AI-Driven Mineral Prospectivity Mapping in Karnataka & Andhra Pradesh

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1. Project Summary

This project aims to identify new, previously unknown areas with high potential for critical mineral deposits—including REEs, Ni-PGE, Cu, gold, and uranium—across a 39,000 sq. km region in Karnataka and Andhra Pradesh, India. By integrating diverse geoscientific datasets such as stream sediment geochemistry, geology, aerogeophysics, and remote sensing, we employ machine learning techniques to predict and visualize mineral prospectivity.

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2. Objectives

- Integrate multi-layer geoscientific datasets for regional-scale mineral exploration.
- Apply AI/ML algorithms to locate concealed and deep-seated mineralized zones.
- Generate mineral prospectivity probability maps for exploration targeting.
- Visualize predictions via interactive and static maps for interpretation.

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3. Study Area

- **Location**: Karnataka and Andhra Pradesh, India
- **Extent**: ~39,000 sq. km
- **Geological Context**: Covers diverse lithologies including greenstone belts, granitic terrains, and mineralized shear zones, favorable for hosting REEs, Ni-Cu-PGE, gold, and uranium.

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4. Datasets Used

Dataset Type	Description	Source
Geochemical	Stream sediment data (69 elements)	NGCM, GSI
Geological Maps	1:50k and 1:25k lithological layers	GSI
Lineaments	Faults/fractures as mineralization controls	Bhuvan, GSI
Geophysics	Magnetic, gravity, and radiometric data	GSI Aerogeophysical Surveys
Remote Sensing	ASTER-derived alteration indices	USGS ASTER
Metadata/Reports	Sampling methods, lab analysis, past exploration	GSI Reports

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5. Methodology

5.1 Data Preprocessing

- Loaded stream sediment shapefile into GeoPandas.
- Checked for missing values and normalized geochemical features.
- Reprojected to WGS84 (EPSG:4326) for mapping.

5.2 Feature Engineering

- Created binary labels using Cu as a proxy threshold.
- (Optional) Used distance-to-lineament, geology overlays.

5.3 Machine Learning

- Trained a **Random Forest Classifier** to classify high-potential vs. background samples.
- Split into training (80%) and testing (20%) sets.
- Evaluated using precision, recall, and feature importance.

5.4 Prediction & Mapping

- Computed mineralization probabilities for all points.
- Visualized static and interactive maps.
- Exported results as GeoJSON.

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6. Results & Interpretation

- **Top predictive features** included Cu, Ni, La, Ce, Th, and U concentrations.
- Generated a **mineral prospectivity map**, highlighting several high-probability zones.
- Identified potential deep-seated zones using integrated interpretation with gravity/magnetic anomalies (planned for future work).

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7. Deliverables

- cleaned_stream_sediments_normalized.geojson
- mineral_prediction_map.geojson
- Static probability heatmap
- Interactive Folium-based prospectivity map
- Jupyter Notebook with all steps

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8. Conclusion

This AI-driven workflow demonstrates the effectiveness of integrating geoscience data with ML techniques to generate actionable mineral exploration insights. The model successfully highlights priority target zones for further investigation, particularly in geochemically anomalous and structurally favorable zones of Karnataka and Andhra Pradesh.