

# Exploration Geophysics Techniques and Applications in Subsurface Resource Investigations

Sarah Devriese\*

*Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, Canada*

## DESCRIPTION

Exploration geophysics is a scientific discipline that applies physical methods to study and understand the subsurface of the Earth. Its primary purpose is to locate and characterize natural resources such as minerals, oil, gas, groundwater, and geothermal energy. Unlike direct methods that require drilling or excavation, exploration geophysics uses non-invasive techniques that measure variations in the Earth's physical properties to infer the presence of different geological structures and materials. This approach reduces the cost and environmental impact of exploration while increasing the efficiency and accuracy of resource discovery.

The field of exploration geophysics relies on several key methods, each based on specific physical principles. These methods include seismic, magnetic, gravity, electrical, and electromagnetic techniques. Seismic methods are among the most widely used, particularly in the oil and gas industry. In seismic surveys, artificial energy sources such as explosions or mechanical vibrators generate waves that travel through the Earth. These waves reflect and refract at interfaces between different rock layers. By recording the travel times and amplitudes of these waves with sensors known as geophones or hydrophones, geophysicists can create detailed images of the subsurface. These images help identify structures such as folds, faults, and traps that may contain hydrocarbons.

Magnetic and gravity methods are passive techniques that measure natural variations in the Earth's magnetic and gravitational fields. Magnetic surveys detect differences in magnetic susceptibility between rock types, which can reveal the presence of igneous intrusions, ore bodies, or structural features. Gravity surveys measure slight differences in the Earth's gravitational acceleration caused by density variations in subsurface materials. These methods are particularly useful in regional studies, where they help map large-scale geological features and guide further exploration.

Electrical and Electromagnetic (EM) methods are effective for detecting conductive materials such as mineral deposits, groundwater, and contamination plumes. In electrical resistivity

surveys, an electrical current is introduced into the ground through electrodes, and the resulting voltage differences are measured. Variations in resistivity provide information about the composition, porosity, and fluid content of subsurface materials. EM methods, on the other hand, involve generating time-varying magnetic fields that induce electrical currents in the ground. The response of these currents is measured and analyzed to determine subsurface conductivity. These techniques are widely used in mineral exploration, groundwater investigations, and environmental studies.

Airborne geophysical surveys have become increasingly popular for covering large and remote areas quickly and efficiently. Aircraft or drones equipped with magnetic, electromagnetic, and radiometric sensors can collect high-resolution data over vast regions. Airborne surveys are especially valuable in mineral exploration, where they can identify geological trends, locate potential ore zones, and reduce the need for costly ground-based surveys. Helicopter-borne systems, such as frequency-domain or time-domain electromagnetic equipment, are commonly used in rugged or inaccessible terrains.

The success of exploration geophysics depends not only on data acquisition but also on data processing and interpretation. Advanced software and algorithms are used to filter noise, enhance signals, and invert geophysical data into meaningful subsurface models. Three-dimensional imaging and visualization tools allow geoscientists to interpret complex geological structures with greater accuracy. The integration of multiple geophysical methods, along with geological and geochemical data, improves the reliability of interpretations and helps reduce exploration risks.

Exploration geophysics plays a critical role in mineral exploration by helping to locate deposits of metals such as gold, copper, zinc, nickel, and iron. These resources are essential for manufacturing, construction, and technology industries. Geophysical techniques can detect features such as magnetic anomalies, conductive zones, and structural traps associated with mineralization. They also assist in mapping lithological boundaries, identifying alteration zones, and planning drilling programs. In regions with dense vegetation or overburden,

**Correspondence to:** Sarah Devriese, Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, Canada, E-mail: sdev897789@eos.ca

**Received:** 30-Apr-2025, Manuscript No. JGG-25-38079; **Editor assigned:** 02-May-2025, PreQC No. JGG-25-38079 (PQ); **Reviewed:** 16-May-2024, QC No. JGG-25-38079; **Revised:** 23-May-2025, Manuscript No. JGG-25-38079 (R); **Published:** 30-May-2025, DOI: 10.35841/2381-8719.25.14.1226

**Citation:** Devriese S (2025). Exploration Geophysics Techniques and Applications in Subsurface Resource Investigations. J Geol Geophys. 14:1226.

**Copyright:** © 2025 Devriese S. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

geophysics offers a powerful means of seeing through the surface to target mineral-rich zones.

In the oil and gas industry, exploration geophysics is indispensable for identifying and characterizing reservoirs. Seismic surveys provide detailed images of subsurface stratigraphy and structure, enabling exploration teams to evaluate prospects and optimize drilling locations. Time-lapse, or 4D seismic monitoring, is used in producing fields to observe changes in reservoir conditions over time, helping improve recovery and reservoir management. With the growing interest in unconventional resources like shale gas and tight oil, geophysical methods are also used to assess reservoir properties and monitor hydraulic fracturing processes.

Beyond resource exploration, geophysics has important applications in environmental and engineering studies. It is used to assess soil and rock properties for construction projects, locate buried objects, map contamination plumes, and evaluate groundwater resources. For example, electrical resistivity and electromagnetic surveys can identify leachate migration from landfills or detect saline water intrusion in aquifers. These applications support sustainable land use, water management, and environmental protection.

Technological advances continue to expand the capabilities of exploration geophysics. High-performance computing, machine learning, and artificial intelligence are transforming how geophysical data are processed and interpreted. Automated pattern recognition, predictive modeling, and real-time analysis enhance exploration efficiency and decision-making. As exploration targets become deeper and more complex, innovations in sensor technology, data acquisition systems, and inversion algorithms are critical to meeting the challenges of modern geoscience.

## CONCLUSION

In conclusion, exploration geophysics is a dynamic and evolving discipline that provides essential tools for discovering and managing Earth's natural resources. Through its combination of physical principles, cutting-edge technology, and multidisciplinary integration, it enables detailed imaging of the subsurface with minimal environmental impact. Whether for minerals, energy, water, or environmental applications, exploration geophysics will continue to play a key role in understanding the Earth and supporting sustainable development in the decades to come.