UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Geological Resources

2526-1-F7603Q003-F7603Q00301

Aims

The module provides the technical, scientific and socio-economic basis required to address the most recent issues of raw materials in the mining sector.
The teaching of this module is aimed at providing knowledge and the methodological basis to know and understand the principles that define the raw materials sector, from finding ore deposits and exploitation to environmental sustainability. The course will focus on some processes and practices currently attributable to the concept of sustainability and respect for the environment in various sectors of society, as examples for specific in-depth discussions on the issues addressed during the course.

Students are invited to consult the syllabus of the entire course for details regarding learning- and skill-related objectives.

Contents

• Ore and industrial minerals, concept of mineral deposit, grade or tenor, tonnage and Clarke (mean crustal tenor).
• Extraction and processing of metallic and industrial minerals, mineral processing, related environmental problems (e.g. AMD - acid mine drainage), mining wastes.
• Energy minerals: oil, gas, coal, uranium, geothermal energy.
• Quarries and mines, national and international legislation. Open and underground mining techniques.
• Open cast and underground mining techniques.
• Evolution of the Earth's crust from the Archean to the Phanerozoic, main metallogenic events.
• Mineral resources and reserves, geochemical and geophysical mineral prospecting, core drilling, examples.
• Critical metals, construction minerals, energy minerals and industrial minerals: key concepts, definitions, and terminology.
• Will we run out of minerals? Considerations of supply and demand.
• The concept of criticality: assessment and implications of criticality for corporate and governmental policy.
• The mining industry and the supply of critical minerals: suppliers of minerals, miners and explorers, industry

dynamics.
• Constraints on mineral supply response: natural, economic, and institutional, and the role of China.

Detailed program

Ore minerals & industrial minerals
• ore deposits;
• ore minerals;
• gangue, tonnage, tenor, tout-vènant, Clarke and concentration Clarke;
• mineral and metal ore prices, commercial classification;
• "critical" metals: REE and PGE;
• import and export of raw materials, Italian and European production;
• recovery and by-products;
• mineralogical form of metals;
• unwanted substances;
• melting processes and ore dressing;
• environmental problems;
• mining waste;
• waste rock and tailings;
• environmental remediation;
• regulatory classification of raw materials: I and II category materials, quarries and mines;
• energy minerals: oil, gas, coal, uranium, geothermal energy;
• concept of EROEI (energy recovered over energy invested);
• capacity factor;
• criticality of renewable energy.

Evolution of the Earth's crust, from the Archean to the Phanerozoic eon
• nature and morphology of ore bodies;
• syngenesis and epigenesis;
• discordant and concordant ore bodies;
• tabular bodies (lodes and veins);
• tubular bodies (pipes and mantos);
• disseminations, stockwork, replacement (*e.g.*, skarn), stratiform and stratabound bodies;
• main types of host rocks and relationships with ore bodies;
• textures and microstructures of ore and gangue minerals, attitude to ore dressing and processing.

Genetic classification of mineral deposits
• magmatic deposits: magmatic crystallization (*e.g.*, diamonds in kimberlites, chromites in stratified basic complexes, feldspars in pegmatites);
• hydrothermal deposits: origin of hydrothermal fluids, ligands, transport, deposition;
• uranium deposits;
• deposits linked to metamorphic processes;
• deposits linked to sedimentary processes, BIF (banded iron formations), placers, evaporites;
• deposits linked to weathering: laterites, bauxites;
• supergene enrichment.

Mineral resources and reserves; mineral prospecting
• geological surveys;
• remote sensing;
• geochemistry;
• geophysics core drilling;
• statistical data processing.

New sources for critical raw materials
• mining wastes and tailings, from waste to resource;
• landfill and urban mining;
• examples of new approaches in raw materials exploration;
• environmental aspects of critical raw materials: are they really “green”?
• LCA (life cycle assessment) for critical raw materials and recycling potential: is recycling really viable?
• settling the diatribe between “green” and “greenwashing”, an accurate definition of “sustainability” and “circular economy”;
• examples from the mining and quarrying industry in Italy and Europe.

Prerequisites

• Basic knowledge of inorganic chemistry.
• Basic notions of geology.

Teaching form

6 CFUs of theoretical lessons in the classroom (48 hours):
• 16 two-hour lectures, in person, Delivered Didactics;
• 8 two-hour lectures, online, reading and discussing scientific articles, case studies, Mixed Didactics, Seminar.

Attendance to lectures and interactive exercises is highly recommended.

Textbook and teaching resource

• Arndt & Ganino (2012) - Metals and Society. An introduction to Economic Geology. Springer, 160 pp.
• Kesler & Simon (2015) - Mineral resources, economics and the environment (II edition). Cambridge University Press, 434 pp.
• Gunn (2014) - Critical metals handbook. AGU Wiley, 439 pp.
• Slides.
• Notes shown during lectures and additional material on selected topics, *i.e.*, scientific articles, made available on the e-learning website of the course.

Semester

II semester (March - June)

Assessment method

Preliminary written test, consisting of 15 multiple choice questions; each correct answer is counted as two points,

and stiudents need to pass the test with at least 18/30 to enter the subsequent oral exam.
The oral exam consists in the discussion of various topics covered in the module, seen in the complexity of the entire course, with an emphasis also on the connections between concepts and processes, such as to arrive at a critical evaluation of work from the point of view of sustainability in mining as a whole.

The final score will be between 18/30 and 30/30 *cum laude*, based on the overall assessment considering the following criteria:
(1) knowledge and understanding;
(2) ability to connect different concepts;
(3) autonomy of analysis and judgment;
(4) ability to correctly use scientific language.

Office hours

Always, after scheduling an appointment *via* phone or e-mail.

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION