

100 YEARS OF GEOPHYSICAL RESEARCH AND PROSPECTING IN ROMANIA
(1925–2025)
GEOPHYSICS – EARTH SCIENCE IN A HISTORICAL AND MODERN PERSPECTIVE

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Abstract. The article presents, in an integrated historical and conceptual perspective, the evolution of geophysics in Romania from the initiation of organized geophysical prospecting in 1925 to the Centenary of 2025. The main development stages are highlighted, from the first systematic investigations carried out in the context of the establishment of the International Union of Geodesy and Geophysics (IUGG), to the consolidation of a national geophysical school connected to international scientific networks. The first part is dedicated to the founders of Romanian geophysics, grouped into two successive “waves”. The first wave – around Ludovic Mrazec, with Sabba S. Ștefănescu, Iulian Gavăt, Toma Petre Ghițulescu and Mircea Socolescu – marks the transition from isolated observations to the systematic use of gravimetry, magnetometry, seismics and electrometry in natural resource exploration. The second wave – represented by Liviu Constantinescu and Radu Botezatu – brought the Romanian school to theoretical and institutional maturity through essential contributions to seismology, geomagnetism, geodynamics and regional modelling. The article further discusses geophysics as an integrated Earth science, the relationship between Earth Physics and applied geophysics, and the role of new technologies (InSAR, GPR, microseismic monitoring, 4D reservoir monitoring, artificial intelligence) in high-resolution subsurface investigation. Key research and educational institutions are presented – the Geological Institute of Romania, INCDFP, the “Sabba S. Ștefănescu” Institute of Geodynamics, GeoEcoMar, Prospectiuni S.A., the Faculty of Geology and Geophysics – as well as examples of graduates who reached leading positions worldwide. The conclusion emphasizes that the Centenary of Romanian Geophysics is not only a celebratory moment, but also reaffirms a mission: advancing the understanding of Earth’s structure and dynamics, ensuring responsible resource exploration, reducing natural risks, and contributing to environmental protection and societal safety.

Keywords: Romanian geophysics; Earth Physics; applied geophysics; geophysical prospecting; seismology and geomagnetism; emerging geophysical technologies; geophysical research institutions.

Résumé. L’article présente, dans une perspective historique et conceptuelle intégrée, l’évolution de la géophysique en Roumanie depuis le lancement des premières campagnes organisées de prospection géophysique, en 1925, jusqu’au Centenaire de 2025. Les principales étapes de développement sont mises en évidence, depuis les premières recherches systématiques menées dans le contexte de la création de l’Union Internationale de Géodésie et de Géophysique (IUGG), jusqu’à la consolidation d’une école nationale de géophysique connectée aux réseaux scientifiques internationaux. La première partie est consacrée aux fondateurs de la géophysique roumaine, regroupés en deux “vagues” successives. La première vague – autour de Ludovic Mrazec, avec Sabba S. Ștefănescu, Iulian Gavăt, Toma Petre Ghițulescu et Mircea Socolescu – marque la transition des observations isolées vers l’utilisation systématique de la gravimétrie, de la magnétométrie, de la sismique et de l’électrométrie dans l’exploration des ressources naturelles. La seconde vague – représentée par Liviu Constantinescu et Radu Botezatu – conduit l’école roumaine de géophysique à la maturité théorique et institutionnelle grâce à des contributions essentielles en

sismologie, géomagnétisme, géodynamique et modélisation régionale. L'article examine ensuite la géophysique en tant que science intégrée de la Terre, la relation entre la Physique de la Terre et la géophysique appliquée, ainsi que le rôle des nouvelles technologies (InSAR, GPR, micro-sismicité, monitoring 4D, intelligence artificielle) dans l'investigation haute résolution du sous-sol. Sont également présentées les institutions clés – l'Institut Géologique de Roumanie, l'INCDFP, l'Institut de Géodynamique "Sabba S. Ștefănescu", GeoEcoMar, Prospectiuni S.A., ainsi que la Faculté de Géologie et Géophysique – de même que des exemples de diplômés ayant atteint des positions de premier plan au niveau mondial. La conclusion souligne que le Centenaire de la géophysique roumaine ne constitue pas seulement un moment de célébration, mais la réaffirmation d'une mission: approfondir la connaissance de la structure et de la dynamique de la Terre, explorer de manière responsable les ressources, réduire les risques naturels et contribuer à la protection de l'environnement et à la sécurité de la société.

Mots-clés: géophysique roumaine; Physique de la Terre; géophysique appliquée; prospections géophysiques; sismologie et géomagnétisme; technologies géophysiques émergentes; institutions de recherche géophysique.

CHAPTER I – INTRODUCTION: ROMANIAN GEOPHYSICS IN THE CONTEXT OF INTERNATIONAL DEVELOPMENTS

Geophysics, as a stand-alone scientific discipline, has developed in Romania at a pace in line with the major international evolutions and, at certain moments, even in an avant-garde spirit. The first systematic geophysical investigations took shape in the first decades of the 20th century, at a time when, on a European and global scale, the physics of the Earth was being institutionally structured with the founding of the International Union of Geodesy and Geophysics (IUGG) in 1919. In this context, the concept of the Earth as an integrated physical system crystallized, a system whose structure and dynamics can be investigated through measurements of fields, waves, and deformations.

In Romania, the premises for the emergence of geophysics were laid by a pleiad of scholars who, even if they did not explicitly define their activity as "geophysics", prepared the intellectual ground: the School of Geodesy and Astronomy developed, astronomical and magnetic observatories were established, and the first seismic observations and gravimetric measurements were carried out. Names such as Gheorghe Demetrescu, Sava Athanasiu, Nicolae Coculescu, Grigore Ștefănescu and, a little later, Sabba Ștefănescu are linked to this stage of accumulation, in which the Earth began to be approached not only descriptively, but also as the object of a rigorous physical analysis.

A foundational moment is represented by the year 1906, when the Geological Institute of Romania was established, the first modern institution dedicated to the geological study of the national territory, with Ludovic Mrazec as its first director. Over time, the Institute became the matrix in which geology and geophysics would meet organically, the place where the classical reading of outcrops was complemented by gravimetric, magnetic, seismic, and electromagnetic data.

In 1925, Romania made a decisive step towards the modern exploration of the subsurface, when the Geological Institute took the initiative to integrate geophysical methods in an organized way into prospecting activities. At a time when geophysical equipment was only just emerging, even globally, Romania had the boldness to use methods of physics for the understanding and valorization of natural resources. This initiative is linked to the name of Ludovic Mrazec, a geologist of international renown and president of the Romanian Academy, who intuited, very early on, that the future of subsurface exploration would depend on indirect, non-invasive techniques.

THE FIRST WAVE OF FOUNDERS:
LUDOVIC MRAZEC AND HIS SCHOOL

Ludovic Mrazec (1867–1944)
Founder of Romanian Applied Geophysics



Ludovic Mrazec is a synthetic figure: geologist, mineralogist and petrographer, university professor, institution builder, and researcher with both theoretical and practical vision. He was the founder and director of the Geological Institute of Romania, the first professor of mineralogy and petrography at the University of Bucharest, a member and later president of the Romanian Academy.

His scientific work is linked primarily to the theory of salt diapirism. In papers published in Romania and abroad, Mrazec introduced the idea that salt masses, due to their particular physical properties, can migrate vertically and pierce the overlying strata, forming diapiric structures – a model known in the international literature as the “Mrazec diapir”. This concept became a fundamental tool in structural geology and in hydrocarbon exploration, from Romanian oil fields to distant provinces.

As director of the Geological Institute and president of the Romanian Academy, Mrazec did not limit himself to formulating the theory. He consistently pursued the application of these ideas in the field and especially in resource exploration. He understood that, in order to confirm and exploit diapiric structures, geophysical methods – gravimetry, magnetometry, seismics, electrometry – were necessary, and he created the framework in which they could be used. He was also concerned with training a new generation of specialists, aware that a discipline cannot be constituted without people and without a school. Around him, the first wave of founders of Romanian geophysics took shape: Sabba S. Ștefănescu, Iulian Gavăț, Toma Petre Ghițulescu, and Mircea Socolescu.

Sabba S. Ștefănescu (1902–1994)
**Pioneer of Electrometry, Co-founder of the Romanian School
of Geophysics**



Sabba S. Ștefănescu is regarded, together with Liviu Constantinescu, as a co-founder of the Romanian school of geophysics. Trained at the École des Mines in Paris, he came into early contact with Western scientific circles and collaborated with the Schlumberger brothers, pioneers of modern electrometry. The experience he gained in France placed him at the center of a methodological revolution that turned electric currents and electromagnetic fields into precise tools for subsurface investigation. After returning to Romania, Ștefănescu worked at the Geological Institute and in the academic structures established after the war. His elaboration of the theory of “alpha media”, a set of models that simplifies the computation of the electric field in stratified geological media, secured him a special place in theoretical geophysics. His works are distinguished by mathematical rigor, clarity of exposition, and a pronounced didactic spirit, which made them accessible to subsequent generations.

As a university professor, head of department, director of institutes, and president of the Romanian National Committee for Geodesy and Geophysics, Sabba Ștefănescu contributed decisively to the organization of geophysical education in Romania and to the training of the first generations of

geophysicists. In the recollections of his contemporaries, he appears as the “undisputed head of the Romanian geophysical school”, a model of professional rigor and intellectual integrity.

Iulian Gavăț (1900–1978)
Founder of Romanian Gravimetry



Iulian Gavăț stands as the defining figure of Romanian gravimetry, a personality who transformed a discipline that was still in an experimental stage into a mature scientific instrument, indispensable for geological research and natural resource exploration. Trained as an engineer and geologist, Gavăț possessed a remarkable combination of technical rigor and geological intuition, which allowed him – already in the interwar period – to recognize the potential of the gravimetric method for investigating regional structures and hydrocarbon deposits.

He introduced the torsion balance in Romania, one of the most sensitive geophysical instruments of its time, and laid the foundations for the first systematic gravimetric networks, gradually covering the most important tectonic units of the national territory. Under his coordination, regional gravimetric maps were produced, offering for the first time a coherent image of the deep structure of sedimentary basins, crystalline massifs, and petroleum-prospective areas.

His contributions had a dual significance. Scientifically, Gavăț’s measurements and interpretations established the understanding of regional-scale density variations and enabled the development of early geodynamic models of the Carpathians and Subcarpathians. Strategically, his results guided petroleum and mining exploration toward the most promising zones, reducing operational costs and risks at a time when modern seismic-reflection techniques were only beginning to be used.

As a professor at the University of Bucharest and author of influential courses, Gavăț had a major impact on the training of generations of geophysical engineers. His rigorous and clear pedagogical style decisively shaped the language, methodology, and standards of Romanian gravimetry, transforming the discipline into a field solidly anchored in international practice.

Toma Petre Ghițulescu (1902–1983)
**Explorer of Gold-Silver Deposits, Founder of Applied Geophysics
in the Apuseni Mountains**



Toma Petre Ghițulescu is one of the emblematic figures of geology and mineral-resource geophysics in the Apuseni Mountains, distinguished by his ability to integrate highly refined geological observation with the emerging geophysical methods of his time. A specialist in gold-silver deposits, he succeeded in identifying and characterizing complex mineralized structures, contributing both to the advancement of scientific knowledge and to the development of modern exploration practices.

Under the guidance of Ludovic Mrazec, Ghițulescu took part in establishing the first geophysical prospecting unit within the Geological Institute of Romania, being among the first Romanian geologists to understand the value of physical methods in subsurface exploration. His integrated approach – combining geological mapping, electrical, gravimetric and magnetic measurements, and mineralogical analysis – became a benchmark for subsequent generations.

His biography was strongly shaped by the post-war political context. Arrested in 1948, like many other scientists of the period, Ghițulescu was nevertheless asked by the authorities – even while

in detention – to coordinate geological exploration in the Apuseni Mountains, with personnel and logistics placed at his disposal. This paradoxical situation reflects the recognition of his exceptional professional competence and the importance of his expertise for the national economy.

As a professor at the Polytechnic Institute and other specialized institutions, Ghițulescu became a true founder of a school of applied geophysics devoted to metallic ore deposits.

Mircea Socolescu (1902–1993)

Researcher, Professor, Builder of Geophysical Infrastructure



Mircea Socolescu, geologist and geophysicist, was one of the close collaborators of Toma Petre Ghițulescu and an active participant in numerous exploration projects carried out during the early decades of Romanian geophysics.

Trained in an interdisciplinary environment, Socolescu made essential contributions to the introduction and consolidation of gravimetric, magnetic, and electrical methods in the study of metallic ore deposits and in the mapping of the deep structure of Romania. An important part of his work is associated with the development of the national geophysical infrastructure. At his initiative, projects were launched for a modern geomagnetic station equipped with amagnetic laboratories, precision instruments, and appropriate measurement standards. These efforts were later materialized in the National Geomagnetic Observatory, a key institution for monitoring variations of the Earth's magnetic field and for integrating Romania into international geomagnetic observation networks.

As a professor, Mircea Socolescu distinguished himself by promoting an integrated vision of geology and geophysics. He insisted on the idea that geologists must understand the principles and limitations of geophysical methods, while geophysicists must grasp the geological context of the data they interpret. This approach, modern for its time, transformed him into a true mentor of generations and a model of interdisciplinary collaboration, contributing to the development of a Romanian geophysical school solidly anchored in international practice.

THE SECOND WAVE: LIVIU CONSTANTINESCU AND RADU BOTEZATU – THE MATURATION OF THE ROMANIAN SCHOOL OF GEOPHYSICS

Building on the foundation laid by the first wave of founders – Mrazec and his disciples – a second wave of major personalities emerged after the mid-20th century, bringing Romanian geophysics to conceptual, methodological, and institutional maturity. This stage is marked by two essential figures: **Liviu Constantinescu** and **Radu Botezatu**, researchers who not only expanded the tradition of geophysical studies but also redefined it in line with international developments in Earth Physics.

At a time when global geophysics was rapidly transforming – through the development of plate tectonics theory, the expansion of seismic networks, the emergence of the first numerical models of the geomagnetic field, and the increasing use of computers in interpretation – the two succeeded in aligning Romanian research with international standards. Their contributions targeted both the advancement of fundamental domains of Earth Physics (seismology, geomagnetism, geodynamics) and the consolidation of a modern institutional framework capable of supporting long-term research.

Together, they succeeded in structuring Romanian geophysics into a solid institutional system, working in close collaboration with the Romanian Academy, with newly established institutes (such as the Centre for Earth Physics, later INCDFP), and with the academic environment. They trained

generations of seismologists, geomagnetists, and geodynamicists, developed national programs for geophysical monitoring, and ensured Romania's integration into international scientific networks, including IUGG and the emerging European structures.

This "second wave" represents the moment when Romanian geophysics moved beyond the pioneering phase and entered the stage of full professionalization, becoming a school recognized for its rigor, continuity, and significant contributions to understanding regional geodynamic processes.

Liviu Constantinescu (1914-1997)

Seismologist, Geomagnetist, Institutional Architect



Academician Liviu Constantinescu is one of the great figures of Romanian geophysics. Seismologist and geomagnetist, university professor, institute director and science organizer, he profoundly marked seismology and geomagnetism in Romania.

In seismology, Constantinescu contributed to understanding the seismogenic structure of Romania, especially the Vrancea zone, through data analysis, modeling, and regional interpretation. In geomagnetism, he worked on variations of the Earth's magnetic field and on the infrastructure of observatories, being one of the key persons in the organization of the National Geomagnetic Observatory. As a professor, he trained generations of seismologists and geophysicists, emphasizing rigor, responsibility, and international openness.

After 1990, he returned to the forefront of academic life as a full member of the Romanian Academy, president of the Section of Geonomic Sciences, and president of the Romanian National Committee for Geodesy and Geophysics, contributing to institutional reconstruction and to re-anchoring Romanian geophysics in international scientific networks.

Radu Botezatu (1921-1988)

Geophysicist of Global Tectonics and Regional Models



Radu Botezatu, corresponding member of the Romanian Academy, is recognized as one of the most important geophysicists of the post-war period. His activity took place in the fields of global tectonics, interpretation of gravity and magnetic fields, and regional geophysical modeling. His volume *Geophysical Models of the Geological Structure of Romania* remains a reference work for the integrated interpretation of geophysical data at regional scale.

As a professor at the Geophysics Department of the University of Bucharest, Botezatu wrote textbooks on geophysical methods and on geological interpretation of prospecting data, the first works of this kind in Romania. Heading the department until almost the end of his life, he formed a strong nucleus of disciples who would continue the Romanian geophysical tradition in fields such as numerical modeling, regional gravimetry and magnetometry, geodynamics, and integrated interpretation of data.

In the second half of the 20th century, Romanian geophysics thus rested on two successive "waves": the founders of geophysical applications (Mrazec, Ștefănescu, Gavăț, Ghițulescu, Socolescu) and the architects of theoretical and institutional maturity (Constantinescu, Botezatu). Against this background, the national seismic network was modernized, gravimetric and magnetic measurements were expanded, the foundations of geomagnetic stations were laid, and the first laboratories dedicated

to geophysics were structured. Geophysical prospecting, initially experimental, gradually became a standard component of natural resource exploration and of the geological mapping of the territory.

CHAPTER II – CONCEPTUAL FOUNDATIONS: GEOPHYSICS AS AN INTEGRATED SCIENCE

Geophysics is a synthetic science that uses concepts, methods and instruments of physics to study the Earth in all its components: the solid interior, the hydrosphere, the atmosphere, the cryosphere, and the gravitational, magnetic, electric, and electromagnetic fields that interconnect them. It is characterized by the use of indirect observations and by the ability to construct, on this basis, a coherent picture of internal processes and subsurface structures.

This indirect nature of observations explains the structural duality of the discipline. On the one hand, there is the theoretical core – Earth Physics – oriented towards understanding the fundamental mechanisms of the planet: internal structure, mantle and core dynamics, ocean circulation, atmospheric behavior, evolution of the magnetic field, and interactions with the cosmic environment. On the other hand, there is the applied dimension – applied geophysics – oriented towards practical solutions: resource exploration, hazard assessment, environmental monitoring, and the design and safety of infrastructures.

The relationship between these two dimensions is organic. Theoretical models of Earth Physics provide the conceptual framework for interpreting signals measured in the field, while data obtained in applications provide critical tests for these models. Thus, geophysics appears as a space of permanent dialogue between knowledge and action, between description and decision, between foundations and applications.

CHAPTER III – EARTH PHYSICS: INTERNATIONAL STRUCTURE AND MAJOR FIELDS

At the international level, Earth Physics is structured within the **International Union of Geodesy and Geophysics (IUGG)**, an organization founded in 1919 that brings together eight major scientific associations dedicated to the integrated study of terrestrial processes. This architecture reflects the way in which the global community has chosen to approach the planet's complexity: through the coordinated investigation of physical phenomena that manifest within the Earth, at its surface, and in its fluid envelopes. Through this structure, Earth Physics becomes an interdisciplinary space in which physical methods intertwine with geology, mathematics, geochemistry, oceanography, and atmospheric sciences.

A first major field is **cryospheric science**, which investigates polar ice sheets, mountain glaciers, seasonal snow, and permafrost. The cryosphere controls, through processes highly sensitive to climatic variations, sea-level changes and ocean circulation, and plays a decisive role in regulating the planet's energy balance. In recent decades, the accelerated melting of polar ice and the loss of glacier mass have become some of the strongest indicators of climate change, providing the scientific community with a barometer of global transformations.

Modern geodesy represents the high-precision measurement infrastructure of Earth's dynamics. Using GNSS constellations, satellite radar interferometry (InSAR), satellite gravimetry, and laser techniques, geodesy provides essential information on crustal displacements, plate motions, variations in ice mass and water reserves, as well as on the evolution of the gravitational field. In practice, it constitutes the invisible backbone of global navigation and a fundamental component of geodynamic and climate research.

Another important domain is **geophysical hydrology**, which studies the circulation of water in the continental and subsurface systems by integrating geophysical observations with mathematical

models. From evaluating water resources and monitoring aquifers to managing flood and drought risks, geophysical hydrology offers indispensable tools for the sustainable management of water resources, especially in a rapidly changing climatic context.

Meteorology and climatology, fundamental branches of Earth Physics, investigate the physical processes of the atmosphere over timescales from hours to centuries. Meteorology focuses on synoptic and local-scale phenomena – frontal systems, cloud formation, cyclone and anticyclone dynamics, precipitation, storms, and energy exchanges between the surface and the atmosphere. Climatology, on the other hand, analyzes statistical patterns of these processes on multi-decadal scales, identifying trends and natural or anthropogenic variability. Modern meteorological tools – station networks, meteorological satellites, radar, numerical forecasting models – have become essential for weather prediction, early warning of severe phenomena, and assessing the impacts of climate change. Directly connected with physical oceanography and cryospheric science, meteorology is one of the central pillars of understanding the global climate system.

Geomagnetism and aeronomy investigate the Earth's magnetic field, the upper atmosphere, and their interactions with the solar wind and magnetosphere. The magnetic field, generated in the Earth's liquid outer core, acts as a protective shield against cosmic radiation and influences sensitive technological processes such as radio communication, air navigation, and the functioning of power grids. Understanding its variations is essential both for technological safety and for investigating the dynamic mechanisms of the core.

Seismology, one of the most developed domains of Earth Physics, analyzes the propagation of waves generated by earthquakes or controlled sources. Through their interpretation, the current model of the planet's interior – with its major discontinuities (Mohorovičić, Gutenberg, Lehmann) and layers – has been constructed. Seismology also plays a crucial applied role: from seismic hazard assessment and structural design of buildings to monitoring microseismicity in volcanic, geothermal, or CO₂ storage zones.

Closely related to this, **volcanology** employs seismic, gravimetric, geodetic, and electromagnetic methods to monitor volcanic activity, magma dynamics, and pre-eruptive processes. Beyond their importance for population safety, major eruptions can influence the global climate by injecting aerosols and gases into the stratosphere.

Finally, **physical oceanography** provides insight into ocean circulation, tides, heat transport, and energy exchange with the atmosphere. Oceans are the planet's main heat reservoir, and their dynamics control climate processes on a global scale.

Through all these domains, Earth Physics constructs a coherent picture of the planet as a complex system in which the lithosphere, hydrosphere, atmosphere, and physical fields interact continuously. This integrated approach underpins the understanding of natural hazards, climate change, and the geodynamic processes that shape Earth's evolution.

CHAPTER IV – APPLIED GEOPHYSICS: FROM CLASSICAL PROSPECTING TO 4D SUBSURFACE MONITORING

Applied geophysics represents the bridge between the theoretical foundation of Earth Physics and the practical need to understand subsurface structure, evaluate natural resources, and ensure infrastructure safety. In Romania, this discipline has evolved in close connection with both economic development and international technological progress. The first geophysical applications, introduced in the 1920s-1930s under the impetus of the Geological Institute, employed gravimetry and magnetometry to identify diapiric structures and major tectonic units. At a time when instruments

were scarce and methods only beginning to take shape, Romania managed to align itself rapidly with global trends, using geophysics as a tool to guide petroleum and mineral exploration.

A decisive moment was the introduction of reflection seismics in the 1950s-1960s, which enabled the acquisition of detailed subsurface images. This technological leap opened the way to a new era of hydrocarbon exploration, making it possible to map deep structures in the Romanian Plain, the Transylvanian Basin, and the Black Sea shelf. Applied geophysics thus became a standard component of the energy industry, and Romania developed internal capabilities for seismic acquisition, processing, and interpretation that were regionally competitive.

As the economy and society evolved, the range of geophysical applications expanded significantly. Electrical and electromagnetic methods came into use not only for exploring ore deposits, but also for hydrogeology and environmental studies, complementing the information obtained through classical geological observation. Natural radiometry became a useful tool for lithological mapping and identifying mineralized zones. Later, microgravimetry and high-resolution magnetometry enabled investigations of shallow structures, cavities, anthropogenic fills, and geological instabilities, becoming essential in geotechnical projects in urban environments.

In recent decades, technological development has profoundly transformed applied geophysics. 2D and 3D seismics, microseismics, passive seismics, state-of-the-art electromagnetic methods, high-precision gravimetry and magnetometry, ground-penetrating radar, and satellite radar interferometry have created a portfolio of techniques capable of providing an integrated and detailed image of the subsurface. These methods are now routinely used not only in energy exploration but also in infrastructure projects – metro construction, highways, bridges, dams – in natural hazard assessment, geotechnical studies, geothermal exploration, and carbon storage projects.

A fundamental transformation of modern geophysics is the shift from data acquisition to their integration into complex models capable of reflecting real subsurface variations. In this process, petrophysics plays a central role, linking geophysically measured properties to the geological characteristics of rocks. Increasingly, geophysical interpretation has become an interdisciplinary exercise, in which geology, mathematics, computer science, and engineering contribute to the construction of robust models used in strategic decision-making. In parallel, the emergence of advanced inversion methods and the introduction of machine learning and artificial intelligence are opening new possibilities for detecting subtle structures, reducing uncertainties, and monitoring subsurface evolution over time.

Through this combination of tradition, innovation, and interdisciplinarity, applied geophysics in Romania presents itself today as an essential component of natural resource management, infrastructure safety, and geological hazard assessment. It thus provides a solid foundation for the emerging technologies of the 21st century, for the development of petrophysics, and for the integration of geophysics into national strategies for adapting to global change – topics that will be further developed in the following chapters.

CHAPTER V – EMERGING TECHNOLOGIES: DIGITALIZATION AND HIGH-RESOLUTION GEOPHYSICS

Technological developments in recent decades have profoundly transformed geophysics. Digitalization of instruments, increasing computing power, the emergence of Earth observation satellites, and the development of drones have considerably expanded the possibilities for observation and interpretation.

Satellite radar interferometry (InSAR) enables the detection of crustal deformations at millimetric scale and is used in monitoring landslides, urban subsidence, deformations associated with natural or anthropogenic reservoirs, and, in some cases, volcanic systems. Geophysical drones, equipped with magnetometers, radiometers, or lightweight electromagnetic systems, can rapidly cover large areas with high spatial resolution, including in difficult or hazardous terrain.

Ground-penetrating radar (GPR) has become a basic tool for shallow investigations, being used in archaeology, geotechnics, infrastructure diagnostics, and environmental studies. Microseismics and microgravimetry, along with local seismic tomography and advanced inversion methods, enable monitoring the evolution of reservoirs and of geothermal or CO₂ storage systems.

In this context, geophysics is becoming a science of large data volumes, where processing, integration, and coherent interpretation are just as important as acquisition. Artificial intelligence and machine learning methods are beginning to be used for pattern recognition, filtering, forecasting, and uncertainty reduction.

CHAPTER VI – PETROPHYSICS: THE LINK BETWEEN MEASUREMENT AND INTERPRETATION

Petrophysics is the discipline that relates measured physical properties of rocks to their geological nature. It studies density, porosity, permeability, seismic velocities, magnetic susceptibility, electrical resistivity, dielectric constants, thermal properties, and other parameters as a function of mineralogy, composition, texture, degree of fracturing, type of pore fluid, pressure, and temperature.

In Romania, petrophysics initially developed in direct connection with the oil industry, in well-logging and core-analysis laboratories, where correct interpretation of reservoir properties was essential for production decisions. Later, the field expanded to research institutes and universities, including applications in geothermal energy, geotechnics, and environmental geophysics.

The role of petrophysics is to transform geophysical anomalies into geological models. A density contrast observed gravimetrically can be interpreted as a change in lithology or as the presence of a diapiric structure; a seismic velocity jump may mark the boundary between unconsolidated and compact rocks; a resistivity variation may indicate differences in saturation with water, oil, or gas. Without petrophysics, geophysics would be limited to phenomenological description of signals; through petrophysics, it becomes a science of interpretation, capable of reconstructing subsurface architecture.

CHAPTER VII – ROMANIAN GEOPHYSICS AND THE CHALLENGES OF THE 21ST CENTURY

Romania has a complex geodynamic and geological setting, characterized by the presence of the seismogenic Vrancea zone, Carpathian and Subcarpathian structures, the subsiding plain, and the Black Sea basin. This framework generates both challenges and responsibilities for geophysics.

Seismic hazard in Vrancea, with intermediate-depth earthquakes that can affect a large part of the territory, remains one of the major concerns. Hazard and risk assessment, impact-scenario development, definition of intensity zones, early-warning systems, and public information are areas in which geophysics plays a central role.

Urban development, the expansion of critical infrastructures, construction of dams, bridges, highways, energy networks, and industrial facilities require careful evaluation of geotechnical conditions and geological hazards. Shallow and medium-depth geophysical methods are increasingly used in design and monitoring phases to reduce uncertainties and increase safety.

Responsible exploration of resources – groundwater, geothermal energy, mineral resources – and use of geological space for projects such as carbon storage require detailed geophysical investigations and close collaboration with geology, engineering, and environmental sciences. Romanian geophysics participates in European projects on CCS, geothermal energy, geodynamics, and geophysical environmental monitoring, making significant contributions.

At societal level, geophysics also has an educational role. Information on earthquakes, geological risks, and environmental changes must be communicated correctly, balanced, and accessibly. A culture of risk is built over time, and geophysics, through its data and models, can provide a solid foundation for this culture.

CHAPTER VIII – GEOPHYSICAL INSTITUTIONS AND EDUCATION IN ROMANIA

The development of Romanian geophysics is inseparable from the institutions in which this activity takes place. People and ideas cannot flourish without a framework that ensures continuity, infrastructure, data archives, and the training of new generations.

GEOLOGICAL INSTITUTE OF ROMANIA – A FOUNDATIONAL INSTITUTION AND CENTRAL NODE IN THE DEVELOPMENT OF ROMANIAN GEOPHYSICS



The Geological Institute of Romania, founded in 1906, is one of the oldest and most prestigious scientific institutions in the country and represents the cradle in which nationally organized geophysical prospecting was born under the visionary impetus of Ludovic Mrazec. From its inception, the Institute had the fundamental mission of producing the systematic geological mapping of Romania, an extensive undertaking that gradually required the integration of modern methods and technologies, including geophysics.

As geological sciences evolved, the Institute's role expanded beyond field observations and lithological mapping. In the first half of the 20th century, the first laboratories dedicated to gravimetry, magnetometry, and electrometry were established, alongside stratigraphic and mineralogical research. These initiatives formed the nucleus of applied geophysics in Romania and enabled geophysical data to be integrated into the understanding of the deep structure of sedimentary basins, hydrocarbon exploration, and the identification of diapiric structures.

In the following decades, the Geological Institute became a multidisciplinary center in which classical geology was complemented by new directions: geochemistry, marine geology, engineering geology, geodynamics, and advanced petrography. Especially after the 1960s, influenced by international developments in geophysics, specialized laboratories were created that allowed for the integrated interpretation of geological and geophysical data. The Institute played an active role in producing Romania's gravimetric and magnetic maps, assessing mineral, petroleum, and hydrogeological potential, and participating in large-scale interdisciplinary research programs.

Over time, units within the Institute were reorganized or separated and evolved toward fundamental geophysics and geodynamics, contributing to the formation of a national network of specialized institutes. Among these were the Centre for Earth Physics (the nucleus of the future INCDFP), the laboratories that later formed the Romanian Academy's "Sabba S. Ștefănescu" Institute of Geodynamics, and the working groups that laid the foundations of modern marine geocological research, which eventually led to the creation of GeoEcoMar.

In parallel, the Geological Institute has played an essential role in the professional training of Romanian geologists and geophysicists, providing a framework for internships, instruction, and mentorship for entire generations of specialists. Its archives – maps, boreholes, field reports, geophysical profiles, and collections of rocks and fossils – constitute today a scientific patrimony of strategic importance for Romania.

Thus, the Geological Institute of Romania is not only a foundational institution but also a matrix in which research directions, scientific schools, and infrastructures were formed, decisively contributing to the development of Romanian geophysics in both its applied and fundamental dimensions.

In applied geophysics, the company Prospectiuni S.A., specialized in geological and geophysical prospecting, plays a special role.

Prospectiuni S.A. – A Pillar of Applied Geophysics Development in Romania

70
Years of
Discovering
Earth's
Resources



Prospectiuni S.A. is the most important industrial entity dedicated to geophysical prospecting in Romania, with a history beginning in 1950, when the first enterprise specialized in geological and geophysical data acquisition across the entire national territory was established. In the post-war context, marked by an acute need for energy and mineral resources, the company's activity became fundamental to the development of applied geophysics, transforming modern investigation techniques into operational tools of the industry.

Over the decades, the company evolved from basic gravimetric and magnetic methods to advanced 2D and 3D seismic systems, becoming the main data provider for hydrocarbon exploration in Romania. Its acquisition teams have covered diverse regions – from the Romanian Plain to the Subcarpathian hills, from the Transylvanian Basin to the Black Sea shore – contributing decisively to mapping deep geological structures and identifying new areas with petroleum and gas potential.

Prospectiuni S.A. has consistently invested in equipment modernization and specialist training, becoming a vector of technological transfer between academic geophysical research and the energy industry. Over time, its portfolio expanded to include electrical and electromagnetic methods, well logging, microseismics, and integrated geophysical processing and interpretation services. The company also participated in numerous international projects, strengthening its status as a competitive partner in the global prospecting market.

Through the scale of its activities, Prospectiuni S.A. has had a substantial impact on the professional development of Romanian geophysicists, offering fieldwork, practical training, and specialization opportunities to entire generations of engineers. Thus, the company has become not only an economic actor but also a pivotal bridge between research, industry, and the professional formation of specialists in geophysics.

National Institute for Earth Physics – The Center of Romanian Seismology



The National Institute for Research and Development in Earth Physics (INCDFP), established in 1977 through the integration of the Seismology Department of the Institute of Geology and Geophysics with the Geodynamics Laboratory of the Romanian Academy, has become the principal center of excellence in seismology and geodynamics in Romania. The creation of the institute responded to the need for a modern national seismic-monitoring infrastructure capable of characterizing the complex tectonic activity of the Vrancea region and contributing to seismic hazard assessment for the entire country.

Over the decades, INCDFP has developed one of the densest and most modern seismic networks in Eastern Europe, integrating broadband stations, accelerometric equipment, and automated data-analysis systems. This infrastructure has enabled landmark research on the focal mechanisms of Vrancea earthquakes, the spatio-temporal distribution of microseismicity, and the relationships between tectonics, deformation, and hazard.

In addition to monitoring activities, the institute carries out research projects in geodynamics, seismic tomography, numerical modeling of stress fields, surface-wave analysis, and the development of early-warning systems for earthquakes. INCDFP represents Romania in international networks such as ORFEUS, EMSC, and EPOS, contributing data and expertise to global efforts aimed at monitoring and reducing seismic risk.

The institute also plays a crucial role in public communication and in developing seismic design regulations, collaborating with national authorities to strengthen risk culture at the societal level. Through its activities, INCDFP remains one of the essential actors in Romanian geophysical research and a strategic partner in understanding regional seismogenic processes.

“Sabba S. Ștefănescu” Institute of Geodynamics – The Continuation of a Fundamental Tradition in Romanian Geophysical Research



The “Sabba S. Ștefănescu” Institute of Geodynamics of the Romanian Academy represents the natural continuation of an intellectual and scientific tradition inaugurated by the first major Romanian geophysicists. Although its conceptual roots lie in the work of the founders of the Romanian school of geophysics – particularly Sabba S. Ștefănescu and Liviu Constantinescu – the institutionalization of geodynamic research as a distinct domain is due essentially to the initiative and vision of Dorel Zugrăvescu, Corresponding Member of the

Romanian Academy and close collaborator of these two great scientists.

Trained in an environment of scientific rigor and intellectual discipline, Zugrăvescu understood the necessity of building a structure dedicated to the study of the lithosphere’s dynamic processes, at a time when modern geodesy, crustal monitoring, and precision gravimetry were beginning to gain strategic importance in global geophysics. He founded the Institute of Geodynamics with the goal of transforming the theoretical directions developed by Ștefănescu and Constantinescu into a coherent program of institutional research, equipped with its own infrastructure and capable of contributing to major questions of regional geodynamics.

Under his leadership, the institute became a center of excellence in the study of crustal deformation, active tectonic movements, and the processes responsible for the characteristic seismogenesis of the Vrancea region. Its research included advanced applications of absolute and relative gravimetry, geomagnetic monitoring, electromagnetic methods, analysis of gravitational variations associated with tectonic deformation, as well as the early introduction of high-precision GPS techniques for measuring crustal movements.

The institute quickly integrated into European and international scientific networks such as INTERMAGNET and EPOS, participating in projects dedicated to regional tectonic motions, monitoring magnetic-field variations, and developing geodynamic models. Its work has been essential in defining a modern perspective on the tectonics of the Carpathians and Subcarpathians, developing models of the seismogenic evolution of the Vrancea zone, and contributing to the interpretation of deformation processes within the Romanian lithosphere.

Beyond its strictly scientific dimension, the Institute served as a training ground for a new generation of geodynamicists who inherited and further developed the intellectual legacy of the Romanian geophysical school. Under the conceptual influence of Dorel Zugrăvescu, and in continuity with the ideas of Ștefănescu and Constantinescu, the institute became a pivotal institution linking the tradition of fundamental geophysics with contemporary needs for monitoring geological and tectonic hazards.

Thus, the Institute of Geodynamics is not merely an administrative structure, but a pillar of continuity and maturity in Romanian geophysics – a place where the historical evolution of the discipline intersects with modern research and with a sustained commitment to understanding the dynamic processes that shape the territory of Romania.

National Institute for Marine Geology and Geoecology (GeoEcoMar) – The National Hub of Marine Research and Coordinator of the European DANUBIUS-RI Infrastructure



The National Institute for Marine Geology and Geoecology – GeoEcoMar is Romania’s principal center of excellence for the integrated study of the Danube-Danube Delta-Black Sea system. Since its establishment, the institute has developed a unique interdisciplinary approach that combines marine geology, marine geophysics, geoecology, environmental geochemistry, and sediment dynamics, using a wide range of modern investigation methods.

GeoEcoMar operates complex research infrastructures – research vessels, marine laboratories, and both deep- and shallow-water geophysical systems (seismics, multibeam bathymetry, gravimetry, magnetometry, sub-bottom profiling) – through which it characterizes the structure of the marine subsurface, the evolution of sedimentary deposits, slope instability, and the impact of geomorphological and anthropogenic processes on the coastal environment.

A defining element of GeoEcoMar’s international role is its involvement in **DANUBIUS-RI – The International Centre for Advanced Studies on River-Sea Systems**, one of the most ambitious pan-European research infrastructures dedicated to the study of river-sea systems. Romania, through GeoEcoMar, is the host country of the DANUBIUS-RI Central Hub and the institutional coordinator of the entire distributed infrastructure, which brings together more than 25 European partners.

DANUBIUS-RI aims to investigate in an integrated manner the critical transitions between continental and marine environments, where hydrological, geological, ecological, and anthropogenic influences intersect. GeoEcoMar coordinates the development of key concepts, standards, and infrastructures of the project, ensuring Romania’s connection to leading European scientific networks and strengthening the country’s status as a leader in river-sea system research.

Through DANUBIUS-RI, the institute plays a strategic role in promoting a transdisciplinary approach that integrates geophysical monitoring, sedimentology, natural hazard studies, pollution assessment, ecosystem dynamics, and modeling of sedimentary and biogeochemical transfer processes. Thus, GeoEcoMar contributes not only to fundamental research, but also to European policies on environmental protection, sustainable water-resource management, coastal resilience, and adaptation to climate change.

Active participation in European programs such as EMODnet, EPOS, Eurofleets, and BSRN, together with its central role in DANUBIUS-RI, has consolidated GeoEcoMar as a pivotal institution within international marine and river research networks, capable of generating data, expertise, and solutions that transcend the regional scale.

Thus, GeoEcoMar is not merely a research institution, but a strategic vector of Romania in marine and river-sea sciences – a place where the interaction between geophysics, geology, ecology, and environmental sciences is transformed into applied knowledge, modern infrastructures, and major contributions to the international scientific community.

In education, the Faculty of Geology and Geophysics of the University of Bucharest is the core of academic training in geophysics.

Faculty of Geology and Geophysics, University of Bucharest – The Core of Academic Training in Romanian Geophysics



The Faculty of Geology and Geophysics of the University of Bucharest has been, for more than a century, the principal pillar of academic education in Earth sciences and, in particular, in Romanian geophysics. It is here that the only complete Geophysics specialization in Romanian higher education was developed – a program that has evolved continuously in line with international advancements in the discipline and the needs of society.

Over time, the Faculty has benefited from an exceptional academic staff, formed by leading personalities who shaped the development of Romanian geophysics and contributed to consolidating a school characterized by rigor, interdisciplinarity, and openness to new directions in international research. Under their guidance, geophysics has been taught in a manner that integrates theoretical foundations, field observations, and geophysical interpretation techniques into a coherent whole, capable of training specialists fully prepared for the field.

The Faculty's modern curriculum includes courses and laboratories dedicated to seismology, gravimetry, magnetometry, geoelectricity, seismic prospecting, petrophysics, geodynamics, geophysical inversion, and environmental geophysics, alongside advanced modules in structural geology, geoinformatics, and numerical modeling. The combination of theoretical training with extensive fieldwork and internships at institutes such as GeoEcoMar, INCDFP, and the Institute of Geodynamics provides students with a comprehensive framework for professional development.

A defining element of the Faculty of Geology and Geophysics is the long-term impact of its graduates. Many have contributed significantly to the advancement of Romanian geophysics in research institutes, industry, and academia. Others, trained within the Romanian school's tradition, have achieved international recognition and today hold prestigious positions in universities, research centers, and specialized companies around the world. This geographical and professional reach confirms the strength of the Faculty's training and its relevance within the broader context of global geophysics.

Thus, the Faculty of Geology and Geophysics remains a fundamental node of scientific education in Romania – a place where tradition intertwines with innovation, and where the contributions of its professors and graduates continue to strengthen the prestige of the Romanian school of geophysics.

ROMANIAN GRADUATES AT THE TOP OF WORLD GEOPHYSICS

To illustrate the level of excellence reached by the Romanian school of geophysics, it is fitting to mention two emblematic examples of graduates of the Faculty of Geology and Geophysics, Geophysics specialization, who have reached the highest international positions in Earth Physics and applied geophysics.



Mioara Mandea – Earth Physics, IUGG President (2027–2031)

Mioara Mandea is one of the most highly regarded Romanian geophysicists worldwide, a specialist in the study of the Earth's magnetic field and its variations. A graduate of the Geophysics specialization at the University of Bucharest and later doctor of the University of Bucharest and of Université Paris VII, she has spent much of her career in France, at the Institut de Physique du Globe de Paris and at the Centre National d'Études Spatiales (CNES), where she coordinates scientific activities in the Solid Earth domain.

Her research covers measurement and modeling of the Earth's magnetic field, from ground observatories to satellite missions; the study of the

lithospheric magnetic field and of variations in the field generated in the core; and the relationship between the magnetic field, gravity, and Earth rotation. She has contributed to the development of series of reference geomagnetic models, to the concept of “virtual observatory”, and to European projects dedicated to dynamic processes in the fluid core.

In 2023, at the IUGG General Assembly in Berlin, Mioara Mandea was elected President-Elect of the International Union of Geodesy and Geophysics, and she will assume the position of IUGG President for the period 2027–2031. She is the first person of Romanian origin to lead this centenary organization, a fact that represents top-level recognition of the Romanian school of geophysics and of its contributions to Earth Physics.

**Paul Constantin Sava – Applied Geophysics,
Department Head at Colorado School of Mines**



Paul Constantin Sava is a leading figure in contemporary applied geophysics, especially in seismic imaging and full-waveform inversion. A graduate of the Geophysics specialization at the University of Bucharest, with master’s and doctoral studies at Stanford University, he is currently Head of Department and C.H. Green Chair of Exploration Geophysics at Colorado School of Mines, one of the world’s most prestigious technical universities in geosciences.

His scientific activity focuses on wavefield imaging, seismic inversion, and microseismic monitoring, with direct applications in hydrocarbon exploration and characterization of complex geological structures. He has published numerous papers in top journals, coordinates research projects, and heads the Center for Wave Phenomena, an internationally recognized center in seismic data processing and interpretation.

Through his position at Colorado School of Mines and his contribution to training new generations of geophysicists, Paul Sava is a benchmark for Romanian geophysics internationally. His career confirms the strength of the initial training provided by the Faculty of Geology and Geophysics and the ability of Romanian graduates to excel at the highest level.

OTHER UNIVERSITY CENTERS

Beyond the Faculty of Geology and Geophysics of the University of Bucharest, other Romanian universities have made sustained contributions to academic training in fields connected to geophysics, offering courses, laboratories, and research programs that complement and diversify the preparation of Romanian specialists in Earth sciences. Although these institutions do not in all cases offer a specialization dedicated exclusively to geophysics, they have integrated the discipline into their geology, geography, geotechnical, or engineering programs, thus contributing to the professional formation of numerous researchers and practitioners.

At “**Alexandru Ioan Cuza**” University of Iași, the Faculty of Geography and Geology continues an academic tradition of more than a century. Within its programs, geophysics is represented through courses and modules dedicated to the Earth’s internal structure, geodynamics, natural hazards, geophysical exploration methods, and geological applications. The Faculty’s laboratories are equipped with modern instruments for basic geological and geophysical analyses, and collaborations with research institutes and European centers provide students with training opportunities in interdisciplinary projects. Researchers from Iași have contributed over time to the study of Vrancea earthquakes, regional geomorphodynamics, and sedimentary processes, offering a complementary perspective on Romania’s geodynamics.

At “**Babeş-Bolyai**” **University in Cluj-Napoca**, geophysics is integrated into several study programs within the Faculty of Environmental Science and Engineering, the Faculty of Geography, and the Faculty of Natural Sciences. The emphasis is placed on structural geology, geophysical-assisted geological mapping, geological modeling, and the application of geophysical methods in mineral and hydrogeological resource assessment. Cluj benefits from a strong geological tradition and a solid academic infrastructure, and local teams participate in international projects on environmental monitoring, geological hazards, and the use of modern Earth-observation technologies. Through its geographic position and interdisciplinary profile, the Cluj academic center contributes significantly to the understanding of the complex geological context of the Western Carpathians and the intra-Carpathian basins.

A significant role in applied professional training is also held by the **University of Petroşani**, particularly through the Faculty of Mining. Programs in mining engineering, mine surveying, mining geology, and geotechnics include courses and applied geophysical methods used in exploring coal deposits, metallic ore bodies, and unconventional energy resources; in slope stability assessments; in the design of underground works; and in evaluating geotechnical risks. Graduates of this faculty have contributed over recent decades to the development of applied geophysics tailored to industrial needs, in close collaboration with mining companies and technical institutes in Romania.

Other universities – including those in Timișoara, Craiova, Suceava, and Târgoviște – integrate fundamental elements of geophysics, structural geology, geoinformatics, geophysical-assisted geological mapping, and geotechnical methods within their study programs, contributing to the dissemination of a solid academic culture in Earth sciences. These institutions participate in regional projects on landslide monitoring, geological mapping, hazard assessment, and environmental protection, and some collaborate with national institutes to develop a distributed training network across the country.

Through their cumulative contribution, these university centers complete Romania’s geophysics educational ecosystem, providing a diversified base of competencies and integrating geophysics naturally within the broader field of Earth sciences. They represent not only nodes of academic training but also sources of applied research, adapted to local specificities and the needs of contemporary society.

CHAPTER IX – CONCLUSIONS

Geophysics today presents itself as a unifying science, capable of explaining the fundamental phenomena of the Earth and of providing concrete tools for responsible exploration and management of the subsurface. It integrates theoretical models, field observations, cutting-edge technologies, and interdisciplinary interpretations, bringing physics, geology, mathematics, chemistry, computer science, and engineering into dialogue.

In Romania, the path from 1925, when, under the impetus of Ludovic Mrazec, the Geological Institute of Romania initiated the first organized geophysical prospecting campaigns, to 2025, when the Centenary of Romanian Geophysics is celebrated, is a remarkable one. A first wave of founders – Sabba S. Ștefănescu, Iulian Gavăt, Toma Petre Ghițulescu, Mircea Socolescu – laid the foundations of a discipline that was consolidated and brought to maturity by a second wave – Liviu Constantinescu, Radu Botezatu – and by subsequent generations of researchers, active in institutes, universities, and the applied environment.

The current institutions – the Geological Institute of Romania, Prospectiuni S.A., the National Institute for Research and Development in Earth Physics, the “Sabba S. Ștefănescu” Institute of Geodynamics, the GeoEcoMar Institute, the Faculty of Geology and Geophysics of the University of

Bucharest, and other university centers – represent the infrastructure through which this tradition is kept alive, adapted to new technologies and new challenges.

The Centenary of Romanian Geophysics is not only an occasion for homage, but also a reaffirmation of a mission: to understand in depth the structure and dynamics of the Earth, to explore natural resources responsibly, to assess and reduce natural risks, and to contribute, through scientific knowledge, to environmental protection and societal safety. From this perspective, Romanian geophysics is fully part of the international geophysical community and confirms its status as a school of excellence.

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