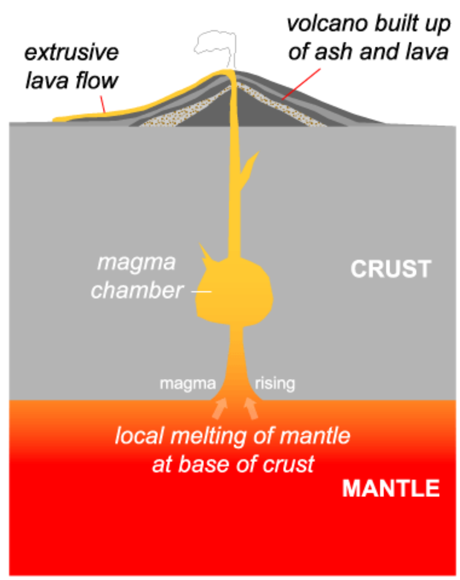
For visitors to our website who are interested in finding out more about the quarry process and the rocks quarried, but who are not geologically minded, this section gives a very simplified look at the topic of rock classification. Most types of rock can be placed into one of three broad groups, according to how the rock originated, as follows:

1. Igneous
2. Sedimentary
3. Metamorphic

## IGNEOUS ROCKS

These form in the earth's interior when parts of it melt. The molten rock which forms seeps upwards into the upper layers of the earth's crust, forming underground bodies of magma. Breaking-up and dissolution of the surrounding "country" rock by the rising magma also occurs as the magma is emplaced. Magma may even force a way through the crust to the surface of the earth where it can erupt to form volcanoes.

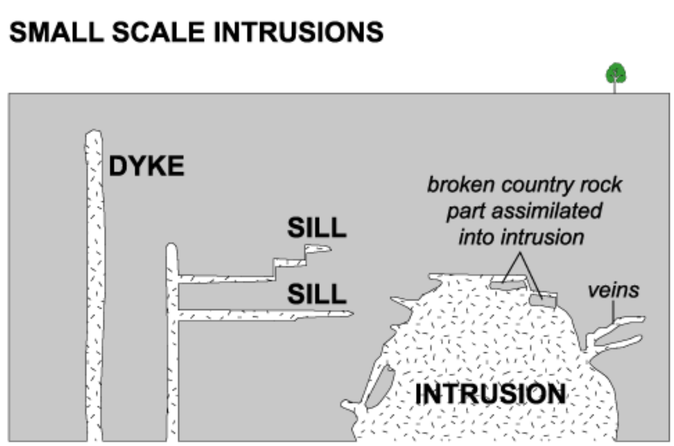



Igneous rocks are classified in several ways:

### Extrusive / Intrusive

Magma which reaches and flows onto the earth's surface is called lava and is termed **extrusive**. Extrusive rocks tend to be very hot and fluid. The majority of lavas are of silica poor basaltic composition. Present day basalt lavas on Hawaii are molten between 1100 - 1200$^{o}$c. If the lava has a high gas content, or if it is a thick viscous type of lava, the pressures involved can cause explosive activity which pulverises rock and lava and explosively ejects large clouds of ash and debris from the volcano as a result. The ash clouds settle to form layers of ash around the volcano.

Magma which does not reach the surface, but instead cools and solidifies within the crust instead, is termed **intrusive**. Large scale intrusions, which may be hundreds of square kilometres in extent, are called batholiths. Small scale intrusions include dykes (vertical sheets) and sills (horizontal sheets), domes, stocks and bosses. Intrusions are only revealed at the earth's surface when erosion has stripped away the strata covering the top or roof



of the intrusion. Magmas that form intrusions tend not to be as hot and are more viscous than extrusive basalt lavas. The majority of intrusive rocks are of silica rich granitic composition. Emplacement temperatures are thought to be around 800 $^{o}$c.

**Grain size**

The size of the mineral grains in an igneous rock is related to the cooling history of the rock. Lavas, being extruded onto the earth's surface, cool rapidly. This does not give enough time for crystals to form and grow, therefore lavas tend to be fine grained. Magmas in minor intrusions cool more slowly than lavas, hence crystals growth is longer and the final crystals are larger, hence dykes and sills tend to be medium grained. Major intrusions are so large that cooling is slower and the crystals formed are even bigger in size and the rock formed is coarse grained. In the past, for rocks having the same chemical composition, different names were given to them depending on the grain size (see summary igneous rock classification table).

**Silica content**

This subdivision is based on the silica ($SiO_2$) content of the igneous rock.

Low silica rocks are called **BASIC** rocks.

Medium silica rocks are called **INTERMEDIATE** rocks.

High silica rocks are called **ACID** rocks.

**Mineral content**

The final classification of igneous rocks is based on the different minerals each type of rock contains:

| **Rock** | **Constituent minerals** |
|---|---|
| **Basic** | Calcium feldspar, pyroxene, olivine, amphibole, iron ores |
| **Intermediate** | Sodium/potassium feldspar, some calcium feldspar, amphibole, pyroxene, mica |
| **Acid** | Sodium/potassium feldspar, quartz, amphibole, mica |

**Simplified summary classification of igneous rock:**

| | Extrusives (fine grained) | Minor intrusives (medium grained) | Major intrusives (coarse grained) | | |
|---|---|---|---|---|---|
| Basic | *Basalt* | *Dolerite* *(Diabase in USA)* | *Gabbro* | high temperature melt | low SiO |
| Intermediate | *Andesite* | *Micro-diorite* | *Diorite* | ⇓ | ⇓ |
| Acid | *Rhyolite* | *Micro-granite* | *Granite* | lower temperature melt | high SiO |

**Sedimentary rocks**

There are three main groups of sedimentary rocks, those of mechanical origin, those of chemical origin, and those of biological origin. The salient feature of most sedimentary rocks is that they are formed through the agency of water (excepting wind blown soils and desert sands, not dealt with here). Formation of sediments is basically a superficial process that occurs only on the earth's surface.

**Sedimentary rocks of mechanical origin**

These rocks are formed by erosion of previously existing rocks (whether igneous, sedimentary or metamorphic), the transportation of the erosion products (e.g. rivers, sea currents, floods or storm surges) and their eventual deposition at some point from where they can be transported no farther (lake bottoms, plains, ocean floors).

**Erosion** (weathering)

Rock exposed at the earth's surface is continually being subjected to weathering which gradually breaks the rock down from large bits to smaller bits. This breakdown is achieved by the action of several agencies:

1 Mechanical breakdown

Freeze thaw action

Thermal shock (daily heating and nightly cooling in hot climates)

Mechanical attrition during transportation

Wind action (e.g. sandblasting in deserts)

2 Chemical breakdown

Alteration of unstable or weak minerals by chemical action (e.g. breakdown of feldspars into clays)

3 Organic breakdown

Breakdown of particulate matter by the action of animal life and bacteria to form soils

## Transportation

Once a sediment has been formed by erosion, it can be transported by various means to its final resting place as follows:

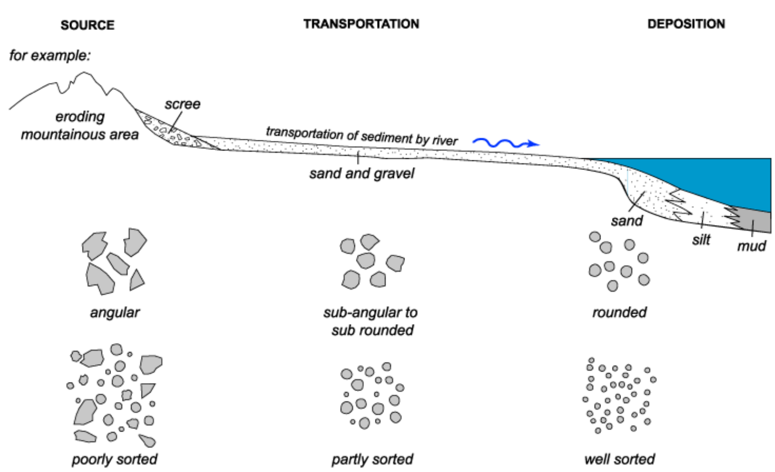
| | | |
|---|---|---|
| 1 | Transportation by gravity | Mass downward movement by soil-creep, rock falls or mud or debris slides. |
| 2 | Transportation by water | Moving water (rivers, sea currents, floods and storm surges) has enough energy to transport considerable quantities of sediment. |
| 3 | Glacial transportation | Not dealt with here. |

Water is the main transportation medium. The quantity of sediment carried by a flow of water is directly proportional to the water velocity, i.e., the greater the flow, the greater the load of sediment carried both in suspension and along the bed. The maximum size of particle moved or carried also increases with increasing velocity.

Transportation imparts important characteristics to the sediments as follows:

- Sediment particles become more rounded the longer the transportation process (both in time and distance), i.e., angular fragments close to sediment source, rounded grains furthest from source. Rate of rounding will increase in high-energy situations, e.g., floods.
- Sediment particles become better sorted the longer the transportation process (both in time and distance), i.e., badly sorted deposits with a jumble of all sizes (boulders to sands) close to source, well sorted deposits of one particular size of grains (sands, silts) furthest from source.
- Size decreases with increasing distance from source, i.e., large boulders closest to source, finest silts and clays furthest from source.

SEDIMENT TRANSPORTATION & SORTING



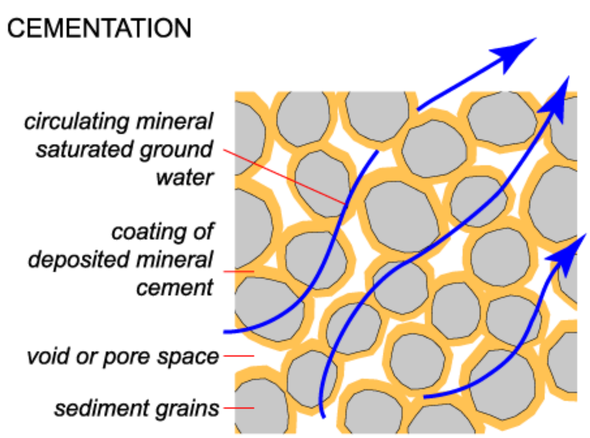
## Deposition

Deposition mostly occurs in or through the agency of water. When moving water that is carrying a burden of sediment slows down, e.g., when a river enters a lake or the sea, or a flood dissipates, its sediment carrying capacity significantly reduces and it drops its load. The heaviest particles drop out first, finest particles last (Stoke's Law). Continuous and repeated deposition builds up the thickness of the sediment deposit. Rapid deposition of thick beds of sediment can occur in flood conditions.

## Lithification or diagenesis

Having produced a loose unconsolidated deposit, several changes have to occur to turn the soft sediment into a hard rock. This can happen in a combination of several different ways:

1. Movement of mineral rich ground-water through the sediment. If chemical conditions are right, the mineral matter in solution can be deposited out around the sediment grains, thus cementing it together. Cements can be carbonate ($CaCO_3$) or silica (SiO) or various metal oxides, particularly iron. Cementation can be very rapid.




2. Accumulations of great quantities of sediments in depressions in sea floors caused by movements of the earth's crust. These great thicknesses of sediments are then compacted and dewatered under their own weight to form hard rock, perhaps in combination with cementation as described previously and/or dynamically by earth movements.

## Sedimentary rocks of chemical origin

Precipitates or evaporites are sedimentary rocks of chemical origin.

Precipitates are thought to have formed in shallow waters or seas that contained large amounts of dissolved minerals which precipitated out of solution when conditions dictated precipitation should occur. Precipitation can occur due to chemical or temperature changes. Some limestone deposits are chemical precipitates.

Evaporites occur due to evaporation of water from shallow lakes or seas. Dissolved ions in the water precipitate from the water when their concentration becomes over-saturated.

Rock salt or halite (NaCl), gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$) are some evaporite minerals.

Salt beds many thousands of feet thick are known to occur at depth in many areas of the world and these may have formed from chemical precipitation rather than evaporation.

### Sedimentary rocks of organic origin

These are rocks formed by organisms (e.g. limestones formed by reef building corals) or by accumulations of organic matter (e.g. peats, guano).

### Simplified summary of sedimentary rocks:

| | Coarse (> 2mm) | Medium (2 – $^{1}/_{16}$ mm) | Fine ($^{1}/_{16}$ – $^{1}/_{256}$ mm) | Clay (< $^{1}/_{256}$ mm) |
|---|---|---|---|---|
| Mechanical origin | *Conglomerate (rounded)* | *Sandstone* | *Silstone* | *Mudstone* |
| | *Breccia (angular)* | *Greywacke (gritstone)* | | *Shale (harder than mudstone)* |
| Chemical origin | *Calcareous mudstone*<br>*Oolitic limestones (some)*<br>*Flint, chert*<br>*Ironstones, ore deposits*<br>*Rock salt*<br>*Gypsum*<br>*Phosphates (some)* | | | |
| Organic origin | *Limestones*<br>*Peat, lignite, coal*<br>*Phosphates* | | | |

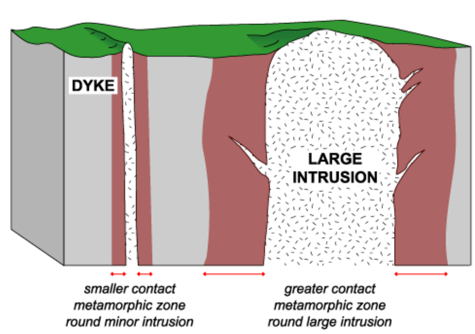
### Metamorphic rocks

### Regional metamorphism

These metamorphic rocks are formed when rocks of any type (igneous, sedimentary or previously metamorphosed) are caught up in large scale earth movements. These movements fold and push large masses of rocks together. Heat, pressure and chemical factors in such dynamic situations cause the original minerals in the rock to change and orientate themselves in response. Rocks that have been so transformed are termed metamorphic rocks.

### Contact metamorphism

CONTACT METAMORPHISM

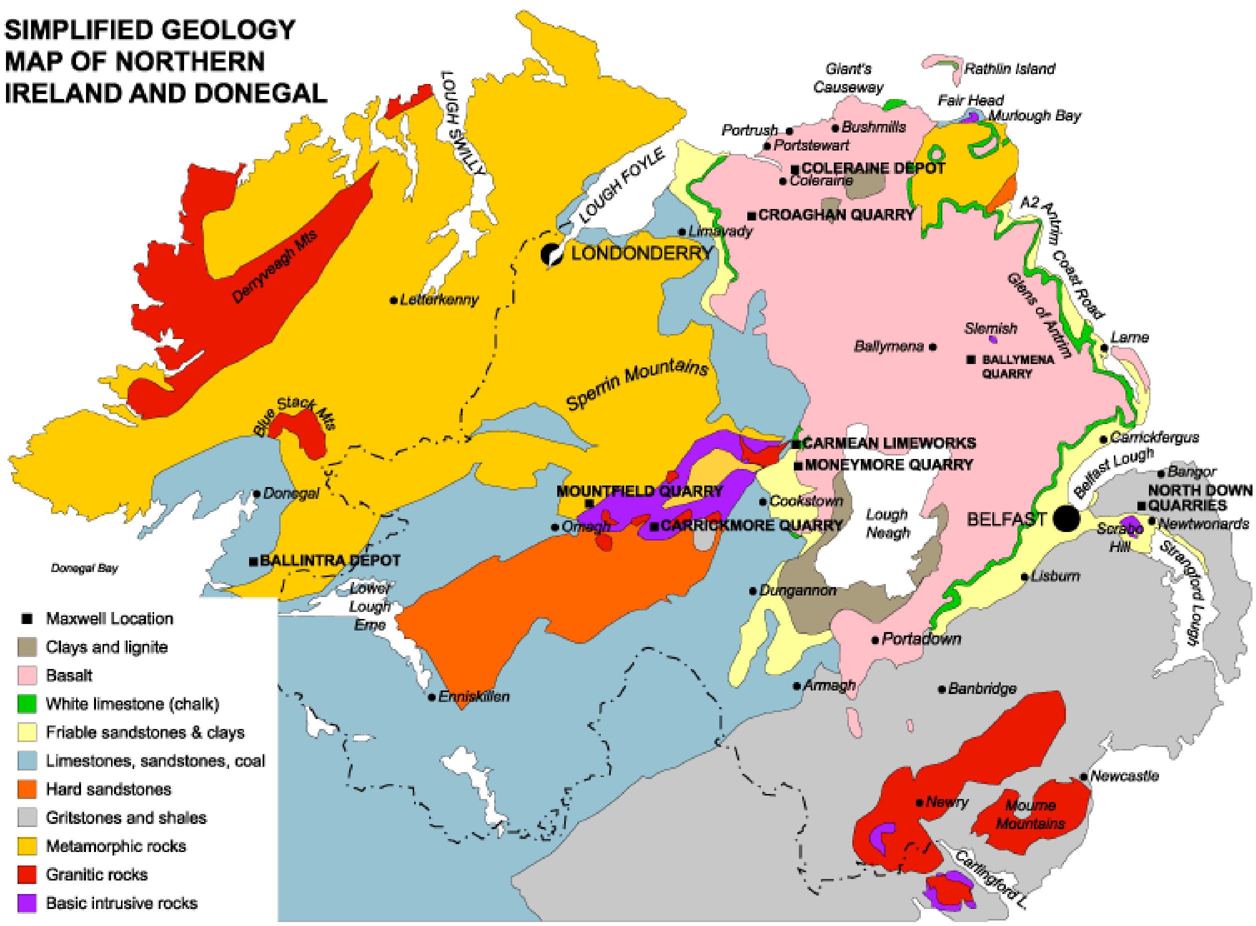



Contact metamorphism is confined to rocks (often referred to as country rocks) immediately surrounding an igneous intrusion. The alteration of the surrounding country rocks is caused by heat and fluids emanating from the intruding igneous body. The zone of alteration (metamorphic aureole) can vary from only a few centimetres to several kilometres in width. The size of the alteration zone depends on the size and temperature of the intrusion. Contact metamorphism is greater round very large, hot intrusions.

### Simplified summary classification of metamorphic rocks

| Original rock type ⇓ | Type of metamorphism | | | |
|---|---|---|---|---|
| | low grade | medium grade | high grade | contact |
| | *original rock is metamorphosed to:* | | | |
| Quartz sandstone | *Quartz schist* | *Quartzite* | *Quartzite* | *Quartzite* |
| Greywacke | *Schist* | *Schist* | *Gneiss/Granulite* | *Hornfels* |
| Pure limestone | *Marble* | *Marble* | *Marble* | *Marble* |
| Impure limestone | *Calcareous schist* | *Calcareous silicate* | *Gneiss* | *Calcareous hornfels* |
| Shale/mudstone | *Phyllite/slate* | *Schist* | *Gneiss* | *Hornfels* |
| Basalt | *Greenschist* | *Amphibolite* | *Amphibolite* | *Basic hornfels* |

### Northern Ireland geology




Simplified geology map of Northern Ireland showing location of Maxwell quarries

For those interested in looking at some of the geological features noted previously, a selected list of well known locations in Northern Ireland, where the geological features are particularly easy to see and study, is given below:

| Location | Featuring |
|---|---|
| **County Antrim** | |
| A2 Coast Road from Larne to Glenarriff; Ballycastle to Portrush | Basalt lavas overlying white chalk, landslips, particularly over soft underlying clays |
| A2 Coast Road from Red Bay to Cushendun | Hard red sandstones and conglomerates (conglomerates best seen at Cushendun). |
| A2 Coast Road from Cushendun to Ballycastle | Metamorphic rocks |
| Fairhead (partly National Trust) | Large sill ending in a 100m cliff, intruded into sandstone (easy access from Murlough Bay) |
| Murlough Bay (National Trust) | See above<br>White chalk overlying red sandstones<br>Landslips<br>Old chalk kilns<br>Lavas on foreshore<br>Coal mines (do not enter)<br>Metamorphic rocks in southern part of bay |
| Carrickarede (National Trust) | Remnant volcanic vent showing vent agglomerate |
| Larrybane (National Trust) | Old chalk quarry, dolerite sill previously worked to produce stone paving setts, old limestone kiln |
| Giants Causeway (National Trust & World Heritage Site) | Basalt lava flows, spectacular columnar jointing formed from cooling lava, red interbasaltic bed |
| Ballintoy harbour | Basalt and chalk faulted together, dolerite plug east of harbour, old chalk quarry, old limestone kilns |
| Slemish, Co Antrim | Eroded plug of extinct volcano |
| **Co Down** | |
| Scrabo Country Park, Newtownards | Multiple sills intruded into sandstone, old sandstone quarries |
| Mourne Mountains | Multiple granite intrusions<br>Hornfelsed greywacke (Glen River walk, Donard Park, Newcastle; Bloody Bridge coastal walk, near Newcastle) |