

Elements of the Safety Case for the Morsleben Repository Based on Probabilistic Modelling

Jürgen Wollrath¹, Matthias Niemeyer², Georg Resele²,
Dirk-Alexander Becker³, Peter Hirsekorn³

¹Bundesamt für Strahlenschutz (BfS), Germany

²Colenco Power Engineering Ltd, Switzerland

³Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), Germany

Content

- Introduction
- Closure Concept
- Safety Assessment Concept
- Results of Reference Case Calculations
- Results of Probabilistic Calculations
- Conclusions

Introduction – ERAM: LLW Repository in Rock Salt

- Repository in a former salt production mine
- Waste emplacement started in 1971 and ended in 1998
- 36,800 m³ of waste with activity of $\sim 1.7 \cdot 10^{14}$ Bq
- Safety assessments to support license application for closure

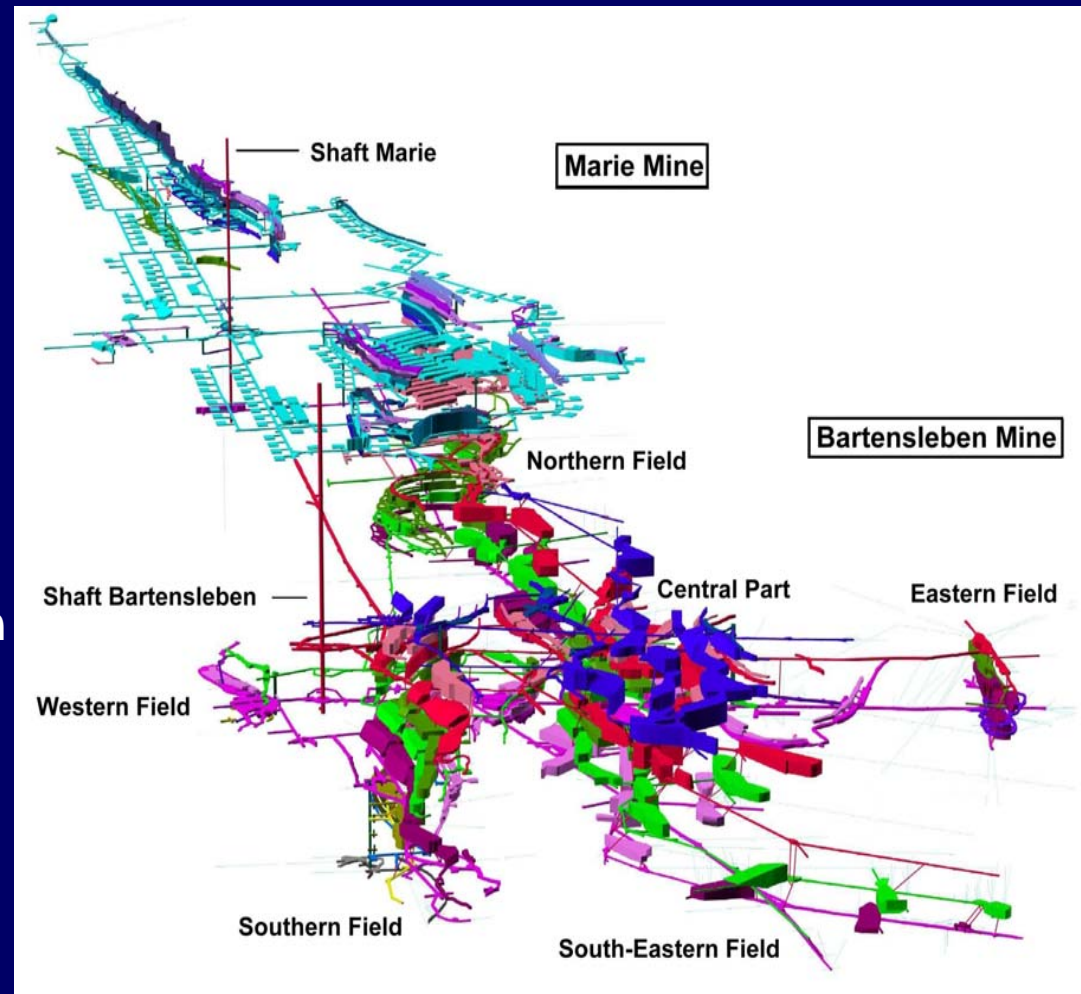


OECD/NEA Symposium Safety Cases for the Deep Disposal of Radioactive Waste: Where Do We Stand?, Paris 23-25 January 2007

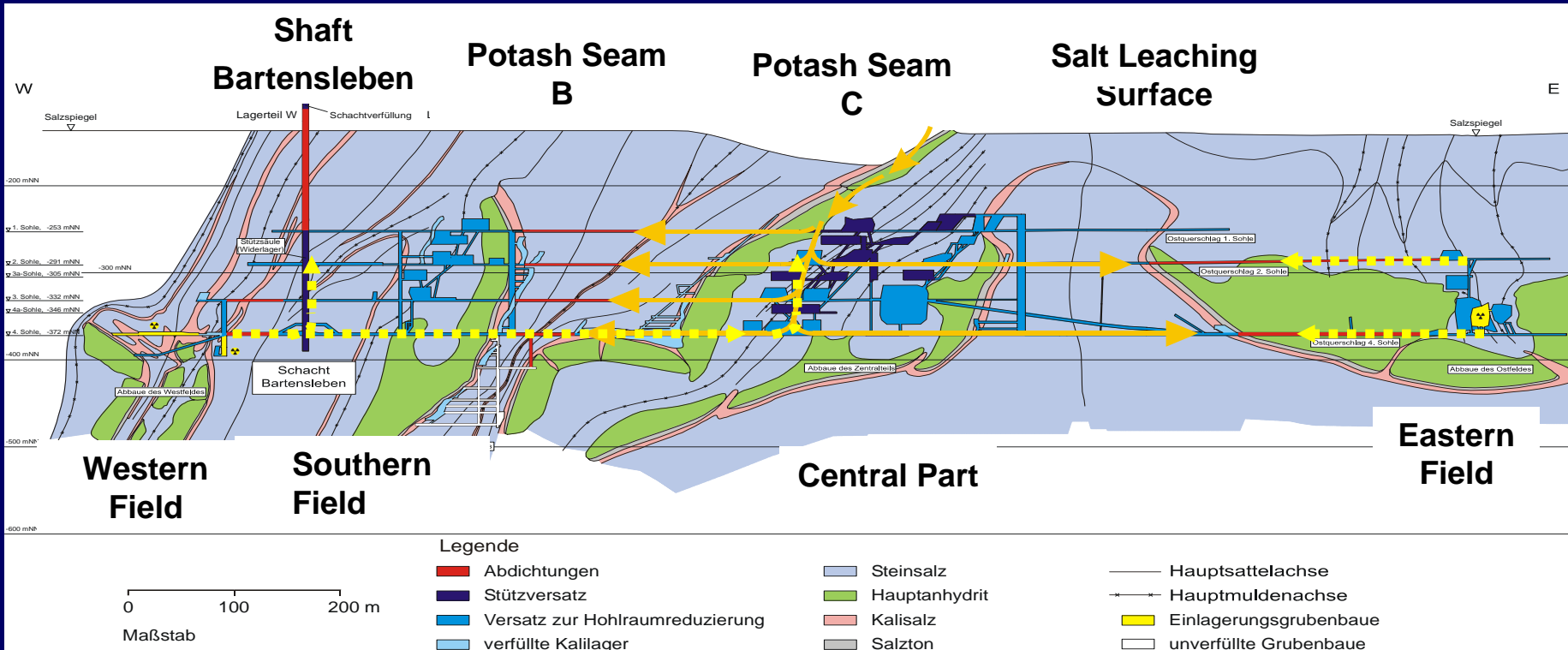
3

Introduction – Repository in a Former Production Mine

- 2 connected mines:
“Bartensleben” and “Marie”
- 2 shafts, 4 main levels
between 386 m and 596 m
- Total volume of mined
structures: $\sim 8.7 \cdot 10^6 \text{ m}^3$
- Waste emplacement
exclusively in Bartensleben
mine
- Mainly in the peripheral
parts (WF, SF, EF), but
also in CP, NF



Closure Concept - Scenario



potential flow paths

Closure Concept – Step-wise Iterative Approach

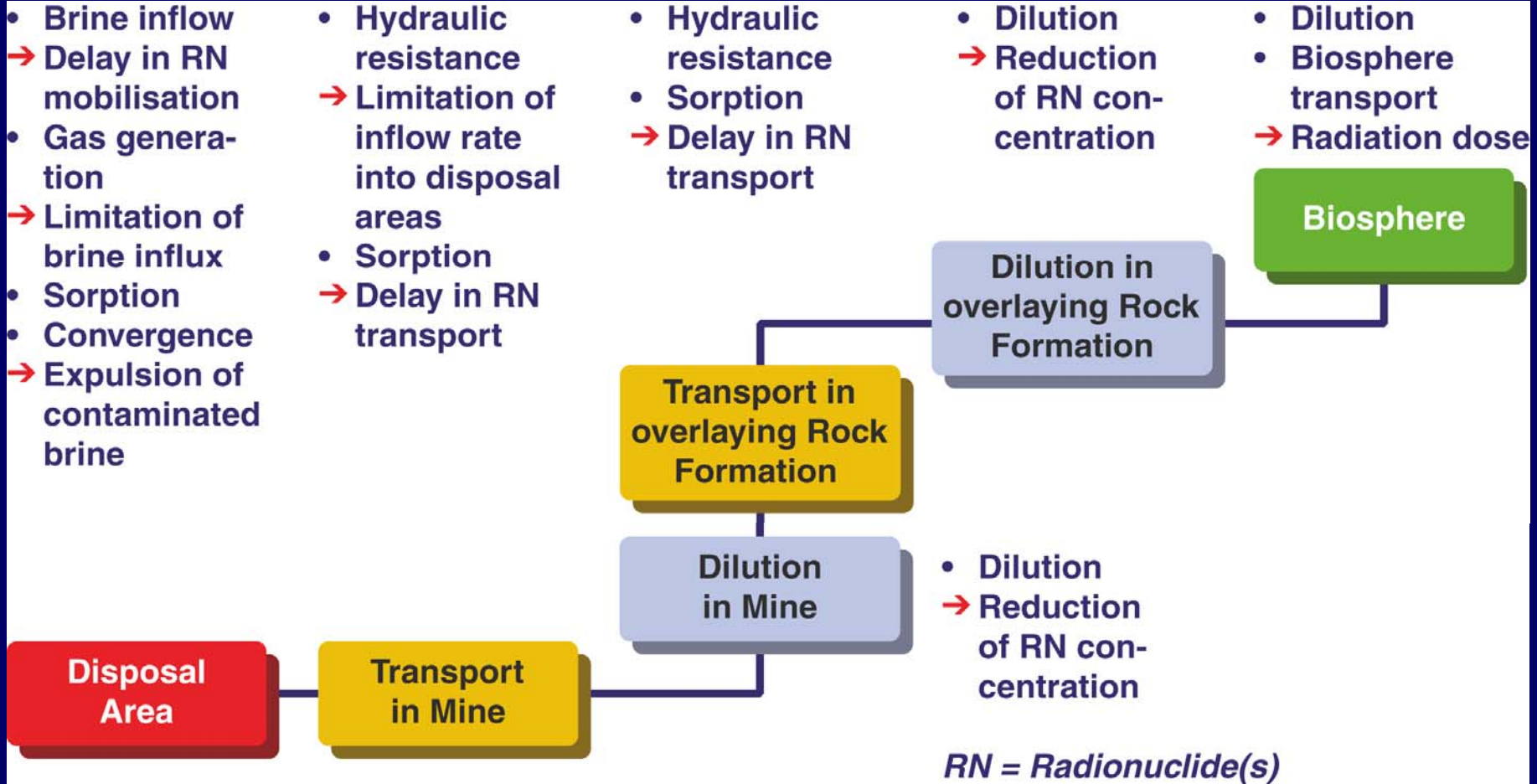
- Elaboration of several concepts
 - Assessment by different teams with respect to technical feasibility and long-term safety
 - Encapsulation concept: excluded due to lack of technical feasibility
 - Pore reservoir concept: discarded because of required sophisticated technical measures and very detailed exploration of the host rock
 - Sealing concept
 - Concept of extensive backfilling
 - ↪ Sealing of major disposal areas and extensive backfilling of open cavities with inexpensive material using state-of-the-art technology
- combined

Closure Concept – Main Features

- Extensively backfilled mine has a high resistance to movement of brine
- Extensive backfilling stabilises the mine structures and reduces the convergence of remaining openings
- Sorption and limited solubility reduce the fraction of radionuclides being released from the sealed emplacement areas
- Backfill material provides a medium for sorption at least for some of the radionuclides
- Remaining open volumes and porous backfill allow for temporary storage of at least part of the generated gas, thus reducing potential pressure build-up
- Remaining open volumes contribute to dilution with non-contaminated brine

7

Safety Concept - Processes



OECD/NEA Symposium Safety Cases for the Deep Disposal of Radioactive Waste: Where Do We Stand?, Paris 23-25 January 2007

8

Safety Assessment Concept – Model Characterisation

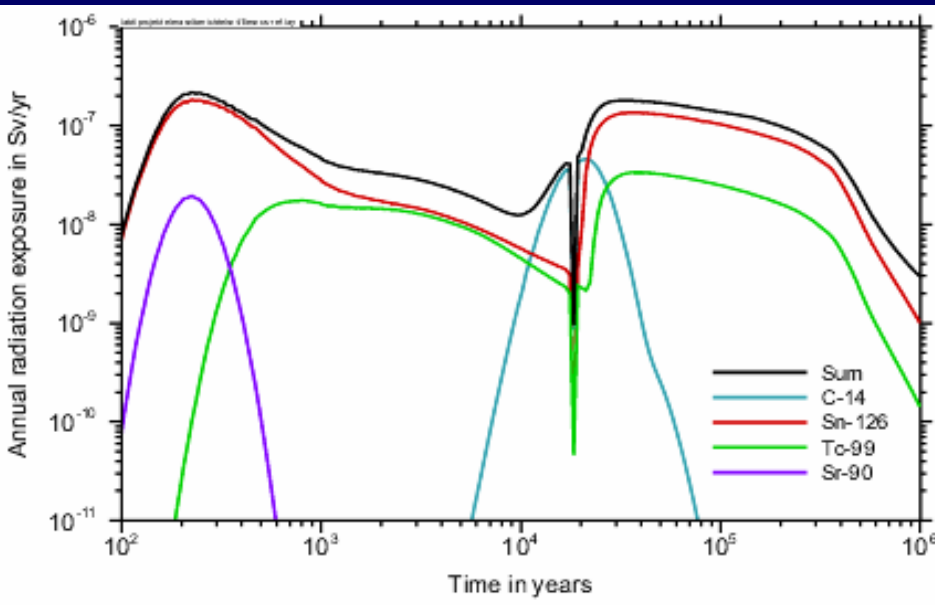
- **Model describes all important processes**
- **Model covers a multitude of possible system configurations**
- **Conceptual simplifications and numerical approach result in short computation times**
- **> 200 parameters necessary to describe the system + parameters for ~ 50 radionuclides**
- **A number of parameter values cannot be determined exactly and are therefore considered with a rather large bandwidth**
- **The response of the system to parameter variations is highly non-linear, therefore selection of a conservative parameter set is not possible**

Safety Assessment Concept – Confidence Building

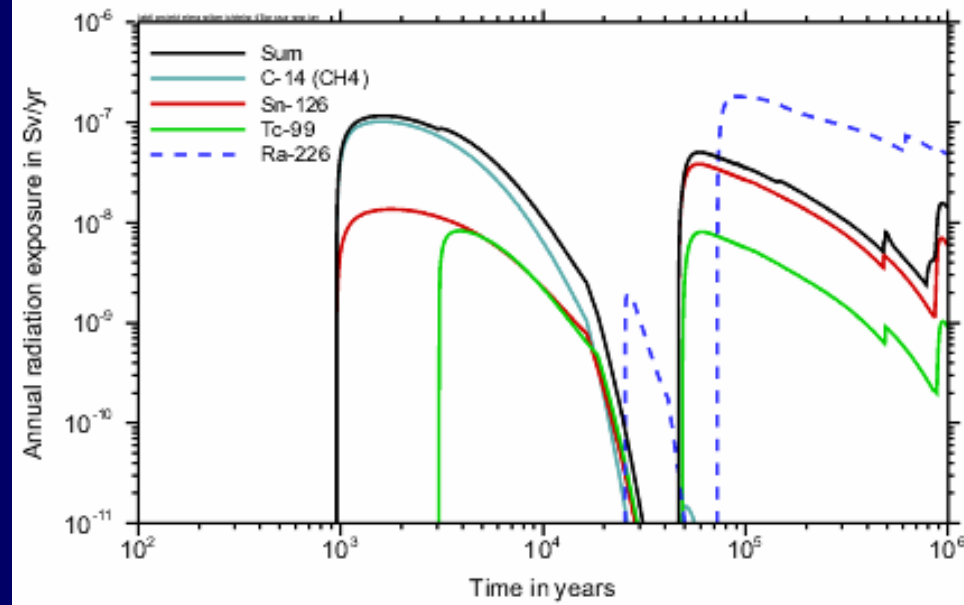
- Safety assessment concept was developed independently by two groups
- The models differ
 - in the conceptual simplification of the mine building,
 - in the assumptions on the composition of brine in contact to the seals,
 - in the conceptualisation of the two-phase processes and
 - in the conceptualisation of the water flow in the overburden and in the aquifer
- The final safety assessments are based on the same data set but different codes
- From time to time, intermediate reports were written and compared
- ↪ Independence was kept and critical review of each others' results was possible

10

Results of Reference Case Calculations



GRS - EMOS



Colenco - PROSA

Results of Reference Case Calculations

- The calculated exfiltration of RN within the first several 1000 years is a consequence of the conservative assumption that the entire mine outside the sealed areas is instantaneously saturated by inflow of brine from the cap rock
- The first calculated peak is caused by the small amount of radwaste in disposal areas that cannot be sealed
- The delay of the first peak is caused by transport through the cap rock and overburden
- The second peak is caused by the radwaste in the sealed disposal areas
- The delay of the second peak is caused by the resistance of the seals to corrosion by brine for tens of thousands of years

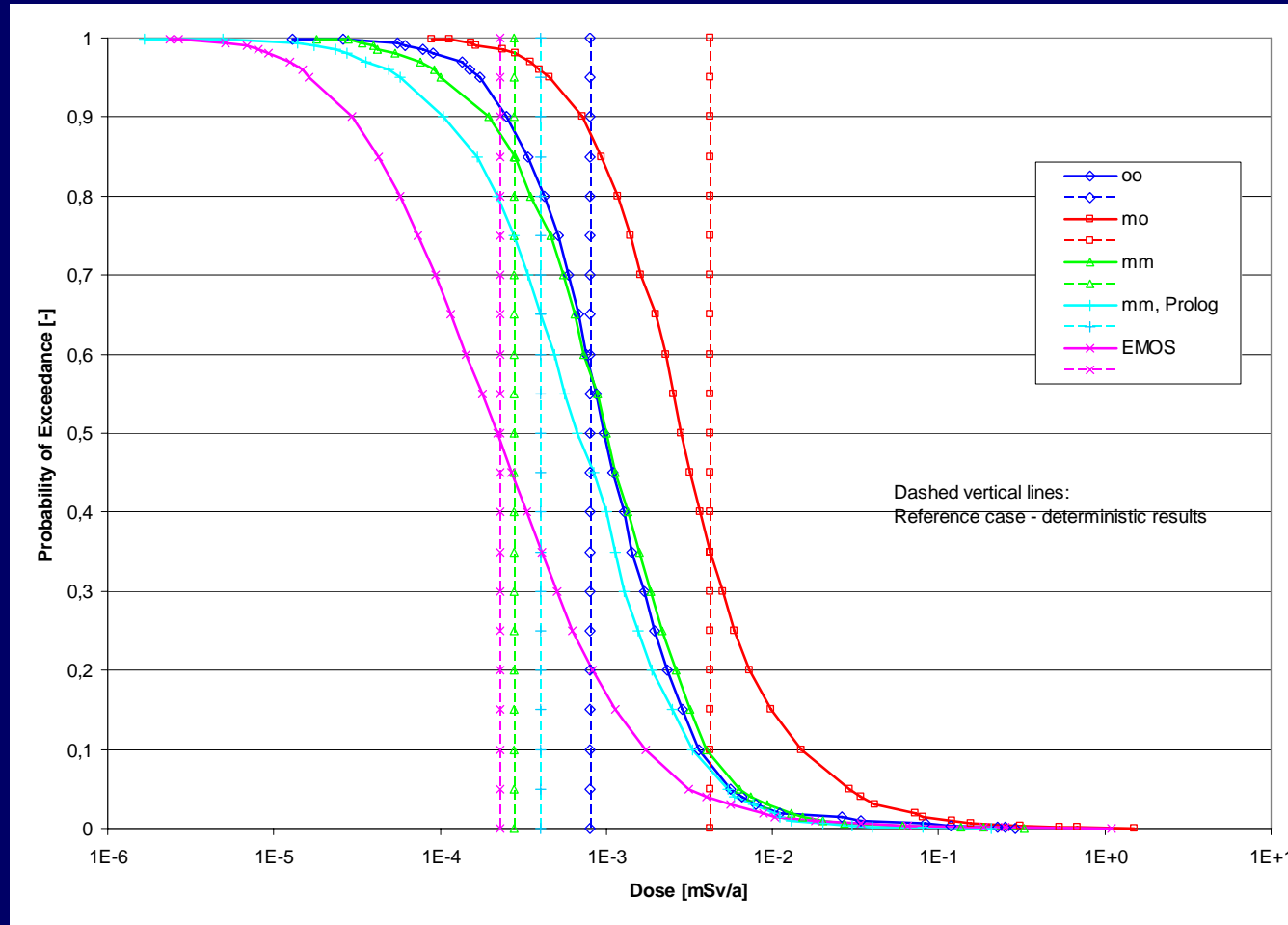
12

Results of Reference Case Calculations (cont.)

- The differences between the results of EMOS and PROSA are caused by differing conceptual assumptions
- In EMOS the gas generated outside the sealed disposal areas displace contaminated brine, resulting in a high flow rate and a rather short transport time during the first few 100 years
- Based on the assumption that gas in this early period cannot really displace contaminated brine, PROSA calculates a lower flow rate and a longer transport time resulting in a bigger delay of the first arrival of RN in the biosphere
- The bigger delay of the second peak calculated by PROSA is caused by different assumptions concerning the corrosion capacity of the brine migrating through the seals

13

Results of Probabilistic Calculations



PROSA

oo: 1,000 runs where gas generation does not influence the inflow of brine into the disposal areas and does not enhance the displacement of brine from the disposal areas

mo: 1,000 runs where gas generation enhances pressure build-up in the disposal areas; the gas hinders first the inflow of brine and later expels brine from the disposal areas; the gas cannot escape from the disposal areas

mm: 1,000 runs where gas generation enhances pressure build-up in the disposal areas; the gas hinders first the inflow of brine into the disposal areas; gas and brine are later simultaneously expelled through the seals

mm, Prolog: 1,000 runs like mm, but delayed inflow of brine from the cap rock into the mine

EMOS

2,000 runs

Results of Probabilistic Calculations

- With PROSA 3 different conceptualisations regarding gas behaviour and 1 conceptualisation regarding delayed inflow of brine with 1,000 randomly chosen parameter sets for each conceptualisation were calculated
- With EMOS 2,000 randomly chosen parameter sets were calculated covering the 3 conceptualisation of PROSA regarding the behaviour of gas
- > 99 % of all realisations are well below the dose constraint of 0.3 mSv/a
- The few realisations which slightly exceed the dose constraint result from parameter values lying close to the extremes of their bandwidth
- Because EMOS covers a broader range of system behaviour than one set of PROSA the slope of EMOS results is not as steep

Conclusions

- Safety assessment for ERAM has been performed by two groups
 - using different conceptual models and codes
 - but identical parameters and distribution functions
- Calculated radiation exposures are well below applicable dose constraints
- The results of the two groups correspond satisfactorily
- The results from the probabilistic calculations corroborate the one from the deterministic calculations
- Differences in the results from the two independent groups are well explainable
- They are related to the different model conceptualisations
- These findings significantly enhance the confidence in the model results
- Therefore, they contribute significantly to the safety case for ERAM

16

Thank you

OECD/NEA Symposium Safety Cases for the Deep Disposal of Radioactive Waste: Where Do We Stand?, Paris 23-25 January 2007

17

| Verantwortung für Mensch und Umwelt |

COLENCO
Colenco Power Engineering Ltd

GRS


Bundesamt für Strahlenschutz