Geology for Rock Art Recording

An understanding of basic geology is valuable for Rock Art Recording. Appreciation of the variety of natural geological forms allows identification of rock types, helps carved motifs to be distinguished from natural features, and provides a basis for assessing both the current condition and identification of potential threats to the rock surface.

Scientists classify rocks into three main groups, according to how they were formed. The first rocks to form were **igneous** rocks. These crystallised from molten magma (underground) or lava (on the surface). Igneous rocks were then weathered and eroded over many years. They broke down into tiny particles, becoming sands or muds which were eventually laid down in layers to form **sedimentary** rocks. These may be altered by extreme heat from magma or lava or by pressure and heat deep underground. They then become transformed into **metamorphic** rocks.

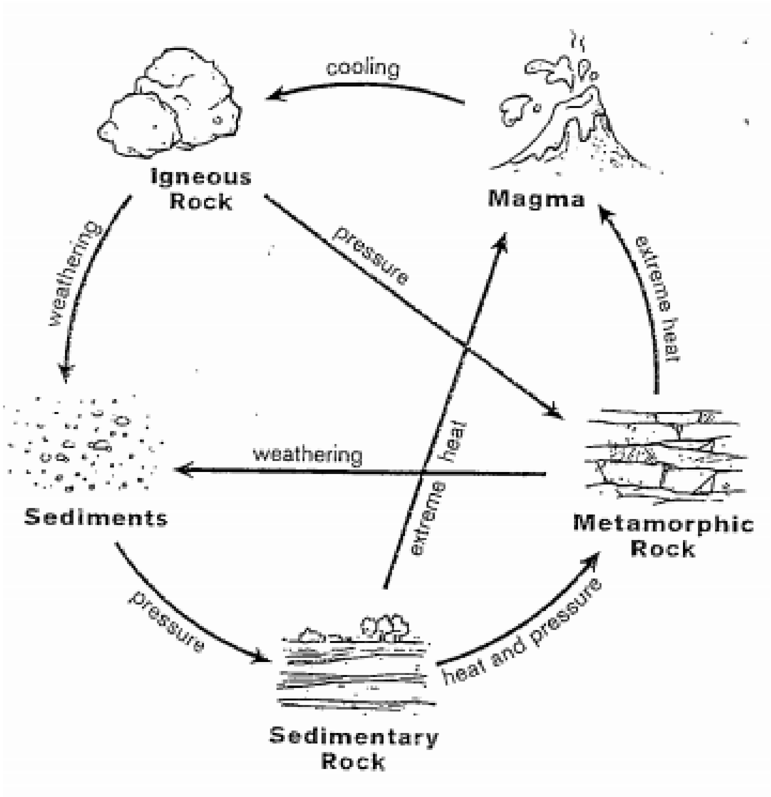


Diagram illustrating the cycle of how rocks are transformed over time.

ROCK IDENTIFICATION TIPS

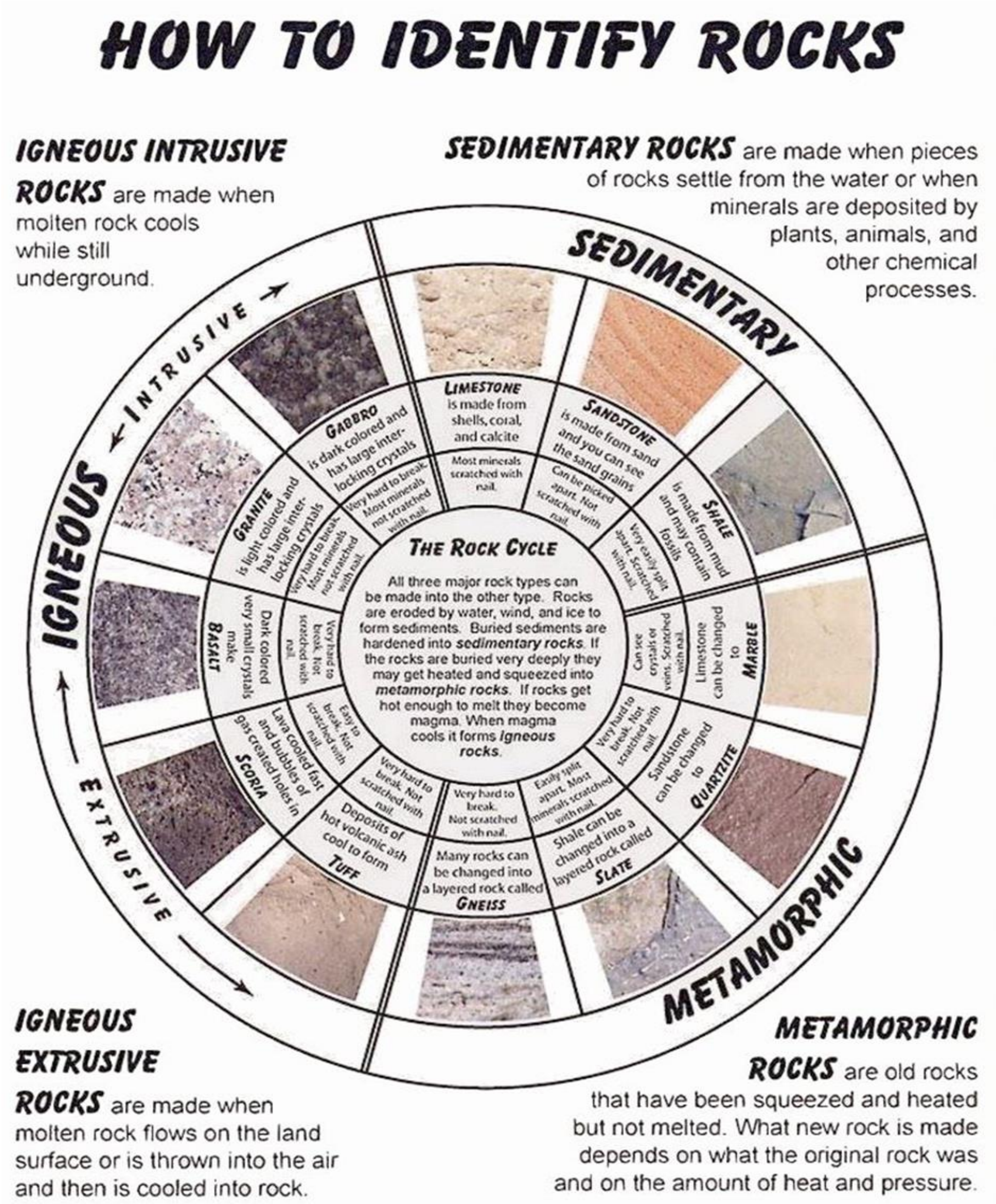
1. **First of all, try to find out whether the rock is igneous, sedimentary or metamorphic. You can do this by assessing the following:**

- **Igneous rocks** are **tough**, frozen melts with **little texture or layering**; mostly **black**, **white** and/or **grey minerals**. They often look like granite.
- **Sedimentary rocks** are **hardened** sediments with **sandy** or **clay-like layers**; mostly **brown** to **grey in colour**. They may have **fossils** and **water or wind marks**.
- **Metamorphic rocks** are **tough**, with **straight or curved layers** (foliation) of **light and dark minerals**; they come in **various colours**. They are often **glittery with mica**.

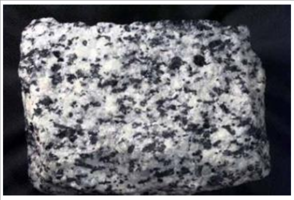
2. **Next, check your rock's grain size and hardness**

- **Grain Size**: "Coarse" grains are visible to the naked eye, and the minerals can usually be identified using a magnifier; "fine" grains are smaller and usually cannot be identified with a magnifier.
- **Hardness:** Hardness (as measured with the Mohs scale) actually refers to minerals rather than rocks, so a rock may be crumbly yet consist of hard minerals. But in simple terms, "hard" rock scratches glass and steel, usually signifying the minerals quartz or feldspar (Mohs hardness 6 to 7 and up); "soft" rock does not scratch a steel knife but scratches fingernails (Mohs 3 to 5.5); "very soft" rock does not scratch fingernails (Mohs 1 to 2). Igneous rocks are always hard. Metamorphic rocks are generally hard.

3. **Now use the tables provided in the following pages to confirm your finds.**



Igneous Rock Identification

Grain Size	Hardness	Usual Colour	Composition	Other	Rock Type	Picture
fine or mixed	Medium	Black, brown, grey	low-silica lava	has no quartz; opaque rock	**Basalt**	
coarse	Hard	Black, grey, orange, pink, white	feldspar and quartz with minor mica, amphibole or pyroxene	It has a veined o pebbled appearance; granular texture	**Granite**	
coarse	Hard	Black, brown, grey, white	low-calcium plagioclase and dark minerals	little or no quartz; shinny appearance	**Diorite**	
coarse	Hard	Dark grey to black	high-calcium plagioclase and dark minerals	no quartz; may have olivine; opaque rock	**Gabbro**	

Sedimentary Rock Identification

Grain Size	Hardness	Usual Colour	Composition	Other	Rock Type	Picture
Coarse (sand sized; visible to the naked eye)	Soft to hard (variable)	Grey, yellow, red to white	clean quartz	Gritty to touch	**Sandstone**	
Mixed (visible to the naked eye)	Soft to hard (variable)	Grey to black	mixed sediment with rock grains and clay	Often with quartz veins	**Wacke/ Graywacke**	
Mixed (easily visible to the naked eye)	Soft to hard (variable)	Variable (dependent on the clast and matrix composition)	mixed rocks and sediment	round rocks in finer sediment matrix, may appear shiny	**Conglomerate**	
Fine	Medium	Beige, black, blue, brown, cream, green, grey, red, pink, white, yellow	calcite	fizzes with acid; opaque rock; rough appearance	**Limestone**	

Metamorphic Rock Identification

Foliation	Grain Size	Hardness	Usual Colour	Other	Rock Type	Picture
foliated	fine	Medium	Black, brown, buff, green, purple, red, shades of blue	strong cleavage; opaque rock; dull appearance	***Slate***	
foliated	Coarse, but also fine to medium grains	Medium	Black, blue, brown, green, grey, silver	wrinkled foliation; often has large crystals	***Schist***	
foliated	Coarse, but also medium grains	Hard	Black, brown, pink, red, white	banded	***Gneiss***	
Non-foliated	Medium grained rock	Medium	Black, blue, brown, grey, pink, white	Opaque rock; granular texture	***Marble***	
Non-foliated	Medium grained rock	Hard	Black, blue, brown, green, grey, purple, white, yellow	quartz (no fizzing with acid); granular texture.	***Quartzite***	

Characteristics of Main Rock Types

Igneous Rocks

Igneous rock forms when magma (molten rock) cools and solidifies, being composed of a mosaic of mineral crystals forming without layers. **Extrusive** igneous (i.e. basalt) rocks are those formed when magma reaches the surface (at which point it is called lava), cooling and solidifying quickly. **Intrusive** igneous (i.e. granite) rocks are formed when magma slowly cools deep below the surface of the earth. Different sized grains form, depending on the conditions of the rock formation. Intrusive rocks are generally more coarse-grained than extrusive.

Some of the most relevant igneous rocks in Scotland, and their main characteristics include:

- ✓ <u>**Basalt**</u>
  Rock Type: igneous (extrusive/volcanic)
  Composition: feldspar, olivine, pyroxene, amphibole
  Texture:
  Grain size: fine

Colour: red-brown to black
Equivalent to: Gabbro (intrusive/plutonic)
Environment: Basalt is solidified lava, like rhyolite. However, it flows much quicker because it is less viscous. The Hawaiian Islands are made of basaltic lava. The ocean floor is also mostly basalt.
Distinguishing Characteristics: red-brown to black, frothy with small visible holes where gas escaped while the lava cooled.
Uses: Basalt is crushed and used as crushed stone, concrete aggregate and railroad ballast. Basalt fibres are used in the production of high quality textile fibres, floor tiles, basalt plastic reinforcement bars, basalt fibre roofing felt and glass wool (fibre glass).

✓ **Gabbro**
Rock Type: igneous (intrusive/plutonic)
Composition: feldspar, olivine, pyroxene, amphibole (mafic)
Texture: coarse
Grain Size= 1mm to 10mm
Colour: dark grey-black
Equivalent to: Basalt (extrusive/volcanic)
Environment: Gabbro is formed by magma that cools very slowly into hard rock below or within the Earth's crust.
Distinguishing Characteristics: dark grey-black, shiny surfaces of feldspar are visible.
Uses: Gabbro is too fragile to use in construction. Often chromium, nickel and platinum occur in association with Gabbro.

✓ **Granite**
Rock Type: igneous (intrusive/plutonic)
Composition: feldspar, quartz, mica, hornblend (felsic)
Texture: coarse
Grain Size: 1 mm to 10 mm
Colour: Black, grey, orange, pink, white
Equivalent to: rhyolite (extrusive/volcanic)
Environment: Granite is formed by magma that cools very slowly into hard rock below or within the Earth's crust.
Distinguishing Characteristics: Visible crystals of pink feldspar, white or grey quartz, and black mica. There is no horizontal banding in granite.
Uses: Granite is used for kitchen countertops and as a decorative building material. Granite is not fire-safe because it can crack in high heat.

Sedimentary Rocks

Sedimentary rocks form when layers of sand and pebbles are compressed enough to form a rock, being one of their main characteristics. They are formed from particles eroded from pre-existing rocks, transported by rivers, winds, glaciers and gravity. As layers build up the weight and pressure squeezes out water and packs the particles together. Mineral enriched fluids may seep into any spaces left by the water. These form natural cements binding the particles together. Common cements include calcite (calcium carbonate) present in limestone and quartz (silicon dioxide), which is common in many types of sandstone. Many types of sediment undergo colour changes as they harden. Iron compounds seeping into the pore spaces may colour sandstone red or yellow.
Whilst sedimentary rocks are formed, namely limestone, fossils are often preserved within the layers. This is because limestone is formed in warm, shallow seas and organisms and shells get fossilized at the bottom.

There are three different grain sizes in sedimentary rock. Coarse which you can see with the naked eye. Medium which you can see with a hand lens, and fine which you can see with a microscope.

Some of the most relevant sedimentary rocks in Scotland, and their main characteristics include:

- ✓ **<u>Conglomerate</u>**
  Rock Type: sedimentary
  Composition: fragments of other rocks and minerals cemented by silica, calcite, or iron oxide.
  Texture: clastic (fragmental)
  Grain Size: pebbles, cobbles and/or boulders embedded in sand, silt and/or clay
  Colour: Dark-grey
  Environment: The rock fragments can be rounded from being rolled along a stream bed or a beach **during** transportation. If the fragments embedded in the matrix are angular instead of rounded, the rock is called a breccia (pronounced BRECH-i-a).
  Distinguishing Characteristics: dark grey with imbedded fragments
  Uses: conglomerate is used in the construction industry

- ✓ **<u>Greywacke or Wacke</u>**
  Rock Type: sedimentary
  Composition: mixture of grains o sand, silt and clay size. May contain quartz and other delicate minerals and small fragments of rocks (lithics).
  Texture: Clastic
  Grain Size: Fine grained rock
  Colour: Beige, black, brown, colourless, cream, dark brown, green, grey, light green, light to dark grey, pink, red, white, yellow
  Environment: Greywacke is defined as a dark coarse-gained sandstone rock, which contains more than 15% clay.
  Distinguishing Characteristics: Wacke is a name for a poorly sorted sandsone. Greyeacke is a specific type of wacke. Its grains are not well rounded.
  Uses:

- ✓ **<u>Limestone</u>**
  Rock Type: sedimentary
  Composition: mostly calcite
  Texture: chalky texture (bioclastic)
  Grain Size: microscopic to coarse
  Colour: white/grey
  Environment: There are several ways for limestone to form. Calcite dissolves easily in warm water but when the concentration reaches a certain threshold, the calcite comes out of solution and is deposited on the sea floor as a chemical precipitate. The precipitates can build up along with other sediments or on their own and eventually form limestone. Another way for limestone to form is by the build up of the shells and skeletons of marine animals.
  Distinguishing Characteristics: cemented shell fragments or precipitates of biologic origin may occur.
  Uses: This highly pure limestone is used as flux in the steel making process and is used in the production of glass. Other applications include paper production, sugar refining, acid lake treatment and flue gas desulphurisation. Limestone has construction, agricultural and automotive applications. It is also supplied to feed mills and chicken farmers.

- ✓ **<u>Sandstone</u>**
  Rock Type: sedimentary
  Composition: grains of sand that can be feldspar or quartz and minerals in less quantities (i.e.

clays, hematite, ilmenite, amphibole and mica). The amount of other minerals such as mica, depend on how much weathering has occurred. May contain fragments of other rocks.
Texture: clastic (fragmental)
Grain Size: sand (0.2 to 0.600g cm)
Colour: Depending on the cement, he colour may range from nearly white to nearly black, with beige, grey, brown, red, pink and bluff in between.
Environment: Already existing rocks are eroded and the grains are transported and sorted by rivers. The resulting sand is deposited on beaches, along floodplains or in deltas, where it is eventually buried by other sediments. This causes a slow squeezing of the sediments. As the sediments are compacted, fine clay helps to fuse the larger particles together. The sediments are also cemented by chemicals (usually silica, calcium carbonate or iron oxide) left by the water in the original sediment. These may infiltrate the matrix and bind i together, r they may ill he spaces where there is no matrix. The presence of sandstone indicates that there was water with fairly high energy (waves on a beach or a fast moving river)
Distinguishing Characteristics: Coarse to very fine grains, beige to grey colour, feels like sandpaper.
Uses: Sandstone is used for flagstone to line your walkway or patio. It is also an important building stone.

- ✓ <u>**Shale**</u>
  Rock Type: sedimentary
  Composition: mostly quartz, feldspar and clay minerals. May contain fragments of other rocks.
  Texture: Smooth **-** clastic (fragmental)
  Grain Size: clay (less than 0.0004 cm)
  Colour: Black, brown, buff, green, grey, red, yellow
  Environment: Shale sediments are deposited in still water (low energy) such as a lake or a deep, slow river.
  Distinguishing Characteristics: dull, reddish- brown, very fine grains (smooth to the touch), breaks easily. If an edge is dipped in water and drawn along a surface, shale will leave a muddy streak.
  Uses: Shale is used for a number of architectural arrangements but also in cement manufacture.

METAMORPHIC ROCKS

Metamorphic rocks form when rocks are subjected o heat and pressure, but not to the point of melting. Depending on whether it was formed under just heat or heat and pressure, the orientation of the crystals will be different. Contact metamorphic rocks are formed in just heat and crystals are randomly arranged. Regional metamorphic rocks are formed in both heat and pressure, and have crystals that are aligned. The greater the pressure and temperature these rocks are exposed to, he larger the grains. Regional metamorphism occurs when mountain building, associated with the movement of the Earth's crust takes place and changes may take tens of millions of years.
Rocks formed in this way are recognisable by their texture: due to the stresses in the rock, minerals are streaked out in layers.

Some of the most relevant metamorphic rocks in Scotland, and their main characteristics include:

- ✓ <u>**Gneiss**</u>
  Rock Type: metamorphic
  Composition: quartz, feldspar, mica, amphibole, garnet, pyroxene
  Original Rock: granite, gabbro
  Type of Metamorphism: Regional – high-grade metamorphism, some mica changed to feldspar, segregated by mineral type into bands.

Texture: foliated (banding)
Grain Size: medium to coarse
Colour: Black, brown, pink, red, white
Environment: Gneiss forms at high temperatures and pressures. A sedimentary or igneous rock has been buried and subjected to high temperatures and pressures. The temperature needed is about 700°C and the pressure needs to be about 12-15 kilo bars, which is at a depth of about 40 km! Nearly all traces of he original structure (including fossils) and fabric (such as layering and ripple marks) are wiped out as the minerals migrate and recrystalize.
Distinguishing Characteristics: banded with alternating layers of dark and light minerals. The streaks contain minerals such as hornblende, that do not occur in sedimentary rocks. Unlike schist, gneiss does no fracture along the planes of the mineral streaks. Thicker veins or large-grained minerals form in it, unlike the more evenly layers appearance of schist.
Despite its highly altered nature, gneiss can preserve chemical evidence of its history, especially in minerals like zircon which resist metamorphism.
Uses: Gneiss is used in construction, aggregate and for ornamental purposes.

- ✓ **<u>Marble</u>**
Rock Type: metamorphic
Composition: very pure, recrystallized calcite and/or dolomite
Original Rock: limestone or dolostone
Type of Metamorphism: Regional or contact (metamorphism of limestone or dolostone, causing heir microscopic grains to combine into larger crystals)
Texture: non-foliated
Grain Size: fine to coarse
Colour: From white to black, ranging through the warmer colours in between, depending on the other mineral impurities.
Environment: Marble forms at many temperatures and pressures**.**
Distinguishing Characteristics: medium to coarser grained, light coloured and calcite crystals may be visible. Holding these samples up to the light and slowly turning them will reveal a slight sparkle.
Uses: Marble is used for construction, countertops, and carvings, and may be a source for magnesium.

- ✓ **<u>Quartzite</u>**
Rock Type: metamorphic
Composition: recrystallized quartz grains
Original Rock: sandstone or chert
Type of Metamorphism: Regional or Contact (metamorphism of quartz and sandstone)
Texture: non-foliated
Grain Size: fine to coarse
Colour: light grey or white
Environment: Quartzite forms at many temperatures and pressures. There are two main ways in which this rock forms. In some occasions, sandstone or chert recrystallize resulting in a metamorphic rock under the pressures and temperatures of deep burial. A quartzite in which all traces of the original grains and sedimentary structures are erased may also be called *metaquartzite.*
The second method involved sandstone at low pressures and temperatures, where circulating fluids fill the spaces between sand grains with silica cement. This kind of quartzite is also called *orthoquartzite* but it is considered o be a sedimentary rather than metamorphic rock, since the original mineral grains are still there and bedding planes and other sedimentary structures are still evident.
Distinguishing Characteristics: medium grained, very hard. The traditional way to distinguish quartzite from sandstone is by viewing quartzite's fractures across or through the grains:

sandstone splits between them.
Uses: Quartzite is the raw material for the glass and ceramics industries.

- ✓ **Schist**
  Rock Type: Metamorphic
  Composition: mica, quartz, feldspar, amphibole, garnet
  Original Rock:
  Type of Metamorphism: Regional Metamorphism
  Texture: foliated (mineral alignment)
  Grain Size: fine to medium
  Colour: Black, blue, brown, dark brown, green, grey, silver
  Environment: There are many types of schist. However, the main characteristic is the fact that is splits into thin layers (the word *Schist* comes from the ancient Greek for 'split). It is formed by dynamic metamorphism at high temperatures and high pressures that aligns he grains of mica, hornblende and other flat or elongated minerals into thin layers or foliation.
  Distinguishing Characteristics: Schist is commonly described in terms of their predominant minerals. It splits into thin layers.
  Uses:

- ✓ **Slate**
  Rock Type: metamorphic
  Composition: mica and clay minerals
  Original Rock: shale
  Type of Metamorphism: Regional Metamorphism (low grade)
  Texture: foliated (mineral alignment)**;** smooth to the touch
  Grain Size: fine
  Colour: usually dark grey to black, but it can be colourful too.
  Environment: Slate forms from the heat and pressure when shale is buried deep in the crust. The depth of burial to make slate out of shale is about 10 km. The temperature at that depth is about 200°C.
  Distinguishing Characteristics: harder than shale, distinct layers are visible.
  Uses: slate is used in flooring and roofing materials. In the past, slate was used as chalkboards.

You can explore the geology of the area in which you are working using the British Geological Survey (BGS) online Geology of Britain Viewer (http://mapapps.bgs.ac.uk/geologyofbritain/home.html), or download the free 1:50k BGS maps:
http://www.bgs.ac.uk/data/maps/maps.cfc?method=listResults&mapName=&series=S50k&scale=&pageSize=100&

Mineral Identification Tips

Minerals are one class of chemical compounds, composed by several types of bonds between atoms, the building blocks for the world around us. For the purpose of rock study, we are mostly interested in Silicate Minerals, the most important mineral class as they are by far the most abundant rock-forming minerals.

The main rock-forming minerals are quartz, feldspars, micas, amphiboles, pyroxenes and olivine.

Here are a few of the minerals you are likely to encounter when looking at the structure of he carved rocks and heir main characteristics:

Luster	Hardness	Colour	Cleavage	Transparency	Mineral	Picture
Pearly, Vitreous	2.5 - 3	Black, dark brown, dark green	Basal	Translucent to opaque	*Biotite Mica*	
Vitreous, Resinous, Waxy, Pearly	3	Colourless, white, yellow, brown, orange, pink, red, blue, purple, gray, black	Perfect; Rhombohedral; three directions	Transparent, translucent	*Calcite*	
Vitreous to pearly	6	White, yellow, pink, orange, light blue, light green, brown, grey	Basal, Prismatic, Pinacoidal Cleavage is about 90 degrees	Transparent or opaque	*Feldspar*	
Pearl y	2.7-3	Colourless, white, beige, yellow, brown, grey, pink, purple, red, black	Perfect	Transparent to translucent	*Muscovite Mica*	
Vitreous	7	Colourless, white, purple, pink, brown, black. Grey, green, orange, yellow, blue, red.	None	Transparent to opaque	*Quartz*	

CHARACTERISICS OF MAIN MINERALS

- ✓ Biotite Mica
  Mineral type: Silicate Mineral
  Composition: iron-rich, magnesium (mafic)
  Luster: Vitreous, Pearly
  Hardness: 2.5 to 3
  Cleavage: basal cleavage
  Colour: black, dark green, dark brown
  Streak: white to grey, flakes often produced
  Transparency: Translucent to opaque. Thin flakes will always be translucent if held up to the light.
  Crystal System: Monoclinic
  Environment: Biotite is a common rock-forming mineral, and is especially noted in metamorphic rocks such as schist and gneiss. It is also found in igneous rock such as granites.
  Distinguishing Characteristics: Dark colour, perfect cleavage . Flaky habit, crystals. splits in thin, often transparent, flexible sheets. It occurs widely throughout many different rock types, adding gliter to schist, "pepper" in salt-and-pepper granite and darkness to sandstones.
  Diagnostic Properties:

- ✓ Calcite
  Mineral type: Carbonate Mineral
  Composition:
  Luster: Vitreous
  Hardness: 3
  Cleavage: Perfect, rhombohedral, three directions
  Colour: usually white but also colourless, grey, red, green, blue, yellow, brown and orange
  Streak: white
  Transparency: Transparent to opaque.
  Crystal System: Hexagonal
  Environment: Extremely common and found throughout the world in sedimentary, metamorphic and igneous rocks. The main constituent of limestone and marble.
  Distinguishing Characteristics: Hardness, cleavage, fluorescence and effervescence with hydrochloric acid.
  Diagnostic Properties:

- ✓ Feldspar (Orthoclase)
  Mineral type: Silicate Mineral
  Composition:
  Luster: Vitreous
  Hardness: 6 to 6.5
  Cleavage: 2,1 – basal; 2,1 – prismatic; 3,1 – pinacoidal. The cleavage angle is about 90 degrees.
  Colour: Usually white, pink, grey or brown. Also colourless, yellow, orange, red, black, blue, green.
  Streak: white
  Transparency: Transparent to opaque
  Crystal System: Blocky crystals
  Environment: Found in igneous, metamorphic and sedimentary rocks. They are important constituents of rocks such as granite, diorite, gabbro, basalt.
  Distinguishing Characteristics: Feldspar is the name of a large group of rock-forming silicate minerals that make up 0% of Earth's crust. Feldspar minerals have very similar structured, chemical compositions and physical properties. Orthoclase is one type of feldspar.
  Diagnostic Properties: Perfect cleavage, with cleavage faces usually intersecting at or close o 90 degrees. Consistent hardness, specific gravity and pearly luster on cleavage faces.

- ✓ Muscovite Mica
  Mineral type: Silicate Mineral
  Composition: High-aluminium
  Luster: Pearly to Vitreous
  Hardness: 2.5 to 3
  Cleavage: Perfect
  Colour: Thick specimens often appear to be black, brown or silver in colour. However, when split into thin sheets muscovite is colourless, sometimes with a tint of brown, yellow, green or rose.
  Streak: White
  Transparency: Transparent to translucent
  Crystal System: Monoclinic
  Environment: Muscovite is a common rock-forming mineral and is an important constituent in many environments. Present in igneous and metamorphic rocks.
  Distinguishing Characteristics: Together with biotite, it gives metamorphic rocks a glittery appearance. It also cleaves in thin transparent sheets.
  Diagnostic Properties: cleavage, colour, transparency; flaky habit.

- ✓ Quartz
  Mineral type: Silicate Mineral
  Composition:
  Luster: Vitreous
  Hardness: 7
  Cleavage: None – typically breaks with a conchoidal fracture
  Colour: Quartz occurs in almost every colour, the most common being clear, white, grey, purple, yellow, brown, black, pink, green and red.
  Streak: Colourless
  Transparency:
  Crystal System: Hexagonal
  Environment: The most abundant and widely distributed mineral found on Earth. Present and plentiful in all parts of the world. It forms at all temperatures and it is abundant in igneous, metamorphic and sedimentary rocks. It is the dominant mineral of mountaintops and the primary constituent of beach, river and desert sand.
  Distinguishing Characteristics: Hardness
  Diagnostic Properties: Conchoidal fracture, glossy luster, hardness

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GEOLOGICAL GLOSSARY

Abrasion Wearing down of rock surfaces by mineral and rock grains in transport.

Algae Plants that mostly grow in the sea. Most are microscopic organism that float around in the surface water (plankton).

Angular Word used to describe sediment gains that have not been much rounded off in transport.

Basal Cleavage Cleavage exhibited on a horizontal plane of the mineral by the way of its base. Minerals with basal cleavage can sometimes be “peeled” (i.e. micas).

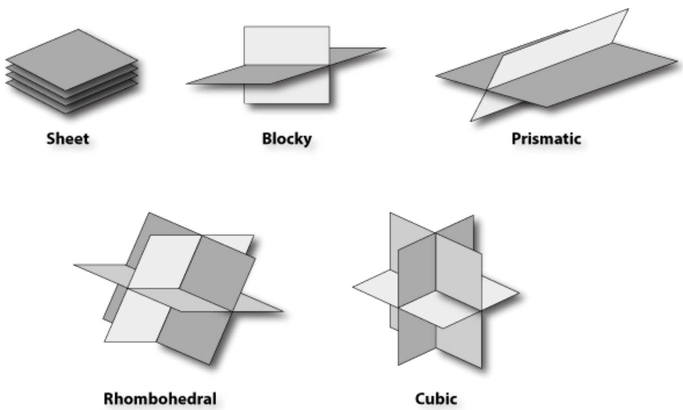
Batholith A large intrusion of igneous rock, usually granite, formed beneath the surface so the rock cooled very slowly.

Bedding/Bedding Planes Layering formed in sedimentary rocks as the ate of sediment deposition varies. Layer boundaries are called bedding planes.

Biological weathering Breakdown of rock (see weathering) by the action of bacteria, plants and animals.

Chemical Weathering Breakdown of rock (see weathering) by chemical reaction with air, water and dissolved acids.

Cleavage The splitting or tendency of a crystal to split along definite crystalline planes to produce smooth surfaces. It describes how a crystal breaks when subject to stress on a particular plane. A mineral that never produces any crystallized fragments when broken has no cleavage. Cleavage is often measured according to three factors: 1) Quality of Cleavage (perfect, good, poor, indiscernible, non); 2) Number of Sides Exhibiting Cleavage (1,2,3 or all directions); 3) Cleavage Habit (basal cleavage, cubic cleavage, octahedral cleavage, prismatic cleavage, pinicoidal cleavage, rhombohedral cleavage).



Colour: the most eye-catching feature of many minerals. Some minerals will always have a similar colour, such as Gold, whereas others, such as Quartz and Calcite, come in all colours. Some minerals exhibit a colour change when exposed to certain factors such as feat, light, radiation, etc.

Course-Grained a rock whose grains (crystals or sediment particles) are roughly pea-sized or larger.

Contact Metamorphism Metamorphism resulting from high temperatures close o an intrusion hot magma.

Cubic Cleavage Cleavage exhibited on minerals of the isometric crystal system that are crystallized as cubes. In this method of cleavage, small cubes evenly break off of an existing cube.

Fracture: Fracture is the characteristics mark left when a mineral chips of breaks. Cleavage and fracture differ in that cleavage is the break of a crystal face where a new face (resulting in a smooth plane) is formed, whereas fracture is the "chipping" shape of a mineral. All minerals exhibit fracture, even those that exhibit cleavage. If a mineral with cleavage is chipped a certain way, it will fracture rather than cleave. Fracture can be conchoidal, uneven, hackly, splintery, earthy or crumbly, even or smooth, subconcoidal.

Foliation Foliation refers to repetitive layering. *Foliated: a 'squashed' texture common in metamorphic rocks (e.g. schist) where crystals of plat minerals like mica lie in the same direction.

Grains (in rock)Mineral crystals or sediment particles that make up all rocks.

Hardness The resistance of an object to scrapes and scratching. The harder it is, the greater its resistance. It plays an important role in identifying a mineral and usually measured through the Mhos Scale, ranging from the softest mineral Talc (1) to the hardest one, Diamond (10).

HARDNESS SCALE	INDEX MINERAL	COMMON OBJECTS
1	Talk	
2	Gypsum	Fingernail
3	Calcite	
4	Fluorite	Copper Penny
5	Apatite	Glass
6	Orthoclase (Feldspar)	
7	Quartz	
8	Topaz	
9	Corundum	
10	Diamond	

Hydrolysis Weathering process where acidic rain water slowly reacts with many common rock-forming minerals to form clay and dissolve salts.

Intrusion (igneous) A body of igneous rock that cooled and crystallised from magma deep underground (see also sills, dykes and batholiths).

Joints Cracks (usually vertical) in rock caused by shrinkage o release of pressure as rocks above are eroded away.

Luster Luster refers to how light is reflected from the surface of a mineral. The two main types of luster are metallic or non-metallic.

- Vitreous: the luster of glass;
- Resinous: the luster of resin;
- Pearly: the luster of pearls;
- Greasy: looks like it is covered in a thin layer of oil;
- Silky: The luster of silk;
- Adamantine: a hard, brilliant luster

Medium-Grained A rock in which the grains (crystals or sediment particles) are large enough to see unaided, but smaller than pea-sized.

Metamorphism Process of changing rocks (minerals and texture) through heat and/or pressure.

Mineral Naturally-occurring chemical compound (e.g. calcium carbonate), often with a regular crystal structure. The ‘building blocks’ of rocks.

Octahedral Cleavage Cleavage exhibited on minerals of the isometric crystal system that the crystallized as octahedrons. In this method of cleavage, flat, triangular “wedges” peel off of an existing octahedron.

Oxidation A weathering process where iron-rich minerals (usually) react with air to form rusty-brown oxides.

Parting: Parting is characteristically similar to cleavage. It is easily confused with cleavage, and it may be present on minerals that do not exhibit any cleavage. There are two causes of parting: 1) two separate pressures pushed towards the centre of a crystal after its formation, causing the crystal interior to evenly dislodge on a flat, smooth plane; 2) twinned crystals that separated from one another, leaving a flat, smooth plane.

Physical Weathering Mechanical breakdown of rock material a the surface, e.g. by changes in temperature.

Pinicoidal Cleavage Cleavage exhibited on some prismatic and tabular minerals in which a crystal cleaves on the pinacoidal plane, which is the third dimension aside from the basal and prismatic sides.

Porous, Porosity Rock (usually sedimentary) with spaces between the grains, usually filled by groundwater. Porosity measures amount of pore space.

Prismatic Cleavage Cleavage exhibited on some prismatic minerals in which a crystal cleaves as thin, vertical, prismatic crystals off of the original prism.

Regional Metamorphism Metamorphism of rocks over large areas, usually resulting from both heat and pressure during plate collision and mountain-building.

Rhombohedral Cleavage Cleavage exhibited on minerals crystallizing in the hexagonal crystal system as rhombohedrons, in which small rhomboedrons break off of existing rhombohedron (i.e. calcite).

Rounded Word used to describe mineral grains and rock fragments that have become worn down by attrition during transport.

Sand Sediment particles from 0.1 to 2 mm diameter. Most sand grains are made of quartz, a very hard and chemically resistant mineral.

Sediment Material deposited by water, wind or ice. Includes pebbles, sand, mu, organic remains (e.g. shells) and salts left by evaporation.

Solution (weathering) Chemical weathering process where water (usually slightly acidic) dissolves away rock material, especially limestone.

Strata Layers of rock formed by deposition of sediment (and sometimes lava and pyoclastic material).

Streak Streak is the colour of a crushed mineral's powder. A mineral's powder may differ from the actual colour of the mineral. This property can be used for mineral identification.

Texture (of rocks) Describes grain sized (coarse/medium/fine). Shapes (rounded/angular) and relationships (e.g. crystalline/fragmental) in rocks.

Transparency The amount of light to be passed through a mineral. Light is able to pass through transparent minerals. It can be used for mineral identification.

Transport Movement of sediment by water, wind or glacier ice.

Weathering Slow breakdown of rock at the Earth's surface, due to climatic and biological processes.

ROCK ART AND GEOLOGY

An appreciation of the processes which create rocks and affect their current condition, and a familiarity with the results of these in the field, are helpful for rock art researchers. It is important to be able to identify natural markings and distinguish them from motifs.

Rock art can occur in a number of different types of rocks. In Scotland, a great number of carvings will be found depicted on **sandstone**. However, motifs also occur on harder **igneous** and **metamorphic** rocks, such as **schists** and **wackes** and even in **granite** and **gabbro**.

Natural Features

The rock surface which we view today is a product of many processes, from the formation of the rock itself to the action of natural elements such as water, ice and temperature. Evidence of all these may be present on the rock alongside any carved motifs; sometimes it is very difficult to distinguish natural marks from those which were added by prehistoric people. Indeed, some natural features appear to have been enhanced by pecking, or incorporated into designs. Some researchers believe that the presence of natural, geological features may have stimulated the addition of carved motifs.

Fissures and cracks

Research suggests that the presence of fissures, and the type of 'frames' they form may influence the nature of the motifs applied to the rock surface. Prehistoric carvers did not always choose a smooth 'canvas' and on some panels the fissures appear to have been an integral part of the design. Fissures may be the result of mechanical weathering, when water in the joints of the rock freezes and expands, or may result from the pressure of tree roots breaking up bedrock.

Natural Hollows

Although prehistoric people may not have distinguished between carved and natural markings it is important that we are able to tell them apart. One of the most difficult motifs to confirm as artificial is the simple cup-mark. Natural hollows which look like cup-marks can occur in both igneous and sedimentary rocks through different processes. Many igneous rocks, especially lavas that cool on the Earth's surface, contain large amounts of gas. The bubble cavities in the rock, caused by small pockets of gas, are called **vesicles**. Vesicles are originally rounded, but if the lava continues to flow they become oval and elongated. They give the hardened rock a rough and pock-marked appearance.

In sedimentary rocks hollow occur as a result of concretions. During the formation process, cementing material, commonly a carbonate mineral like calcite, precipitates locally around a nucleus, often organic, such as a leaf, tooth, piece of shell or fossil. Concretions vary in size, shape, hardness, and colour. Most are a few cm across but may also be microscopic or can measure several metres in diameter. They often appear in rows, concentrated along bedding planes. When the bedding plane is exposed, weathering may cause the minerals to dissolve, leaving behind a hemispherical depression. They may appear near-circular, but can be flattened as a result of compression.

Bedding planes

Many sedimentary rocks are deposited in layers that geologists call strata or 'bedding planes'. Each one represents the sea bed or land surface at the time it was laid down. The bedding planes were originally deposited horizontally but when the Earth's crust moves they may become tilted and folded. The term is generally applied to sedimentary strata, but may also be used for volcanic flows or ash layers.

Erosion channels/fluting

Erosion channels, also known as 'decantation runnels', are formed by the dissolution of the soluble rock surface by acids in the water which flows across it. The channels tend to be smooth and rounded (as opposed to the fissures and cracks which tend to be sharp and angular). The term 'fluting' is applied to the same phenomenon where it occurs in the vertical plane. Although these features tend to be associated with limestone landscapes, the same processes also affect sandstone.

Weathering

Weathering is caused by many agents including temperature changes, rain, wind, bacteria, animals and plants, and is defined as the decomposition of the rock which does not involve movement or transportation. **Mechanical weathering** is mainly the result of temperature changes. Water in cracks and joints expands when it freezes. This creates stresses which cause the rock to disintegrate. Temperature can cause different minerals in the rock to expand and contract at different rates. This may lead to thin sheets of rock peeling away like onion skins. **Chemical weathering** is caused by acidic water dissolving the rock. Rainwater is a mild carbonic acid, which increased pollutants, becomes more acidic. Limestone is particularly vulnerable. The calcium carbonate reacts with acid rainwater to produce soluble calcium bicarbonate.

Note: ***Erosion*** is the breakdown of rocks by processes that involve movement, for example by rivers, glaciers or the sea.