Geology - The Basics

A Few Definitions

A mineral is any naturally formed inorganic solid that has a specific chemical composition and a distinct crystal structure. It is a chemical or molecule made from elements or atoms of the periodic table.

Important points to note: minerals have a specific composition, e.g. quartz SiO_2. They have an individual crystal structure based upon the chemical structure. There are over 4000 different minerals, but luckily we tend to encounter 10 to 20 common ones.

A rock is a naturally formed coherent solid mass of one or more minerals. One or many minerals can form a rock.

Rock Types

There are 3 basic rock types; sedimentary, metamorphic, and igneous. These definitions are manmade and there is some overlap, as the boundaries are a bit fuzzy. Is coal a sedimentary rock formed by the deposition and compression of plant material, or is it metamorphic, that is undergone some change due to pressure? Rock type is the first thing to consider when looking at a rock.

Sedimentary rocks are made of particles that are compressed or glued together to form a rock. The particles can be any size, of one or many types, from microscopic clay particles to large boulders left in a moraine by a glacier. The particles may be cemented together or not. Sedimentary means aggradation or compaction. It comes from the Latin word which means settling down.

Metamorphic rocks are made from another rock by the effects of heat, pressure, water or chemicals or a combination of these. Metamorphism changes the texture and often the minerals, but basic elements making up the rock are usually the same. Metamorphic comes from meta meaning change, and morph meaning shape. The original rock changes in mineral content and structure to another.

Igneous rocks are formed in a variety of ways from originally molten rock. The word "ignis" means fire. They are composed of crystals growing as the molten rock solidifies.

So in summary the formation of the rock determines the type of rock produced and the features it has.

The Rock Cycle

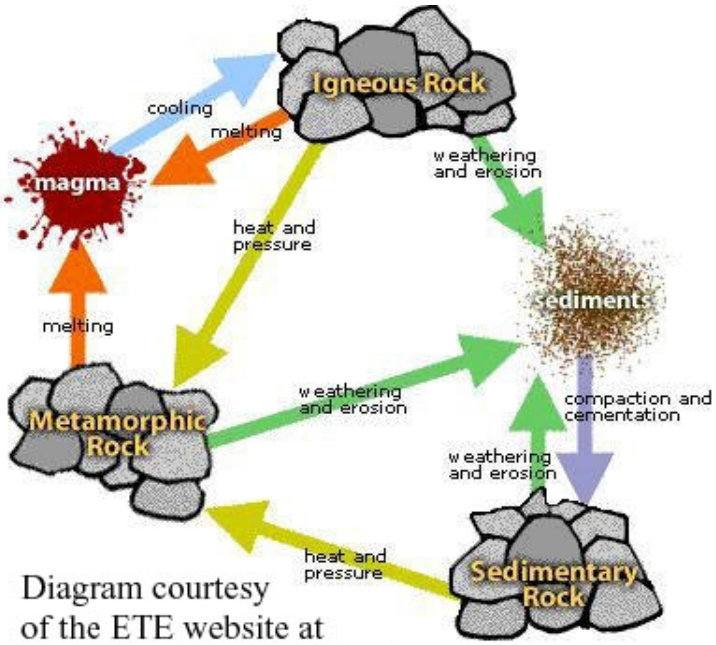

Diagram courtesy of the ETE website at http://davem2.cotf.edu/ete/modules/msese/earthsysflr/rock.html

The Earth isn't just blue, it's also green, as it is the ultimate recycling machine. Nothing leaves, excepts a bit of gas from the edge of the atmosphere and the occasional space rocket, and matter doesn't get created here, so everything must be recycled.

Igneous rocks forming a chain of volcanoes on the edge of Gondwana got ground down into sediment by rivers and carried to the sea, and deposited onto the sea bed. Over time the sediment gets buried, and is compacted into rock, such as mudstone. If the rock is buried deep enough, and subjected to heat and pressure, it may change or metamorphose into schist. This is the underlying story of the South Island of New Zealand.

Igneous Rocks

Igneous rocks are formed from the cooling and solidification of molten rock. Magma is molten rock occurring under the ground, lava is molten rock extruded onto the surface. Igneous rocks occur everywhere in and on the Earth. They are always associated with volcanism. Most of the continental plates and many areas of mountain building contain igneous rocks. Large igneous provinces are lava extruded in vast quantities on land and under the sea. They have sometimes played a part in the big extinction events in earth's history.

There is a huge variety of igneous rocks, over 700 different types. Common examples include; andesite, basalt, diorite, gabbro, granite, obsidian, pumice and rhyolite. Igneous rocks come in many colours and names, and have lots of terminology describing them. All igneous rocks have a distinct texture of random interlocking crystals that reflects their origin by crystallisation of molten rock.

The basic types of igneous rocks are based on where they form. Extrusive or volcanic rocks are originally extruded onto the surface, often from volcanoes. They undergo rapid cooling, so form small crystals. Intrusive or plutonic rocks form in the ground, intrude in the crust from deeper parts of the Earth. They undergo slow cooling so form large crystals. So different types of igneous rocks contain similar chemicals which controls the minerals formed but the different environment of formation controls the texture or crystal size.

The classification of igneous rocks is based on the texture or crystal size, and the mineral composition. To identify an igneous rock first determine the texture then determine mineral content. But classification is difficult because there is so much variety and fine grained or small crystal sizes makes identification hard. Geologists use light microscopy and mass spectrometers to aid identification.

1. Texture or Crystal Size. Coarse grained igneous rocks have crystals visible to the naked eye which are greater than 2 mm in size. They are intrusive or plutonic, so have cooled slowly. Fine grained igneous rocks have crystals smaller than 2 mm, usually requiring magnification to identify them. They are extrusive or volcanic in origin and so are fast cooling.

Some special terminology includes: pegmatites which are intrusive igneous rocks with exceptionally large crystals, greater than 2cm in size. A porphyry or a porphyritic rock is an intrusive rock consisting of large-grained crystals in a fine-grained/small crystal matrix or groundmass. The larger crystals are called phenocrysts.

Of course there are always special cases. Glassy rocks are ones quenched or undergo very rapid cooling. There is no time for crystals to form, so they are glassy, and have conchoidal fracture, like a block of glass. Obsidian is the common example, and is also called volcanic glass. Pumice is a type of frothy rough textured glass full of gas bubbles or vesicules.

2. Mineral composition. The next step in igneous classification is to identify minerals and quantify their proportions. A few common minerals are important to know about, including; quartz, feldspars, micas, pyroxenes, amphiboles, and olivine.

Common Minerals in Igneous Rocks

Quartz is SiO_2. It forms 6 sided prisms ending in a 6 sided pyramid and comes in many types due to different impurities. It is found in all rock types and is the second most abundant mineral on Earth. Quartz has various colours, ranging from colourless through to glassy black and has a conchoidal fracture when broken. It is a hard mineral with Moh hardness of 7.

Feldspars are a large varied group ranging in chemical composition($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$). They are the most common mineral on Earth, comprising 60% of all minerals. Colours include pink, white, gray, and brown. Common examples are potassium/orthoclase and plagioclase feldspars. They are a bit softer than quartz with a Moh hardness of 6-6.5.

Micas are sheet silicate, with a perfect cleavage in 1 plane, meaning they form sheets. Chemical composition is varied $X_2Y_{4-6}Z_8O_{20}(OH,F)_4$ in which X, Y and z are different elements.

Pyroxenes have a complex structure allowing for much variation. They show cleavage 2 planes at 90 degrees, have square cross sections and dark colours, are short & stubby, and have a Moh 5-7. Augite is a common example.

Amphiboles are long prisms or needles, with a lozenge or diamond cross section, that cleaves in 2 planes at 120 degrees. Hornblende (black), and actinolite (green) are found in NZ.

Olivines are green, have no cleavage, but show a concoidal fracture like glass. They have a hexagonal cross section and common in basalt or dunite.

Common Igneous Rocks

Common examples of igneous rocks found in New Zealand include andesite, basalt, granite, obsidian, and rhyolite.

Andesite is a gray, purple, green extrusive or fine grained rock. Found in Mt Taranaki and Mt Edgcumbe. It is often porphyritic, and contains amphibole, pyroxene, plagioclase feldspar, but no quartz.

Basalt is a black, dark gray extrusive or fine grained rock. It is found in the Auckland Volcanic Field, Dunedin, volcanoes of the east coast of the South Island and the Chathams Islands. It forms most of the oceanic crust. It contains feldspars, pyroxenes, olivine, but no quartz.

Granite is usually coloured white, gray, pink. It is an intrusive, coarse grained rock found in Stewart Island and the West Coast. It contains quartz, feldspars (potassium, plagioclase), and mica. It forms continental crust, batholiths or massive intrusions of magma and mountains. Karamea Granite is a common example.

Obsidian is black, red, or brown glassy rock. An extrusive rock that cooled very quickly without forming crystals. It is found in the Taupo Volcanic Zone and Coromandel. It is the equivalent to granite and rhyolite.

Rhyolites have pale colours (light gray, yellow, red), are extrusive or fine grained rocks that occur in the Taupo Volcanic Zone and Coromandel. Banded and spherolytic forms are found. They are the extrusive equivalent of granite.

A number of different processes are involved with the formation of magma, resulting in many types of igneous rock. Firstly, magma may be derived from different source rocks deep inside the Earth. When originally solid rocks melts, only some of the constituent minerals may melt, due to differences in the melting points of the minerals making up the magma, this is partial melting. Magmas may incorporate or assimilate parts of the solid rock it moves through on its ascent to the Earth's surface. Magmas from different sources in the Earth may mix together. And finally, when the magma solidifies , different liquid minerals may solidify into crystals at different temperatures met as the magma slowly cools. The higher density minerals may settle out and the lighter density liquid move on, and undergo further crystallisation as it cools, producing a different set of minerals.

Knowing how to identify and describe an igneous rock in the hand, helps us understand how the rock formed and where it fits into the bigger picture of plate tectonics.