MINERAL DEPOSITS IN THE FIELD
Raw Materials Exploration and Sustainability

CONTACT INFORMATION

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COURSE CONTENT AND INTENDED LEARNING OUTCOMES (ILOs):

The rationale of this course is to illustrate and provide an overview of the role deformation plays in both the genesis and spatial distribution of ore deposits. This will be done by combining a few traditional class lectures and lab style exercises with seminar-style classes based on reading and student presentations and, above all, several days directly at the outcrop. This combined approach will allow students to develop theoretical and practical skills related to asking and assessing scientific questions as well as summarizing and presenting the results of scientific studies dealing with the role exerted by rock deformation and fluid/rock interaction in deformed contexts.
At the start, the course will concisely review the concepts, theoretical knowledge and techniques of Structural Geology that are relevant to understanding ore deposit genesis and exploration. Hands-on fieldwork will help students to further strengthen the theoretical knowledge and will provide them with a solid understanding of fundamental processes. They will develop solid understanding of how to elaborate the best practices for structural data collection and analysis in mineral exploration and mining.

The course is split in two modules taught by the two lecturers but works as a single, coherent learning experience elaborating on the following topics:

Module A (Prof. Viola):
- Summary of fundamentals: deformation, stress and strain, porosity and permeability, brittle and ductile regimes, kinematic and dynamic approach to deformation;
- Structural geology mapping, data collection and observations, structural data analysis and interpretation; unravelling the 3D geometry of structures;
- Faults and fault-related structures;
- Shear zones and ductile deformation;
- Folds and related structures;
- Structurally-controlled fluid flow and mineralizations.

All these topics will be discussed in the classroom and strengthened by working and exercising at the outcrop during the field excursions.

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Module B (Prof. Antonellini):
This module will be taught in a "seminar" style fashion. Students will be handed out reading material, which will be then discussed in the classroom. Students will proactively lead the discussion by presenting a few slides on the assigned reading topic. Participation to the discussion by all students is mandatory and the proactivity of each student as well as the quality of their individual work will contribute to their final grade.

In general, frontal lectures will be kept to the minimum during both modules, with students being involved in seminaries, hands-on practical exercises and fieldwork. A one-day excursion will be held in the Porretta Terme area to observe, study and characterize the relationships between fracturing, fluid ingress and flow and fluid-rock interaction. A five-day field trip to mainland Tuscany and the Island of Elba will expose students to outstanding examples of hydrothermal metaldeposits. Fieldwork will be used to challenge students to try to unravel and constrain the genetic relationships between brittle deformation, fluid ingress and ore genesis in the examined settings.

Summary bullet list of expected, course-specific learning outcomes:

At the end of the course, students will be able to:

- Understand and untangle the role of deformation in the genesis and distribution of ore deposits;
- Elaborate the best practices for structural data collection and analysis in mineral exploration and mining;
- Develop theoretical and practical skills related to asking and assessing scientific questions;
- Plan and execute scientific activities and summarize, elaborate, interpret and present the results thereof;
- Think in a multidisciplinary and flexible way to elaborate conceptual models that can be used to account for- and explain their own observations;
- Work independently and as part of teams while elaborating conceptual models starting from their own individual observations.

Aligning with the EIT Overarching Learning Outcomes:

☐ EIT OLO 1 - Making value judgments and sustainability competencies.

☐ EIT OLO 2 - Entrepreneurship skills and competencies.

☑ EIT OLO 3 - Creativity skills and competencies: The ability to think beyond boundaries and systematically explore and generate new ideas – 2: highly relevant

The proposed course is far from the traditional approach of most university courses. It is meant to teach advanced concepts while having students think beyond the pages of a reference textbook. Fieldwork and trial and error at the outcrop will be key in this respect: direct observations of rocks, structural relationships and mineralizations will be used to invite students to think in a multidisciplinary, comprehensive and flexible way to elaborate conceptual models that can be used to account for- and explain their own observations. Field outcrops act as perfect laboratories where to engage with exciting research. It is important to stress that the lecturers will not have ready answers and models to offer to the class and will thus work proactively with students to figure out the complexities of the studied deposits.

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All field examples chosen for the course are complex and are still being explored and actively studied by the lecturers. This represents the ideal training ground to have students explore and generate new ideas. The days spent in the field will thus represent a unique opportunity to think critically individually as well as in a team, while trying to match the theory knowledge with the real case scenario.

☐ EIT OLO 4 - Innovation skills and competencies.

☐ EIT OLO 5 - Research skills and competencies.

☑ EIT OLO 6 - Intellectual transforming skills and competencies: The ability to transform practical experiences into research problems and challenges – 2: highly relevant

By spending much time at the outcrop, students will be offered the unique opportunity to use the fundamental observational skills of Earth Scientists to derive solid constraints and transform them into conceptual models to account for their own observations. Field work offers students the outstanding chance to engage directly with the identification of research challenges and issues. Lecturers will accompany students through a steep learning curve whereby the "unknown" at the outcrop will become much valued as powerful input to critical thinking and the creation of conceptual frameworks.

☐ EIT OLO 7 - Leadership skills and competencies.

ASSESSMENT METHODS AND GRADING SYSTEM

The grades in the Italian university system are 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 honours (lode).
The proposed assessment methods below are believed to be well suited to evaluate students regarding the overall proposed learning outcomes. The continuous interaction at the outcrop is a valuable tool for the lecturers to monitor the progressive learning by students and the way data is collected and continuously elaborated to produce conceptual models that are capable to account for the observations made. Field tasks and their assessment offer the possibility to also adjust the pedagogic approach during the course so as to effectively cater for all learning needs. While the on-the-field tasks are meant to progressively build a solid performance by the candidates, the evaluation of the written outputs reflects a more comprehensive grading approach, with the lecturers studying carefully more mature products, which should reflect a higher level of critical thinking and synthesis by the candidates. The final oral examination will be used to sum-up all evaluation components.

ASSESSMENT METHOD	WEIGHT ON FINAL GRADE
Lab / on-the-field task	50%
Written outputs (essay, position papers, case study.)	40%
Oral exam	10%

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Suggested pre-course reading materials:
Selected scientific papers and focussed reading material will be handed out by the lecturers during the course.

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