# GEOPHYSICAL INTERPRETATION AND PROSPECTING

Earth Science Engineering MSc Course

2022/2023 / 1st Semester

COURSE COMMUNICATION FOLDER

**University of Miskolc**
**Faculty of Earth Science and Engineering**
**Institute of Geophysics and Geoinformatics**

## *Course datasheet*

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| **Course Title:** Geophysical Interpretation and Prospecting<br>**Instructors:**<br>**Dr. Ernő Takács**, PhD, Head of Institutional Department at the Faculty of Earth Science and Engineering / Geoscience Consultant at the Supervisory Authority for Regulatory Affairs<br>**Dr. Tamás Fancsik**, CSc, Associate Professor at the Faculty of Earth Science and Engineering / Director at the Supervisory Authority for Regulatory Affairs | **Code:** MFGFT730025<br>**Responsible department/institute:** Department of Geophysics / Institute of Geophysics and Geoinformatics<br>**Type of course:** Compulsory |
| **Position in curriculum (which semester)**: 3 | **Pre-requisites (if any)** |
| **No. of contact hours per week (lecture + seminar):** 2+2 | **Type of Assessment (examination / practical mark / other):** examination |
| **Credits:** 4 | **Course:** full time |

**Course Description:**

The aim of the course is to provide a comprehensive knowledge about the closing phases of geophysical exploration (interpretation and prospecting). In this subject, students will learn the linkage between the different geophysical methods. They will study how to set up the most probable geological model by the utilization of geophysical data and other geoscience information. They will get an overview on the variety of geophysical methods, and will learn about the most effective procedures applied in geophysical exploration targeting different kinds of natural resources (i.e. ore minerals, hydrocarbon, coal, aquifer, and geothermal energy). The most important practical issues of the lectures will be discussed in seminars. A practical exercise on real geophysical data will also be helpful to understand how to obtain geological and lithological information from the geophysical data.

**Competencies to evolve:**

***Knowledge:*** T1, T2, T3, T4, T5, T7, T8, T9
***Ability:*** K1, K2, K3, K5, K6, K7, K8, K9, K10, K11, K12, K13
***Attitude:*** A1, A2, A3, A4, A5, A7
***Autonomy and responsibility:*** F1, F2, F3, F4, F5

**Short curriculum of the subject:**

1) Formation of the unconformity type uranium deposits. Geophysical methods applied in their exploration and the ‘seismic uranium indicators’ (case studies from Canada).
2) Hydrocarbon generation, the elements of a petroleum system, and the stages of HC exploration (lead, prospect, play). Surface seismic reflection method and VSP. Seismic sequence stratigraphy.
3) Lithological reasons for the seismic amplitude anomalies. Seismic attribute sections, post-stack (Seislog®) and pre-stack (AVO®) analyses. Advantages of the joint utilization of well-log and seismic data.
4) Multifold seismic reflection surveys. Survey planning and implementation. Explosive and vibroseis sources, data acquisition, quality control, and field documentation.
5) Seismic data processing utilizing ProMAX®. Basic steps in reflection data processing (necessary corrections of the raw data and signal/noise enhancement procedures).
6) Seismic interpretation in Kingdom®. Loading seismic, borehole and well log data, picking horizons, tracking faults and fault zones.
7) Well-logging techniques. In-situ rock physical parameters and lithological/stratigraphical information. The relationship between the well-log and surface seismic data.
8) Electromagnetic methods for both the near surface and the deep crustal investigations. The obtained petrophysical parameters and their interpretation.
9) No education.
10) Tracing coal bearing sequences by well-log, core, and seismic data (Eastern Mecsek Mountains). The elaborated structural development model and deformation history.
11) Some types of aquifers and the most useful geophysical methods (e.g. geoelectrical, IP, and EM methods) utilized in water exploration. Case histories including water base protection.
12) Deep seismic imaging, regional and local geothermal explorations. Fault zones intersecting the whole earth-crust penetrating down to the Moho. The peculiarity of the Pannonian Basin from structural and geothermal viewpoints.
13) Utilization of archive geophysical and geological data for the success of subsequent exploration projects. From Romeo and Juliet to the artificial intelligence.
14) Final discussion and conclusions. How to prepare for the final examination?

**Assessment and grading:**

During the semester the following tasks have to be completed: a report covering the aims of the practical exercise (60%), and a successful exam (40%). Grading limits:

> 80%: excellent,
70-79%: good,
60-69%: medium,
50-59%: satisfactory,
< 50%: unsatisfactory.

**Recommended literature:**

Related books:

1. Bacon, M., Simm, R., Redshaw, T.: 3-D Seismic Interpretation, 2003
2. Chopra, S. and Castagna, J.P.: AVO, Investigations in Geophysics 16, Society of Exploration Geophysicist, Tulsa, Oklahoma, 2014
3. Kearey, P., Brooks, M., Hill, I.: An Introduction to Geophysical Exploration, 2002
4. Serra, O.: Well Logging and Reservoir Evaluation, 2007
5. Yilmaz, Ö.: Seismic Data Analysis: Processing, Inversion, and Interpretation, 2001

Some related papers:

1. Gúthy, T., Takács, E., Kovács, A.Cs., Fancsik, T., Csabafi, R., Török, I., Hegedűs, E. 2018: Recent developments in imaging the earth's crust by deep seismic data beneath the eastern parts of the Pannonian Basin. *Interpretation*, 6(1), p. SB23-SB35.
2. Hajnal, Z., Takács, E., Pandit, B., Annesley, I.R. 2015: Uranium mineralization indicators from seismic and well log data in the Shea Creek area at the southern margin of the Carswell Impact Structure, Athabasca Basin, Canada. *Geophysical Prospecting*, 63, p. 861-880.
3. Takács, E., Kummer, I., Sipos, J., Pápa, A. 2001: Bright spot analysis within the Pannonian Basin using horizon velocity estimation and Hilbert and AVO attributes. *First Break*, 17(3), 79-85.
4. Takács, E., Hajnal, Z., Pandit, B., Annesley, I.R. 2015: Mapping of alteration zones with seismic-amplitude data and well logs in the hard-rock environment of the Keefe Lake area, Athabasca Basin, Canada. *The Leading Edge*, 34, p. 530-538.

Periodicals for attention: The Leading Edge, First Break, Geophysical Prospecting

## *Syllabus of the semester*

| Week | Lecture |
|---|---|
| 1 | Geophysical methods in ore exploration |
| 2 | Seismic methods in hydrocarbon exploration |
| 3 | Direct Hydrocarbon Indicators |
| 4 | Seismic survey planning and implementation |
| 5 | Seismic data processing utilizing ProMAX |
| 6 | Seismic interpretation utilizing Kingdom |
| 7 | Well-logging methods |
| 8 | Electromagnetic methods |
| 9 | No education |
| 10 | Coal stratigraphy and deformation history by well-log and seismic data |
| 11 | Aquifer exploration by geophysical methods |
| 12 | Deep seismic soundings and geothermal investigations |
| 13 | Earth science databases for interpretation |
| 14 | Final discussion and conclusions |

| Week | Seminar |
|---|---|
| 1 | Building geological models based on geophysical data |
| 2 | Practical issues of the seismic methods |
| 3 | Seislog and AVO analyses from practical viewpoint |
| 4 | How to design and carry out seismic surveys? |
| 5 | How to build up a data processing flow? |
| 6 | How to map geological horizons, faults, and fault zones? |
| 7 | Practical issues of the well-logging methods |
| 8 | From near-surface geo-engineering to deep magmatic plums |
| 9 | No education |
| 10 | Coal seam identification and characterization |
| 11 | Case studies in aquifer exploration |
| 12 | Why is the Pannonian Basin so special? |
| 13 | Utilization of archive geoscience data for recent exploration projects |
| 14 | How to prepare for the final examination? |

## *Some sample questions for the final exam with answers*

1. What kind of geophysical methods are utilized for the unconformity-type uranium exploration in the North Canadian Shield?

   *Actually, every geophysical method (gravity, magnetic, geoelectric, reflection seismic, well logging, rock sample measurements).*

2. What are the seismic ‘uranium indicators’?

   *Fracture zone in the basement, low-reflectivity sandstone/basement unconformity, high-energy but chaotic reflections in the sandstone.*

3. How do you classify the seismic noises? Provide some examples of unwanted events from the viewpoint of reflection processing.

   *Linear and random noises. Ground roll, airwave, first arrivals, wind, rain, and human activity in the survey area (e.g. agricultural work or traffic)*

4. What are the ‘direct hydrocarbon indicators’ and what kind of seismic attributes are used to recognize them?

   *Flat spot, bright spot, dim spot, polarity reversal, and low frequency reflections. Reflection strength, instantaneous phase, apparent polarity, and instantaneous frequency.*

5. What are the basic AVO attributes and what kind of other helpful attributes can be derived from them? Define the acoustic and elastic impedances (AI and EI).

   *Intercept (A) and gradient (B), AVO product (A*B), shear-wave reflectivity (A-B), and scaled Poisson’s ratio change (A+B).* $AI = V_P * \rho$, $EI = \lambda * \rho$ and $\mu * \rho$.