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EDUCATION

Docent, Engineering Geology, 2000, Royal Institute of Technology, Sweden. The Swedish academic title Docent corresponds to the level of Senior Lecturer (UK) or Associate Professor (US).

Ph.D. Engineering Geology, 1995, Royal Institute of Technology, Sweden. Thesis title: "Coupled Stress-Flow Properties of Rock Joints from Hydraulic Field Testing"

Technical Licentiate, Rock Mechanics, 1990, Luleå University of Technology, Sweden

Ms. Geotechnology, 1988, Luleå University of Technology, Sweden

EXPERIENCE

2019-Present	**Department Head, Hydrogeology**, Earth and Environmental Sciences Area, Lawrence Berkeley National Laboratory
2016-Present	**Senior Scientist**, Energy Geosciences Division, Lawrence Berkeley National Lab
2004-2016	Staff Scientist, Energy Geosciences Division, Lawrence Berkeley National Lab
1998-2004	Geological Scientist, Earth Sciences Division, Lawrence Berkeley National Lab
1996-1998	Post-doctoral fellow, Lawrence Berkeley National Laboratory, Berkeley, California
1991-1995	Research and teaching at Royal Institute of Technology, Stockholm, Sweden
1988-1990	Research and teaching at Luleå University of Technology, Sweden
1986-1987	Seasonal Rock Mechanics Consultant at LKAB's underground iron mine, Malmberget, Sweden.

RESEARCH ACTIVITIES

Research on **coupled thermal, hydraulic, mechanical and chemical (THMC) processes in geological media** with special expertise on **hydromechanical (HM) couplings**. The coupled phenomena in fractured rock, soil or clay are studied through *in situ* field experiments and field data and numerical modeling of those experiments. Two main numerical simulators developed and applied in these simulations are 1) **ROCMAS**—a

finite element code for modeling of fully coupled THM processes in unsaturated and saturated medium, 2) **TOUGH-FLAC**—a simulator using sequential coupling techniques for analysis of coupled THM processes under multi-phase flow conditions. Currently collaborative efforts include coupled THMC processes with coupling of **FLAC** to the reactive transport simulator **TOUGHREACT**, as well as linking the TOUGH multiphase flow and heat transport simulator to a number of geomechanical simulators leveraging on previous experience with TOUGH-FLAC sequential coupling.

Current special research topics:

- **Coupled THM and THMC processes around nuclear waste repositories:** Non-isothermal multiphase fluid flow and geomechanics in fractured crystalline, clay and salt host rocks. Implementation and application of advanced constitutive models for bentonite, clay and salt geomechanical behavior under partially saturated conditions, some including damage sealing and healing, as well as chemically induced permeability changes and mechanical swelling.

- **Deep underground injection of CO_2**: rock mechanical aspects and coupled HM processes including potential fault activation and induced seismicity.

- **Hydraulic fracturing and stimulation associated extraction of methane gas from tight rock (shale):** Coupled fluid flow and geomechanical modeling of hydraulic fracturing and potential fault activation.

- **Coupled THM and THMC processes in geothermal reservoirs:** Injection/production induced seismicity, surface deformations and well integrity.

- **Coupled geomechanical modeling of hydrate-bearing sediments:** Mechanical stability of hydrate-bearing sediments during gas production.

- **Coupled THM processes associated with compressed air energy storage (CAES) in underground caverns:** Thermodynamics and geomechanics associated with compression and decompression in storage operations.

- **Hydraulic injection in rock fractures:** Coupled HM phenomena during well testing and hydraulic fracturing stress measurements.

Have performed coupled THM analysis of the following major sites and field experiments:

- Full Scale Emplacement (FE) Experiment, **Mont Terri**, Underground Research Laboratory, Switzerland (2012-Present). A large-scale heater test in a bentonite-buffer and rock (Opalinus Clay) system.

- Engineered Barrier System (EBS) experiment at **Horonobe Underground Research Laboratory**, Hokkaido, Japan (2013-2015). A heater test for a bentonite-backfilled and rock (mudstone) system.

- Half-scale Emplacement (HE-E) Experiment, **Mont Terri**, Underground Research Laboratory, Switzerland (2013-2015). A heater test in a bentonite-buffer and rock (Opalinus Clay) system.

- HE-D Experiment, **Mont Terri** Underground Research Laboratory, Switzerland (2012-2013). A heater test in Opalinus Clay.

- Coupled reservoir-geomechanical modeling of the **In Sala** industrial CO2 storage site, Algeria (2007-2017).

- Coupled THM analysis of induced seismicity at **The Geysers** Geothermal field, California (2006-2018).

- Coupled HM modeling of excavation disturbed zone at the tunnel sealing experiment (TSX) in massive granite at the **Manitoba URL** in Canada (2006-2007).

- Coupled HM modeling of major fault reactivation during the 1960 **Matsushiro** Earthquake Swarm at Matsushiro Japan (2006-2007).

- Hydraulic injection tests and mechanical measurements at the **Coaraz** fractured rock site in France (2004-2009).

- Drift Scale Test (DST), **Yucca Mountain**, Nevada (1997-2005). A high temperature (above water boiling) heater test conducted in highly fractured unsaturated rock

- Full Scale Engineering Barriers Experiment (**FEBEX**), Grimsel Test Site, Switzerland (1997-2003). A large-scale heater test in a bentonite-buffer and rock system.

- **Kamaishi Mine** heater test, Japan (1995-1998): A heater test in a bentonite-buffer and fractured rock system

- Hydraulic injection test in a 1700-meter deep borehole at the Laxemar site, **Äspö Hard Rock Laboratory**, Sweden (1995-1996): Injection tests for *in situ* determination of normal stiffness of natural fractures and for studies of coupled HM effects during hydraulic stiffness measurements.

INTERNATIONAL RESEARCH COLLABORATIONS

Active in a number of international collaborative projects, starting with the DECOVALEX project on development and validation of coupled models, a project that has been ongoing since 1992 with high scientific output, including numerous journal publications and books. Hosted numerous international visiting scientists and students at LBNL and thereby fostering long-term research collaborations in the field of coupled processes in geological media.

1992-Present Active in a Research Team as well as Task Leader for the international collaboration project **DECOVALEX I, II, III**, **THMC**, **2011, 2015, 2019**

and 2023 (Development of COupled models and their VAlidation against EXperiments in nuclear waste isolation). The project typically involves over 40 Research and Funding agencies in 10 countries. Served as Research Team on the behalf of Funding Organizations in Sweden, USA and U.K.

2003-Present Collaboration with a number of international researchers on the development of linked TOUGH-family codes and FLAC3D simulations for coupled THMC modeling of wide range of geoengineering applications.

2011-Present Collaboration with AIST and JAPEX, Japan for TOUGH-FLAC modeling of coupled geomechanical processes associated with underground CO2 injection and heavy oil production with steam-assisted gravity drainage (SAGD).

2016-Present Collaboration with Korean Atomic Energy Research Institute (KAERI) on coupled THM processes in bentonite and crystalline rock.

2011-2016 Collaboration with the Korean Institute of Geosciences and Mineral Resources (KIGAM) on compressed air energy storage and thermal storage in underground caverns.

2011-2013 Partner in the In Salah Joint Industry Project for CO2 storage, Algeria, including BP and Statoil for the geomechanical analysis associated with the CO2 injection.

2009-2011 Collaboration with Taisei Corporation, Japan for modeling of coupled geomechanical processes and ground surface deformations associated with underground CO2 injection using the TOUGH-FLAC.

2009-2011 Collaboration with Taisei Corporations, Japan for modeling of coupled THM processes in engineered barrier systems using TOUGH-FLAC and the Barcelona Basic Model for unsaturated clay behavior in the Japanese nuclear waste program.

2006-2007 Joint research project on 1960s Matsushiro Earthquake Swarm as a natural analogue for CO2 storage and leakage with Mizuho Info and Research Institute, funded Ministry of Trade and Industry Ministry (METI) of Japan.

2004-2010 Collaboration with the Geoscience Azur Laboratory, and University of Nice, France for modeling of coupled processes at the Coaraz fractured rock site in Southern France.

2000-2002 Active as a Research Team in an international code comparison project for numerical models related to geological sequestration of greenhouse gases. The project involves 10 Research Organizations in 7 countries. Also task coordinator for Test Case on hydromechanical aspects.

1991-1995 Technical Secretary and task coordinator of the international collaboration projects **DECOVALEX** I and II (Development of COupled models and their VAlidation against EXperiments in nuclear waste isolation). The work included arrangements of international workshops, technical coordination and reporting of work conducted by 10 Research Teams in 8 contras.

PROFESSIONAL ACTIVITIES

2018-present **Associate Editor**: *International Journal of Rock Mechanics and Mining Sciences*.

2014-present Editorial Board, **vice Editor-in-Chief** since 2018: *Journal of Rock Mechanics and Geotechnical Engineering (JRMGE)* since 2014.

2014-present Editorial Board: Board of Area Editorial Advisor: *Geomechanics for Energy and the Environment (GETE)* since 2014.

2014-present Review Editorial Board of *Frontiers in Carbon Capture, Storage, and Utilization*, Nature Publication Group since 2014.

2019-present Editorial Board of *Geosystems Engineering*, Taylor & Francis.

2018-present Member of Professional Staff Committee, Earth and Environmental Sciences Area, Lawrence Berkeley National Laboratory

2021 Member of International Scientific Committee of The Biot-Bažant Conference on Engineering Mechanics and Physics of Porous Materials, Northwestern University, Evanston, Indiana, June 1-3, 2021.

2021 Guest Co-Editor of Special Issue on Geomechanics for Deep Resource and Energy Exploitation in *Geomechanics and Geophysics for Geo-energy and Geo-resources.*

2020 **Chair of CouFrac2020**: 2nd International Conference on Coupled Processes in Fractured Geological Media, Seoul, Korea, November 11-13, 2020.

2020 Guest Co-Editor of Special Issue on Coupled Thermal-Hydro-Mechanical-Chemical Processes in Fractured Media for Hazard Control and Energy Exploration for the *Journal of Rock Mechanics and Geotechnical Engineering.*

2020 Guest Co-Editor of Special Issue on Coupled Processes in Fractured Geological Media: Applied analysis in Deep Underground Tunneling, Mining and Nuclear Waste Disposal for *Tunneling and Underground Space Technology.*

2020 Guest Co-Editor of Special Issue on Observations of Coupled Processes in Fractured Geological Media at various space and time. *Rock Mechanics and Rock Engineering.*

2020 Guest Co-Editor of Special Issue on Coupled Thermal-Hydro-Mechanical-Chemical Processes in Fractured Media: Microscale to Macroscale Numerical Modeling. *Computational Geosciences.*

2019 Co-convener of minisymposia at the 2019 SIAM Conference on Mathematical & Computational Issues in the Geosciences, March 10-14, 2019, Houston, Texas. Minisymposia title: advances in Modeling of Non-linear Elasticity and Plasticity for Geomaterials.

2019 Member of Scientific Committee of COGGUS^2 Computational & Geoenvironmental Geomechanics for Underground and Subsurface Structures, Nancy, France, 12-14 February, 2019.

2018 **Chair of CouFrac2018**: International Conference on Coupled Processes in Fractured Geological Media, Wuhan, China, November 12-14, 2018.

2018 Member of Scientific Committee of the 5th International Symposium on Fracturing Geomechanics & Hard Rock Forum, Dalian, 11-13 July 2018.

2018 Co-convener of session at European Geophysical Union (EGU) General Assembly 2018, Vienna, April 8-13, 2018:.Session title: Evaluation of coupled THMC processes related to geo-energy applications: from laboratory to reservoir scale.

2017 Panel Member on Forecasting and Managing Induced Seismicity at the Mission Innovation Carbon Capture, Utilization and Storage Experts' International Workshop, Houston, September 25-29, 2017.

2017 Member of Scientific Committee of GeoProc2017, the 6th International GeoProc Conference, Paris, July 5-7, 2017.

2017 Member of the International Scientific Committee for 6th Biot Conference on Poromechanics, July 9-13 Ecole Nationale des Ponts et Chaussées, Paris, France.

2017 Member of Scientific Committee for 2017 International Society of Rock Mechanics (ISRM) International Symposium "EUROCK 2017", 20-22 June, 2017, Ostrava, Czech Republic.

2017 Co-convener of session at European Geophysical Union (EGU) General Assembly 2017, Vienna, April 23-28, 2017: Session title: Process quantification and modelling in subsurface utilization.

2017 Co-convener of session at the 51st US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, USA, June 25-28, 2017. Session title: Coupled Process Modeling.

2016 Co-convener of session at European Geophysical Union (EGU) General Assembly 2016, Vienna, April 17-22, 2016:.Session title: Process quantification and modelling in subsurface utilization.

2016	Co-chair of International Forum on Rock Mechanics Aspects of CO2 Geological Storage, May 23-24, 2016, Chinese Academy of Sciences, Wuhan, China.
2016	Guest Editor of Special Issue on Rock Mechanics Aspects of CO2 Geologic Storage for the *Journal of Rock Mechanics and Geotechnical Engineering.*
2015	Organizing Committee Member of the 2015 TOUGH Symposium, September 28–30, 2015, Lawrence Berkeley National Laboratory, CA, USA,
2015	Co-convener of session at American Geophysical Union (AGU), 2015 Fall Meeting, San Francisco, California, December 14-18, 2015. Session title: "Coupled thermo-hydro-mechanical-chemical processes related to geo-energy and geo-engineering applications."
2015	Co-convener of session at the 49th US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, USA, 28 June- 1 July 2015. Session title: Coupled Process Modeling.
2014	Guest Co-Editor of Special Issue on TOUGH Symposium 2012 in *Nuclear Technology* (International Journal).
2013	Co-convener of session at the 47th US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, USA, 23-26 June 2013. Session title: Coupled processes affecting fluid flow and geomechanics.
2012	Organizing Committee Member of the 2012 TOUGH Symposium, September 17–19, 2012, Lawrence Berkeley National Laboratory, CA, USA,
2011	Organizing Committee Member of the 45th US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, USA, 28-29 June 2011.
2011	Co-convener of session at the 45th US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, USA, 28-29 June 2011. Session title: CO2 Sequestration.
2009	Co-convener of programmatic theme at the 43rd US Rock Mechanics Symposium, Asheville, NC, USA, 28 June-1 July 2009. Theme title: Coupled Processes.
2008	Co-convener of session at the 42nd US Rock Mechanics / Geomechanics Symposium, San Francisco, CA, USA, 28-29 June 2008. Session title: Coupled Processes - Flow and Transport
2007	Guest co-editor of special issue containing research results generated using the TOUGH codes in *Energy Conversion Management* (International Journal).
2003-2007	Research Area Leader on Geomechanical Modeling. Department of Geophysics, Earth Sciences Division, Lawrence Berkeley National Laboratory.

2003 Member of Organizing Committee, International Conference on Coupled T-H-M-C Processes and Modeling of Geosystems (GEOPROC), October 13-15, 2003, Stockholm, Sweden.

HONORS AND AWARDS

2017 A team member of the National Risk Assessment Partnership, receiving R&D Magazine's 2017 R&D 100 Award for Toolset on Risk Assessment and Uncertainty Quantification Software for Geologic Carbon Storage.

2016 Excellent Paper Contribution Award: The 2013 paper "Linked multicontinuum and crack tensor approach for modeling of coupled geomechanics, fluid flow and transport in fractured rock" was Among the 5 most cited papers in 2016 of the Journal of Rock Mechanics and Geotechnical Engineering.

2016 Certificate in Excellence in Reviewing 2015/2016 Geomechanics for Energy and Environment (International Journal).

2015 Lawrence Berkeley National Laboratory, Spot Recognition Award for excellent and highly successful team effort orchestrating and organizing the 2015 TOUGH Symposium.

2014 American Rock Mechanics Association Applied Rock Mechanics Research Award for work for work related to modeling of fault reactivation and seismicity associated with geologic CO2 sequestration.

2012 Lawrence Berkeley National Laboratory, Director's Award for Exceptional Tech Transfer Achievement, as part of the TOUGH developer's team.

2010 American Rock Mechanics Association Case History Award for work reported in the paper entitled "Coupled analysis of change in Fracture Permeability during the cooling phase of the Yucca Mountain Drift Scale Test".

2009 American Rock Mechanics Association Applied Rock Mechanics Research Award for work reported in the paper entitled "Fractured rock hydromechanics: from borehole testing to solute transport and CO2 storage" - by the Geological Society, London.

2006 American Rock Mechanics Associations Rock Mechanics Award for paper on "Coupled thermal-hydrological-mechanical analysis of the Yucca Mountain Drift Scale Test".

2004 Recognition of commitment of performance excellence in contributing to the Regulatory Integration Team effort of the Yucca Mountain Project.

2001 Outstanding Performance Award—for work on coupled THM processes—Lawrence Berkeley National Laboratory.

1996-1997 Wennergren Post-doctoral award (Sweden) for research commitment at Lawrence Berkeley National Laboratory, California.

REVIEW AND DISSERTATION COMMITTEES

2020 Member of Review Committee for the First Qian Lecture, established by the Chinese Society for Rock Mechanics & Engineering and Editorial Board on the Journal of Rock Mechanics and Geotechnical Engineering.

2019 Preliminary Examiner for Doctoral Thesis "Techno-economic aspects of seasonal underground storage of solar thermal energy in hard crystalline rocks" at Aalto University, Helsinki, Finland, August, 2019.

2019 Assessor of academic accomplishment for the appointment of a Docent in Solid Earth Geophysics, Faculty of Sciences, University of Helsinki, Finland, August 2019.

2018 Preliminary Examiner for Doctoral Thesis "A large deformation model for chemoelastic porous media – bentonite clay in spent nuclear fuel disposal" at Aalto University, Helsinki, Finland, December, 2018.

2018 Member of the Technical Program Committee's Technical Advisory Group (TAG) on the topic of geomechanics for the 14th International Conference on Greenhouse Gas Control Technologies (GHGT - 14), Melbourne, Australia, 21st -26th October 2018.

2017 External Referee for PhD thesis "Induced Seismicity in Enhanced Geothermal Systems: Assessment of Thermo-Hydro-Mechanical Effects" at University of Catalonia, Barcelona, Spain, February 2017

2016 Thesis committee member for Ph.D. defense on "Model Development of Coupled Hydromechanical Processes in Heterogeneous Media Using Numerical Manifold Method" at Ho-Hai University, Nanjing, China, May 29, 2016.

2016 Member of the Technical Program Committee's Technical Advisory Group (TAG) on the topic of geomechanics for the 13th International Conference on Greenhouse Gas Control Technologies (GHGT - 13), 14-18 November, 2016, Lausanne, Switzerland.

2014 Member of the Technical Program Committee's Technical Advisory Group (TAG) on the topic of geomechanics for the 12th International Conference on Greenhouse Gas Control Technologies (GHGT - 12), 5-9 October, 2014, Austin, Texas, USA

2012 Thesis committee member for Ph.D. defense on "Thermo Hydro Mechanical Impacts of CO2 Injection in Deep Saline Aquifers" at University of Catalonia, Barcelona, Spain, July 2012.

2011 Faculty opponent for Ph.D. defense on "Tunnel Grouting: Engineering Methods for Characterization of Fracture Systems in Hard Rock and Implications for Tunnel Inflow", at Chalmers University of Technology, Sweden.

2007-2008 Member of the Radiation and Nuclear Safety Authority (STUK) review team as an expert on thermo-hydro-mechanical evolution associated with the Finish nuclear waste program.

2007 Faculty opponent for Ph.D. defense on "Thermomechanics of Swelling Unsaturated Porous Media-Compacted bentonite clay in spent fuel disposal", Helsinki University of Technology, Finland.

2006-2010 Member of the Swedish Nuclear Power Inspectorate (SKI) review team as an expert on thermo-hydro-mechanical evolution and rock mechanics associated with the Swedish nuclear waste program.

2005 Opponent (French "Repporteur") for Ph.D. defense on "Coupled Hydromechanical Processes in Heterogeneous Fractures Networks", at University of Nice, France.

1999 Faculty opponent for Ph.D. defense on "Hydro-mechanical Behavior of a Pressurized Single Fracture: An In situ Experiment", at Chalmers University, Sweden.

INVITED (1st Author) TALKS

2021 1. "Coupled Thermo-Hydro-Mechanical Processes Associated with Nuclear Waste Disposal in Different Host Rocks" Invited presentation to the Department of Energy, Nuclear Engineering, Spent Fuel Waste Disposition (SFWD) Telecommuting Seminar Series, March 4, 2021.

2. "Coupled Processes Modeling in Energy Geosciences" Invited presentation for the Science for Protection of Engineered Environments (SPREE) Seminar Series at the Department of Civil and Environmental Engineering, Northwestern University, Evanston, Illinois, January 27, 2021.

2020 3. "Potential Seismicity and Leakage Associated with Fault Activation in Geologic CO2 Sequestration". Invited presentation at American Geophysical Union (AGU), Fall Meeting, San Francisco, December 15, 2020.

4. "Coupled Thermo-Hydro-Mechanical Processes Associated with Nuclear Waste Disposal in Different Host Rocks" Invited presentation to the American Rock Mechanics Association's (ARMA's) Underground Storage and Utilization Technical Community Webinar Series, October 28, 2020.

5. "Coupled Processes Modeling in Energy Geosciences" Keynote presentation at China Rock 2020-Hard Rock Forum, hosted by the Chinese Society for Rock Mechanics & Engineering (CSRME), October 26, 2020.

6. "Coupled Fluid Flow and Geomechanics" Invited lecture at the Department of Energy Resources Engineering, Seoul National University, Seoul, Korea, November 9, 2020.

7. “Coupled Thermo-Hydro-Mechanical Processes in Nuclear Waste Disposal” Invited lecture at the Department of Energy Resources Engineering, Seoul National University, Seoul, Korea, November 9, 2020.

2019 8. “Coupled Thermo-Hydro-Mechanical Processes Associated with Nuclear Waste Disposal in Different Host Rocks” Invited presentation at American Geophysical Union (AGU), Fall Meeting, San Francisco, December 9, 2019.

9. “Modeling Fault Activation, Seismicity and Leakage in Geologic CO2 Sequestration” Invited presentation at the International Energy Agency Greenhouse Gas R&D Programme (IEAGHG) Fault Workshop, Calgary, Canada, August 23, 2019.

10. “Thermo-Hydro-Mechanical (THM) Perturbations in Bentonite/Argillite Repositories: Heater Tests at Mont Terri and Bure” Invited Presentation at the U.S. Nuclear Waste Technical Review Board Workshop, Burlingame, California, April 24-25, 2019.

11. “Gas Migration in Clay-Based Materials – International Collaboration Activities as Part of the DECOVALEX Project” Invited Presentation at the U.S. Nuclear Waste Technical Review Board Workshop, Burlingame, California, April 24-25, 2019.

2018 12. “Fault activation, seismicity and leakage in geologic CO2 sequestration” Invited Keynote Lecture at International Symposium on Energy Geotechnics (SEG-2018), Lausanne, Switzerland, September 26, 2018.

2017 13. “Thermally-driven Coupled THM Processes in Shales” Invited presentation at American Geophysical Union (AGU), Fall Meeting, New Orleans, December 12, 2017.

14. “Geomechanical Modeling for Improved CO2 Storage Security” Invited presentation at American Geophysical Union (AGU), Fall Meeting, New Orleans, December 15, 2017.

15. “Pressure Management and Induced Seismicity” Invited presentation for National Academy of Sciences’ Study on Carbon Dioxide Removal and Reliable Sequestration; Workshop on Geologic Capture and Sequestration of Carbon, Stanford, California, Nov 28, 2017

16. “Modeling Fault Activation and Seismicity in Geologic Carbon Storage and Shale-gas Fracturing – Under what conditions could a felt seismic event be induced?” Invited presentation at the Society of Exploration Geophysicists (SEG) Annual Meeting, Special Session on Injection-induced Seismicity, Houston, September 26, 2017.

17. “Modeling of fault reactivation and seismicity in geologic carbon storage and shale-gas fracturing” Invited presentation at Centre de Géosciences Mines ParisTech, Fontainebleau, France July 4, 2017.

2016

18. “Modeling of Fault Reactivation and Seismicity in CO2 Sequestration and Shale-gas Fracturing” Claude R. Hocott Graduate Seminar Speaker the University of Texas at Austin, Petroleum and Geosystems Engineering, October 3, 2016.

19. “Fault activation and induced seismicity in geologic carbon storage” Invited Keynote Speaker at the International Forum on CO2 Geological Storage Geomechanics, Wuhan, China, May 23-24, 2016.

20. “Modeling injection-induced Seismicity Associated with Geologic CO2 Sequestration, Shale-gas Fracturing and Stimulation of a Geothermal Reservoir” Invited presentation at China University of Mining & Technology, Beijing, China, May 26, 2016.

21. “Fractured-rock permeability-versus-stress relationships from in situ experiments” Oral solicited presentation in Session NH3.10/GM8.2 - Hydro-geomechanical aspects of fractured bedrock systems: geotechnical, geomorphological and geohazard implications at the European Geosciences Union (EGU) General Assembly 2016 in Vienna, Austria, April 18-22, 2016.

22. “Modeling of Injection-Induced Fault Reactivation and Seismicity in Geologic Carbon Storage and Shale-gas Fracturing”. Invited presentation at SEG/SPE Workshop: Injection Induced Seismicity-Engineering Integration, Evaluation and Mitigation. Fort Worth, Texas, 28-30 March, 2016.

2015

23. “Modeling Caprock Failure, Fault Activation, Induced Seismicity and Leakage Associated with Geologic CO2 Storage”. Invited keynote speech at the International Workshop on Fracturing Geomechanics, Shandong University of Science and Technology, Qingdao, China, November 25, 2015.

24. “Modeling Fault Reactivation, Induced Seismicity, and Leakage during Underground CO2 Injection”. Invited keynote presentation at the UK Carbon Capture and Storage Research Centre (UKCCSRC) specialist meeting, Leeds, U.K., November 3, 2015.

25. “Modeling injection-induced Seismicity Associated with Geologic CO2 Sequestration, Unconventional Hydrocarbons and a Geothermal System”. Invited seminar at University of Leeds, Institute for Applied Geosciences, School of Earth and Environment, November 4, 2015.

26. “Modeling Injection-induced Seismicity Associated with Geologic CO2 Sequestration, Shale-gas Fracturing and Stimulation of a Geothermal Reservoir". Invited presentation at the German Research Center for Geosciences (GFZ), Potsdam, Germany, June 25, 2015.

27. “Modeling Injection-induced Seismicity Associated with Geologic CO2 Sequestration, Shale-gas Fracturing and Stimulation of a Geothermal Reservoir". Invited presentation at University of Uppsala, Department of Earth Sciences, Uppsala, Sweden, June 18, 2015.

28. “Modeling Fault Reactivation and Induced Seismicity during Underground CO2 Injection”. Invited guest speaker at Stanford Center for Carbon Storage (SCCS) Annual Meeting, Stanford, California, May 28, 2015.

29. “Modeling Fault Reactivation, Induced Seismicity, and Leakage during Underground CO2 Injection” Invited seminar Department of Earth Sciences (HPT Laboratory), Faculty of Geosciences, Utrecht University, The Netherlands, March 27, 2015.

30. “Geomechanical Aspects of CO2 Leakage”. Invited presentation at Center for Nanoscale Control of Geologic CO_2 (NCGC) Scenarios Workshop, Berkeley, February 24, 2015.

2014

31. “TOUGH-FLAC Coupled Fluid Flow and Geomechanical Simulations Related to Geologic CO2 Storage”. Invited presentation at the State Key Laboratory of Geomechanics and Geotechnical Engineering, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, China, December 4, 2014

32. “Geomechanical Aspects of Geologic CO2 Storage” Invited presentation at Hohai University, Geotechnical Engineering Institute, Nanjing, China, December 8, 2014.

33. “Modeling Fault Reactivation, Induced Seismicity, and Leakage during Underground CO2 Injection” Invited presentation at the International Energy Agency (IEA) Greenhouse Gas R&D Programme’s Monitoring Network and Modelling Network – Combined Meeting, Morgantown, West Virginia, August 7, 2014.

34. “Modeling of Fault Responses and Induced Seismicity during Underground CO2 Injection”. Invited talk at Istituto Nazionale di Geofisica e Vulcanologia, in Bologna (Italy), July 4, 2014.

2013

35. “Coupled Reservoir-geomechanical Analysis Associated with Geologic CO2 Storage in Deep Sedimentary Formations”. Invited special speaker at the 6th International Symposium on In-situ Rock Stress (RS2013), Sendai, Japan, 20-22 August, 2013.

36. “Recent TOUGH-FLAC Coupled Fluid Flow and Geomechanical Simulations Related to Geologic CO2 Storage”. Invited talk at the National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, August 26, 2013.

37. “Modeling of Fault Reactivation and Induced Seismicity During Hydraulic Fracturing of Shale-Gas Reservoirs”. Invited speaker at American Rock Mechanics Association (ARMA), Unconventional Resources Geomechanics Workshop, San Francisco, June 21, 2013.

38. “Modeling of Coupled Thermal-Hydrological-Mechanical (THM) Processes of Fractured Rocks for Multiphase Flow Applications”. Invited seminar at Sejong University, Seoul, South Korea, April 19, 2013.

39. “Geomechanical aspects of geologic CO2 storage critically important for safety and public acceptance”. Invited plenary speaker at the 3rd Korea CCS Conference, Jeju Island, Korea, 13-15 March, 2013.

40. “Coupled THM Processes During Deep Injection Near Brittle-Ductile Rock Transition at The Geysers Geothermal Field, California” 10th International Workshop on Water Dynamics, Deep Carbon Cycle, and ICDP Japan Beyond-Brittle Project (JBBP). Sendai, Japan, 12-16 March, 2013.

2012

41. “Modeling of Geomechanical Performance of Sloping Oceanic Hydrate Deposits Subjected Production Activities”. Invited presentation at American Geophysical Union (AGU), 2012 Fall Meeting, San Francisco, California December 6, 2012.

42. “Geomechanical modeling of fault responses and the potential for notable seismic events during underground CO2 injection”. Invited presentation at American Geophysical Union (AGU), 2012 Fall Meeting, San Francisco, California, December 3, 2012.

43. “Coupled THM Processes During Deep Injection Near Brittle-Ductile Rock Transition at The Geysers Geothermal Field, California”. Seoul National University, Seoul, South Korea, October 19, 2012.

44. “Demonstration of an Enhanced Geothermal System at the Northwest Geysers Geothermal Field, CA”. Invited talk at the Geothermal Stimulation Workshop Entitled “Reservoir Stimulation Current Understanding and Practice, and the Path Forward”, Reno, Nevada, September 28 and 29, 2012.

45. “Modeling of the Potential Fault Reactivation in CO2 sequestration and Shale Gas Fracking” Invited speaker at American Rock Mechanics Association (ARMA), Unconventional Resources Geomechanics Workshop, San Francisco, June 22, 2012.

46. “Coupling geomechanics and flow and transport: some recent studies at the Berkeley Laboratory”. Invited Lecture at the post-TIMODAZ Workshop, Saint Ursanne, Switzerland, February 6, 2012.

2011

47. “Stress-versus-permeability relationships of fracture rock from in situ experiments and effects of chemical-mechanical coupling”. Invited presentation at the American Geophysical Union (AGU), Fall Meeting, San Francisco December 16, 2011.

48. “Geomechanical Modeling and Monitoring of Fault Responses and the Potential for Earthquakes During Underground CO2 Injection”. Invited presentation at the American Geophysical Union (AGU), Fall Meeting, San Francisco December 16, 2011.

49. “Modeling of Coupled THM Processes in Deep Systems”, Invited presentation at the Uppsala Deep Hydrogeology Workshop, Uppsala, Sweden, September 22, 2011.

50. “Geomechanical Aspects and Modeling Associated with Geological Sequestration of CO2”, Invited presentation at University of Uppsala, Department of Earth Sciences, Uppsala, Sweden, September 23, 2011.

51. “Modeling Coupled Thermal-Hydro-Mechanical-Chemical Processes Associated with Geological Sequestration of CO2”, Invited Keynote presentation at the 8th International Conference on Calibration and Reliability in Groundwater Modeling MODELCARE2011, Leipzig, Germany, September 18-22, 2011.

52. “NW Geysers EGS Demonstration Project”, Invited presentation at the 2nd Annual Enhanced Geothermal Systems Conference, San Jose, California, June 29-30, 2011.

53. “CO2 Sequestration Geomechanics and Modeling” Keynote speaker at American Rock Mechanics Association (ARMA), Unconventional Resources Geomechanics Workshop, San Francisco, June 24, 2011.

2010

54. “Geomechanical Aspects of CO2 Sequestration and Modeling”. Invited Keynote Lecturer of the International Workshop on Numerical Analysis for Geomechanics-Establishing Ceremony for Shi Gen-hua Numerical Manifold Method Research Center in Nanjing, China, October 14, 2010.

55. “Pre-Stimulation Coupled Geomechanical Modeling Associated with the North West Geysers EGS Demonstration Project”. Invited presentation at GFZ German Research Center for Geosciences, Potsdam, Germany, September 24, 2010.

56. “Geomechanical Aspects of CO2 Sequestration and Modeling”. Guest lecture in the framework of rock mechanics II & applied rock mechanics in petroleum engineering, Institute of Petroleum Engineering, Technical University of Clausthal, Germany, September 23, 2010.

57. “Coupled Non-Isothermal Modeling of Ground Surface Deformations and Induced Seismicity at the In Salah CO2 Storage Operation”. American Association of Petroleum Geologists (AAPG) Geoscience Technology Workshop on Carbon Sequestration, Colorado School of Mines, Golden, CO, August 10-12, 2010.

58. “Modeling of Coupled Multiphase Fluid Flow and Geomechanical Processes Associated with Geologic CO2 Sequestration”. Keynote Lecture at the Research Institute of Innovative technology for the Earth (RITE) Technical Workshop on Geomechanics and CO2 Sequestration, Kyoto, Japan, January 22, 2010.

60. “Status of TOUGH-FLAC and Recent Applications”. Invited presentation at Kyoto University, Department of Civil and Earth Resources Engineering, Kyoto, Japan, January 21, 2010.

2009

61. “Coupled Hydro-Geomechanical Modeling of Geological Carbon Sequestration Systems”. The 2009 Philomathia Forum on Energy and Environment: Berkeley-Stanford-Beijing U.S.-China Workshop on Carbon

Dioxide Capture and Storage, Peking University, Beijing, China, November 11-12, 2009.

63. "Geomechanical modeling and geophysics associated with CO_2 sequestration." The Society of Exploratory Geophysicists (SEG) Summer workshop in Banff, Canada, August 23-27, 2009.

64. **"**Modeling of Coupled Thermal-Hydrological-Mechanical (THM) Processes of Fractured Rocks for Multiphase Flow Applications at Four Major Field Sites." Seoul National University and Korean Institute of Geology, Mining and Materials, Seoul and Taejon, South Korea, March 24, 2009.

65. "Coupled THM Processes Associated with Geologic CO2 Storage". The Ohio State University Conference on Advancing the Science of Geologic Carbon Sequestration. Columbus, Ohio, March 8-10, 2009.

66. "Analysis of Thermal-Hydraulic-Mechanical Processes in Porous and Fractured Rocks and Geomechanical Performance of Hydrate-Bearing Sediments." StatoilHydro's Gas Recovery Workshop, Oslo, Norway, 5-6 March, 2009.

67. "Geomechanical Modeling Associated with Geological CO2 Sequestration." The 1st Workshop of The International Energy Agency (IEA) CO2 Modeling Network, Orleans, France, February 8 to 14, 2009.

68. Estimating stress-versus-permeability relationships of fractured rock using data from in situ experiments and effects of chemical-mechanical coupling." Special Lecture at the International Conference on Rock Joints and Jointed Rock Masses, Tucson, Arizona, Jan 4-10, 2009.

2007 69. "Stress-versus-permeability Relationships of Fractures from In Situ Experiments." American Geophysical Union (AGU), Fall Meeting, San Francisco December 15, 2007.

2006 70. **"**TOUGH-FLAC: A Computer Simulator for Analysis of Coupled THM Processes under Multi-phase Conditions with Applications to CO2 Sequestration." Mizuho Information & Research Institute, Inc., Tokyo, Japan, September 8, 2006.

2005 71. "TOUGH-FLAC: A Computer Code for Soil and Rock Mechanics Coupled with Multiphase Fluid Flow." University of Nice, France, November 3, 2005.

SELECTED PROJECTS SINCE 2005 (PI or Co-PI):

Field Evaluation of the Caney Shale as an Emerging Unconventional Play, Southern Oklahoma. LBNL participate in a project lead by Oklahoma State University (OSU) and partnered by the Continental Resources independent oil producer to develop technology for extracting hydrocarbon from a ductile shale gas play. 2019-2023. Total LBNL funding $1.5M for coupled multiphase flow and geomechanical modeling with field data

interpretation whereas the entire project is budgeted at $19M. Sponsor: U.S. Department of Energy, Office of Fossil Energy.

Performance-based earthquake engineering assessment tool for natural gas storage and pipeline systems. The goal of the program is to produce an open-source analysis tool that will be easily usable by regulators and utilities that implements updated methodologies for assessment of seismic risk to underground and aboveground natural gas infrastructure. LBNL's role in the project is conduct targeted research to advance the seismic risk assessment tool, focusing on integrity and vulnerability wells and caprocks associated with underground gas storage facilities. 2019-2022. Total LBNL funding $1.0M. Sponsor California Energy Commission (CEC).

Comprehensive Physical-Chemical Modeling to Reduce Risks and Costs of Flexible Geothermal Energy Production. The objectives are to investigate the impacts of flexible geothermal energy production on the reservoir-wellbore system, including wellbore and reservoir integrity, scaling and corrosion of wellbore and pipeline, and flow and transport under the influence of injection and production. 2017-2020. Total funding $1.0M. Sponsor California Energy Commission (CEC).

Characterize Actual and Future Impact of California's Drought on Three-component Ground Deformations and their Influence on the Natural Gas Infrastructure. The goal is to develop and demonstrate a new methodology to more accurately identifying areas with relatively high risk of potential natural gas infrastructure damage due to subsidence, and to identify possible remedial actions. 2017-2020. Total funding $1.6M. Sponsor California Energy Commission (CEC).

In Sala Industrial-scale CO2 storage project 2006-2015. About $400 K/year (total about $3.5 M), part of LBNL's GEO-SEQ and Consolidated Sequestration Research Project (CSRP). The objectives of the research related to the In Salah Industrial-Scale CO2 Storage Project were (1) to assess the effectiveness of CO2 storage in low-permeability formations using long-reach horizontal injection wells, and (2) to investigate monitoring techniques to evaluate the performance of a high pressure CO2-injection operation. Sponsor: U.S. Department of Energy, Office of Fossil Energy.

Northwest Geysers EGS Demonstration Project 2009-2015: Modeling and interpretation of field data during stimulation of a cubic-kilometer rock volume at 3 km depth and production. Total funding $1.5 M for LBNL part of modeling and field data interpretation whereas the entire EGS project is budgeted at $10.7 M. Sponsor: Department of Energy, Geothermal Technology Program.

Geothermal Code Intercomparison Study, 2015-2016 $100 K/year, Sponsor: DOE Geothermal Technology Program through Pacific Northwest National Laboratory.

Field Testing and Geomechanical Modeling of Fault Slip at Mont Terri Underground Research laboratory: Key Coupled Processes in Seal Breaching and Loss of Inventory, 2015-2016, $200 K, Core Carbon Storage and Monitoring Research (CCSMR), Sponsor: U.S. Department of Energy, Office of Fossil Energy.

Quantitative Characterization of Impacts of Coupled Geomechanics and Flow on Safe and Permanent Geological Storage of CO2 in Fractured Aquifers, 2015-2017, in partnership

with Colorado School of Mines, Total Funding for LBNL: $300 K, Sponsor: U.S. U.S. Department of Energy, Office of Fossil Energy.

Coupled Thermal-Hydrological-Mechanical-Chemical Model and Experiments for Optimization of Enhanced Geothermal System Development and Production. 2009-2014: About $300 K/year. Code developments involving sequential coupling of TOUGHREACT to mechanics codes. Sponsor: Department of Energy, Geothermal Technology Program.

Coupled THM process modeling in bentonite-backfill and clay host rock nuclear waste disposal option, since 2010, $150K/year average funding for TOUGH-FLAC modeling, including heater experiments within the international DECOVALEX-2015, DECOCALEX-2019 and Mont Terri projects. Sponsor: U.S. Department of Energy, Office of Nuclear Energy, Used Fuel Disposition Campaign.

Coupled THMC process model development in bentonite-backfill and clay host rock nuclear waste disposal option, since 2011. Code development and applications of TOUGREACT-FLAC. About 100K/year. Sponsor: U.S. Department of Energy, Office of Nuclear Energy, Used Fuel Disposition Campaign.

Evaluation of Salt as a Host Rock for Geologic Disposal of Radioactive Waste, since 2013, FY13-18 funding $250 K/year average, FY19-20 $450K/year average. Sponsor: U.S. Department of Energy, Office of Nuclear Energy, Used Fuel Disposition Campaign.

Deep Borehole Disposal Demonstration Project – Borehole Seal Modeling, since 2015, FY16 funding: $192K, FY17 funding $200K. Sponsor: U.S. Department of Energy, Office of Nuclear Energy, Used Fuel Disposition Campaign.

National Risk Assessment Partnership – Seal Integrity/Induced Seismicity National Laboratory Consortium for the development of quantitative risk assessment methods for geologic carbon sequestration, since 2010, $150 K/year average for TOUGH-FLAC fault activation modeling. Sponsor: U.S. Department of Energy, Office of Fossil Energy.

Laboratory and Numerical Investigation of Hydraulic Fracture Propagation and Permeability Evolution in Heterogeneous and Anisotropic Shale, 2014-2018, Total Funding: $400 K, Sponsor: U.S. Department of Energy, Office of Fossil Energy.

Sustainability of Hydraulic Fracture Conductivity in Ductile and Expanding Shale, 2016-2018, Total Funding: $500 K, Sponsor: U.S. Department of Energy, Office of Fossil Energy.

THMC Modeling in Support of the Newberry EGS Demonstration Project, 2011-2015., $600 K, Sponsor: Alta Rock Energy Inc.

Coupled Geomechanical Modeling of Underground Compressed Air Energy and Thermal Storage, 2011-2014 $100K, Sponsor: Korea Institute of Geoscience and Mineral Resources (KIGAM).

In Sala Joint Industry Project 2011-2013: $360 K/year, work-for-others project funded by Is Salah Joint Industry Project and their partners BP, Statoil and Sonatrach, providing co-funding to the DOE project, and conducted in collaboration with Lawrence Livermore National Laboratory.

Hydro-Fracturing Design Studies for Sealing Experiment at Mont Terri, 2013, $50K, Sponsor: Carbon Capture Project through BP Corporation North America.

To support research in modeling coupled thermo-hydro-mechanic processes in heterogeneous fractured media (GIFT), Since 2011, total funding $90, JAPEX, Japan.

DECOVALEX-2011: Modeling of Coupled HMC Phenomena in Fractured Rocks, 2008-2011, $180 K, Sponsor: Nuclear Decommissioning Agency (NDA) through SERCO Group PLC (U.K).

Participation in International Model Comparison Project DECOVALEX-THMC, 2005-2008, Average Annual Funding: $150K, Sponsor: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

Integrated Assessment of Critical Chemical and Mechanical Processes Affecting Drift Performance: Laboratory and Modeling Studies. 2005-2007, in partnership with Penn State University, LBNL funding $200K/year, Sponsor: Department of Energy, Office of Science & Technology and International (OSTI).

Predictive Modeling Analysis of the Drift-Scale Thermal-Hydrological-Mechanical Conditions in the Vicinity of Future Waste Emplacement Drifts at Yucca Mountain, 2002-2008, Average Annual Funding: $100 K, Sponsor: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

Natural Analogue Study in High Gas Fluid Region for Risk Analysis of CO2 Geological Sequestration, 2005-2006. $300K Ministry of Economy, Trade and Industry (METI) Japan through Mizuho Information Research Institute, Japan

Research on modeling coupled thermo-hydro-mechanic processes in heterogeneous fractured media (GIFT), Since 2000, total funding about $400K. Swedish Nuclear Power Inspectorate, Sweden.

PUBLICATIONS

Publication Metrics

- +600 technical publications, including +200 refereed journal papers.
  - Web of Science: **H-index = 48** and over **8000 citations** (as of March 2021).
  - Google Scholar: **h-index 63** and over **15,000 citations** (as of March 2021).
- Researcher ID: F-4957-2015 (http://www.researcherid.com/rid/F-4957-2015)
- Google Scholar:

  (https://scholar.google.com/citations?user=hU1EjukAAAAJ&hl=en&oi=ao)

Refereed Journal Papers

1. Hu M., Steefel C., and **Rutqvist J.** Mesh generation and optimization from digital rock fractures based on neural style transfer. *International Journal of Rock Mechanics and Geotechnical Engineering* (Accepted on February 4, 2021).
2. Seyedi D.M., Plúa C., Vitel M., Armand G., **Rutqvist J.**, Birkholzer J., Xu H., Guo R., Thatcher K.E., Bond A.E., Wang W., Nagel T., Shao H., Kolditz O. Upscaling THM modelling from small-scale to full-scale in-situ experiments in the Callovo-Oxfordian claystone. *International Journal of Rock Mechanics and Mining Sciences* (Accepted on December 21, 2020).
3. Sasaki T. and **Rutqvist J.** Estimation of stress and stress-induced permeability change in clay/shale formation in a thermo-hydrologically coupled modelling of a geological nuclear waste repository. *Computers and Geotechnics*, **129**, 103866 (2021). https://doi.org/10.1016/j.compgeo.2020.103866.
4. Xu H., Zheng L., **Rutqvist J.**, and Birkholzer J. Chemo-Mechanical behavior of bentonite in nuclear waste disposal based on the Barcelona expansive model. *Computers and Geotechnics* 132, 103968 (2021). https://doi.org/10.1016/j.compgeo.2020.103968.
5. Tao S., Tang X., **Rutqvist J.**, Quansheng Liu Q., Hu M. The influence of stress anisotropy and stress shadow on frost cracking in rock *Computers and Geotechnics*. **133**, 103967 (2021). https://doi.org/10.1016/j.compgeo.2020.103967.
6. Tamayo-Mas E, Harrington J.F., Brüning T., Shao H., Dagher E.E., Lee J., Kim K., **Rutqvist J.**, Kolditz O., Lai S.H., Chittenden N., Wang Y., Damians I. and Olivella S. Modelling advective gas flow in compact bentonite: lessons learnt from different numerical approaches. *International Journal of Rock Mechanics and Mining Sciences*. **139**, 104580 (2021). https://doi.org/10.1016/j.ijrmms.2020.104580.
7. Shiu W., Guglielmi Y., Graupner B., **Rutqvist J.** Modelling the water injection induced fault slip and its application to in-situ stress estimation. *International Journal of Rock Mechanics and Mining Sciences*. **137**, 104537 (2021). https://doi.org/10.1016/j.ijrmms.2020.104537.

8. Plúa C., Vu M.N., Armand G., **Rutqvist J.**, Birkholzer J., Xu H., Guo R., Tatcher K.E., Bond A.E., Wang W., Nagel T., Shao H., Kolditz O. A reliable numerical analysis for large-scale modelling of a high-level radioactive waste repository in the Callovo-Oxfordian claystone. *International Journal of Rock Mechanics and Mining Sciences* International Journal of Rock Mechanics & *Mining Sciences*. **140**, 104574 (2021). https://doi.org/10.1016/j.ijrmms.2020.104574.

9. **Rutqvist J.**, Graupner B., Guglielmi Y., Kim T., Maßmann J., Nguyen T.S., Park J.W., Shiu W., Urpi L., Yoon J.-S., Ziefle G., Birkholzer J. An international model comparison study of controlled fault activation experiments in argillaceous claystone at the Mont Terri Laboratory. *International Journal of Rock Mechanics and Mining Sciences*. **136**, 104505 (2020). https://doi.org/10.1016/j.ijrmms.2020.104505.

10. Vasco D.W., **Rutqvist J.**, Jeanne P., Samsonov S.V., Hartline C. Using geodetic data in geothermal areas. *The Leading Edge*, **39**(12), 883-892, December (2020). https://doi.org/10.1190/tle39120883.1.

11. Li T., Tang C., **Rutqvist J.**, Hu M. TOUGH-RFPA: Coupled Thermal-Hydraulic-Mechanical Rock Failure Process Analysis with Application to Deep Geothermal Wells. *International Journal of Rock Mechanics and Mining Sciences* (in revision).

12. Kim K., **Rutqvist J.**, Harrington J.F., Tamayo-Mas E., and Birkholzer J.T. Discrete dilatant pathway modeling of gas migration through compacted bentonite clay. *International Journal of Rock Mechanics and Mining Sciences.* **137**, 104569 (2020). https://doi.org/10.1016/j.ijrmms.2020.104569.

13. Hu M. and **Rutqvist J.** Microscale mechanical modeling of deformable geomaterials with dynamic contacts based on the numerical manifold method. *Computational Geosciences*. 24, 1783–1797 (2020). https://doi.org/10.1007/s10596-020-09992-z.

14. Xu H., **Rutqvist J.**, and Birkholzer J. A study of thermal pressurization and potential for hydro-fracturing associated with nuclear waste disposal in argillaceous claystone. *International Journal of Rock Mechanics and Mining Sciences*. 132 (2020) 104536. https://doi.org/10.1016/j.ijrmms.2020.104536.

15. Xiao T., Xu H., Moodie N., Esser R., Jia W., Zheng L., **Rutqvist J.**, McPherson B. Chemical-mechanical impacts of CO2 intrusion into heterogeneous caprock. *Water Resources Research*, 56, e2020WR027193 (2020). https://doi.org/10.1029/2020WR027193.

16. Yoo H., Park, S., Xie, L., Kim K.-I., Min K.-B., **Rutqvist J.**, Rinaldi A.P. Hydro-mechanical Modeling of the First and Second Hydraulic Stimulations in a Fractured Geothermal Reservoir in Pohang, South Korea. *Geothermics*. 89, (2021). https://doi.org/10.1016/j.geothermics.2020.101982.

17. Park J.-W., Guglielmi Y., Graupner B., **Rutqvist J.**, Kim T., Park E.-S., and Lee C. Modeling of Fluid Injection-Induced Fault Reactivation Using Coupled Fluid Flow and Mechanical Interface Model. *International Journal of Rock Mechanics and Mining Sciences*. **132** 104373. (2020) https://doi.org/10.1016/j.ijrmms.2020.104373.

18. Tao S., Tang X., **Rutqvist J.**, Hu M., Liu Q. Simulating three dimensional thermal cracking with TOUGH-FEMM. *Computers and Geotechnics*. **124**, 103654 (2020). https://doi.org/10.1016/j.compgeo.2020.103654.

19. Xu H., **Rutqvist J.**, Plúa C., Armand G., Birkholzer J. Modeling of Thermal Pressurization in Tight Claystone using Sequential THM Coupling: Benchmarking and Validation against In-situ Heating Experiments in COx Claystone. *Tunnelling and Underground Space Technology.* 103, 103428. (2020) https://doi.org/10.1016/j.tust.2020.103428.

20. Hu M. and **Rutqvist J.** Finite volume modeling of coupled thermo-hydro-mechanical processes with application to brine migration in Salt. *Comput Geosci* **24,** 1751–1765 (2020). https://doi.org/10.1007/s10596-020-09943-8.

21. Lei Q., Wang X., Min K.-B., **Rutqvist J.** Interactive roles of geometrical distribution and geomechanical deformation of fracture networks in fluid flow through fractured geological media. *Journal of Rock Mechanics and Geotechnical Engineering*. 12, 780-792 (2020). https://doi.org/10.1016/j.jrmge.2019.12.014.

22. Hu M. and **Rutqvist J.** Numerical manifold method modeling of coupled processes in fractured geological media at multiple scales. *Journal of Rock Mechanics and Geotechnical Engineering*, 12, 667–681 (2020). https://doi.org/10.1016/j.jrmge.2020.03.002.

23. **Rutqvist J.** Thermal Management Associated with Geologic Disposal of Large Spent Nuclear Fuel Canisters in Tunnels with Thermally Engineered Backfill. *Tunnelling and Underground Space Technology*. Volume 102, August (2020), 103454. https://doi.org/10.1016/j.tust.2020.103454.

24. Guiltinan E.J., Kuhlman K.L., **Rutqvist J.**, Hu M., Boukhalfa H., Mills M., Otto S., Weaver D.J. Dozier B., Stauffer P.H. 2020. Temperature response and brine availability to heated boreholes in bedded salt. *Vadose Zone Journal*. 19:e20019 (2020). https://doi.org/10.1002/vzj2.20019.

25. Zheng L., Xu H., **Rutqvist J.**, Reagan M., Birkholzer J., Villar M.V., Fernández A.M. The hydration of bentonite buffer material revealed by modeling analysis of a long-term in situ test. *Applied Clay Science*, **185**, 24–32 (2020). https://doi.org/10.1016/j.clay.2019.105360.

26. Kim K., **Rutqvist J.** and Birkholzer J. Lattice modeling of excavation damage in argillaceous clay formations: Influence of deformation and strength anisotropy. *Tunneling and Underground Space Technology*, **98**, (2020). https://doi.org/10.1016/j.tust.2019.103196.

27. Guglielmi Y., Nussbaum C., Jeanne P., **Rutqvist J.**, Cappa F., and Birkholzer, J. Estimating Perturbed Stress from Three-Dimensional Borehole Displacements Induced by Fluid Injection in Fractured or Faulted Shales. *Geophysical Journal International*, **221**, 1684–1695 (2020). https://doi.org/10.1093/gji/ggaa103.

28. Guglielmi Y., Nussbaum C., Jeanne P., **Rutqvist J.**, Cappa F., and Birkholzer, J. Complexity of fault rupture and fluid leakage in shale: Insights from a controlled

fault activation experiment. *Journal of Geophysical Research: Solid Earth*, 125, e2019JB017781 (2020). https://doi.org/10.1029/2019JB017781.

29. Li T., Tang C., **Rutqvist J.**, Hu M., Li L., Zhang L., and Huang B. The Influence of an Interlayer on Dual Hydraulic Fractures Propagation. *Energies*, 13, 555 (2020). https://doi.org/10.3390/en13030555.
30. Urpi L., Rinaldi, A. P., **Rutqvist, J.** and Wiemer, S. Fault stability perturbation by thermal pressurization and stress transfer around a deep geological repository in a clay formation. Journal of Geophysical Research: Solid Earth, **124**, 8506–8518 (2019). https://doi.org/10.1029/2019JB017694.
31. Jeanne P., Farr T.G., **Rutqvist J.** and Vasco D.W. Role of agricultural activity on land subsidence in the San Joaquin Valley, California. Journal of Hydrology, **569,** 462-469 (2019). https://doi.org/10.1016/j.jhydrol.2018.11.077.
32. Park J-W., Guglielmi Y., Graupner B., **Rutqvist J.**, and Park E.-S. Numerical modelling of Fault Reactivation Experiment at Mont Terri Underground Research Laboratory in Switzerland: DECOVALEX-2019 TASK B (Step 2). *Tunnel & Underground Space (in Korean)*, **29**, 197-213 (2019). https://doi.org/10.7474/TUS.2019.29.3.197.
33. Vilarrasa V., Carrera, J., Olivella S., **Rutqvist J.**, and Laloui L. Induced seismicity in geologic carbon storage. *Solid Earth*, **10**, 871–892 (2019). https://doi.org/10.5194/se-10-871-2019.
34. Liu J., Haeckel M., **Rutqvist J.**, Wang S. and Yan W. The mechanism of methane gas migration through the gas hydrate stability zone: insights from numerical simulations. DOI:10.1029/2019JB017417. *Journal of Geophysical Research*: Solid Earth, 124 (2019) https://doi.org/10.1029/2019JB017417.
35. Nguyen T.S., Guglielmi Y., Graupner B., and **Rutqvist J.** Mathematical Modelling of Fault Reactivation Induced by Water Injection. *Minerals*, 9, 282 (2019). http://dx.doi.org/10.3390/min9050282.
36. Lee J., Kim K.-I., Min K.-B. and **Rutqvist J.** TOUGH-UDEC: A Simulator for Coupled Multiphase Fluid Flows, Heat Transfers and Discontinuous Deformations in Fractured Porous Media. *Computers and Geosciences* **126**, 120–130 (2019). https://doi.org/10.1016/j.cageo.2019.02.004
37. Rinaldi A.P and **Rutqvist J.** Joint opening or hydroshearing? Analyzing a fracture zone stimulation at Fenton Hill. *Geothermics*, **77**, 83–98 (2019). https://doi.org/10.1016/j.geothermics.2018.08.006.
38. Chen Y., Huang L…..,**Rutqvist J.**, EGS Collab Team et al. Optimal design of 3D borehole seismic arrays for microearthquake monitoring in anisotropic media during stimulations in the EGS collab project. 79, 61-66 (2019). https://doi.org/10.1016/j.geothermics.2019.01.009.
39. Tang X.H, **Rutqvist J.**, Hu M., and Rayudu N.M. Modeling three-dimensional fluid-driven propagation of multiple fractures using TOUGH-FEMM. *Rock Mechanics and Rock Engineering*, **52**, 611–627 (2019). https://doi.org/10.1007/s00603-018-1715-7

40. Kim H.-M., Guglielmi Y., **Rutqvist J.** and Eui-Seob Park E.-S. A technical review of hydromechanical properties of jointed rock mass accompanied by fluid injection. *Tunnel & Underground Space (in Korean)*, **29**, 12-29 (2019). https://doi.org/10.7474/TUS.2019.29.1.012.

41. Zhou Q., Oldenburg C.M., and **Rutqvist J.** Revisiting the analytical solutions of heat transport in fractured reservoirs using a generalized multirate memory function. *Water Resources Research*, 55, 1405–1428 (2019). https://doi.org/10.1029/2018WR024150

42. Lin J.S., Uchida S., Myshakin E.M., Seol Y., **Rutqvist J.** and Boswell R. Assessing the geomechanical stability of interbedded hydrate bearing sediments under gas production by depressurization at NGHP-02 Site 16. Marine and Petroleum Geology, **108,** 648-659 (2019). https://doi.org/10.1016/j.marpetgeo.2018.08.018.

43. Graupner B.J., Shao H., Wang X.R., Nguyen T.S., Li Z., **Rutqvist J.**, Chen F., Birkholzer J., Wang W., Kolditz O., Pan P.Z., Feng X.T., Lee C., Maekawa K., Stothoff S., Manepally C., Dasgupta B., Ofoegbu G., Fedors R., Barnichon J.D., E. Ballarini E., Bauer S., Garitte B. Comparative modelling of the coupled thermal-hydraulic-mechanical (THM) processes in a heated bentonite pellet column with hydration. *Environmental Earth Sciences* (2018) 77:84. https://doi.org/10.1007/s12665-018-7255-3.

44. Blanco-Martin L., **Rutqvist J.**, Battistelli A. and Birkholzer J.T. Coupled processes modeling in rock salt and crushed salt including halite solubility constraints: application to disposal of heat-generating nuclear waste. *Transport in Porous Media*, **124**, 159–182 (2018) https://doi.org/10.1007/s11242-018-1057-7.

45. Jeanne P., Guglielmi Y., **Rutqvist J.**, Nussbaum C and Birkholzer J. Permeability variations associated with fault reactivation in a claystone formation investigated by field experiments and numerical simulations. *Journal of Geophysical Research,* **123**, 1694–1710 (2018).

46. **Rutqvist J.** An overview of TOUGH-based geomechanics models. *Computers & Geosciences*, **108**, 56–63 (2017). https://doi.org/10.1016/j.cageo.2016.09.007.

47. Ma T., **Rutqvist J.**, Liu W., Zhu L. and Kim K. Modeling of CO_2 sequestration in coal seams: role of CO2-induced coal softening on injectivity, storage efficiency and caprock deformation. *Greenhouse Gas Sciences & Technology*, **7,** 562–578 (2017).

48. Jeanne P., **Rutqvist J.**, Foxall W., Rinaldi A.P., Wainwright H.M., Zhou Q., Birkholzer J. and Layland-Bachmann C. Effects of the distribution and evolution of the coefficient of friction along a fault on the assessment of the seismic activity associated with a hypothetical industrial-scale geologic CO_2 sequestration operation. *International Journal of Greenhouse Gas Control*, **66**, 254–263 (2017).

49. Zhou Q., Oldenburg C.M., **Rutqvist J.** and Birkholzer J.T. Revisiting the fundamental analytical solutions of heat and mass transfer: The kernel of multirate and multidimensional diffusion. *Water Resources Research*, **53**, 9960–9979 (2017).

50. Zheng L., **Rutqvist J.**, Birkholzer J.T., and Liu H.H. Coupled THMC models for bentonite in an argillite repository for nuclear waste: illitization and its effect on swelling stress under high temperature. *Engineering Geology*, **230,** 118–129 (2017).

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52. Jeanne P., Guglielmi Y., **Rutqvist J.**, Nussbaum C. and Birkholzer J. Field Characterization of Elastic Properties Across a Fault Zone Reactivated by Fluid Injection. *Journal of Geophysical Research Solid Earth*, **122,** 6583–6598 (2017).

53. Figueiredo, B., Tsang C.F., **Rutqvist J.**, and Niemi A. The effect of nearby fractures on hydraulically induced fracture propagation and permeability changes. *Engineering Geology*, **228**, 197–213 (2017).

54. Vilarrasa V., Rinaldi A.P., and **Rutqvist J.** Long-term thermal effects on injectivity evolution during CO2 storage. *International Journal of Greenhouse Gas Control*, **64**, 314–322 (2017).

55. Ma T., **Rutqvist J.**, Oldenburg C.M., Liu W. and Chen J., Fully coupled two-phase flow and poromechanics modeling of coalbed methane recovery: Impact of geomechanics on production rate. *Journal of Natural Gas Science and Engineering* **45**, 474–486 (2017).

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