Metamorphic rocks

Metamorphic rocks are rocks which 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, complex geochemical reactions within the rock may have produced suites of new minerals.

Metamorphic rocks may occur over very wide areas which have been greatly effected by a variety of earth movements such as mountain building events, where heat and pressure may both have been of great importance causing regional metamorphism. They are also commonly found adjoining bodies of intrusive igneous rocks, where the effects of great heat have usually been most significant.

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 chemical by permeating chemically reactive fluids, a process referred to as metasomatism.

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 simpli- fied map the distribution of metamorphic rocks within Great Britain.

The largest areas of metamorphic rocks in Britain occur within the Scottish Highlands where a great variety of different original rock types have been subjected, in some cases on several occasions in the geological past, to 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, or very hot, bodies of magma, zones of contact metamorphism, or aureoles, can be rather extensive. The intensity of alteration typically declines with distance from the igneous intrusion. Such 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 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.

Geological SSSIs

The following sites lie within the Upper Moorhouse–Upper Teesdale National Nature Reserve and SSSI, though the individual geological features are not specifically designated for their geological importance:

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]

Durham County geological sites

Cronkley Pencil Mill, Upper Teesdale [NY 848 296]

Widdybank Fell, Upper Teesdale [NY 820 290]

Metamorphic rocks in County Durham

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

The Ordovician mudstones and volcanic rocks in the Teesdale Inlier almost all exhibit evidence of low grade regional metamorphism and up to two phases of cleavage, mainly resulting from 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. The most highly cleaved rocks here may be described as phyllites.

Contact metamorphic rocks occur associated with many of the intrusive igneous rocks within the county.

The largest single body of intrusive igneous rock within County Durham is the wholly concealed Weardale Granite. A substantial contact metamorphic aureole must surround the granite, though direct evidence for this is limited. Slates, reached at the bottom of a deep borehole at Roddymoor, near Crook, were found to contain garnets, thought to be a product of thermal metamorphism due to the Weardale Granite: similar rocks may be widespread in the aureole of the granite beneath the Pennines. Signs of thermal alteration in the slates exposed in the Teesdale Inlier have also been interpreted as evidence of thermal alteration due to the Weardale Granite.

Most obvious, and best developed, are the metamorphic rocks associated with the Whin Sill, especially in parts of Teesdale. In places high temperature alteration, 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, idocrase, diopside and magnetite. Wollastonite has been recorded from one locality on Cow Green. Elsewhere shales may have been baked to a very fine-grained hornfels or porcellanite, sometimes known to Northern Pennine miners and quarrymen as 'whetstone'. Purer limestones may have been recrystallised to coarse-grained marbles, of which that developed from the Melmerby Scar Limestone, known locally as 'Sugar Limestone' is probably the most familiar. Similar, though rather less intense, metamorphic effects can be seen in the Robinson and Peghorn limestones above the Melmerby Scar Limestone. The succession of Carboniferous mudstones, calcareous mudstones, siltstones and impure limestones, which underlie the Melmerby Scar Limestone at Falcon Clints lie within the thermal aureole of the Whin Sill where they have been intensely altered to a series of calc-silicate bearing hornfels containing minerals such as garnet, chlorite, feldspar, diopside and idocrase.

Good exposures of generally rather less intensely metamorphosed Carboniferous rocks adjoining the sill are to be seen around Scoberry and Wynch bridges, also in Teesdale. Pyrite nodules within mudstones between the Cockleshell and Single Post limestones have here been altered to pyrrhotite by the thermal effects of the sill. A large xenolithic raft of sandstone, here recrystallised to a hard siliceous quartzite occurs within the sill, near Wynch Bridge.

Calc-silicate rocks containing conspicuous and abundant garnet and idocrase, 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.

Significant, but less intense and much more restricted areas of contact metamorphism are associated with several of the dykes, both those of the Whin Sill suite and those of Palaeogene age belonging to the Cleveland–Armathwaite suite.

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 locally.

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.

Influence on the landscape

The landscape characteristics of the county's metamorphosed Ordovician rocks have been discussed above.

In general the contact metamorphic rocks associated with the Whin Sill and the associated dykes of this and the Cleveland–Armathwaite suite exert little influence on the present landscape.

Only in the parts of Upper Teesdale do metamorphic rocks impose any perceptible characteristics on the landscape. In this area the comparatively wide outcrops of the Melmerby Scar Limestone, here altered to coarse-grained marble, is locally very well exposed forming rather rounded, water-worn, pale grey outcrops. In some of these can be seen areas of crumbly disintegration of the limestone producing the mineral soil largely made up of individual calcite crystals, which has earned this rock the local name of 'Sugar Limestone'.

Influence on biodiversity

The very limited impact of metamorphosed Ordovician rocks on biodiversity has been discussed above.

The presence of metamorphosed Melmerby Scar Limestone and the included mudstones have had a most profound effect upon biodiversity. This is most obviously seen in the vegetation. Exposures of the highly friable 'Sugar Limestone', and the quantities of it in the glacial deposits, have produced a base-rich, and in places unstable, substrate. Rendzina and Brown Calcareous soils have developed on the limestone. 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, relics of the more widespread late-glacial and pre-forest–maximum flora. Northern arctic/alpine species (spring gentian, alpine bistort), growing together with southern continental (hoary rockrose). As the county hosts the only English locality for some plants, as well as the most southern and northern locality for others, it is of very great botanical importance.

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

Economic use

The area's metamorphic rocks have attracted little economic interest.

The low grade metamorphic slates within the Teesdale Inlier were formely worked for the making of slate pencils at the small quarry at Pencil Mill, on the banks of the Tees near Cronkley. Little is known of the physical requirements which made a rock suitable for 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 the making of sharpening, or 'whetstones'.

No other examples are known of the working of any of the area's metamorphic rocks for any specific purpose.

Future commercial interest

None of these metamorphic rocks is worked today and it is extremely unlikely that any will ever attract economic interest.

Threats

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

Selected references

Burgess and Holliday, 1979; Dunham, 1990; Johnson, 1970, 1973, 1995; Johnson and Dunham, 1963; Mills and Hull, 1976; Robinson, 1970; Taylor et al. 1971.

Photographs

(Photo 39) Wynch Bridge, Teesdale. Raft of metamorphosed sandstones in Whin Sill. SM Clarke, BGS, ©NERC, 2004.

(Photo 40) Sugar limestone outcrop on Widdybank Fell, Teesdale. B Young, BGS, ©NERC, 2004.

Full references

(Photo 39) Wynch Bridge, Teesdale. Raft of metamorphosed sandstones in Whin Sill. SM Clarke, BGS, ©NERC, 2004.

(Photo 40) Sugar limestone outcrop on Widdybank Fell, Teesdale. B Young, BGS, ©NERC, 2004.