NEA/IAEA/EC Symposium

Safety Cases for Deep Disposal of Radioactive Wastes: Where Do We Stand?

How Has the Safety Case Evolved in the Swiss Programme?

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Paris 23 – 25 January 2007

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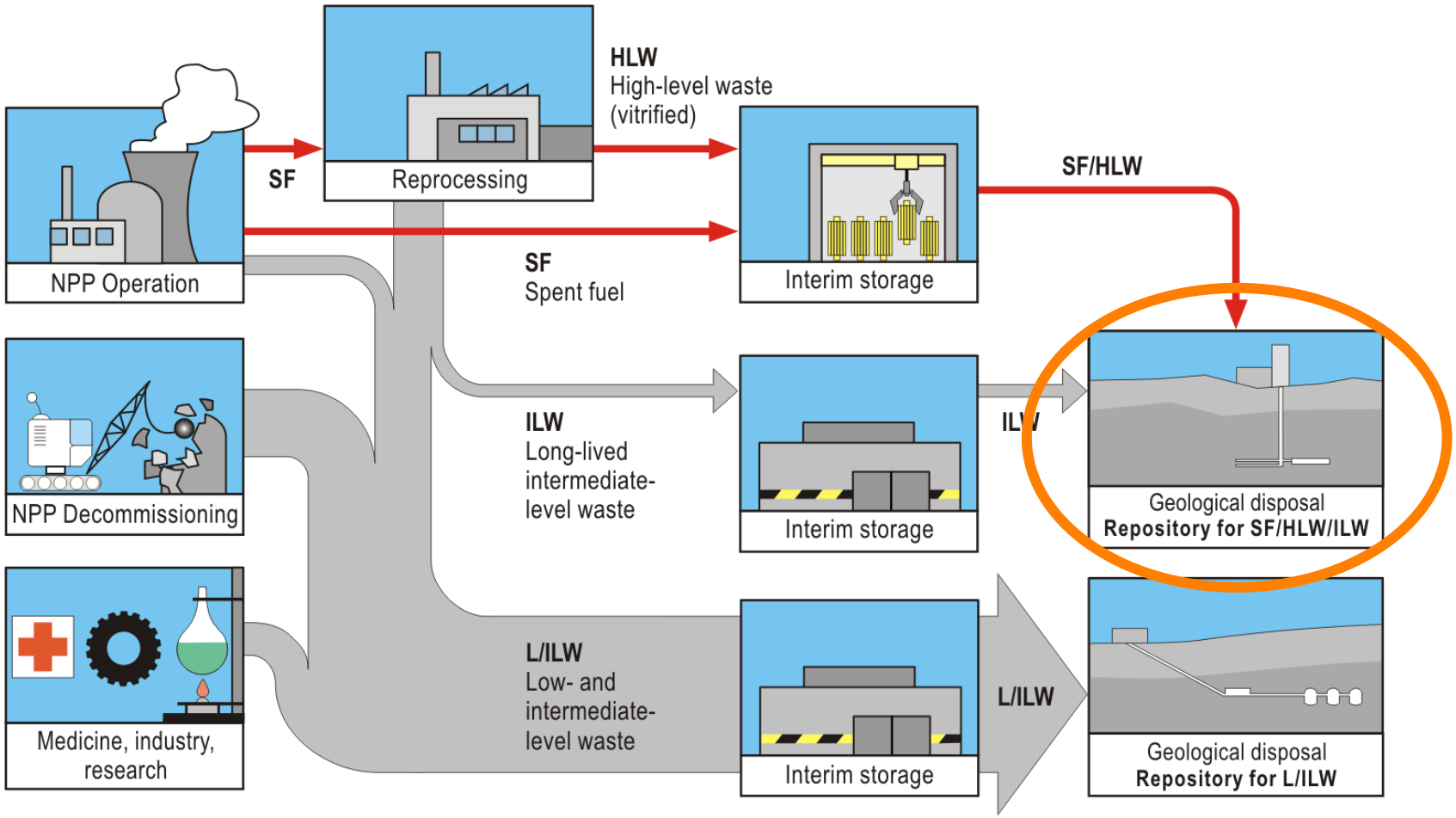
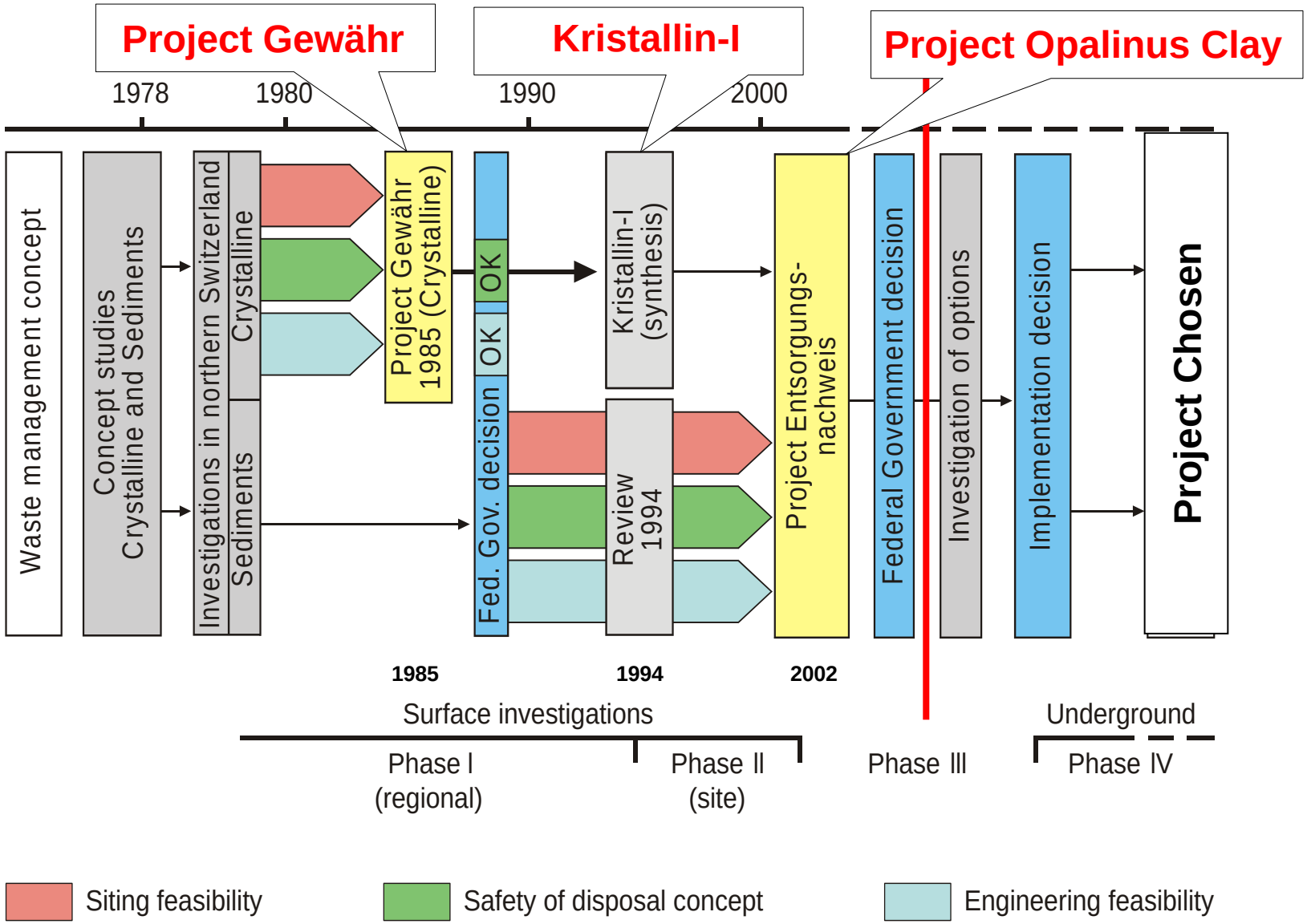
Swiss waste management concept



Swiss HLW programme - a stepwise approach



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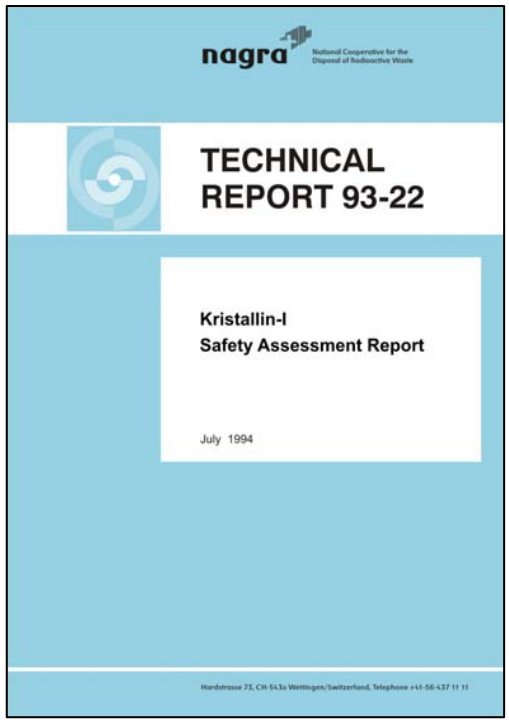
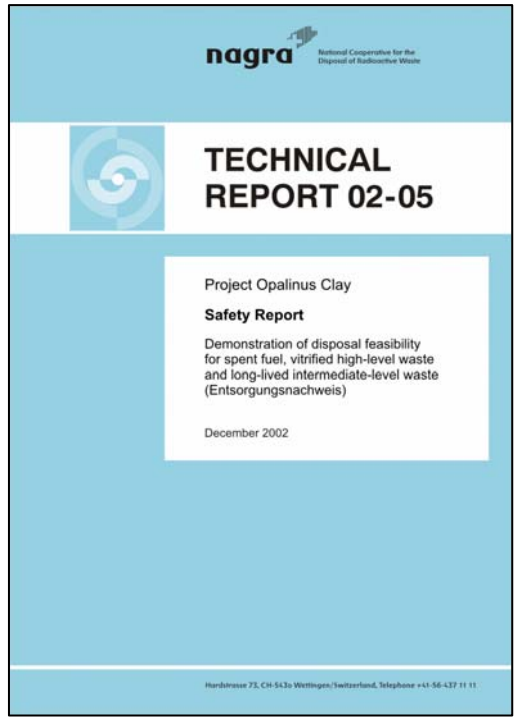
Overview Swiss Programme - 3 Safety Reports





- Projekt Gewähr (1985): formal assessment of feasibility (crystalline basement)
- Kristallin-I (1994): assessment of disposal in crystalline basement (programme decision)
- Project Opalinus Clay (2002): formal assessment of feasibility & assessment of disposal in clay stone (programme decision)

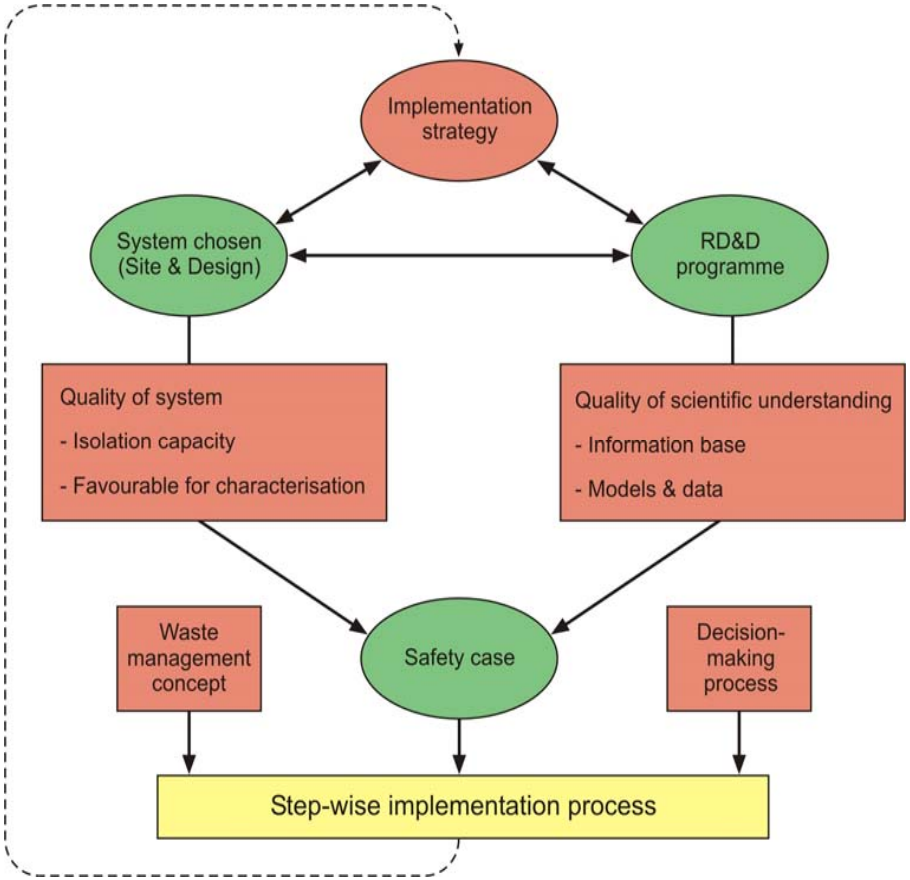
Safety Case: its role in the stepwise approach

- Aims of Safety Reports / Safety Case
  - Legal requirements: demonstration of disposal feasibility[1)] (connected to nuclear power), (licensing) steps for repository development
  - Programme decisions: choice of system (siting options, EBS, ...), content & priorities in work programme (products)
  - Input / guidance for developing the necessary infrastructure: team (internal, external), tools, lab, URLs, etc.
- Target audiences of Safety Case
  - Federal Government: decisions on legal requirements
  - Safety authorities
    - preparation of government decisions
    - advice for future programme (system, work programme (content, time))
    - supervision of work: field, URLs, ...
  - Public: *'Is it safe?', 'Can it be done?'*
  - Waste management organisation: strategic decisions (system, work programme), development of requirements, ...

1) disposal feasibility: siting feasibility, engineering feasibility, safety

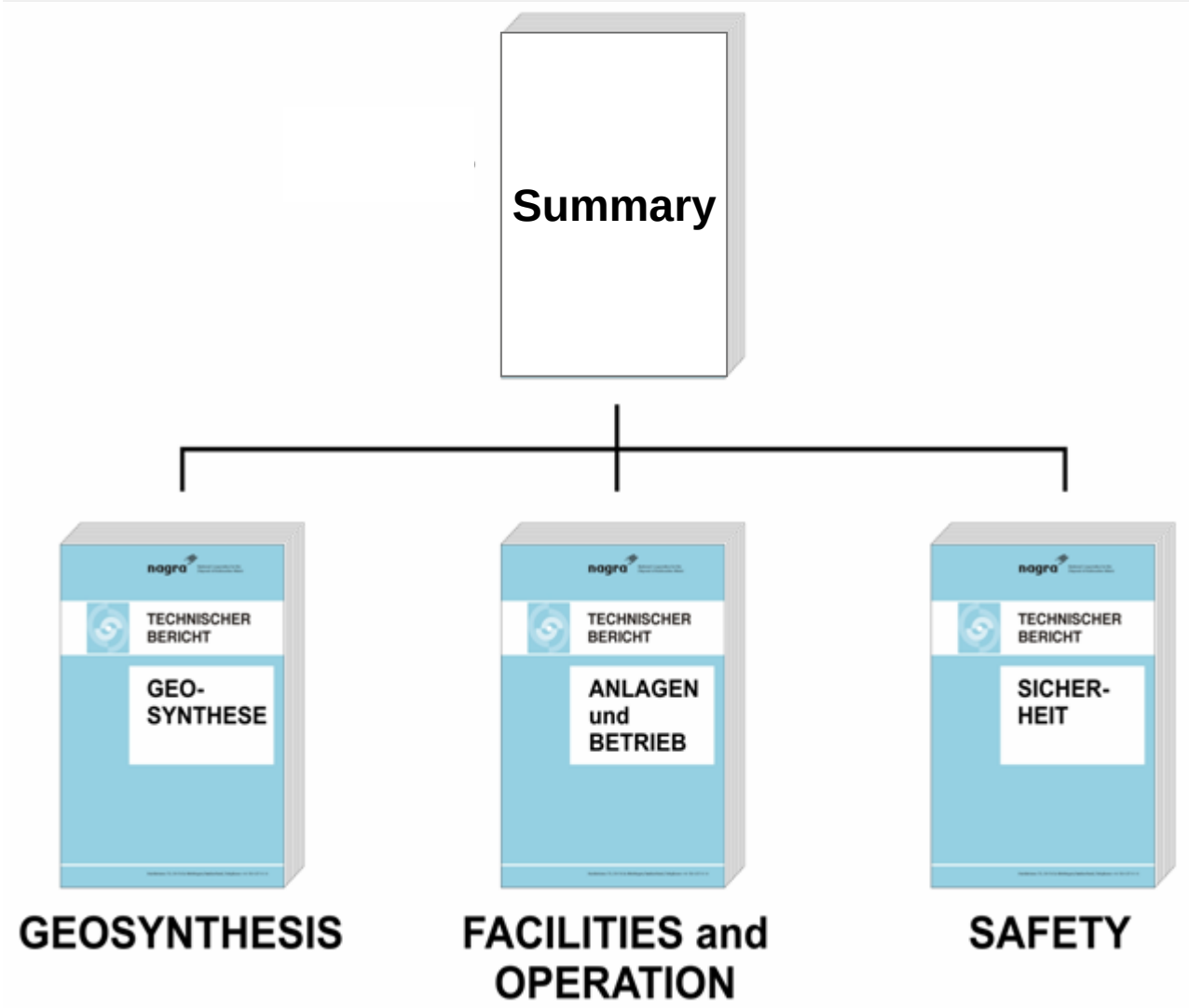
Role of the Safety Case in decision-making

The issues at a decision point (milestone)



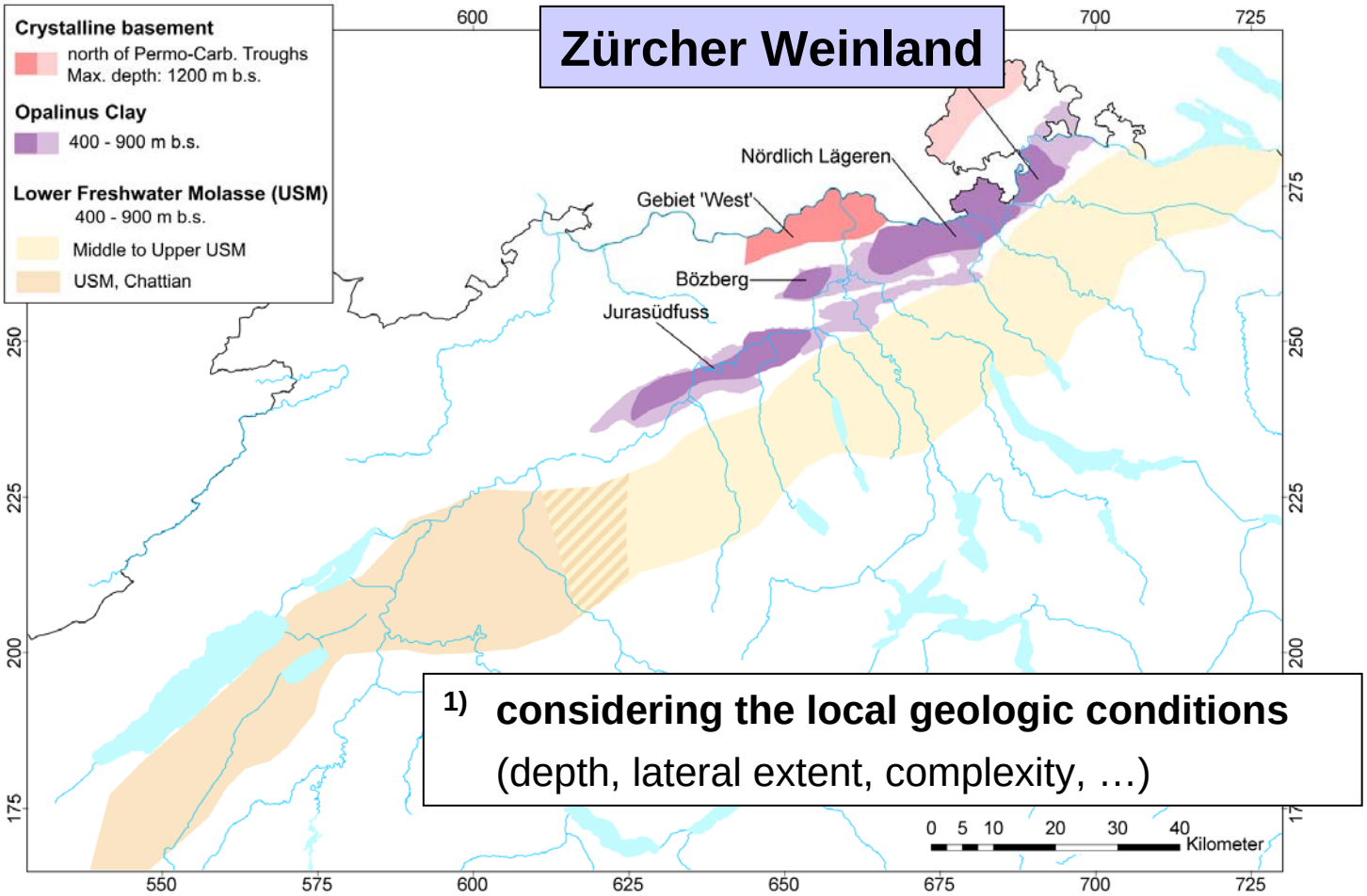
- **Implementation strategy**
  - Choice of system
  - RD+D - programme
- **Safety case: periodic assessment of strategy**
  - Quality of system
  - Quality of understanding
- **The societal element**
  - Geological disposal adequate ?
  - Decision-making process (who? what? when? how?)
  - What next? flexibility left ?
- **Any changes in plan?**

An observation: *'it is not the Safety Report in isolation'*



Evaluation of Safety: an important element for decisions

Example: HLW repository - possible siting regions[1)] (NTB 05-02)

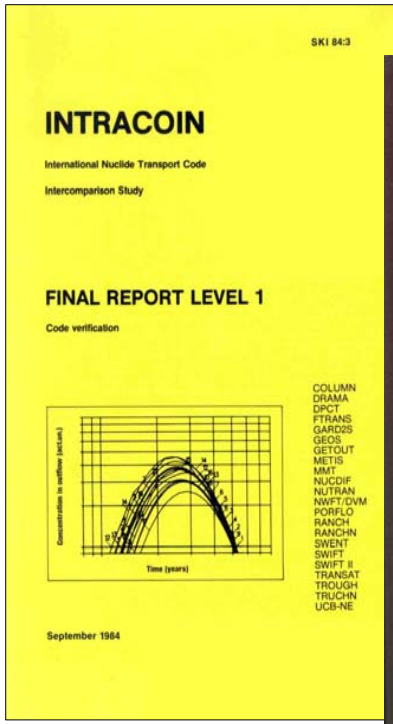


1) **considering the local geologic conditions**
(depth, lateral extent, complexity, …)

Boundary conditions for Safety Case

- The **Swiss regulations** (HSK/R-21): 1980 → 1993 ('smooth evolution')
  - dose target complemented by **risk target**
  - more explanatory comments on safety analysis
    - increased importance of **uncertainty** (e.g. explorability & predictability of geology)
    - importance of **system** (site, initial complete isolation (HLW), 'optimisation', ...)
    - more guidance on **modelling**, including definitions
- **International guidance & discussion** (IAEA, NEA, conferences, ...)
  - early days: **verification** → benchmarks
  - then: **validation** → 'model testing' (importance of experiments: URL, lab)
  - 'a more integrated approach': robustness, **confidence**, ...
  - today: **Safety Case** (overall system: phenomenological analysis, safety functions, ..., methodological aspects, ...)
- and **progress in science & technology**
  - growing **geological** information base & improved understanding (regional, site, URLs)
  - improved understanding of **engineered barrier system**
  - more detailed **design concepts**
  - in **many other areas** (wastes, geochemistry, ...): more details, better understanding

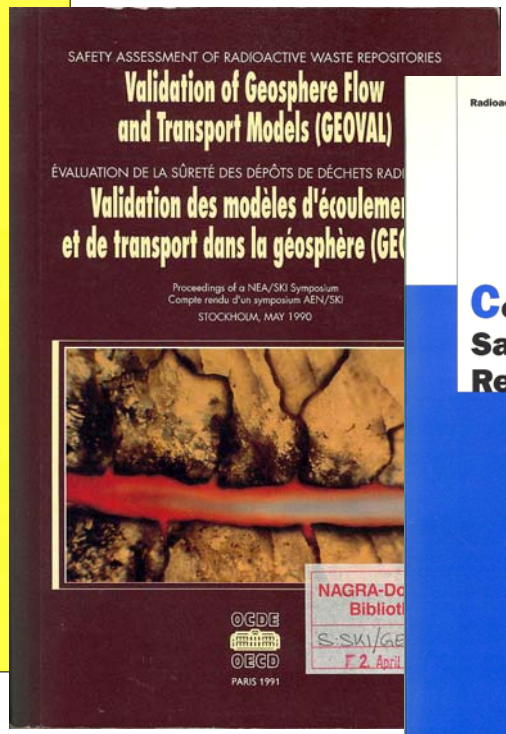
Increase in complexity & breadth (examples)



Verification ...

(the codes)

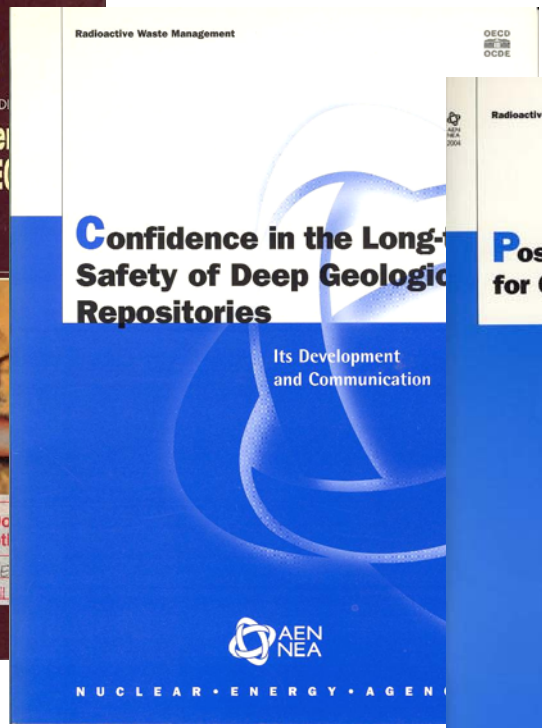
(1984ff)



Validation ...

(the processes)

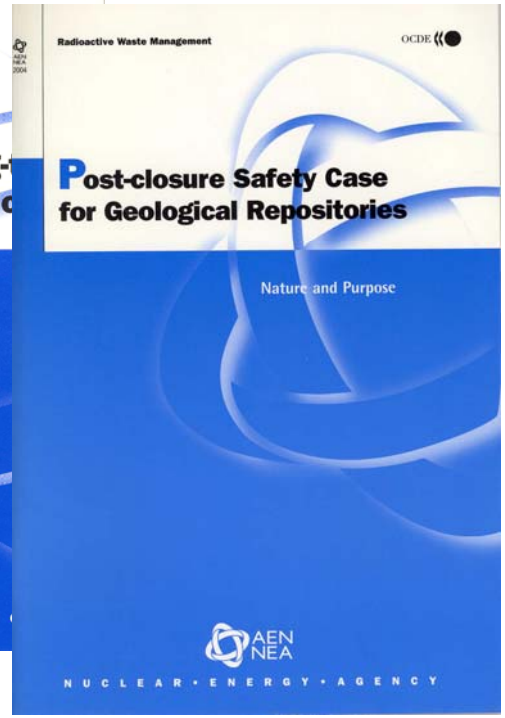
(1991ff)



Confidence ...

(the system & the methodology)

(1999)



Safety Case ...

(the system & the process)

(2004)

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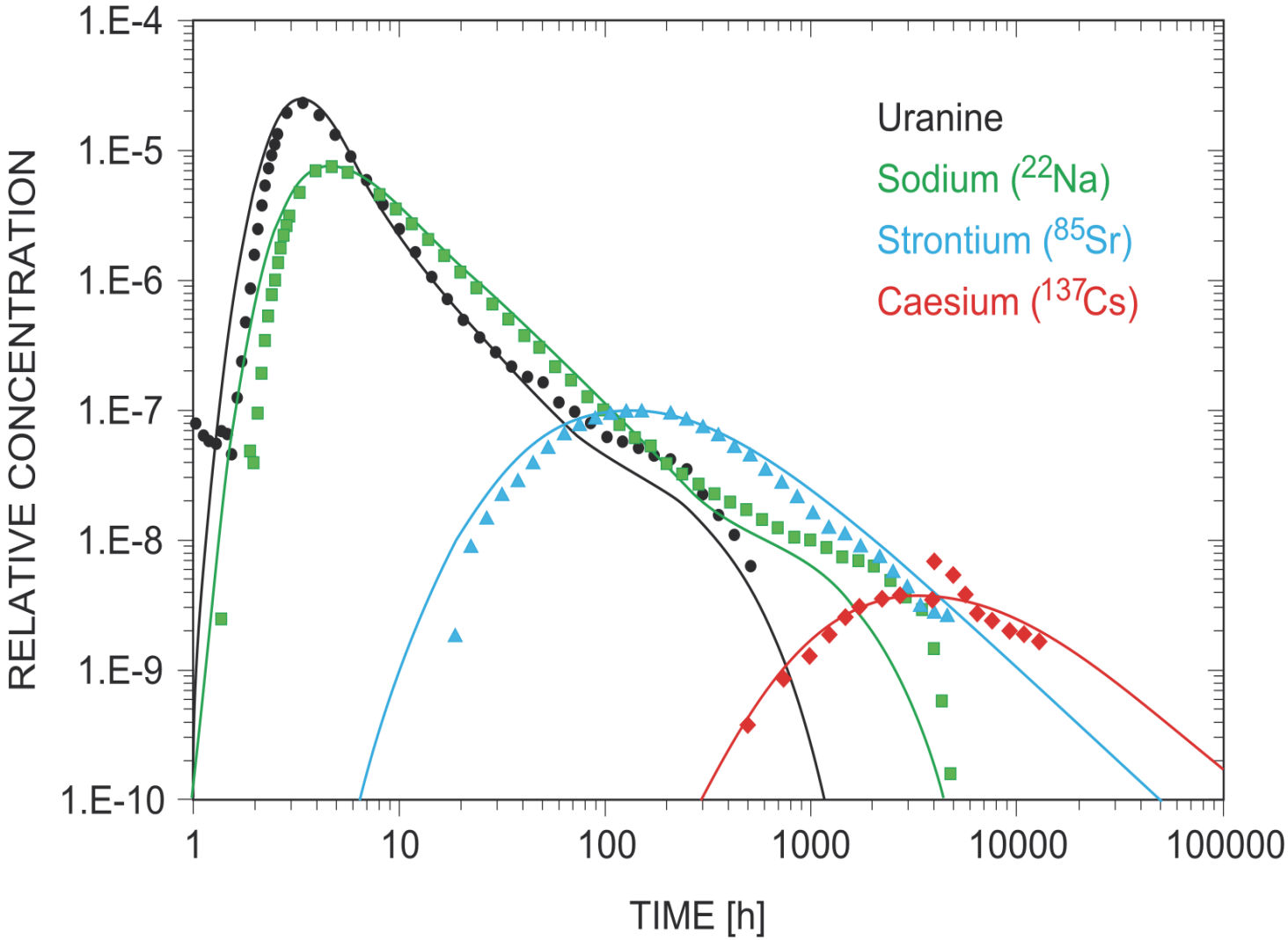
Model testing: Migration experiment - Grimsel Test Site



e.g.: Heer, NTB 04-03 (Fig. 14)

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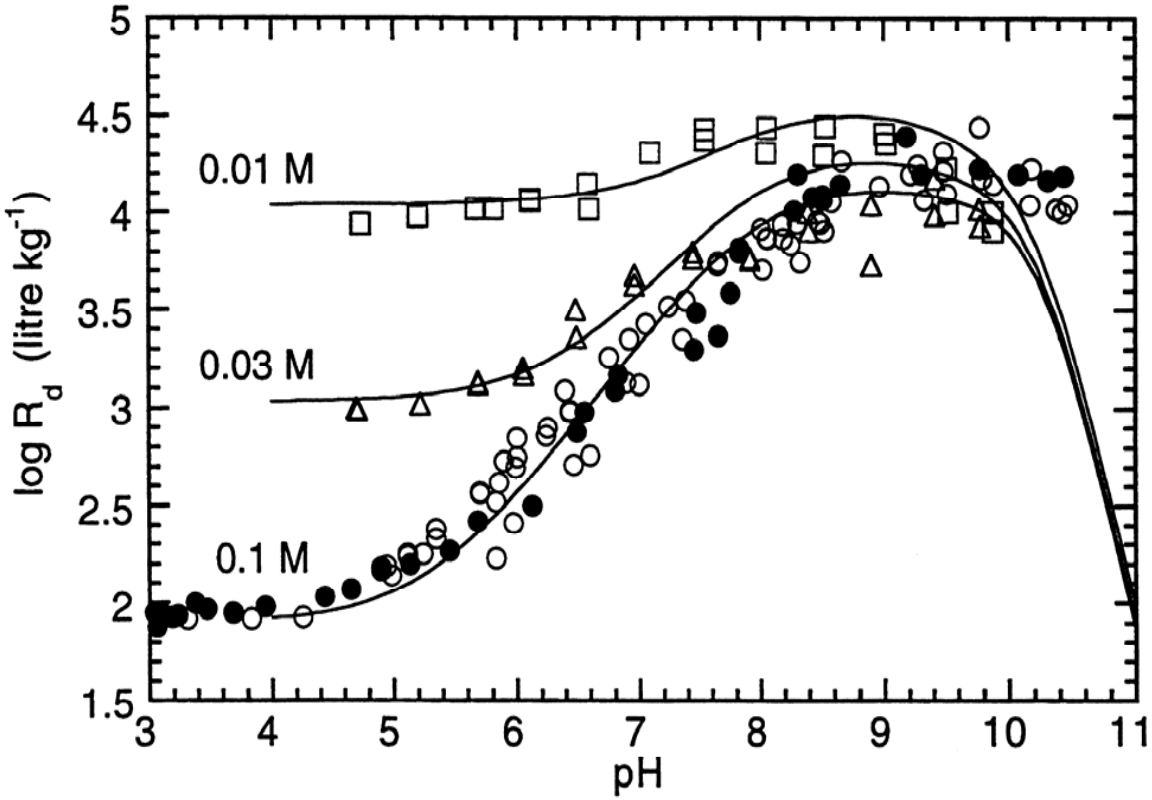
Model testing: sorption



Experimental data and modelled curves for Ni edges on conditioned Na-montmorillonite at 0.1 M (O,●); 0.03 M (Δ) and 0.01 M (❑) $NaClO_4$

Bradbury & Baeyens, NTB 95-06

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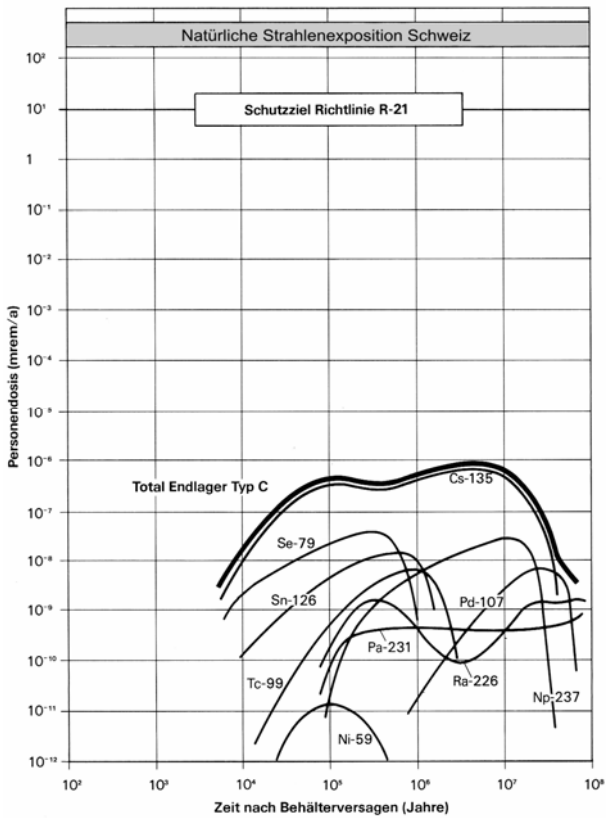
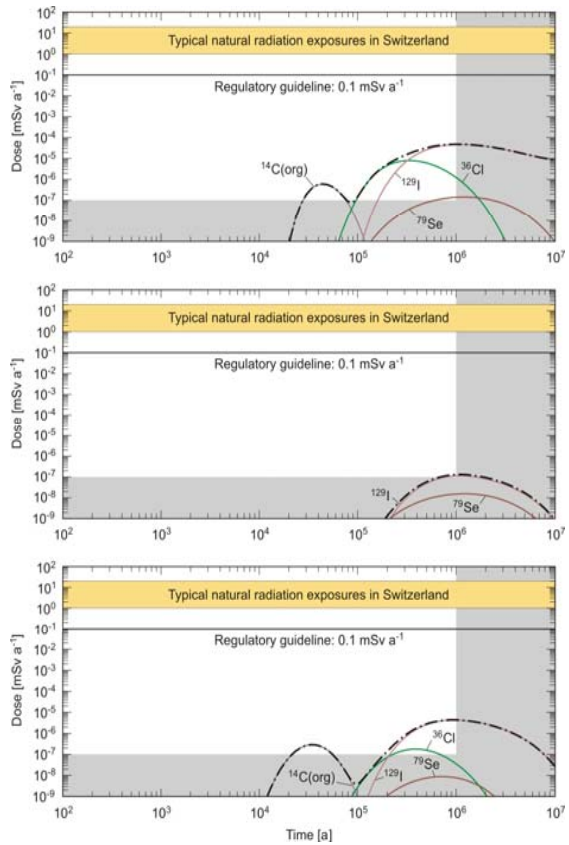
Dose curves from deterministic calculations ...

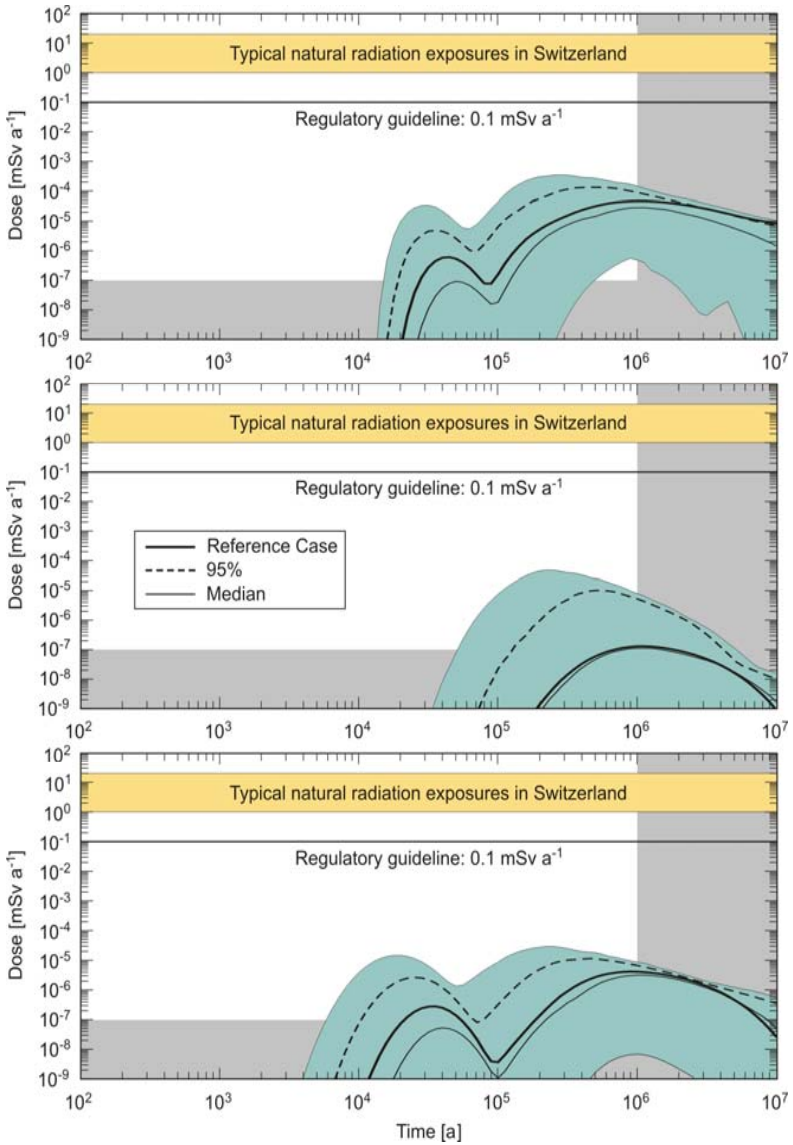
- Projekt Gewähr
- Project Opalinus Clay (EN)

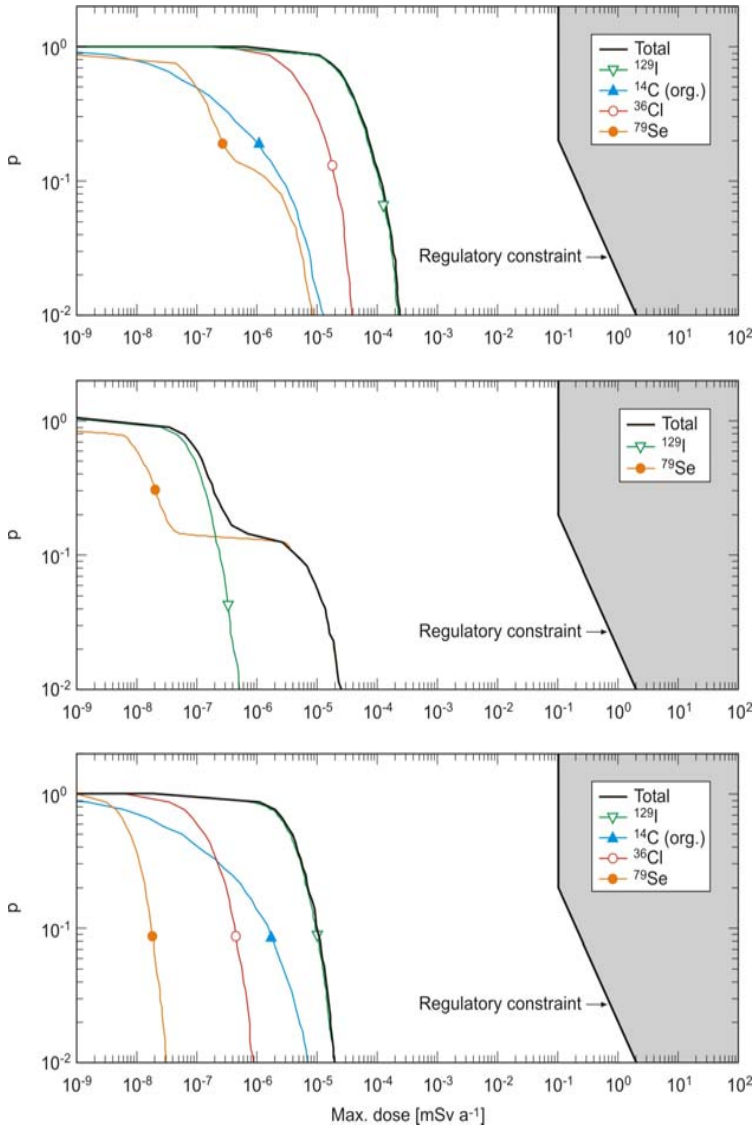




- broader scope (importance of other / minor waste streams)
- ~ same nuclides important (some differences) & similar doses
- presentation of results (avoid misunderstandings): shading of low doses / long time scales

... complemented by probabilistic analyses (P EN)





SF

HLW

ILW

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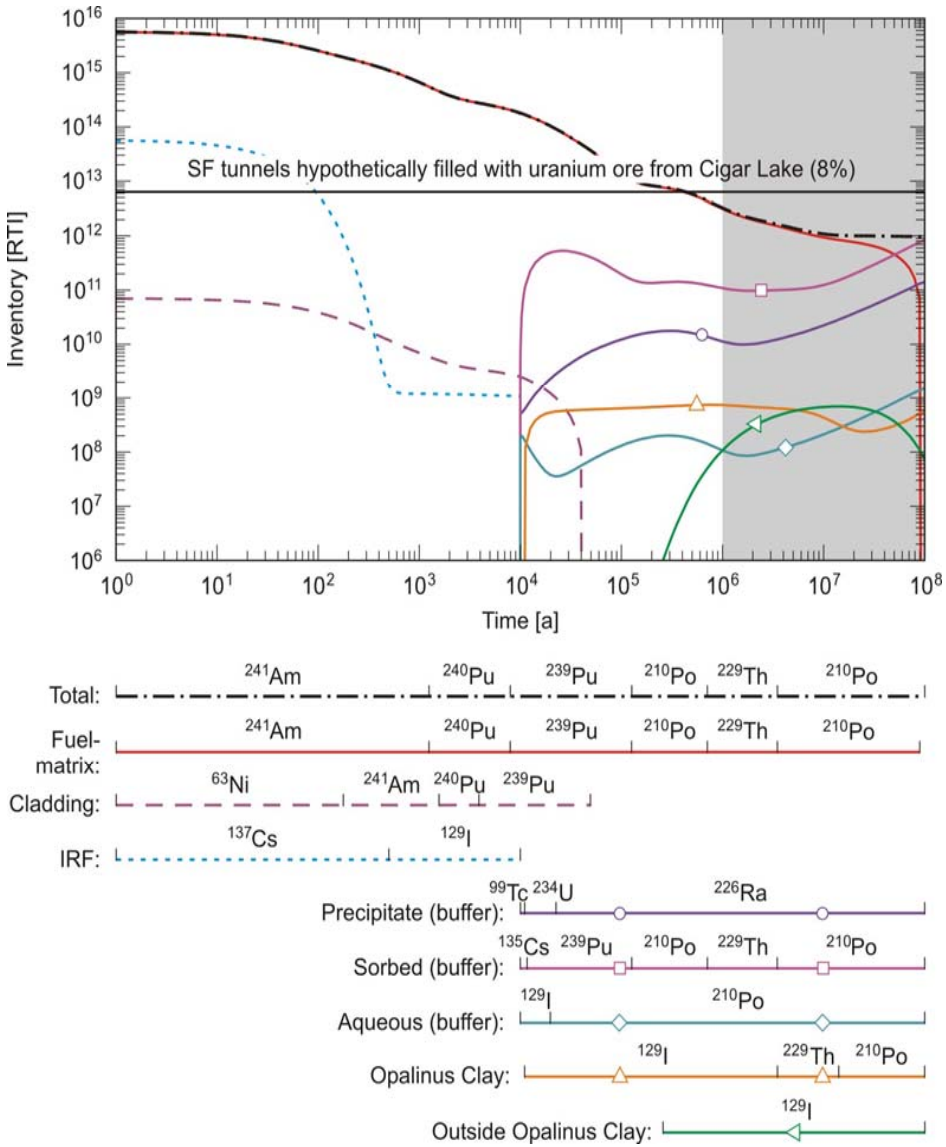
The fate of radionuclides in the disposal system (SF)



Understanding of ....

- phenomena that lead to **immobilisation**
- phenomena that lead to **transfer** from one component to the next
- the **time** involved
- the importance of **decay**

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Key observations - overview

- the issues in decision-making: the **quality of the system** & the **quality of our understanding** (ability to evaluate system performance) [1)]
- the importance of a sound **scientific basis** for the Safety Case
- the importance of identifying the relevant **uncertainties** & the availability of adequate means for their evaluation
- the importance of an adequate **team** & a suitable **methodology** to integrate the scientific basis & perform the evaluation
- the importance of the **tool box** (codes, computers, experimental methods, ..., information exchange, ...)
- the challenge of **documentation** (transparency & traceability → the importance of an appropriate structure)

1) disposal principles & assessment principles to enhance transparency

Key observations - some details (1)

- the importance of the **scientific basis** for the Safety Case
  - science as such (including: *how good is good enough?*)
  - interaction between science & performance assessment (incl. mutual respect) → completeness → simplifications → justification
  - unbiased integration of information (scientists, PA-specialists)
- the need for both **quantitative & qualitative arguments** and their **clear presentation**
- **quantitative arguments** for safety (safety indicators)
  - calculated dose & risk in comparison with regulatory targets
  - calculated doses in comparison with doses due to other sources
  - RN fluxes & RN concentrations (& comparison with those from natural RNs)
  - the fate of RNs (how far do they move, where do they decay)
- **qualitative arguments** for safety
  - clear qualitative understanding & description of the safety functions
  - transparent phenomenological evaluation
  - clear description of uncertainties & their potential impact

Key observations - some details (2)

- the importance of uncertainty
  - **importance of feedback** (*what to do with uncertainties)*: accept, reduce by more R+D, avoid / mitigate by modification of repository system[1)]
  - **elicitation** of uncertainties (completeness, appropriate description)
  - **analysis** of meaning of uncertainties
- ... and the different means to evaluate them (the tool box: methods, codes, computers, ...)
  - **phenomenological analyses** (incl. use of safety functions)
  - the role & the nature of **FEP analysis** ('book keeping', reserve FEPs, ...)
  - **process models**
  - insight calculations
  - sensitivity analyses (deterministic, probabilistic)
  - what-if calculations (deterministic, probabilistic)
  - broad spectrum of **deterministic calculations**
  - **probabilistic calculations / analyses**

1) different systems differ in the nature of their uncertainties (process, structure, ...)

Summary & conclusions

- The Safety Case is **integral part of stepwise approach**
- The Safety Case needs to be **focused on the decision at hand**
- Key elements of a successful Safety Case
  - Importance of **scientific basis** (*what is known? what not?*)
  - **Systematic processing** of information (*complete, unbiased, balanced*) with an adequate tool box (methods, codes, computers, etc.)
  - Assessment of **uncertainties**
  - **Feedback** (within current phase & input for next phase)
  - **Summary (quantitative & qualitative)** of key findings (*quality of system & quality of understanding*) → a well structured documentation (transparency & traceability)
  - The need for an **integrated & dedicated team**
- **None** of these issues **has been ignored** in the early times of PA, but the way how they are handled & their relative importance / breadth has changed
- Thus: we have seen a **(gradual) evolution** in developing the Safety Case - no revolution
- This is also reflected in the change in wording:

  Safety Analysis / Performance Assessment → Safety Case

  However, in Switzerland we did call and continue to call it a Safety Report (Sicherheitsbericht)

Thank you!

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Conference venue

Zentrum Paul Klee
Monument im Fruchtland 3
CH-3006 Berne (Switzerland)
www.zpk.org

Organiser

National Cooperative for the Disposal
of Radioactive Waste (Nagra)
Hardstrasse 73
CH-5430 Wettingen (Switzerland)
Tel.: + 41 56 437 11 11

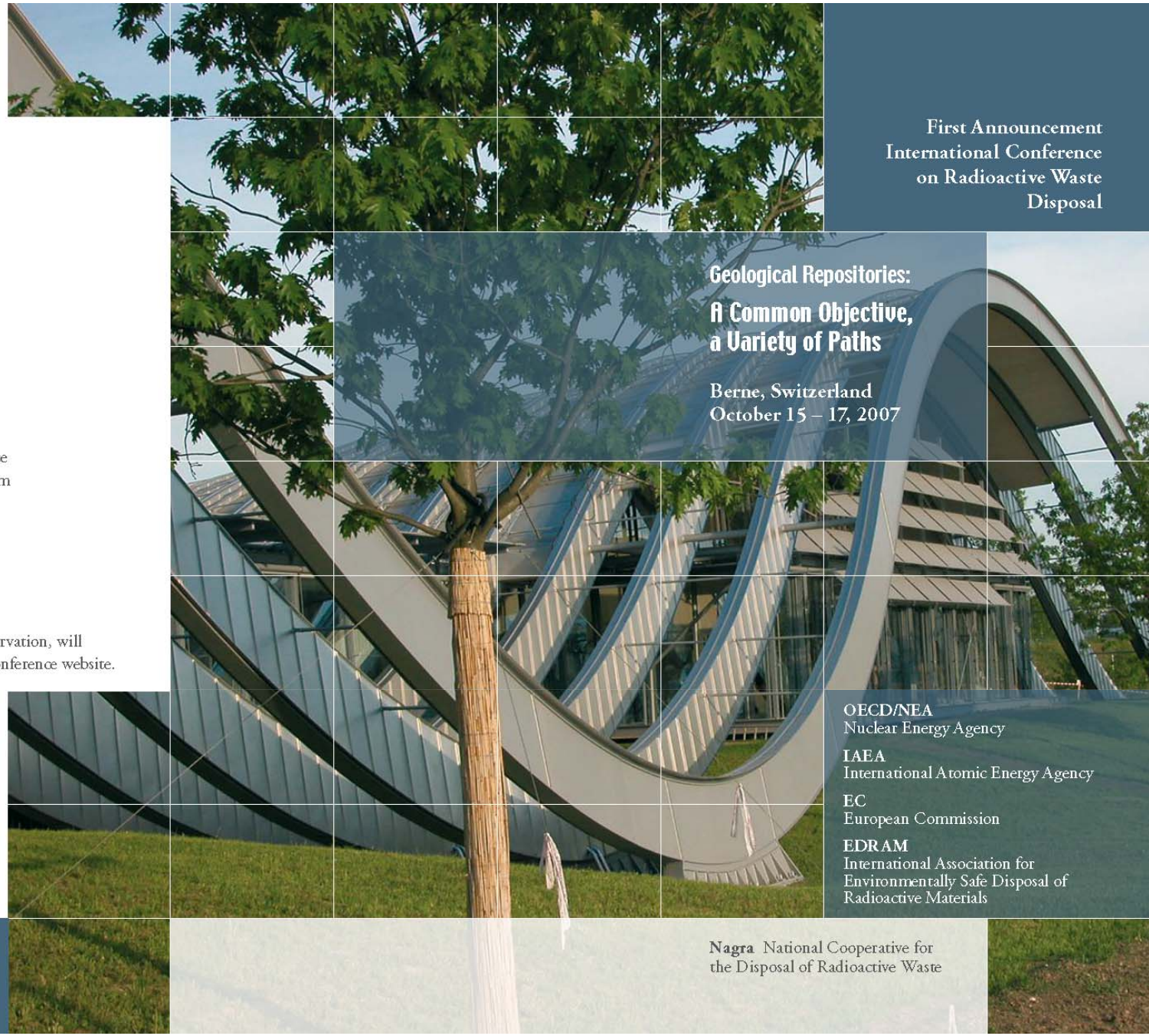
Language

The working language of the Conference
is English. Simultaneous translation from
French and German will be provided.

Information

www.icgr2007.org
info@icgr2007.org

Online registration, including hotel reservation, will
be available from March 2007 on the conference website.



First Announcement
International Conference
on Radioactive Waste
Disposal

Geological Repositories:
A Common Objective, a Variety of Paths

Berne, Switzerland
October 15 – 17, 2007

OECD/NEA
Nuclear Energy Agency

IAEA
International Atomic Energy Agency

EC
European Commission

EDRAM
International Association for
Environmentally Safe Disposal of
Radioactive Materials

Nagra National Cooperative for
the Disposal of Radioactive Waste

Photograph: Zentrum Paul Klee Berne