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The scientific basis for nuclear waste disposal

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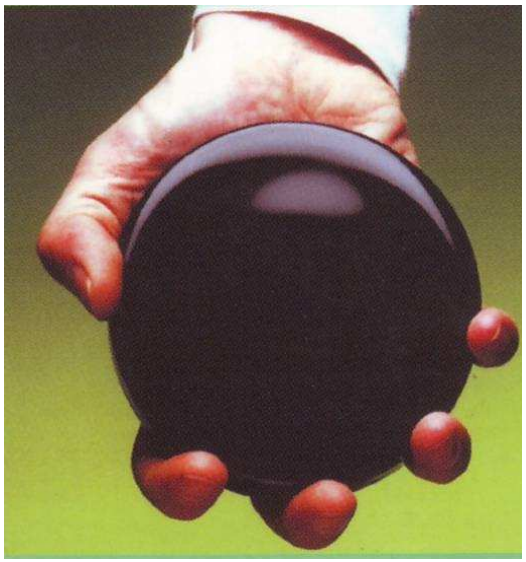
High level radioactive waste

High level radioactive waste makes < 10 vol% of all radioactive waste but contains 99% of the radioactivity (**HIGH radiotoxicity**). [Spent fuel and vitrified waste after reprocessing]

The composition and physical-chemical properties of high level radioactive waste are very well known.

There will be only relatively small amounts of high level radioactive waste (e.g. in Germany in total ~28,000 m³ accumulated until 2021)



Volume of high level radioactive waste after electricity generation for one person for 80 years by nuclear power (from Ojovan & Lee, 2005).

Safety of nuclear waste disposal

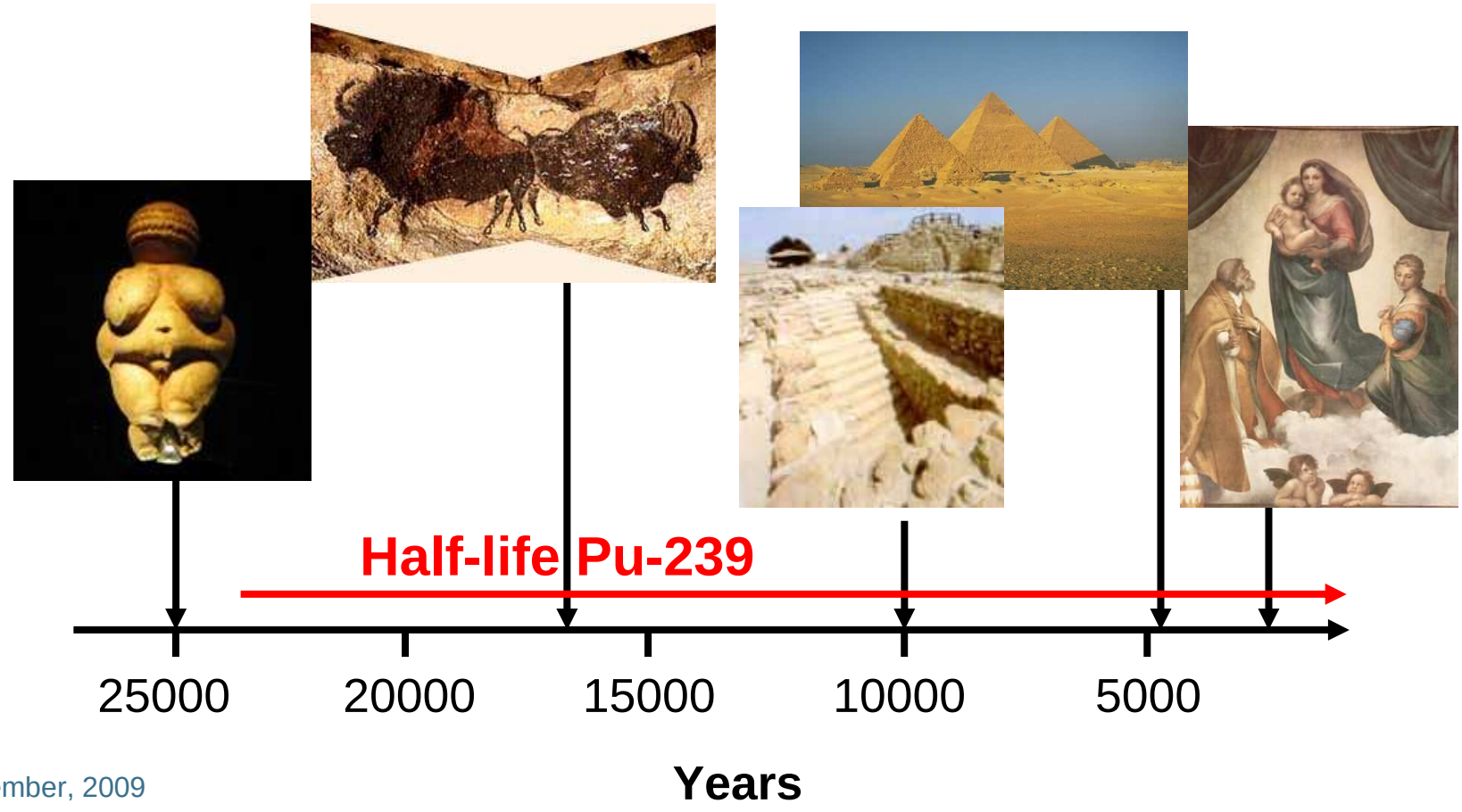
The disposal of high level radioactive waste in a deep geological formation is considered world wide as the best option.

The safe operation of a nuclear waste repository has been demonstrated (e.g. WIPP since 1999).

The isolation of high level nuclear waste in a deep geological formation by (geo)technical systems is assured for 10,000 years.

Long-term safety of nuclear waste disposal

The scientific & technical challenge is to demonstrate the safety over extremely long (geological) time scales – up to several 100,000 years.



Long term safety of nuclear waste disposal

Safety assessment for geological time scales of several 100,000 years (due to long-lived radioisotopes).

We cannot predict exactly what will happen in the next 1 mio years – in the sense of a weather forecast. However, this is not necessary …

For specific scenarios we CAN say something reasonable about the behaviour of a nuclear waste repository system even for extremely long time scales (FEP – features, events and processes). *We can say what will not happen.*

The need for basic research

How do radionuclides behave in a nuclear waste repository system?

We have to rely on fundamental laws of physics and chemistry, which requires a system understanding on a molecular level (for relevant processes).

Fundamental principles in physics and chemistry can be extrapolated in time and space.

The applicability of these concepts can be tested on natural analogues, such as the natural nuclear reactor in Oklo (Gabon).

Oklo: A natural fossil nuclear reactor

17 natural nuclear reactors within the uranium ore deposits in Oklo and Bangombe (Gabon) operated 2 billion years ago (for 500,000 years @ 100 kW).

High level radioactive waste was produced (such as 4 t Plutonium).

The behaviour of high level nuclear waste in the geosphere over 2 billion years can be studied. Long-term safety assessment procedures can be tested.

No migration of the radionuclides over 2 billion years – efficient retention of the radionuclides.

The benefit of scientific progress

Impressive scientific progress during the last 10 – 20 years has resulted in a detailed level of understanding of nuclear waste repository systems.

Most long term safety relevant issues were known 20 years ago. However, recent scientific progress has provided a significant reduction of uncertainties.

Increased confidence in long-term safety assessment of high level nuclear waste disposal .

Innovative disposal strategies

Transmutation – Convert long-lived radionuclides into short-lived radionuclides by nuclear reactions (e.g. by neutrons).

Reduction of radiotoxicity. From geological time scales to historical time scales.

Transmutation is not an alternative to geological disposal but a promising addition.

The scientific perspective of the long term safety of nuclear waste disposal

Limited amounts of high level nuclear waste

Extremely long (geological) time scales

The need and role of basic research

Reduction of radiotoxicity by innovative disposal strategies

From a scientific point of view, the disposal of high level radioactive waste in a deep geological formation is justifiable.