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Original Paper

Exploration of Geophysical Field Teaching and Industry-Education Integration: A Case Study of Production Practice in the Datong Volcano Geopark

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Abstract

Geophysical exploration is essential for obtaining subsurface geological information and has broad applications in resource prospecting, environmental management, and engineering construction. As a core component in the cultivation of geophysics professionals, practical teaching is increasingly integrating multidisciplinary, multi-platform, and multi-agent resources.

This study takes the Datong Volcano Geopark as a practical teaching platform to explore a collaborative field instruction model involving multiple methods, including UAV-based aeromagnetics, gravity, electrical methods, and passive seismic surveys. By adopting a group rotation system, the program effectively optimizes teaching schedules and equipment usage, enhancing students' hands-on skills and analytical abilities. During the internship, students completed key stages such as data acquisition, preprocessing, processing, and inversion interpretation, preliminarily revealing the deep structural features of volcanic cones and their underlying magma conduits. The outcomes have been compiled into standard maps and reports, providing important data support for local geological research and science outreach in the park.

This practice has also promoted integration between universities, local governments, and research institutions, establishing a triadic "teaching–research–service" collaboration model. The experience presented in this paper offers a practical reference for reforming geophysical field education and cultivating a new generation of application-oriented talent.

Keywords

Geophysical exploration, practical teaching, industry-education integration, Datong Volcano, UAV aeromagnetics

1. Introduction

Geophysical exploration is a key technology that obtains subsurface structural information based on variations in physical fields (Chen et al., 2021). It holds wide application value in areas such as resource exploration, geological hazard assessment, hydrogeological surveys, and site selection for engineering projects (Ding et al., 2020). With continuous advancements in detection technologies and data processing capabilities, geophysical methods are becoming increasingly diversified, higher in resolution, and more integrated. Particularly under the impetus of cutting-edge technologies such as airborne remote sensing and unmanned systems, geophysical field teaching is shifting from mere tool use to systematic thinking.

Geophysics programs at universities bear the responsibility of cultivating talents equipped with comprehensive capabilities in field operations, data analysis, and system modeling. Within the curriculum, field practice teaching not only serves as a bridge between theory and practice but also plays a central role in developing students' observational skills, hands-on abilities, and scientific literacy. Traditional teaching methods often encounter challenges such as site limitations, resource redundancy, and methodological fragmentation, making it difficult to meet the demands of cultivating interdisciplinary professionals in the new era.

In recent years, industry-education-research integration has become a vital direction in higher education reform. Through joint training platforms, shared research equipment, and collaborative talent cultivation mechanisms, universities, research institutions, local governments, and enterprises have effectively integrated educational resources, enhancing students' practical abilities and employment readiness (Li et al., 2021). This program uses the Datong Volcano Geopark as a typical teaching scenario, integrating various geophysical exploration methods and innovating instructional organization to explore a new path for geophysical teaching characterized by 'collaborative industry-academia practice, hands-on operation, and research-driven learning,' providing replicable experience for future course design and optimization.

2. Objectives and Significance of Field Practice Teaching

Field teaching in geophysics is a vital component of the curriculum, aiming to transform abstract theoretical knowledge into tangible and applicable experience. By conducting field operations in real geological environments, students can directly understand the applicable conditions and technical procedures of various geophysical methods. They also master key steps in data acquisition, processing, and interpretation while strengthening their ability to identify and solve problems.

Using the Datong Volcano Geopark as a practice platform allows students to conduct comprehensive geophysical investigations in regions with distinct geological features. It helps them understand complex issues such as volcanic structure evolution, magma transport pathways, and geophysical anomaly responses, thereby deepening their interdisciplinary understanding of volcanic geophysics.

Additionally, field practice helps cultivate students' organizational and coordination skills, communication abilities, and teamw spirit through collaborative work in groups. It enhances their professional awareness and scientific literacy, laying a solid foundation for future careers in engineering surveys, mineral resource exploration, and geological hazard assessment.

3. Result

3.1 Convenient Transportation and Safety Assurance

Located in Yunzhou District, Datong City, Shanxi Province, the Datong Volcano Geopark is approximately a two-hour drive from Beijing. The site enjoys convenient access via a developed transportation network. The surrounding area provides adequate accommodation and living facilities, ensuring reliable logistical support. Furthermore, the park maintains a safe environment, with proactive administrative staff providing safety assistance and emergency response during student activities.

3.2 Favorable Geological Conditions

The Datong volcanic group represents a classic Quaternary volcanic system in northern China, with well-preserved cones and lava flows (Fig. 1). It encompasses basaltic and pyroclastic formations, distinct tectonic features, and significant geophysical anomalies. These attributes make the site highly suitable for applying multiple geophysical survey methods—such as gravity, magnetics, electrical, and seismic techniques—offering students hands-on experience with multiscale, multiphysics exploration.

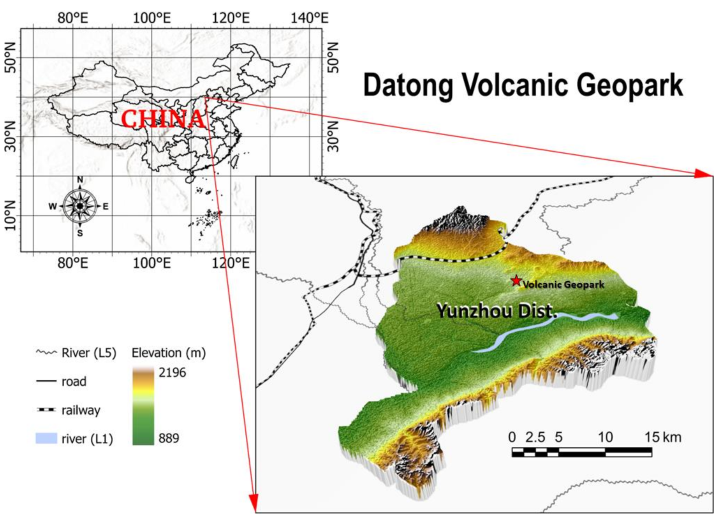

Figure 1. Location Map of Datong Volcano Geopark

3.3 Support from Local Government and Institutions

The local government of Yunzhou District provides strong support for field education, offering logistical coordination and institutional resources. The university works closely with the National Geopark Development Center, jointly operating the Ministry of Education's Key Laboratory of Intra-continental Volcanism and Earthquakes. This partnership ensures consistent and robust support for high-level field teaching activities.

4. Principles and Arrangement of Internship Organization

4.1 Field Reconnaissance Design

Prior to the internship, the teaching team conducted a detailed reconnaissance of the Datong Volcano Geopark. Using existing geological and geophysical data—such as magnetic susceptibility, density, and resistivity—they identified representative sites suitable for training. Survey layouts were optimized based on terrain and accessibility. The field guidebook was then revised to clarify operational procedures and quality control standards, ensuring students had a clear understanding of their assigned tasks.

4.2 Rational Grouping of Participants

The teaching team consisted of senior faculty members with extensive field experience, assisted by junior instructors and graduate teaching assistants. Roles and responsibilities were clearly defined. Students were divided into groups based on their academic background and technical proficiency. Each group had a designated leader and specific assignments. Under the supervision of instructors, students completed the full workflow—from data acquisition to processing—independently, fostering teamwork and accountability.

4.3 Internship Schedule and Rotation System

To ensure efficient use of time and equipment, a two-group rotation system was implemented. Each rotation cycle lasted nine days, divided as follows:

Group A: Gravity, Magnetics, and Radiometric methods

Further divided into three subgroups

Each subgroup rotated every three days

Group B: Electrical and Seismic methods

Split into two subgroups

Each subgroup conducted four-day surveys

The ninth day of each cycle was dedicated to data integration and rest. After one full cycle, the two groups switched roles, ensuring every student gained hands-on experience with all five geophysical methods (Fig. 2).

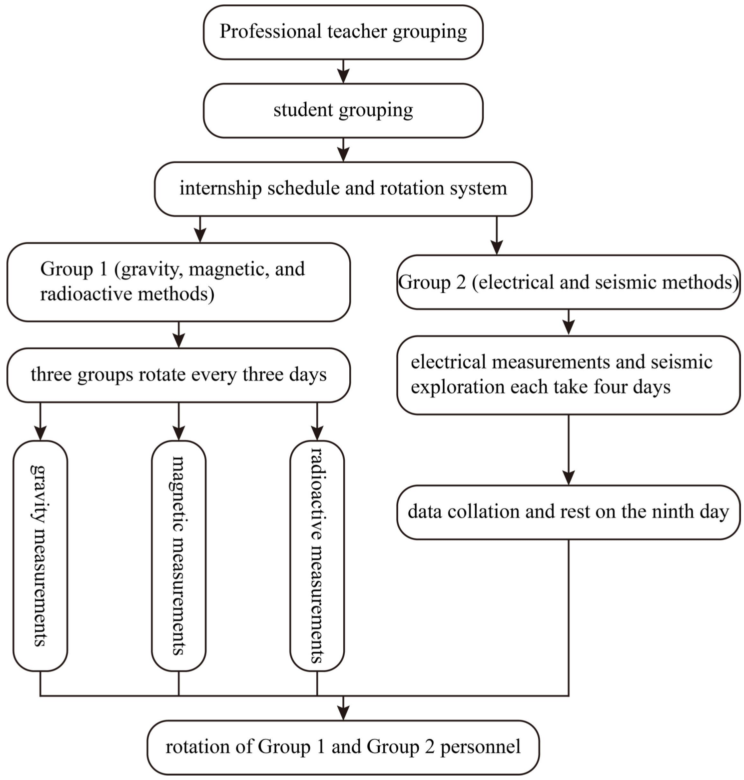

Figure 2. Internship Organization and Rotation Flowchart

5. Optimization of Teaching Methods in Field Practice

5.1 Step-by-step Progression

During the internship, instructors adhered to the teaching principle of progressing from simple to complex and from shallow to deep. Before each new task, teachers guided students through demonstrations and case-based explanations to help them understand the technical procedures and key considerations. They then gradually shifted responsibility to the students, allowing them to independently complete data acquisition and processing tasks. This hands-on, feedback-driven approach helped students master foundational skills and deepen their understanding of geophysics.

5.2 Emphasis on Scientific Thinking and Innovation

In the teaching process, instructors emphasized the development of students' scientific thinking. By posing typical questions and organizing group discussions, they guided students to identify problems, formulate hypotheses, and attempt verification through practical work. During the data interpretation phase, students were encouraged to experiment with multiple inversion models and processing methods to enhance their ability for independent thinking and methodological innovation, thereby strengthening their scientific literacy.

5.3 Focus on Hands-on Skills

Field practice places strong emphasis on hands-on operation and data acquisition. Students are required to complete the full workflow, including survey point layout, instrument operation and measurement, data recording, preprocessing, and preliminary interpretation. Through a daily feedback mechanism, instructors promptly identify issues in students' operations, helping them continuously improve their proficiency with instruments and the accuracy of data processing, thereby strengthening their practical skills.

5.4 Strengthening Industry Awareness and Endurance

The fieldwork environment is often complex and unpredictable. Instructors placed great emphasis on cultivating students' professional ethics, guiding them to develop a clear understanding of the geophysical exploration industry and to foster qualities such as perseverance and resilience. Through work schedules carried out regardless of weather conditions and training in handling real-world challenges, students developed a strong sense of responsibility and mission, inspiring their passion for the discipline and dedication to scientific research.

5.5 Strict Evaluation System

To ensure the quality of practical teaching, a comprehensive assessment mechanism was implemented throughout the internship. The evaluation covered students' attitude and performance during field operations, the quality and completeness of acquired data, the accuracy of data processing results, and the clarity and coherence of final reports. This assessment system encouraged students to approach each task with seriousness and professionalism, motivating them to pursue technical precision and effective teamwork during the internship.

6. Case Studies and Results of Practice Teaching

Taking magnetic surveying as an example, students in this field training combined UAV aeromagnetic surveys with ground-based magnetic measurements to carry out high-precision magnetic investigations of representative volcanic cones such as Gelao Mountain and Langwo Mountain within the Datong Volcano Geopark (Wang et al., 2022; Hu et al., 2017). Throughout the process, students completed key tasks including survey planning, flight route design, magnetometer calibration, on-site measurement, and data correction and processing—gaining a comprehensive understanding of modern magnetic survey techniques and applications.

During the data processing stage, students used the Geoprobe professional software to perform diurnal correction, leveling, reduction to the pole, and field separation, ultimately generating raw magnetic anomaly maps and related figures of the study area. The results revealed significant high magnetic anomalies over Gelao and Langwo Mountains, with anomaly values ranging from 300 to 500 nT, indicating the presence of high-magnetic susceptibility bodies beneath the surface (Fig. 3). These may represent basaltic columns or concealed magma conduits formed during a relatively recent volcanic episode. The interpretation aligns closely with regional geological survey findings and provides reliable geophysical support for further studies.

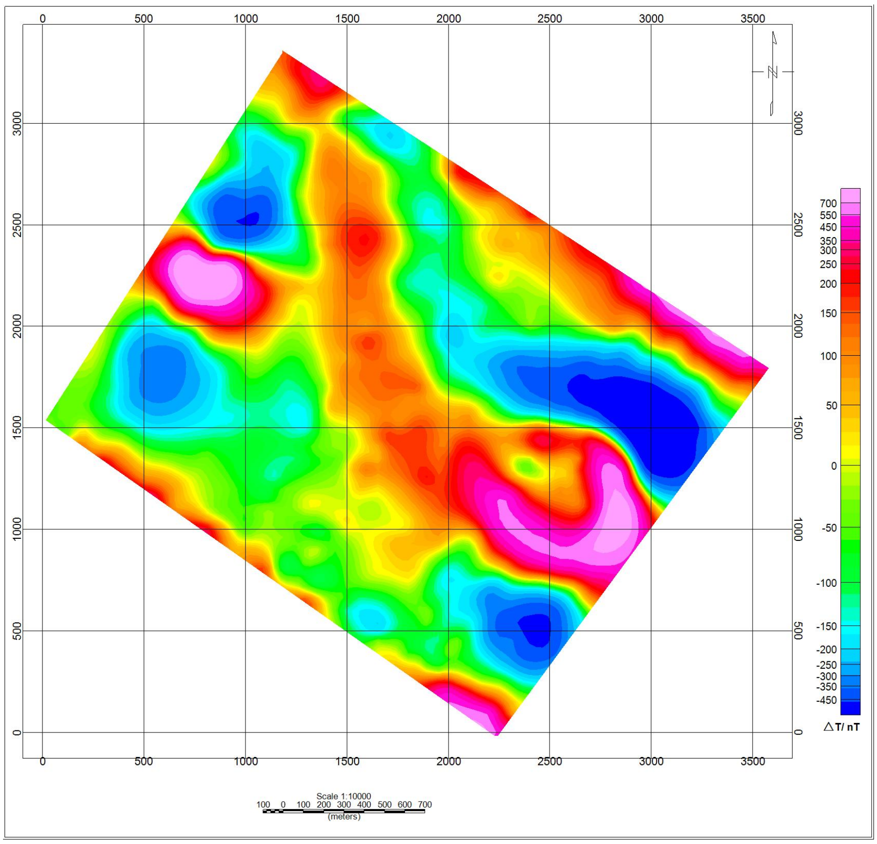

Figure 3. Magnetic Anomaly Map of the Study Area (ΔT)

Using MAG3D inversion software based on the UBC-GIF framework, students also constructed a 3D model of subsurface magnetic structures (Li et al., 1996). The inversion revealed a prominent columnar high-magnetic body beneath the volcanic cone, with magnetic intensity gradually decreasing with depth. Initial interpretations suggest that Langwo Mountain and Jinshan may share a common magma conduit system (Telford et al., 1990). This modeling exercise not only deepened students' understanding of magnetic inversion theory but also offered new insights into volcanic group structures and their evolution (Chen et al., 2021).

In addition, students were actively involved in field organization, data archiving, and final report preparation. These tasks enhanced their project execution, technical communication, and academic presentation skills (Zhao et al., 2018). Some of the internship outcomes were compiled into maps and research reports submitted to local authorities, providing data support for science education, tourism planning, and resource protection in the Datong Volcano Geopark—demonstrating a successful integration of teaching and regional service (Li et al., 2020).

7. Conclusion and Outlook

The geophysics field internship carried out at the Datong Volcano Geopark significantly improved students' theoretical understanding and hands-on abilities by immersing them in real geological survey tasks. Through direct participation in multi-method investigations—including UAV aeromagnetics, gravity, electrical, and seismic techniques—students experienced the full geophysical workflow, from data acquisition to processing and interpretation. This immersive approach not only sharpened their analytical and technical competencies but also fostered scientific literacy and problem-solving skills.

Beyond educational outcomes, the program generated actionable geophysical data that supported regional geological studies and contributed to the development planning of the volcanic geopark. The experience demonstrated a viable “teaching–research–service” model that aligns academic training with local development needs, offering mutual benefits to both students and community stakeholders.

In the future, the integration of intelligent sensing technologies and virtual reality is expected to transform geophysical field teaching into more intelligent, visual, and platform-based formats. To keep pace with these advancements, universities should deepen their collaboration with research institutions and local governments. This includes building advanced field training platforms and strengthening the linkage among industry, academia, research, and application, thereby cultivating highly skilled and innovative geophysics professionals.

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