

Solution Mining and Salt Cavern Challenges, SMRI's Role and Research Focus

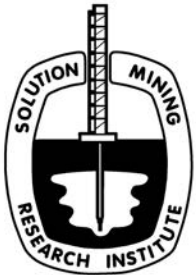
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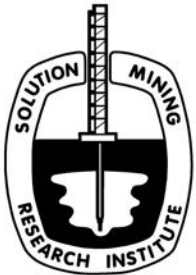
Solution Mining Research Institute (SMRI)
www.solutionmining.org



What is SMRI? Solution Mining Research Institute



- **Non-profit organization based in the US, with world-wide members.**
- **53 years old with 168 member organizations.**
- **Individuals in our database, since 2008, increased from 647 to 2721, of which members went from 410 to 1288.**
- **www.solutionmining.org**
- **Members produce salt, potash, trona, and other water soluble minerals.**
- **Members use salt caverns created by solution mining, i.e. 'storage caverns' for oil, gas, etc. storage.**
- **Members represent all aspects of the industry: production, storage, universities, government regulators, technical services, etc.**



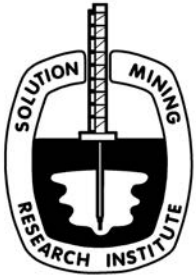
SMRI Goals and Objectives: Research and Education

- **RESEARCH** - SMRI sponsors research on subjects of interest to our members and the industry.
- **REFERENCE LIBRARY** - SMRI maintains a reference library of over 50 years of our research reports, technical papers, and World Salt Symposia papers. 3 **SOFTWARE PROGRAMS** developed and in use.
- **CONFERENCES** – SMRI typically holds 2 technical conferences each year, one in North America, one in Europe. Optional **TECH CLASSES** are offered at each conference, technical papers and research reports are presented, field trips visit local facilities, and an **SMRI business meeting** is held. (both open to non-members)



SMRI Goals and Objectives: Research and Education

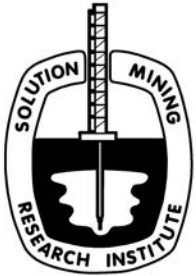
- **COMMUNICATION and NEWS** - SMRI uses e-mail and our website as primary means of communication with widespread audience. We offer value and irreplaceable importance of in-person, networking and informal communication at conferences.
- **SUPPORT of SAFETY and ENVIRONMENTAL EFFORTS** – These are core values of SMRI, and an integral part of utmost importance to our members.



SMRI Software, Developed as research projects

- **SALT_SUBSID** – Model predicts subsidence above salt caverns and mining, RESPEC
- **SALGAS** - Models solution mined cavern development, SMRI Eyermann
- **TOOLBOX** – a collection of calculations and information useful to cavern and storage operators, Brouard Consulting

(All available as PC versions)

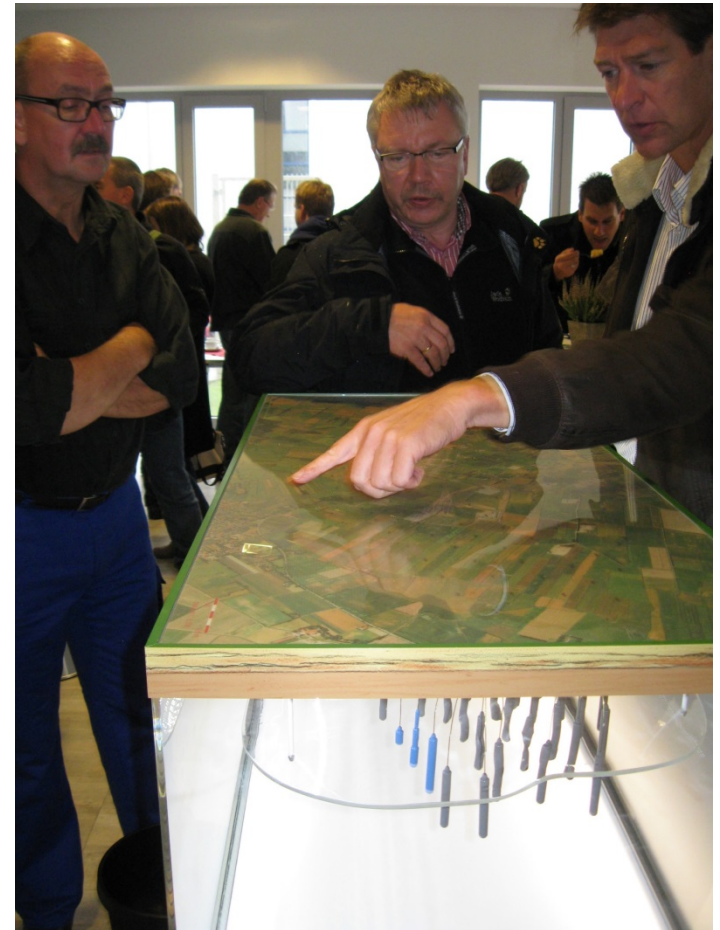


Who we are: SMRI field trip to Texas, domal salt, gas cavern storage facility, Spring 2016





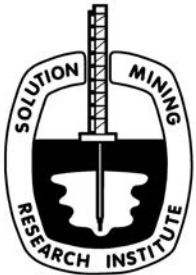
Who we are: SMRI field trip, Bremen, Germany, gas and oil storage facility, Fall 2012





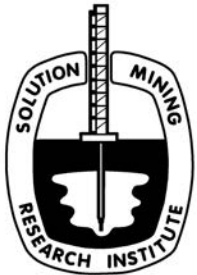
Who we are: Tech Classes and Field Trips





SMRI'S RESEARCH PROGRAM

- **Directed by Research Coordinator Dr. Leo Van Sambeek.**
- **Supported by member dues.**
- **Research subjects are determined by volunteer members of the Research Committee and approved by the membership.**
- **SMRI is always open to opportunities for research partnerships with outside organizations, for specific projects, (as currently with PRCI with McGill Univ.).**
- **Researchers need not be SMRI members**
- **RRs are available only to members first year after release**
- **About 45 research projects completed since 2000, following are most recent RRs**



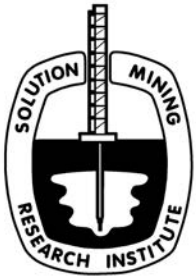
RECENT SMRI RESEARCH REPORTS

RR No.	TITLE
2012-1	Deformation of cemented casings
2012-2	High Freq Cavern Cycling Phase 2
2012-3	Gas Cavern Common Practices
2013-1	Analysis of Moss Bluff Cavern #1 Blowout Fatigue
2013-2	High Freq Cavern Cycling Phase 2B Extensional Cyclical loading
2014-1	Hanging string vibration analysis, phase 2
2015-01	Renewable Energy Storage Thermodynamics H ₂ CH ₄ and air
2015-02	Barber's Hill Deep Cavern Abandonment Field Tests, phase 2



RECENT SMRI RESEARCH REPORTS

RR No.	TITLE
2016-01	Salt Mine Low Temperature mine tests, France
2017-01	Very Slow Creep Tests, underground salt mine, Austria
2017-02	Cavern Incident Database Phase I
2017-3	High Freq Cavern Cycling Phase 3, or II-C ?
<i>2017-4</i>	<i>Salt Dome Edge location - distance from Caverns</i>
<i>2017-5</i>	<i>Update of Worldwide Salt Deposits & cavern fields</i>
2018-1	Hanging string vibration analysis, phase 3, (joint with PRCI)



ONGOING RESEARCH EFFORTS

- **Solution Mined Salt Caverns are commonly used for natural gas storage, (over 50 year record)**
- **~50 SMRI members with gas/hydrocarbon caverns**
- **Cavern and monitoring technology**
- **Brief review of cavern failures and post-failure responses**
- **SMRI's role in advancing cavern integrity**



RR2017-4 Wille (DEEP.KBB)

Salt Caverns and Salt Dome Boundaries

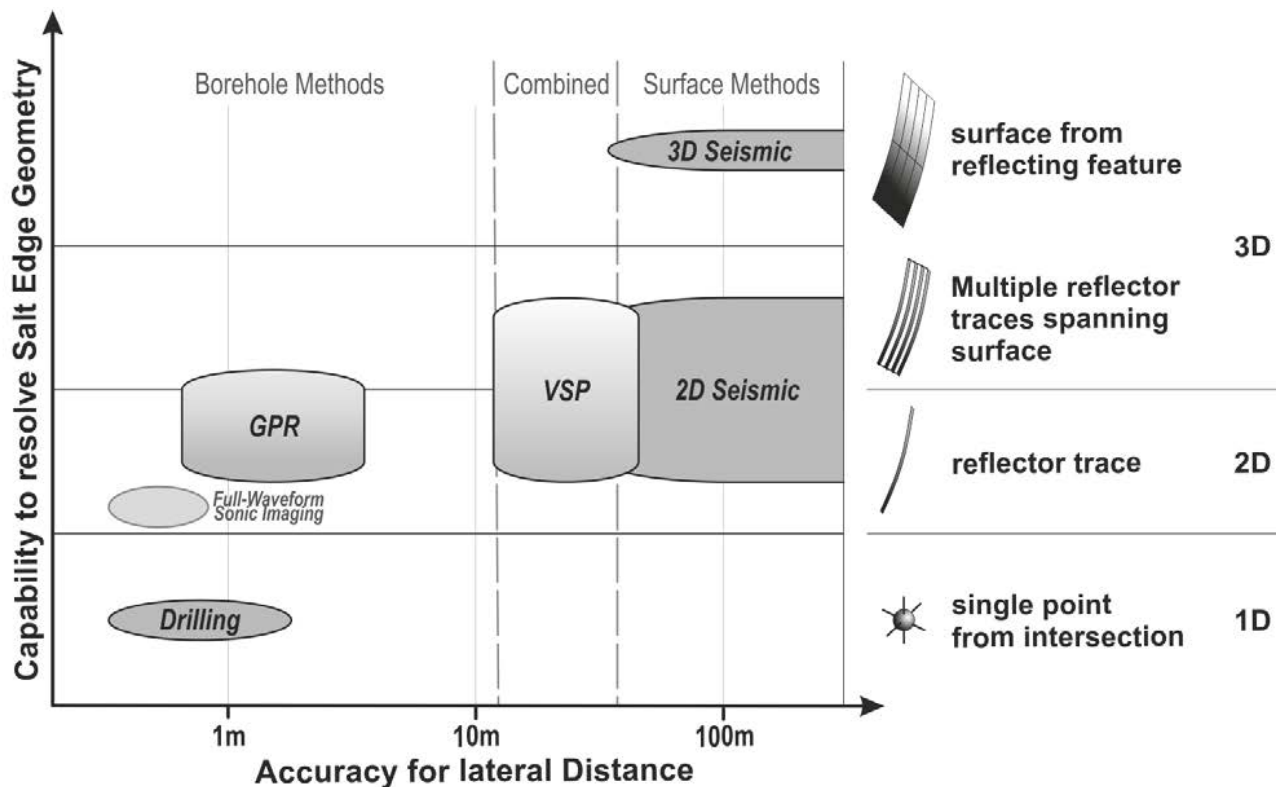
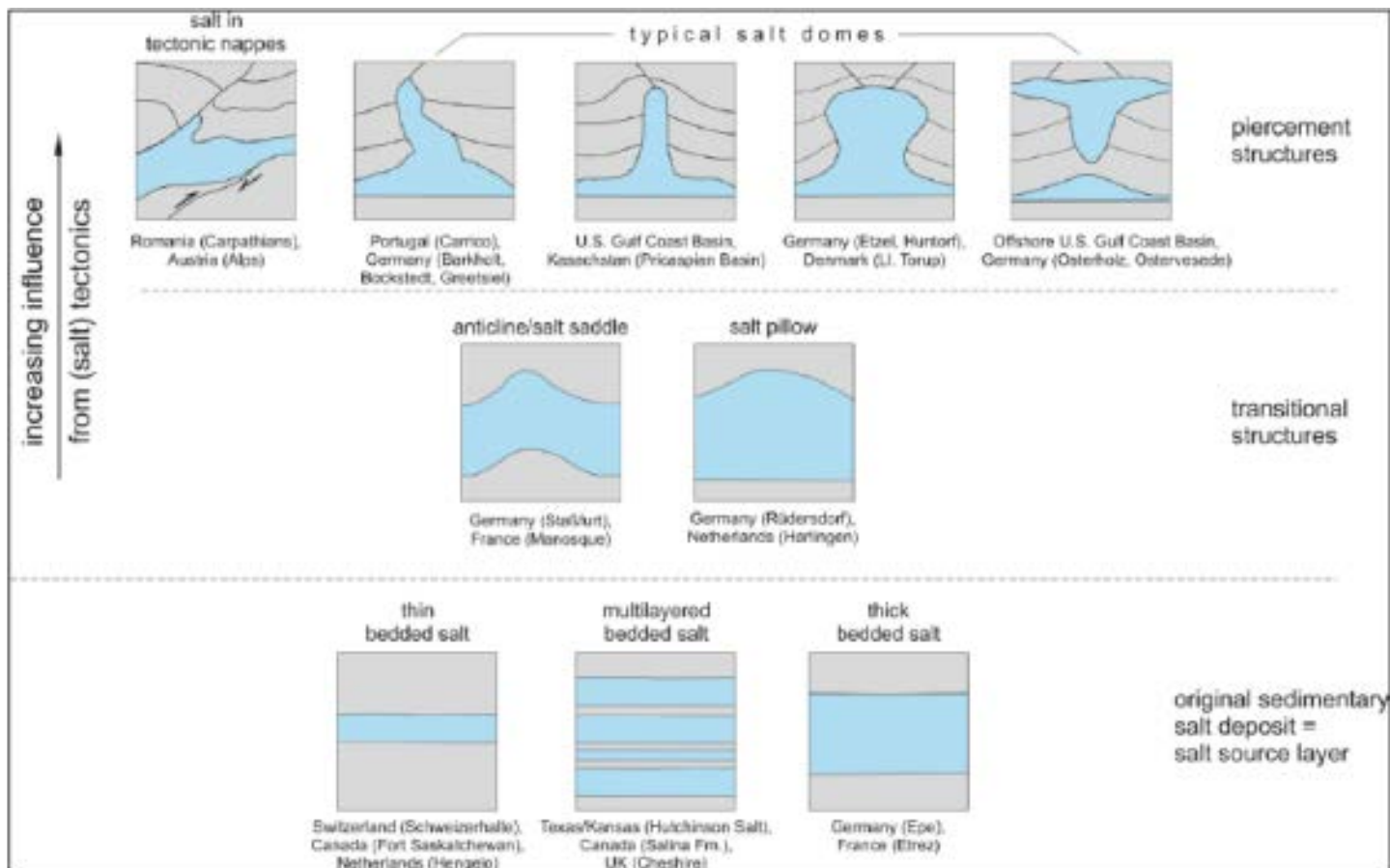


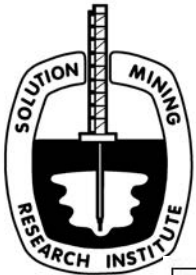
Figure 3-4: Overview of outlined methods for salt dome boundary mapping with respect to capabilities to resolve the salt edge geometry and accuracy for determination of the lateral distance, inaccuracy for drilling due to uncertainty of well trajectory



SMRI RR2017-5 Bernhardt, (DEEP.KBB)

Schematic of various salt structures (Gillhaus & Horvath, 2008)





SMRI RR2017-1 Bérest (Ecole Polytechnique)

Very Slow Creep Tests As a Basis for Cavern Stability Analysis

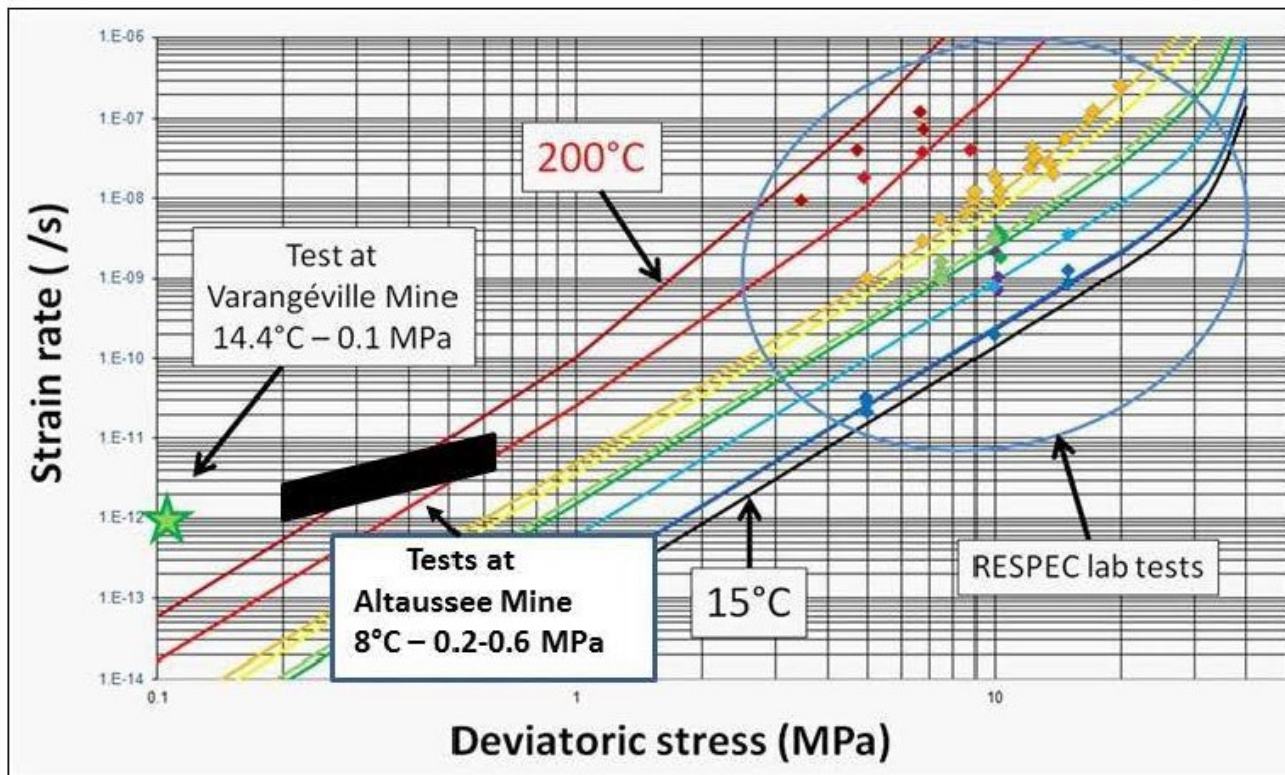


Figure 2 - Steady-state strain rate as a function of deviatoric stress and temperature for Avery Island salt (After DeVries, 1988).



SMRI can help you ...

- **Benefit from an international research approach, library, and group of industry specific experts**
- **Strengthen your internal team's solution mining and cavern storage knowledge**
- **Address your specific cavern & mining challenges**
- **Learn how to reduce risk and avoid mistakes**