

Zhilei Han

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EDUCATION

King Abdullah University of Science and Technology (KAUST), Saudi Arabia

Ph.D. in Energy Resources and Petroleum Engineering, 2026 Fall

Dissertation: Hybrid AI and Numerical Modeling for Underground Gas Storage

China University of Petroleum - Qingdao (UPC), China

M.S. in Petrophysics, July 2015, GPA: 87.6/100 (Top 5%)

China University of Petroleum - Qingdao (UPC), China

B.S. in Exploration Technology & Engineering, July 2012, GPA: 87.7/100 (Top 5%)

PROFESSIONAL PROFILE

Saudi Aramco, Saudi Arabia

Reservoir Engineer

June 2025 - August 2025

- Developed a novel simulation approach for coupled bio-geochemical reactions in underground gas storage, supporting operational decision-making.

SINTEF, Norway

Visiting Researcher

June 2023 - July 2023

- Developed and validated flash calculation algorithms for hydrogen-containing gas mixtures to improve compositional modeling accuracy.
- Contributed to the development of a two-phase compositional simulator for underground hydrogen storage.

China National Offshore Oil Corporation (CNOOC), China

Formation Evaluation Engineer

July 2015 - July 2022

- Performed reservoir characterization & formation evaluation for **200+** wells to build petrophysical models and support reservoir modeling.
- Conducted reserves estimation for **6+** oilfields in collaboration with geology and geophysics teams.
- Designed and optimized Overall Development Plans (ODPs) for **5+** oilfields to support development and production strategies.
- Performed geomechanical analysis to estimate rock mechanical parameters, supporting hydraulic fracturing design for **10+** oilfields.

RESEARCH INTERESTS

- Modeling Coupled Processes of Fluid Flow and Reactive Transport.
- AI-based Surrogate Model for Rapid Decision-making and Reservoir Management.
- Underground Hydrogen & Gas Storage – Field-scale Modeling.
- Formation Evaluation and Petrophysical Interpretation

SERVICES

- Technical Reviewer for High-impact Journals, including *SPE Journal*, *Geoenergy Science and Engineering*, *Gas Science and Engineering*, etc.
- SPWLA KAUST Student Chapter: **President** (2025), **Vice President** (2024).
- SPE KAUST Student Chapter: Membership Chairperson (2024).

PROJECT EXPERIENCES

Research Aspect:

1) **AI-Accelerated Robust Optimization and Reservoir Management**

KAUST In-House Project | 01/2023 – 07/2024

- Developed a GPU-accelerated deep learning surrogate model integrated within a genetic algorithm-based optimization framework, accelerating decision-making under dynamic reservoir conditions.
- One of 9 global recipients of the **Best Student Paper Award** at the *InterPore Annual Conference (2024)*. The study was published in the *Interpore Journal* as an invited student paper.

2) **AI-Accelerated Flash Calculation for Compositional Simulation**

KAUST Center Competitive Funding Project | 07/2023 – 07/2025

- Conventional EOS models show limited accuracy in systems with hydrogen-bonding species, while advanced EOS models (e.g., PC-SAFT) are computationally intensive.
- Developed a cubic + Henry's law flash calculation framework, achieving a relative RMSE of 2.22% against experimental H₂ solubility data across a wide range of p-T-salinity.
- DNN proxies cut flash iterations by 30% and CPU time by 50% vs. Wilson correlation.

3) Advanced Simulator Development by Coupling Two-Phase Compositional Flow and Reactive Transport

KAUST In-House Project | 12/2024 – 12/2026

- Limited understanding exists of hydrogen compositional flow, microbial and geochemical interactions, and hydrogen mixing with cushion gases and brine at the reservoir scale.
- Developed a compositional simulator that couples compositional flow and reactive transport for underground hydrogen storage. Validation against CMG GEM shows strong agreement.
- Ongoing work focuses on development of a physics-informed neural network (PINN)-based reservoir simulator.

4) Simulation Tool for Evaluating Coupled Bio-Geochemical Interactions in Underground Gas Storage (UGS)

Aramco-KAUST In-House Project | 03/2025 – 12/2025

- **Business Need:** Previous field projects of underground methane-rich gas storage revealed significant gas purity degradation caused by bio-geochemical interactions. Gas Reservoir Management Department (GRMD) plans to conduct subsurface gas storage, highlighting the need for an accurate and efficient reservoir-scale modeling solution.
- Developed a biogenetics-informed kinetic model that couples microbial activity with geochemical reactions at the reservoir scale.
- Ongoing work focuses on validation against commercial reservoir simulators and application to complex 3D geological models for enhanced predictive performance.

Industry Aspect:

5) Reserves Estimation

Formation Evaluation Lead | 2015 - 2022

- Led integrated petrophysical evaluation for more than 200 exploration and development wells across 6+ offshore oilfields, delivering reservoir characterization and hydrocarbon saturation assessments for reserve certification.
- Integrated logging, core, mud logging, well testing, and geological information to determine reservoir net pay, porosity, permeability, and fluid contacts under complex geological conditions.
- Collaborated with geologists, reservoir engineers, and development teams to support reserve estimation, identifying over 150 million tonnes of proven hydrocarbon reserves.

6) Overall Development Plan (ODP) Support

Integrated Reservoir Evaluation for Field Development | 2018 - 2022

- Led petrophysical evaluation and reservoir quality assessment supporting ODPs for 5+ offshore oilfields.
- Quantified reservoir properties, fluid distribution, and reservoir continuity to optimize well placement, completion strategy, and production forecasting.
- Worked closely with multidisciplinary asset teams to provide technical recommendations that improved development planning and reduced subsurface uncertainty.

7) Hydraulic Fracturing Design Support

Rock Mechanics and Geomechanics Evaluation | 2019 - 2022

- Performed geomechanical characterization for 10+ offshore oilfields, estimating Young's modulus, Poisson's ratio, in-situ stress, brittleness, and fracture gradients from well logs and laboratory measurements.
- Built rock mechanical property models to support hydraulic fracturing design, stage selection, and completion optimization.
- Delivered integrated technical recommendations that improved stimulation effectiveness and enhanced hydrocarbon recovery from low-permeability reservoirs.

8) Unconventional Reservoir Characterization

Petrophysical Research for Unconventional Reservoirs | 2012 - 2015

- Led and participated in multiple industry-funded research projects on tight sandstone gas, shale gas, and tight carbonate reservoirs.
- Developed petrophysical interpretation workflows integrating NMR, conventional logs, laboratory core analysis, and rock physics models to improve reservoir characterization.
- Evaluated pore structure, movable fluids, and reservoir quality, providing technical support for exploration appraisal and development planning.

HONOURS AND AWARDS

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| • Best Student Paper Award, 16th InterPore Annual Conference | 05/2024 |
| • KAUST Fellowship | 2022 - Present |
| • CNOOC Excellent Staff Award of the Year | 12/2019 |
| • Outstanding Undergraduate Thesis | 07/2012 |
| • First- and Second-Class Academic Scholarships (5 times) | 2009 - 2015 |

PUBLICATIONS

Have authored and co-authored **13** peer-reviewed journals, **16** conference papers, **2** granted and disclosed patents, **1** software copyright.

Peer-reviewed Journals:

1. **Han Z.**, Yan B., 2026. Development of a Reservoir Simulator for Coupled Two-Phase Compositional Flow and Microbial Reactive Transport in Underground Hydrogen Storage. **(Inner Review)**
2. **Han Z.**, Yan B., 2026. Deep Learning-Accelerated Phase Equilibrium Calculations for Underground Hydrogen Storage. **(Under Review)**
3. **Han Z.**, Alanazi A., Yan B., 2026. A Coupled Thermo-Kinetic-Equilibrium Model for Bio-Geochemical Simulation in Underground Hydrogen Storage. *International Journal of Hydrogen Energy*, 258, 156483.
4. Alanazi A., **Han Z.**, ..., 2026. Microbial and Geochemical Reactions in Underground Hydrogen Storage: A Comprehensive Review of Experimental, Modeling, and Field Studies. *Energy Conversion and Management*: X, 101974.
5. **Han Z.**, Tariq Z., Yan B., 2025. A Novel Robust Optimization Framework Based on Surrogate Modeling for Underground Hydrogen Storage in Depleted Natural Gas Reservoirs. *InterPore Journal*, 2(3). **(Invited Student Paper)**
6. Feng Z., Yan B., Shen X., Zhang F., Tariq Z., Ouyang W., **Han Z.**, 2025. A Hybrid CNN-Transformer Surrogate Model for the Multi-Objective Robust Optimization of Geological Carbon Sequestration. *Advances in Water Resources*, p.104897.
7. Mustafa A., Tariq Z., Yan B., **Han Z.**, Iqbal A., 2024. Towards Rapid Prediction of Nuclear Magnetic Resonance-Based Bimodal Porosities: An Example from the Middle Eastern Carbonate Reservoir. *Arabian Journal for Science and Engineering*, pp.1-21.
8. Lu Y., Xu S., Zheng Y., **Han Z.**, 2023. Water Saturation Calculation Method of Low Resistivity Reservoir with Clay Additional Conductivity Correction. *China Offshore Oil and Gas*, 35(01): 63-69.
9. **Han Z.**, Cui Y., Xu S., Lu Y., Guan Y., 2019. A New Method of Log Evaluation for Sand Production in Unconsolidated Sandstone Reservoirs. *China Offshore Oil and Gas*, 31(1): 77-85.
10. Cui Y., Lu Y., Wang R., Li Z., **Han Z.**, 2018. A Reservoir Fluid Identification Technology Based on Equivalent Medium Theories. *China Offshore Oil and Gas*, 30(2): 71-77.
11. Xu S., Cui Y., Bie X., **Han Z.**, Zheng Y., 2017. Identification Methods for Low-Resistivity Contrast Oil Payments in the Dongying Formation, Bohai oilfield. *Journal of Yangtze University (Natural Science Edition)*, 14(23): 39-44.
12. Xu S., Cui Y., Lu Y., Xu J., Bie X., **Han Z.**, 2017. New Quantitative Calculation Method for Buried-Hill Reservoir Productivity by Rock Mechanical Parameters. *Fault-Block Oil and Gas Field*, 24(05): 674-677.
13. Sun J., **Han Z.**, Qin R., Zhang J., 2015. Log Evaluation Method of Fracturing Performance in Tight Gas Reservoir. *Acta Petrolei Sinica*, 36(1): 74-80.

Conference Papers:

14. **Han Z.**, Yan B., 2026. Deep Learning-Assisted Initialization for Accelerating Flash Calculations in Underground Hydrogen Storage. In *SPE Europe Energy Conference & Exhibition*. SPE.
15. Alanazi A., **Han Z.**, ..., 2026. Impact of Microbial Activity on Sales Gas Purity in Underground Gas Storage: Mechanisms and Control Strategies. In *SPE Europe Energy Conference & Exhibition*. SPE.
16. **Han Z.**, Yan B., 2026. GYMS-H₂: A Reservoir Simulator for Coupled Two-Phase Compositional Flow and Microbial Reactive Transport in Underground Hydrogen Storage. In *Frontiers in Energy Storage*.
17. Alanazi A., **Han Z.**, Yan B., 2026. Experimental Insights into Multi-Phase Interactions in Porous Media: Gas-Water-Rock-Microbe Dynamics for Underground Hydrogen Storage. In *18th InterPore Annual Conference*. InterPore.
18. **Han Z.**, Yan B., 2025. Numerical Simulation of Coupling Compositional Two-Phase Flow and Micro-Bio Reactive Transport in Underground Hydrogen Storage. In *SPE Reservoir Simulation Conference*. SPE.
19. **Han Z.**, Yan B., Tariq Z., Feng Z., Li H., 2024. Optimizing Underground Hydrogen Storage through Surrogate Modeling: A CNN-LSTM-Attention Network Approach. In *16th InterPore Annual Conference*. InterPore. **Best Student Paper Award**.
20. **Han Z.**, Tariq Z., Yan B., Shi X., 2024. Prediction of NMR T₂ Macro- and Micro-porosity with Machine Learning Techniques: Considering the Constraints of ECS Lithology Classification. In *International Petroleum Technology Conference*. IPTC.
21. **Han Z.**, Yan B., Tariq Z., Feng Z., 2024. Surrogate Modelling for Optimization of Underground Hydrogen Storage based on Convolutional LSTM-Attention Network. In *85th EAGE Annual Conference & Exhibition*. EAGE
22. Feng Z., Ouyang W., Tariq Z., **Han Z.**, Shen X., Yan B., Zhang F., 2024. Transformer-Based Surrogate Model for the Optimization of Geological Carbon Sequestration. In *Asian Rock Mechanics Symposium (pp. 59-68)*. ARMS.
23. Shi X., Ming J., Huang J., Zheng Y., Xu G., **Han Z.**, 2024. Study on the Method of Identifying Low Resistivity Pay by LWD NMR Water Spectrum Reconstruction Based on Permeability Model in the Guantao Formation, Bohai Basin. In *International Petroleum Technology Conference*. IPTC.
24. Shi X., Cui Y., Xu S., Xu W., Niu S., **Han Z.**, 2024. Deriving Effective Permeability to Improve Productivity Prediction Based on Mobility from Pressure Measurement While Drilling and Relative Permeability Test. In *International Petroleum Technology Conference*. IPTC.
25. Duan X., Ding H., Zhang J., Ma Z., and **Han Z.**, 2024. Internal Multiple Suppression Method and Its Application in Complex Buried Hill of Bohai Bay. In *International Petroleum Technology Conference*. IPTC.
26. **Han Z.**, Cui Y., Ma C., Zheng Y., 2022. Experimental Study on Mechanical Properties for Hydraulic Fracture Design of Weakly Consolidated Sandstone: A Case Study in Bohai. In *Offshore Technology Conference*. OTC.
27. **Han Z.**, Cui Y., Zhu M., Lu Y., 2021. Research and Application of Wellbore Stability Based on Quantitative Risk Analysis. In *International Field Exploration and Development Conference*. IFEDC.
28. Li S., Liu L., **Han Z.**, Wu R., Guo N., 2021. 3d Stress Field Modeling for Wellbore Stability Analysis. In *Offshore Technology Conference*. OTC.
29. Shi X., Zhang J., Lu Y., **Han Z.**, He Y., 2021. Quantitative Evaluation of Water Flooding in a Low Resistivity Heavy Oil Reservoir with NMR and Conventional Logs. In *SPE Annual Technical Conference and Exhibition*. SPE.

Granted & Disclosed Patents:

- 1) An Improved Method for Calculating In-Situ Stress of Loose Sandstone. *National Intellectual Property Administration*, 2024.
- 2) A Method for Calculating Bound Water Saturation in Loose Sandstone based on Thin Section Image Data. *National Intellectual Property Administration*, 2024.

Software Copyright:

- 1) Rock Fracability Well Log Evaluation Software V1.0, 2015.

-Updated August 01, 2026-