GEOPHYSICAL INTERPRETATION AND PROSPECTING

Earth Science Engineering MSc

2020/2021 / 1st Semester

COURSE COMMUNICATION FOLDER

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

Course datasheet

<table>
<tr><td>Course Title: Geophysical interpretation and prospecting

Instructors:
Dr. Ernő Takács, PhD, Department Head at the faculty of Earth Science and Engineering, Chief Counsellor at the Mining and Geological Survey of Hungary
Dr. Tamás Fancsik, CSc, Associate Professor at the faculty of Earth Science and Engineering, President of the Mining and Geological Survey of Hungary</td><td>Code: MFGFT730025

Responsible department/institute: Department of Geophysics / Institute of Geophysics and Geoinformatics<hr>Type of course: Compulsory</td></tr>
<tr><td>Position in curriculum (which semester): 3</td><td>Pre-requisites (if any)</td></tr>
<tr><td>No. of contact hours per week (lecture + seminar): 2+2</td><td>Type of Assessment (examination/ practical mark / other): examination</td></tr>
<tr><td>Credits: 4</td><td>Course: full time</td></tr>
<tr><td colspan="2">Course Description:
The aim of the course is to provide a comprehensive knowledge of the closing phases of geophysical exploration (interpretation and prospecting). In this subject, students learn about the linkage between the different geophysical methods. They will study how to set up the most probable geological models 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 the seminars. A practical exercise on real data will also be helpful to understand how to obtain geological 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</td></tr>
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Short curriculum of the subject:

1) Formation of the unconformity type uranium deposits. Geophysical methods applied in the exploration and the ‘seismic uranium indicators’ (four 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 of the seismic amplitude anomalies. Seismic attribute sections, post-stack (Seislog) and pre-stack (AVO) analyses. The advantage of the joint utilization of well-log and seismic data.
4) Gravity and magnetic maps around the Rudabánya–Martonyi study area, Northeast Hungary. The appearance of the Darnó Shear Zone on reflection seismic sections.
5) Well logging techniques. In-situ rock physical parameters and lithologic/stratigraphic information. The relationship between the well-log and surface seismic data.
6) 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.
7) Tracing coal bearing sequences by well-log, core, and seismic data (Eastern Mecsek Mountains). The elaborated structural development models and deformation history.
8) Geophysical methods applied for near-surface investigations and the provided petro-physical parameters. Near-surface seismology, seismic tomography and ground penetrating radar.
9) Educational break
10) Deep seismic imaging carried out with specific survey parameters. Fault zones intersecting the whole earth-crust, penetrating down to the Moho. Case studies from Canada and Hungary.
11) Radioactive heat production and propagation. The geothermal peculiarity of the Pannonian Basin and a case study of a successful exploration project carried out in the Little Hungarian Plain.
12) Seismic interpretation in Petrel. Loading data, tracking horizons, marking faults and fault zones.
13) Utilization of archive geophysical and geological data for the success of recent exploration projects.
14) Summary and conclusions (discussion).

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.

Compulsory or recommended literature:

Some related books:

1. Bacon, M., Simm, R., Redshaw, T.: 3-D Seismic Interpretation, 2003
2. Kearey, P., Brooks, M., Hill, I.: An Introduction to Geophysical Exploration, 2002
3. Serra, O.: Well Logging and Reservoir Evaluation, 2007
4. Sheriff, R.E., Geldart, L.P.: Exploration Seismology, 1995
5. Sheriff, R.E.: Seismic Stratigraphy, 1980
6. 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., White, D.J., Takács, E., Györfi, I., Annesley, I.R., Wood, G., O'Dowd, C., Nimeck, G. 2010: Application of modern 2D and 3D seismic reflection techniques for uranium exploration in the Athabasca Basin. *Canadian Journal of Earth Sciences*, 47, p. 761-782.
3. 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.
4. 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.
5. 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	Introduction to the geophysical interpretation and prospecting
2	Seismic methods in hydrocarbon exploration
3	Direct Hydrocarbon Indicators and AVO analysis
4	Geophysical features of the Darnó Shear Zone
5	Application of well logging methods
6	Aquifer exploration by geophysical methods
7	Coal stratigraphy and deformation history by well-log and seismic data
8	Near-surface geophysical methods for shallow investigations
9	Educational break
10	Deep seismic soundings to image the whole earth-crust
11	Regional and local geothermal investigations
12	Geophysical interpretation in Petrel
13	Earth science databases for geophysical interpretation
14	Summary and conclusions (discussions)

Week	Seminar
1	Geophysical exploration, data acquisition, data processing, interpretation, and prospecting
2	Theoretical and practical basics of the seismic methods
3	Direct Hydrocarbon Indicators and AVO analysis from theoretical and practical viewpoints
4	Main tasks of the practical work (Rudabánya–Martonyi study area, Northeast Hungary)
5	Theoretical and practical basics of the well logging methods
6	Geophysical methods applied in aquifer exploration
7	Coal seam identification and characterization by well-log and seismic data
8	Solving near-surface geological and geoengineering tasks by geophysical methods
9	Educational break
10	Understanding tectonic and geodynamic processes of the deep earth-crust
11	Geothermal investigations in large and small scales
12	Introduction to Petrel geophysical interpretation system
13	Utilization of archive data in recent exploration projects
14	Summary and conclusions (discussion)

Some sample questions for the midterm exam with answers

1. What kind of geophysical methods are utilized in the uranium exploration?

   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 on 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 useful attributes can be derived from them? Define the acoustic and elastic impedances.

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