Radioactivity in the Environment

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NNMCAB

Radioactivity and Radiation

- **Radioactive material: atoms**
- **Radiation: transfer of energy**
- **Radiation dose: deposition of energy**

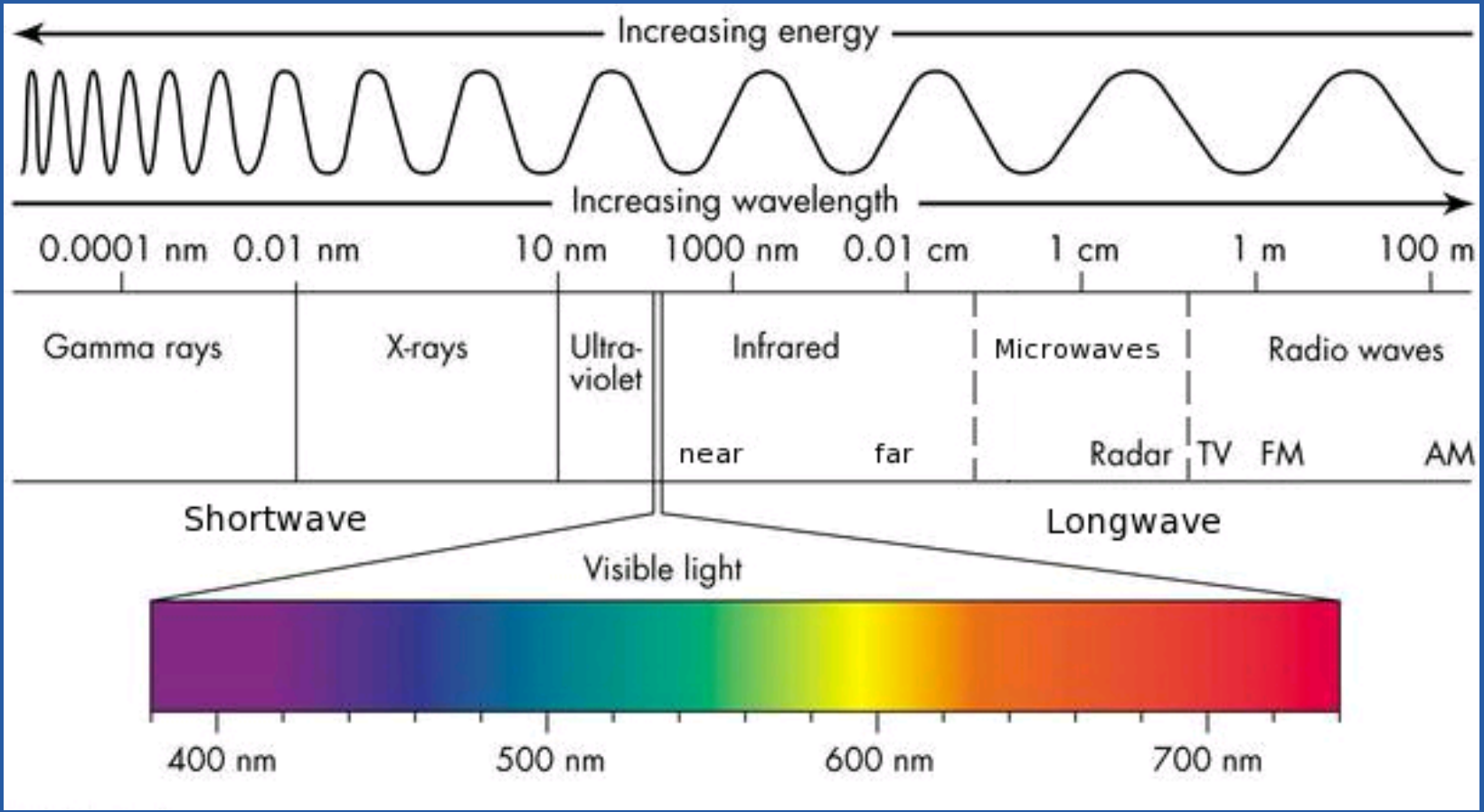
- **Different concepts, different units**

What is a radioactive atom?

- **Every atom has a nucleus.**

- **“Nuclide” means “type of nucleus.”**
  - For example, “plutonium-239” is a nuclide.
- **Some nuclides are unstable.**
- **They emit energy to become stable.**
  - Unstable atoms are called "radioactive".
  - The emissions are called “radiation”.

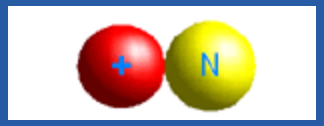
What is radiation?

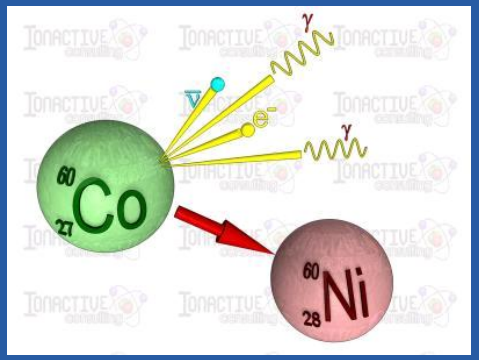


What is radiation?

- Alpha particles 

- Beta particles 

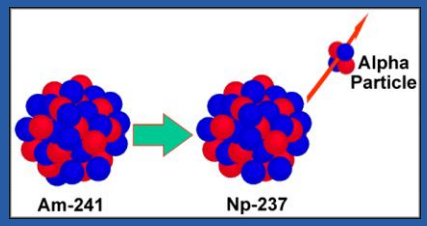
- Neutrons 

- Ultraviolet rays
- X rays
- Gamma rays 

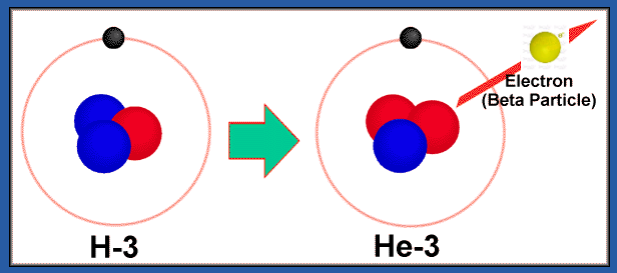
What is ionizing radiation?

Produced by Radioactive Decay

- Alpha particles

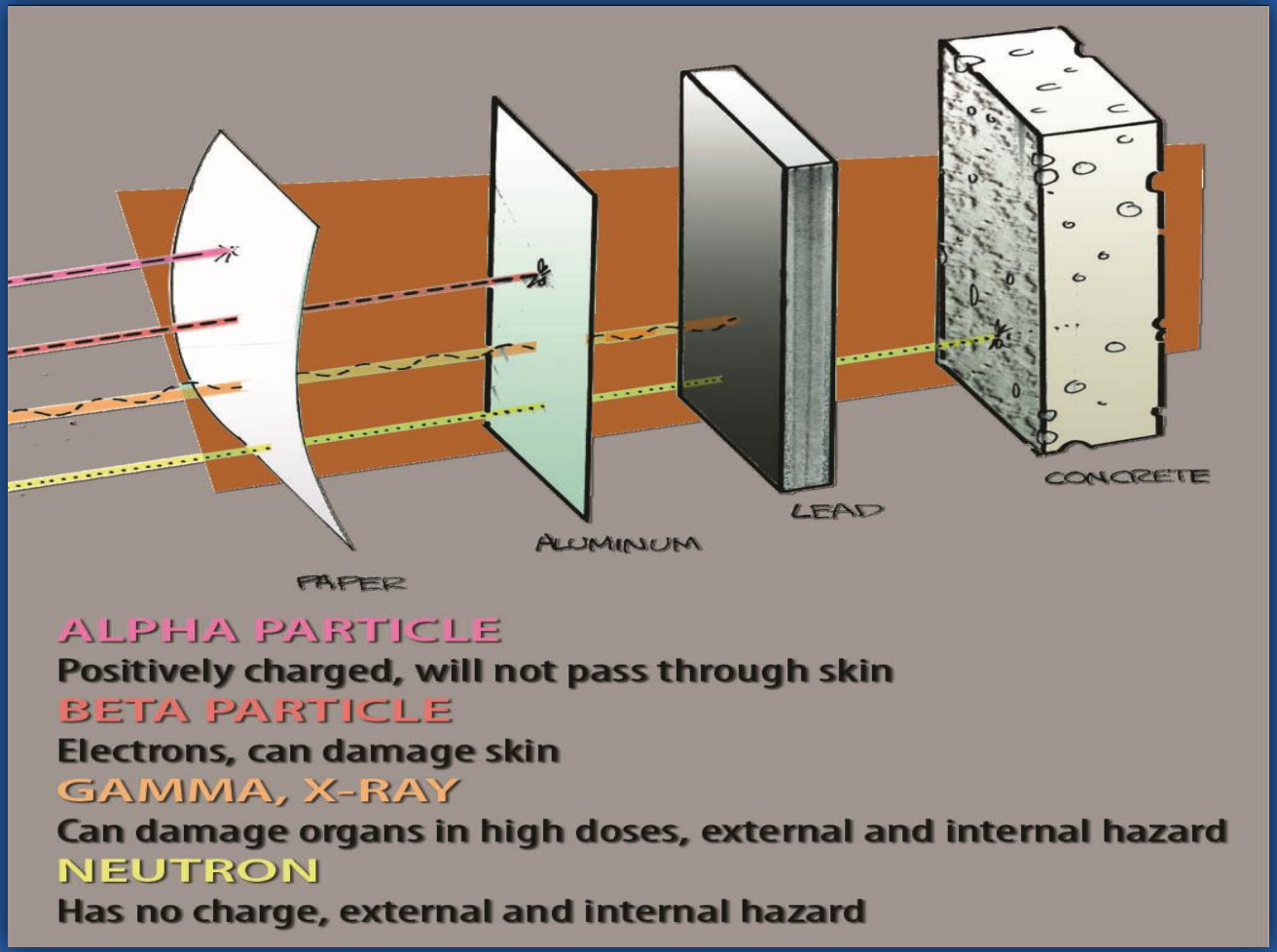


- Beta particles



- Gamma rays
  - Accompany alphas and betas

Radiation & Dose



Radiation Dose

- **“Dose” is the measure of the health effect of radiation.**
- **“rem” is a measure of “effective” or “equivalent” dose.**
- **Loose explanation of “REM” (not historical):**
  - R → “radiation” (historically “Roentgen”)
  - E →“effective” (historically “equivalent”)
  - M →“mammal” (historically “man”!)
- **Effective or equivalent dose is affected by**
  - Type of radiation
  - Internal or external
  - Properties of the radioactive material

ABC of Radioactive atoms

	Units	Description
atoms		Number of radioactive atoms
becquerels	Bq	International unit 1 Bq = 1 disintegration per second
curies	Ci	Historical unit 1 Ci = 37,000,000,000 Bq

Units that measure atoms begin with B or C.

R is for Radiation; S is too

	Units	Description
Radiation	R	Historical
Equivalent or effective	rem	U.S.A.
Equivalent or effective	sievert, Sv	International 1 Sv= 100 rem

Units that measure radiation dose begin with R or S.

Radioactive atoms and Radiation

Atoms and material: amount of burning wood.

Radiation and dose: amount of heat and energy

Examples

1 rem = 1000 mrem

Example	Radiation Dose
Natural Background	100 - 1000 mrem/year
Global Fallout	1 mrem/year
Trans-continental flight	1 - 4 mrem
Chest x-ray	5 mrem
Medical (average)	300 mrem/year

Radiation Dose Limits

- **National and international standards and regulations limit the radiation dose received by workers and the public.**

Annual dose limits	
Public and general workers	100 mrem (in addition to background radiation dose)
Radiological workers	1,000 mrem, average (in addition to background radiation dose)
Radiological workers	5,000 mrem maximum (in addition to background radiation dose)
Life saving in emergency	25,000 mrem

Time and rate

- Speed: rate is different from distance.
- (50 miles/hour)(4 hours) = 200 miles

- Dose: rate is different from dose.
- (50 mrem/hour)(4 hours) = 200 mrem

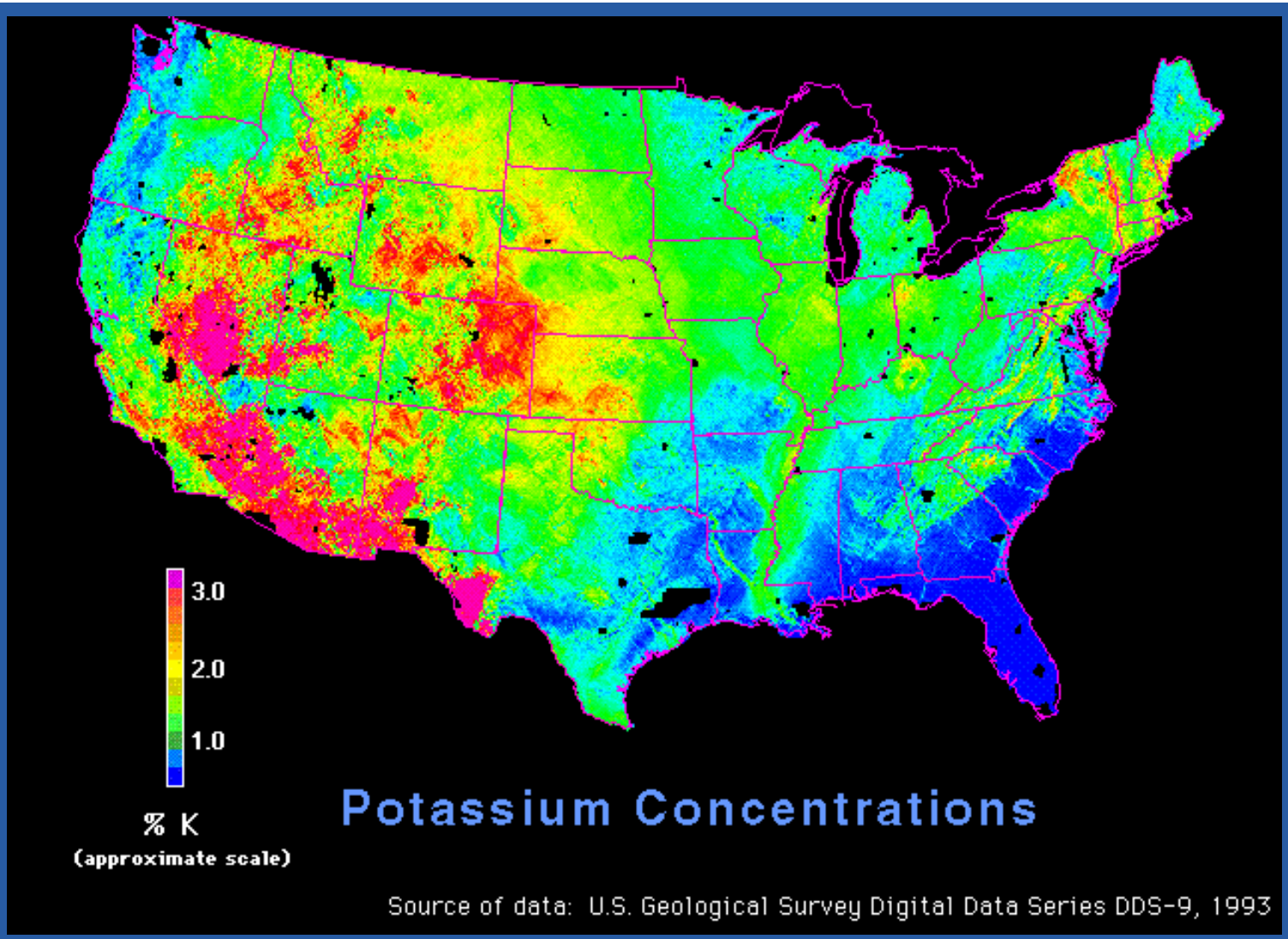
Categories of radioactive material

- Natural radioactivity
  - Radon, potassium-40, uranium, thorium
- Global fallout
  - Cesium-137, strontium-90, plutonium, americium
- LANL radioactive materials
  - Tritium, plutonium, americium, depleted uranium, cesium-137, strontium-90, cobalt-60

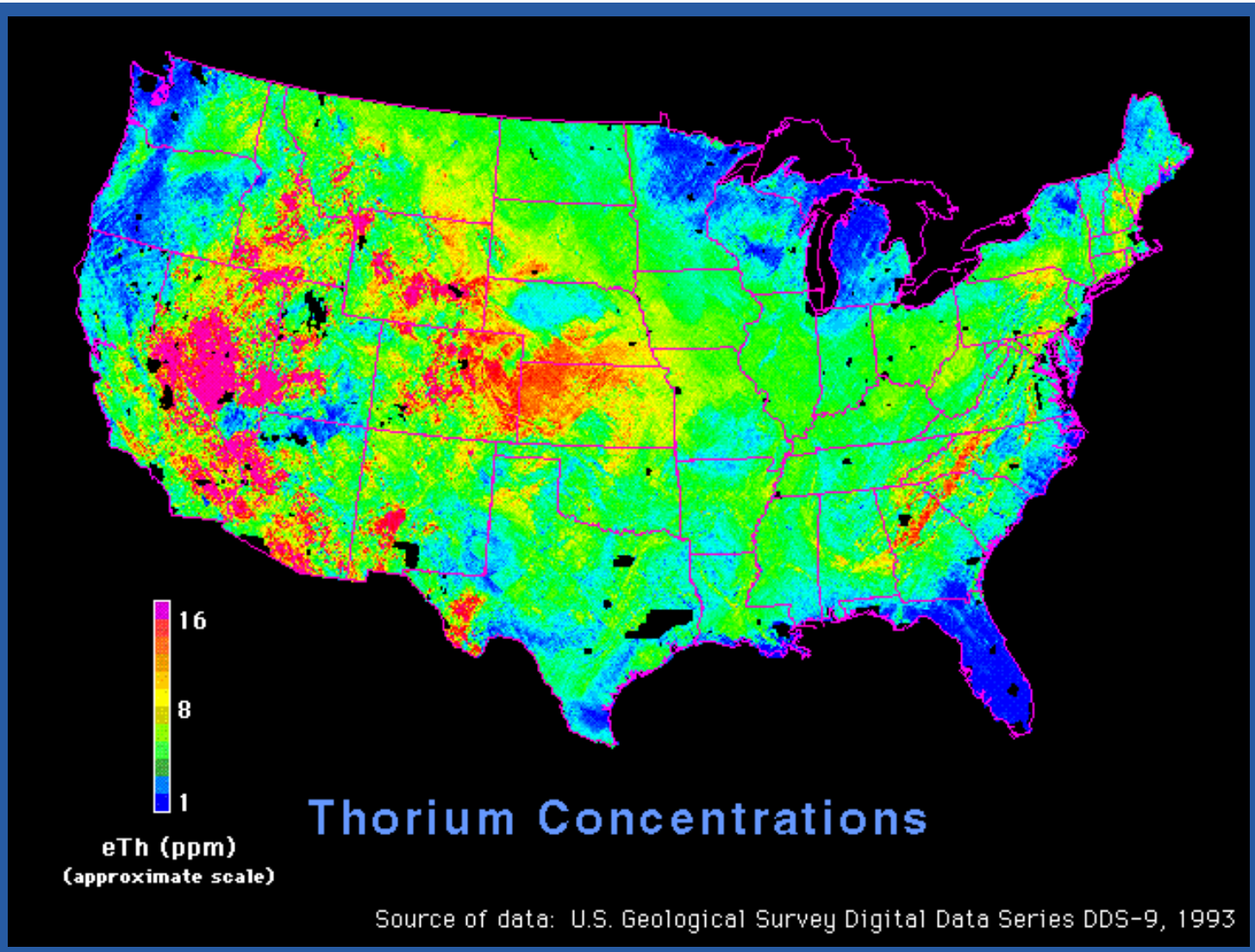
Variability

- The concentrations of natural radioactivity vary by more than a factor of 10.
- High background locations
  - Ramsar, Iran
  - Kerala, India
  - Yangjiang, China
  - others

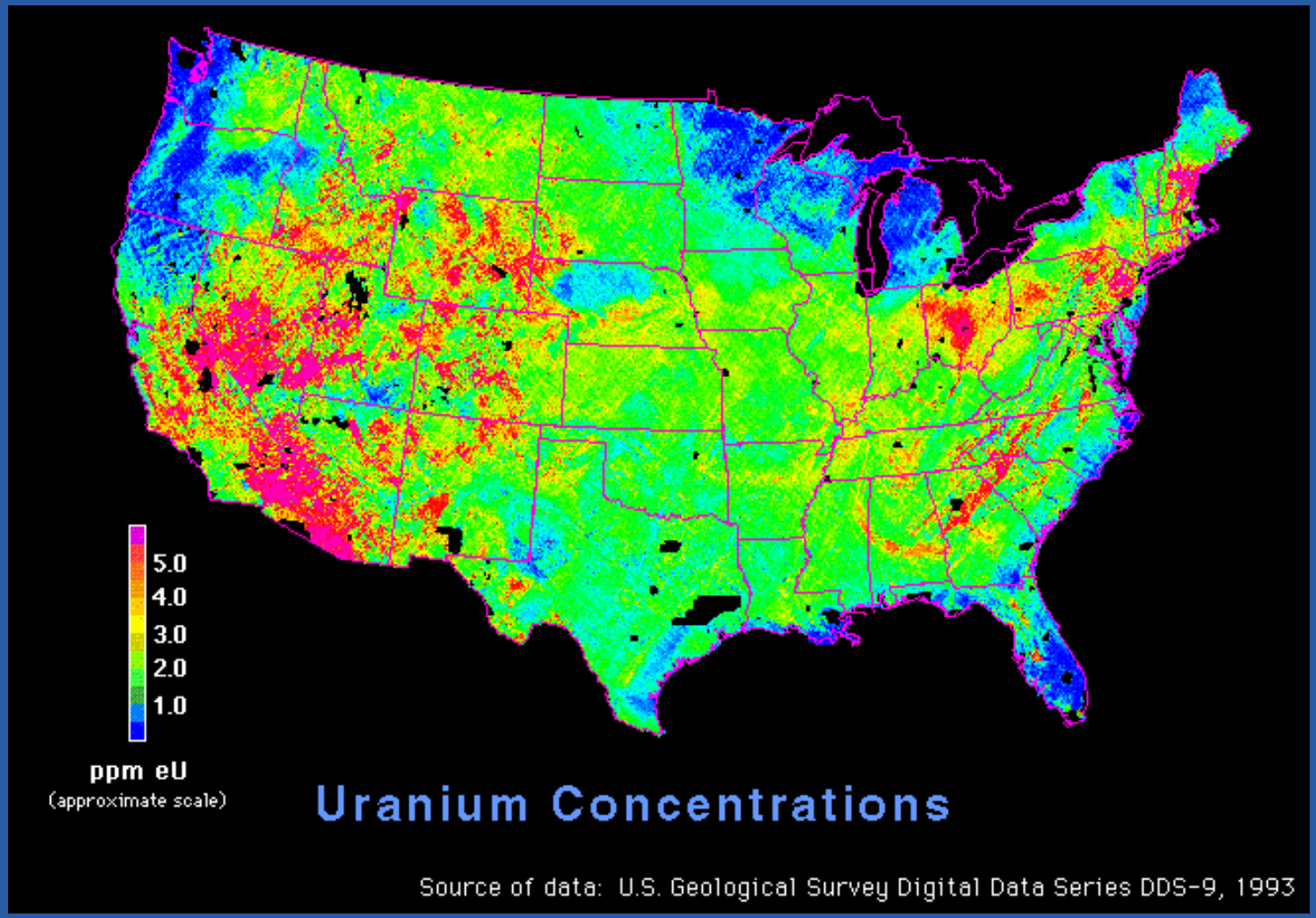
Potassium-40 in soils: large variations



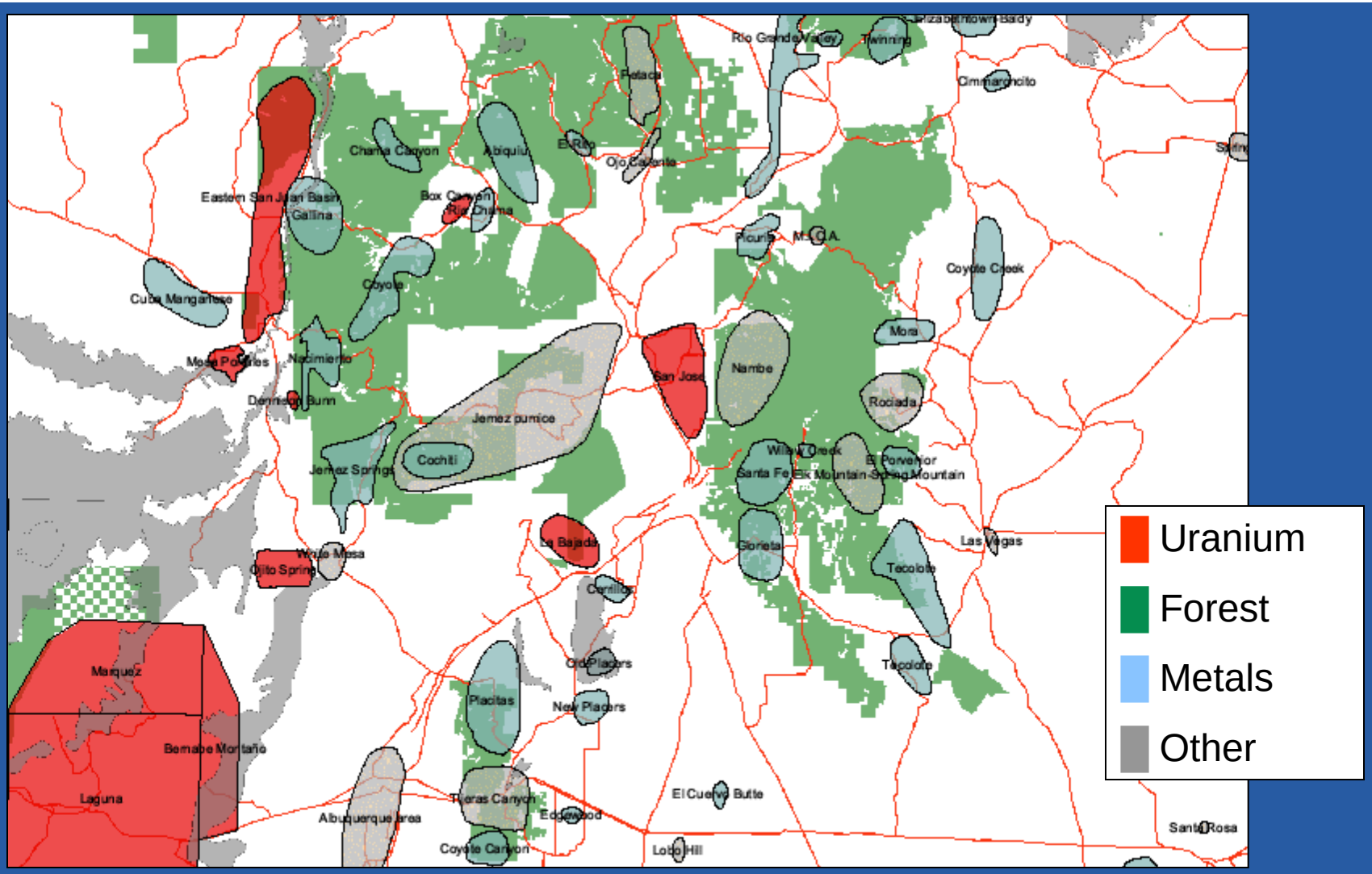
Thorium in soils: large variations



Uranium in soils: large variations



NM Mining Districts



Aerial Gamma Survey of LANL

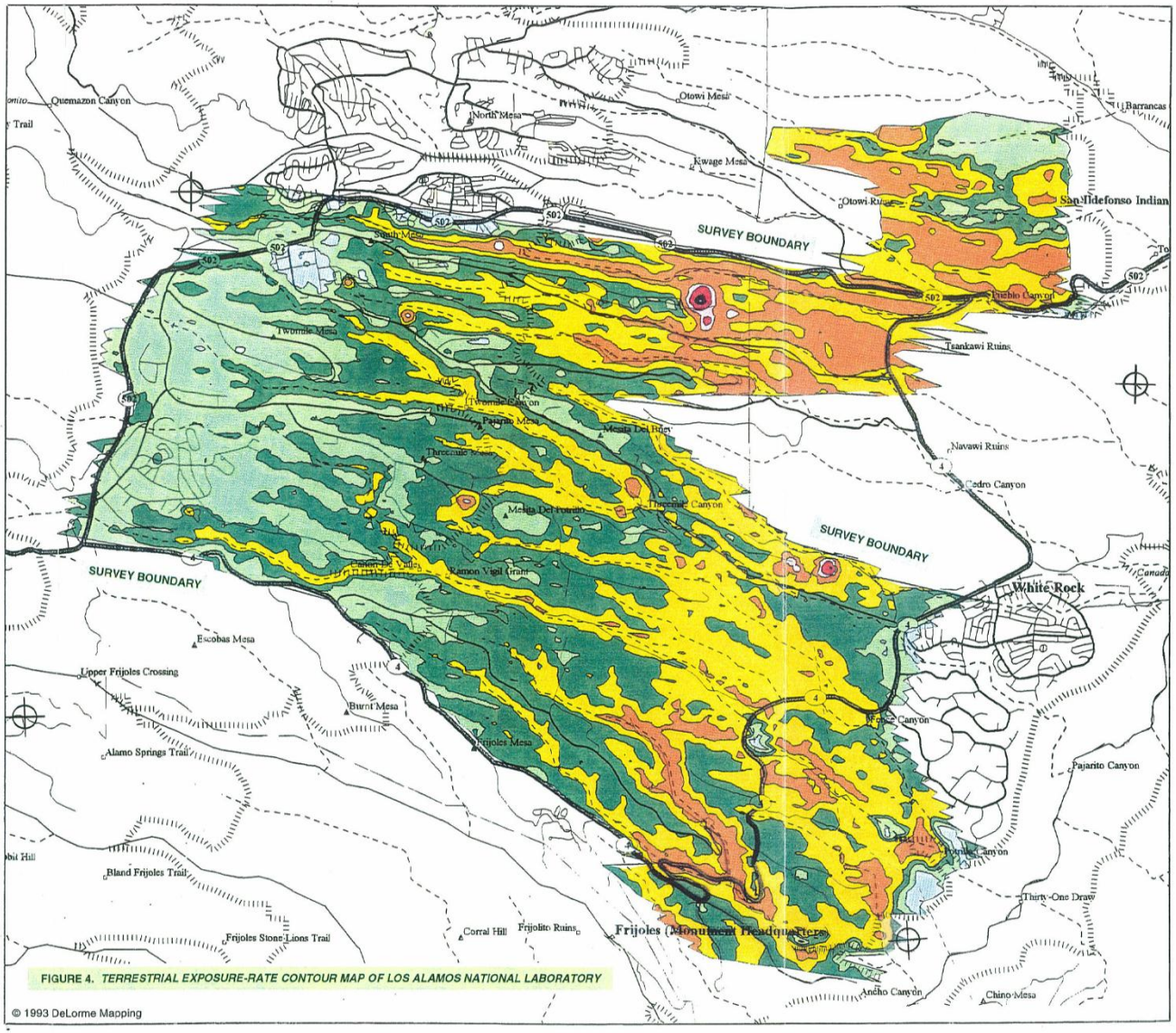
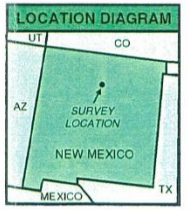


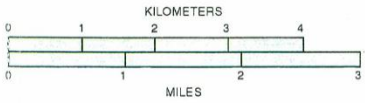
FIGURE 4. *TERRESTRIAL EXPOSURE-RATE CONTOUR MAP OF LOS ALAMOS NATIONAL LABORATORY*

CONVERSION SCALE		
Color	Terrestrial Gamma Count Rate (cps)	Terrestrial Exposure Rate at One Meter AGL[a] (μR/h)
	5,580 – 7,440	6 – 8
	7,440 – 9,300	8 – 10
	9,300 – 11,160	10 – 12
	11,160 – 13,950	12 – 15
	13,950 – 23,250	15 – 25
	23,250 – 46,500	25 – 50
	46,500 – 232,500	50 – 100
	232,500 – 465,000	100 – 500

[a] The exposure rate is inferred from gamma count-rate data measured at 61 m (200 ft) above the ground. Only the gamma fraction originating in or on the ground is presented here. The cosmic fraction, about 7.5 μR/h, and the airborne radon fraction, from 0 to 0.5 μR/h, are not included.

Date of Survey: April--May 1994

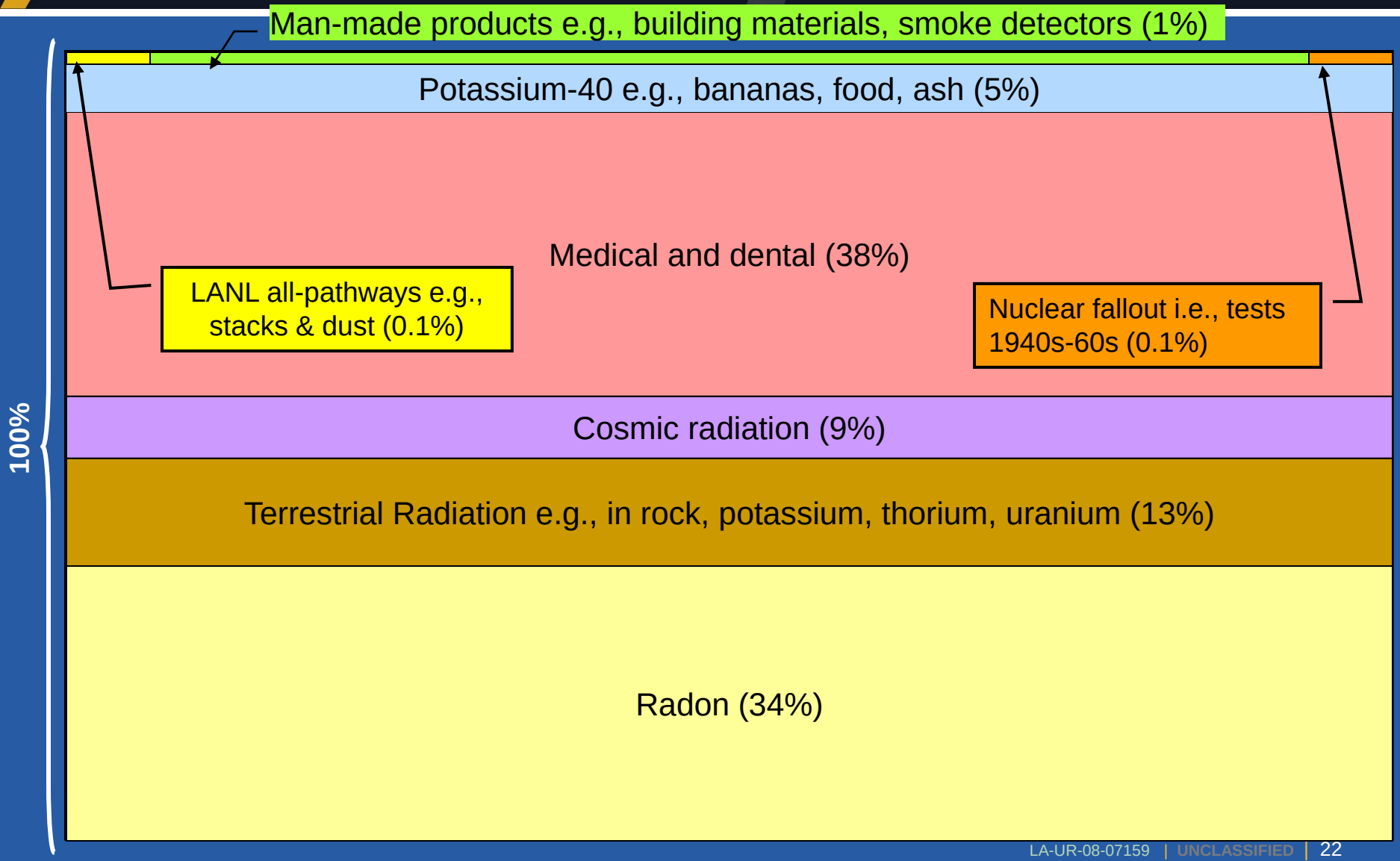




Road and Place Map From DeLorme XMap® Professional

2010 Sources of Airborne Radiation Exposure Around LANL

Background radiation ~ 792 mrem/year: Additional from LANL ~ 0.1 mrem/year



Conclusions

- Radioactive material is different from radiation.
- It is not easy to assess the effects of radioactive material (Atoms, Bq, Ci).
- Radiation is measured in rem and Sv;
- rem and Sv measure the health effects.

- This course comes with a lifetime guarantee.
- To know you don't know is wise – Lao Zi.