

# Integrated Application of Artificial Intelligence and Remote Sensing Techniques for Improved Subsurface Resource Exploration

Marat Nurtas,<sup>1,4</sup> Elmira Orynbassarova,<sup>2</sup> Mohammed Atef Mohammed,<sup>3</sup> Sydyk Nurmakhambet,<sup>1</sup> Aizhan Altaibek,<sup>1,4</sup> Elmira Serikbayeva<sup>1</sup> and Berik Iskakov<sup>1,\*</sup>

<sup>1</sup>*Institute of Ionosphere, Gardening Partnership "Ionosphere", 117, Almaty, 050020, Kazakhstan*

<sup>2</sup>*Satbayev University, 22 Satbayev street, Almaty, 050013, Kazakhstan*

<sup>3</sup>*Faculty of Science, Sohag University, Sohag University Street, 82524, Egypt*

<sup>4</sup>*International Information Technology University, 34/1 Manas Street Almaty, 050000, Kazakhstan*

\*Email: [berikiskakov@ionos.kz](mailto:berikiskakov@ionos.kz) (B. Iskakov)

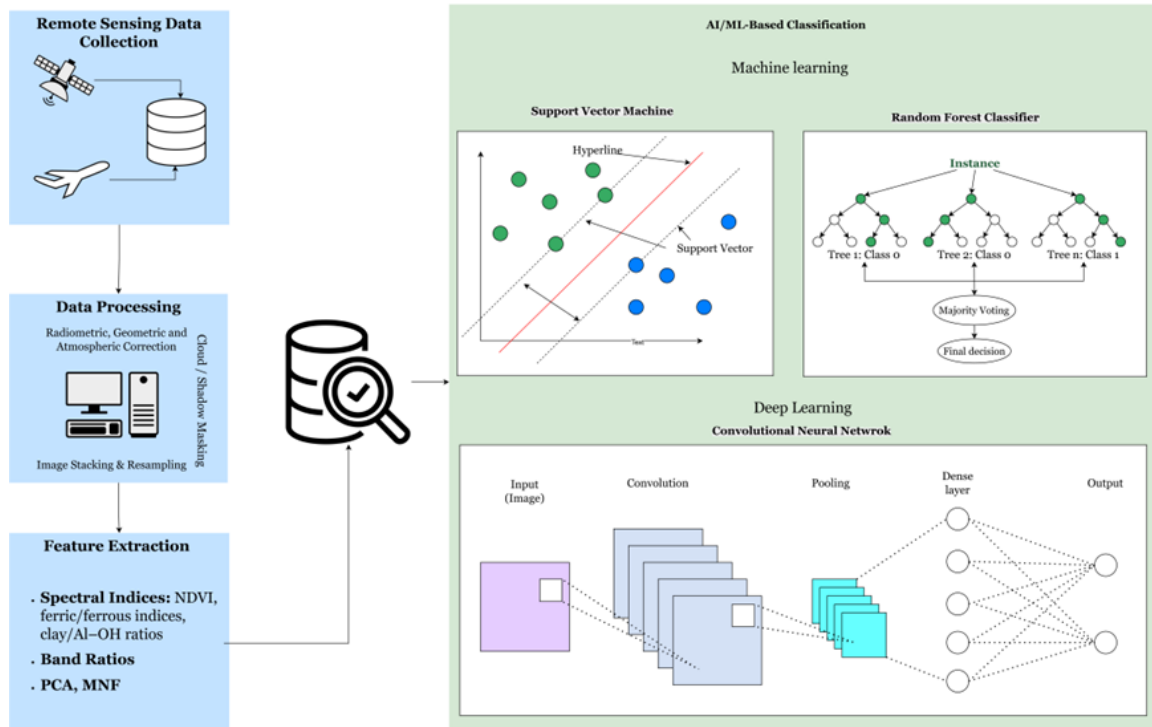
Received: 28 November 2025; Revised: 01 December 2025; Accepted: 12 December 2025

Type: Review article.

## Abstract

Mineral exploration is undergoing a significant transformation driven by the integration of remote sensing technologies and artificial intelligence (AI). While conventional methods remain foundational, they are often constrained by high costs, limited spatial coverage, and subjective data interpretation. This review critically examines the emerging synergy between multisensory remote sensing platforms and AI-based analytical frameworks, highlighting their potential to enhance the accuracy, efficiency, and scalability of subsurface mineral prospecting. This study reviews traditional geophysical methods alongside the evolving roles of satellite and airborne platforms in mineral exploration. Particular attention is given to recent advancements in data-driven analytics, encompassing machine learning, deep learning, and hybrid physics-informed models. Emphasis is placed on sensor fusion, real-time geospatial mapping, and the integration of explainable AI to improve model interpretability and transparency. The study also addresses key challenges, including the limited availability of labelled ground-truth data, the difficulty of achieving model generalization across diverse geological settings, and the ethical implications associated with the application of AI in geosciences. By synthesizing insights from recent case studies and state-of-the-art methodologies, this paper outlines future research directions aimed at fostering more accurate, efficient, and sustainable approaches to mineral exploration.

## Table of Contents



*Innovative Description:* The integration of remote sensing data with artificial intelligence and machine learning (AI/ML) methodologies is illustrated.