Mineral veins and flats

Mineral veins are sheet-like bodies of mineral which occupy more or less vertical cracks or fissures in the surrounding rocks, or wall-rocks. These fissures are commonly faults. Mineral veins are usually concentrated in groups in particular areas, or geological environments. The term 'orefield' is commonly applied to such concentrations of veins where they have been important sources of economically valuable minerals.

Veins generally comprise concentrations of minerals composed of elements, which may otherwise be extremely rare or widely scattered through the rocks. Some mineral veins are composed almost entirely of one introduced mineral, though more usually a variety of minerals is present, commonly forming crude bands more or less parallel to the vein walls. Minerals present may include one or more metal ore minerals, generally accompanied by a variety of non-metallic minerals, known as gangue minerals, or as 'spar' minerals by miners.

Flats are roughly horizontal bodies of mineral which may extend for several metres on one, or both, sides of a vein, usually where the vein cuts limestone wall-rocks. They represent bodies of limestone, wholly or partly replaced by the minerals found in the adjoining vein, including both ore and gangue minerals. Many of the features present within the original limestone, such as bedding and sometimes fossils, may be recognisable in the flat where they are replaced by minerals.

Mineral veins and flats in Great Britain

Mineral veins of many different types are found in many parts of Great Britain, in a wide variety of geological environments. Many of these have been important sources of metallic ores and other economically valuable minerals.

Mineral veins and flats provide clear evidence of the circulation of large volumes of warm or hot mineral-rich waters deep beneath the earth's surface. By studying their form, distribution, mineral content, chemical composition, and many other characteristics, it is possible to deduce much about the sources of the chemical elements within the deposits, their temperature and age of formation, and the geological environments in which they formed and evolved. Such investigations not only contribute to interpreting the deposits of any single area, but are also vital to understanding the nature and origins of comparable deposits elsewhere, thus helping to inform and guide exploration for similar deposits worldwide.

Geological SSSIs

SSSI Name/GCR Name/Grid Reference

Close House/Close House Mine Mine [NY 850 227]

Foster's Hush/Foster's Hush [NY 859 204]

Old Moss lead Killhope Head Vein [NY 820 433]

Upper Teesdale Lady's Rake Mine and Trial Shaft [NY 803 344]

Upper Teesdale Pikelaw Mines [NY 902 314]

Upper Teesdale Willyhole Mine [NY 911 391]

West Rigg Open West Rigg Open Cutting Cutting [NY 911 391]

Durham County geological sites

Boltsburn Mine and Rookhope Borehole [NY 937 428]

Cement Works Quarry, Eastgate, Weardale [NY 935 360]

Chilton Quarry, Ferryhill [NZ 300 314]

Closehouse Mine [NY 84 22] — [NY 85 22]

Coldberry Gutter [NY 920 292]

Cow Green Mine [NY 815 308]

Dirt Pit Mine [NY 891 290]

Greenhurth Mine [NY 795 320]

Greenlaws Mine [NY 889 370]

Grove Rake Mine and Opencast [NY 897 442]

Hunters Vein [NY 860 204]

Killhope Lead Mining Museum [NY 823 433]

Old Towns Quarry, Newton Aycliffe [NZ 257 256]

Noah's Ark Quarry, Stanhope [NY 985 409]

Raisby Railway Cutting [NZ 345 350]

Scoberry Bridge — Dine Holm Scar, Teesdale [NY 910 274]

Sedling Mine, Cowshill, Weardale [NY 859 409]–[NY 868 407]

Wynch Bridge [NY 820 290]

Mineral veins and flats in County Durham

The veins, and associated 'flat' deposits of County Durham include part of the very large group of deposits within Carboniferous rocks which collectively form the Northern Pennine Orefield. Lead and iron minerals were the principal ores worked, though smaller amounts of zinc and copper ores were raised locally and some silver was recovered from most mines as a by-product. The non-metallic minerals fluorspar, barytes and witherite were also mined, especially in more recent years.

Veins within the county mostly occupy normal faults, typically with a maximum displacement, or throw, of only a few metres. Veins may vary from as little as a few millimetres to over 10 metres in width, though most of the veins worked have been less than 5 metres wide. The county's veins typically exhibit crude bands of more or less pure minerals roughly parallel to the walls of the veins. Non-metallic 'gangue' or 'spar' minerals such as fluorite, baryte, witherite or quartz usually comprise most of the vein, with ore minerals such as galena or sphalerite typically present as discontinuous bands or pockets within these other minerals. In some places, notably where the veins are narrow or occur between weak wallrocks such as shale, the veins may be composed largely or wholly of crushed rock fragments, known as 'gouge'.

One of a number of characteristic features of the area's veins is their close relationship to the adjacent wallrocks. In hard, or competent, rocks such as limestone, hard sandstone and Whin Sill dolerite, veins tend to be comparatively wide and to

stand almost vertically. It is these areas of vein which usually proved most profitable to the miners. Workable portions of veins of this sort are known as 'ore shoots'. Between or against weak, or incompetent, wallrocks such as shales and soft sandstones, veins are generally narrow and commonly are inclined, or 'hade', at a lower angle. Such sections of vein have usually proved worthless for mining. In this area of alternately strong and weak rocks, the long, wide oreshoots between vein walls in strong beds are often termed 'ribbon oreshoots'.

In most 'flats' within the Northern Pennines the main mass of the original limestone has been replaced by a compact aggregate of crystalline ankerite, siderite or quartz, though fluorite and baryte also replace the limestone locally. Within this altered rock occur bands or pockets of the ore minerals galena or sphalerite. Many 'flats' proved to be richer in ore minerals than the adjoining vein. Cavities or 'vugs' are common in most 'flats' and typically are lined with well- crystallised examples of the constituent minerals.

One of the best known features of the orefield is the striking zonal distribution of certain constituent minerals within the veins and 'flats'. The deposits within a central zone, which embraces much of Alston Moor, Weardale, Rookhope, parts of Teesdale, East Allendale and the Derwent Valley, are distinguished by containing an abundance of fluorite. Outside of this zone, fluorite is generally absent, its place being taken by the barium minerals baryte, witherite, and locally, barytocalcite. County Durham includes substantial portions of the inner, fluorite zone, and a large section of the outer, barium-rich zone, which extends into the Durham Coalfield.

The veins and 'flats' are believed to have formed during one major mineralising episode after the intrusion of the Whin Sill, in late Carboniferous or early Permian times.

Millions of years of erosion since their emplacement have exposed the deposits at the surface, where weathering has altered some of the minerals. Particularly important economically has been the oxidation of large amounts of siderite and ankerite in several flats, to give large workable deposits of 'limonitic' iron ores.

The Magnesian Limestone, in the east of the county, hosts small concentrations of fluorite, baryte, galena, sphalerite and locally rare copper ores. These may, at least in part, comprise distant expressions of the main Northern Pennine mineralisation. None has proved of economic interest.

Surface exposures of mineral veins, and associated flats, may be seen at several sites within the county. However, many of the county's most important deposits are no longer accessible and can today be understood only from contemporary reports, augmented in some instances by remaining accumulations of mine spoil. Although excellent and instructive in situ exposures of mineral veins and flats remain accessible underground at several abandoned mines within the Northern Pennines, only one safely accessible working remains in County Durham, at Rogerley Mine, near Frosterley.

Influence on the landscape

Despite the very small area occupied by mineral veins and associated 'flat' deposits within County Durham, their impact upon the landscape is profound. Centuries of exploitation for metal ores and other minerals have left an indelible mark upon almost every part of the physical and cultural landscape of the Durham dales.

The North Pennine Orefield is celebrated for the remains of the early form of opencast mining known as 'hushing'. This involved the periodic sudden release of torrents of water from specially constructed dams high on a hillside, above a known or likely vein outcrop. The scouring effect of the water tore away at loose surface deposits, exposing the underlying rocks and any contained mineral deposits. Large, elongated trenches, or hushes, are conspicuous features of the County Durham landscape.

By far the greater number of the county's mineral deposits were worked from adit levels, driven into hillsides, or from shafts. Stone-arched adits are common landscape features, often closely associated with spoil heaps, the remains of mine buildings and dressing floors. Many adits have today collapsed, or 'run in', and can be detected as distinctive shallow depressions in hillsides, often marked by a flow or seepage of mine water through the collapsed material. Shafts may be open, with or without protective fencing or walling, or may be seen as 'run in', sometimes water-filled, circular

depressions.

Mining sites are typically marked by derelict buildings, in varying states of dilapidation, and by heaps of coarse mine spoil or spreads of fine- grained tailings.

One of the most widespread influences the county's mineral veins have had on the landscape lies in the pattern of fields and settlements. The widespread development of the dual economy of farming and mining, during the 18th and 19th centuries, resulted in the enclosure of large areas of otherwise unproductive hillside and the development of scattered, isolated settlements.

Influence on biodiversity

An important feature of the Northern Pennine Orefield is the widespread occurrence of a number of specialised plant species and communities which exhibit a clear preference for colonising soils in which there are higher than normal concentrations of heavy metals. These metallophyte and sub-metallophyte species include plants such as spring sandwort (*Minuartia verna*), alpine pennycress (*Thlaspi caerulescens*), scurvy grass (*Cochlearia pyrenaica*), mountain pansy (*Viola lutea*), thrift (*Armeria maritima*) and moonwort (*Botrychium lunaria*). One or more of these species are commonly found on, or close to, the outcrops of mineral veins. They are especially common on areas of mine spoil or tailings.

Several areas of mine spoil which remain virtually devoid of continuous vegetation cover, even after over a century, are likely to carry levels of contamination, either as high metal concentrations or as adverse soil pH values, which effectively inhibit plant growth. Striking examples of such poorly vegetated ground may be seen at the head of the Hudeshope valley, Teesdale, adjacent to the extensive workings on the Lodgesike–Manorgill Vein.

Mine water discharges may carry high levels of contaminants which can affect land immediately surrounding the discharge. Where such water discharges into streams and rivers this can have an adverse effect on the biodiversity of that watercourse. Perhaps the most notable example of metalliferous mine-water contamination of a surface stream in County Durham is the Rookhope Burn which, since shortly after the cessation of pumping at the Groverake–Frazer's Hush fluorspar mine, has carried elevated levels of elements such as iron and zinc.

Severe heavy metal contamination, apparently largely due to high lead concentrations, is a feature of soils close to a number of former lead smelting sites. In some instances small, but significant, areas of soil remain wholly unvegetated well over a century after the end of smelting.

Influence on archaeology

There is a rich legacy of remains, in the western parts of the county, relating to the working of lead ores and associated minerals over many centuries. These remains comprise opencast workings, including hushes, spoil heaps, mine entrances and mine buildings. All have considerable historical interest. Many are scheduled, or proposed for scheduling, as historical monuments.

Economic use

The mineral veins and associated deposits have, over several centuries, provided the foundation for much of the economy of the western part of the county.

Available records indicate that from the veins and associated flat deposits of County Durham have been mined about 1.4 million tonnes of lead ore, about 1.5 million tonnes of iron ore, over 2 million tonnes of fluorspar, almost 1 million tonnes of barytes, over 0.25 million tonnes of witherite, and almost 1000 tonnes of zinc ore.

Lead and iron mining can be reliably traced back to Medieval times, and earlier working, perhaps even by the Romans is possible, though not proved. The heyday of lead mining came in the 19th century. The collapse in world lead prices in the

closing years of the 19th century brought the end for all but a handful of mines, and in 1931 increasing production costs resulted in the closure of Boltsburn Mine, the county's last significant lead mine. Since then, apart from a little mining for lead at Coldberry, lead ore production in the county has been as a by- product of fluorspar mining.

Iron mining also reached its peak of production in Weardale in the 19th century with large quantities of ore being supplied to the ironworks at Tow Law, Consett, Spennymoor and further afield.

A small amount of zinc ore was mined in the Harwood valley, Teesdale in the early years of the 20th century and a modest tonnage was recovered from the Killhope mines in the 1950's.

County Durham was one of the world's first commercial sources of fluorspar when industrial demand for this former waste product of lead mining developed in the 1880's. Fluorspar mining to a small extent helped to mitigate the severe economic consequences of the collapse of lead mining in the closing years of the 19th century. For many years large tonnages of fluorspar were recovered from old spoil heaps, from backfilled waste in former lead mines, and from mines re- opened or developed specifically to work this mineral. Large quantities of Weardale fluorspar were exported to the USA in the early years of the 20th century. A resurgence of exploration and increased production in the 1970's and 80's was followed by a progressive decline in output as the world price of fluorspar fell to levels which rendered the Weardale mines uneconomic. Large scale mining for fluorspar ended in 1999 with the final closure of the combined Groverake–Frazer's Hush fluorspar mine in Rookhope.

Barytes was for long periods an important mineral in the economy of County Durham. Substantial deposits were worked at Cow Green, Teesdale and at Close House, Lunedale, the latter mine finally being abandoned late in the 1990's. Barytes was mined alongside coal from a number of rich veins in the Durham coalfield, notably at New Brancepeth and Ushaw Moor collieries. A large vein of witherite in the Coal Measures was mined at South Moor until 1958, making County Durham one of the world's very few sources of this unusual mineral.

At the time of writing, working for vein minerals in County Durham is restricted to Rogerley Mine at Frosterley, where a small fluorite-rich 'flat' is being mined for several months each year as a source of fine mineral specimens by a small partnership of California-based mineral dealers.

Future commercial interest

In common with many of the world's disused mineral mines, the end of mining in the North Pennines owes more to the economic vagaries of world markets than to the exhaustion of the deposits. The collapse in world lead prices precipitated the closure of all but a handful of lead mines towards the end of the 19th century, and by the mid 20th century even this small number of survivors had succumbed to global economics. The county's fluorspar mines suffered a similar fate in the closing years of the 20th century.

Good prospects exist for the discovery of substantial reserves of fluorspar, particularly within the E-W Quarter Point vein structures such as the Rookhope Red and Slitt veins. Any serious interest in commercial exploration depends on a significant rise in world prices. Similar considerations apply to possibilities for future working of lead or zinc ores, though within County Durham any future for the working of these is likely to be as by-products of fluorspar mining.

Renewed interest in barytes, witherite or iron ores within the county must be considered unlikely.

Environmental issues

Centuries of mining for vein minerals have left a widespread legacy of opencast and underground workings, spoil heaps, buildings and smelting sites. Whereas several of these features may be considered essential elements in the county's physical and cultural landscape, and in some cases are protected as scheduled Ancient Monuments, others may be viewed less sympathetically.

Opencast workings, dilapidated buildings, open shafts and adits may comprise obvious hazards. Underground workings eventually collapse and may create craters or 'crown holes' at the surface. Metal-rich spoil heaps or accumulations of mine tailings or smelting wastes may be sources, or potential sources, of contamination. Numerous adits, whose original functions included mine drainage, may be discharging contaminated water. The contamination of Rookhope Burn (see page 100) remains unresolved.

Threats

Several of the surface exposures of mineral veins and associated flats within the county are reasonably robust. However, some of the finest surviving exposures of mineralisation lie within abandoned quarries. Particularly significant are the exposures of lead — fluorite mineralisation within Eastgate Quarry and similar vein mineralisation in Newlandside and Parson Byers quarries. Restoration or filling of these sites could destroy extremely instructive occurrences of important mineralisation.

In many places spoil heaps provide the only remaining evidence of the deposits once worked. They thus constitute important, in some instances unique, resources of geological and mineralogical material and information. Removal of spoil heaps, either as sources of low-grade aggregate, or as part of programmes of land reclamation, may pose very serious threats to these resources.

Important mineral occurrences in spoil heaps and exposures are locally threatened by uncontrolled collecting.

Wider significance

The mineral veins and associated deposits exhibit a number of features which give them national and international importance.

Similar orefields within the USA have given the term 'Mississippi Valley Type' to these orefields worldwide. The Northern Pennine orefield is one of the worlds finest, and best known, examples of such a 'Mississippi Valley Type' orefield.

Of particular importance is the very clear zonal arrangement of minerals within the orefield, and the significance of this in understanding the origins and evolution of the mineralisation, particularly the relationship with the concealed Weardale Granite. Concepts and theories developed here continue to be of importance in understanding similar orefields across the world.

Whereas many aspects of the mineralisation have clear parallels with broadly similar orefields elsewhere, the North Pennines exhibits several very distinctive or unique features.

The orefield is remarkable for the abundance of carbonates of iron, magnesium, manganese and calcium as the minerals dolomite, siderite and ankerite, which occur widely in veins and flats. These mineral assemblages still offer very considerable research potential, likely to shed important light on the origin of these, and similar, deposits.

The widespread abundance of barium carbonate minerals in the area's mineral deposits is a feature which makes the North Pennines unique in the world.

The veins and associated deposits of the North Pennines have long been a source of beautifully crystallised examples of many of the constituent minerals.

Selected references

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Figures and photographs

(Photo 21) Gas vent to allow drainage of mine gases from old workings. B Young, BGS, ©NERC, 2004.

(Photo 22) Crime Rigg Quarry, Sherburn Hill. Thick Yellow Sands beneath Raisby Formation and Marl Slate. DJD Lawrence, BGS, ©NERC, 2004.

(Photo 43) West Rigg Opencut, Westgate, Weardale. Worked out iron ore flats adjoining Slitt Vein. The vein remains as an unworked pillar in the centre of the quarry. B Young, BGS, ©NERC, 2004.

(Photo 44) Ankerite and galena-rich flat in Great Limestone. Wellheads Hush, Weardale. B Young, BGS, ©NERC, 2004.

(Photo 45) Raisby Railway Cutting, Coxhoe. Exposure of copper mineralisation in Magnesian Limestone adjoining the Butterknowle fault. B Young, BGS, ©NERC, 2004.

(Photo 46) Queensberry Ironstone Workings,Cowshill, Weardale. Long-abandoned and overgrown workings in ironstone flats adjacent to the Burtreeford Disturbance. B Young, BGS, ©NERC, 2004.

(Photo 47) Groverake Mine, Rookhope. Surface plant and buildings of County Durham's last fluorite mine. B Young, BGS, ©NERC, 2004.

(Photo 48) Aerial view of Groverake Mine, Rookhope. The course of Groverake vein is marked at the surface by a line of large crown holes. Infoterra.

Full references

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