Kristalline Medien zur Entsorgung von HAA: Lehren aus der Natur

Albert-Ludwigs-Universität Freiburg

UNI FREIBURG

Prof. Dr. Reto Gieré
Institut für Geo- und Umweltnaturwissenschaften

Zeitachse

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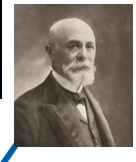
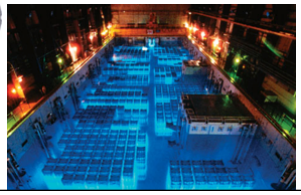


-1 Mio | -100,000 | -10,000 | -1000 | -100 | -10 | heute | +10 | +100 | +1000 | +10,000 | +100,000 | +1 Mio






Tiefenlager für HAA

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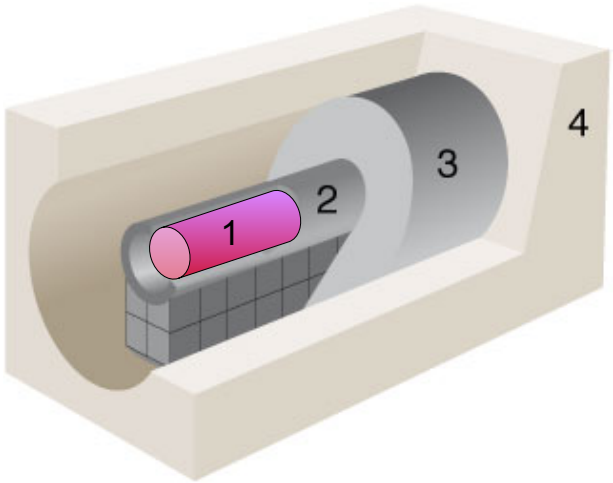

http://www.nagra.ch/de/fuerhaa.htm

Glas oder Keramik?

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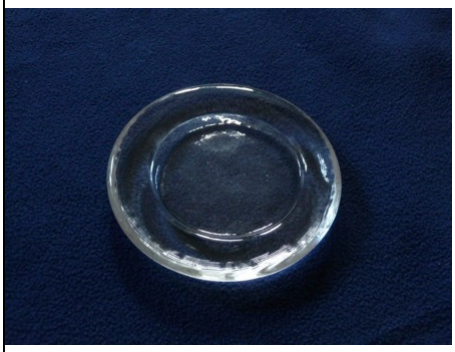

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Glas oder Keramik?

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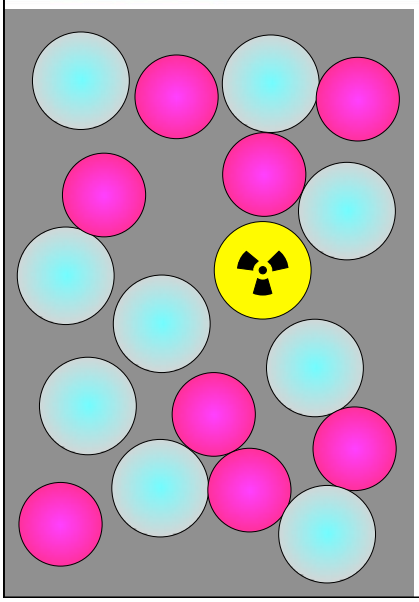

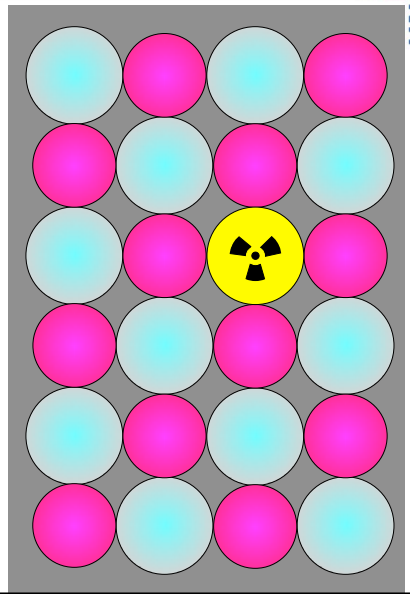

Zirkonolit

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Chukanov et al. (2014)

Zirkonolit

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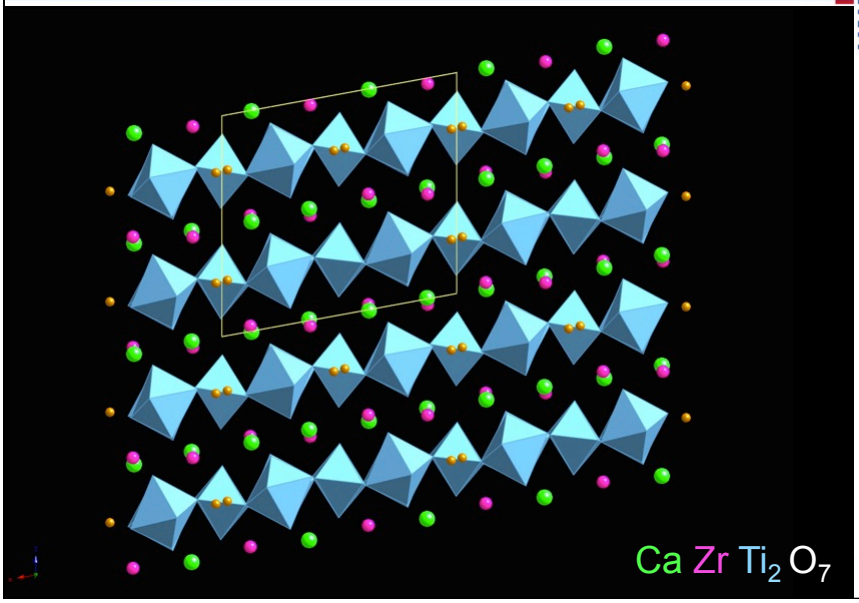

Pyrochlor, Mozambique

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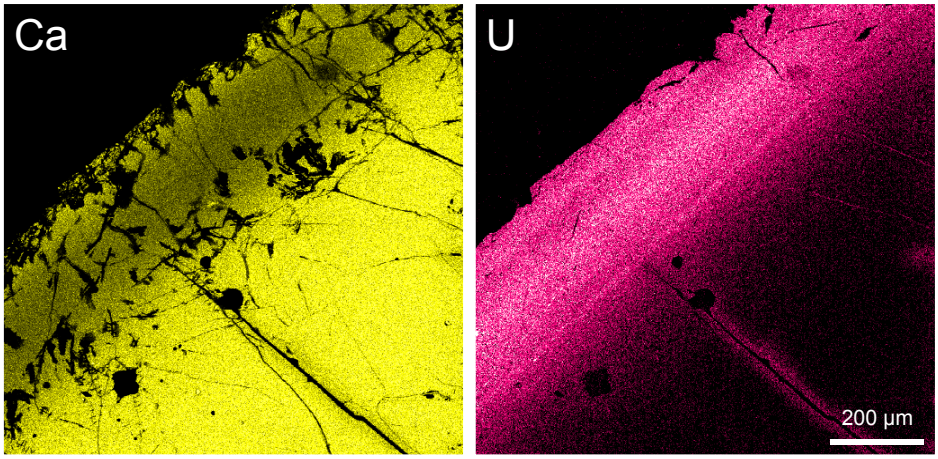
440 Ma

Pyrochlor, Mozambique

Albert-Ludwigs-Universität Freiburg

440 Ma



Gieré *et al.* (2001)

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Radioaktiver Zerfall

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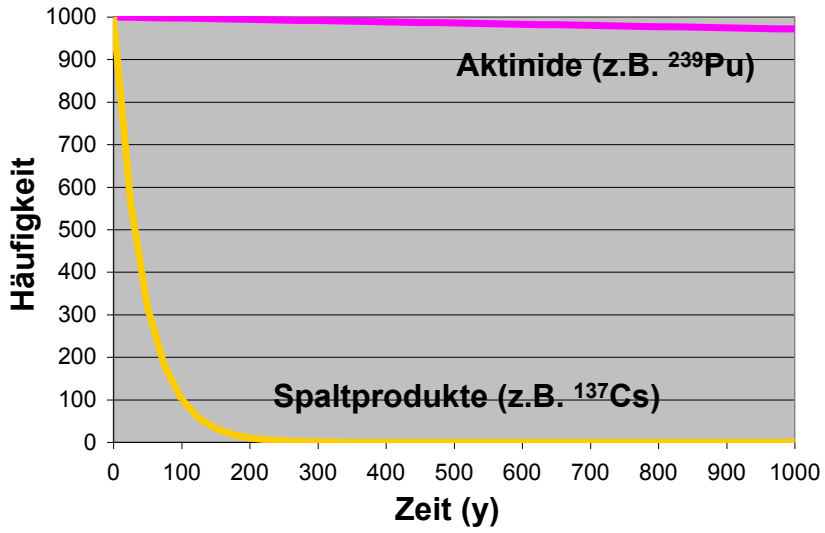

12

Radioaktiver Zerfall

- $^{238}U \rightarrow {}^{206}Pb + 8\,\alpha + 6\,\beta^- + E$
- $^{235}U \rightarrow {}^{207}Pb + 7\,\alpha + 4\,\beta^- + E$
- $^{232}Th \rightarrow {}^{208}Pb + 6\,\alpha + 4\,\beta^- + E$

⇨ **Dosis (α/mg)**

$$D = 8N_{238}\left(e^{t\lambda_{238}} - 1\right) + 7N_{235}\left(e^{t\lambda_{235}} - 1\right) + 6N_{232}\left(e^{t\lambda_{232}} - 1\right)$$

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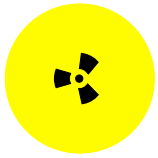
α- Zerfall



14

α- Zerfall

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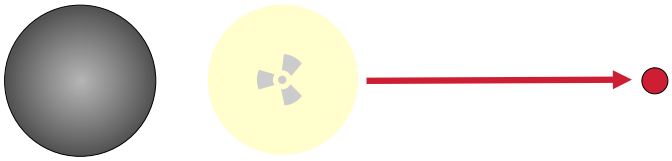

α-Spur (fission track)
Reichweite: 10-20 µm

15

α- Zerfall

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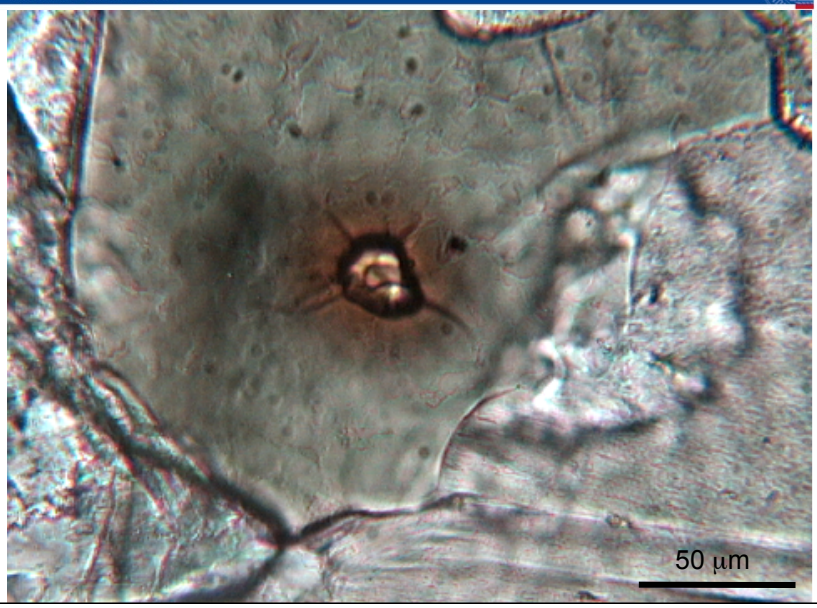

α- Zerfall

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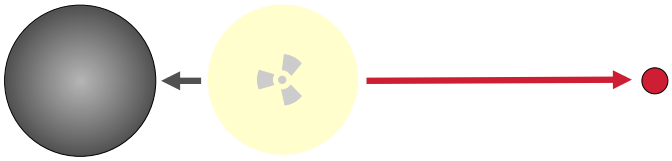

α-Rückstoss-Spur
Reichweite: 10-20 nm

α-Spur (fission track)
Reichweite: 10-20 µm

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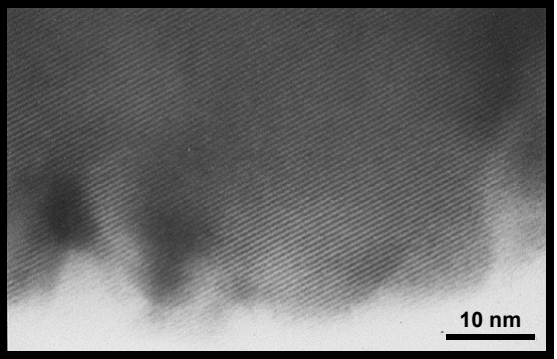
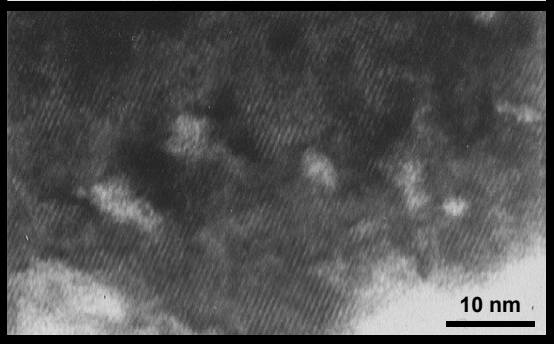
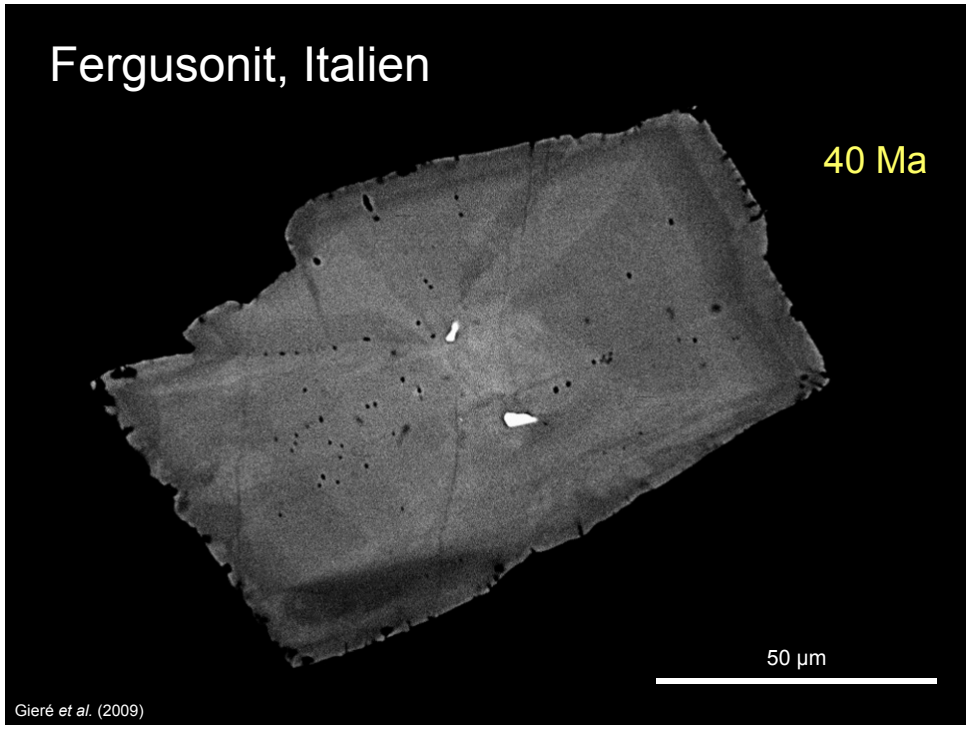
Zirkonolit

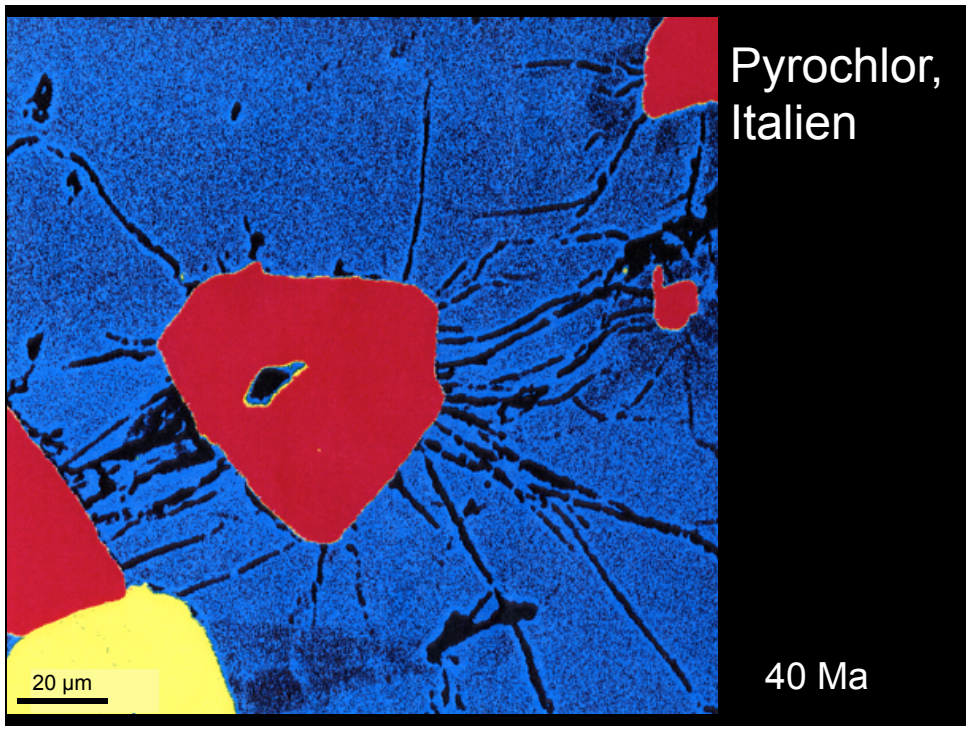
Bergell (Italien)
32 Ma
0.06×10^{16} α/mg

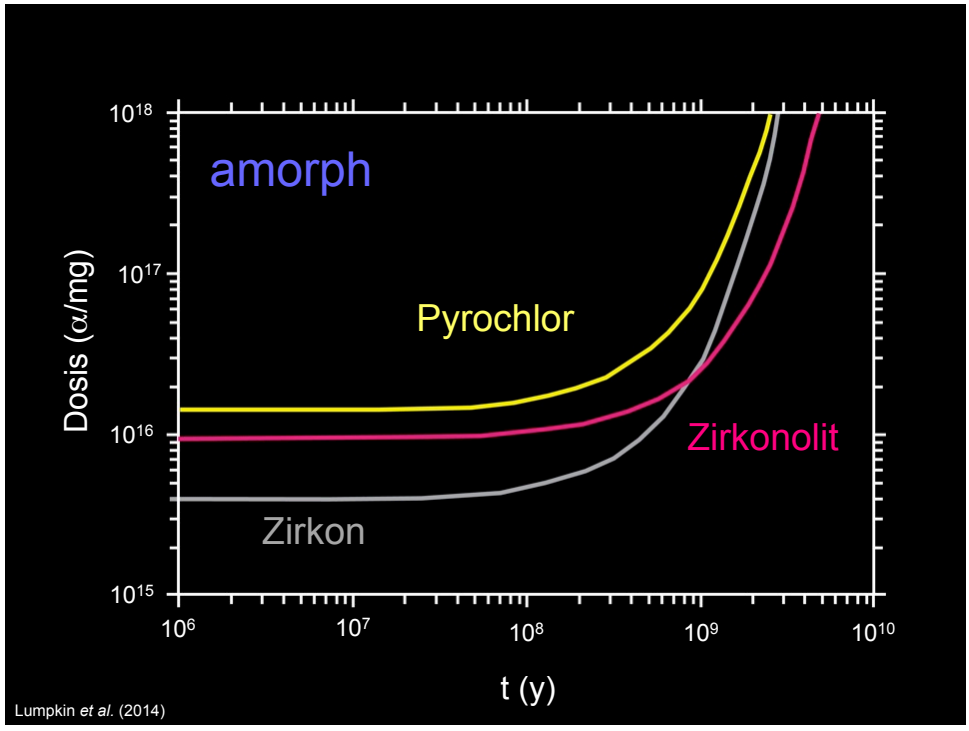


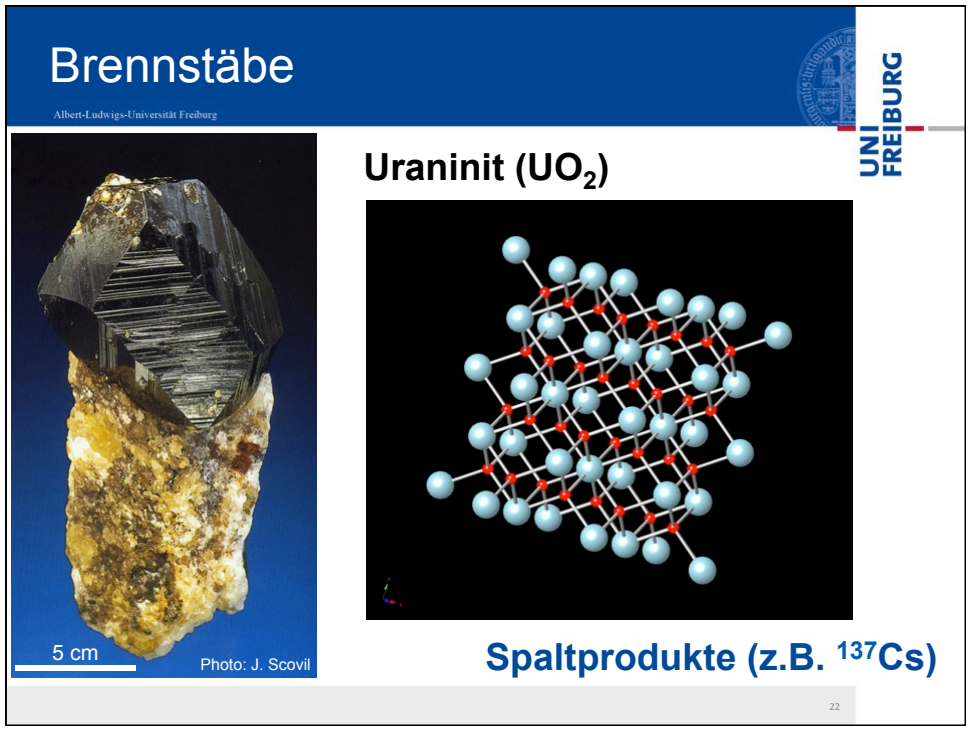
Stavern (Norwegen)
300 Ma
0.3×10^{16} α/mg




Fergusonit, Italien
40 Ma
50 µm
Gieré *et al.* (2009)


Pyrochlor, Italien
20 µm
40 Ma


amorph
Pyrochlor
Zirkonolit
Zirkon
Dosis (α/mg)
10^18
10^17
10^16
10^15
10^6
10^7
10^8
10^9
10^10
t (y)
Lumpkin et al. (2014)


Brennstäbe
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5 cm
Photo: J. Scovil
Uraninit (UO_2)
Spaltprodukte (z.B. ^{137}Cs)
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Tiefenlager für HAA

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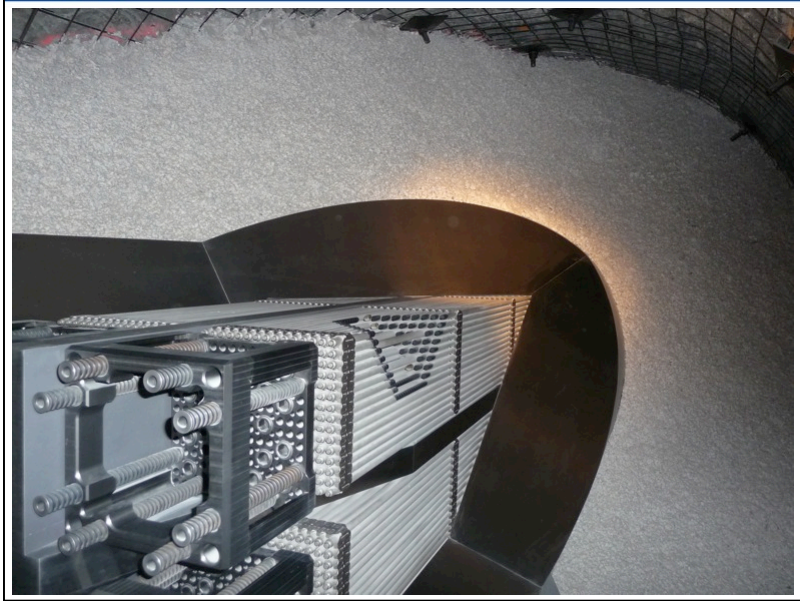

Cigar Lake, Canada

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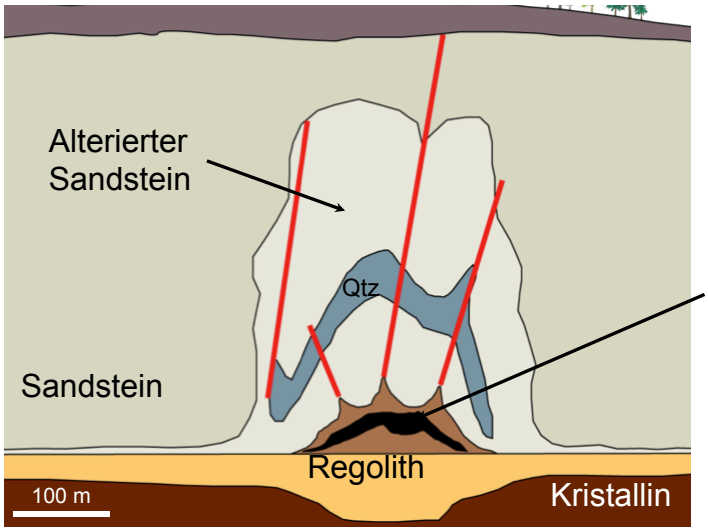

Lagerstätte (~1.5 Ga), eingebettet in **Tone**

Gauthier-Lafaye *et al.* (2004)

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Oklo, Gabon

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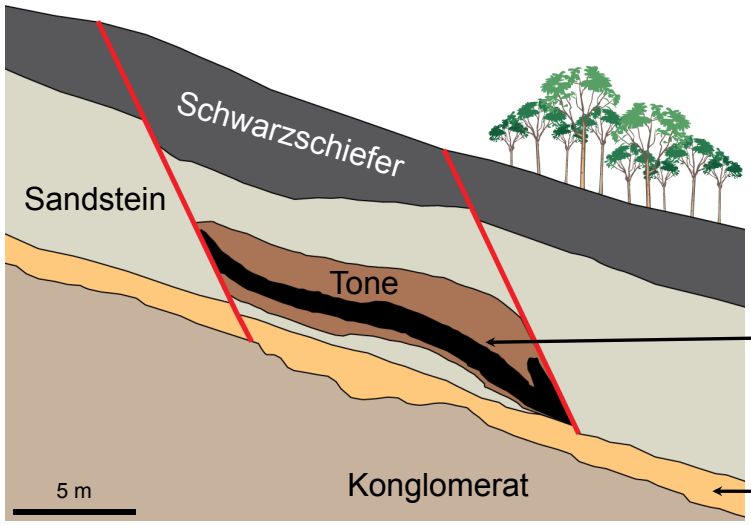

Gauthier-Lafaye *et al.* (1989)

25

Tongesteine

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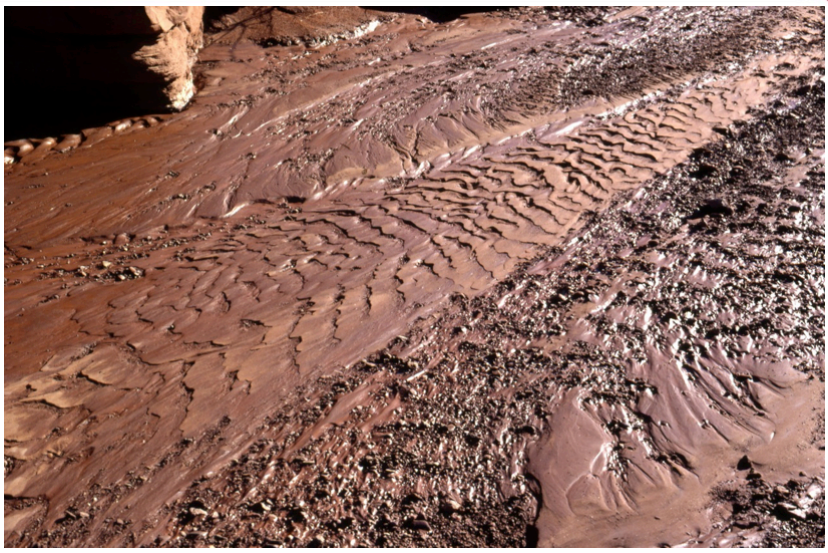

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Salz

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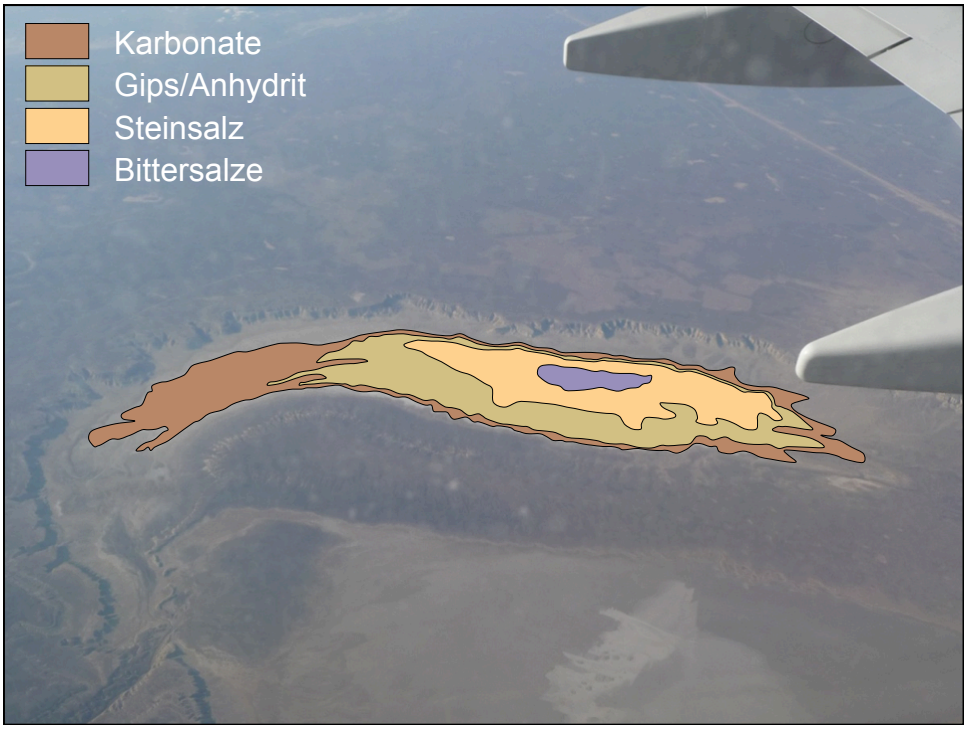
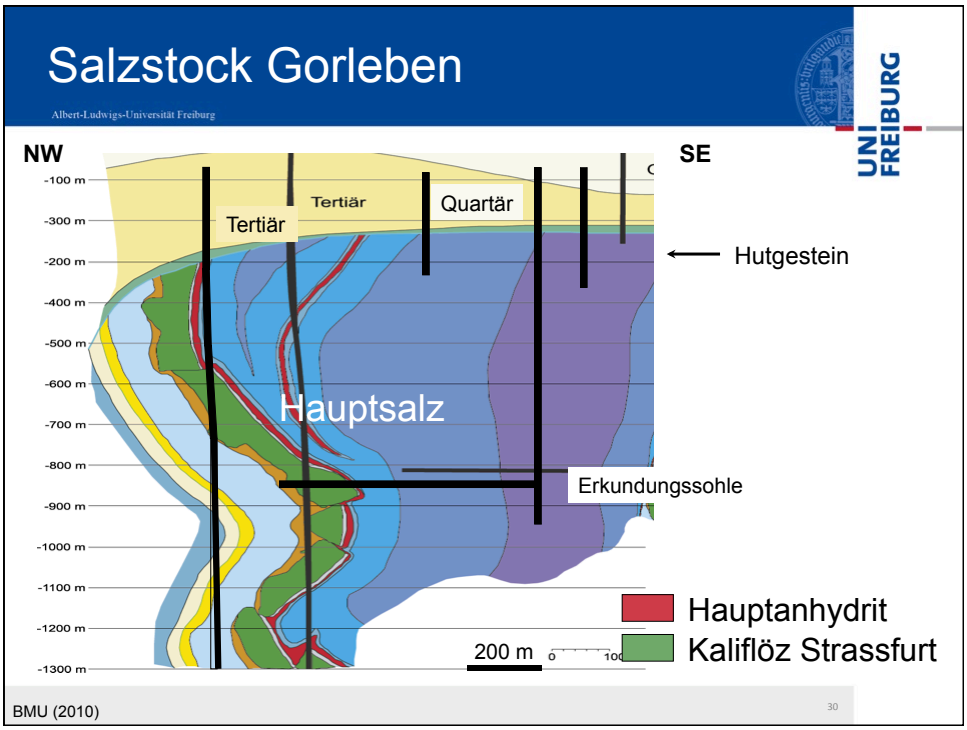
National Geographic Society (February 2007)

27


Karbonate
Gips/Anhydrit
Steinsalz
Bittersalze


Salzstock Gorleben
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NW
SE
-100 m
-300 m
-200 m
-400 m
-500 m
-600 m
-700 m
-800 m
-900 m
-1000 m
-1100 m
-1200 m
-1300 m
Tertiär
Tertiär
Quartär
Hutgestein
Hauptsalz
Erkundungssohle
Hauptanhydrit
Kaliflöz Strassfurt
200 m
BMU (2010)

Salzstöcke

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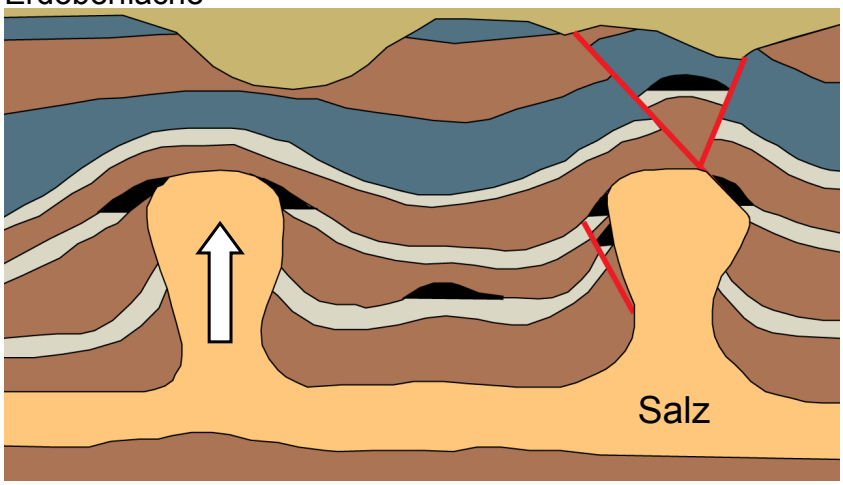
Erdoberfläche



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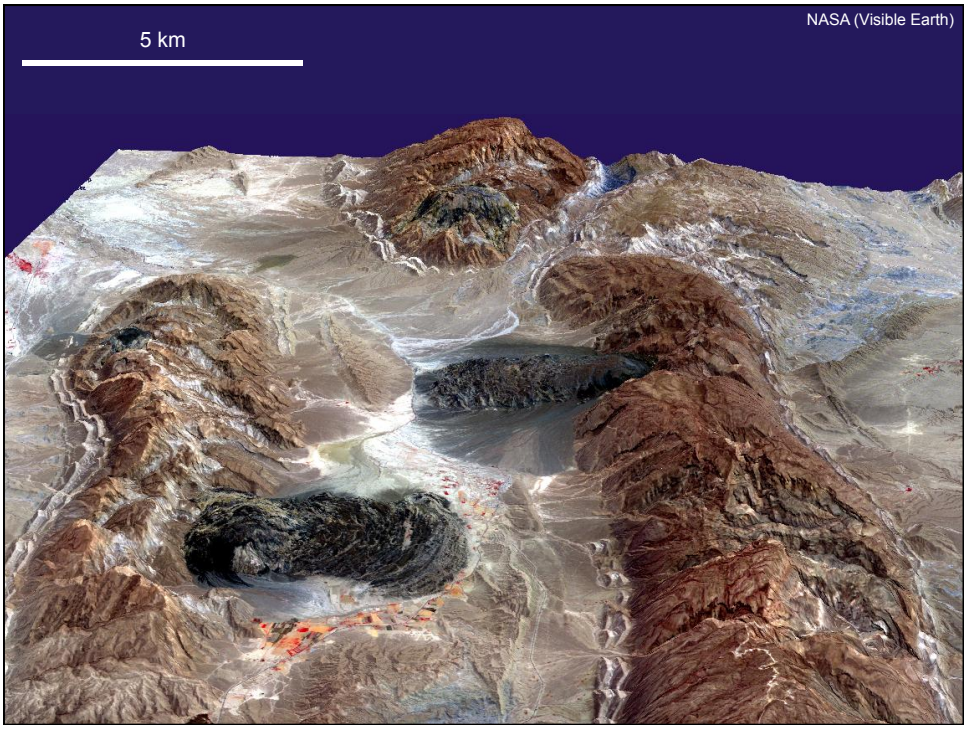
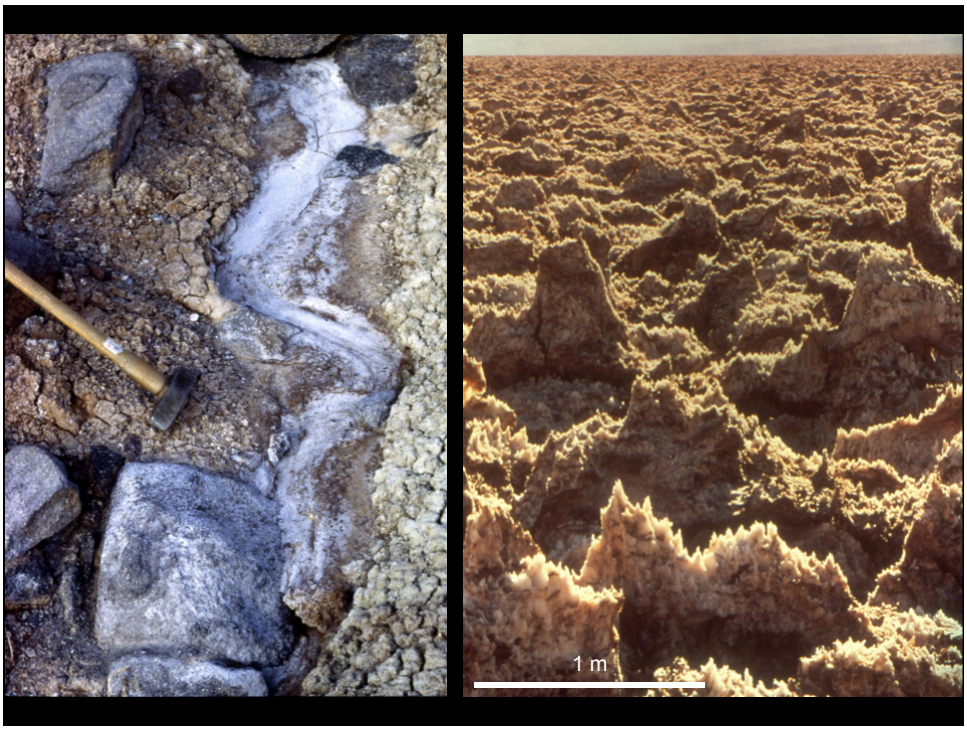
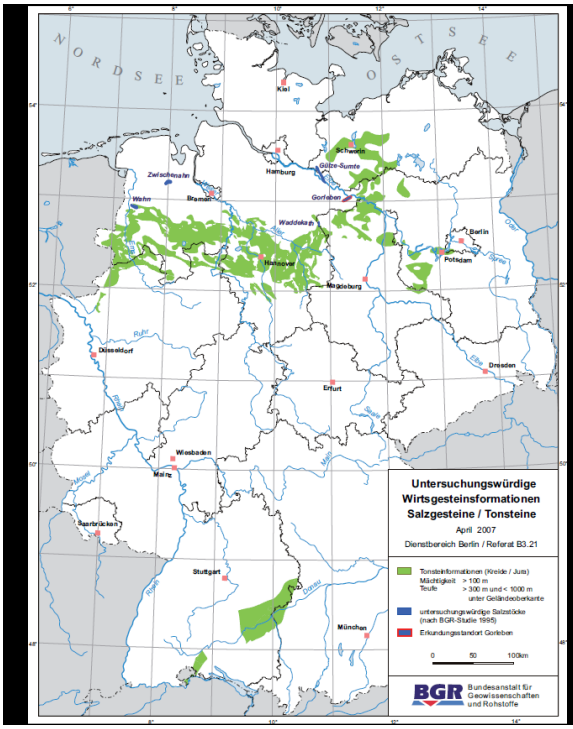

5 km
NASA (Visible Earth)


1 m



Untersuchungs-würdige Wirtsgesteine

Tone
Salz

BGR (2007)

Lösung des Problems

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Lehren aus der Natur
Materialien für HLW
Technische Barrieren
Wirtsgesteine
Zeitachse

Herausforderungen
Bevölkerung
Atomsemiotik
Politik

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Zitierte Literatur

BGR (2007) Endlagerung radioaktiver Abfälle in Deutschland: Untersuchungen und Bewertung von Regionen mit potenziell geeigneten Wirtsgesteinsformationen. Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover

BMU (2010) Weitererkundung des Salzstocks Gorleben - Broschüre zur Öffentlichkeitsarbeit. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit und Bundesamt für Strahlenschutz (www.bmu.de)

Gauthier-Lafaye F., Weber F., Ohmoto H. (1989) Natural Fission Reactors of Oklo. Economic Geology 84, 2286-2295

Gauthier-Lafaye F., Stille P., Bros R. (2004) Special Cases of Natural Analogues: The Gabon and Cigar Lake U ore deposits. In: Gieré R. & Stille P.: Energy, Waste and the Environment: A Geochemical Perspective. Geological Society, London, Special Publications 236, 123-134

Gieré R., Buck E.C., Guggenheim R., Mathys D., Reusser E., Marques J. (2001): Alteration of uranium-rich microlite. Materials Research Society, Symposium Proceedings 663, 935-944

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Lumpkin G.R., Gao Y., Gieré R., Williams C.T., Mariano A.N., Geisler T. (2014): The role of Th-U minerals in assessing the performance of nuclear waste forms. Mineralogical Magazine, 78, 1071-1096