
Metamorphic rocks

Metamorphic rocks are rocks that have been altered from their original condition or composition due to the effects of heat or pressure, or both. The mineral constituents of the original rock may either have been recrystallised or, more commonly, due to complex geochemical reactions within the rock, may have been altered into suites of new minerals.

In large areas affected by heat and pressure during mountain building, rocks may have suffered regional metamorphism. Adjacent to igneous intrusions rocks have commonly been affected by contact or thermal metamorphism.

The nature and composition of metamorphic rocks reflect the intensity or grade of alteration. In most cases metamorphic rocks also reflect chemical and mineralogical changes resulting from the introduction of a variety of elements by permeating chemically reactive fluids, a process referred to as metasomatism.

Currently protected sites of Metamorphic rocks within the AONB SSSIs

The following sites lie within the Upper Teesdale-Moorhouse National Nature Reserve and SSSI:

Cronkley Pencil Mill, Upper Teesdale [NY 848 296]

Low Force and Wynch Bridge, Teesdale [NY 905 279]

Falcon Clints, Upper Teesdale [NY 820 281]

Cow Green Reservoir, Upper Teesdale [NY 815 294]

High Force, Upper Teesdale [NY 880 283]

RIGS

Metamorphic rocks are not present within any of the RIGS sites designated within the Cumbrian portion of the AONB.

Durham County geological sites

The following Durham County geological sites include significant exposures of metamorphic rocks:

Pencil Mill [NY 848 296]

Widdybank Fell [NY 820 290]

Other representative sites in the area

Greengates Quarry, Lunedale [NY 933 234]

Scoberry Bridge–Wynch Bridge, Teesdale [NY 910 274] and [NY 904 279]

Metamorphic rocks in Great Britain

Metamorphic rocks are widespread in Great Britain in a variety of geological environments. It is not feasible to depict clearly on a simplified map the distribution of metamorphic rocks within Great Britain.

The largest areas of metamorphic rocks Britain occur in the Scottish Highlands. Here, a great variety of different original rock types have been subjected to a complex process of regional metamorphism of varying intensity or grade, during widespread episodes of mountain building. Most of the older sedimentary and volcanic rocks of the Southern Uplands of

Scotland, the Lake District and Central and North Wales have been subjected to widespread regional metamorphism, though of a much lower grade or intensity than that generally seen in the rocks of the Scottish Highlands.

Adjacent to very large bodies of intrusive igneous rock, zones of contact metamorphism, known as metamorphic aureoles, can be extensive. The intensity of alteration typically declines with distance from the igneous intrusion. Contact alteration may bake shales into very tough fine-grained rocks known as hornfels; limestones may be recrystallised to marbles or, if more impure to a variety of calc-silicate bearing rock types. Metamorphic aureoles are commonly associated with all major igneous intrusions throughout the Great Britain. The zones of thermal alteration adjoining smaller igneous intrusions are generally much narrower and may be almost imperceptible adjacent to small intrusions such as narrow dykes.

Metamorphic rocks in the AONB

The Ordovician and Silurian rocks which crop out along the foot of the North Pennine escarpment in the Cross Fell Inlier, and in the Teesdale Inlier, almost all exhibit evidence of low grade regional metamorphism. This is mainly the result of their involvement in earth movements and mountain-building events over millions of years. Metamorphism within these rocks has produced a number of new minerals within them, though the nature of the original rock is still evident in most cases.

Contact metamorphic rocks occur associated with many of the intrusive igneous rocks in the North Pennines. The largest single body of intrusive igneous rock is the wholly concealed Weardale Granite. A substantial contact metamorphic aureole must surround the granite, though direct evidence for this is limited. Signs of thermal alteration in the slates exposed in the Teesdale Inlier, and those penetrated in some deep boreholes, have also been interpreted as evidence of thermal alteration due to the Weardale Granite.

Contact metamorphism is particularly associated with the Whin Sill, especially in parts of Teesdale where a range of Dinantian rocks exhibit varying intensities of alteration, particularly in the Cow Green, Falcon Clints and Cronkley Fell areas. In places, high temperature metamorphism, almost certainly accompanied by the introduction of chemically active fluids (metasomatism) has altered mudstones and impure limestones to calc-silicate rich metamorphic rocks containing an abundance of minerals such as garnet, feldspar, chlorite, epidote, vesuvianite, diopside and magnetite. Wollastonite has been recorded from one locality. Elsewhere, shales may have been baked to a very fine grained hornfels or porcellanite, sometimes known to North Pennine miners and quarrymen as 'whetstone'. Purer limestones may have been recrystallised to coarse-grained marbles; the best known of these is that which developed from the Melmerby Scar Limestone, known locally from its highly distinctive crumbly weathering as 'sugar limestone.'

In the area between Scoberry and Wynch bridges in Teesdale [NY 910 274]–[NY 904 279], pyrite nodules in mudstones between the Cockleshell and Single Post limestones have been altered to pyrrhotite by the thermal effects of the sill. Also near Wynch bridge, a large xenolithic raft of sandstone, here recrystallised to a hard siliceous quartzite, occurs within the sill.

Metasomatism of Whin Sill to form the clay-rich rock known to miners as 'white whin', mainly adjacent to mineralised faults and veins, is common in parts of the North Pennines.

Outcrops of metamorphic rocks within the AONB cannot readily be depicted on a map as they have generally not been separately mapped, typically have transitional boundaries with their unaltered counterparts and usually occur in extremely narrow zones adjoining igneous intrusions.

Whereas the most extensive, most intensely altered, and clearest exposures of contact metamorphic rocks associated with the Whin Sill are found in Upper Teesdale, rather similar, though mostly less intensely altered, limestones and mudstones are to be seen, mainly above the sill, on the North Pennine escarpment at the Hilton and Murton mines, near Appleby.

Calc-silicate rocks containing abundant garnet and vesuvianite, developed within the limestones and mudstones of the Three Yard Limestone cyclothem, occur adjacent to the Greengates Dyke, part of the Whin Sill suite, at Greengates Quarry, Lunedale.

Very narrow zones of thermal alteration in a variety of Carboniferous sedimentary rock types adjoin a number of dykes belonging to both the Whin Sill suite and the Cleveland–Armathwaite suite.

Impact on the landscape

Only in the Cow Green and Cronkley Fell areas of Teesdale do metamorphic rocks impose any perceptible characteristics on the landscape. In these areas the comparatively wide outcrop of the Melmerby Scar Limestone, here in the form of 'sugar limestone', is locally very well exposed, forming rather rounded, water-worn, pale grey outcrops. In some of these can be seen areas of crumbly disintegration producing a mineral soil largely made up of individual calcite crystals.

Impact on biodiversity

The presence of the metamorphosed Melmerby Scar Limestone and the included mudstones has had a most profound effect on the biodiversity of the North Pennines. This is most obvious in the vegetation. Base-rich, and in places unstable, Rendzina and Brown Calcareous soils have developed on exposures of 'Sugar Limestone' and on areas of glacial deposits rich in 'Sugar Limestone' debris. Where interbedded mudstones are exposed, and at the junction of the limestone with the top of the Whin Sill, base-rich gravelly flushes occur. These habitats support the 'Teesdale Assemblage' of rare plant species. This unique plant assemblage is considered to be a relic of the more widespread late-glacial and pre-forest-maximum flora that probably covered a much larger area of the North Pennine uplands during the wasting of the last ice sheets to occupy the area. Northern and arctic/alpine species (spring gentian, alpine bistort), grow together with southern continental (hoary rockrose). As the AONB includes the only English locality for some of this plant assemblage, as well as the most southern and northern locality for other plants, it is of great botanical importance.

The relationship between plant communities and underlying bed-rock associated with the only other substantial outcrop of metamorphic rocks, comprising mudstones, calcareous mudstones, siltstones and impure limestones, which underlie the Melmerby Scar Limestone at Falcon Clints, seems to have attracted little or no modern research.

Economic use

The area's metamorphic rocks have generally attracted little economic interest. The low grade metamorphic slates within the Teesdale Inlier were formerly worked for the making of slate pencils, known locally as 'widdies', at the small quarry at Pencil Mill, on the banks of the Tees near Cronkley. Little is known of the physical requirements which suited the rock to this purpose, though the comparatively soft, fine-grained nature of the slates found here, together with their pale streak, are likely to have been key factors.

Although the term 'whetstone' is locally given to metamorphosed, or hornfelsed shale, within the contact zone of the Whin Sill, no authenticated examples are known of the working of this material for making 'whetstones' (sharpening stones).

Blocks of a variety of Lower Palaeozoic rock types are incorporated into a number of vernacular buildings, drystone walls etc. in the area along the foot of the North Pennine escarpment.

Wider importance

The contact metamorphic rocks associated with the Whin Sill include some of the best examples of such contact altered sedimentary rocks in England. Despite the voluminous literature resulting from research on the Whin sill rocks themselves, the associated contact metamorphic rocks have hitherto attracted surprisingly little research interest. However, in recent years the discovery of suites of unusual metamorphic rocks, associated with the roof of the Sill in

upper Teesdale, has prompted new research interest of relevance not just to the Whin Sill, but to the origins of similar metamorphic rocks in comparable environments far beyond the AONB. In addition to its importance as a fine example of a contact-altered limestone, the 'sugar limestone' of Teesdale hosts an internationally renowned flora.

Conservation issues

Most of the exposures of metamorphic rocks are comparatively robust, though small exposures of contact rocks in long-abandoned igneous rock quarries may be at risk from destruction due to landfilling or landscaping works.

Selected references

Dunham, 1990; Robinson, 1970; Stone et al, 2010.

Figures

(Figure 34) Raft of altered sandstone in Whin Sill, Wynch Bridge, Teesdale. © S. Clarke, BGS, NERC.

(Figure 35) Outcrops of 'Sugar Limestone' Widdybank Fell © B. Young, BGS, NERC.

[Full references](#)



Raft of altered sandstone in Whin Sill, Wynch Bridge, Teesdale. © S. Clarke, BGS, NERC.



Outcrops of 'Sugar Limestone' Widdybank Fell © B. Young, BGS, NERC.