TU Clausthal

Economic Geology

Summary

Module 6

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Content and structure

- Module 1: Intro, element abundance, plate tectonics, economics
- Module 2: Minerals, Rock types
- Module 3: Ore forming processes
- Module 4: Base metals and their ore deposit types
- Module 5: Precious and rare metals and their ore deposit types
- **Module 6: Summary**

Economic geology

- We are interested in finding metals that are enriched in the Earth crust in high enough concentrations to be mined at a profit.
- Many factors play a role whether a profit can be obtained or not (geological, technological, environmental, social, economic).

Ore deposit formation

- An accumulation of metals in the earth crusts is a geochemical anomaly and requires special physical and chemical processes.
- Ore deposits can be hosted in any of the three rock types.
- Structures are often important in guiding and focussing fluids.

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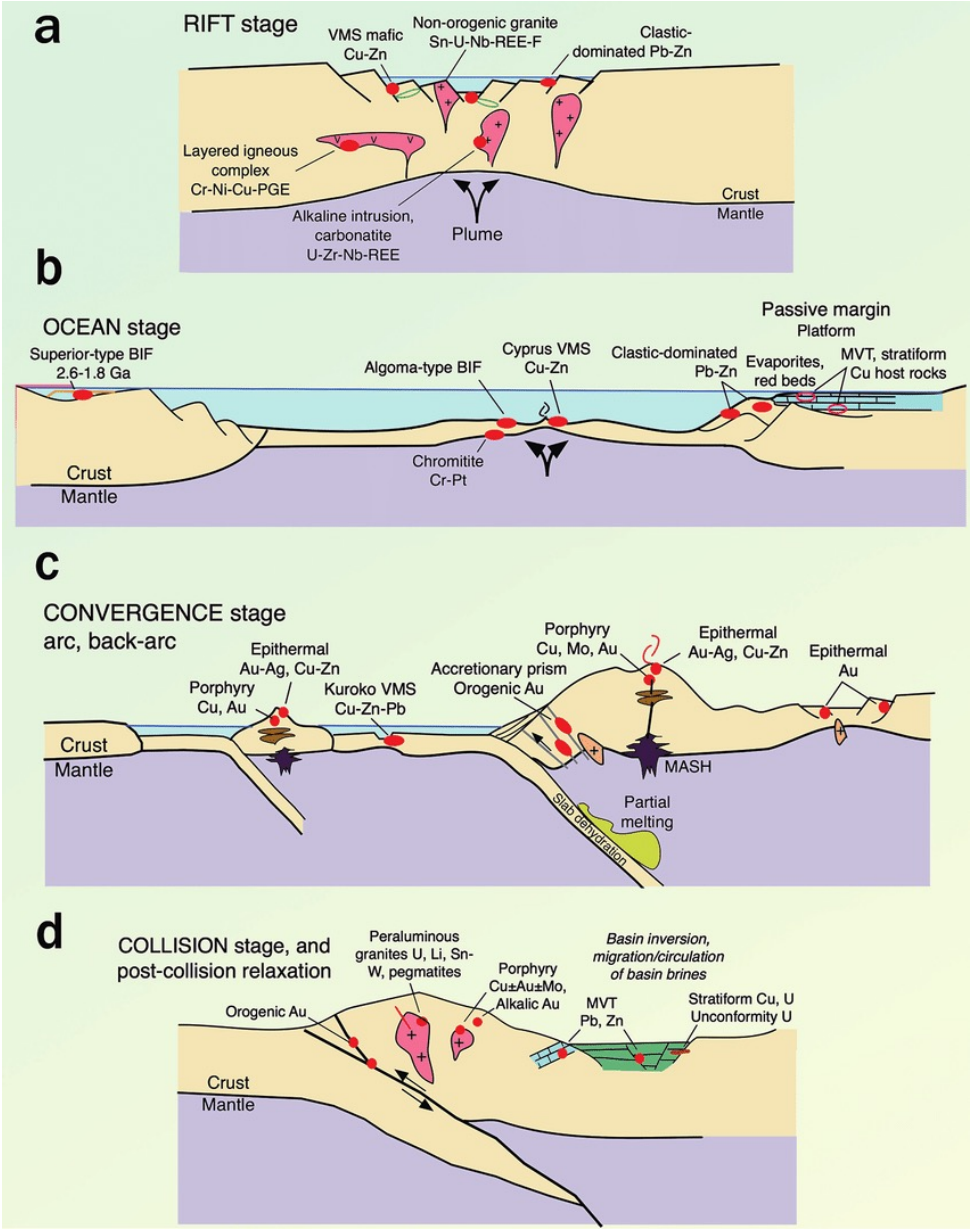
Ore deposits and tectonic settings

Different ore deposits are related to certain tectonic settings and rock types. Important to consider for mineral exploration.



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Ore deposits and tectonic settings

- **Rift zones (continental)**
  - Rise of mantle derived melts
    - *Carbonatites (REE, Ta, Nb)*
    - *Alkaline intrusions (REE, Ta, Nb)*

Ore deposits and tectonic settings

- **Divergent margin**
  - Heated seawater circulation, black smokers
    - *Volcanic massive sulphide deposits (Cu-Pb-Zn)*
    - *Algoma type BIF*
  - Intrusion of mafic and ultramafic melts
    - *Magmatic massive sulphide deposits (Ni-Cu-PGE)*
    - *Chromite deposits*

Ore deposits and tectonic settings

- **Rift zones, basins**
  - Circulation of basinal brines in sedimentary package
    - *Sedimentary exhalative Pb-Zn deposits (SEDEX)*
    - *Mississippi Valley Type Pb-Zn deposits (MVT)*
    - *Sedimentary Cu deposits (Kupferschiefer)*

Ore deposits and tectonic settings

- **Rift zones, oceanic stage**
  - Chemical sedimentation
    - *Banded iron formation (BIF)*

Ore deposits and tectonic settings

- **Convergent margin** (subduction zones)
  - Magma generation due to fluids released from subducting slab
    - *Porphyry Cu-Mo-Au deposits*
    - *Epithermal Au-Ag deposits*

Ore deposits and tectonic settings

- **Convergent margin** (collision, mountain building)
  - Metamorphic reactions, shear zones
    - *Orogenic Au deposits*
  - Partial melting of crust
    - *Sn-W and rare element granites*
    - *Pegmatites*

Important ore-forming processes

- **Magmatic** (mafic, ultramafic melts)
  - Melt immiscibility
    - Magma mixing
    - Magma contamination
      - *Magmatic Ni-Cu-PGE massive sulphide deposits*
      - *Chromite deposits*

Important ore-forming processes

- **Magmatic** (felsic melts)
  - Fractional crystallization (+some hydrothermal activity)
    - *Rare-metal granites (REE, Sn-W)*
    - *Pegmatites (Li, Nb, Ta)*
    - *Carbonatites/alkaline intrusions (REE, Ta, Nb)*

Important ore-forming processes

- **Hydrothermal**
  - Magmatic-hydrothermal
    - Fluids and metals originate from a magma
      - *Porphyry Cu-Mo-Au deposits*
      - *Sn-W granites*
      - *Skarn deposits*
      - *Epithermal Au-Ag deposits* *(involve also some meteoric fluid)*

Important ore-forming processes

- **Hydrothermal**
  - Seawater-hydrothermal (black smokers)
    - Seawater leaching metals from oceanic crust
      - *Volcanic massive sulphide deposits (Pb-Zn-Cu)*

Important ore-forming processes

- **Hydrothermal**
  - Basinal-hydrothermal
    - Basinal brines leaching metals from sediments/ basement
    - Fluid mixing
      - *Sedimentary exhalative Pb-Zn deposits (SEDEX)*
      - *Mississippi Valley Type Pb-Zn deposits (MVT)*
      - *Sedimentary Cu deposits (Kupferschiefer)*

Important ore-forming processes

- **Hydrothermal**
  - Metamorphic-hydrothermal
    - Metamorphic fluids released due to mineral dehydration reactions during metamorphism
    - Structural control, shear zones
      - *Orogenic Au deposits*

Important ore-forming processes

- **Hydrothermal**
  - Meteoric-hydrothermal
    - Meteoric fluids circulating through earth crust leaching metals. Minor mixing with other fluids or evaporation
      - *Li Brine deposits*
      - *Epithermal Au-Ag deposits (low sulphidation type)*

Important ore-forming processes

- **Supergene enrichment**
  - Weathering without erosion
    - Leaching of soluble elements, enriching insoluble elements. Redox reactions.
      - *Bauxite (Al) deposits*
      - *Ni-laterite deposits*
      - *Supergene enrichment zones above e.g., porphyries*

Important ore-forming processes

- **Sedimentary processes**
  - Physical sedimentation (heavy sands)
    - Fluvial transport, sorting
      - *Placer deposits (Au, Sn, Ti, Zr)*

Important ore-forming processes

- **Sedimentary processes**
  - Chemical sedimentation
    - Precipitation from (sea)water. Change in redox conditions.
      - *Banded Iron Formation (BIF)*
      - *Manganese nodules*

Metals and the ore deposits they can be found in

- **Gold (Au)**
  - Orogenic Au deposits
  - Epithermal Au-Ag deposits
  - Placer Au deposits
  - Porphyry Cu-Au deposits

Metals and the ore deposits they can be found in

- **Copper(Cu)**
  - Porphyry Cu-Mo-Au deposits
  - Sedimentary Cu deposits (Kupferschiefer, African copper belt)
  - Volcanic massive sulphide deposits
  - Magmatic massive sulphide Ni-Cu-PGE deposits

Metals and the ore deposits they can be found in

- **Nickel (Ni)**
  - Magmatic massive sulphide Ni-Cu-PGE deposits
  - Laterite (supergene enrichment)

Metals and the ore deposits they can be found in

- **Plantinum group elements (PGE)**
  - Magmatic massive sulphide Ni-Cu-PGE deposits

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Metals and the ore deposits they can be found in

- **Chromium (Cr)**
  - Stratiform, layered mafic intrusions
  - Podiform, ophiolites

Metals and the ore deposits they can be found in

- **Lead and zinc (Pb-Zn)**
  - Sedimentary exhalative deposits (SEDEX)
  - Mississippi Valley type (MVT)
  - Volcanic massive sulphide deposits
  - Polymetallic veins

Metals and the ore deposits they can be found in

- **Tin and tungsten (Sn-W)**
  - Granites, veins
  - Skarn deposits
  - Placer deposits

Metals and the ore deposits they can be found in

- **Iron (Fe)**
  - Banded Iron Formation (BIF)
  - Ironstones

Metals and the ore deposits they can be found in

- **Aluminium (Al)**
  - Bauxite (supergene enrichment)

Metals and the ore deposits they can be found in

- **Lithium (Li)**
  - Pegmatites
  - Brines

Metals and the ore deposits they can be found in

- **Rare earth elements (REE)**
  - Carbonatites
  - Pegmatites
  - Alkaline intrusions
  - Supergene enrichment

Metals and the ore deposits they can be found in

- **Tantalum and niobium (Ta-Nb)**
  - Carbonatites
  - Pegmatites
  - Alkaline intrusions

Metals and the ore deposits they can be found in

- **Carbon (C)**
  - Diamonds
    - Kimberlites
    - Placer deposits
  - Graphite
    - Metamorphic deposits