
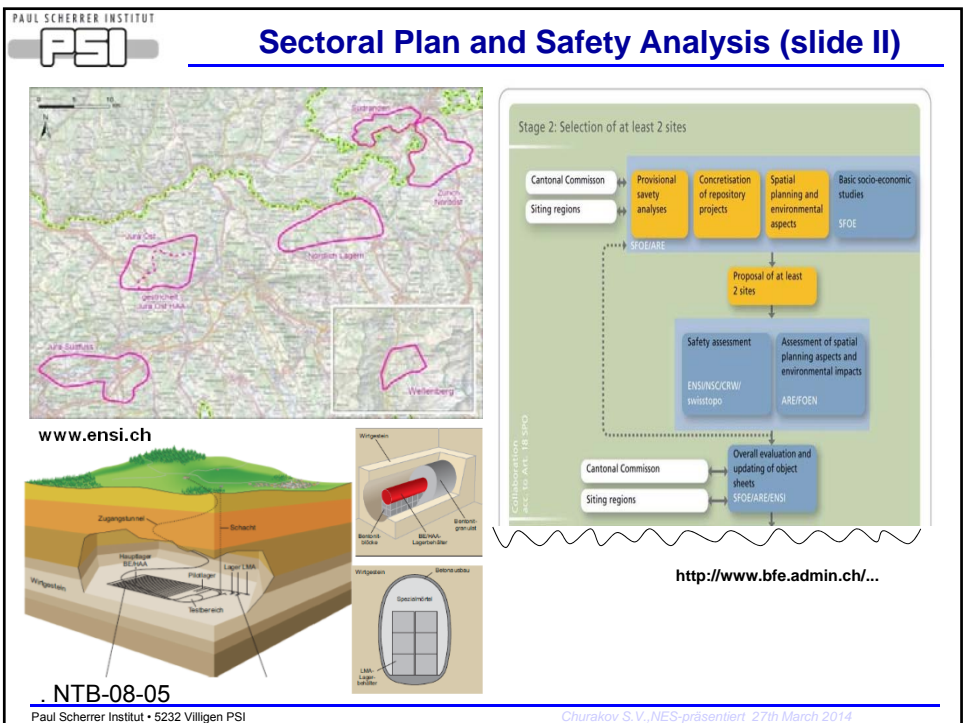
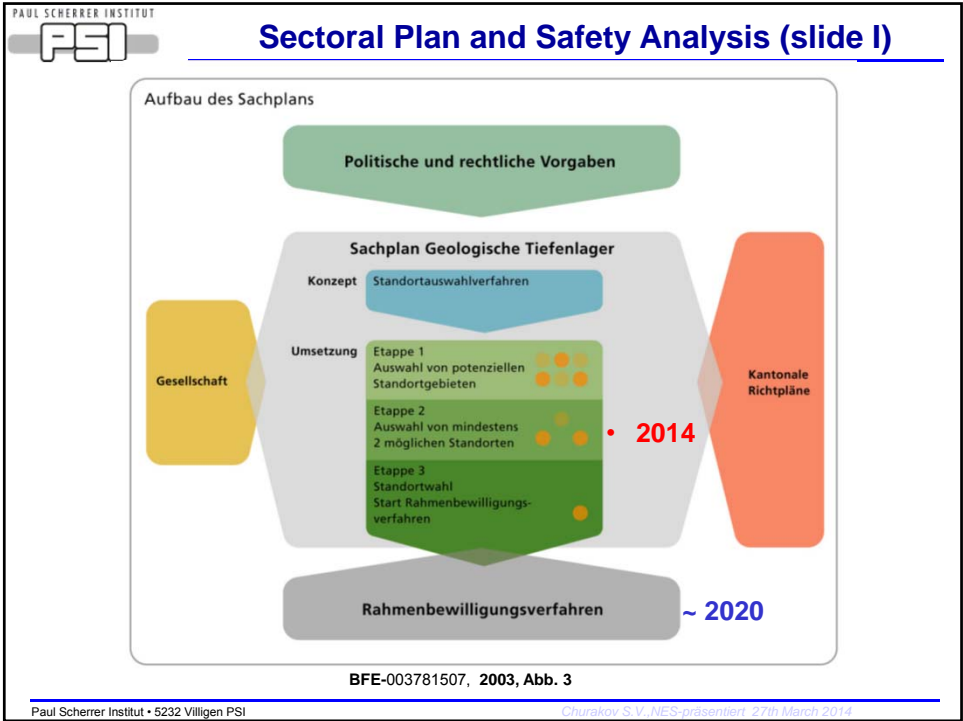


 <p>PAUL SCHERRER INSTITUT</p>	<p>Nuclear Energy and Safety Research Department Laboratory for Waste Management</p>
	
<p>Wir schaffen Wissen – heute für morgen</p>	
	<p>Paul Scherrer Institut</p> <p>Sergey V. Churakov</p> <p>Laboratory for Waste Management (LES)</p> <p>20 March 2014</p>

 <p>PAUL SCHERRER INSTITUT</p>	<h2>Outline</h2> <hr/>
<ul style="list-style-type: none">• Why LES is needed in Switzerland?• History• Mission• Vision• Core competences• Research foci• Laboratory structure• Selected Projects and highlights• Facts and figures• Summary	
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Sectoral Plan and Safety Analysis (slide III)

Fig. 1. ENSI 33/075

Fig. 3.3-6: Berechnete Dosen für ein SMA-Lager in einem homogen-porösen Wirtgestein. NTB-08-05

Sorption data and models

Diffusion data and models

Thermodynamic data and models

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History

- Federal Act on the Peaceful Use of Atomic Energy 6 Oct. 1978
- Projekt Gewähr 1985 -1988
- PES: Program Entsorgung 1988 - 06/1993
- LES: Labor für Endlagersicherheit 07/1993 - 07/2015
- A joint professorship between PSI and Uni-Bern 08/2015 -

**Laboratory for
Waste Management, PSI**

**Laboratory for
Mineralogy, Bern**

- Strengthen national collaboration in the field of waste disposal
- Complement and expand core competences
- Use synergies and eliminate weaknesses

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LES Mission

- LES carries out **experimental program on geochemical retention and transport** of trace elements in the field of **radioactive waste disposal**.
- LES develops **holistic descriptions of transport and sorption processes, in situ conditions and up-scaling**.
- Together with the laboratory of Mineralogy in the University of Bern, LES focuses on **basic and applied research** in the physical chemistry of **high surface area materials** and their **technological applications**.

The aim is to provide **realistic model concepts**, reliable expert knowledge and robust data for **Performance Assessment studies of the Swiss waste disposal program** which are supported by the broad scientific community.

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LES Vision

Multi-disciplinary **center of excellence** on the **geochemistry of deep geological repositories**, the physical chemistry of **functional geo-materials** and applied **environmental geochemistry**.

The laboratory takes a **national lead in education** in the areas of:

- Geochemistry of **waste disposal** and **environmental pollution**
- **Experimental** and **computational** environmental **mineralogy**

Makes full use of the the **large scale facilities** at PSI and world wide, **analytical infrastructure** at the University of Bern, and the **high performance computing** resources at national and international centers.


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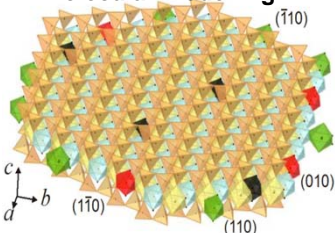
PSI **Core Competences (Slide 1)**

- Sorption measurements and model development for mechanistic understanding of contaminants retention by minerals

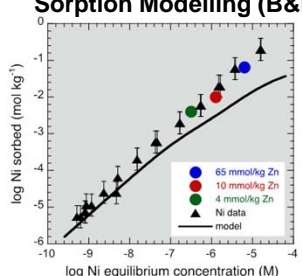
Sorption Experiment



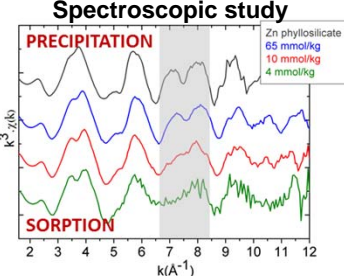
Molecular modelling



Sorption Modelling (B&B)



Spectroscopic study



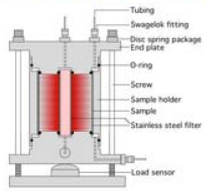

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PSI **Core Competences (slide 2)**

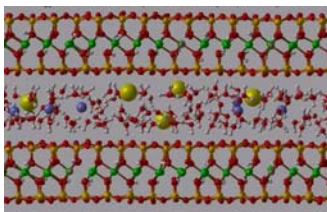
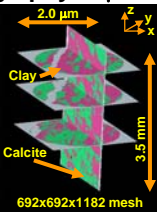
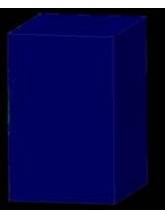
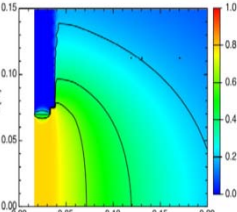
- Diffusion measurements and multi-scale transport simulations from an atomic level to a geological scale

Laboratory and Field scale diffusion experiments

Diffusion parallel to bedding

Tomography at μm scale

Multi-scale simulations

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Core Competences (slide 3)

- Geochemical modelling of in situ conditions in energy-related subsurface systems (e.g. waste repositories, geothermal reservoirs, contaminated sites)

Modelling of natural and engineered system

Experimental benchmarks and natural analogues

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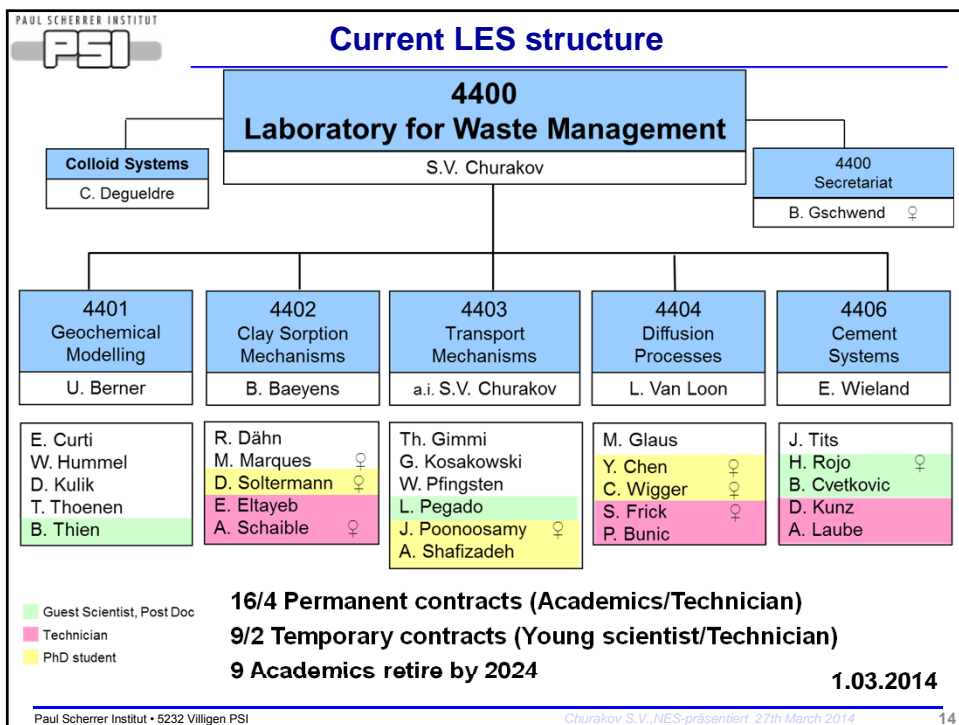
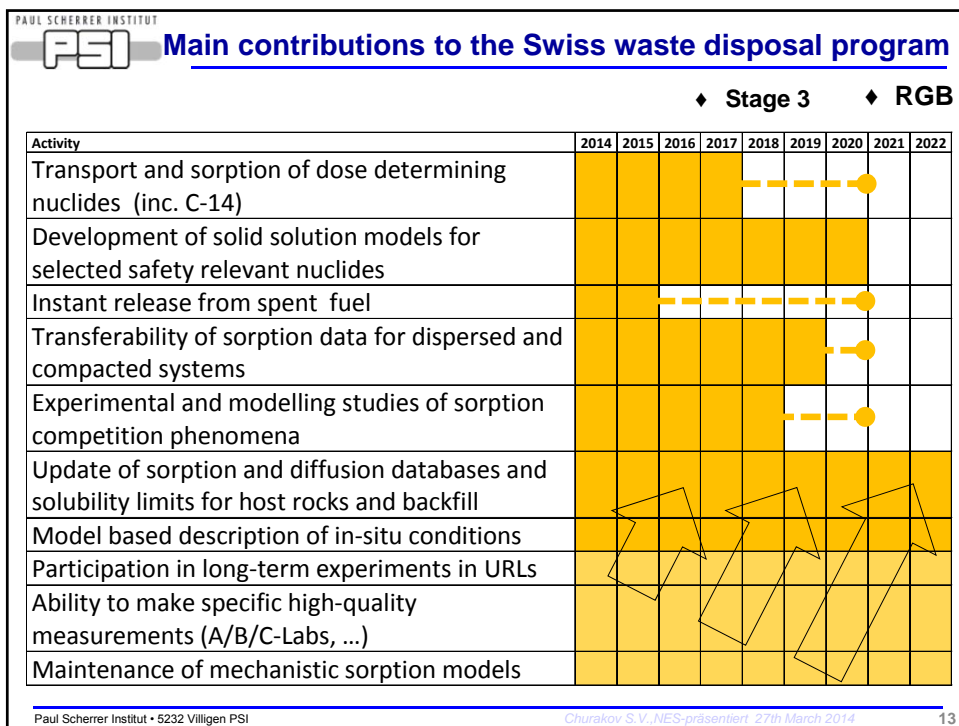
Core Competences

Scientific basis for the safety assessment of Swiss radioactive waste repositories

- Process understanding, models and databases
- Reactive transport modeling of repository in situ conditions

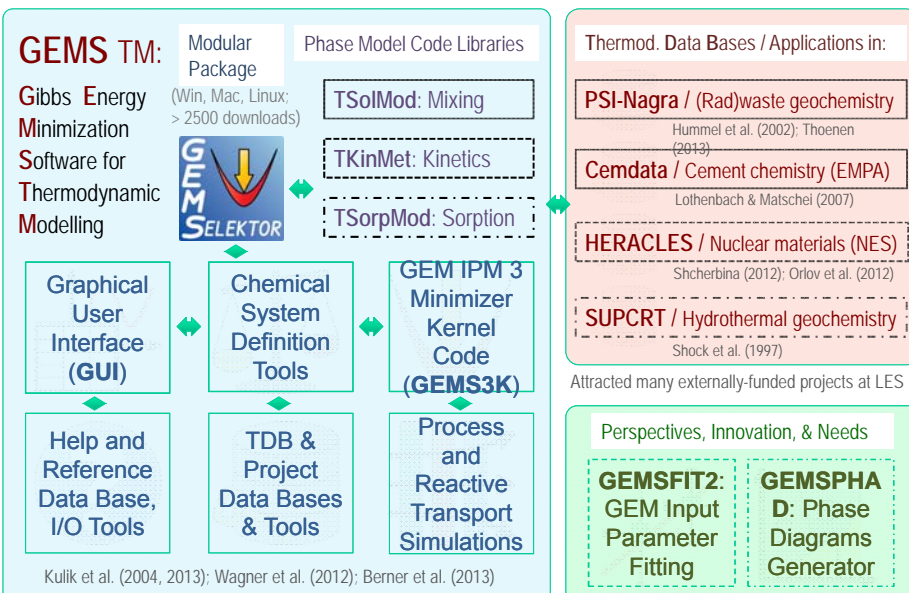
59 NTBs reports since 1995

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Selected projects and scientific highlights

Collaborative project GEMS gems.web.psi.ch




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Reactive transport modelling

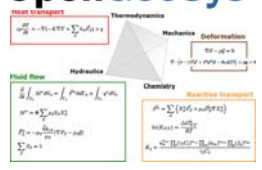


GEM-Selektor: thermodynamic modelling of aquatic (geo)chemical systems by Gibbs Energy Minimization



PSI/Nagra thermodynamic database, CEMDATA, SUPCRT92 dataset, etc.

OpenGeoSys



modeling platform for coupled phenomena in porous and fractured media

OpenGeoSys-GEM

- Fully and partially saturated fluid flow (H) in fractured and porous media
- Multi-species solute transport (T)
- Heat transport (T)
- Chemical thermodynamic and kinetics (C)

-> coupled T-T-H-C phenomena

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HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG
UFZ

Cooperative development and application platform

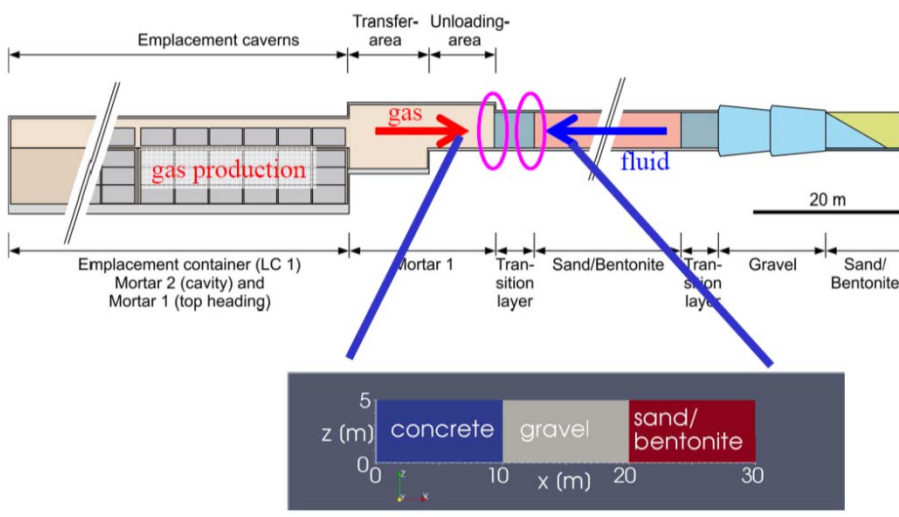
Kosakowski, G., Watanabe, N. 2014. OpenGeoSys-Gem: A numerical tool for calculating geochemical and porosity changes in saturated and partially saturated media. Physics and Chemistry of the Earth, Parts A/B/C.
 Shao H., Dmytrieva S., Kolditz O., Kulik D.A., Pflingsten W., Kosakowski G. (2009) Modeling reactive transport in non-ideal aqueous-solid solution system, Applied Geochemistry, 24 1287-1300

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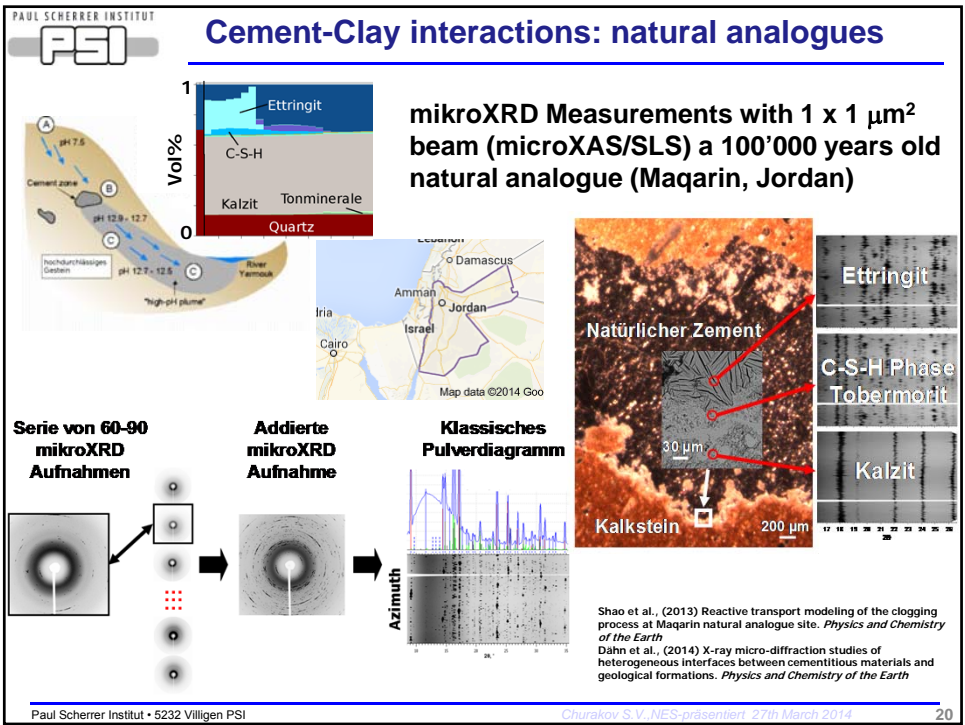
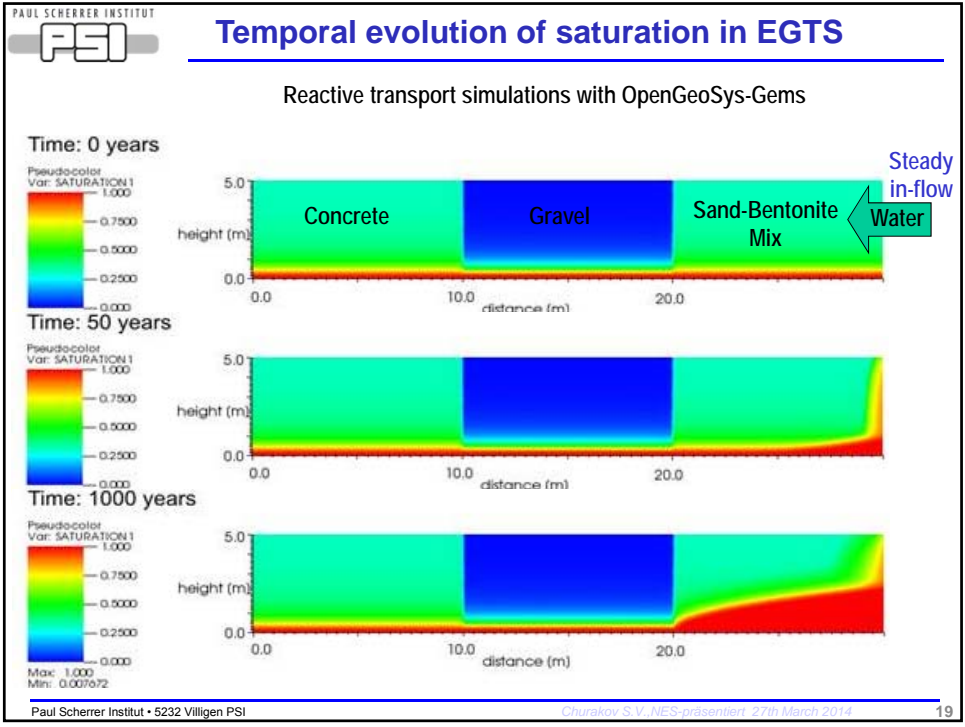
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Chemical evolution of EGTS

EGTS: Engineered Gas Transport System



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PSI **Determination of the ^{14}C inventory in activated steel**

Compound specific quantification of ^{14}C inventory formed during anoxic corrosion of activated steel
 Project partially financed by Swissnuclear; Cooperation: PSI – AHL/LCH/LES – Nagra

Result from Phase I: Characterization of activated steel nuts from Swiss NPP

1) Preparation of samples for laboratory experiments

Position of steel nuts in the reactor core („Führungrohrmuttern“)

Transport from NPP to the PSI hot lab

10 mm

Cutting

2) Determination of ^{14}C inventory in small segments from the steel nuts

Stepwise dissolution of steel segment in boiling acid:
 Transformation of $\text{C} \rightarrow \text{CO}_2$

Apparatus

Summary:
 ^{14}C inventory in activated steel from a Swiss NPP has been determined for the first time
 ^{14}C inventory is very low ($17 \cdot 841 \pm 2 \cdot 524 \text{ Bq g}^{-1}$)
 The data to be compared with ^{14}C estimations by Nagra's activation model

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PSI **EU FP-7 project FIRST-Nuclides (PSI contribution)**

Material: high-burnup NF fragments \pm cladding from Swiss NPP
 Leach solution: 19 mM NaCl + 1 mM NaHCO_3
 Sampling: 7, 28, ... 364 days (15 or 30 mL)
 Analyses: ^{137}Cs , ^{129}I , ^{79}Se , ^{14}C , ...
 => Instant Release Fractions (IRF)

total activity: 45 LA
 Dispersed SNF particles in Kapton (pellet "inprint")

SNF data
 Se(-II) reference
 Micro XANES suggests Se may occur as selenide (Se-II) in SNF

Monochromatic X-ray (microbeam)


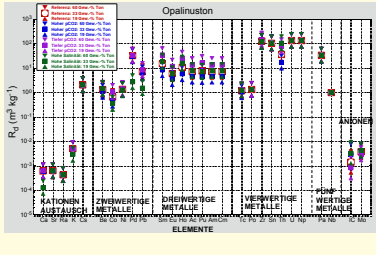
MicroXAS beamline @ SLS

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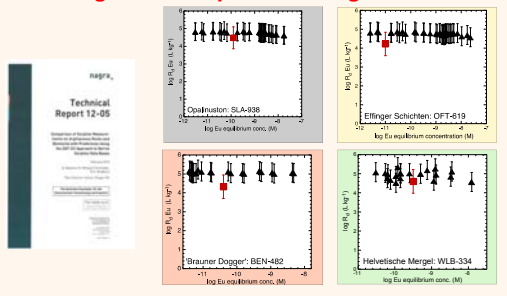
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Sorptionsdatenbasis: Methodik, Messungen, Ergebnisse

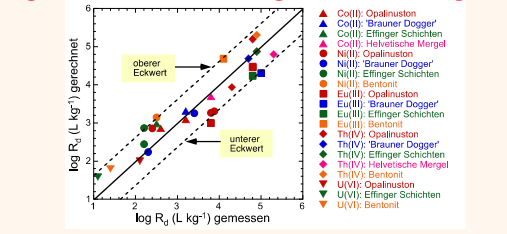
Sorptionsdatenbanken an Wirtgesteine für die Sicherheitsanalysen für SGT-E2

Messungen von Sorption an Wirtgesteine



Vergleich zwischen Messungen und Rechnungen




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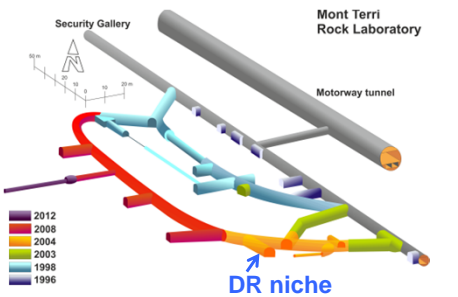
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Experiments and Modelling at field scale

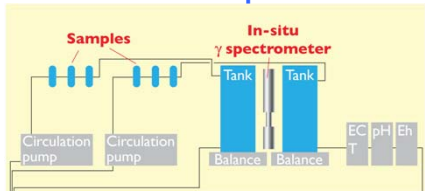
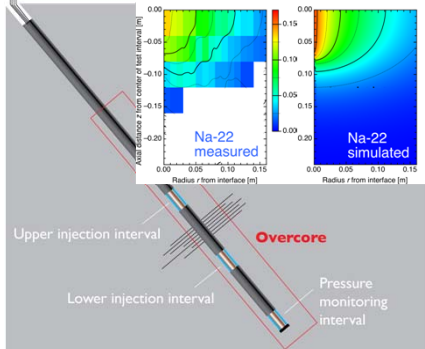
Mont Terri Project



Funded by 15 organizations from 8 countries



DR field experiment

Gimmi et al., 2014, *Geochim. Cosmochim. Acta*, 125, 373-393

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Facts and Figures

Important infrastructure

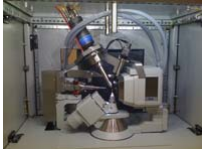
SLS (PSI)



SINQ (PSI)



XRD-Lab (UniBe)



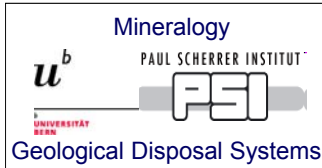
Hot Laboratory (PSI)



CSCS



Modeling Platform



Mont Terri and Grimsel URLs



Education platform



National and international co-operations

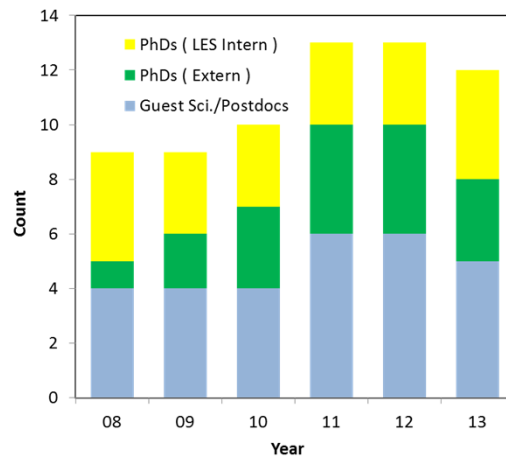
Nagra	Financial, PA, experiment, technical working groups
Multinational	7 th EU FP, OECD/NEA SDB and TDB. Mont Terri Project, Grimsel Test Site.
Research Centers	CEA, F; CIEMAT, E; EAWAG, CH; EMPA, CH; INE/KIT, D; FZR, D; FZJ, D; JAEA, J; UFZ, D.
Universities	Bern, CH; EPFL, CH; ETHZ, CH; Mainz, D; Surrey, UK; Tübingen, D;
High Schools	FHNW, CH;
Lectures	Bern; ETHZ; Tübingen; Geneva;

(Direct collaborative activities. Indirect collaboration)

PhD and Postdoc projects

Educating the next generation: PhDs and post docs in LES - very important

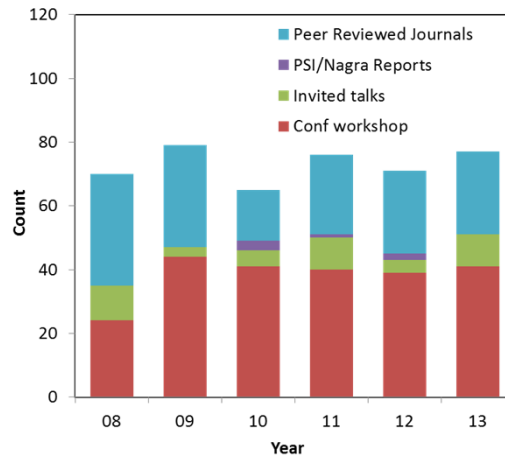
Overall aim: 1 to 2 PhDs per group, plus a postdoc.



Funding: SNF, EU, Swiss nuclear, Nagra, Federal programs

LES Publications

Am. Mineral., Appl. Clay Sci., Appl. Geochem., Cem. Concr. Res., Clays
Clay Miner., Colloids Surf., Comput. Geosci., Environ. Sci. Technol.,
Geochim. Cosmochim. Acta., J. Colloid Interface Sci., J. Contam.
Hydrol., Radiochim. Acta., Reviews in Mineral. Geochem.



430 peer reviewed scientific articles since 1995

Source of financing

- **Swiss waste management program (Nagra) and BUND** 50:50 Basis
(including personnel, infrastructure and operational costs)
- ... 2004 to 2014+, LES generated approximately ~ 7.9 MCHF in second/third party (non-Nagra) funding

EU programs	(50%)
Swissnuclear	(14%)
«Erweiterungsbeitrag»/CCES	(11%)
SNF	(10%)
Other (PSI/Canada/Japan)	(18%)

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www.psi.ch/les

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Team

Groups

Projects

Teaching and Education

Software

Annual Reports

Publications

Laboratory for Waste Management (LES)

LES is the Swiss competence center for geochemistry and multi scale radionuclide and mass transport in argillaceous rocks and cement and their applications to deep geological systems and Swiss radioactive waste repositories.

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