Cermet Waste Packages Using Depleted Uranium Dioxide and Steel

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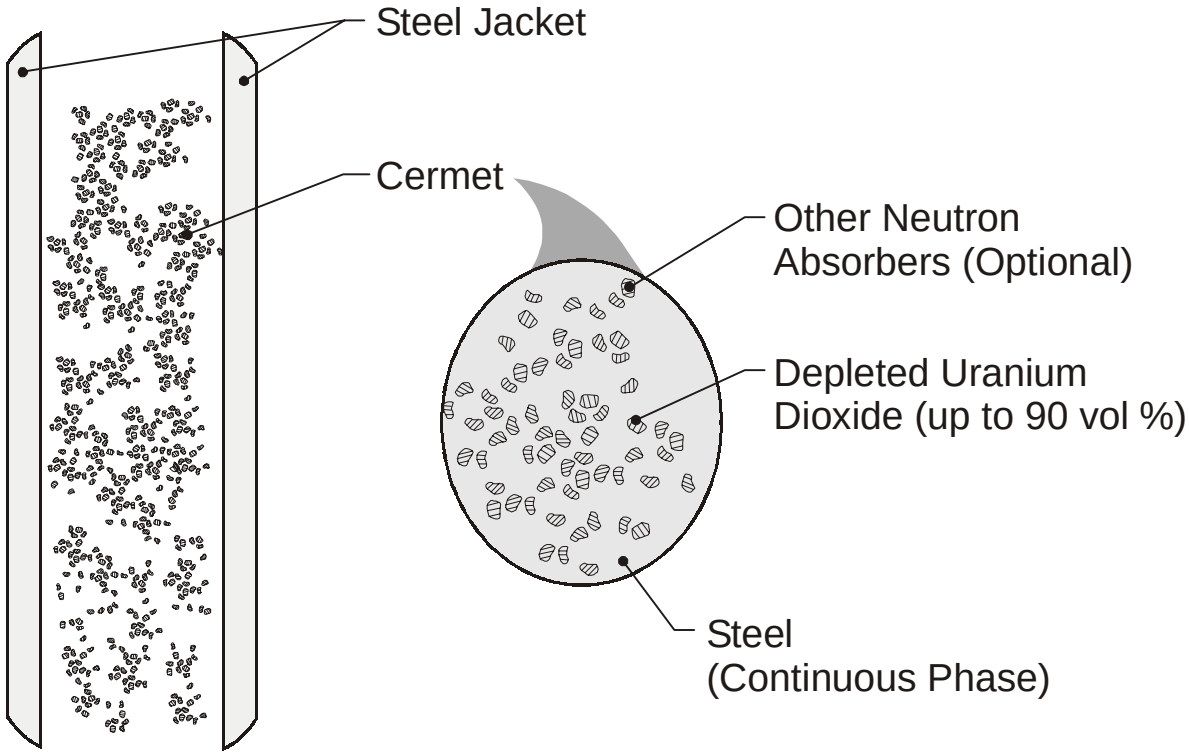
Outline

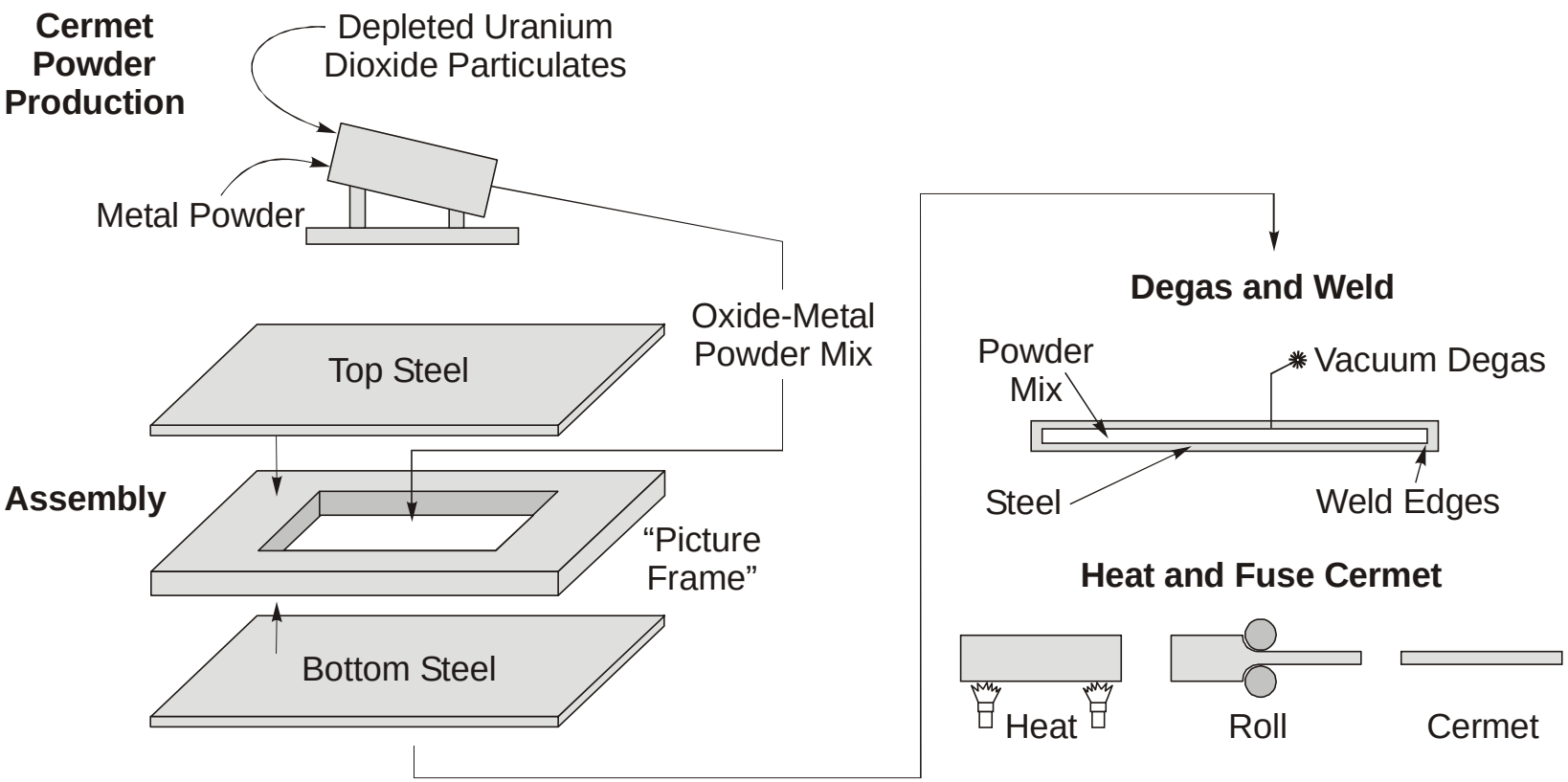
- **Characteristics of cermets**
- **Near-term waste package (WP) applications**
- **Long-term repository benefits**
- **Disposal of excess depleted uranium (DU)**
- **Conclusions**

Characteristics of Cermets

A CERMET Is a *CER*amic *MET*allic Composite
(The Designer Defines the Ratio of DUO_2 to Steel)

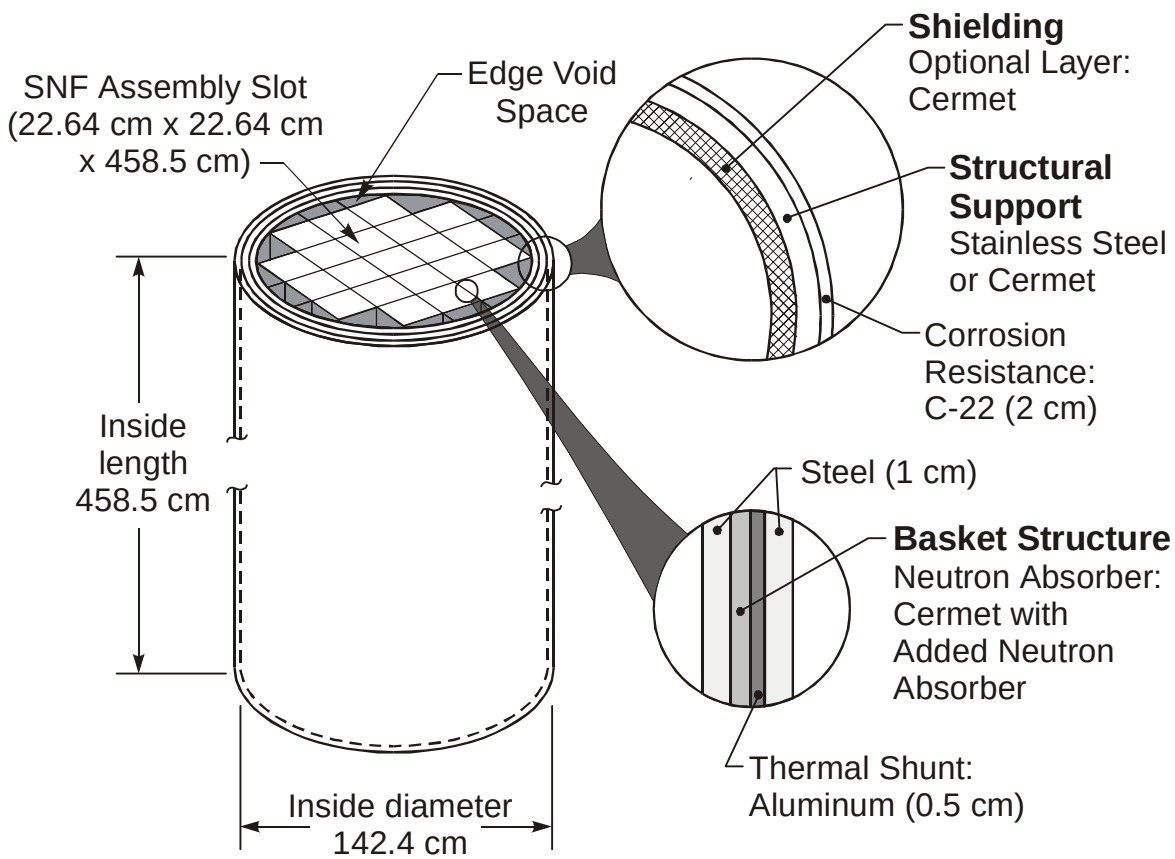


Example Method for Cermet Production



Near-Term WP Applications

Uses of Cermet in PWR SNF Waste Packages



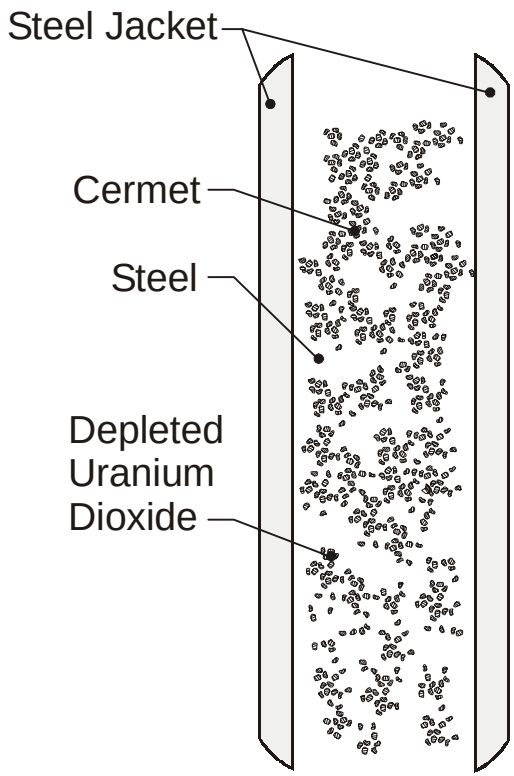
A DUO_2-Steel Cermet Is Compatible with WP Requirements

- **Chemical compatibility is ensured**
  - **The same steels can be used to make cermets**
  - **The DUO_2 is in the same chemical form as SNF UO_2**
- **A cermet changes DUO_2 properties**
  - **Adds mechanical strength and ductility**
  - **Provides clean (noncontaminated) surfaces**
- **Cermet properties can be varied**
  - **Oxide/metal ratio**
  - **Addition of other neutron absorbers**

Uranium Metal (the Other DU Form) May Not Be Suitable for Repository Use

- **Advisory letter from the U.S. Nuclear Regulatory Commission**
  - **Uranium oxides are acceptable for disposal**
  - **Raises questions about the acceptability of metal**
- **Metal chemical compatibility issues**
  - **Chemical oxidation with water forms hydrides that are chemically reactive (Hanford-N SNF)**
  - **Complicates long-term predictions of WP behavior (new chemistry)**
- **Higher costs (metal conversion step)**

Cermets Are Good Shielding Materials with Some Unique Capabilities



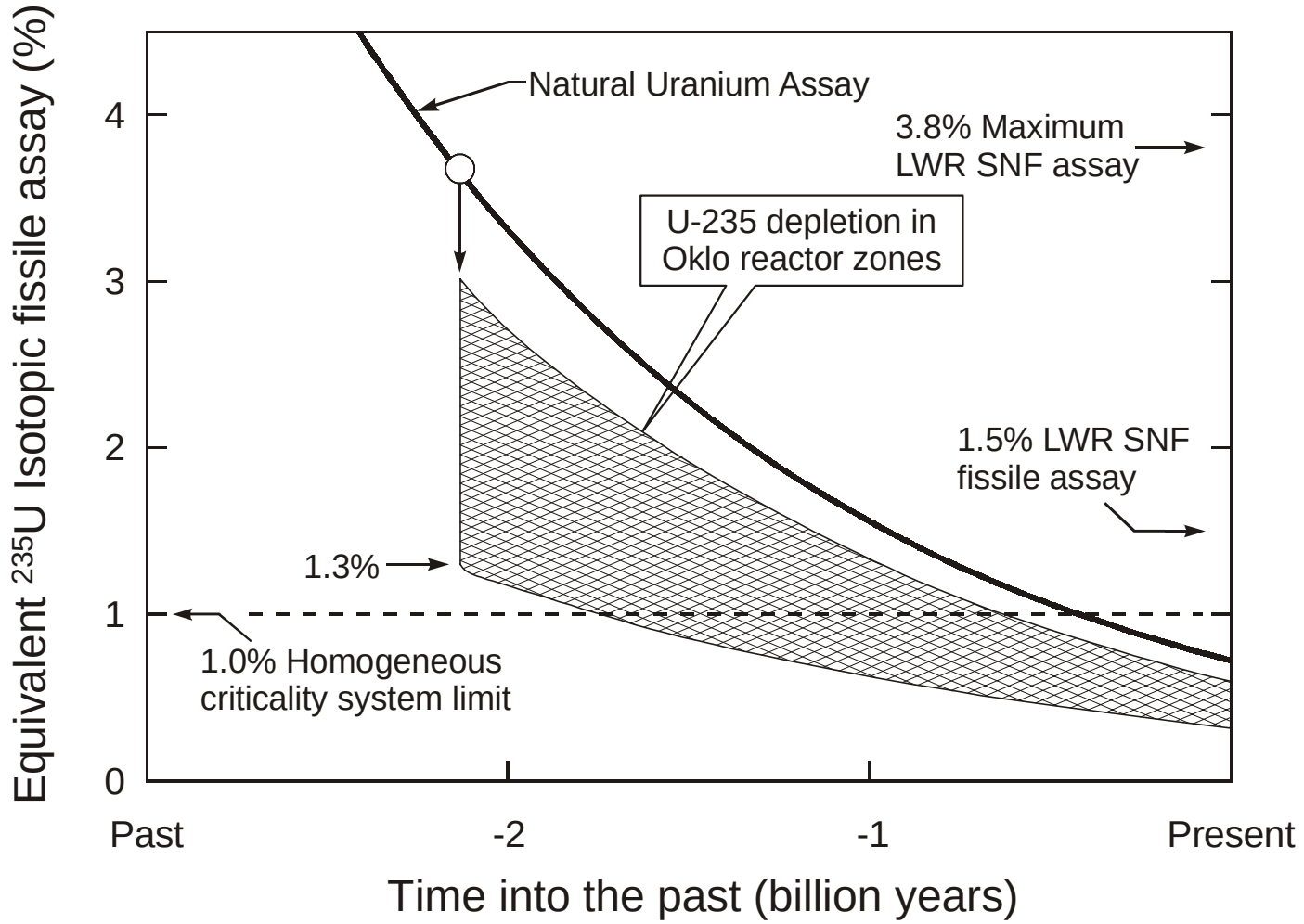
- Gamma Shielding Better Than Steel
  - Steel: 7.86 g/cm^3
  - DUO_2: 10.9 g/cm^3
- Neutron Shielding
  - High density oxygen (DUO_2) moderator
  - Other neutron absorbers can be added
- Good Physical Properties
  - High thermal conductivity
  - No organics (no fire, acceptable to repository)

Long-Term Repository Benefits

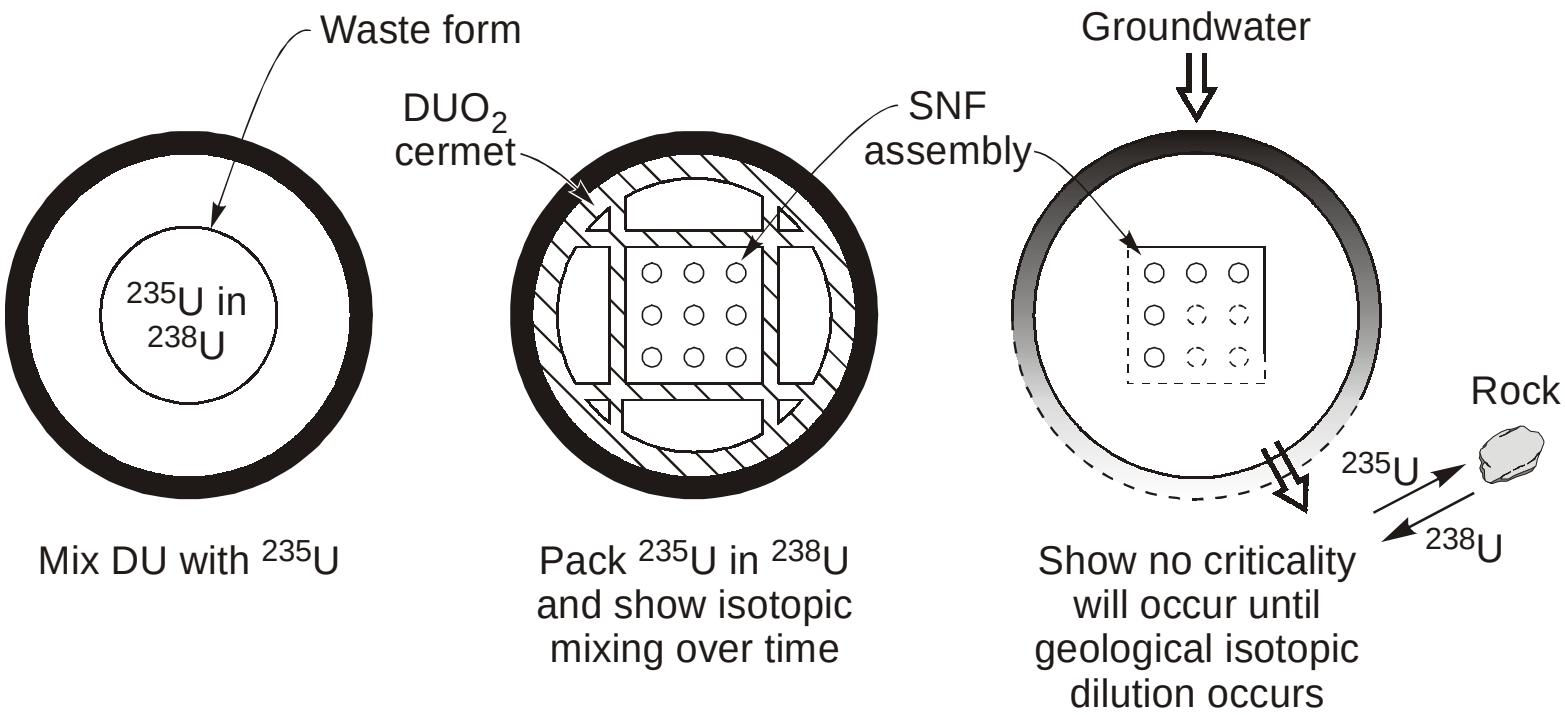
Nuclear criticality control

Reduced radionuclide release rates

Nature Has Created Nuclear Reactors when the Fissile Assay Exceeds 1.3 wt % ^{235}U Equivalent

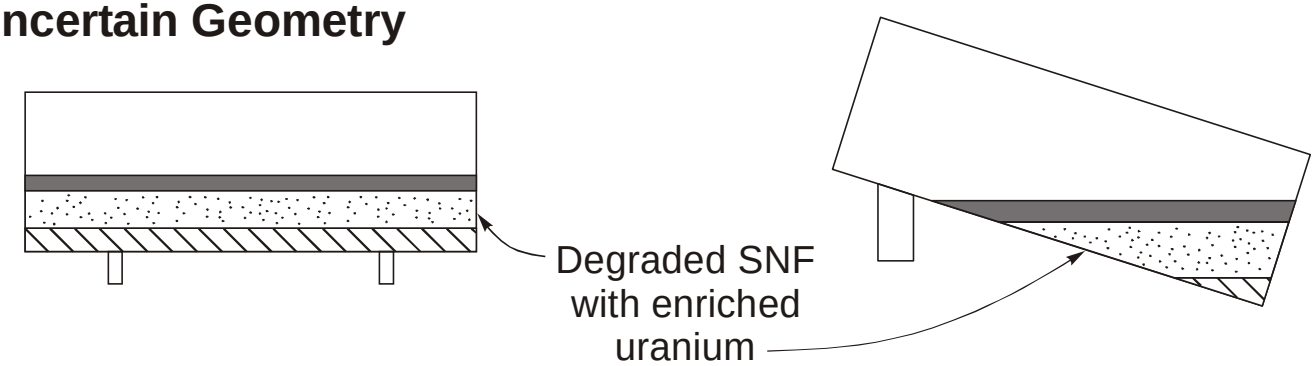


Three Strategies To Show That Repository Criticality Will Not Occur

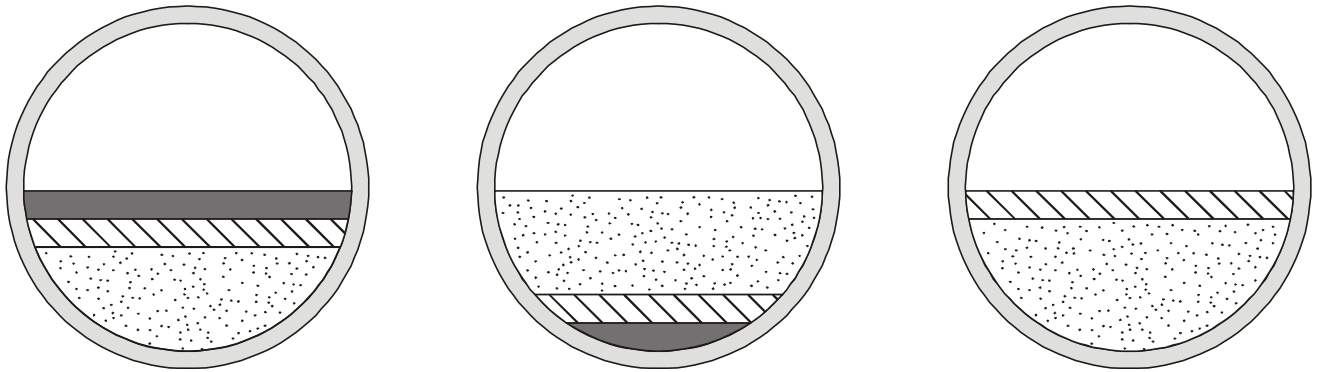


The Potential for Criticality in a Degraded Waste Package Is Difficult To Estimate

Uncertain Geometry

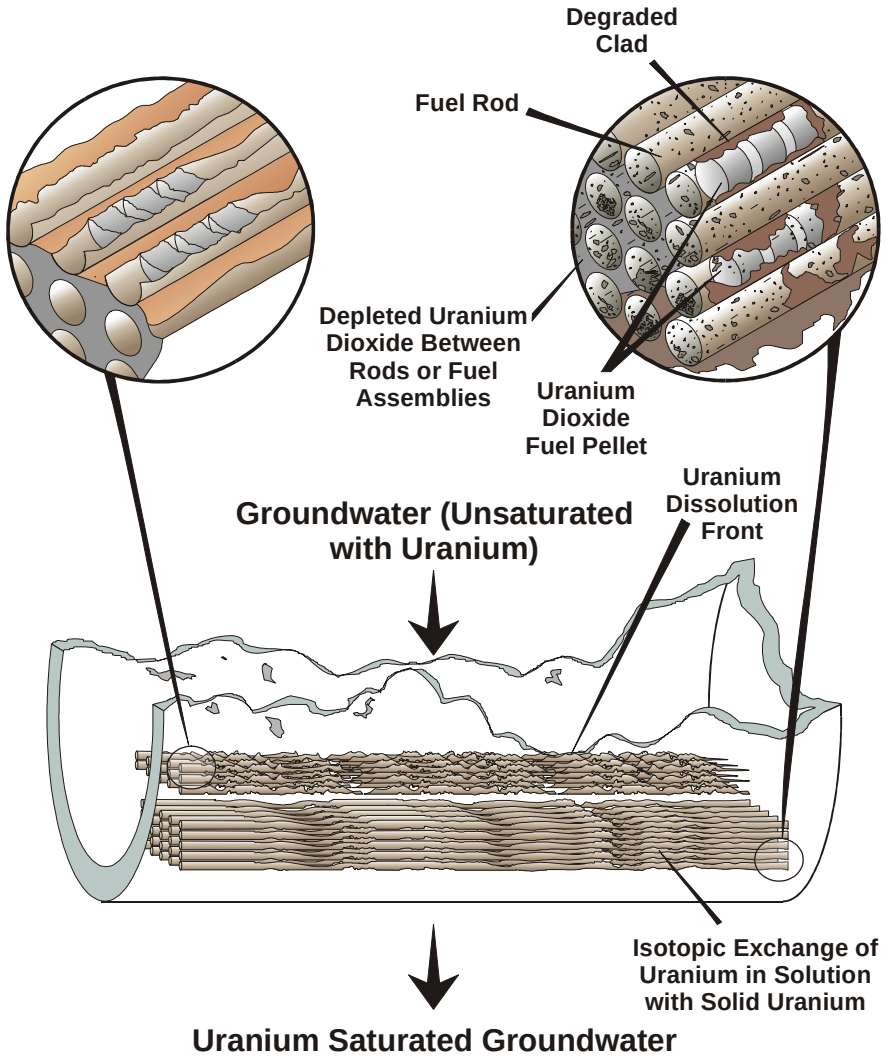


Uncertain Composition



Density separation | Particle size separation | Solubility (leaching) separation

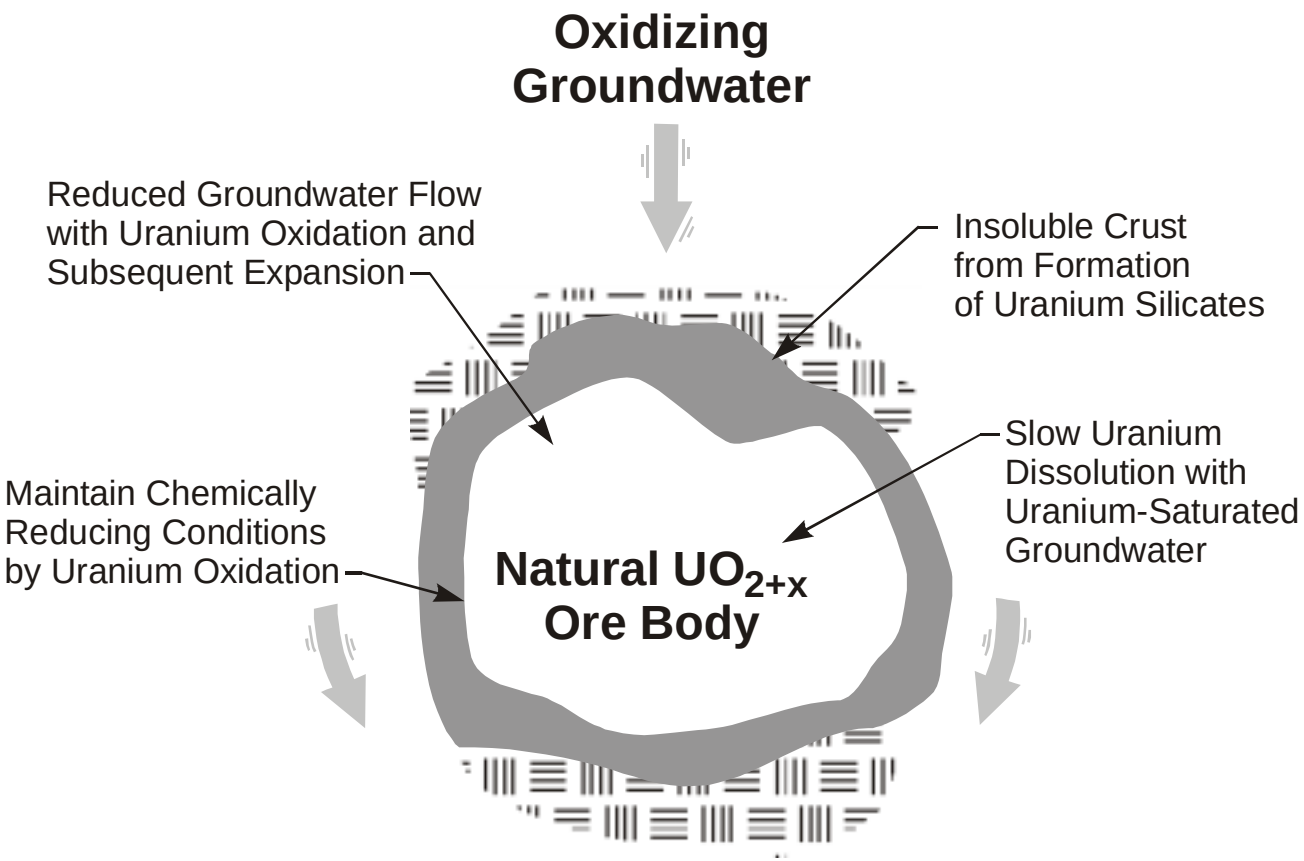
Isotopic Dilution of SNF Uranium (Including Decayed ^{239}Pu) with DU Occurs with SNF Degradation



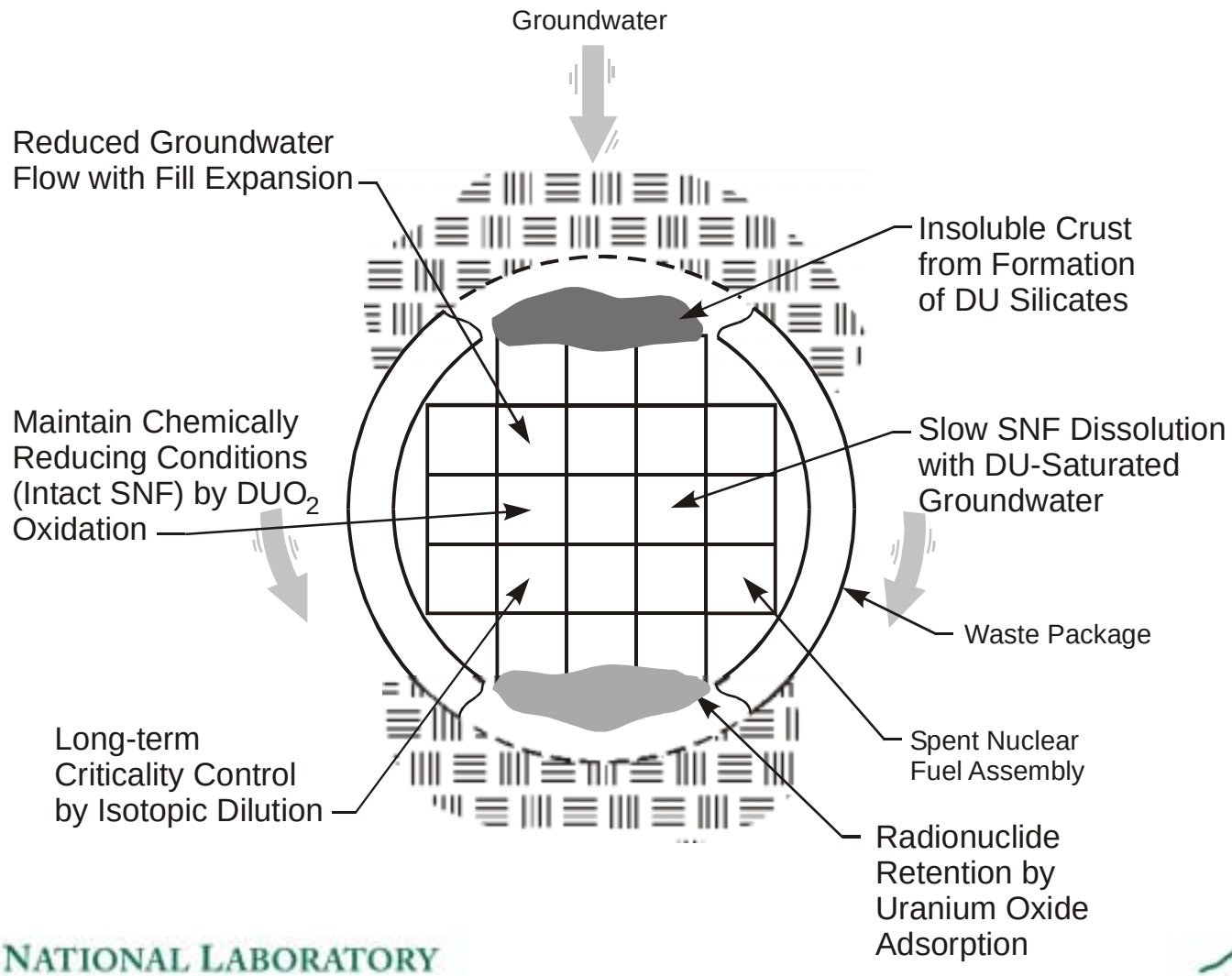
Long-Term Repository Benefits

Reduced radionuclide releases

The Interiors of Natural Uranium Ore Deposits Are Preserved for Extended Times by Degradation of Uranium Oxides on the Outside Surfaces of the Deposits



WP with DUO_2 Can Use the Same Mechanisms To Help Preserve SNF



Disposal of Excess DU

Cermet WPs Could Consume Half or More of the 500,000 Tons of Excess DU

Conclusions

- **DUO_2-steel cermets can potentially replace structural, shielding, and basket components of WPs to meet operational requirements**
- **There are multiple potential long-term advantages**
  - **Long-term criticality control**
  - **Reduced radionuclide releases from WPs**
  - **Disposal of excess DU**
- **Further examination of cermets in WPs is warranted**