Dr. Muhammad Amar Gul
(Geoscientist/Data Scientist)

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Career Objective

Aspiring to contribute my expertise in AI, machine learning, and geoscience to a dynamic organization, leveraging data-driven approaches for mineral exploration, geochemical analysis, and geospatial intelligence. Passionate about applying advanced data science techniques to solve complex geological challenges.

Professional Experience

Project Geologist (AI & ML/Big Data) — **China National Geological & Mining**
June, 2024-Present — Corporation, Jeddah KSA

Exploration Geologist — **Mehta Brothers, Lahore**
March 2022-April 2023 — Pakistan

Academic Qualification

PhD Geology (AI & ML)
2024
University of Science & Technology China (USTC: THE World University Ranking 53)

MS Geological Sciences
2013-2016
University of Engineering &Technology **(UET)** Lahore-Pakistan (**QS WUR: 791)**

BS (Hon.) Geology
2008-2012
Federal Urdu University of Art, Science & Technology, Karachi-Pakistan

Professional Certifications & Skills

- **Geochemistry** (LA-ICP-MS, EPMA, XRD, XRF, ioGAS)
- **Critical Metals Exploration** (Pb, Zn, Au, Cu, Ge, Ga, In, Sb)
- **Data Visualization** (Tableau, Power BI, SQL, Seaborn lib.)
- **Data Science** (Data Analysis, Data Mining, Python, Scikit-learn)
- **AI & ML** (ML/DL algorithms, Reinforcement Learning, TensorFlow, PyTorch)
- **Geospatial Analysis** (GIS, QGIS, GIS Pro, Geopandas, ArcPy)
- **Remote Sensing** (ENVI /Google Earth Engine)
- **Project Management** & Bid Proposal Writing

Key Professional Research Projects

Deep Learning-Based Classification of Pyrite Geochemistry for Discriminating Tectonic Settings in Sedimentary Environments

- Developed a novel deep learning approach to classify sedimentary pyrite based on trace element geochemistry.
- Implemented **CNN and XGBoost models** to classify pyrite samples from **nine distinct tectonic settings**.
- Utilized LA-ICP-MS dataset **(1837 spot analyses)** from **43 global locations** for model training and validation.
- Addressed class imbalance using **SMOTE and** Random Undersampling with Clustering **(RUC)** techniques.
- Applied **t-SNE** and **UMAP** for data visualization and feature interpretation.
- Achieved **>95%** classification accuracy on unseen datasets using **K-Fold Cross-Validation (CV)** and AUC analysis.
- Identified key geochemical discriminators (Sb, Co, Se, Mo, Bi) using **SHAP** (Shapley Additive Explanations).
- Presented an **AI-based application** for automated tectonic setting classification.

AI-Driven Classification of Pb-Zn Deposits using Pyrite Geochemistry (Metallogenic Discrimination)

- Developed classification models based on pyrite trace element compositions using Random Forest **(RF),** Support Vector Machine **(SVM),** Gradient Boost **(GB),** and Multilayer Perceptron **(MLP)** algorithms.
- Trained models on **5400 data points from 134 mineral deposits**.
- Applied leave-one-group-out (LOGO) cross-validation to ensure model generalization.
- Achieved high classification accuracy **(> 90 %)**, demonstrating the effectiveness of machine learning in mineral deposit discrimination.
- Applied models to **newly collected geochemical data from the Gunga Pb-Zn deposit**, successfully identifying its source as **sedimentary-hydrothermal** with enrichment in Pb, Zn, Sb, Tl, As, and Ge.

Deep Learning for Ore Genesis and Critical Metal Enrichment in Gunga Pb-Zn Deposit

- Investigated the Gunga Pb-Zn deposit using deep learning techniques to analyze **sphalerite** trace elements and isotopic compositions.
- Developed models trained on **3800** data points from **99** global mineral deposits.
- Applied **k-fold cross-validation** to validate model predictions.
- Results revealed that the Upper Mineralization Zone (UMZ) and Lower Mineralization Zone (LMZ) exhibit distinct geochemical signatures.
- The deep learning model confirmed that **the Gunga deposit is a Clastic-Dominant (CD)-type deposit** based on its low temperature, lack of magmatic sources, and sedimentary setting.

Big Data Mining on Pyrite Geochemistry for Deposit type Discrimination

- Compiled **5200** pyrite spot analyses from **138 global deposits**, covering **six deposit types** (Sedimentary, SEDEX, Orogenic Gold, VMS, Skarn, and Porphyry).
- Applied **RF, SVM, GB, and MLP** algorithms to classify deposits using trace element geochemistry.
- Used t-distributed Stochastic Neighbor Embedding (**t-SNE)** for feature importance assessment.
- Achieved classification accuracy of **>93% (GB & SVM models)** with an **AUC score of >0.99**.
- Developed an **interactive web application** using Python **Gradio library** for real-time deposit classification.

Big Data Mining on Galena Geochemistry for Metallogenic Discrimination

- Classified **galena** samples from **37 Pb-Zn** deposits worldwide using **RF, GB, MLP, and SVM** models.
- Addressed dataset imbalance using **SMOTE and RUC resampling techniques**.
- Applied **K-fold cross-validation** to ensure robustness.
- Achieved highest accuracy of **98.19%** (GB model) and **97.62%** (RF model).
- Identified **Sn, Tl, and Ag** as key trace elements for deposit differentiation.
- Used **t-SNE visualization** to validate clustering of galena samples based on geochemistry.

Mineral Alteration Mapping of Arabian Shield using Remote Sensing Data

- Conducted **remote sensing-based mineral alteration mapping** across **600,000 km² of the Arabian Shield**.
- Utilized satellite imagery **(Landsat-8/9)** and GIS techniques to detect mineral alterations.
- Implemented **supervised classification methods** and spectral indices to differentiate lithological units.
- Developed a **predictive model for mineral prospectivity**, aiding future exploration efforts.

Research Articles (Under Review in SCI Journals)

1. **Gul, M.A**., Kanwal, A., Faisale, M., Akhtar, S., Zhang, H., Sun, C., Awan, R.S., Nawaz, A., and Yang, X., (2025) **Machine learning-based classification** of pyrite geochemistry for discriminating tectonic settings in sedimentary environments: Insights from big data analysis and interpretable SHAP model, ***Gondwana Research,* IF: 7.2**
2. **Gul, M.A.,** Asia Kanwal., Yang, X., Zhang, H.S., Faisal, M., (2025) **Big Data mining** on Pyrite geochemistry using machine learning algorithms: Implications for Metallogenic Discrimination, ***Lithos,* IF: 2.9**
3. **Gul, M.A.,** Asia Kanwal., Yang, X., Zhang, H.S., Faisal, M., (2025) **Big Data mining** on Galena geochemistry using machine learning algorithms: Implications for Metallogenic Discrimination, ***Mathematical Geosciences, IF*: 2.8**

4. Faisal, M., Li, H., Sun, C., **Gul, M. A.**, Amuda, A. K., Sun, W., Ullah, J., Khalifa, I. H., and Mustafa, S., 2024, Geodynamic record of Rodinia breakup to Gondwanaland formation: Insights from bulk geochemistry, whole-rock Sr-Nd isotopes, and zircon U-Pb-Hf data: ***Geoscience Frontiers***, **IF: 8.5**
5. Faisal, M., Li, H., Yang, X., **Gul, M. A.,** Amuda, A. K., Zhou, Z., Tende, A. W., Cheng, G., Ullah, J., and Seif, R. A., 2024, Exploring auriferous VMS prospective zones in the South Eastern Desert, Egypt, using integrated remote sensing data, field studies, EPMA chemistry, and XRD analysis: ***Journal of Geochemical Exploration*****, IF: 3.4**
6. Awan, S, R., Liu, B., Yasin, Q., Wood, D. A., **Gul, M. A.,** Ali, S., Altaf, K. H., and Khan, A., 2024, Paleoenvironmental conditions and key drivers of organic matter accumulation in the Early Cretaceous Talhar Shale, Lower Indus Basin, Pakistan: ***Marine and Petroleum Geology***, **IF: 3.7**

Research Publications

1. **Gul, M.A.,** Zhang, H.S., Yang, X., Yu, Y., Sun, C., Faisal, M., (2025) **Machine Learning-Driven** Classification of Pb-Zn Ore Deposits Using Pyrite Trace Elements and Isotopic Signatures: A Case Study of the Gunga Deposit, ***Journal of Geochemical Exploration,*** *https://doi.org/10.1016/j.gexplo.2025.107693* **IF: 3.4**
2. **Gul, M.A.,** Zhang, H.S., Yu, Y., Sun, C., Faisal, M., Yang, X., (2025) Ore genesis and critical metal enrichment using **deep learning algorithms** in Gunga Pb-Zn deposit, Southern Pakistan: Constraints from geochemistry and isotopic compositions, ***Journal of Geochemical Exploration***, *https://doi.org/10.1016/j.gexplo.2025.107771*
3. Faisal, M., Li, H., Heritier, R.N., **Gul, M.A.,** Khedr, F.A., Zhou, Z., and Ghoneim, S.M., 2025, Geological and geochemical evolution of the Derhib sulfide-talc deposit in the South Eastern Desert, Egypt: Insights into ore genesis and metasomatic alteration: ***Lithos,*** *https://doi.org/10.1016/j.lithos.2025.108049* **IF: 2.9**
4. Awan, S, R., Liu, B., Li, H., Ali, S., **Gul, M. A.,** and Khan, A., 2024, Unlocking paleolatitudinal secrets of the Early Cretaceous by rare earth element imprints: Implications for seawater chemistry, depositional environments, and paleoclimate in the Talhar Shale, Lower Indus Basin, Pakistan: ***Palaeogeography, Palaeoclimatology, Palaeoecology, https://doi.org/10.1016/j.palaeo.2025.112985 , IF: 2.6***
5. Mujtaba, A., Gilani, S. N., Hafeez, M., Khan, I., Shah, A., Khan, S., Ahmed Gillani, S. A., and **Gul, M. A.*,** 2024, Geochemical and petrographic analysis of hydrothermal mineralization in the Chitral region, Northern Pakistan: Implications for tectonic and diagenetic processes: ***Advancements in Mining & Mineral Engineering***, v. 1, no. 3, p. 1-22, DOI:10.33552/AMME.2024.01.00051.
6. Faisal, M.; Li, H.; Yang, X.Y.; Sun, C.; Amuda, A.K.; Khalifa, I.H., **Gul, M.A.** (2025). Gold in volcanogenic massive sulfide deposits in Egypt. In: Hamimi, Z.; Goldfarb, R.J.; Pradhan, B.; Abd El-Rahman, Y.; Fowler, A.; Abdelnasser, A.; Abd El Monsef, M. (eds). Gold Deposits in Egypt: Geology, Settings, Types, Genesis and Spatiotemporal Distribution. SLPNRM. ***Springer***, Cham. https://link.springer.com/book/97830317597.
7. **Gul, M.A.,** Yang, X., Zhang, H., Faisal, M., and Akhtar, S., 2022, Sediment Hosted Pb-Zn Deposits in Pakistan, ***36th International Geological Congress, India.***

8. **Gul, M.A.,** Khan, M.S., and Sohail, GMD. 2016, Evaluation of Shale Gas Prospect in Datta Formation Upper Indus Basin Evaluation of Shale Gas Prospect in Datta Formation Upper Indus Basin, Pakistan: www.piche.org.pk/journal.
9. Awan, R.S., Liu, C., Aadil, N., Yasin, Q., Salaam, A., Hussain, A., Yang, S., Jadoon, A.K., Wu, Y., and **Gul, M.A.,** 2021, Organic geochemical evaluation of Cretaceous Talhar Shale for shale oil and gas potential from Lower Indus Basin, Pakistan: ***Journal of Petroleum Science and Engineering***, v. 200, doi: 10.1016/j.petrol.2021.108404.
10. Faisal, M., Yang, X., Zhang, H., Amuda, A.K., Sun, C., Mustafa, S., and **Gul, M.A.,** 2022, Mineralization styles, alteration mineralogy, and sulfur isotope geochemistry of volcanogenic massive sulfide deposits in the Shadli Metavolcanics Belt, South Eastern Desert, Egypt: Metallogenic implications: ***Ore Geology Reviews,*** v. 140, doi: 10.1016/j.oregeorev.2021.104402.
11. Akram, N., Ahmed, N., Khan, M.S., Ehsan, M.I., **Gul, M.A.,** and Ahmad, M., 2020, Reservoir Characterization by using Petrophysical-Electrofacies Analyses and Subsurface Structural Interpretation of the Nandpur Gas Field, Middle Indus Basin, Pakistan, ***Himalayan Geology.***
12. Awan, R.S., Liu, C., Khan, A., Iltaf, K.H., Zang, Q., Wu, Y., Ali, S., and **Gul, M.A.,** 2023, Geochemical Characterization of Organic Rich Black Rocks of the Niutitang Formation to Reconstruct the Paleoenvironmental Settings during Early Cambrian Period from Xiangxi Area, Western Hunan, China*:* ***Journal of Earth Science***, v. 34, p. 1827–1850, doi:10.1007/s12583-021-1524-x.
13. Khan, A.U.R., **Gul, M.A.,** Awan, R.S., Khan, A., Iltaf, K.H., and Butt, S.E.H., 2023, 2D seismic interpretation of Sawan gas field integrated with petrophysical analysis: A case study from Lower Indus Basin, Pakistan: ***Energy Geoscience***, v. 4, doi: 10.1016/j.engeos.2022.100143.

Communication Skills

- English
- Urdu
- Excellent Presentation Skill
- Chinese

Personal Information

- Father Name : Gul Muhammad
- Date of Birth : 21st October, 1988.
- Marital Status : Married
- Nationality : Pakistani
- C.N.I.C No. : 38101-1327597-7
- Passport No. : FS4795972

References

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