

## Ang Liu, Ph.D.

Assistant Teaching Professor in Energy and Mineral Engineering

John and Willie Leone Family Department of Energy and Mineral Engineering

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### EDUCATIONAL DETAILS

2018 - 2021: Ph.D., Energy and Mineral Engineering, Pennsylvania State University, United States.

2015 - 2018: M.S., Mine Safety Science and Engineering, China University of Mining and Technology-Beijing, China.

2011 - 2015: B.S., Mining Engineering, Henan Polytechnic University, China.

### PROFESSIONAL DETAILS

2021 - present: Assistant Teaching Professor. Department of Energy and Mineral Engineering, Pennsylvania State University.

2018 - 2021: Research and Teaching Assistant. Department of Energy and Mineral Engineering, Pennsylvania State University.

2015 - 2018: Research Assistant. School of Emergency Management and Safety Engineering, China University of Mining and Technology (Beijing), China.

### RESEARCH INTERESTS

- Geomechanics and rock mechanics
- Multiphase reactive flow and transport behaviors in porous media
- Mathematical modeling and numerical simulations on coupled processes
- Rock characterizations and imaging
- GeoH<sub>2</sub> production
- Hydrogen cleaning and carbon dioxide storage in coal seams
- Mine ventilation optimization, ground control

### TEACHING COURSES

Course	Type	Course Title	Credits	Enrollment*
EGEE 101	In-person	Energy and Geo-Environmental Engineering	3	1197
EGEE 101	Online	Energy and Geo-Environmental Engineering	3	7228
MNG 422	In-person	Mine Ventilation and Air Conditioning	3	6
		Mine Ventilation and Air Conditioning _ Lab Session		
MNG 331	In-person	Rock Mechanics	3	5
		Rock Mechanics _ Lab Session		
MNG 410	In-person	Underground Mining	3	5
MNG 401	Online	Introduction to Mining Operations	1	27
ENVSE 450	In-person	Environmental Health and Safety Engineering	3	180

\*Data up to Spring 2025

## PEER-REVIEWED JOURNAL PUBLICATIONS

1. **Liu, A.**, Liu, S., Zhang, K., Xia, K., 2024. Competitive sorption of binary CH<sub>4</sub>-CO<sub>2</sub> mixture and its implication for carbon storage in coals. *Separation and Purification Technology*, 354, 129399. (IF:8.2)
2. **Liu, A.**, Liu, S., 2024. Evaluation of parameters impacting grey H<sub>2</sub> storage in coalbed methane formations. *Renewable and Sustainable Energy Reviews*, 202, paper 114686. (IF:16.3)
3. **Liu, A.**, Liu, S., Zhang, R., Sang, G., Xia, K., 2023. Cyclical water vapor sorption-induced structural alterations of mine roof shale. *International Journal of Coal Geology*, 273, paper 104267. (IF:5.6)
4. **Liu, A.**, Liu, S., Xia, K., Liu, P., Yang, Y., Wang, G., 2023. Characterizing Anisotropic Swelling Strains of Coal Using Combined Rosette Strain Gauge and CT-Scans. *Rock Mechanics and Rock Engineering*, 56, 5405-5426. (IF:5.5)
5. **Liu, A.**, Liu, S., 2023. Hydrogen sorption and diffusion in coals: implications for hydrogen geo-storage. *Applied Energy*, 334,120746. (IF:10.1)
6. **Liu, A.**, Liu, S., Wang, K., 2023. Coupled model of multi-mechanistic gas–water transport behavior in tight shale. *Energy and Fuels*,37(4):2860-2874. (IF:5.2)
7. **Liu, A.**, Liu, S., Wang, K., 2022. Moisture retention and multi-mechanistic transport behavior in nanoporous coal. *Langmuir*,38:14941-14958. (IF:3.7)
8. **Liu, A.**, Liu, S., Liu, Y., Liu, B., Liu, T., 2022. Characterizing mechanical heterogeneity of coal at nano-to-micro scale using combined nanoindentation and FESEM-EDS. *International Journal of Coal Geology*,261,104081. (IF:5.6)
9. **Liu, A.**, Liu, S., 2022. Mechanical property alterations across coal matrix due to water-CO<sub>2</sub> treatments: A micro-to-nano scale experimental study. *Energy*,248,123575. (IF:9.0)
10. **Liu, A.**, Liu, S., 2021. A fully-coupled water-vapor flow and rock deformation damage model for shale and coal its application for mine stability evaluation. *International Journal of Rock Mechanics and Mining Sciences*,146,104880. (IF:7.0)
11. Liu, P., **Liu, A.\***, Zhong, F., Li, J., 2021. Pore/fracture structure and gas permeability alterations induced by ultrasound treatment in coal and its application to enhanced coalbed methane recovery. *Journal of Petroleum Science and Engineering*,205,108862. (IF:5.2)
12. **Liu, A.**, Liu, S., Liu, P., Wang, K., 2021. Water sorption on coal: effects of oxygen-containing function groups and pore structure. *International Journal of Coal Science and Technology*,8:983-1002. (IF:6.9)
13. **Liu, A.**, Liu, S., Harpalani, S., Liu, P., 2021. The role of sorption-induced coal matrix shrinkage on permeability and stress evolutions under replicated in situ condition for CBM reservoirs. *Fuel*,294,120530. (IF:6.7)
14. **Liu, A.**, Liu, P., Liu, S., 2020. Gas diffusion coefficient estimation of coal: a dimensionless numerical method and its experimental validation. *International Journal of Heat and Mass Transfer*,162,120336. (IF:5.0)
15. **Liu, A.**, Liu, S., Wang, G., Elsworth, D., 2020. Continuous compaction and permeability evolution in longwall gob materials. *Rock Mechanics and Rock Engineering*,53,5489-5510. (IF:5.5)
16. **Liu, A.**, Liu, S., Hou, X., Liu, P., 2020. Transient gas diffusivity evaluation and modeling for methane and helium in coal. *International Journal of Heat and Mass Transfer*,159,120091. (IF:5.0)
17. **Liu, A.**, Liu, S., Wang, G., Sang, G., 2020. Modeling of coal matrix apparent strains for sorbing gases using a transversely isotropic approach. *Rock Mechanics and Rock Engineering*, 53(9),4163-4181. (IF:5.5)

18. **Liu, A.**, Liu, S., Wang, G., Elsworth, D., 2020. Predicting fugitive gas emissions from gob-to-face in longwall coal mines: coupled analytical and numerical modelling. *International Journal of Heat and Mass Transfer*, 150, 119392. (IF:5.0)
19. **Liu, A.**, Wang, K., Zang, J., Du, F., Zhou, A., 2018. Relative permeability of gas for unconventional reservoirs. *Transport in Porous Media*, 124:289-307. (IF:2.7)
20. Wang, K., **Liu, A.**, Zhou, A., 2017. Theoretical analysis of influencing factors on resistance in the process of gas migration in coal seams. *International Journal Mining Science and Technology*, 27:315–319. (IF:11.7)
21. **Liu, A.**, Huang, Y., Jiang, Y., 2016. Theoretical research on tortuosity of coal based on the matchstick model. *Mining Engineering*, 4:72-78 (In Chinese).
22. Xiao, J., Liu, J., Xu, Y., Li, X., **Liu, A.**, Xia, K., 2024. An improved three-dimensional extension of Hoek–Brown criterion for rocks. *Geomechanics and Geophysics for Geo-Energy and Geo-Resources*, 10(1), 1-24. (IF:3.9)
23. Zhao, S., Guo, H., **Liu, A.**, Chen, Z., Li, G., Chen, L., Shen, Y., 2024. Methane production and microbial community characteristics in the co-digestion of biodegradable plastics with lignite. *Energy*, 305, 132405. (IF:9.0)
24. Azam, S., Liu, S., Bhattacharyya, S., **Liu, A.**, 2023. Measurement and modeling of water vapor sorption on nano-sized coal particulates and its implication on its transport and deposition in the environment. *Science of The Total Environment*, 889, 164095. (IF:8.2)
25. Liu, Y., **Liu, A.**, Liu, S., Kang, Y., 2022. Nano-scale mechanical properties of constituent minerals in shales investigated by combined nanoindentation statistical analyses and SEM-EDS-XRD techniques. *International Journal of Rock Mechanics and Mining Sciences*, 159, 105187. (IF:7.0)
26. Liu, Y., Liu, S., **Liu, A.**, Kang, Y., 2022. Determination of mechanical property evolutions of shales by nanoindentation and high-pressure CO<sub>2</sub> and water treatments: A nano-to-micron scale experimental study. *Rock Mechanics and Rock Engineering*, 55(12):7629-7655. (IF:5.5)
27. Liu, P., **Liu, A.**, Liu, S., Qi, L., 2021. Experimental evaluation of ultrasound treatment induced pore structure and gas desorption behavior alterations of coal. *Fuel*, 307, 121855. (IF:6.7)
28. Hou, X., Liu, S., Li, G., Zhu, Y., **Liu, A.**, 2021. Quantifying and modeling of in situ stress evolutions of coal reservoirs for helium, methane, nitrogen and CO<sub>2</sub> depletions. *Rock Mechanics and Rock Engineering*, 54:701-719. (IF:5.5)
29. Liu, T., Lin, B., Fu, X., **Liu, A.**, 2021. Mechanical criterion of coal and gas outburst: A perspective from multiphysics coupling. *International Journal of Coal Science and Technology*, 8(6):1423-1435. (IF:6.9)
30. Zang, J., Wang, K., **Liu, A.**, Zhang, X., Yan, Z., 2019. An orthotropic coal permeability model. *International Journal of Mining Science and Technology in Chinese*, 01.
31. Yan, Z., Wang, K., Zang, J., Wang, C., **Liu, A.**, 2019. Anisotropic coal permeability and its stress sensitivity. *International Journal of Mining Science and Technology*, 29 (3): 507-511. (IF:11.7)
32. Zang, J., Wang, K., **Liu, A.**, 2019. Phenomenological over-parameterization of the triple-fitting-parameter diffusion models in evaluation of gas diffusion in coal. *Processes*, 7(4):241. (IF:3.5)
33. Jiang, Y., Kan, T., **Liu, A.**, Chang, X., Xu, G., 2016. Study on methane adsorption characteristics of different rank coals in the presence of moisture. *Journal of Mines, Metals & Fuels*, 587.

## PEER-REVIEWED CONFERENCE PROCEEDINGS

1. **Liu, A.**, Liu, S., 2019. Modeling of anisotropic sorption-induced coal deformations. *53rd U.S. Rock Mechanics/Geomechanics Symposium*, ARMA-2019-0506.
2. **Liu, A.**, Liu, S., Sang, G., 2020. Characterizing gas-water transport behavior in tight shale and its application on the well productivity. SPE Annual Technical Conference and Exhibition 2020. Houston City, TX, USA, 27-29 October 2020. SPE-201651-MS.
3. Yang, Y., Liu, S., **Liu, A.**, 2022. Evaluating the pressure-dependent equivalent permeability evolutions for shale matrix: experiments and modeling. SPE Western Regional Meeting, OnePetro, 2022.

## CONFERENCE PROCEEDINGS REVIEWED BY ABSTRACTS

1. **Liu, A.**, Liu, S. Competitive sorption of CH<sub>4</sub> and H<sub>2</sub> on coals and its implication for hydrogen geo-storage. The American Geophysical Union Fall Meeting, 15-19 December 2024, Washington, D.C., U.S.
2. **Liu, A.**, Liu, S. Hydrogen transport and storage in coal. The 11<sup>th</sup> Asian Rock Mechanics, 21-24 October 2021, Beijing, China.
3. **Liu, A.**, Liu, S., Sang, G., Yang, Y., 2021. Shale matrix swelling and its residual water saturation and their implications on matrix permeability for gas shale reservoirs. The 34<sup>th</sup> International Symposium of the Society of Core Analysts, Austin, Texas, USA, 20-23 September 2021. Paper T047.
4. **Liu, A.**, Liu, S., 2021. Quantifying the principal swelling strain tensor induced by sorption using combined rosette strain gauge measurement and digital imaging technique. The 55<sup>th</sup> US Rock Mechanics/Geomechanics Symposium, Woodlands-Houston, Texas, USA, 20-23 June 2021. Abstract Control #1351.
5. **Liu, A.**, Liu, S., 2021. Development of time-dependent rock-fluid-geomechanics model and software suites: Application for time-dependent shaly roof stability analysis. The 2021 International Conference on Ground Control in Mining, Canonsburg, PA, USA, 27-29 July 2021.
6. **Liu, A.**, Liu, S., 2021. Experiment and modeling of cyclic CO<sub>2</sub> huff 'n' puff process in artificially fractured shale core sample. The AAPG Annual Convention & Exhibition, Denver, Colorado, USA, 24-26 May 2021. Abstract Number: 6101.
7. **Liu, A.**, Liu, S., Liu, T., 2021. Experiment and modeling of relative permeabilities of gas-bulk water two phase in unpropped and propped tight shale. SPE Annual Technical Conference and Exhibition 2021, Dubai, U.A.E., 21 - 23 September 2021. Control number: 21ATCE-P-1763-SPE.
8. **Liu, A.**, Liu, S., 2021. Characterization and modeling of water retention behavior and suction potential in unsaturated air-water-shale system. The 55<sup>th</sup> US Rock Mechanics/Geomechanics Symposium, Woodlands-Houston, Texas, USA, 20-23 June 2021. Abstract Control #1349.
9. **Liu, A.**, Liu, S., Yang, Y., Sang, G., 2021. Laboratory and modeling of ad/desorption isotherms of gas-vapor mixtures on coal. The 34<sup>th</sup> International Symposium of the Society of Core Analysts, Austin, Texas, USA, 20-23 September 2021. Paper T009.
10. **Liu, A.**, Liu, S., 2021. Characterization of nano-coal-dusts using XRD, FESEM-EDS, and XPS measurements. The 18<sup>th</sup> North American Mine Ventilation Symposium, Rapid City, South Dakota, USA, 12-17 June 2021. Abstract number 089.
11. **Liu, A.**, Liu, S., 2021. Coupled modeling of methane emissions-ventilation air mixture flow in longwall coal mine. The 18<sup>th</sup> North American Mine Ventilation Symposium, Rapid City, South Dakota, USA, 12-17 June 2021. Abstract number 080.

## INVOLVED PROJECTS

1. PI. *In situ investigation of structural alterations induced by local humidity gradient for nanoporous shale matrix*. Oak Ridge National Laboratory, IPTS#: 27485.1.
2. PI. *Investigating strain localization changes induced by shale-water interaction using combined nanoindentation and digital volume correlation of X-ray nanoscale-tomography*, Energy and Environmental Sustainability Laboratories, Penn State University.
3. PI. *Investigation of Mechanical Property Alterations and Deformation-Failure Behavior of Coal Exposed to Combined Moisture and Heat Conditions*. State Key Laboratory of Intelligent Construction and Healthy Operation and Maintenance of Deep Underground Engineering, No. SDGZK2418, China.
4. PI. *Evaluation of Pumpable Roof Support Deterioration with Mine Air Exposure*. State Key Laboratory of Strata Intelligent Control and Green Mining Co-founded by Shandong Province and the Ministry of Science and Technology, No. SICGM202206, China.
5. Co-PI. *Developing an Integrated Technology for Subsurface Hydrogen Harvesting through Reservoir Creation and Management*. ARPA-E - Department of Energy, No. 2784-1791.
6. Co-PI. *Designing a Safe Electrification System for Smart Mines through Ventilation Modeling, Monitoring, Control, and Training*. CDC – The National Institute for Occupational Safety and Health (CDC-NIOSH), No. 75D30124C20331.
7. Leading Researcher. *Control of Hazardous Gas Emissions to Longwall Face and Bleeder System: Laboratory Experiments, Modeling and Field Monitoring*. Alpha Foundation for the Improvement of Mine Safety and Health, Inc., AFC719-27.
8. Leading Researcher. *Building Capacity and Enhancing Long-Term Coal Mine Weak Roof Stability through Characterization and Modeling of Time-Dependent and Moisture-Sensitive Shale Rock Failures*. CDC – The National Institute for Occupational Safety and Health (CDC-NIOSH), No. NIOSH-200-2016-90385.
9. Leading Researcher. *Understanding and Design of Ventilation Systems and Their Optimization for Large Opening Underground Mines*. CDC – The National Institute for Occupational Safety and Health (CDC-NIOSH), No. 75D30119C05743.
10. Leading Researcher. *Characterization and Modeling of Multimechanistic Flow Behaviors from Nano- to Macro-scale in Shale Matrix*. NSF CBET Fluid Dynamics program, No. CBET 1438398.
11. Leading Researcher. *Experiment and Modeling of Multi-physics Gas Flow Dynamics through Multi-Scale Shale Pores*. Institutes of Energy and the Environment, Penn State.

## AWARDS AND HONORS

- International Outstanding Young Scholar Award, International Committee on Mine Safety Science and Engineering (2024)
- International Journal of Coal Science & Technology, Springer (2022 -)
- Best reviewer, International Journal of Coal Science & Technology, Springer (2021)
- Neutron Sciences Beam Time Award in the 2021-B cycle at the HFIR, Oak Ridge National Laboratory (2021)
- Reg Hardy Memorial Scholarship for Excellence in Mining and Rock Mechanics Contribution, Department of Energy and Mineral Engineering, Penn State University (2021)
- EESL Green Seed Grant Award, Energy and Environmental Sustainability Laboratories (EESL), Penn State University (2021)

- Frank J. Vastola and Ruth J. St. Clair Vastola Graduate Scholarship, Department of Energy and Mineral Engineering, Penn State University (2021)
- Youth Editor, International Journal of Coal Science and Technology, Springer (2021 -)
- Nico van Wingen Memorial Graduate Fellowship (Only one award is given from all nominees in the amount of USD 5,000 each per year, for up to four years), SPE Foundation (2021)
- Excellent Graduate Student Award in Beijing, Beijing Municipal Education Commission (2018)
- Outstanding Graduate Student Award in China University of Mining and Technology-Beijing, China University of Mining and Technology-Beijing (2016, 2017, 2018)
- National Scholarship for Graduate Students Award, Ministry of Education of the People's republic of China (2017)
- First-class Scholarship in China University of Mining and Technology-Beijing, China University of Mining and Technology-Beijing (2016)
- Excellent Undergraduate Student Award in Henan Polytechnic University, Henan Polytechnic University (2015)
- Yueqi Sun Memorial Scholarship, Henan Polytechnic University (2015)
- National Inspirational Scholarship for Undergraduate Student, Ministry of Education of the People's republic of China, (2012, 2014)
- First-class Scholarship in Henan Polytechnic University, Henan Polytechnic University (2013)

#### **PROFESSIONAL AFFILIATIONS**

- American Rock Mechanics Association (Member, 2019 - Pres.)
- Society of Petroleum Engineers (Member, 2020-Pres.)
- American Geophysical Union (Member, 2023-Pres.)
- The Society of Core Analysts (Member, 2020 -Pres.)
- Society of Mining, Metallurgy and Exploration (Member, 2019 -Pres.)

#### **SERVICE TO DISCIPLINE AND PROFESSION**

1. Organizer and session chair for 7th International Symposium on Mine Safety Science and Engineering, Pittsburgh, PA August 17-21, 2024.
2. Committee member for Annual Non-tenure Track Line Faculty Review, Department of Energy and Mineral Engineering, Penn State University, 2023
3. Curriculum Development, Mining Program, Penn State University, 2022-
4. Invited Proposal Reviewer for PA Manufacturing Fellows Initiative 2022-23, December 2022.
5. Handling Editor, International Journal of Coal Science and Technology, Springer (2022 -).
6. Guest Editor, Journals (Remote Sensing, Materials, Energies, Environments, Fractal and Fractional): Special Issue on Geomechanics for Energy and the Environment (2022).
7. Youth Editor, International Journal of Coal Science and Technology, Springer (2021 -).
8. Guest Editor: Frontiers in Earth Science Special Issue on Recent Advances in Unconventional Natural Gas (2022).
9. Organizer for the 1<sup>st</sup> International Symposium on Mine Dust and Aerosol Research (ISMDAR), Virtual, University Park, PA November 15-16, 2021.
10. Reviewer for professional journals:

International Journal of Hydrogen Energy, International Journal of Coal Geology, Fuel, SPE Journal, Transport in Porous Media, Journal of Natural Gas Science & Engineering, Journal of Coal Science & Technology, Geomechanics and Geophysics for Geo-Energy and Geo-Resources, Minerals, Rock Mechanics and Rock Engineering, Transport in Porous Media, International Journal of Heat and Mass Transfer, Environmental Science and Pollution Research, Engineering Fracture Mechanics, ACS Omega.