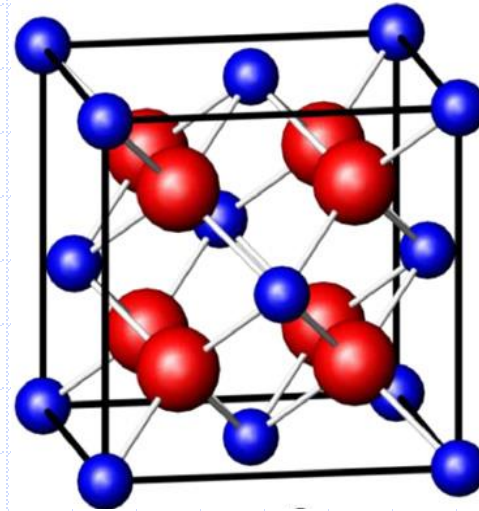


*Zircon and Zirconia
under the
U.S. System of TENORM
Regulation*



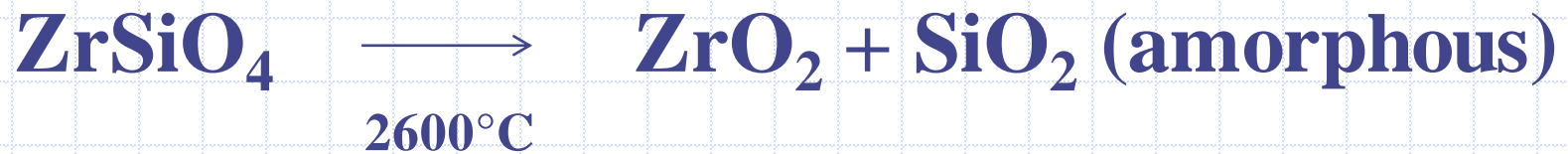
Charles T Simmons

Zircon and Zirconia

Zircon : Zirconium Silicate (ZrSiO_4)

Zirconia : Zirconium Oxide (ZrO_2)

“Fused Zirconia:”



TENORM Defined

CRCPD Part N (2004):

"Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)" means **naturally occurring radioactive material** whose **radionuclide concentrations are increased by or as a result of past or present human practices**. TENORM does not include background radiation or the natural radioactivity of rocks or soils. **TENORM does not include "source material" and "byproduct material"** as both are defined in the Atomic Energy Act of 1954, as amended (AEA 42 USC §2011 *et seq.*) and relevant regulations implemented by the NRC.

Alternate TENORM Definition

"TENORM" means any naturally occurring radioactive materials whose radionuclide concentrations or potential for human exposure have been increased by any human activities.

N.J.A.C. 7:28-1.4

Atomic Energy Act “Source Material”

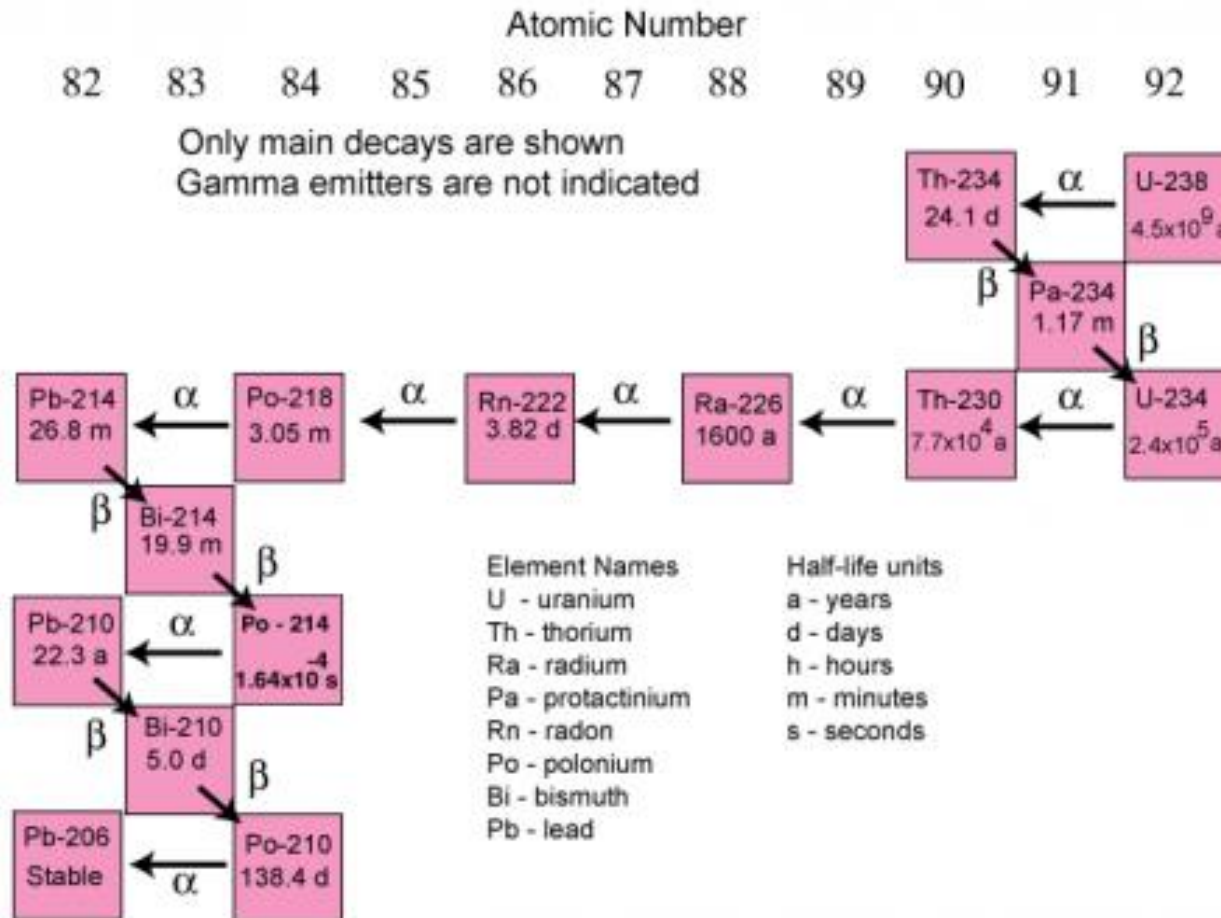
Uranium or Thorium, in any combination, in any physical or chemical form;

Ores, materials containing by weight 0.05% (500 ppm) or more Uranium or Thorium or any combination is **LICENSABLE** Source Material

- ◆ **BUT: Unimportant Quantity Source Material <500 ppm U+Th is EXEMPT from Licensing**
- ◆ **NOT Health-based number; technology based**
- ◆ **Pre-Empts Contrary State Regulations**

Consider U-238 Series in Zircon

The Uranium-238 Decay Chain



Significance of U, Th Inclusions in Zircon

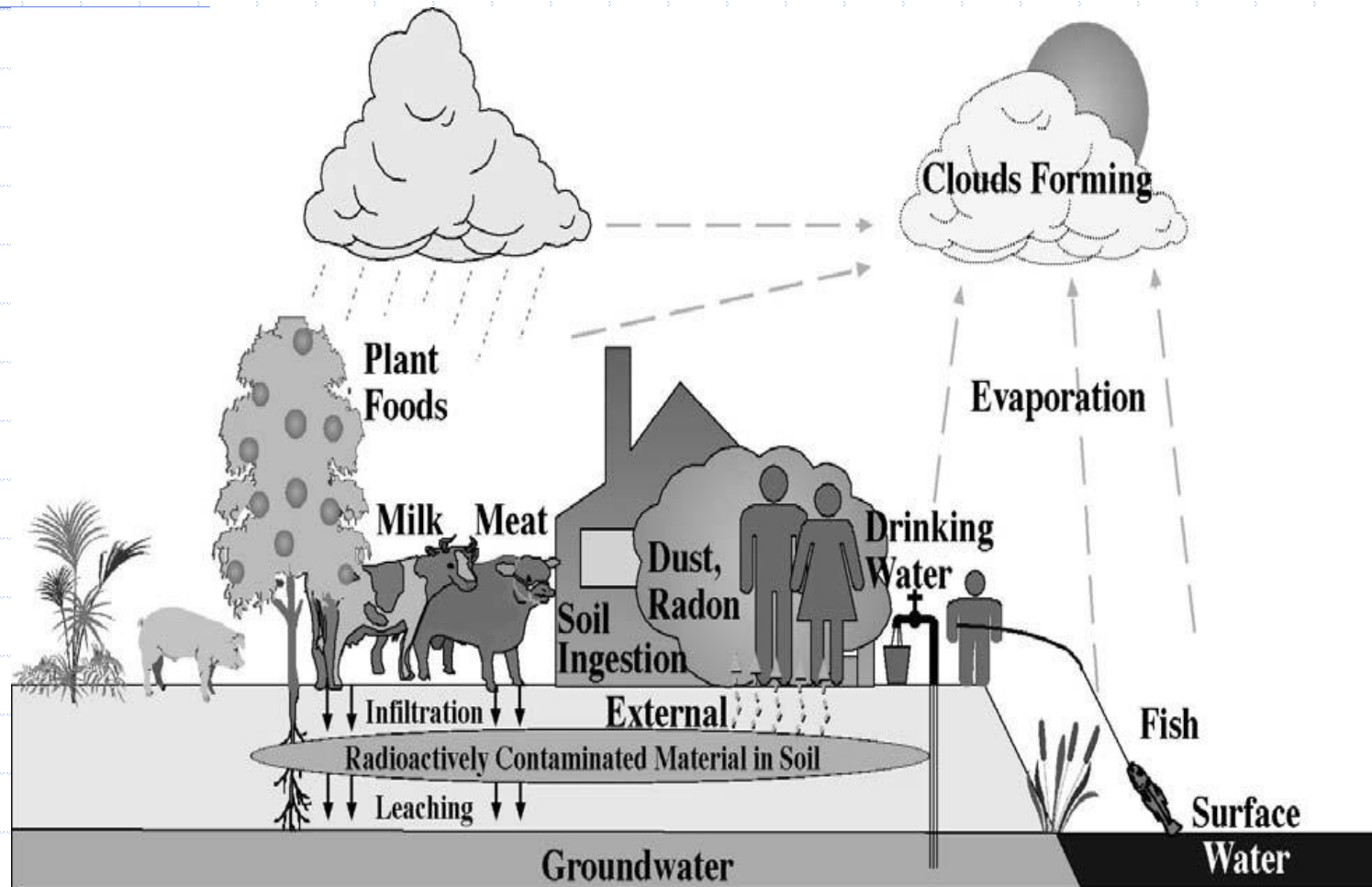
ALL decay chain elements exist within the zircon crystal lattice – a condition known as “SECULAR EQUILIBRIUM”

Importance: Transport Exemption of U, Th *parent*

Environmental Mobility of radionuclides is *de minimis*

- **Low Radon emanation**
- **No Leaching of radioactivity into water / groundwater**
- **Not Bioavailable? No data.**
- **Zircon as U-Th-Pb Geochronometer: world's oldest rock**

Reduced Environmental Mobility = Reduced Exposure



Note on Fused Zirconia

Some Dis-Equilibrium of U, Th decay chains apparent, because:

- **Pb-214 b.p. = 1755 °C**
- **Bi-214 b.p. = 1560 °C**
- **Po-210 b.p. = 962 °C**
- **Electric Arc Furnace T > 2600 °C**

Expectations: downchain disequilibrium;

Po-210 presence in EAF dust;

***Some* radionuclides in amorphous SiO₂**

Problems with γ -spectroscopy analysis (U, Th underestimates)

TENORM Regulatory Interaction Waste Disposal

- **Increased Landfill Radiation Monitoring**
- **Rejection of “traditional” foundry (shell) wastes; spent refractory; crucibles, etc.**
- **Mandatory investigation by radiation authority**
- **TENORM Licensing; Disposal Restrictions**

Regulatory Issues

- **Regulations prohibiting landfill disposal of any radioactive waste aimed against hydraulic fracturing wastes but over-broad.**
- **Concentration-based TENORM standard (5 pCi/g or 0.185 Bq/g) Ra-226+Ra-228 developed for U mill tailings not applicable to zircon / zirconia**
- **Need for US system of radiation protection to update dosimetry models from ICRP-26, 30.**

Hazard Communication Issues

- **Civil Liability FAILURE TO WARN**
- **California Proposition 65 : ALL RADIONUCLIDES ARE PROP-65 LISTED**
- **OSHA Hazard Communication: Safety Data Sheet Disclosure or Not?**

Future of Unimportant Quantity S/M?

CURRENTLY: “No License” AEA § 62

FUTURE? AEA “source material” = “intentionally extracted” for use of U, Th

Requires legislative change to “Source Material” definition

Who regulates non-Nuclear U, Th?

Opens up other regulatory schemes: TSCA, RCRA, CWA

Notable Exemption

zirconia, zircon, ... are exempt from this chapter provided that the radioactive constituent is consistent with the radioactive levels stated in the material safety data sheet

O.A.C. 3701:1-43-07(D)

CRCPD Part N (2004) Exemption:

... zirconia, zircon, and products of zirconia and zircon containing TENORM are exempt from this Part.

... manufactures zirconia or zircon from ore is not exempt from this Part.

... chemically processes ... resulting in increased environmental mobility of TENORM is not exempt from this Part.

Part N Currently Under Revision!

Case History: New Jersey Foundry

- **Landfill monitor alarms at waste shell material**
- **Regulators arrive, take samples, measurements**
- **Zircon flour > 5 pCi/g total Ra; TENORM license!**
- **Request Dose-Based Exemption: < 1mSv/y**
- **Analytical: γ -, α -spectroscopy; personal air monitoring**
- **Workplace γ survey, including BACKGROUND**
- **Worker occupancy time study;**
- **TEDE for foundry and landfill workers << 1 mSv/y**
- **NO LICENSE REQUIRED**

Conclusions

“Source material” complicates U.S. TENORM regulation

Concentration-Based Standards (easy)

Dose -Based Standards (hard)

Both are DESIRABLE:

Concentration = Surrogate for Dose

Zircon and Zirconia ideal candidates for “generic dose modeling”