Episodic Radionuclide Release and Transport at the Repository Analog Site at Peña Blanca

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Natural Analog Support for Geochemical Modeling

- Identification of Conceptual Model Components
- Data on Time and Space Scales Inaccessible to Experimental Study
- Natural Geochemical Systems for Model Testing

Comparisons of the

Potential Yucca Mountain Repository and the Nopal I Deposit at Peña Blanca

Fractured Silicic Volcanic Host Rocks
Semi-Arid Climate
Deep Water Table
Oxidizing Geochemistry
Long-Term Geochemical Processes

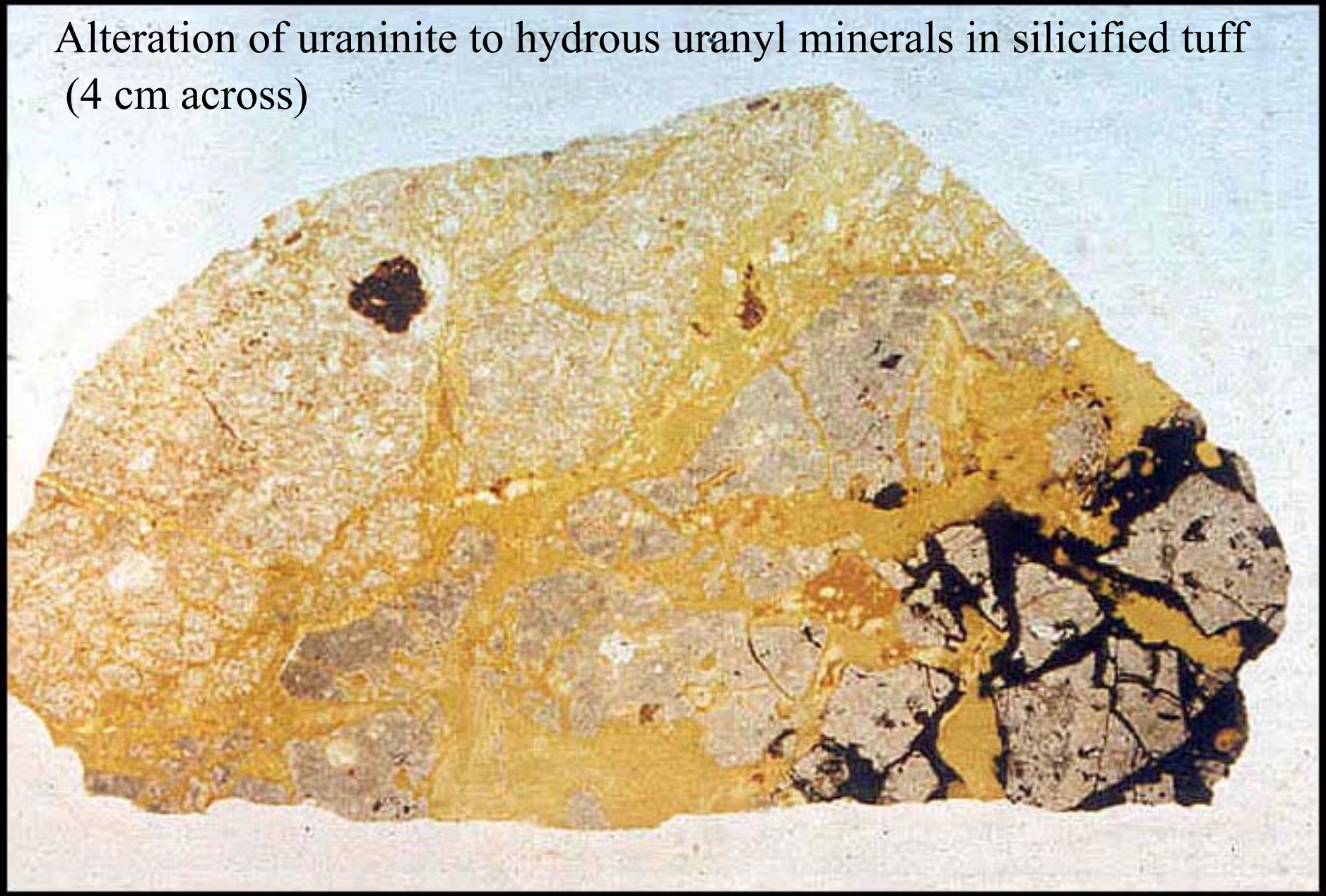
Spent Nuclear Fuel	→	Primary Uraninite
Engineered Barriers	→	Sulfides, Silicification
Thermal Pulse	→	Hydrothermal History
300 m Below Surface	→	Ground Surface Effects

Nopal I Deposit
Location Map
Nevada
Utah
California
Arizona
N. Mexico
Texas
Yucca Mountain
Nopal I
Study Area
San Antonio
Chihuahua
Mexico
Mexico City
N
0
250
500
Kilometers
TERTIARY VOLCANIC ROCKS

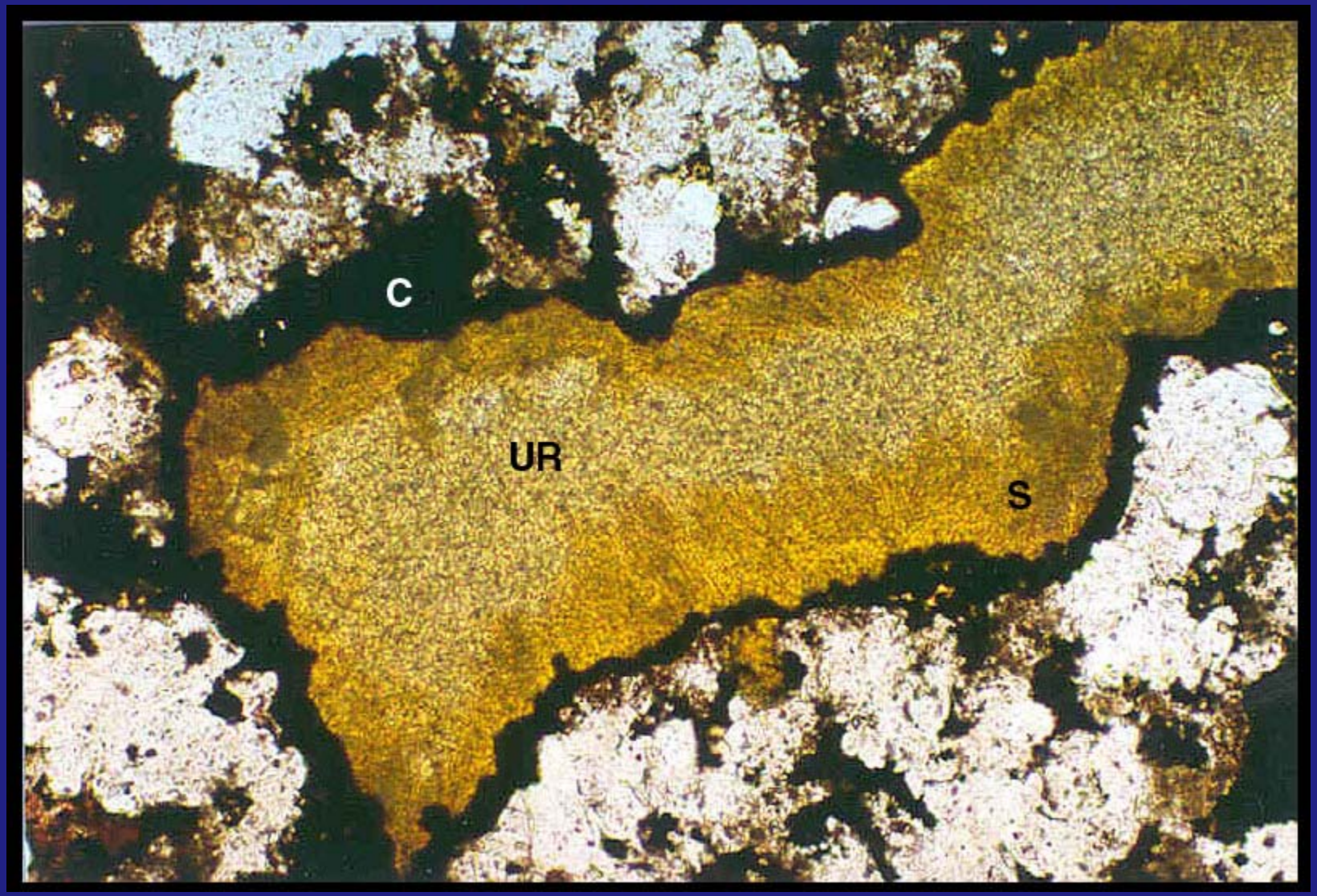
Nopal I Excavations at Peña Blanca

Nopal I Level +00 Adit

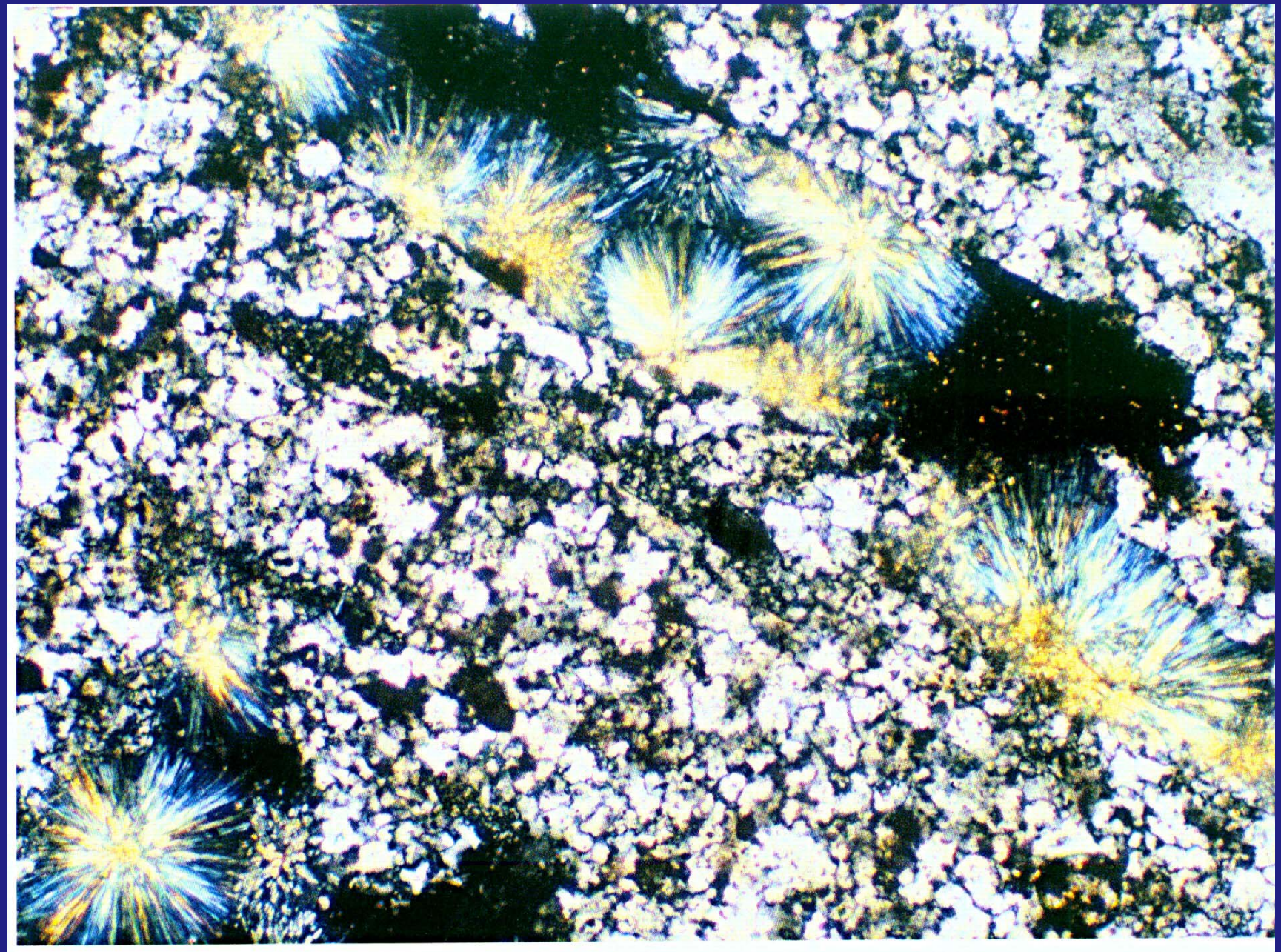
Alteration of uraninite to hydrous uranyl minerals in silicified tuff (4 cm across)



Colloform uraninite (C) succeeded by schoepite (S) and uranophane (UR) (0.8 mm across)



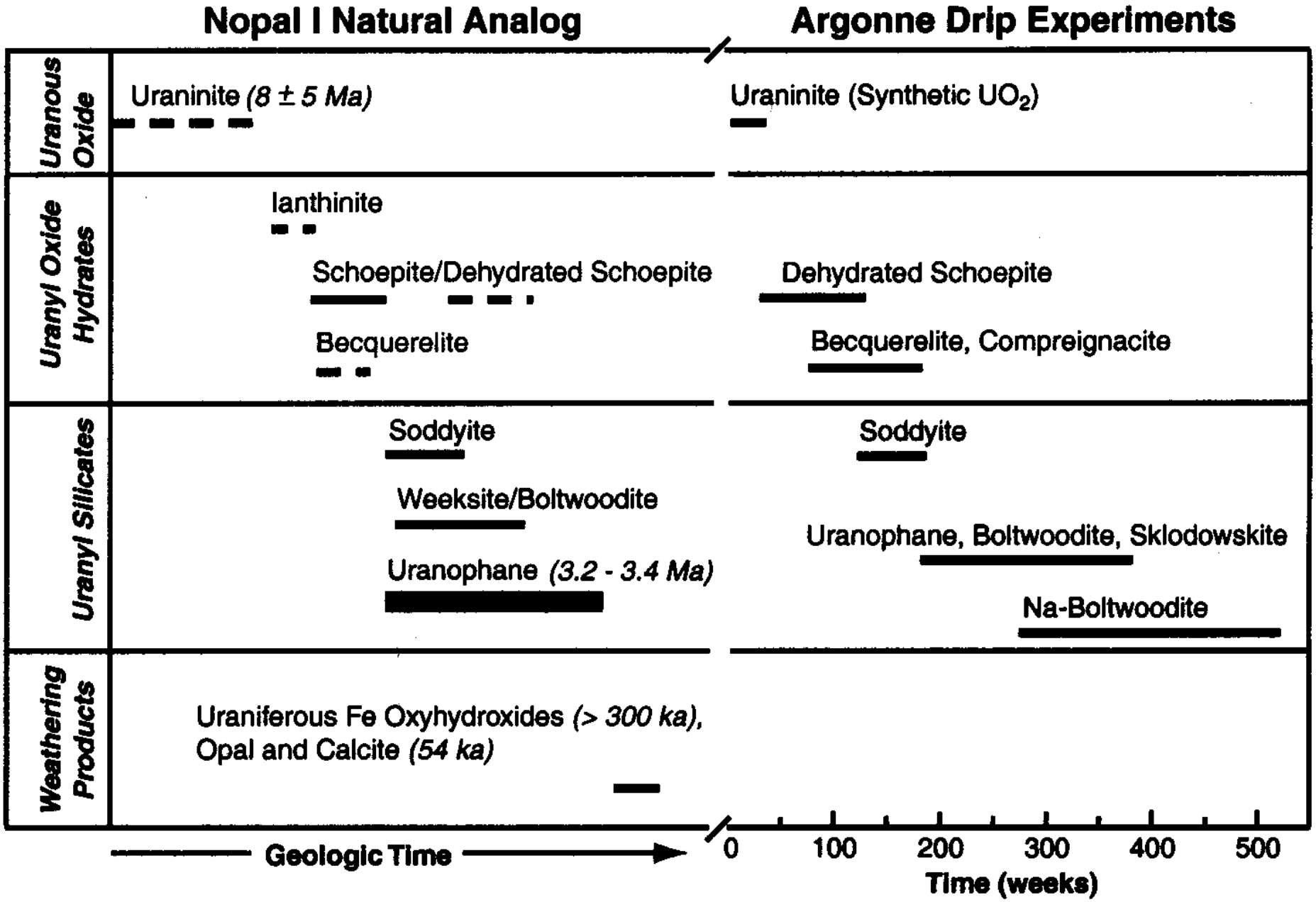
Accicular weeksite crystals in fractures (1 mm across)

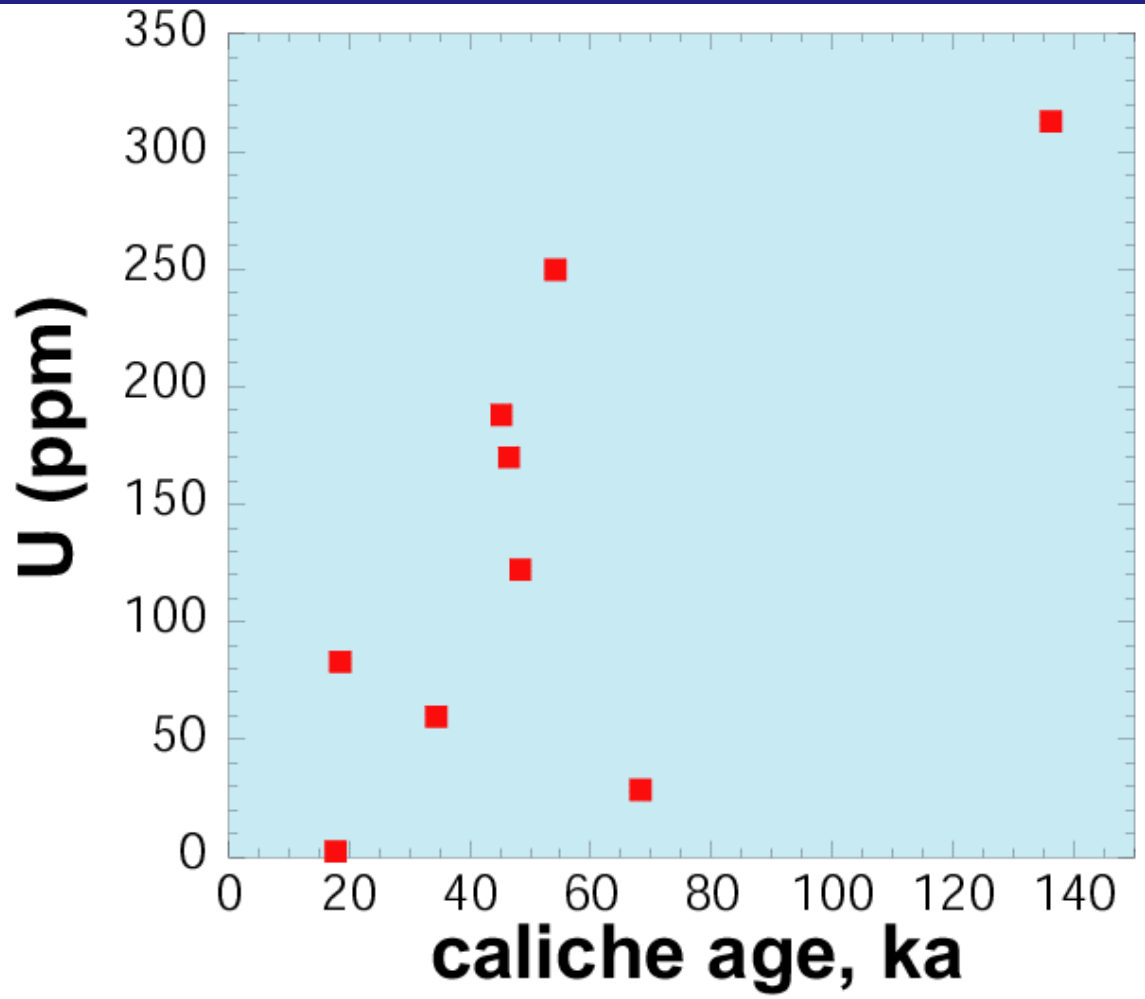


Uranophane on altered brecciated tuff (~15 cm across)

Analogous Paragenesis

(Murphy, 2000)





Nopal I caliche U concentrations through time.

(Pickett, et al., 2001)

Limits on Release and Transport Rates at Peña Blanca

Oxidation Rate Sets a Maximum Limit on the

Average Release Rate:

Rate = (Oxidized Uranium + Uranium Leached from the Site) / Time

= 140 g/y (Murphy and Pearcy, 1992; Murphy, et al., 1997)

Precipitation Rate in Caliche Sets a Minimum Limit on the

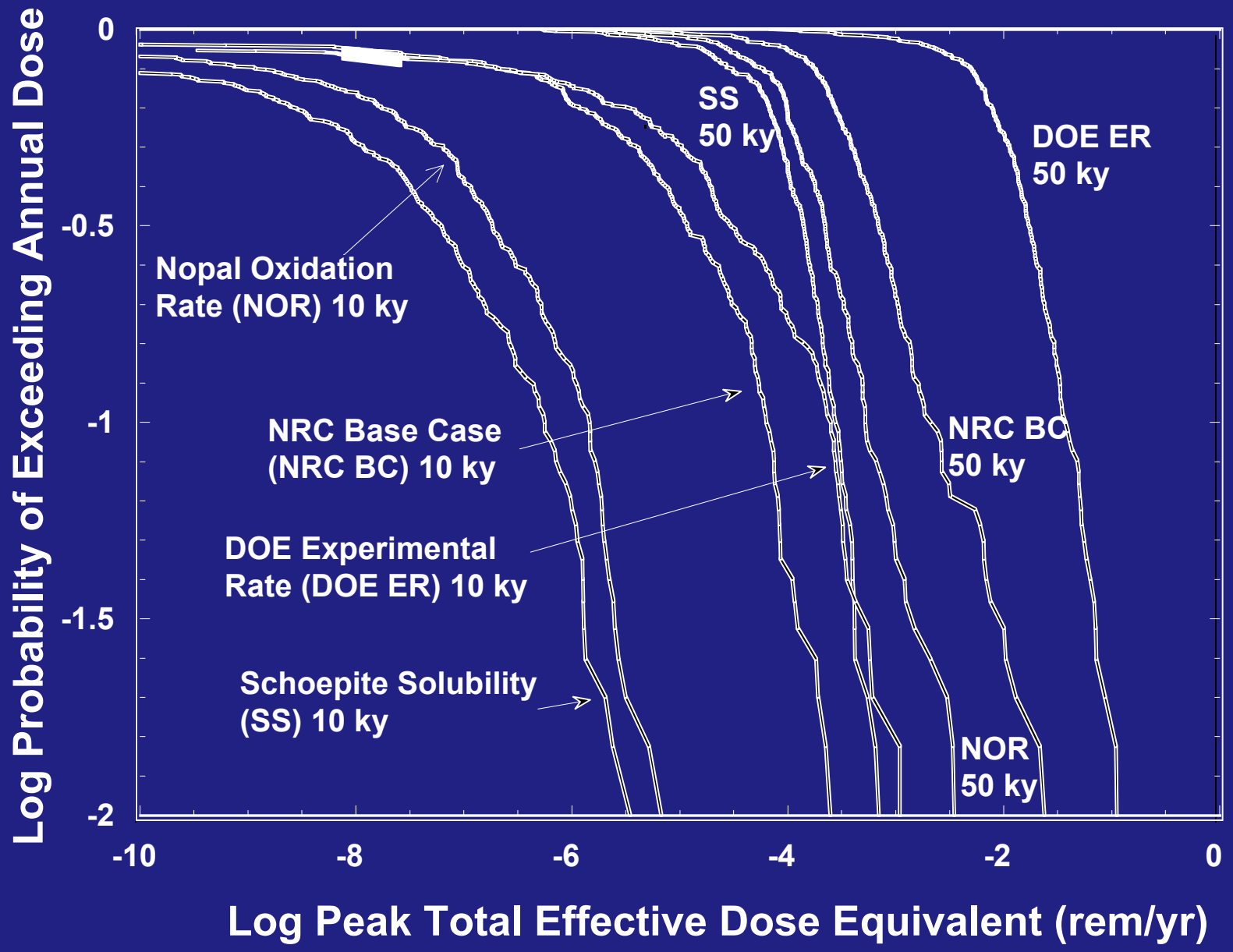
Episodic Leaching Rate:

Rate = Mass of Caliche * U in Caliche / Duration of Episode

= 30 g/y (Pickett, et al., 2001)

Alternate Performance Assessment Models for Yucca Mountain

(Murphy and Codell, 1999)

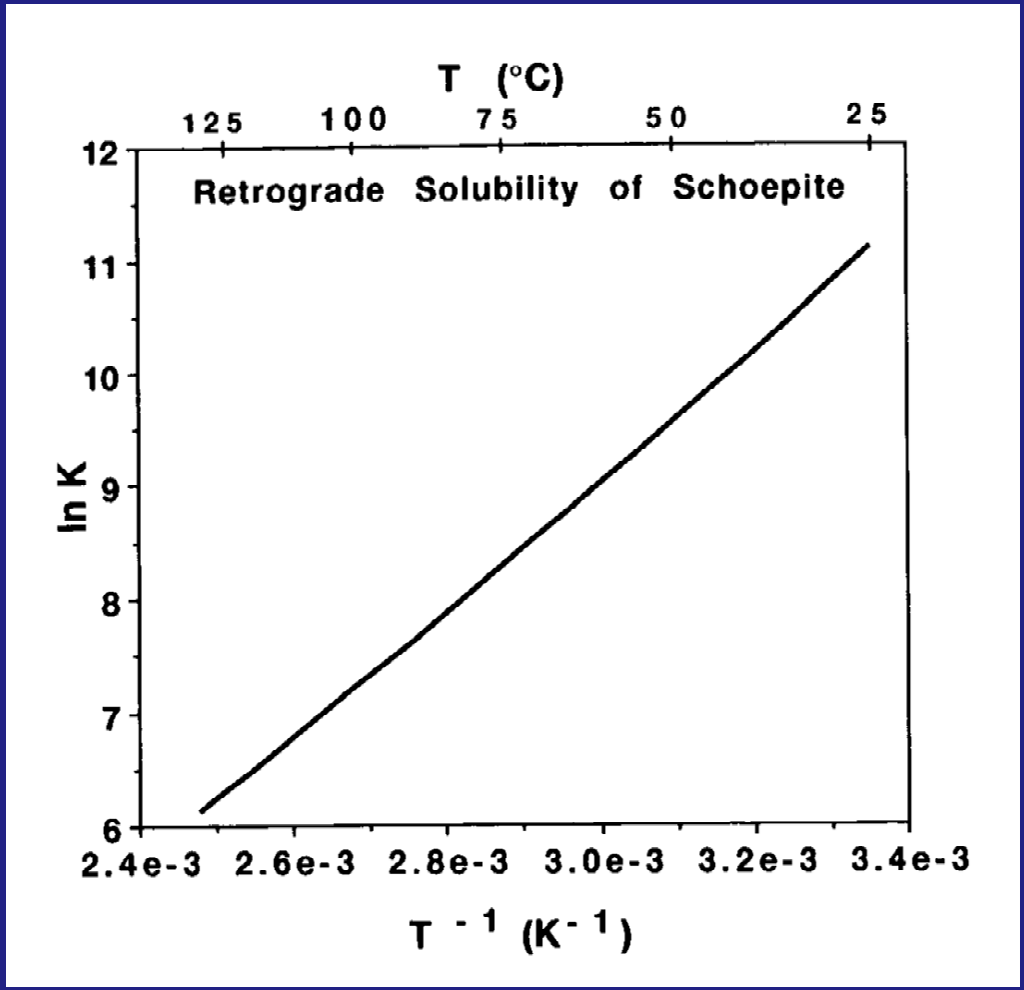


Retrograde Solubilities of Source Term Phases:

Episodic remobilization of coprecipitated radionuclides could accompany successive replacements of secondary phases.

Kinetic Effects on Coprecipitation:

Rate of secondary phase precipitation affects distributions of coprecipitated species.


T (°C)
125
100
75
50
25
Retrograde Solubility of Schoepite
12
11
10
9
8
7
6
ln K
2.4e-3
2.6e-3
2.8e-3
3.0e-3
3.2e-3
3.4e-3
T - 1 (K - 1)

Radioisotope Constraints on Release and Transport

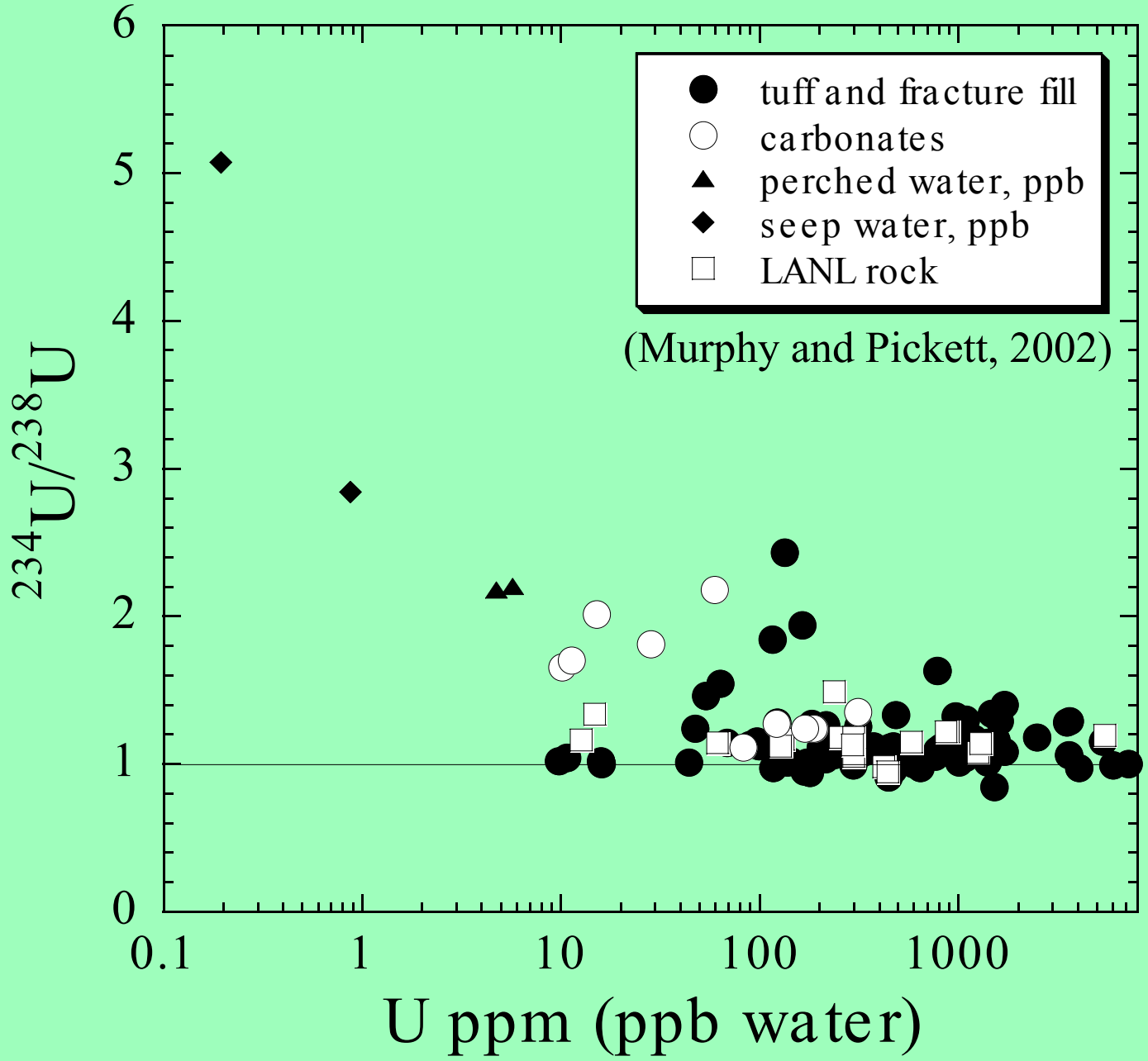
Timing of Mineralization

Open versus Closed Systems

Multiple Stages of Release and Transport

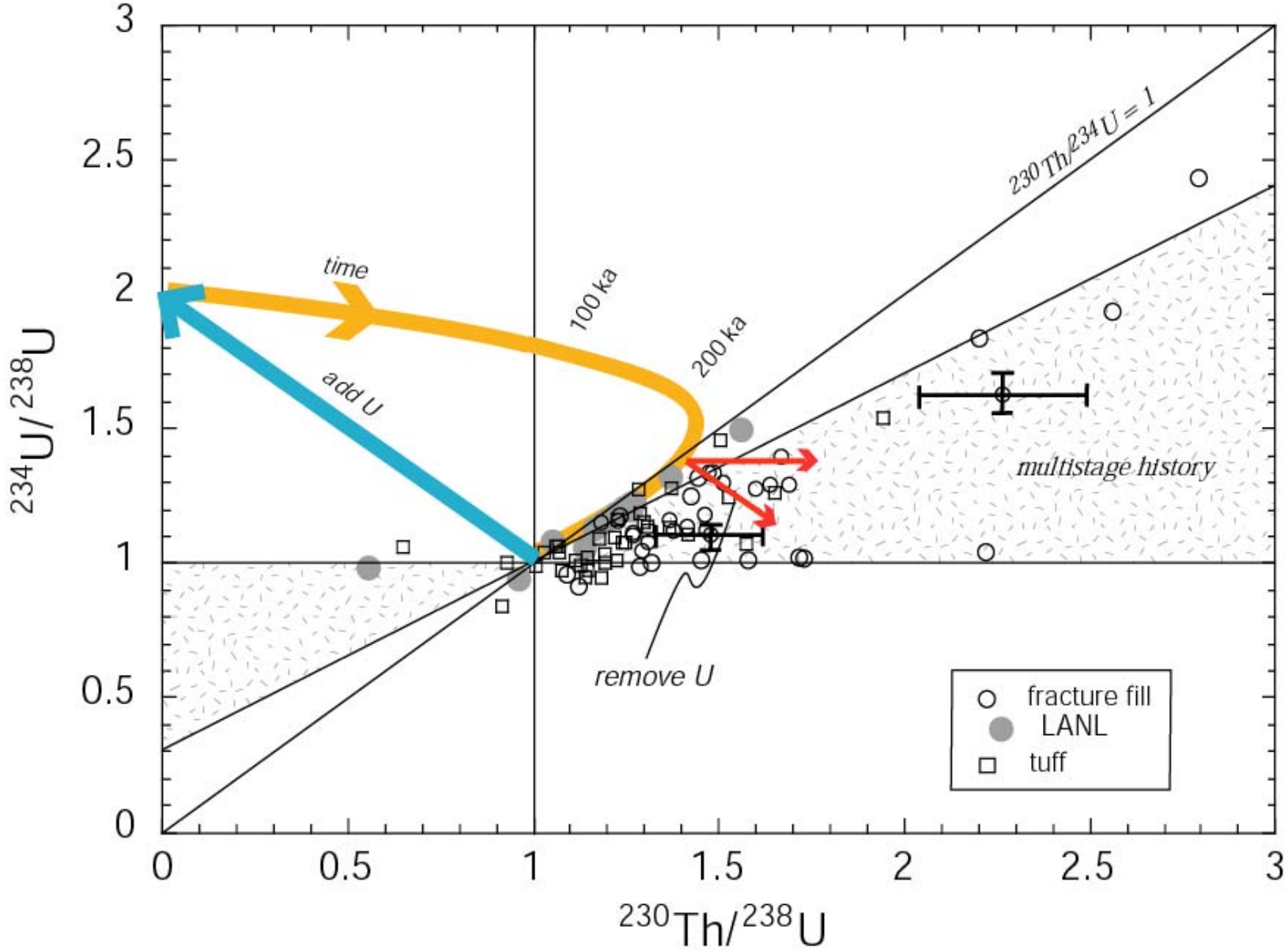
Preferential Releases of Alpha Daughters

Nopal I Preferential U-234 Release

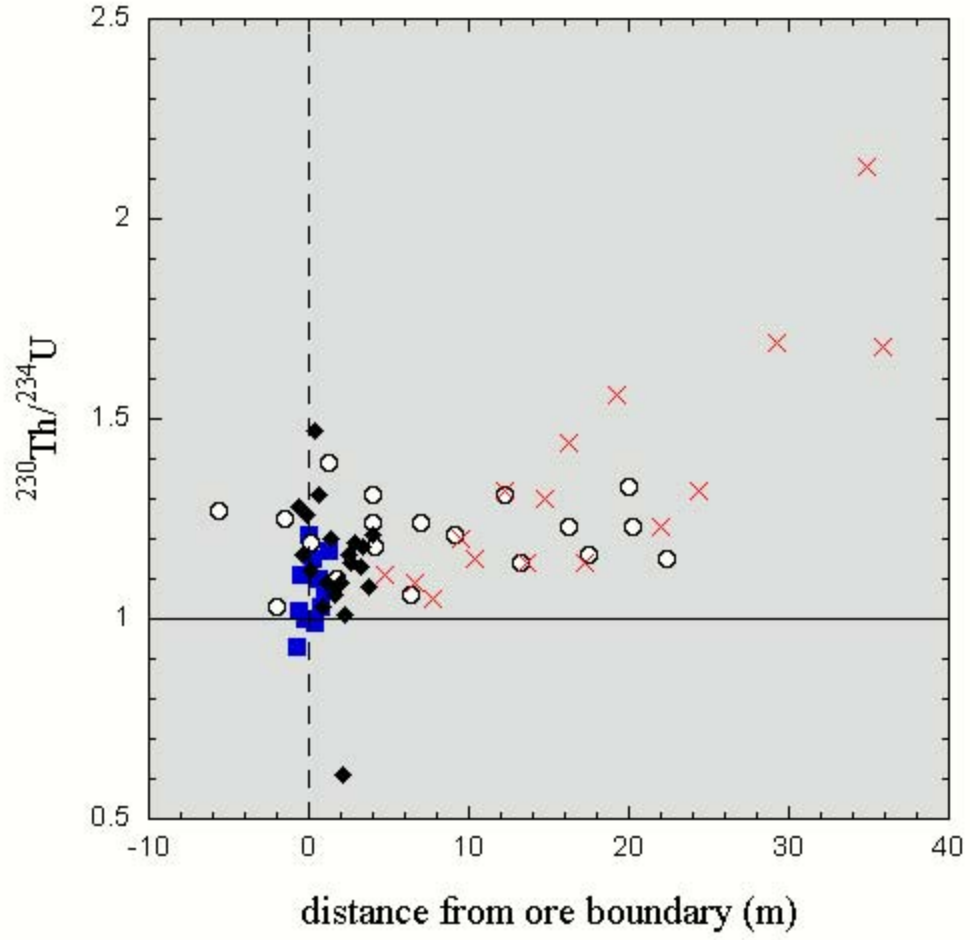


Uranium Decay Series Isotopes Open System Behavior

Pickett and Murphy (1997) plus LANL data

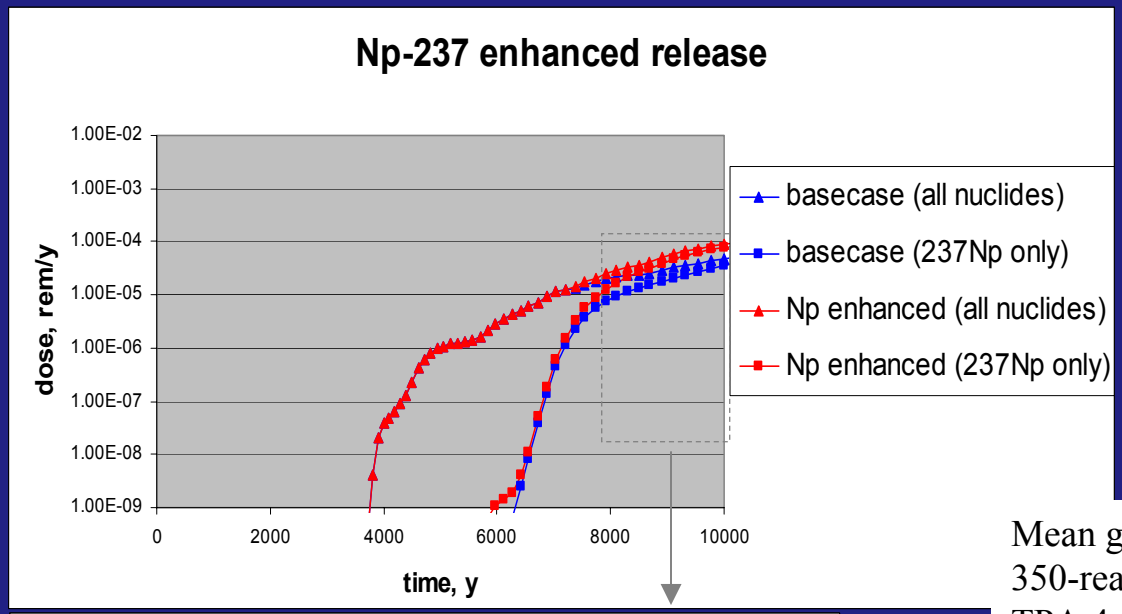


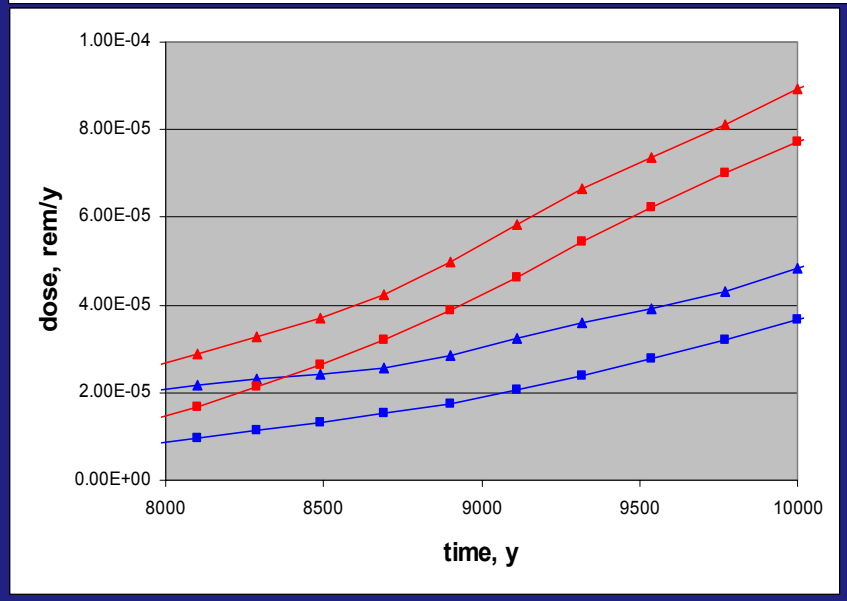
Nopal I, Peña Blanca
x, o = fracture-fill material



7th EC Natural Analogue Working Group Meeting (Pickett and Murphy, 1997)

Dose Effects of Preferential Release of Alpha Daughter Np-237





Mean groundwater dose from 350-realization stochastic TPA 4.1j runs, showing the effects of the preferential release model on ^{237}Np and total groundwater dose (log scale in top plot and linear in bottom plot).

(Pickett and Murphy, 2004)

Alternate Source Term Models in Performance Assessment Modeling for Yucca Mountain Motivated by Peña Blanca Analog Studies

Average Oxidation Rate

Coprecipitation and Schoepite Solubility

Preferential Alpha Daughter Release

Concluding Remarks

Geochemical studies at Peña Blanca play a role in performance assessment modeling for the proposed radioactive waste repository at Yucca Mountain.

Peña Blanca studies indicate additional processes that could affect release and transport at Yucca Mountain (e.g., episodicity).

Continued studies of mineralogy and geochemistry at Peña Blanca are warranted to support Yucca Mountain performance modeling.

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