FIELD METHODS OF RAW MATERIALS EXPLORATION
RAw Materials Exploration and Sustainability

CONTACT INFORMATION

Professor/Instructor: Heikki Vanhala
University/Company/Institution: Geological Survey of Finland (GTK)
E-mail Address: *Heikki.vanhala@gtk.fi*
Webpage: http://en.gtk.fi/

COURSE CONTENT AND INTENDED LEARNING OUTCOMES (ILOs):

The course gives overview of classical geophysical and geochemical exploration methods. It reviews the theoretical and physical principles underlying the basic techniques and will show how the field data are acquired and interpreted. The objective of the course is understanding the fundamental concepts of geophysical and geochemical exploration techniques and give readiness to put these concepts into practice. The course is a hands-on experience of what the true field-based exploration geochemistry and geophysics of primary mineral resources today are.

At the end of the course, the student will have the ability to:

- Plan and execute exploration field work
- Use different methods of data collection, coherently with the different stages of exploration
- Make preliminary data processing and ensure the measured data quality by learning the fundamental approaches to interpretation of the measured and processed data

Aligning with the EIT OLOs:

☑ EIT OLO 1 - Making value judgments and sustainability competencies
2 = highly relevant to the course content – this course heavily focuses on exploration of raw materials. Although technical in nature, the course tasks the students with taking decisions that are efficient and factor in the economic and environmental consequences of exploration.
☐ EIT OLO 2 - Entrepreneurship skills and competencies
☐ EIT OLO 3 - Creativity skills and competencies

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

☑ EIT OLO 4 - Innovation skills and competencies

1 = peripherally relevant to the course – Innovative technologies in mineral exploration are key for an efficient and sustainable future of the EU raw materials sector: Through sampling, testing, collection and analysis of the data, the students are stimulated to justify their choices and use effectively methodology and thus technology. The hands-on experience through fieldwork make them aware of the state-of-the-art technology of exploration and what is still needed to support the digital transformation of the raw materials sector.

☑ EIT OLO 5 - Research skills and competencies

2 = highly relevant to the course content – the course provides the students with a thorough knowledge of the main exploration methods, which can be used both in research and business venture, as the Mines-in-Time of the RaMES partner SpacEarth Technology illustrates.

☑ EIT OLO 6 - Intellectual transforming skills and competencies

2 = highly relevant to the course – the course is very practical and technical in nature. Practical experience is fundamental to foster the students' ability to transform their field experiences in research problems and challenges that the raw materials sector of the EU is facing.

☐ EIT OLO 7 - Leadership skills and competencies

ASSESSMENT METHODS AND GRADING SYSTEM

Different assessment methods will be used to evaluate the students: content-based, competence-based and impact-based assessments. Content-based assessment refers to assessment tasks that mainly ask the learner about facts. Competence-based assessment refers to assessment of intended learning outcomes that ask the learner to show ability to also use these facts. Impact-based assessments take the assessment of competencies one step further and ask the learner to use these competencies in a real-life situation to create a change or solve a challenge.

The course will grade the students using the Italian university system, with grades expressed out of thirty. The passing grade is 18/30. In case of full grade (30/30) the professor(s) may also decide to award honors (lode).

The course is practical and technical one, thus the assessments focus mostly on the ability of students to critically employ different methodologies and be effective in data analysis (classroom and field exercises, practicals). The revision of the fieldwork activities is thus instrumental in discussing not only the data collected, but also the differences between the exploration methods and how this pose challenges and opportunities in terms of sustainability. These aspects all concur to EIT OLO 1, 4 and 2.

The written and oral exam cover the topics of the course, including how innovation – and the digital transformation in particular – need to drive the development of the exploration sector of raw materials (EIT OLO 6).

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

ASSESSMENT METHOD	WEIGHT ON FINAL GRADE
Classroom exercises & participation	20%
Field exercises & practicals	50%
Written exam	20%
Oral exam/presentation	10%

COURSE SESSIONS

Location and info about the course center:

University of Helsinki, Finland; Lammi Biological Station
https://www.helsinki.fi/en/research-stations/lammi-biological-station
Twitter: @LammiStation
Facebook: @LammiBiologicalStation

Accommodation in double rooms:
https://www.helsinki.fi/en/research-stations/lammi-biological-station/for-visitors/accommodation

Suggested pre-course reading materials:

- Barnes, J.W. and Lisle, R.J. (2004): Basic Geological Mapping 4th Edition. The geological field guide series. Wiley. 196 pages.
- Fletcher, W.K., Hoffman, S.J., Mehrtens, M.B., Sinclair, A.J., and Thomas, I. (1986): Exploration Geochemistry – Design and Interpretation of Soil Surveys. In Reviews in Economic Geology, Vol 3. (ISSN 0741-0123). Society of economic geologist. 180 pages.
- Reynolds, J.M. (2011): An Introduction to Applied and Environmental Geophysics. Wiley. 710 pages.
- Van Loon, J.C., Barefoot, R.R. (1988): Analytical Methods for Geochemical Exploration. Academic Press. 334p.
- Burger H.R. , Sheehan, A.F., and Jones, G.F. (2006): Introduction to Applied Geophysics. Norton. 600 pages.
- Keary, P., Brooks, M., and Hill, I. (2002): Blackwell, 2002. An introduction to Geophysical Exploration. Blackwell. 272 Pages.
- Telford, W.M, Geldart, L.P., and Sheriff, R.E. (1990): Applied geophysics, Cambridge University Press. 792 pages.

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Session 1	**INTRODUCTION TO THE COURSE**
Date – hours	• June 1, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Introduction to the course • Mineral exploration process • Bedrock mapping and geochemical techniques • The main geophysical methods in mineral exploration • Geological and geophysical background data and data integration • Introduction to the geological, geochemical and geophysical features of the research area • Field excursion
Readings	• The Lammi training area contains intrusive Ni-Cu bearing ultramafic rocks. Report of the geology and mineralogy will be available for students before the course.
Assignment	none

Session 2	**BEDROCK MAPPING (1)**
Date – hours	• June 2, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Lecture: Bedrock mapping and its application to exploration • Lecture: Crash course to "Kapalo" -application • Field work: Making bedrock observations, storing data using mobile application "Kapalo" • Revision of the day's activities (in small-groups)
Readings	• Help file of the "Kapalo" application*: http://gtkdata.gtk.fi/mobiili/index.html* • Geological guidelines for Kapalo*: http://gtkdata.gtk.fi/mobiili/Mobiilikapalo-ohjeistus_ENG.pdf*
Assignment	none

Session 3	**BEDROCK MAPPING/BOULDER HUNTING (2)**
Date – hours	• June 3, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Lecture: Boulder hunting and its application to exploration • Field work: Bedrock mapping continues accompanied by boulder hunting • Revision of the day's activities (in small-groups)
Readings	• Saurama M. (1924): Tracing of glacial boulders and its application in prospecting. *http://tupa.gtk.fi/julkaisu/bulletin/bt_067.pdf*
Assignment	none

Session 4	**GEOCHEMICAL EXPLORATION**
Date – hours	• June 4, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Content	• Lecture: Geochemical methods; till geochemistry and in situ analysis methods • Field work: till sampling for geochemistry, and heavy mineral and indicator mineralogical studies • Field analyzed techniques (in situ techniques) • Revision of the day's activities (in small-groups)
Readings	• *Sarala, P. (2015): Chapter 10.1 – Survival Geochemical Exploration methods. In: Mineral Deposits of Finland, 2015, 711-731. Elsevier. https://doi.org/10.1016/B978-0-12-410438-9.00027-3* • *http://en.gtk.fi/expert_services/mining/mineral_technology/diamond_surveys/*
Assignment	none

Session 5	**GEOCHEMICAL EXPLORATION (2) AND DATA ANALYSIS**
Date – hours	• June 5, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Lecture: Principles of partial leach and bio-geochemistry techniques • Lecture: Introduction to data analysis • Field work: Till sampling for partial leach and biogeochemistry studies • Revision of the day's activities (in small-groups)
Readings	• Sarala, P. (2015): Chapter 10.1 – Survival Geochemical Exploration methods. In: Mineral Deposits of Finland, 2015, 711-731. Elsevier. *https://doi.org/10.1016/B978-0-12-410438-9.00027-3*
Assignment	none

Session 6	**GEOPHYSICAL TECHNIQUES - ELECTRICAL RESISTIVITY (ER) & INDUCED POLARIZATION (IP)**
Date – hours	• June 8, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Lecture: Electrical properties of mineralized rocks • Lecture: Introduction to the theory of ER and IP techniques • Field work: ER and IP measurements at the training area • Revision of the day`s measurements and preliminary interpretation
Readings	*elctrical resistivity survey: https://mineclosure.gtk.fi/resistivity-surveys/*
Assignment	*none*

Session 7	**GEOPHYSICAL TECHNIQUES – GRAVITY & MAGNETIC METHODS**
Date – hours	• June 9, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Lecture: Introduction to gravity method: density contrast, anomalies, gravimeter, corrections • Lecture: Introduction to magnetic method: induced rock magnetism, anomalies • Field work: Gravity measurements at the training area

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

	• Field Work: Magnetic measurements at the training area • Revision of the day`s measurements and preliminary interpretation
Readings	Potential fielfds, magnetic: *https://pubs.usgs.gov/fs/fs-0236-95/fs-236-95.pdf* Potential fielfds, gravity: *https://pubs.usgs.gov/fs/fs-0239-95/fs-0239-95.pdf*
Assignment	none

Session 8	**GEOPHYSICAL TECHNIQUES – ELECTROMAGNETIC (EM) METHOD AND PETROPHYSICAL SAMPLING**
Date – hours	• June 10, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Lecture: Introduction to the theory of the EM fields and survey methods • Lecture: Introduction to petrophysics, i.e., the use of the physical properties of rock samples in mineral exploration (electrical resistivity, magnetic susceptibility and density) • Field work: EM measurements at the training area • Field work: Petrophysical sampling at the training area • Revision of the day`s measurements and preliminary interpretation
Readings	Airo, M-L. (ed) 2015. Geophysical signatures of mineral deposit types in Finland. Geological Survey of Finland, Special Paper 58, 9–70, 2015. http://tupa.gtk.fi/julkaisu/specialpaper/sp_058_pages_009_070.pdf
Assignment	none

Session 9	**PETROPHYSICS AND GEOPHYSICAL DATA ANALYSIS**
Date – hours	• June 11, 2020, h 08:00 – 21:00 (inl. breakfast, lunch, dinner)
Content	• Petrophysics continues: In situ testing of magnetic and electrical properties of rocks • Introduction to geophysical data analysis • Processing the field data • Preliminary interpretation of the field data • Integration of geological, geochemistry and geophysical data in exploration • Revision of the day`s measurements and preliminary interpretation
Readings	Airo, M.-L. & Säävuori, H. 2013. Petrophysical characteristics of Finnish bedrock – Concise handbook on the physical parameters of bedrock. Geological Survey of Finland. *http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_205.pdf*
Assignment	none

Session 10	**FINAL EXAMINATION**
Date - hours	June 12, 2020 – h 09:00-15:00
Content	• Written test (16 multiple-choice and open questions regarding all course topics. Duration: 2 hours) • Oral examination (presentation of selected field topic, team work, discussion, Duration: 15 minutes/ team, three students in team)

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

- May 31: Flight to Helsinki and transportation to Lammi biological station
- June 13: Travelling to Helsinki airport and flight to Bologna

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation