TU Clausthal

Economic Geology

Minerals and Rock types

Module 2

Thomas Ulrich
Institute for Disposal Research

TU Clausthal

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

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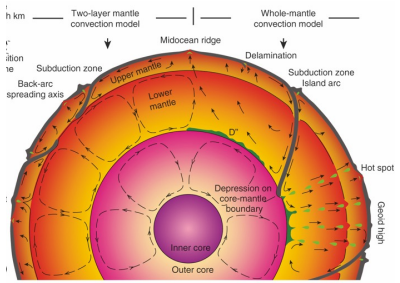
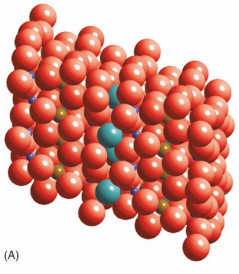
The building blocks of Earth

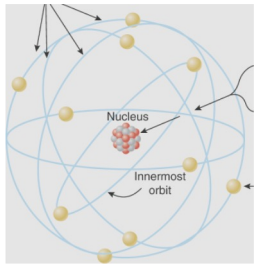


Earth

Rocks



Crystal structure

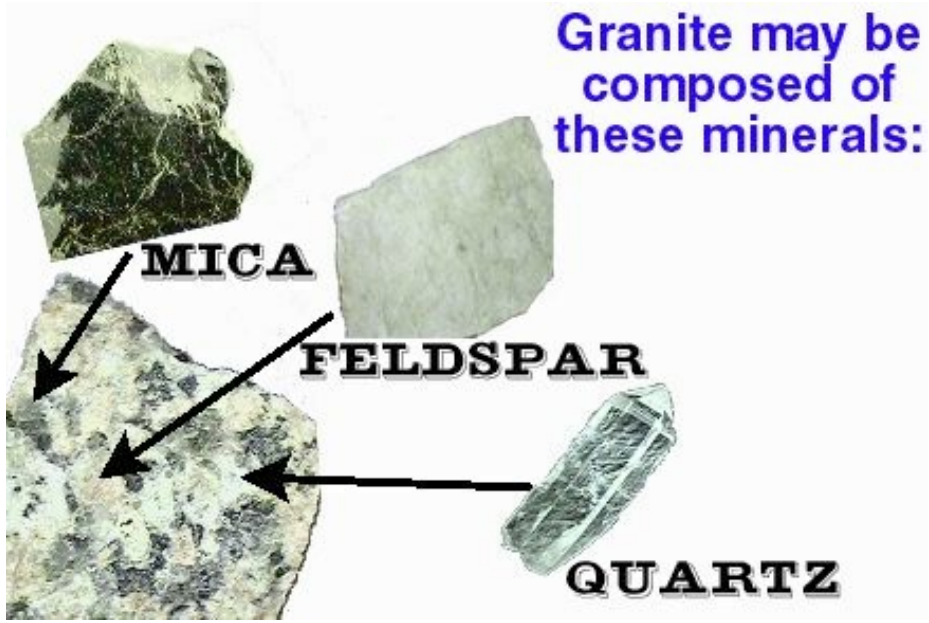


Atom structure

Minerals

Rocks: Assemblage of minerals

- Rocks consist typically of several different minerals. In some cases only of one type of mineral (limestone, quartzite)



Lego

The 3 general rock types

- Magmatic rocks
- Metamorphic rocks
- Sedimentary rocks

These general groups are based on the formation processes, and there are many different rocks in each group (see later).

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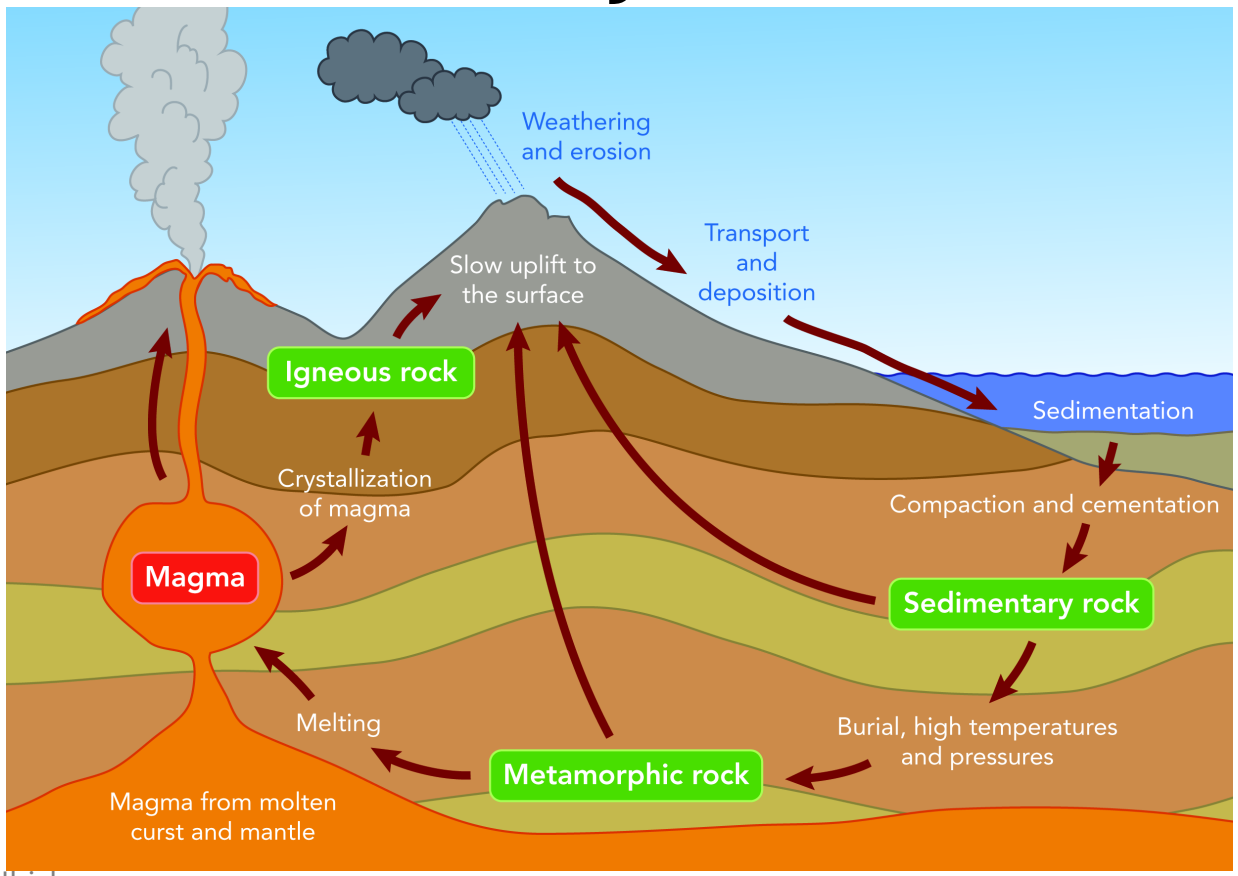
Rocks: The rock cycle



Ore deposits can be hosted in any of the three rock types. Different geological processes lead to the accumulation of metals inn these rocks.

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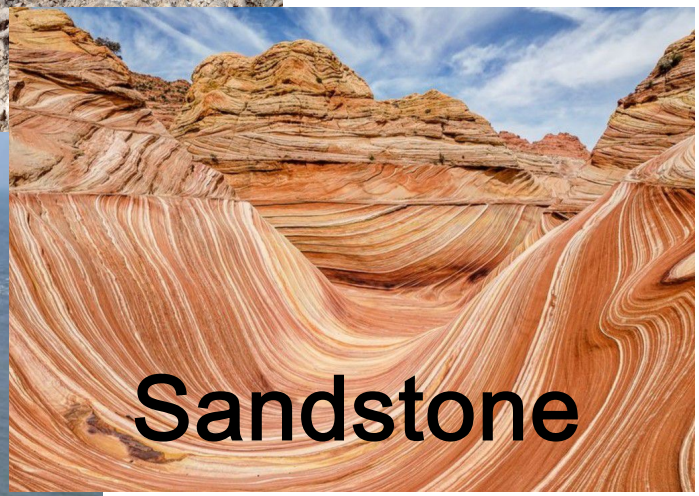
Sedimentary rocks

Sedimentary rocks form due to precipitation from (sea) water, deposition of dead (micro)-organisms or erosion of other rocks.



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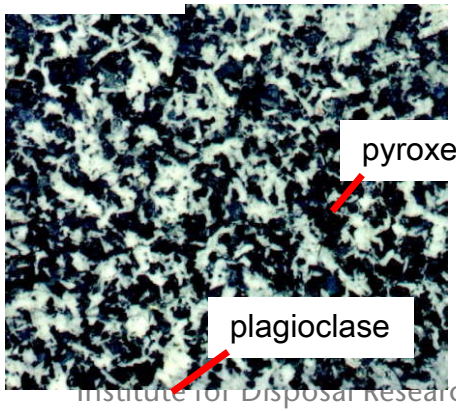
Important sedimentary rock names and potential hosts for metals

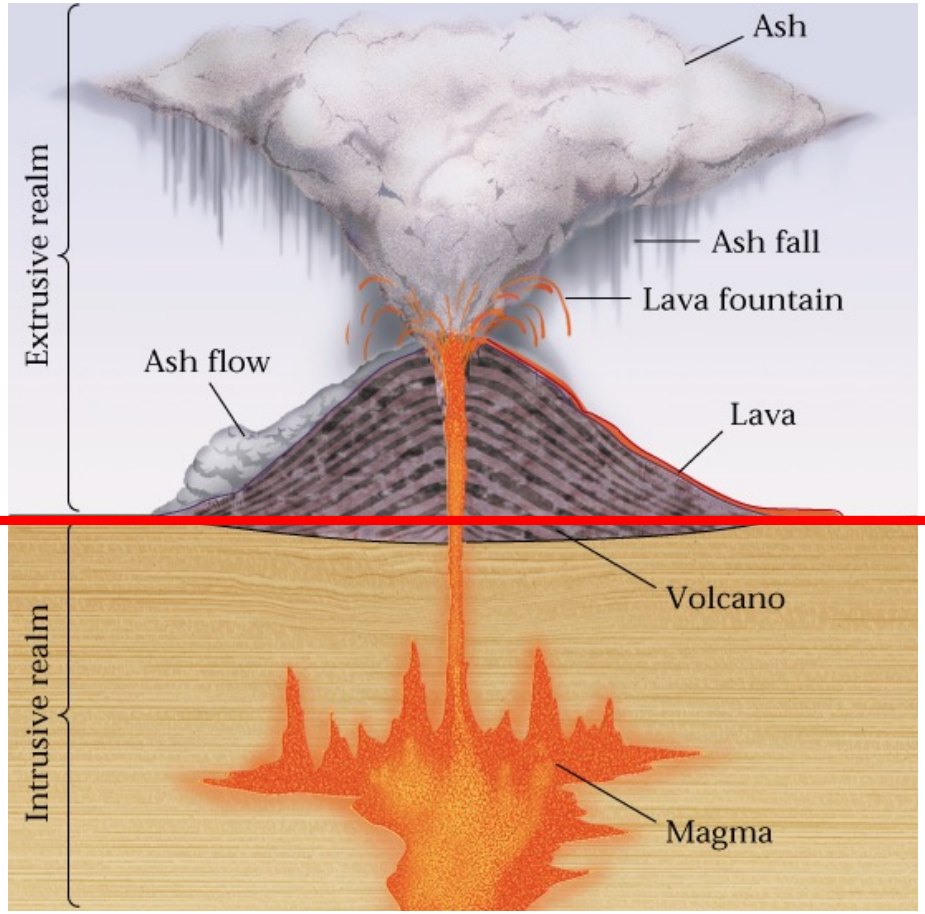
- Limestone (Pb, Zn)
- Shale, Marl (shale and limestone mix) (Mo, V, Au)
- Sandstone, Siltstone (Pb, Zn, Cu, U)
- Evaporite (gypsum, salt)
- Greywacke
- Conglomerate (Au, Sn, Ti)

Magmatic rocks

Basalt

Gabbro





Volcanic rocks
cool down fast, yields small crystal sizes, glass

Plutonic rocks
cool slowly, larger crystal sizes

Important magmatic rock names and potential hosts for metals

- Granite/Rhyolite (Sn, W, Mo, REE, Li)
- Diorite/Andesite (Cu, Mo, Au)
- Syenite/Trachyte (REE, Ta, Nb)
- Gabbro/Basalt (Ni, Cu, PGE, Cr)
- Peridotite/Komatiite (Ni, Cu, PGE, Cr)
- Ignimbrite

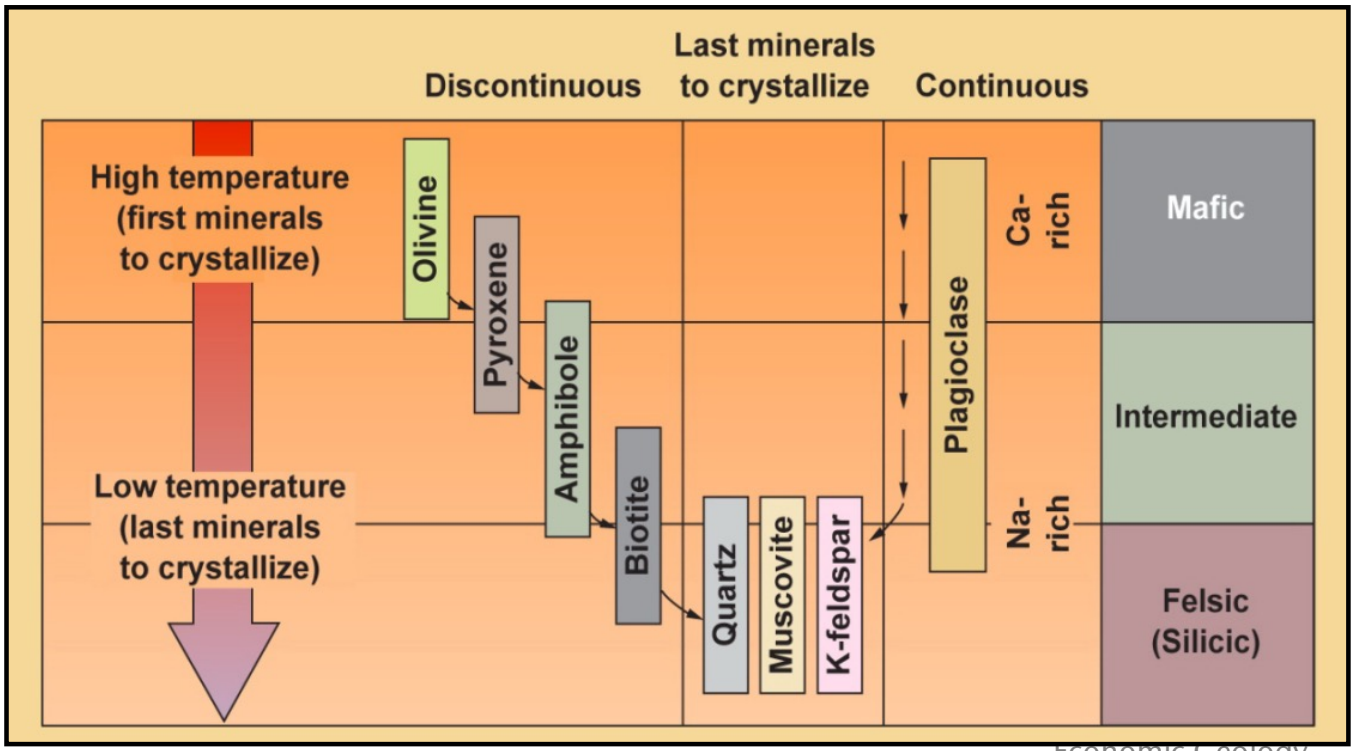
Magmatic Rocks: Fractional crystallization

Plutonic rocks crystallize slowly at depth. With decreasing temperature, new minerals start to crystallize (**Bowen's reaction series**). **Fractional crystallization**

Felsic minerals:
quartz, feldspars, felspathoids, muscovite

Mafic minerals:
olivine, pyroxenes, amphiboles, biotite

Fractional crystallization leads to enrichment of incompatible elements in the melt.

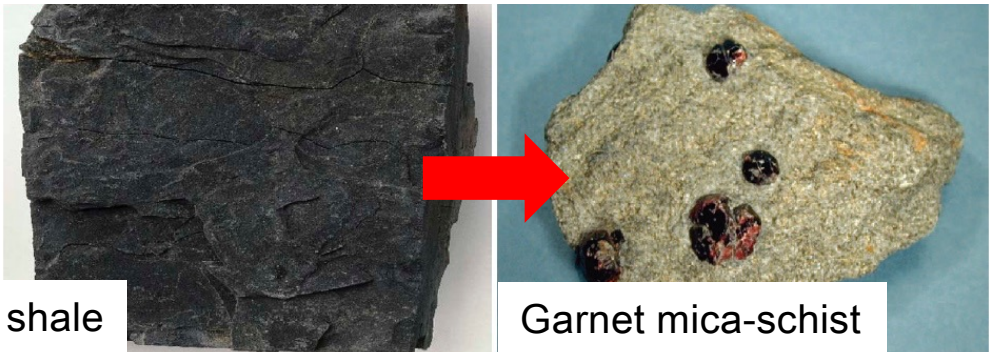


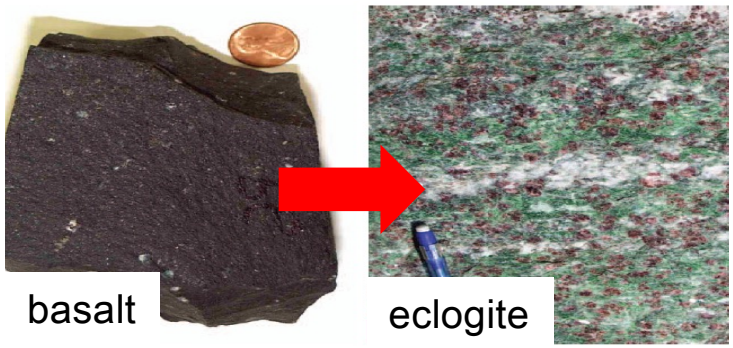
Metamorphic rocks

All rock types can be exposed to high temperature and/or pressure.

⇒ **METAMORPHISM**

This will commonly change the mineralogy in the rock (formation of new minerals). Hydrous minerals release water (metamorphic fluids).





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Metamorphic rocks

Due to pressure and temperature changes the texture in the rock will also change (banding).

Granite

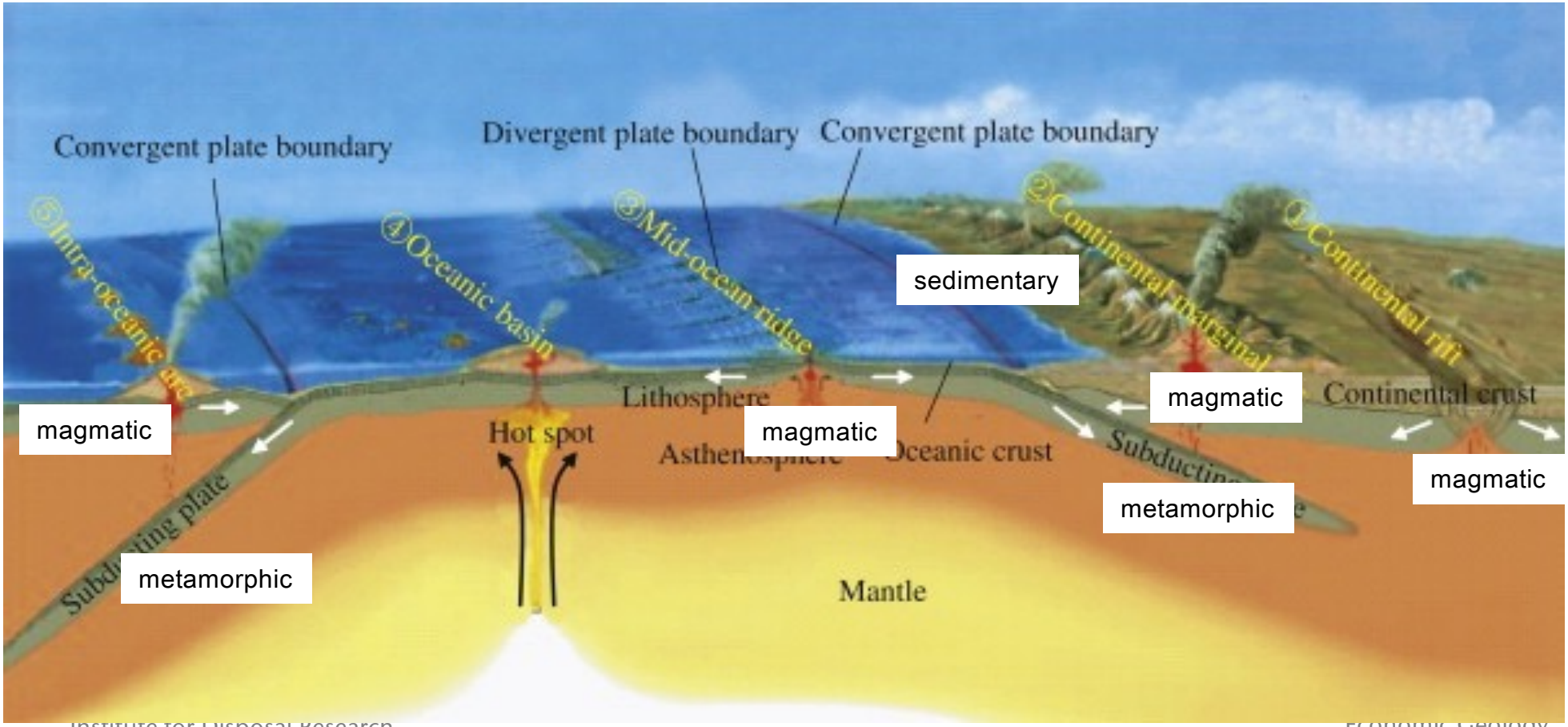
Gneiss

Not to confuse with sedimentary layering!

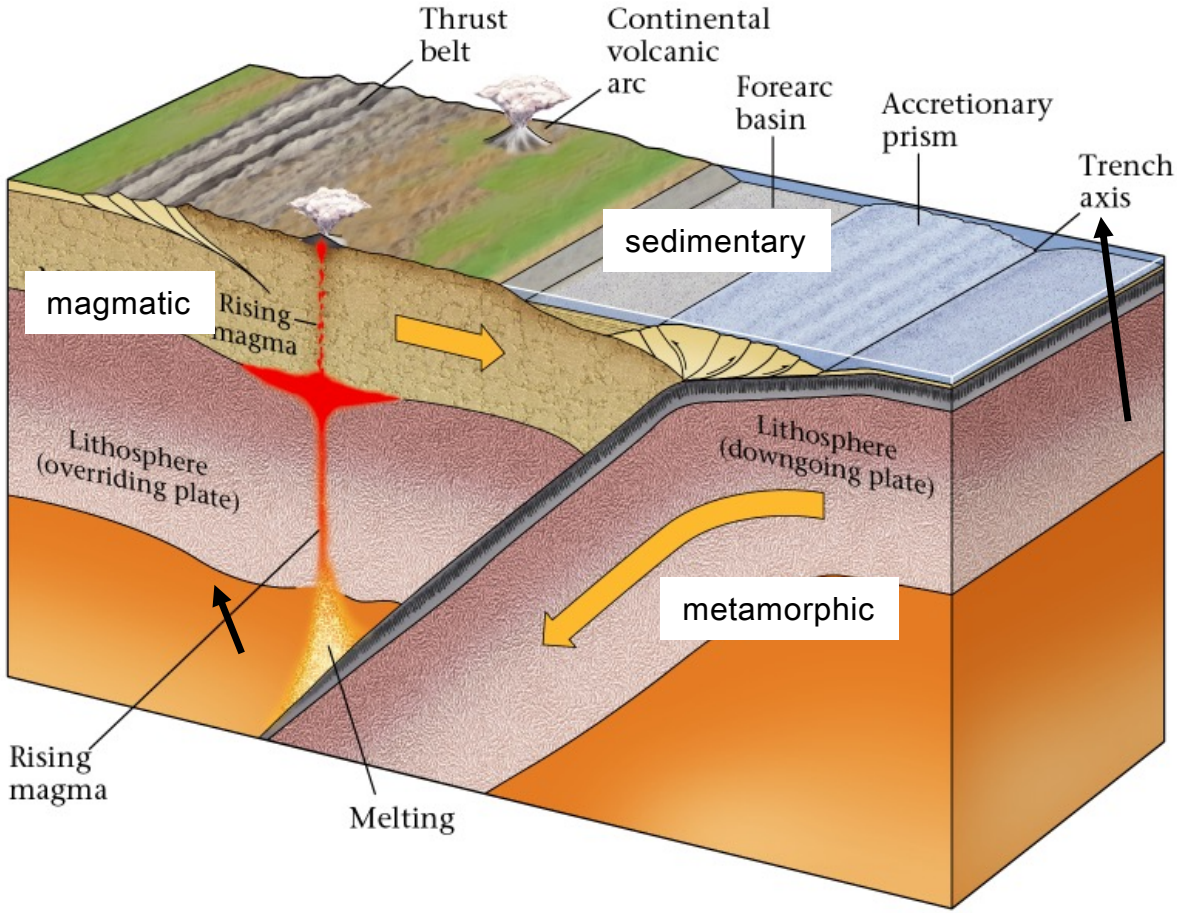
Important metamorphic rock names and potential hosts for metals

- Greenschist (Au)
- Amphibolite (Au)
- Mica schist
- Eclogite
- Gneiss
- Phyllite
- Marble
- Quartzite
- Slate (Au, Mo, V)
- Hornfels
- Skarn (Pb, Sn, W, Cu, Zn, Au, Fe)

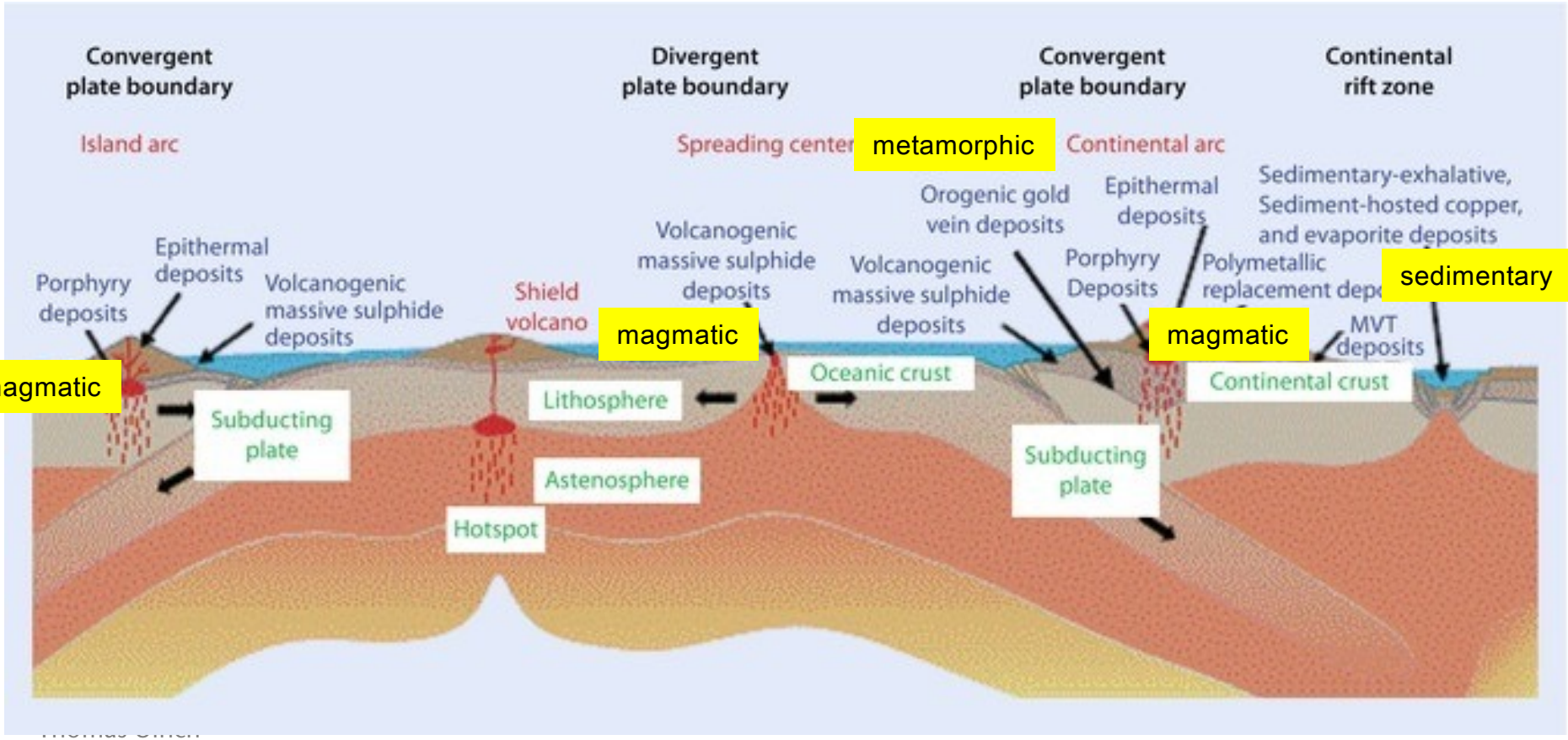
Geological settings and different rocks



Geological settings and different rocks



Ore deposits associated with different rocks



Exercise 1

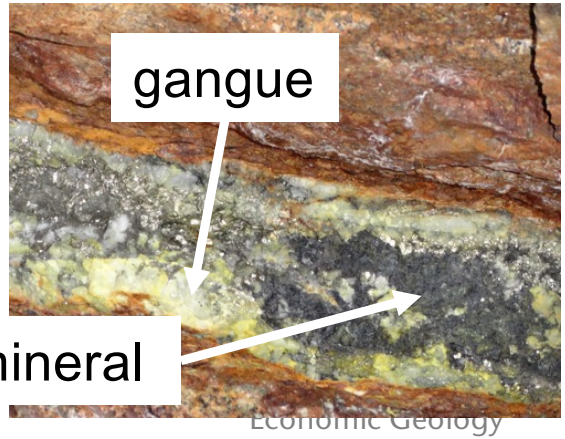
Group the different rocks into the three rock types :

- Sedimentary
- Magmatic
- Metamorphic

Write down the metals that could be hosted by them

Important minerals

- Rocks consist of minerals and minerals consist of elements.
- Elements (metals) are the important part in Economic Geology. These are extracted from **ore minerals** (minerals with a high metal content).
- Minerals that occur together with ore minerals, but are ‘worthless’ are called **gangue minerals**



The main metals/minerals used

- **Au (gold)** native

- **Ag (silver)** native

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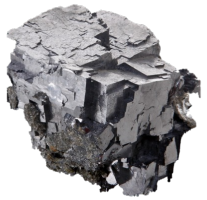
The main metals/minerals used

- **Cu (copper)** chalcopyrite ($CuFeS_2$)
- **Fe (iron)** hematite/magnetite (Fe_2O_3/Fe_3O_4)
- **Al (aluminium)** bauxite
- **W (tungsten)** wolframite/scheelite

The main metals/minerals used

- **Sn (tin)** cassiterite (SnO_2)

- **Pb (lead)** galena (PbS (+Ag))

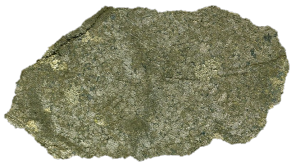


- **Zn (zinc)** sphalerite (ZnS)

- **U (uranium)** uraninite (UO_2)

The main metals/minerals used

- **Ni (nickel)** pentlandite $(Fe,Ni)_9S_8$)



- **Cr (chromium)** chromite ($FeCr_2O_4$)

- **Mn (manganese)** pyrolusite (MnO_2)

- **C (carbon)** graphite (C)

The main gangue minerals

- **Quartz (SiO_2)**
- **Calcite ($CaCO_3$)**
- **Baryte ($BaSO_4$)**
- **Dolomite ($CaMg(CO_3)_2$)**
- **Gypsum ($CaSO_4 .H_2O$)**
- **Anhydrite ($CaSO_4$)**

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Mineral properties for identification

- Colour (streak colour)
- Lustre
- Density
- Cleavage
- Crystal form

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Cool minerals

- Fluorescence
- Birefringence
- Ulexit

Summary: Module 2

- Rocks consist of minerals and minerals consist of chemical elements
- The three rock types: sedimentary, metamorphic, magmatic and their formation processes
- In ore deposits, certain metals are related to certain rock types (sedimentary rocks: Fe, Pb, Zn, Cu, U, Au; magmatic rocks: Ni, Cu, PGE, Cr, REE, Nb, Ta, Sn, W; metamorphic rocks: Au)

Exercise 2

- Identify the ore and gangue minerals based on their properties and write down which metal is extracted from the ore minerals.