Lecture 3A

Rock groups and the rock cycle

Dr Tom Raimondo

UniSA

See Marshak pg. 130–138; 239–245

Figures taken from Earth: Portrait of a Planet, WW Norton & Co.

Why do I need to know all this stuff?

http://www.geolsoc.org.uk/Plate-Tectonics

- As we discussed last week, all engineering structures are **built on rocks and soil**
- Many structures themselves are also **built of rocks**
- Just like minerals, we need to understand the **key properties of rocks** in order to conduct a proper site evaluation and apply tailored engineering solutions
- Being able to distinguish between different rock types, and having a basic idea of the processes behind their formation, is an important step to understanding more specific geological concepts applicable to engineering problems
- It also enables **effective communication** with geological experts brought in for consultation

Lecture outline

- **What is a rock?**
- The three rock groups:
  how are they defined and how do
  we tell them apart?
- How do we study rocks?
- The rock cycle

What is a rock?

Rocks are:

- Coherent (not unconsolidated soil or sand)
- Naturally-occurring
- Aggregates of minerals or glass

Rock components can be held together by:

- Cement (precipitated mineral material that fills space between grains) – **clastic**
- Interlocking grains – **crystalline**

What is a rock?

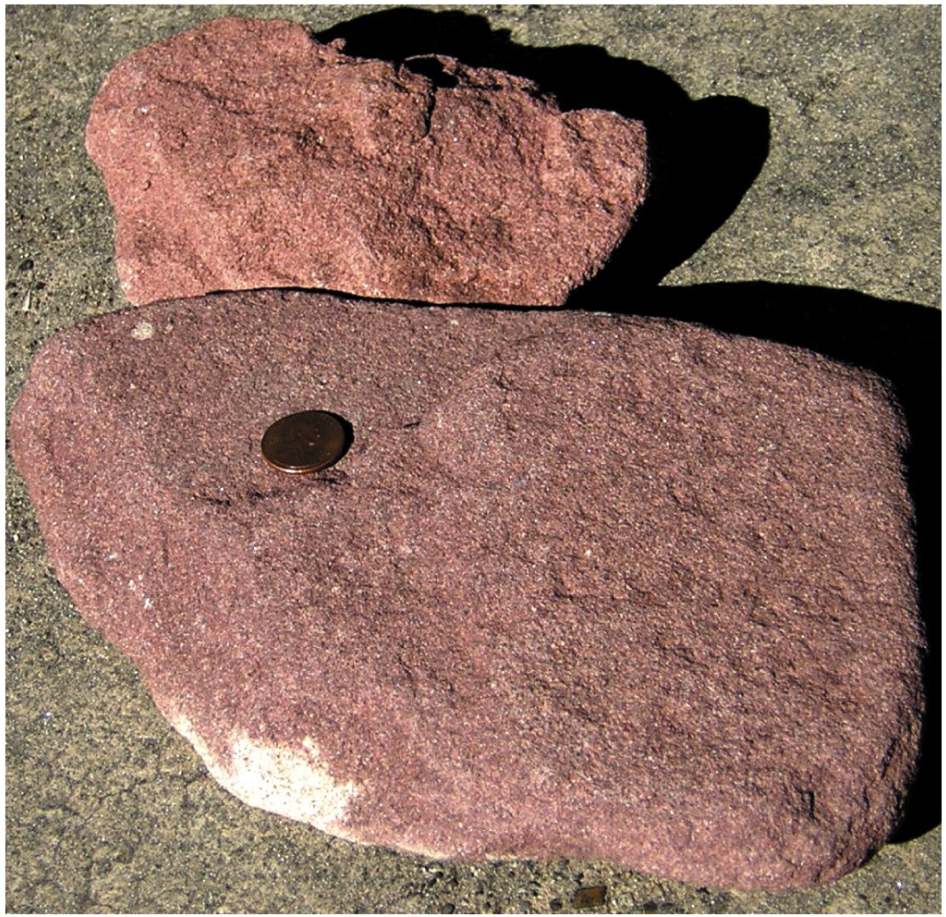


Figure B-1a Earth: Portrait of a Planet 3/e
© Richard P. Jacobs/JLM Visuals

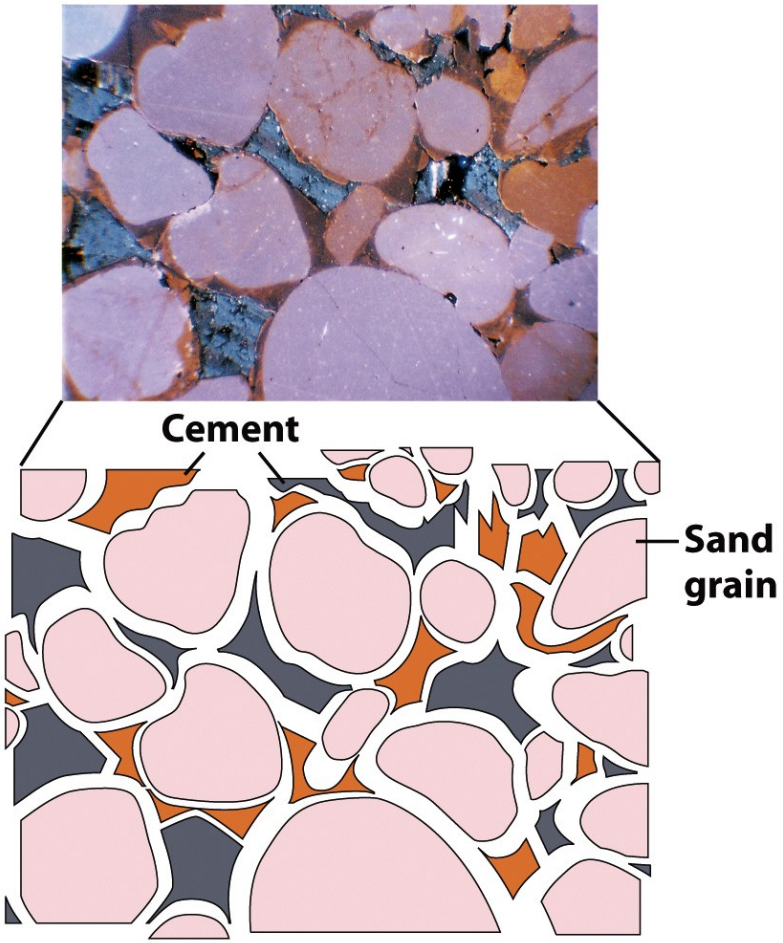
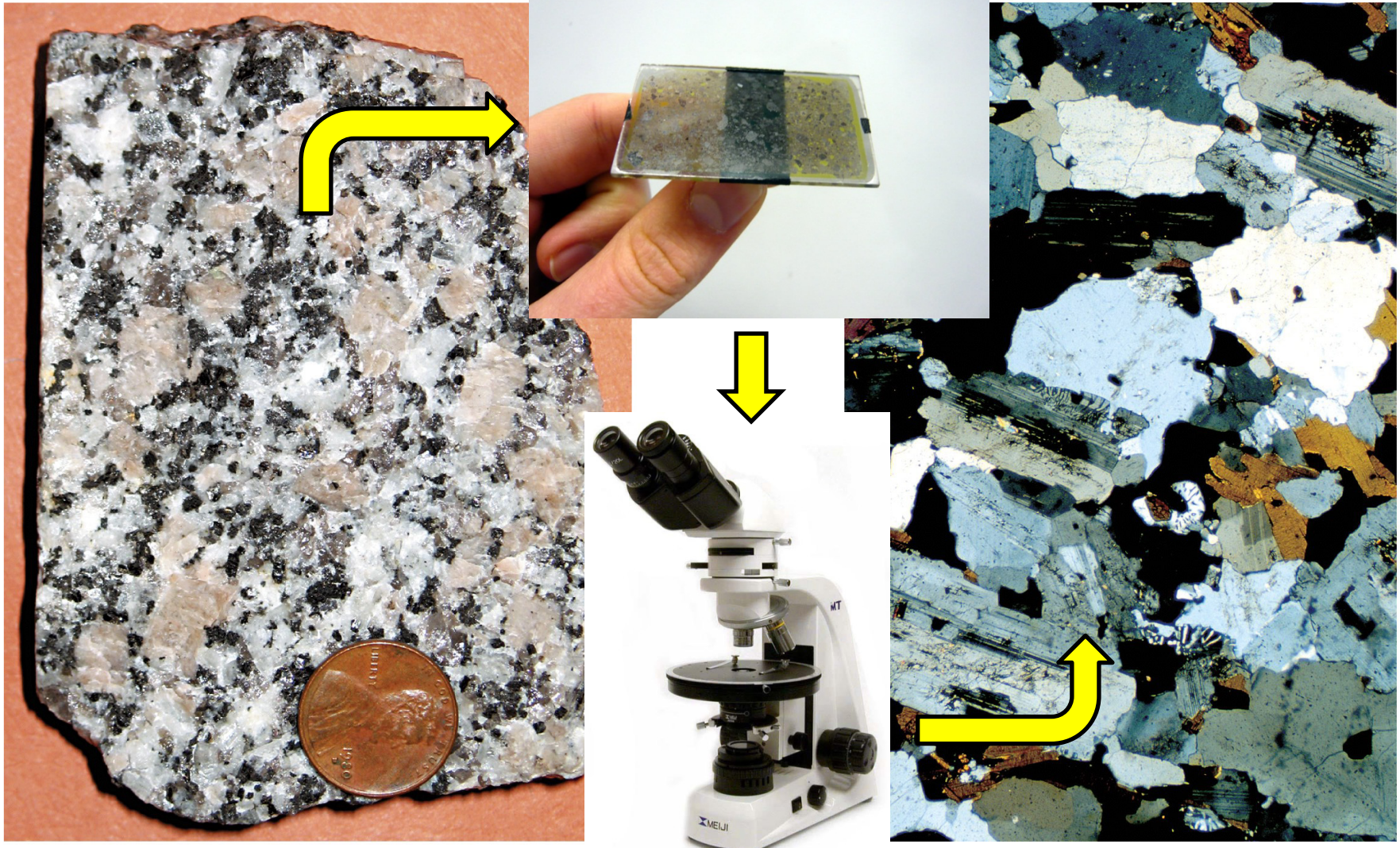


Figure B-1bc Earth: Portrait of a Planet 3/e
Photo courtesy David W. Houseknecht, U.S. Geological Survey

What is a rock?



Lecture outline

- What is a rock?
- **The three rock groups: how are they defined and how do we tell them apart?**
- How do we study rocks?
- The rock cycle

How do we classify rocks?

- By colour?
- By grain size?
- By specific gravity?
- By other rock properties?

The classification scheme for rocks is very different to that of minerals. It is based on how the rock formed – a **genetic classification**. This is most useful for distinguishing how different rock types relate to different Earth processes. You will see this later on when we consider the **rock cycle** and its links to **plate tectonics**.

How do we classify rocks?

There are three major rock groups:

1. **Igneous rocks** are those that have solidified from **molten material**. They include rocks such as granite that were originally emplaced deep within the Earth's crust, and basalt which is extruded at the surface as lava flows.

Igneous rocks

Granite is an igneous rock that forms when magma solidifies **within the Earth's crust**.

e.g. Granite Island, funnily enough!

Igneous rocks

Basalt is an igneous rock that forms from lava **erupted from a volcano**.

Mt Schank is an extinct volcano in southeastern S.A.

http://goo.gl/maps/AjapV

Molten lava, Hawaii

http://goo.gl/maps/zEmrV

Basalt (rock)

How do we classify rocks?

There are three major rock groups:

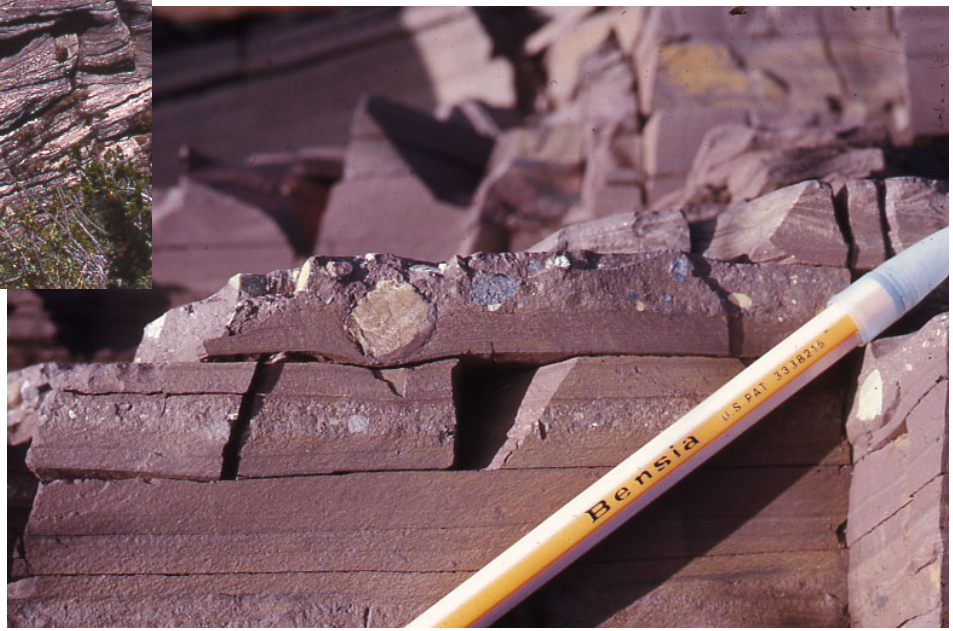
1. Igneous rocks are those that have solidified from **molten material**. They include rocks such as granite that were originally emplaced deep within the Earth's crust, and basalt which is extruded at the surface as lava flows.

2. Sedimentary rocks form from the consolidation of **pre-existing fragments** derived from other rocks or from animal and plant remains such as shells. They can also form from the precipitation of mineral crystals in solution.

Sedimentary rocks

Sandstone is a sedimentary rock that has formed from sand deposited in beaches, dunes, etc.

This sandstone is in Walnut Canyon, Arizona, USA; originally sand dunes in a desert



The sand and pebbles that formed this sedimentary rock were deposited in a glacial lake; Flinders Ranges, S.A.

Sedimentary rocks

Limestone is a sedimentary rock that is composed mostly of calcium carbonate ($CaCO_3$), often from shells.

Limestone cliffs on the River Murray, S.A.

Shelly limestone, St Kilda, S.A.

Sedimentary rocks

The gypsum forming these sedimentary rocks was **chemically precipitated** in a saline lake near Blanchetown, S.A.

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3. Metamorphic rocks form when **pre-existing rocks** (either igneous, sedimentary or even metamorphic) alter their composition and/or appearance in response to a change in pressure and temperature conditions. Unlike igneous rock formation, metamorphic change does not involve complete melting – it occurs in the solid state.

Metamorphic rocks

Marble is a metamorphic rock that was originally limestone. It is comprised of **recrystallised carbonate minerals**, typically calcite or dolomite.

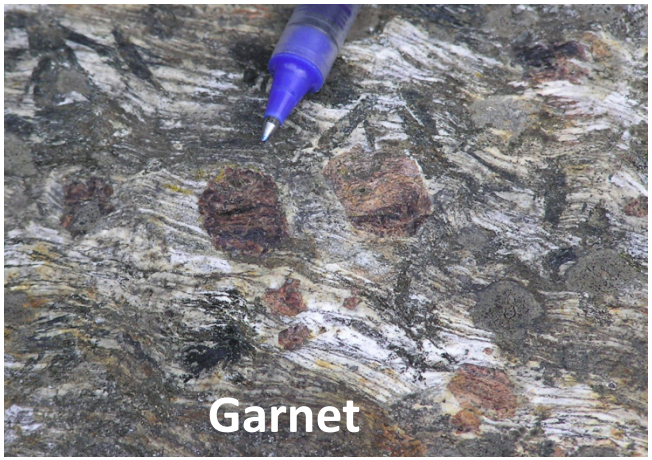
Carrara marble quarry, Tuscany

Slate quarry, Red Pike, UK

Similarly, slate is a metamorphic rock that was originally shale (a fine-grained sedimentary rock). It is comprised of **recrystallised clay minerals**.

Metamorphic rocks

Metapelites are metamorphosed pelitic rocks (pelite = fine-grained sedimentary rock). They have mineral assemblages containing **aluminium-rich minerals**.



Many metamorphic rocks result from **deformation** – squashing, stretching and shearing, which produces folds

How do we distinguish the different rock groups?

Each of the three broad rock groups (igneous, sedimentary and metamorphic) contains many different rock varieties. We determine which rock group an individual rock sample belongs to based on its **physical and chemical properties**:

1. Grain size and shape
2. Mineralogy and composition
3. Texture
4. Layering

Each of these properties may be diagnostic for a given rock group. For example, **graded bedding** (a type of layering) is characteristic of sedimentary rocks. Similarly, a rock that contains the **mineralogy** quartz + feldspar + biotite is characteristic of a granite, an igneous rock. However, **be careful** – usually one property alone is not enough. For example, if a granite is metamorphosed, its composition and mineralogy may not change (it will still be quartz + feldspar + biotite). We need more information, such as its texture – is it **deformed**?

Rock classification

1. Grain size and shape

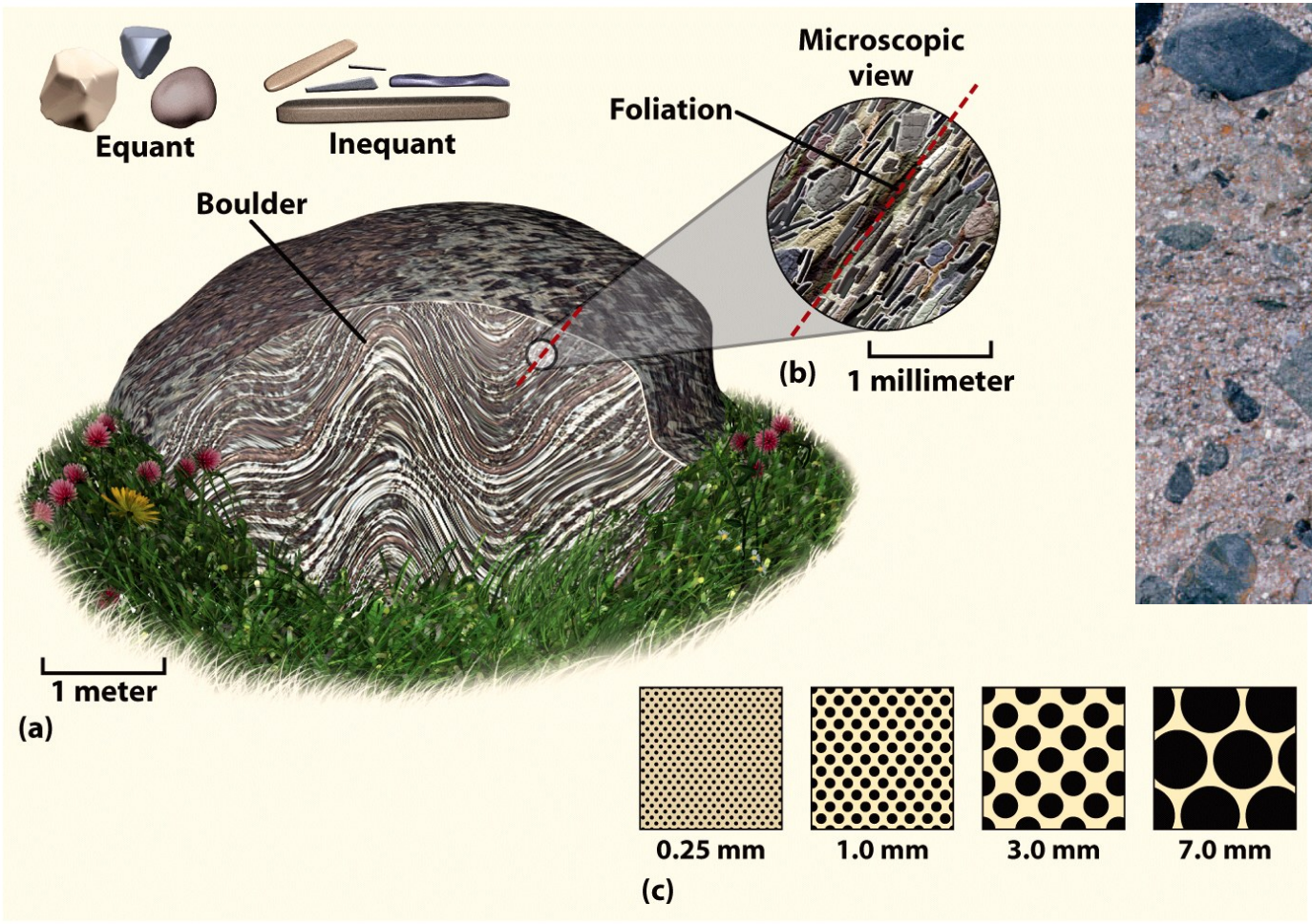
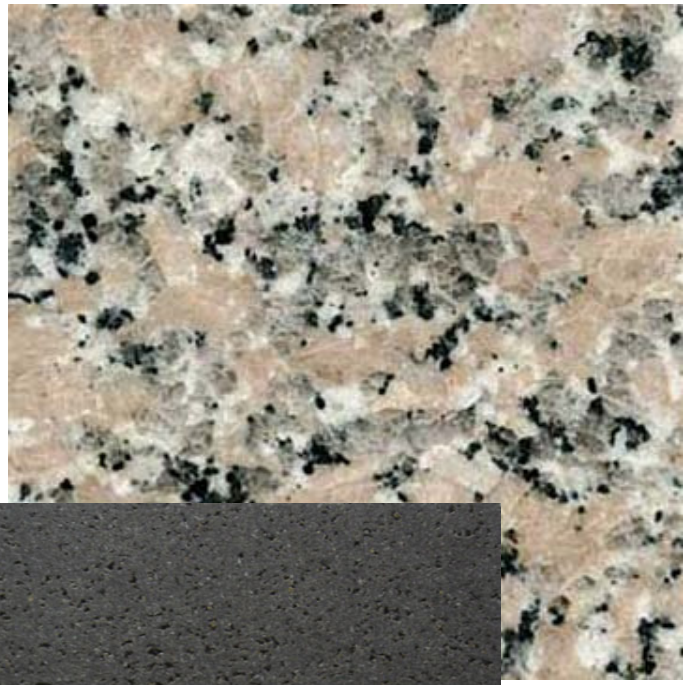


Figure B-5 Earth: Portrait of a Planet 3/e

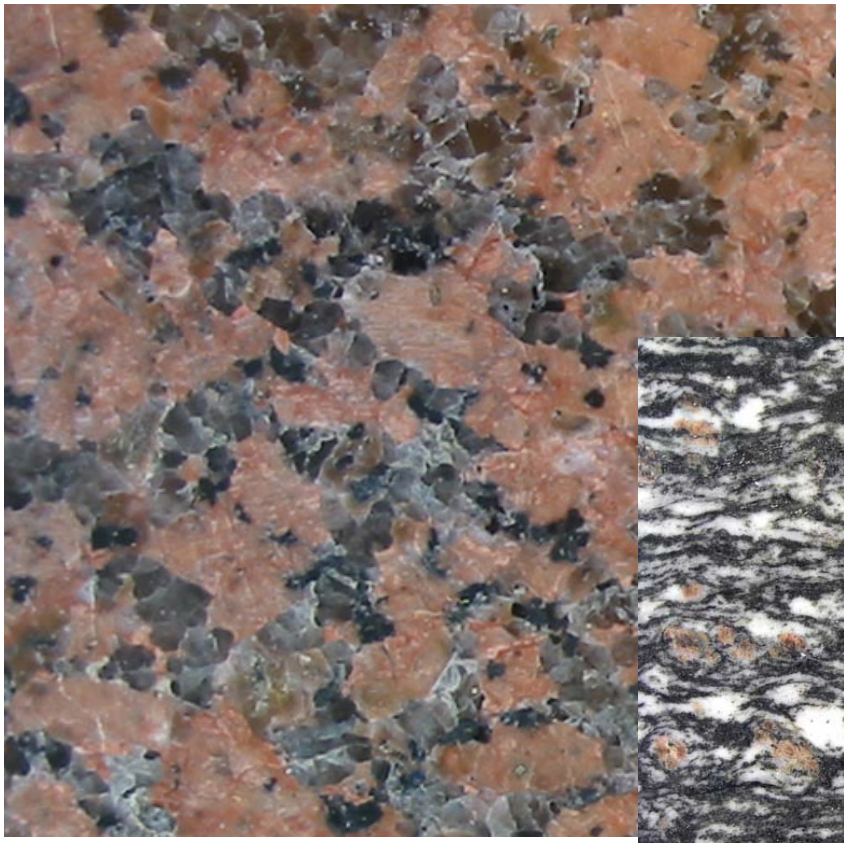
Rock classification

2. Mineralogy and composition



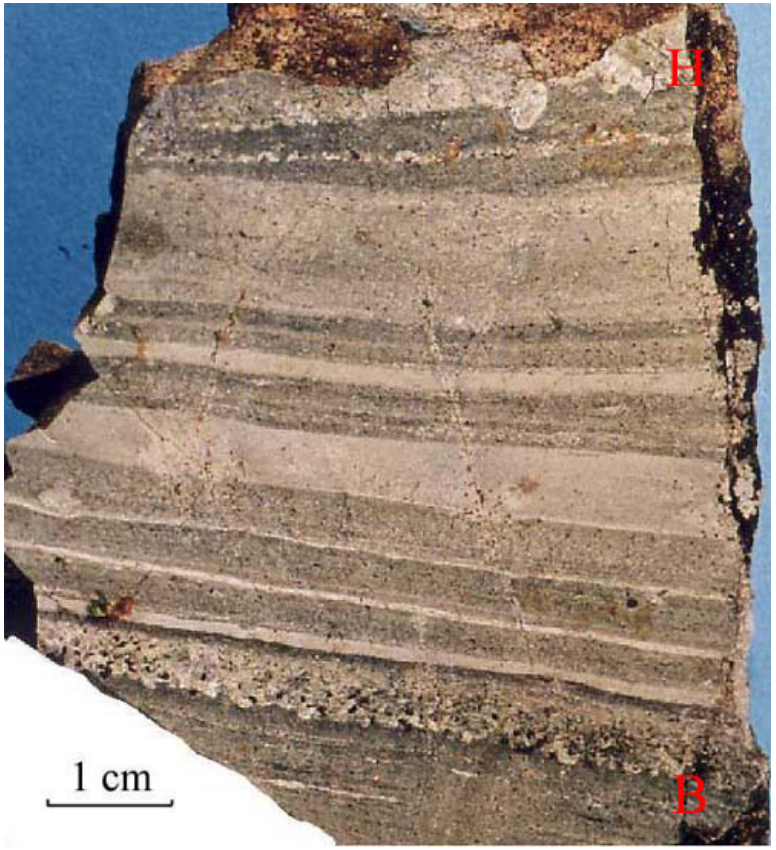
Rock classification

3. Texture



Rock classification

4. Layering

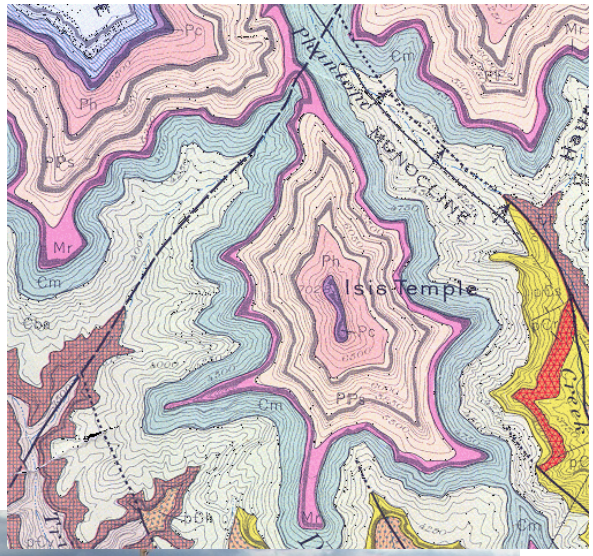


Lecture outline

- What is a rock?
- The three rock groups:
  how are they defined and how do
  we tell them apart?
- **How do we study rocks?**
- The rock cycle

How do we study rocks?

- In the field – outcrop studies



How do we study rocks?

- Hand specimens and thin sections

I am the evil eye rock
You cannot destroy me

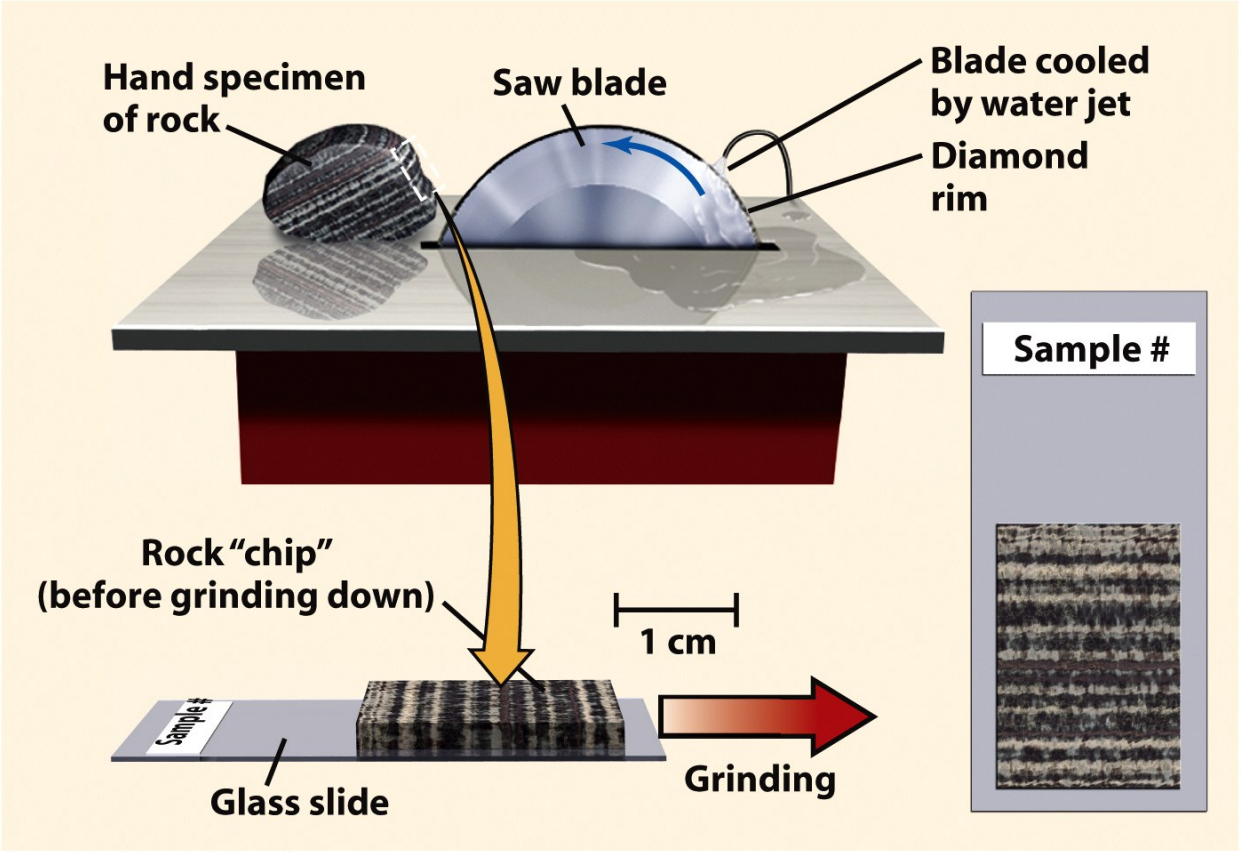
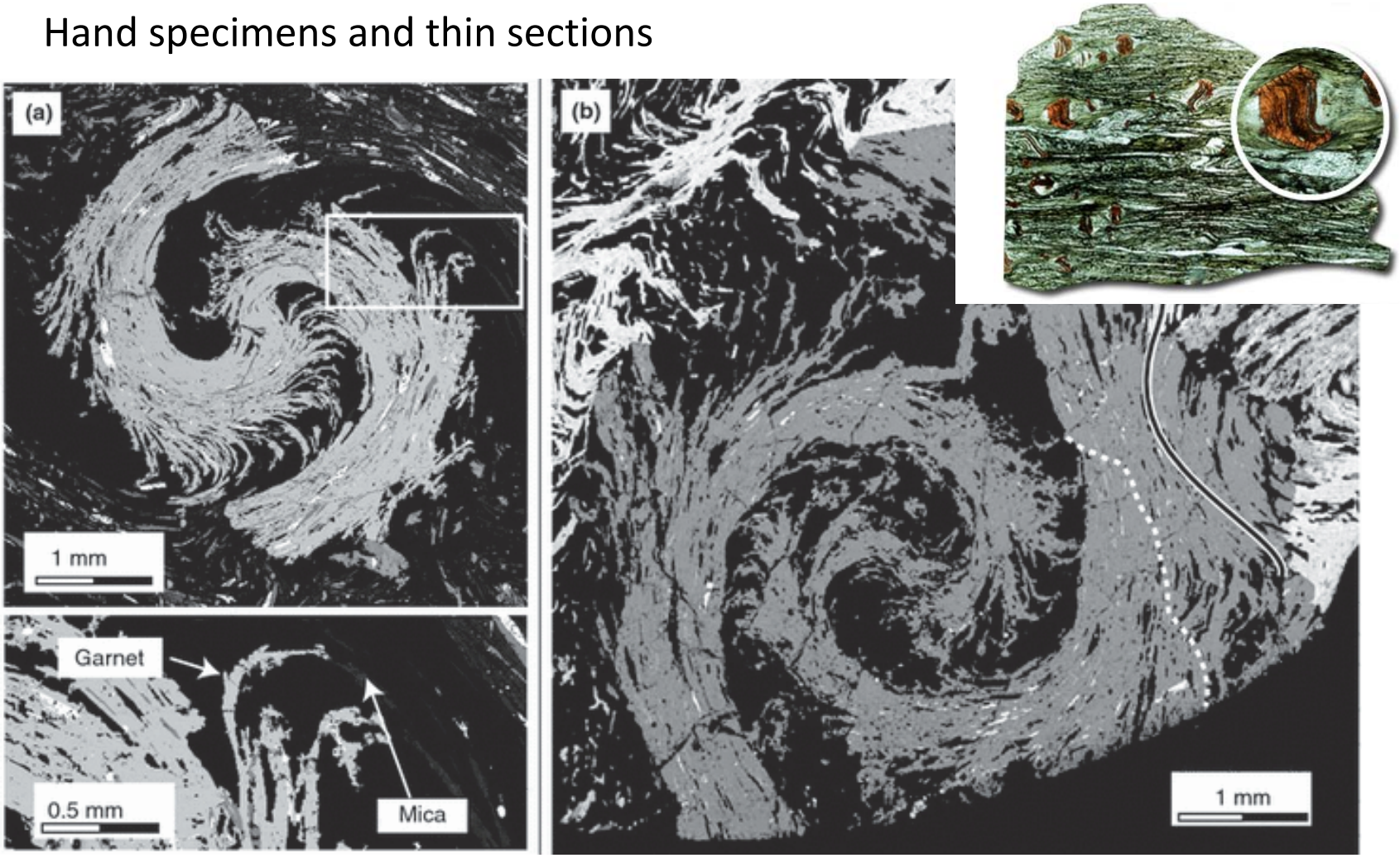


Figure B-7 Earth: Portrait of a Planet 3/e

How do we study rocks?

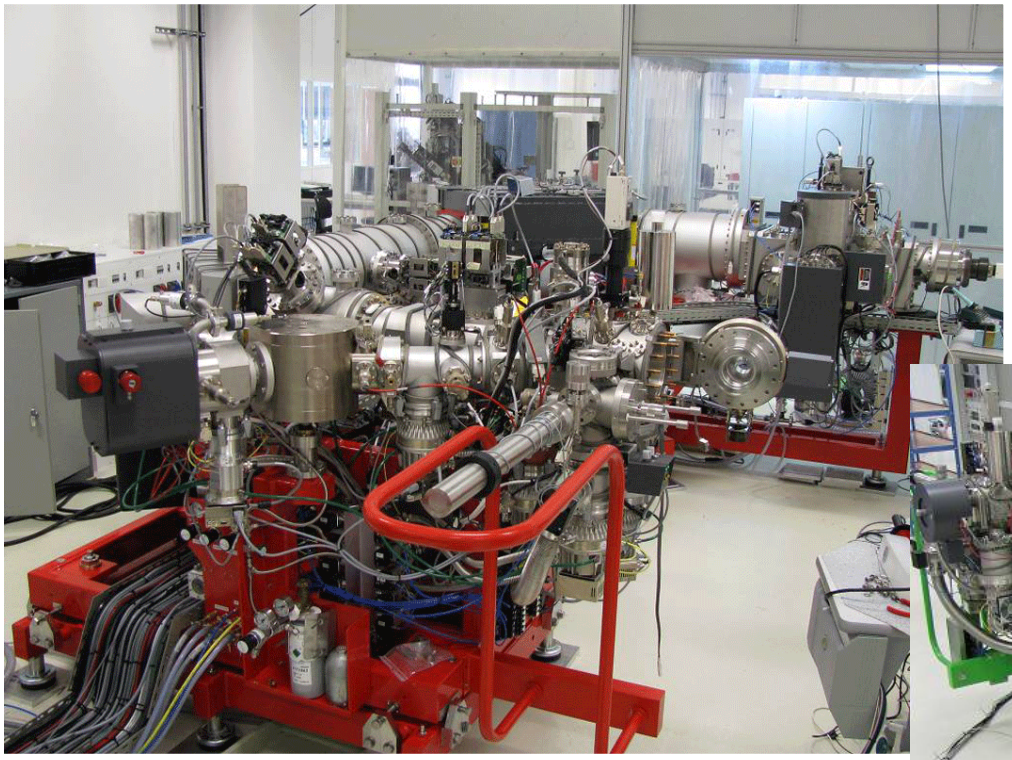
- Hand specimens and thin sections



Robyr, M., Carlson, W. D., Passchier, C., & Vonlanthen, P. (2009). Microstructural, chemical and textural records during growth of snowball garnet. *Journal of Metamorphic Geology*, *27*(6), 423-437.

How do we study rocks?

- Cutting-edge analytical techniques



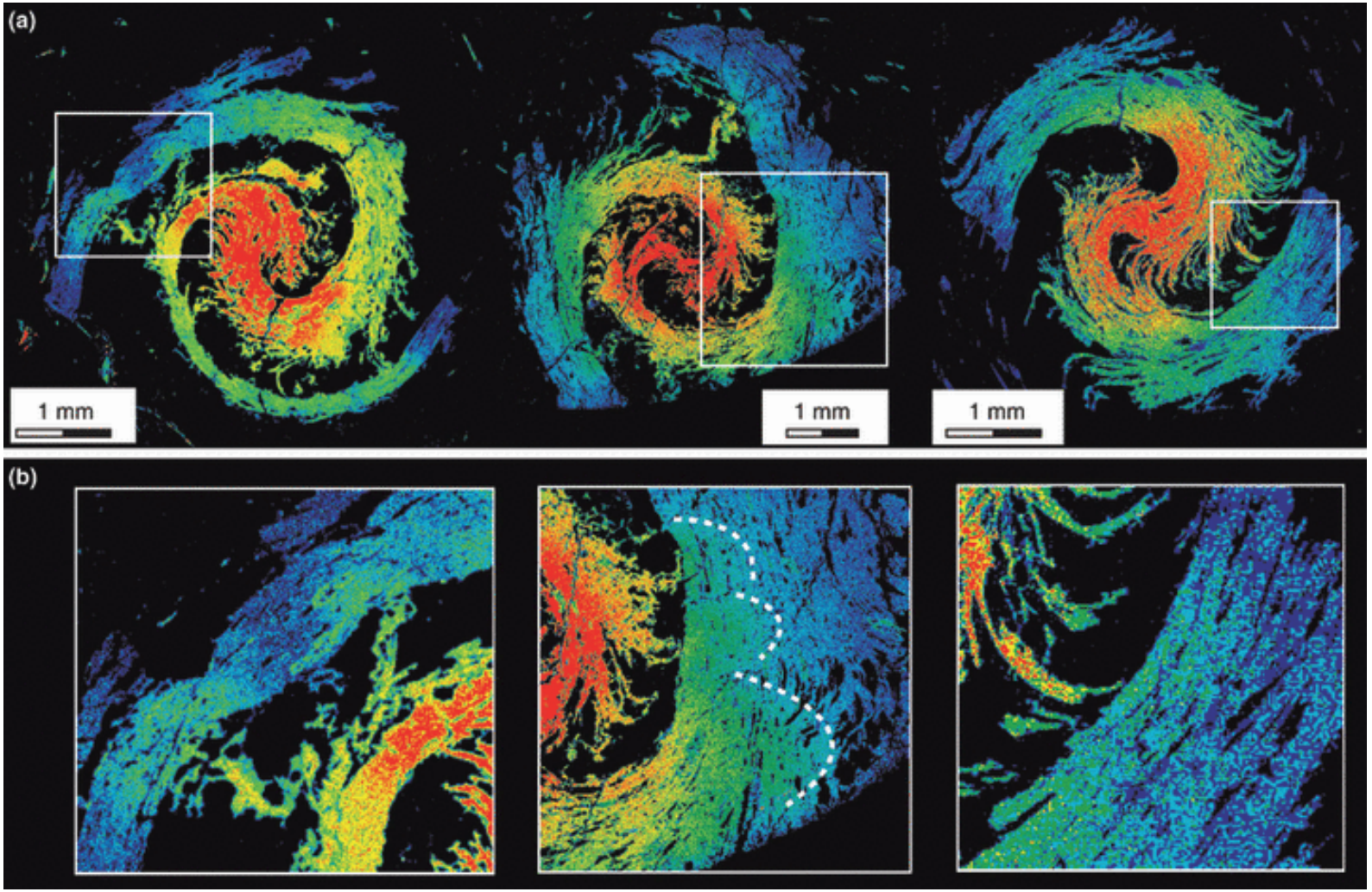
Perth, WA

Which one goes faster?

Wisconsin, USA

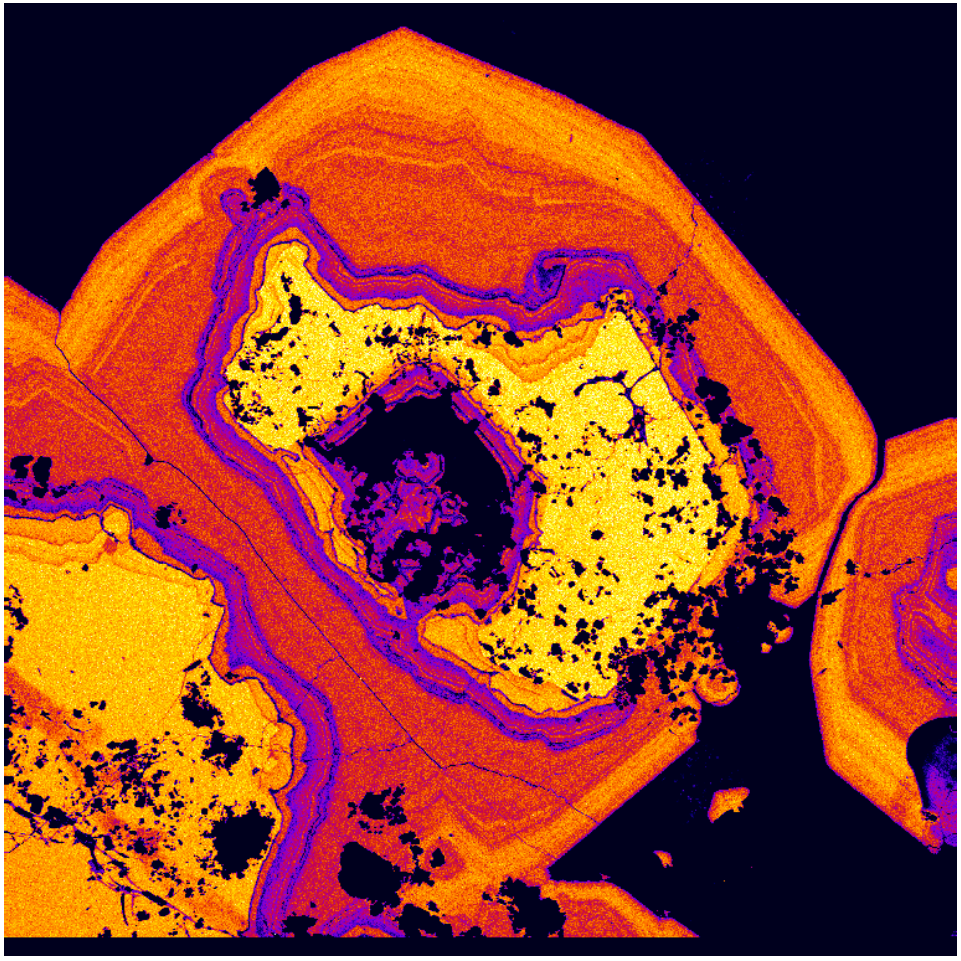
How do we study rocks?

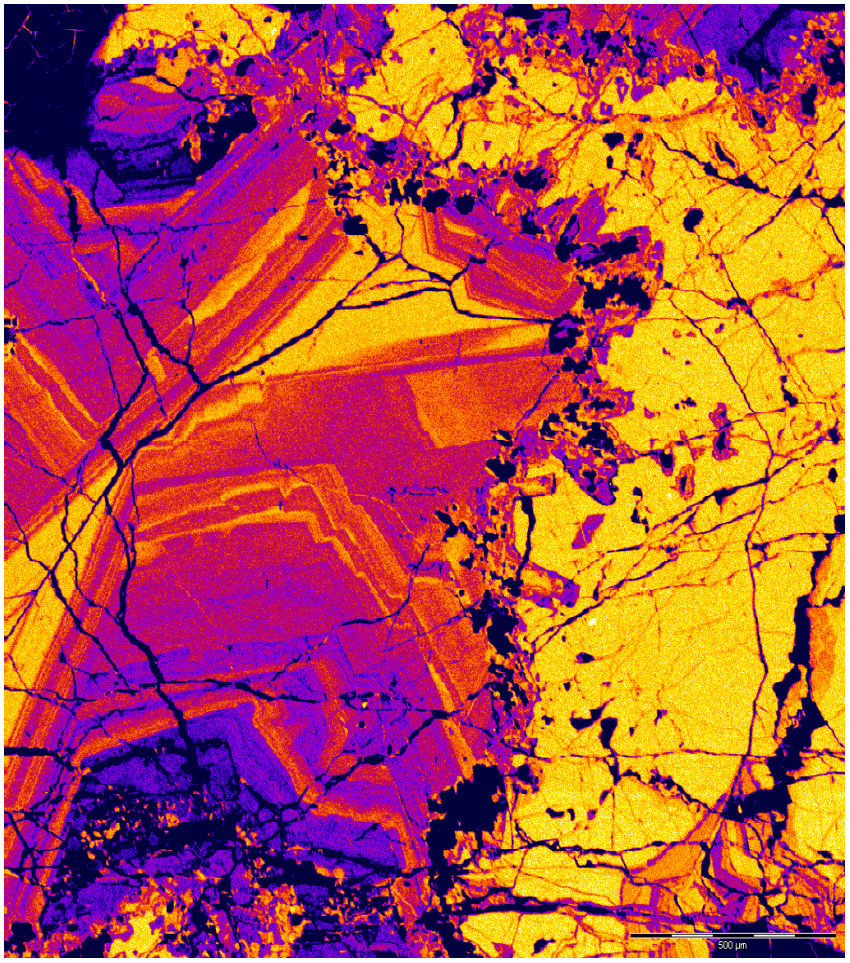
- Cutting-edge analytical techniques



How do we study rocks?

- Cutting-edge analytical techniques





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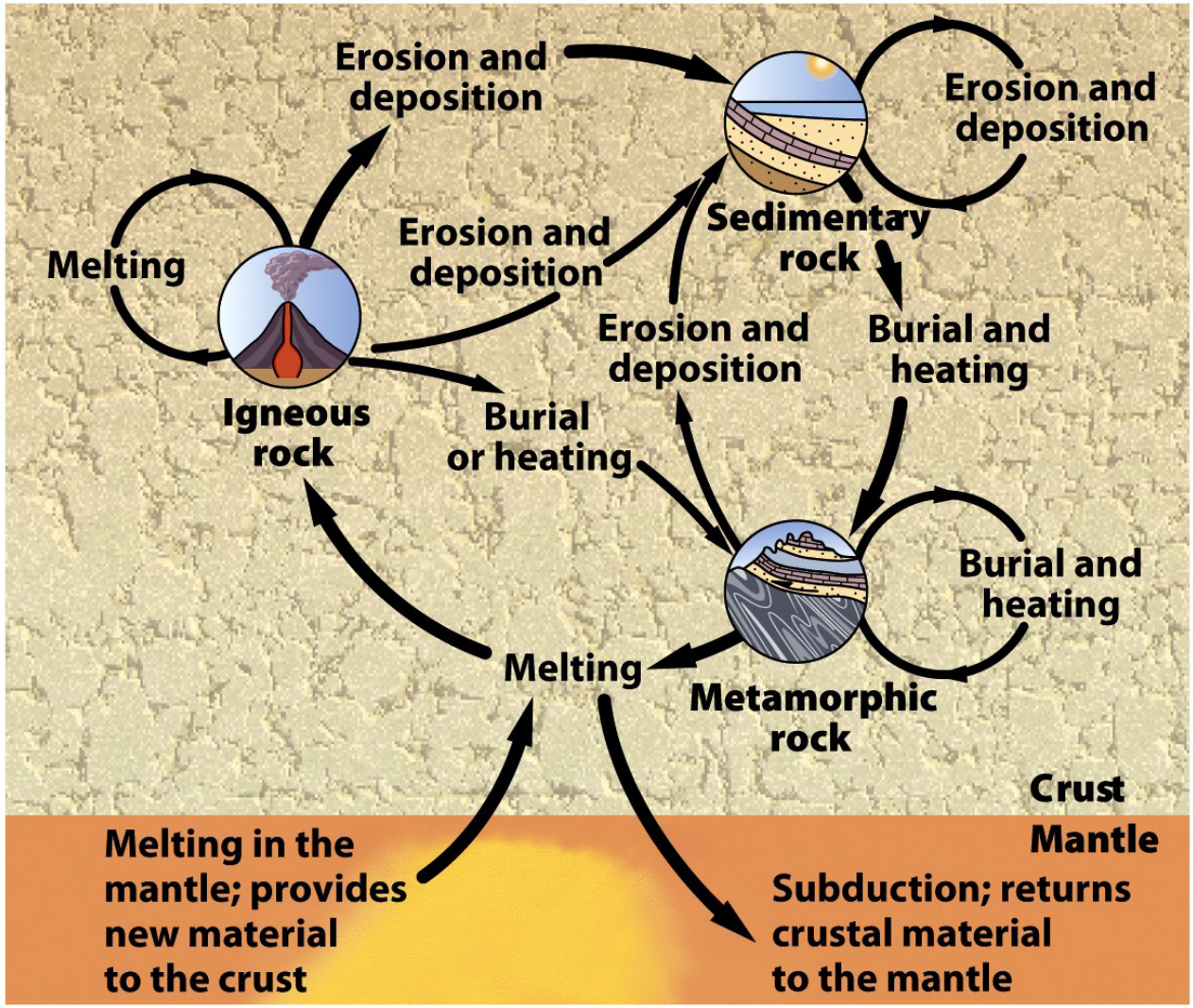
The rock cycle

The rock cycle explains the links between the three rock groups, and the **Earth processes** that contribute to their formation.

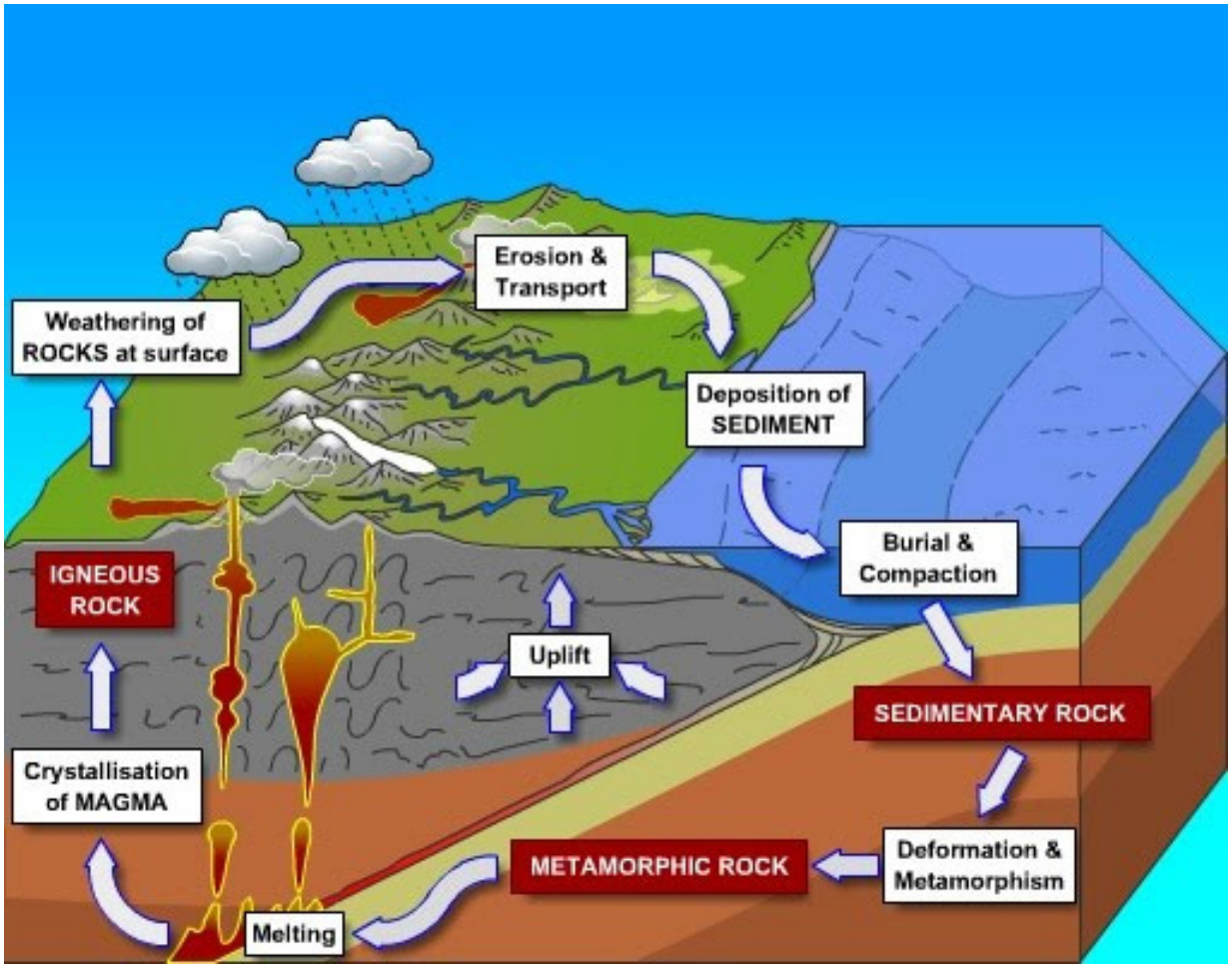
But what is the relationship of rock formation to **plate tectonics**?



The rock cycle

Each rock group forms in a variety of distinctive **tectonic settings**.

The settings are linked by **geological processes** which control rock and sediment transport, including burial, subduction, uplift, weathering and erosion.



http://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle.html