Guidance Sheet No. 6: GEOLOGY FOR ROCK ART RECORDERS

An understanding of basic geology is essential for Rock Art Recording. An 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.

Igneous Rocks

Igneous rocks are made up of a mosaic of mineral crystals, usually without layers. They occur both underground (intrusive) and on the surface (extrusive). Granite is an intrusive igneous rock that forms deep underground and makes up much of the Earth's continental crust. Many igneous rocks such as granite and dolerite, are very hard and durable and are quarried for use in road surfaces. Andesite is another type of igneous rock. It solidifies from lava that erupts from volcanoes. Some andesite lavas are so rich in gas that when they solidify, the rock is filled with gas cavities called vesicles. As well as lava, volcanoes also erupt with broken rock, dust, ash and volcanic bombs. When it settles on the ground and hardens this material is called tuff. Tuff may have features of sedimentary rocks (see below) such as layers or strata.

Sedimentary Rocks

Sedimentary rocks are best recognised by their layers, known as bedding planes or strata, which result from the way the sediment is deposited. Common sedimentary rocks include sandstone, limestone, mudstone, and shale. They are formed from particles eroded from pre-existing rocks, transported by rivers, winds, glaciers and gravity. Eventually they are deposited, for example on the seabed, and fossils are often preserved within the layers. 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 are 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.

Metamorphic Rocks

Metamorphic rocks have been changed by heat and/or pressure. Regional metamorphism occurs when mountain building, associated with movement of the Earth's crust takes place. The changes may take tens of millions of years. Rocks formed in this way are recognisable by their texture: because of the stresses in the rock, minerals are streaked out in layers. The rocks that are most altered, deep in the earth, are called gneiss; at lower depths where the temperature and pressure are lower, a rock called schist is formed; and around the margins of the mountain region where conditions are less extreme, rocks such as slate are created.

Table 1: Examples of different rock types

Igneous	Sedimentary	Metamorphic
Granite	Sandstone	Gneiss
Andesite	Limestone	Schist
Rhyolite	Conglomerate	Shale
Dolerite	Breccia	Marble
Gabbro	Chalk	
Basalt	Coal	

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 important for rock art researchers. It is important to be able to identify natural markings and distinguish them from motifs, and also to evaluate the condition of the panel surface.

Common rock types used for carving

The most common type of rock on which rock art is found in England is sandstone. In Northumberland carvings are found on the rocks of the Fell Sandstone Series; further south motifs are found on the Millstone Grits of North Yorkshire. In Cumbria, the red sandstone of the Eden Valley and St Bee's coastal area was also favoured.

Rock art also occurs on harder igneous and metamorphic rocks. In the west of England examples are found on the Borrowdale Volcanic Series and Skiddaw Slates of the central Lake District. A small number of granite and gabbro panels are also known. On Anglesey, the Isle of Man, and the west coast of Scotland, metamorphic schists are carved. Very few examples of rock art on limestone are known – possibly because they would not survive well on this more vulnerable rock.

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, perhaps influencing where motifs were placed on the panel. It has even been suggested that the natural markings may have been viewed as ancient ancestral carvings to be venerated.

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, and typical examples can be seen on the Duddon Stones in Northumberland, and on Ilkley Moor in West Yorkshire.

Sandstone – a closer analysis

There are many different 'types' of sandstone with different sand grain sizes and different qualities of hardness related to how these sand grains are cemented together. These characteristics can affect the decay rates of the sandstones, and the biological growths that colonise them, with implications for conservation and management of the rock art. Sandstone consists primarily of quartz grains (clear, white or greyish glassy crystals), bonded together by a cement of silica, calcite or iron oxides which give the sandstone its colour. The most common colours are shades of buff, red, or grey, but some may appear almost white if weathering has penetrated deeply. The grains are quite small (rough 0.5-2mm) and rounded, and can usually be seen clearly with a hand lens. In sandstone the most common minerals are quartz, feldspar and mica; their characteristics are described below.

Sandstone is relatively soft and easy to work. It can be pecked and ground to give deep carvings and often elaborate designs; tool marks can often be seen. Sandstone is easiest to recognise once its surface has been etched by weathering. At this point it begins to look like the sand found on the beach.

Table 2: Visible components of sandstone

Quartz	Transparent/white, usually near spherical (80-100% of grains in sandstones, usually >95%)
Mica	Thin sheets of highly reflective grains, usually white-buff in colour (muscovite), usually found along bedding surfaces in fine sandstones (these become layers of weakness along which fine sandstones can be split
Feldspar	White/cream/browny-orange grains. Generally rectangular. Can make up about 20% of sandstones. Usually in local sandstones the feldspar has decayed is stained browny-red. Often these grains are simply washed away, leaving neat rectangular gaps in the rock

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.