

Metamorphic Rocks – Teacher Notes

Metamorphic rocks were once sedimentary, igneous, or metamorphic rocks that have been heated and put under pressure, which fundamentally changed the rock into a new metamorphic rock. The original rock is sometimes called a 'protolith' which comes from Greek; *proto* means 'first' and *lithos* means 'rock'. A cake undergoes a similar process: the batter (protolith) is heated until it changes both physically and chemically. Metamorphism depends on the minerals in the protolith, the amount of water present in those minerals, and the amount of heat and pressure the rock experiences.

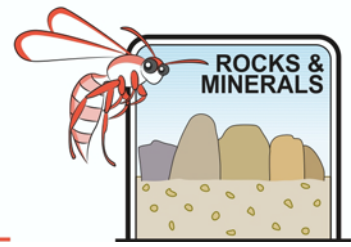
Igneous vs. Metamorphic

Metamorphic rocks and igneous rocks both have crystals. **How do we tell them apart?**

Igneous rocks are made entirely of intergrown crystals, whilst metamorphic rocks have crystals but are NOT entirely intergrown, their crystals are often aligned.

Below is a close-up picture of an igneous rock and a metamorphic rock. Decide if it is an igneous or metamorphic rock and give reasons for your decision









Rock	Metamorphic or Igneous?
	Igneous (pegmatite) = intergrown crystals
	Metamorphic (gneiss) = aligned or banded crystals
	Igneous (gabbro) = intergrown crystals

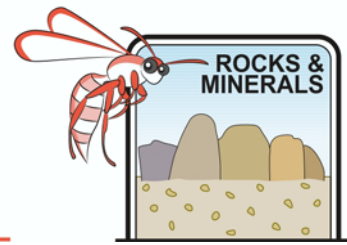


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Baking Rocks

Below are some examples of sedimentary or igneous rocks, and what kind of metamorphic rock they can become. In the third column, list some differences between the original rock (a.k.a., the protolith) and the metamorphic rock.

Protolith	Metamorphic rock	Differences
Mudstone 	Slate – roof tile 	Layers Colour change Slightly shiny Gold crystals (pyrite)
Limestone – block wall in a garden 	Marble – countertop in a kitchen 	Crystals Colour change
Sandstone – hand specimen 	Quartzite 	Layers changed Colour change Crystals
Schist – hand specimen 	Gneiss 	Crystals formed bands Colour change



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Temperature and Pressure

Metamorphic rocks require high temperatures to form. What are some sources of heat for metamorphism on Earth?

Dykes – intrusions of magma into rocks

Depth in Earth's crust, caused by the rocks being buried

Mountain forming processes

Rocks start to metamorphose at temperatures around 150°C to 200°C.

What temperature is a very hot day in Perth? ~40-45 degrees celcius

What temperature does water boil at? 100 degrees celcius

What temperature is needed to bake a cake? ~180 degrees celcius

Your kitchen oven probably reaches temperatures of 150°C to 200°C. Could you metamorphose a rock in your kitchen oven?

No, you also need pressure to metamorphose a rock, not just temperature.

The temperature at which a rock begins to melt depends on how much water is present in the rock.

Which melts first: rocks with lots of water, or rocks with no water?

Water lowers the melting temperature of rocks, so rocks with lots of water will melt sooner than rocks with no water.

Metamorphic rocks also require high pressures to form. Rocks start to metamorphose at pressures above 3000 bars (a bar is a unit of pressure you may learn about in physics or chemistry class). To compare, right now you are feeling the pressure of Earth's atmosphere, which is about 1 bar. Where do rocks experience high pressures on Earth?

Underground, beneath 5-20kms of overlying rock. The weight of the overlying rock creates the high pressures necessary for metamorphism.