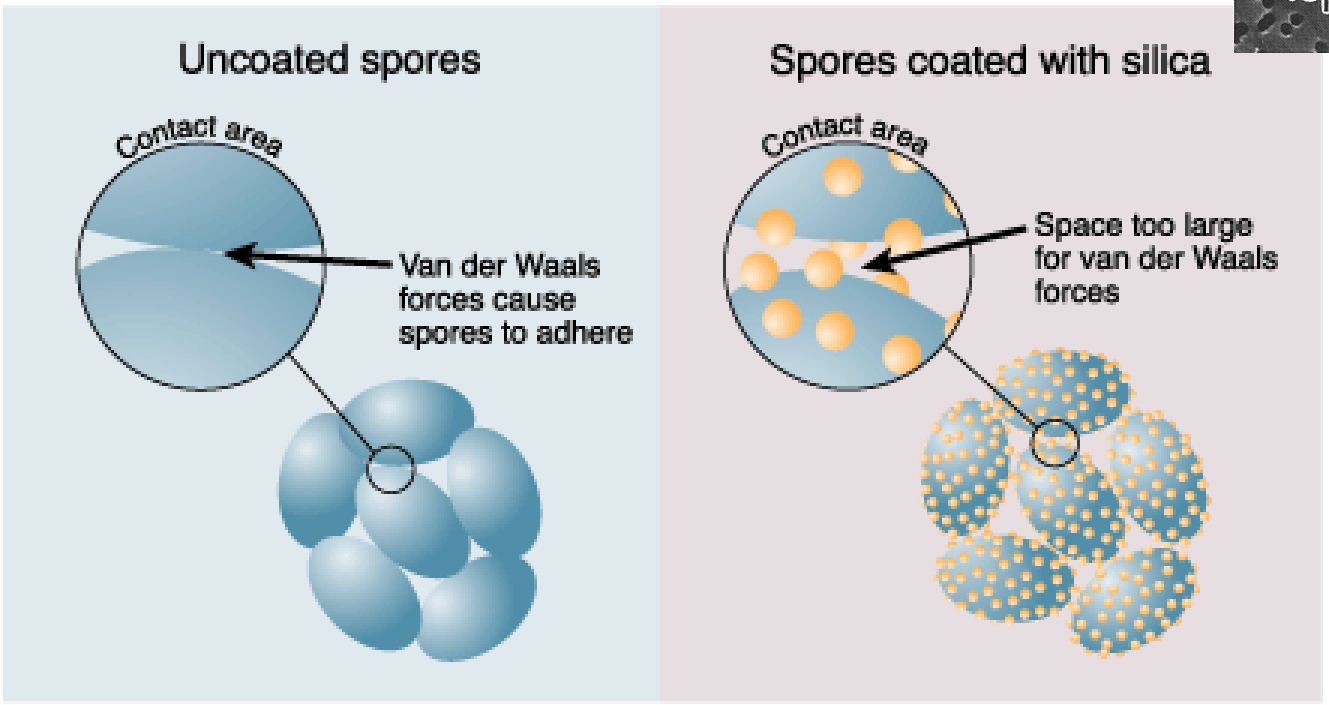
Weaponized *B. anthracis*

For warfare agent

- must withstand processing
- must not clump -
  - silica gel
  - electrically charged

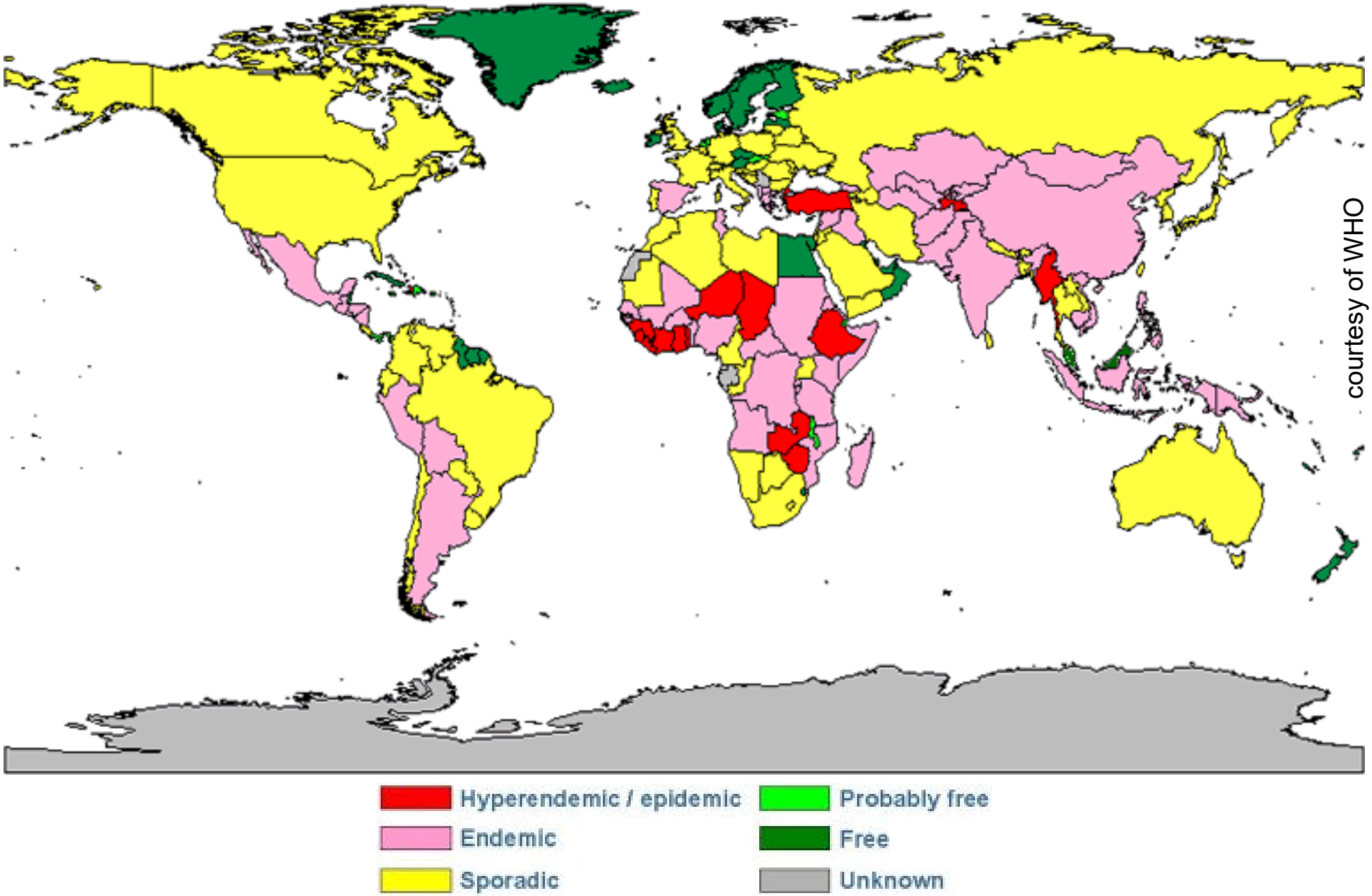


B. anthracis SEM



courtesy of *Science*

Worldwide Anthrax Distribution



Improvised Devices

Courtesy *Emerging Infectious Diseases*

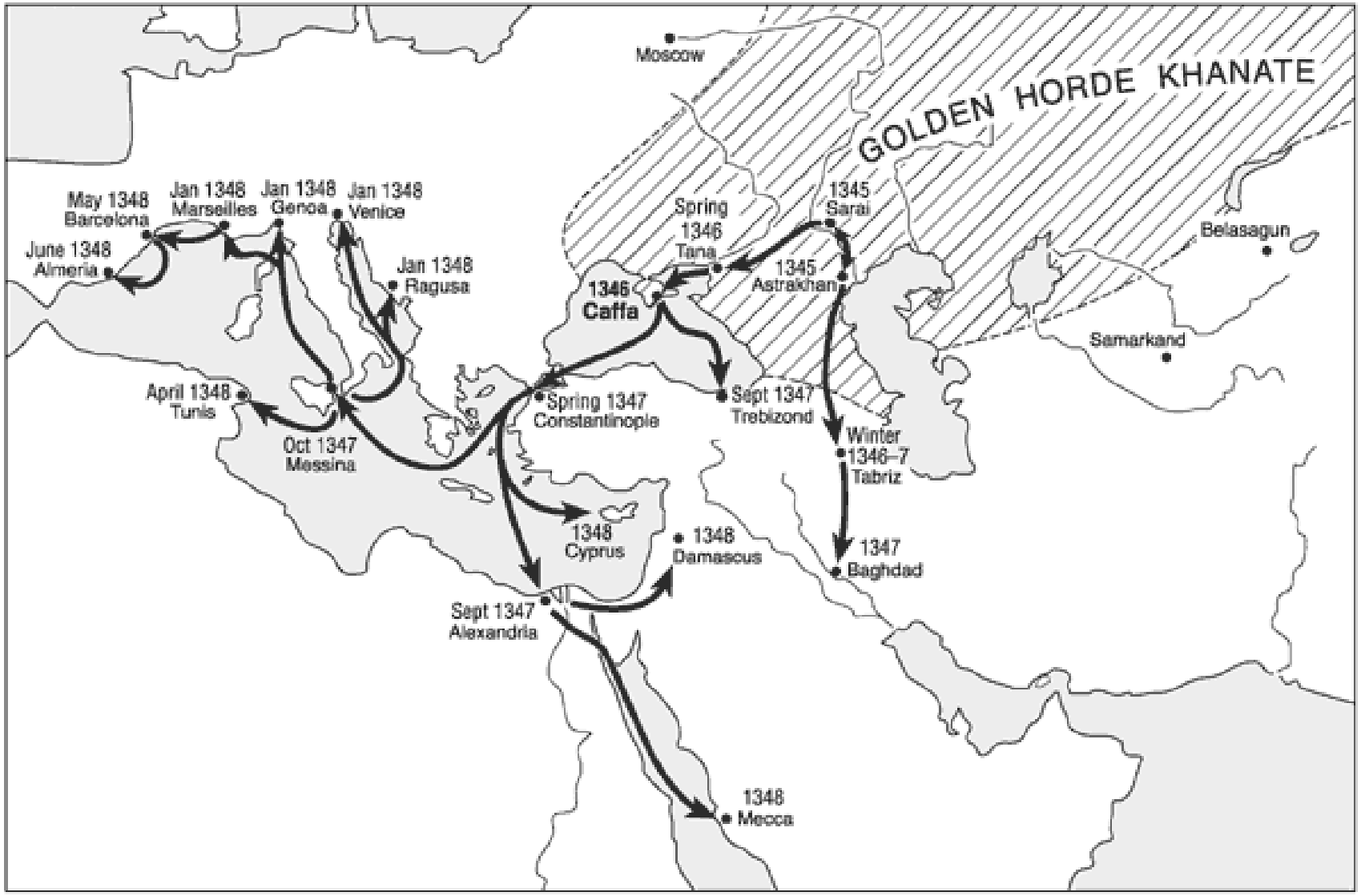
- Amerithrax
  - Envelopes & US Mail system
- Aum Shinrikyo
  - Sprayer on Tokyo rooftop (July 1993)
  - Wet, stinky mess
  - Distributed *B. anthracis* Sterne 34F strain
- Agricultural Sprayers

Yersinia Pestis

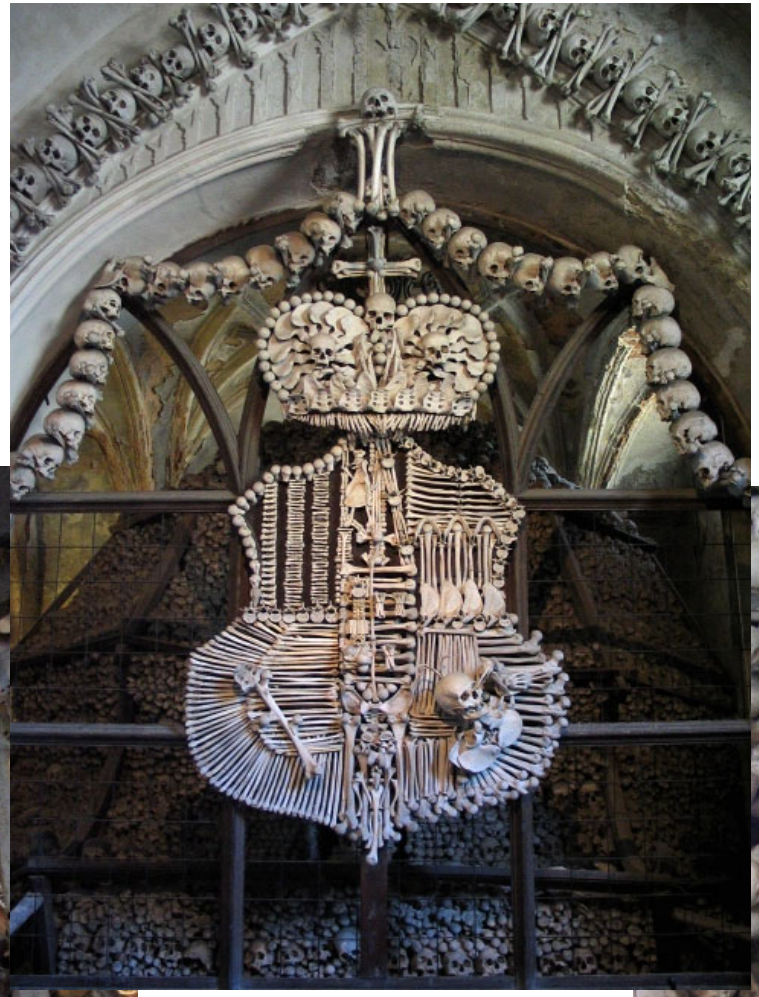
Black Death – the Plague

Illustration of the Black Death from the Toggenburg Bible (1411)

Spread of the Plague



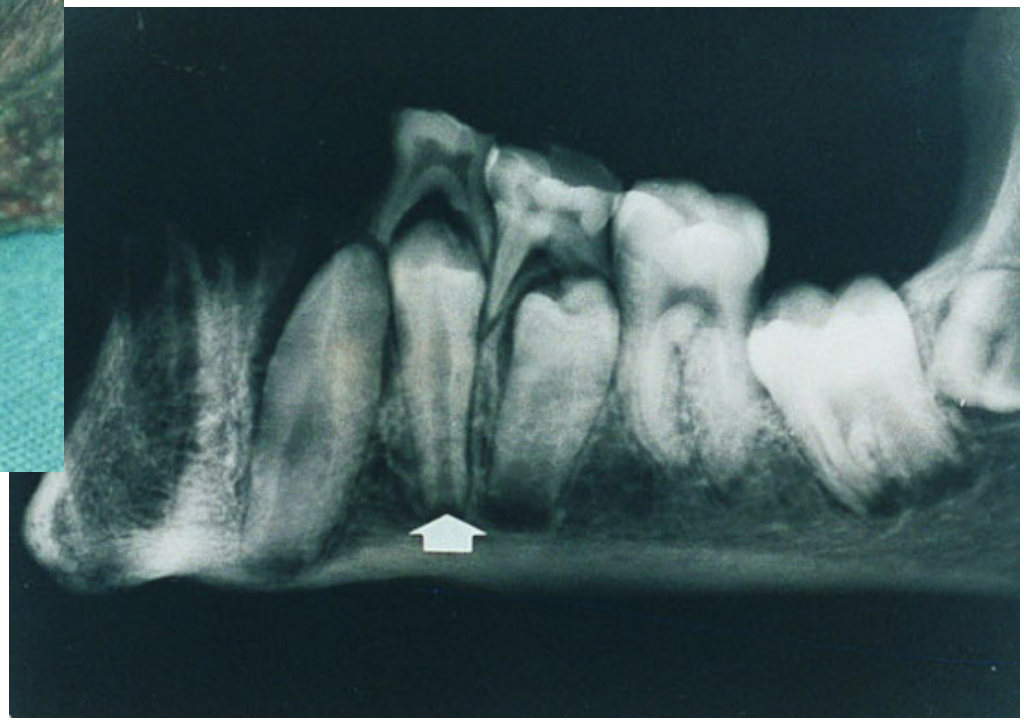
Kutna Hora Ossuary



Paleomicrobiology & Genetic Analysis

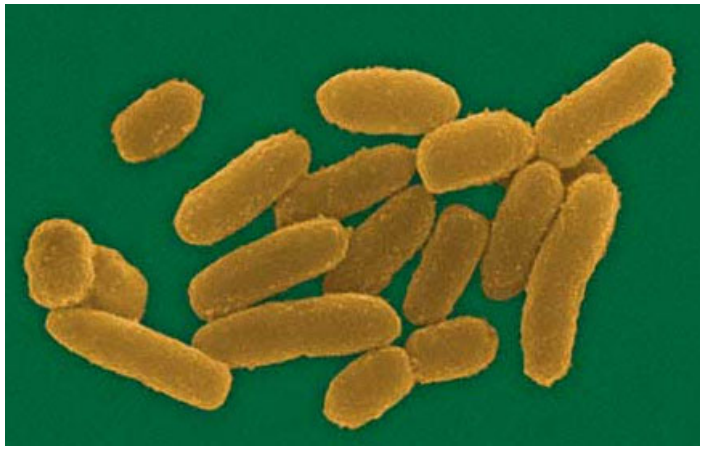
Sample collection

X-ray Analysis

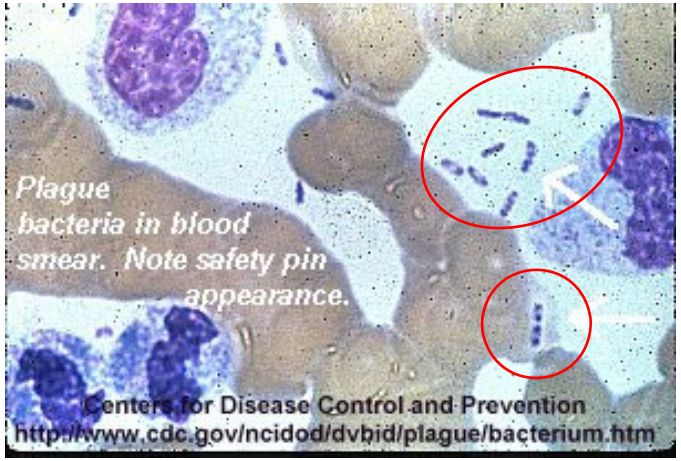


Plague

- Caused by *Yersinia pestis* bacteria
- Three 'varieties'
  - (1) bubonic
    - Natural vector (means of transmission) by fleas on rodents (reservoir)
    - Incubation 2-10 days
  - (2) pneumonic
    - Incubation 1-3 days
  - (3) septicemic … in the blood and spinal fluid
- Symptoms resemble flu or pneumonia
  - **untreated pneumonic plague is 99% fatal**
    - antibiotics, within 12-24h, fatality rate drops significantly (~0-20%)
    - untreated bubonic 30-60% fatal
- Pneumonic is **highly contagious!**
- Fairly fragile as vegetative cells



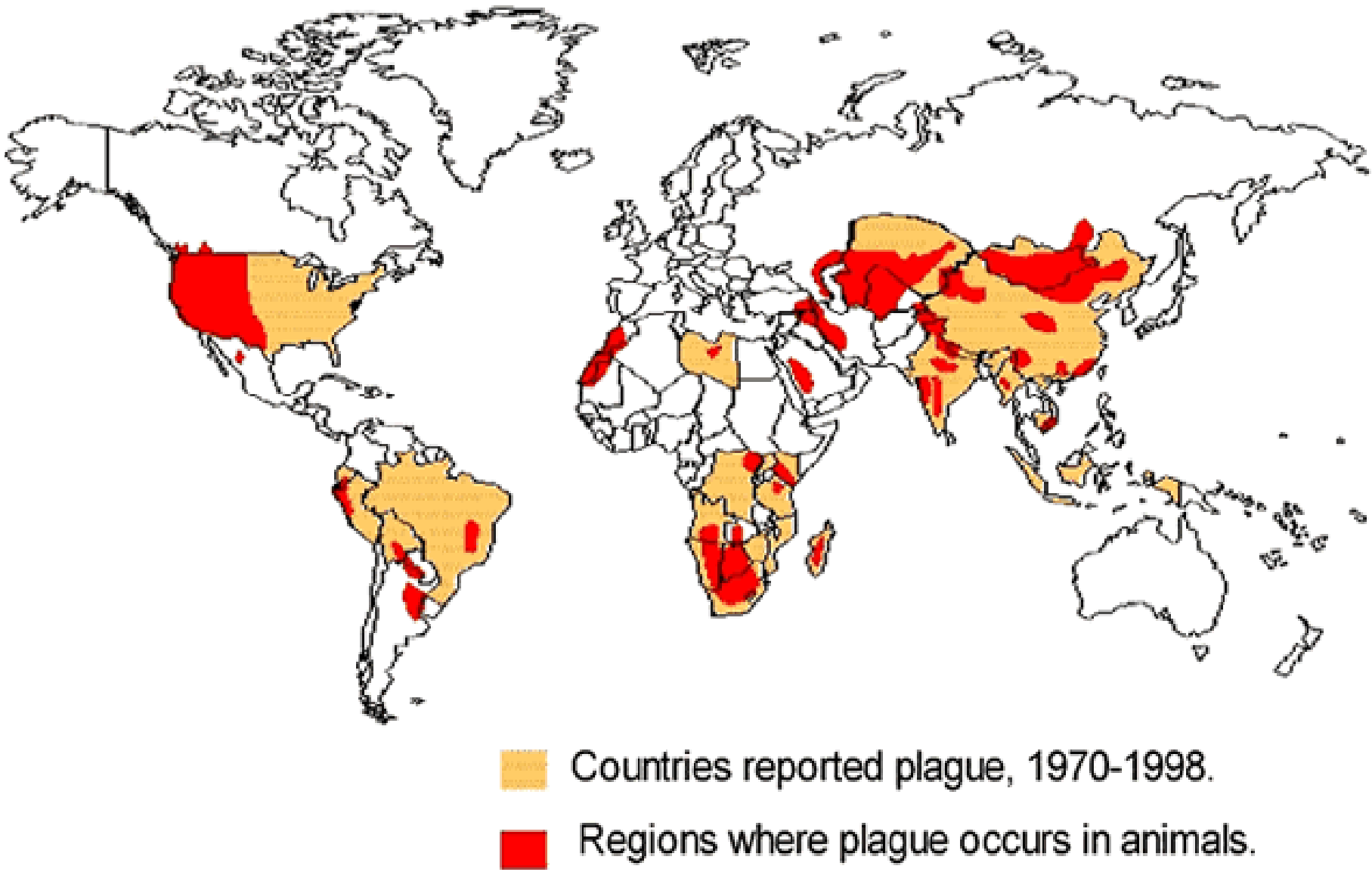
vegetative cells



BW History of *Y. pestis*

- 1346 Tartar siege of Caffa
  - corpses tossed over wall
  - possibly led to European pandemic
- 1710 similarly used by Russians against Swedes, epidemic resulted
- Tested on Chinese as part of Japanese Unit 731 in northeast China in 1930's
  - Infected fleas dropped on Ningpo, China 1940
  - Estimated fatalities vary widely ~500-thousands

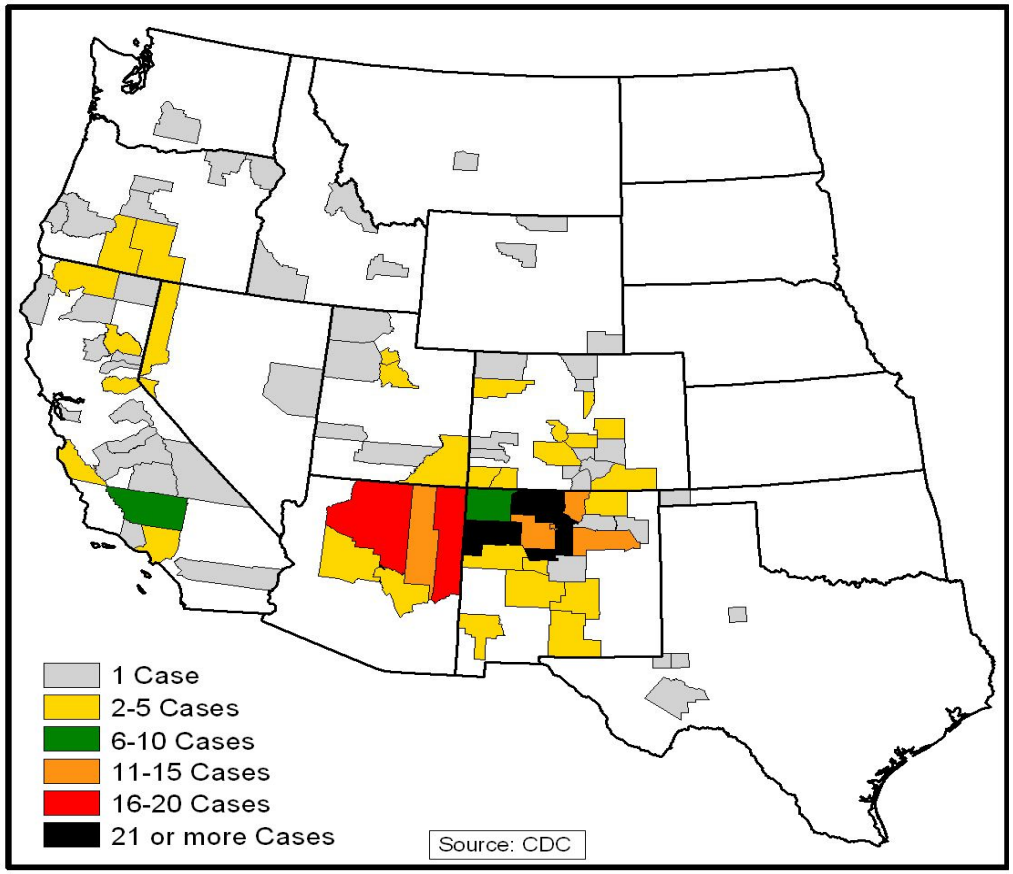
World Distribution of Plague, 1998



Plague in the US

- Southwest (87%)
  - Northern New Mexico
  - Southern Colorado
  - Northern Arizona
  - California

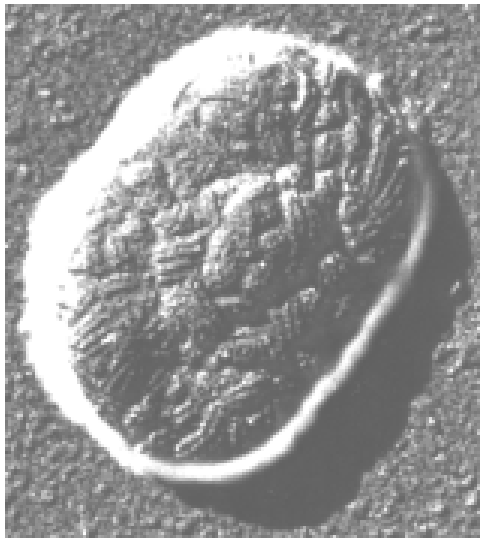
  Reported human cases:
- 1925-1964
  - ~2 cases/yr
- Since 1970
  - ~13 cases/yr



No person to person infection reported since 1924.

Smallpox

- Caused by Vaccinia *variola maj* virus
- Transmission
  - person to person
- Incubation 7-17 days
- Symptoms
  - initially resemble flu
  - 2-4 days, characteristic pox
- Unvaccinated ~30% fatal
- Highly contagious!
- Fairly persistent in dried form



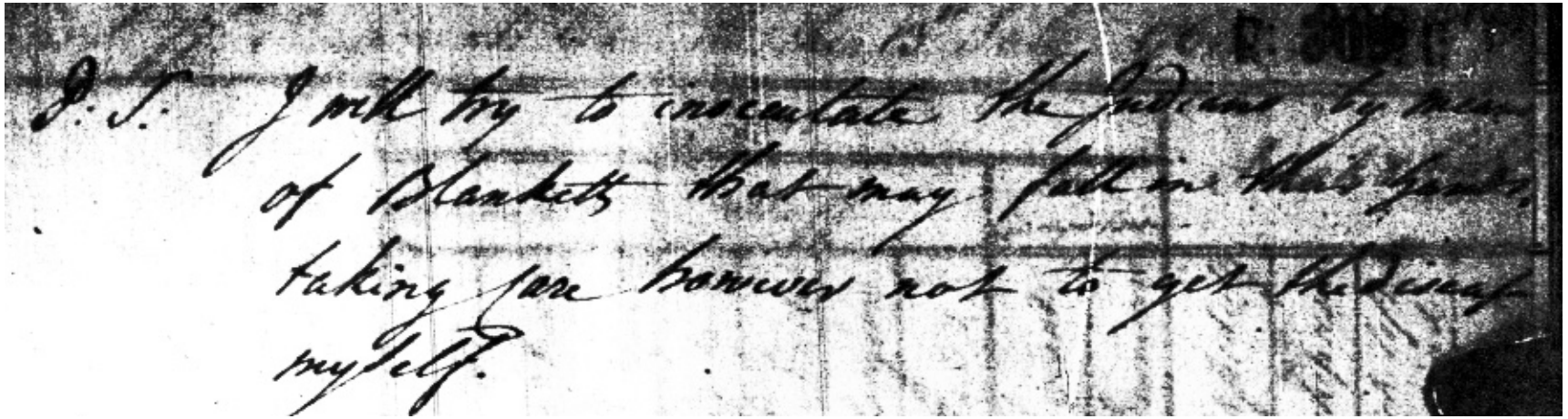
cowpox SEM

National Institute for Biological Standards and Control, Herts, U.K.

BW History of Smallpox

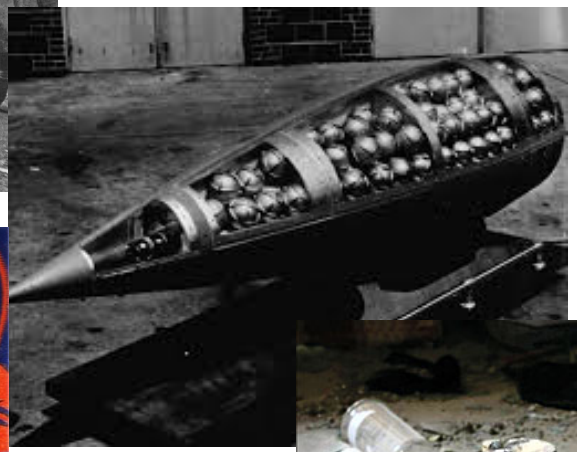
Infested blankets and handkerchiefs (fomites) against Native Americans in 1700s, 1800s & 1900s

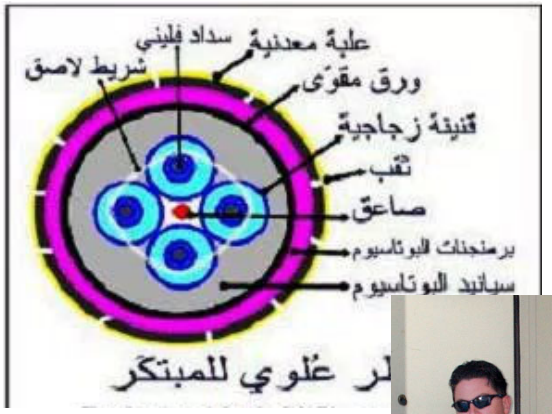
"Could it not be contrived to send smallpox among these disaffected tribes of Indians? We must use every stratagem in our power to reduce them." Jeff Amherst, Commander-in-Chief of the British forces in North America to Colonel Henry Bouquet, 1763



"Out of our regard to them we gave the two Blankets and a Handkerchief out of the Smallpox Hospital. I hope it will have the desired effect" William Trent, 1763

Chemical Weapons Overview





Nerve Agents

not "gases"

The G-Series – developed by the German scientists prior to WWII

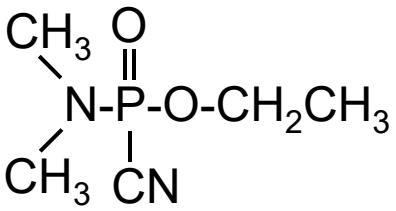
- Tabun, **GA**

  Dimethylamidoethoxyphosphoryl cyanide

  evaporation ~1/20th of water, low persistence

  colorless and odorless if pure

  very rapid effect (all G-series nerve agents)



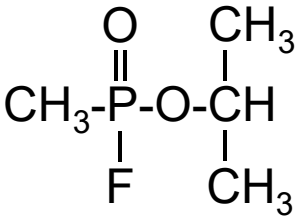
- Sarin, **GB**

  Isopropyl methylfluorophosphonate

  volatility comparable (but less!) than water

  Vp = 2.10mm Hg versus Vp = 17.5mm Hg for H_2O @20℃

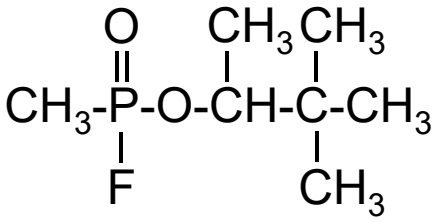
  low persistence



- Soman, **GD**

  less volatile than sarin

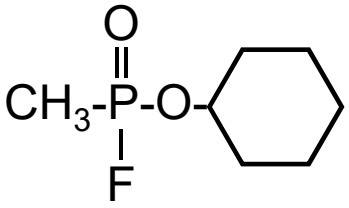
  more persistent than sarin



- Cyclosarin, **GF**

  often synthesized with sarin

  moderate persistency

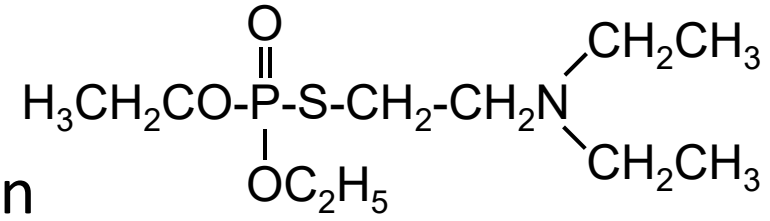


Nerve Agents, con't

The V-Series – the phosphorylthiocholine class of compounds – were first synthesized by the British, Germans and Swedish independently (1952-53); they were developed as CW agents by the British, Americans and Soviets

- **VG**

  marketed as the pesticide Amiton

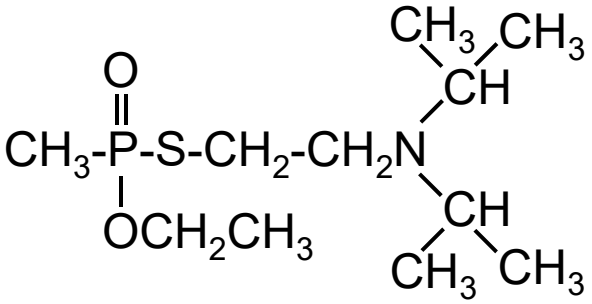


- **VX**

  Ethyl diisopropylaminoethyl methylphosphonothioate

  liquid at SATP

  viscosity similar to motor oil; persistent

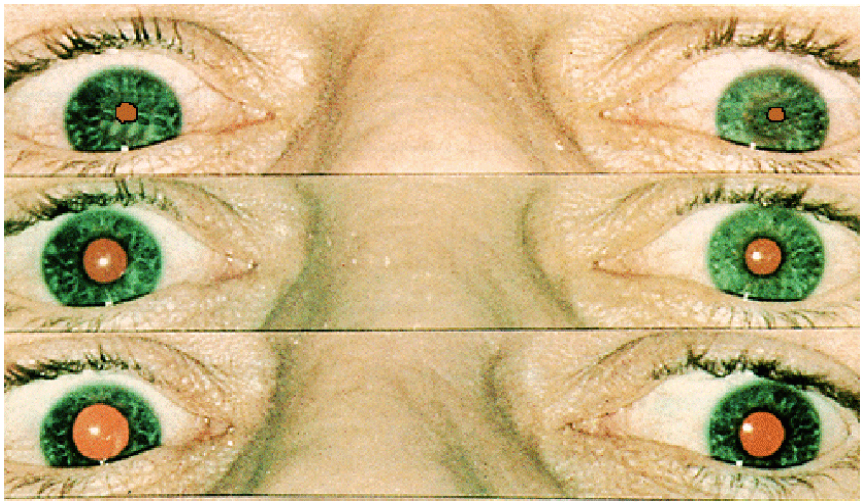


- Other V-agents

Physiological Interactions

Nerve agents

- Targets - nerve cells, particularly of heart and lungs
  - inhalation affects breathing (G-series only) and skin affects cardiovascular system
  - interferes with transmission of nerve impulses
    - By binding ***irreversibly*** to serine (-OH) residue on surface of acetyl cholinesterase (AchE) - the enzyme responsible for shuffling signal molecules (acetylcholine) between nerve cells, including those in muscles that control heart and lungs
  - other enzymes susceptible to interference too
  - aging
- Symptoms
  - visual impairment, “pin-point” pupils
  - respiratory impairment
  - gastrointestinal hyperactivity
    (cramps, vomiting, diarrhea)
  - headache
- Treatment
  - atropine (injection)
  - oximes, e.g., 2-PAM (injection)
- Decontamination - strong bleach (NOCl)



Clinical Toxicology

Nerve Agents - History

- Unspecified nerve agent allegedly used by Egypt against Yemen (1967)
- Tabun and sarin used by Iraq
  - Against Iran (1984-1988)
    - estimated 100,000 fatalities
  - Against ethnic Kurds in northern Iraq (1988)
    - estimates vary widely, 5000 fatalities and 10,000 casualties
- Sarin used by Japanese cult (Aum Shinrikyo) against civilians (1994-1995)
  - 7 fatalities and 150 injured Matsumoto prefecture
  - 12 fatalities and 1000 injured Tokyo subway
- VX used against three individuals by Aum Shinrikyo (December 1994 and January 1995)
  - 1 fatality and 2 injuries
- Used by Syria (2013-)

Sarin victims following Tokyo subway terrorist attack

Aum Shinrikyo

Improvised Devices

Aum Shinrikyo

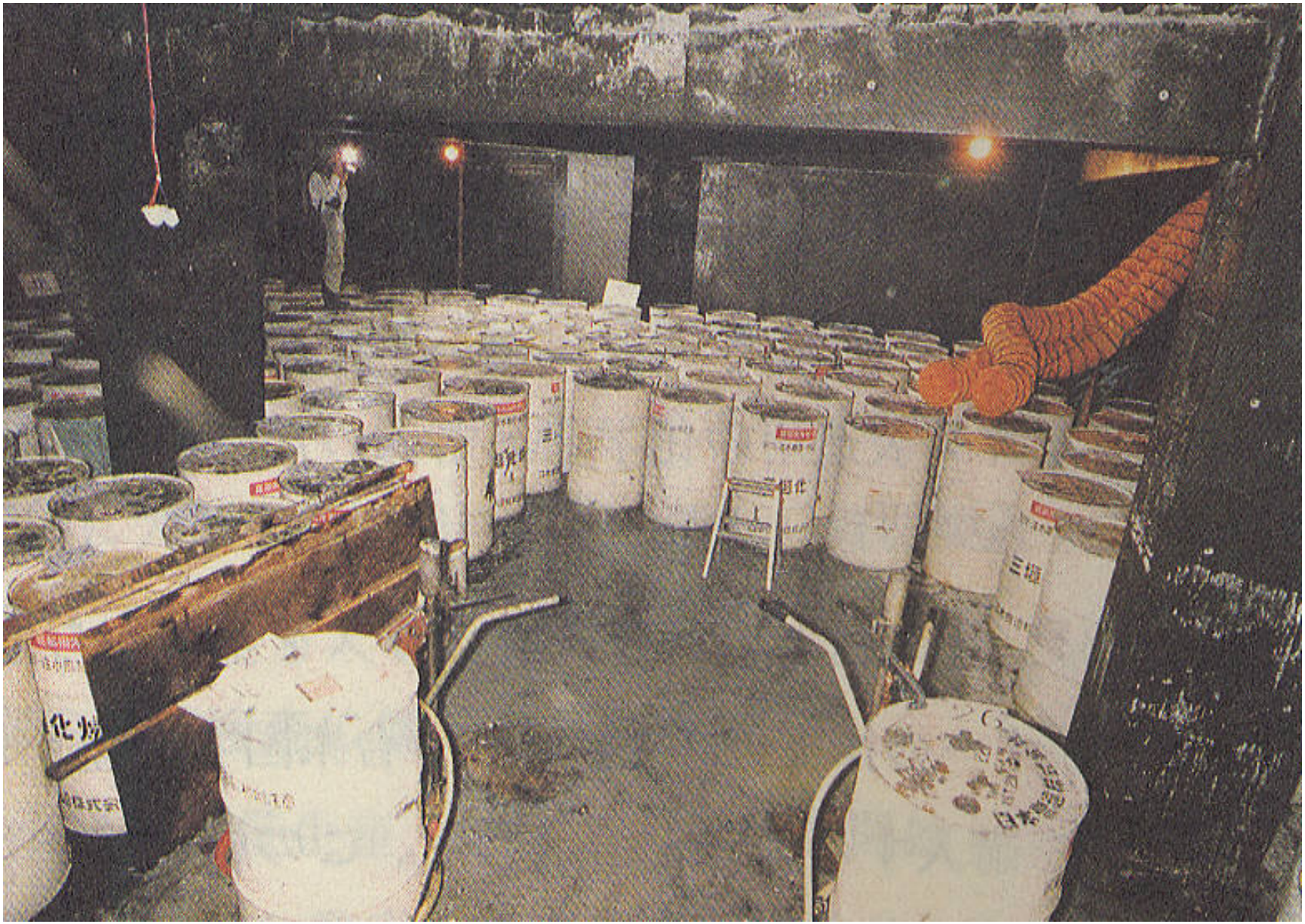
- 10 CW attacks (1990-95)
- Produced: HCN, phosgene, sulfur mustard, sarin, tabun, soman & VX

Some confiscated quantities

- 30 kg Sarin
  - Matsumoto July 1994, 7 fatalities
    - industrial sprayer w/commercial heater on truck
  - Tokyo subway March 1995, 12 fatalities
    - garbage bags, newspapers and sharpened umbrella
- 8.5 kg NaCN
  - Japanese train & subway stations May & July 1995
    - 2 plastic bags filled with NaCN & H_2SO_4, detonator
- "small amounts" VX
  - Tokyo & Osaka - 4 targeted attempts
    - spraying from a hypodermic syringe

Aum Facilities

Aum Starting Materials



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