GEOPHYSICS OF EXPLORATION FOR WATER

MS in Hydrogeological Engeneering

Semester 2, 2017/18

COURSE COMMUNICATION FOLDER

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

Course datasheet

Course Title: Geophysics of exploration for water **Instructors:** Péter Tamás Vass Dr., associate professor, Norbert Péter Szabó Dr., associate professor	**Code:** MFGFT720024 **Responsible department/institute:** Institute of Geophysics and Geoinformatics / Department of Geophysics **Type of course:** Compulsory
Position in curriculum (which semester): 2	**Pre-requisites (if any): -**
No. of contact hours per week (lecture + seminar): 2+2	**Type of Assessment (examination/ practical mark / other):** examination
Credits: 5	**Course:** full time

Course Description:
Students will be provided with geophysical skills applied in the exploration for water. The subject reviews the relation and system of physical, geophysical, hydrogeological and geometrical parameters determined by different geophysical methods. In the seminars students can acquire the basic processing, interpretation and management methods of geophysical data sets and come to know how to use some relevant softwares.
The short curriculum of the subject:
Determination of petrophysical, physical and geometrical parameters by means of geophysical methods for water-exploration. Surveying and detailed geophysical research methods. Studying geophysical forward modeling and inverse problems related to water exploration possibilities and demands. Profiling, mapping, tomographical geophysical methods. Well-logging (borehole geophysical) methods and interpretation procedures. Complex exploration work and interpretation. Documentation for water-exploration.
Practical work: self-made solutions of simple case-study problems.

Compatencies to evolve:
Knowledge: T4, T5
Ability: K1, K3, K5, K8, K9, K10, K12
Attitude: A1, A5, A6, A7, A8, A9
Autonomy and responsibility: F1, F2, F3, F4, F5, F6

Assessment and grading:
Condition for obtaining the signature: the presence in at least 60 % of the lessons.
The determination of the examination grade is entirely based on the result of examination.
Grading scale (% value → grade): 0 – 49 % → 1 (fail), 50 – 64 % → 2 (pass),
65 – 79 % → 3 (satisfactory), 80 – 89 % → 4 (good), 90 – 100 % → 5 (excellent).

Compulsory or recommended literature resources:
Edited by P. Vass: course slides converted in pdf format: http://geofizika.uni-miskolc.hu/education.html
Szabó N. P., 2014. Geophysics of exploration for water. Electronic handout, p. 233.
Edited by R. Kirsch, H Rumpel, W Scheer, H Wiederhold 2006: Groundwater Resources in buried Valleys – a Challenge for Geociences, Leibnitz Institute for Applied Geosciences, Hannover, Germany, ISBN-10: 3-00-020194-7
Edited by Reinhard Kirsch, 2009 : Groundwater Geophysics - A Tool for Hydrogeology, Springer-Verlag Berlin Heidelberg, ISBN: 978-3-540-88404-0
Edited by Yoram Rubin , Susan S. Hubbard, 2005 : Hydrogeophysics, Springer Dordrecht, Berlin, Heidelberg, New York, ISBN-10 1-4020-3101-7 (HB)
Prem V. Sharma, 1997 : Environmental and engineering geophysics, Cambridge University Press, ISBN-10: 0521576326
Asquith, G. B, Krygowski, D., Henderson, S., & Hurley, N., 2004: Basic well log analysis,. 2nd edition, American Association of Petroleum Geologists.

Syllabus of the semester

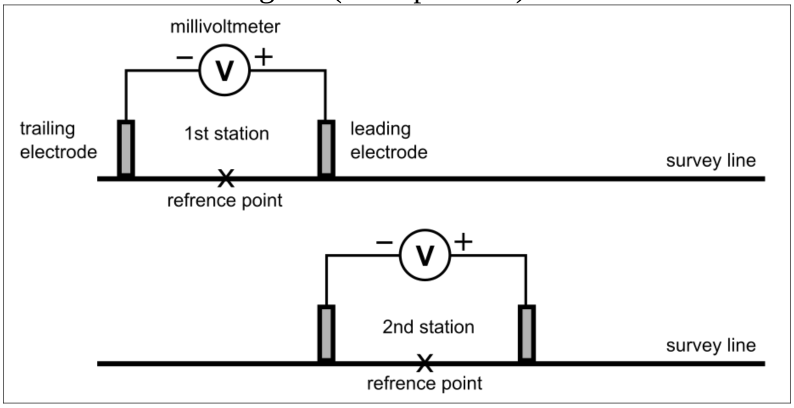
Week	Lecture
15/02/2018	Classification of shallow applied geophysical methods. Basic principles of microgravity surveying methods, correction of measurements. Calculation of derivatives. Hydrogeophyiscal applications
22/02/2018	Basic principles of magnetic methods, correction of measurements. Magnetic gradiometry. Hydrogeophyiscal applications.
01/03/2018	The physical background of surface nuclear magnetic resonance soundings. Determination of the depth distribution of the water content. Well-logging in shallow wells (hydrogeophysical logging in fresh and thermal water wells). The borehole and its environment. Lithology sensitive logs.
08/03/2018	Well logging methods used for the determination of porosity and water saturation. Groundwater well logging applications. Special measurements such as EPT, borehole radar measurements.
22/03/2018	The estimation of lithology, porosity, hydraulic conductivity.
29/03/2018	Theory of engineering geophysical sounding methods. Investigation of the relationship between the petrophysical (water, air saturation, clay content, matrix fraction) and geotechnical (dry density) characteristics and measured physical parameters.
05/04/2018	Statistical interpretation and inversion of direct push logs. Hydrogeologic examples.
12/04/2018	Introduction to geoelectrical methods. Self-potential method
19/04/2018	Induced Polarization Method.
03/05/2018	Introduction to seismic methods. Solid mechanics.
10/05/2018	Field techniques in seismic surveys.
17/05/2018	Seismic refraction method.

Week	Seminar
16/02/2018	Mathematical and physical basics of microgravity method, correction of measurements. The interpretation of gravity data.
23/02/2018	Mathematical and physical basics of magnetic method, correction of measurements. The interpretation of magnetic data.
02/03/2018	Mathematical and physical basics of lithology logging. The estimation of shale volume and clay type.
09/03/2018	Mathematical and physical basics of porosity and resistivity logging. The estimation of water saturation
23/03/2018	Multiple well log interpretation: cross plot techniques, inverse modeling. The Csókás' method.
06/04/2018	A short review of electricity. Electrical resistivity. Resistivity of rocks.
13/04/2018	Direct current resistivity methods. Vertical electrical sounding (VES). Electric profiling (EP). Continuous Vertical Electrical Sounding (CVES).
20/04/2018	Electromagnetic methods – frequency domain. The transient electromagnetic method
04/05/2018	Wave theory. Ray theory. Velocity of seismic waves.
11/05/2018	Seismic reflection method.
18/05/2018	Seismic data processing.

Example of test paper in shallow seismic and geoelectric methods

date

1. Answer the questions below the figure. (max. points 3)



What is the name of the electrode configuration represented by the figure?
…...…...…..………...……...…..………………….…..………..…………….…..………....………
……...……………...………………. (point 1)

What is the name of the geophysical method which uses this electrode configuration?
...…..………….………….……………..……………….………..……………….……..………..………
…………..………………. (point 1)

What is the name of the other electrode configuration used by this method?
…………………………..………………….....………....…..………….………………..……..…………
……..……………………………….. (point 1)

2. Read the sentences below and correct them if it is required. Write the corrected versions on the dotted lines below the sentences. If you think that a statement is true, write the word "true" below the sentence. (points 6x1)

The decrease of temperature increases the conductivity of water bearing rocks.
…………………………………………………………………………………………………
…………..……………………………………………………………………………………
……………………..

A shear wave can propagate not only in solids but fluids, because the stress field does not have a shear component during the wave propagation.
…………………………………………………………………………………………………
…………..……………………………………………………………………………………
……………………..

An elastic body is capable of recovering its original size and shape after the stress field has been removed.
…………………………………………………………………………………………………
…………..……………………………………………………………………………………
…………………….

In the case of shear waves, the motions of the particles in a medium are perpendicular to the direction of wave propagation.
…………………………………………………………………………………………………

…………..……………………………………………………………………………………
……………………..

The electrical resistivity (or simply resistivity) is the ability of a material to pass the flow of electric current through itself.
…………………………………………………………………………………………………
…………..……………………………………………………………………………………
……………………..
The velocity of compressional wave is significantly higher in a highly porous rock filled with water than in a tight consolidated rock.
…………………………………………………………………………………………………
………….………………………………………………………………………………………
…………………….

3. Complete the sentences with the right words. (max. points 12)

The acoustic impedance is an acoustic property of the medium and it can be calculated by the product of …………………….. and …………………….. (point 1)

In the case of sedimentary basins, the bulk density of rocks usually ……………………… with depth. (point 1)

There are two principal types of elastic waves: (point 1)
……………………………..
……………………………..

In the case of sedimentary basins, the velocity of compressional wave usually ………………….. with depth. (point 1)

In the case of sedimentary basins, the dominant frequency of seismic waves …………………….. with depth. (point 1)

In the case of sedimentary basins, the dominant wavelength of seismic waves …………………….. with depth. (point 1)

The most frequently used four elastic moduli are the following: (points 2)
…………………………….
…………………………….
…………………………….
…………………………….

A seismic field equipment is made up of the following main components: (points 2)
…………………………….,
…………………………….,
…………………………….,
……………………………..

The most important factors influencing the resistivity of rocks are the following: (points 2)
…………………………….
…………………………….

…………………………….
…………………………….

4. For the investigation of a buried valley, the following data are known:

two-way travel-time (t_0) of the seismic wave reflected from the bottom of the valley	250 ms
average wave velocity of the sedimentary sequence,	v = 1600 m/s
sampling rate (or frequency) of the seismograph,	f_S = 1000 Hz

a.) Calculate the depth of the buried valley (z). (points 2)

b.) Calculate the Nyquist frequency (f_N) belonging to the sampling rate. (point 2)

c.) Take the half of the Nyquist frequency as the dominant frequency (f) of the seismic wavelet, and calculate the horizontal resolution of the seismic reflection method (d) for the bottom of the valley. (point 4)

d.) At last, calculate the vertical resolution of the seismic reflection method (h_{min}) for the bottom of the valley. (points 2)

Maximum attainable points: 31 Attained points: ……………

Mark: ……………

range	mark
15 ≤ and < 20	2
20 ≤ and < 25	3
25 ≤ and < 28	4
28 ≤	5

Solution of example test

1.
gradient electrode configuration
self-potential method
potential (fixed-base) electrode configuration

2.
False. Corrected statement:
The increase of temperature increases the conductivity of water bearing rocks.

False. Corrected statement:
A compressional (or P-) wave can propagate not only in solids but fluids, because the stress field does not have a shear component during the wave propagation.

True

True

False. Corrected statement:
The electrical contivity (or simply contivity) is the ability of a material to pass the flow of electric current through itself.

False. Corrected statement:
The velocity of compressional wave is significantly lower in a highly porous rock filled with water than in a tight consolidated rock.

3.
The acoustic impedance is an acoustic property of the medium and it can be calculated by the product of *density* and *wave velocity*.

In the case of sedimentary basins, the bulk density of rocks usually *increases* with depth.

There are two principal types of elastic waves:
body waves,
surface waves.

In the case of sedimentary basins, the velocity of compressional wave usually *increases* with depth.

In the case of sedimentary basins, the dominant frequency of seismic waves *decreases* with depth.

In the case of sedimentary basins, the dominant wavelength of seismic waves *increases* with depth.

The most frequently used four elastic moduli are the following:
Young's modulus (or elastic modulus),
Poisson's ratio,
shear modulus,
and bulk modulus.

A seismic field equipment is made up of the following main components:
seismic source ,
geophones,
seismograph,
cables.

The most important factors influencing the resistivity of rocks are the following:
mineral composition,
porosity,
type of fluid filling the pore space,
clay volume fraction.

4 a) $z=200$ m 4 b) $f_N=500$ Hz 4 c) $d=50.6$ m 4 d) $h_{min} = 1.2$ m