

Mengsu Hu

Research Scientist

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Education

PhD, Hohai University, 2010- 2016

Visiting PhD student, Lawrence Berkeley National Laboratory, 2012- 2014

BEng, China University of Mining and Technology, 2006- 2010

Work Experience

Research Scientist, Lawrence Berkeley National Laboratory, 2018-Present

Postdoctoral Fellow, Lawrence Berkeley National Laboratory, 2016-2018

Research Interests

Numerical modeling of coupled thermal-hydro-mechanical-chemical (THMC) processes in the energy geosciences, including:

- ❖ Novel computational methods development: extended finite volume method (XFVM), numerical manifold method (NMM);
 - ❖ Numerical modeling of microscale mechanical-chemical processes such as pressure solution, carbonate compaction, clay swelling, fracture alteration and fracture healing;
 - ❖ Multi-scale, long-term analysis of THM processes in energy-geosciences applications such as nuclear waste disposal, geothermal exploitation.
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Selected Awards

2020-, ARMA Future Leader, American Rock Mechanics Association

2019, Early Career Enrichment Program, Lawrence Berkeley National Laboratory

2018, No. 1 Ranked Outstanding PhD Thesis Award, Chinese Society for Rock Mechanics and Engineering

2018, Spot Recognition Award for the novel and innovative contributions towards the preparation of an Energy Frontier Research Center proposal, Lawrence Berkeley National Laboratory

2016, Spot Recognition Award for outstanding contributions to the field of coupled processes modeling, Lawrence Berkeley National Laboratory

2015, The National Scholarship, Ministry of Education, China.

2014, The National Scholarship, Ministry of Education, China.

2008, The National Scholarship, Ministry of Education, China. (Ranking 1/252)

2007, The National Scholarship, Ministry of Education, China. (Ranking 2/252)

2010, Outstanding Graduate, China University of Mining and Technology, China

2008, Pacemaker to Merit Student, China University of Mining and Technology, China

Journal Publications

- [1] **Mengsu Hu**, Jonny Rutqvist. Microscale mechanical modeling of deformable geomaterials with dynamic contacts based on the numerical manifold method. *Computational Geosciences*. <https://doi.org/10.1007/s10596-020-09992-z>
- [2] **Mengsu Hu**, Jonny Rutqvist. Numerical manifold method modeling of coupled processes in fractured geological media at multiple scales. *Journal of Rock Mechanics and Geotechnical Engineering* 2020. <https://doi.org/10.1016/j.jrmge.2020.03.002>
- [3] **Mengsu Hu**, Jonny Rutqvist. Finite volume modeling of coupled thermo-hydro-mechanical processes with application to brine migration in salt. *Computational Geosciences* 2020. <https://doi.org/10.1007/s10596-020-09943-8>
- [4] Siji Tao, Xuhai Tang, Jonny Rutqvist, **Mengsu Hu**, Quansheng Liu. Simulating three dimensional thermal cracking with TOUGH-FEMM. *Computers and Geotechnics*. <https://doi.org/10.1016/j.compgeo.2020.103654>
- [5] Eric Guiltinan, Kristopher Kuhlman, Jonny Rutqvist, **Mengsu Hu**, Hakim Boukhalfa, Melissa Mills, Shawn Otto, Douglas Weaver, Brian Dozier, and Philip Stauffer. Temperature response and brine availability to heated boreholes in bedded salt. *Vadose Zone Journal* 2020. <https://doi.org/10.1002/vzj2.20019>
- [6] Tianjiao Li, Chun'an Tang, Jonny Rutqvist, **Mengsu Hu**, Lianchong Li, Liaoyuan Zhang, Bo Huang. The influence of an interlayer on dual hydraulic fractures propagation. *Energies* 13: 555, 2020. doi:10.3390/en13030555
- [7] Xuhai Tang, Jonny Rutqvist, **Mengsu Hu**, Nithin Manohar Rayudu. Modeling three-dimensional fluid-driven propagation of multiple fractures using TOUGH-FEMM. *Rock Mechanics and Rock Engineering* 52 (2): 611-627, 2019.
- [8] **Mengsu Hu**, Jonny Rutqvist, Yuan Wang. A numerical manifold method model for analyzing fully coupled hydro-mechanical processes in porous rock masses with discrete fractures. *Advances in Water Resources* 102: 111-126, 2017.
- [9] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. Fully coupled hydro-mechanical numerical manifold modeling of porous rock with dominant fractures. *Acta Geotechnica* 12(2): 231-252, 2017.
- [10] **Mengsu Hu**, Jonny Rutqvist, Yuan Wang. A practical model for flow in discrete-fracture porous media by using the numerical manifold method. *Advances in Water Resources* 97: 38-51, 2016.
- [11] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. On continuous and discontinuous approaches for modeling groundwater flow in heterogeneous media using the numerical manifold method: model development and comparison. *Advances in Water Resources* 80: 17-29, 2015.
- [12] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. Development of a discontinuous approach for modeling fluid flow in heterogeneous media using the numerical manifold method. *International Journal for Numerical and Analytical Methods in Geomechanics* 39: 1932- 1952, 2015.
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[13] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. An effective approach for modeling water flow in heterogeneous media using Numerical Manifold Method. *International Journal for Numerical Methods in Fluids* 77: 459-476, 2015.

[14] Yuan Wang, **Mengsu Hu**, Quanlin Zhou, Jonny Rutqvist. Energy-work-based numerical manifold seepage analysis with an efficient scheme to locate the phreatic surface. *International Journal for Numerical and Analytical Methods in Geomechanics* 38: 1633-1650, 2014.

[15] Yuan Wang, **Mengsu Hu**, Quanlin Zhou, Jonny Rutqvist. A new second-order numerical manifold method model with an efficient scheme for analyzing free surface flow with inner drains. *Applied Mathematical Modelling* 40: 1427-1445, 2016.

Book Chapters

[1] Jonny Rutqvist, Bruno Figueiredo, **Mengsu Hu**, Chin-Fu Tsang. Continuum modeling of hydraulic fracturing in complex fractured rock masses. *Hydraulic Fracture Modeling*. Edited by Yu-Shu Wu. Houston: Gulf Professional Publishing, 2018.

Invited Talks

[1] **Mengsu Hu**. NMM model development for analysis of coupled hydro-mechanical processes in heterogeneous media. 51st meeting of Commission on DDA Application of Rock Engineering, Japan. December 17, 2015, Tokyo, Japan.

[2] **Mengsu Hu**. Model development of NMM for analysis of flow in heterogeneous media with application to hydro-mechanical coupling in fractured rock masses. 5th Northeastern University Forum of Rock mechanics- Numerical Methods for Discontinuous Media. June 23, 2015, Shenyang, China.

Selected Conference Presentations

[1] Jonny Rutqvist, Lehua Pan, Nicholas Spycher, Patrick Dobson, Quanlin Zhou, **Mengsu Hu**. Coupled processes analysis of flexible geothermal production from a liquid-dominated geothermal system: impact on wells. World Geothermal Congress 2021, May 21-26, Reykjavik, Iceland.

[2] Jonny Rutqvist, Quanlin Zhou, Lehua Pan, Nicholas Spycher, Patrick Dobson, **Mengsu Hu**. Coupled processes analysis of flexible geothermal production from steam- and liquid-dominated systems: impact on wells. Stanford Geothermal Workshop 45th Annual 2020. February 10-12, Stanford, USA.

[3] Tianjiao Li, Jonny Rutqvist, **Mengsu Hu**, Lianchong Li, Chunan Tang, et al. Numerical investigation of hydraulic fracturing and well placement in multilayered shale oil reservoirs using RFPA-Petrol. 53rd U.S. Rock Mechanics/Geomechanics Symposium, 23-26 June, 2019, New York City, New York USA.

[4] **Mengsu Hu**, Jonny Rutqvist. Zero-dimensional fracture model for fluid flow and heat transfer in discrete fracture networks. International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application (CouFrac) 2018, November 12-14, Wuhan, China.

[5] **Mengsu Hu**, Jonny Rutqvist. An extended finite volume method model for fully coupled thermal-hydro-mechanical analysis. TOUGH Symposium 2018, October 8-10, Berkeley, USA.

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- [6] **Mengsu Hu**, Jonny Rutqvist. Fully coupled thermal-hydro-mechanical analysis for porous rock masses with discrete fractures by using the numerical manifold method (NMM). CMWR 2018, June 3-7, St Malo, France.
- [7] Antonio P. Rinaldi, Jonny Rutqvist, Laura Blanco-Martín, **Mengsu Hu**, Manuel L. Sentís. Coupling TOUGH3 with FLAC3D for parallel computing of fluid-flow and geomechanics TOUGH Symposium 2018, October 8-10, Berkeley, USA.
- [8] Jonny Rutqvist, Lehua Pan, **Mengsu Hu**. T2Well-FLAC3D for advanced well integrity analysis. TOUGH Symposium 2018, October 8-10, Berkeley, USA.
- [9] Tianjiao Li, Chunan Tang, Jonny Rutqvist, **Mengsu Hu**. TOUGH-RFPA: A coupled thermal-hydraulic-mechanical-damage model for simulation of fracture propagation in unsaturated geological media. TOUGH Symposium 2018, October 8-10, Berkeley, USA.
- [10] Jonny Rutqvist, Lehua Pan, **Mengsu Hu**, Quanlin Zhou, Patrick Dobson. Modeling of coupled flow, heat and mechanical well integrity during variable geothermal production. 43rd Workshop on Geothermal Reservoir Engineering, February 12-14, 2018, Stanford, USA.
- [11] **Mengsu Hu**, Jonny Rutqvist. A dual-continuum model for brine migration in salt associated with heat-generating nuclear waste: fully coupled THM analysis. 2017 AGU Fall meeting, New Orleans.
- [12] **Mengsu Hu**, Jonny Rutqvist, Yuan Wang. A fully coupled hydro-mechanical model for discrete fractured porous rock masses based on numerical manifold method. 50th U.S. Rock Mechanics/Geomechanics Symposium, June 26- June 29, 2016, Houston, Texas, USA.
- [13] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. Numerical manifold modeling of coupled hydro-mechanical processes in fractured rock. 49th U.S. Rock Mechanics/Geomechanics Symposium, June 28- July 1, 2015, San Francisco, California, USA.
- [14] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. On the new approaches for modeling water flow in heterogeneous media with numerical manifold method. The 13th International Symposium on Rock Mechanics, May 10-13, 2015, Montreal, Canada.
- [15] **Mengsu Hu**, Yuan Wang, Jonny Rutqvist. Derivation and comparison of different new approaches for boundary constraints in numerical simulation of water flow in heterogeneous media using Numerical Manifold Method. 48th U.S. Rock Mechanics/Geomechanics Symposium, June 1- 4, 2014, Minneapolis, Minnesota, USA.
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Funded Research Project Awards

2019-2021, **PI**, Extended Finite Volume Method for Coupled Processes in Complex Fractured Geological Systems, Early Career Laboratory Directed Research Development (LDRD), Lawrence Berkeley National Laboratory, USA.

2018-2019, **PI**, Modeling of Hydraulic Fracturing Using Numerical Manifold Method. State Key Laboratory of Geomechanics and Geotechnical Engineering, China.

2015-2016, **PI**, Model Development of Coupled Hydro-mechanical Processes in Fractured Rock Using Numerical Manifold Methods with Application to Geological Storage of CO₂. The Fundamental Research Funds for the Central Universities, China.

2012-2016, **PI**, Modeling of Coupled Hydro-mechanical Processes Associated with Geological Storage of CO₂ Based on Modern Numerical Methods. Graduates Science Innovation Research Project, Jiangsu Province, China.

Scholarly Service

2020, Session Organizer, International Conference on coupled processes in fractured geological media: observation, modeling, and application, CouFrac 2020 (Co-organizers: Adriana Paluszny, Pania Newell, Shaojun Li, Laura Blanco-Martín)

2020, Session Organizer, 54th US Rock Mechanics/Geomechanics Symposium (Co-organizer: Zhou Lei), symposium cancelled due to COVID-19.

2019-2020, Guest Editor, Computational Geosciences Special Issue: CouFrac 2018 (Co-editors: Carl Steefel, Jonny Rutqvist)

2019-, Reviewer, NSF CAREER proposal

2020-, Early/Mid Career Representatives, Commission on Coupled Thermal-Hydro-Mechanical-Chemical Processes in Fractured Rock, International Society for Rock Mechanics and Rock Engineering

2018-2019, General Secretary and Member, Commission on Coupled Thermal-Hydro-Mechanical-Chemical Processes in Fractured Rock, International Society for Rock Mechanics and Rock Engineering

2018, Co-Chair, International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application, CouFrac 2018 (Conference chair: Jonny Rutqvist; Co-chairs: Ki-Bok Min, Pengzhi Pan)

2018, Organizing Committee Member, TOUGH Symposium 2018 (Symposium chair: Curtis Oldenburg; Co-organizers: Yingqi Zhang, Matthew Reagan, Eric Sonnenthal)

2017, Session Co-Chair, 51st US Rock Mechanics/Geomechanics Symposium (Co-organizer: Jonny Rutqvist)

2017, Organizing Committee Member, 13th International Conference on Analysis of Discontinuous Deformation (ICADD 13)

Reviewer for peer-review journals:

Advances in Geosciences, Advances in Water Resources, Applied Mathematical Modelling, Computers and Geotechnics, Computer Methods in Applied Mechanics and Engineering, Engineering Analysis with Boundary Elements, Geofluids, Hydrogeology Journal, International Journal of Rock Mechanics and Mining Sciences, Journal of Geophysical Research - Solid Earth, Journal of Hydrology, Journal of Rock Mechanics and Geotechnical Engineering, Mathematical Methods in the Applied Sciences, Rock Mechanics and Rock Engineering, Scientific Reports, SoftwareX, Tunneling and Underground Space Technology, Structural Engineering, SPE Journal, Water Resources Research

Reviewer, 6th Biot conference on Poromechanics

Reviewer for books:

“Hydraulic Fracture Modeling” (Elsevier), “Science of Carbon Storage in Deep Saline Formation: Process Coupling Across Time and Spatial Scales” (Elsevier).

Teaching Experiences

2019-, Instructor, University of California, Berkeley, EPS 200 001 - LEC 001, Problems in Hydrogeology (Co-teaching with: Carl Steefel, Jonny Rutqvist, Curt Oldenburg)

Supervision/Co-Supervision

Postdocs (PhD institutes): Martin Lesueur (University of New South Wales), Liuchi Li (Caltech)

Graduate students: Yuan Tian (UC Berkeley), Shaswat babhulgaonkar (Cal State East Bay, funded by Berkeley Lab CSUEB Intern Pilot Program)

Undergraduate intern students: Sage Quinn (UC Berkeley, funded by Cal Energy Corps)
