Mineral veins

Mineral veins are sheet-like bodies of mineral which occupy approximately 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 may range from less than a millimetre up to several tens of metres in width. They generally comprise concentrations of minerals that 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 are present, commonly forming crude bands approximately parallel to the vein walls. Minerals present may include one or more metal ores, generally accompanied by a variety of non-metallic minerals, known by miners as gangue, or as 'spar', minerals.

Associated with many mineral veins, particularly those in the North Pennines, are roughly horizontal bodies of mineral, known as 'flats', which may extend for several metres on one, or both, sides of a vein, usually within limestone wall-rocks. They represent bodies of limestone, wholly or partly replaced by the minerals found in the adjoining vein. Many of the features present within the original limestone, such as bedding and sometimes fossils, are replaced by minerals.

Cavities, or 'vugs', in both veins and flats are typically lined with beautifully crystallised examples of the constituent minerals.

Currently protected sites of mineral veins within the AONB SSSIs

SSSI Name/GCR Name/Grid Ref.

Appleby Fells/Scordale Mine [NY 762 226]

Blagill Mine/Blagill Mine [NY 741 473]

Closehouse Mine/Closehouse Mine [NY 850 227]

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

Moorhouse & Cross Fell/Sir John's Mine [NY 762 378]

Moorhouse & Cross Fell/Windy Brow Mine [NY 770 381]

Old Moss Lead Vein/Killhope Head [NY 820 433]

River South Tyne & Tynebottom Mine/Tynebottom Mine [NY 740 418]

Smallcleugh Mine/Smallcleugh Mine [NY 787 431]

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

Upper Teesdale/Pikelaw Mines [NY 902 314]

Upper Teesdale/Willyhole Mine [NY 805 336]

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

RIGS

Haggs Bank, Nentsberry, Alston [NY 767 452]

Howhill Quarry, Alston [NY 730 433]

Nenthead, Alston Moor [NY 785 432]

Masons Holes, Scordale, Warcop [NY 758 224]

Durham County geological sites

Boltsburn Mine and Rookhope Borehole [NY 937 428]

Closehouse Mine [NY 850 227]

Coldberry Gutter [NY 940 292]

Cow Green Mine [NY 810 310]

Dirt Pit Mine [NY 891 291]

Greenhurth Mine [NY 779 328]

Greenlaws Mine [NY 889 369]

Grove Rake Mine and Opencast [NY 895 441]

Hunters Vein [NY 859 205]

Other representative sites in the area

Browngill Vein, River South Tyne, Garrigill [NY 744 418]

Nenthead [NY 788 430]

Nentsberry Haggs Mine, Nenthead [NY 7660 4502]

Rampgill Mine, Nenthead [NY 7818 4350]

St Peter's Mine, Spartylea [NY 8515 4876]

Rogerley Mine, Frosterley [NZ 0104 3814]

Queensberry Ironstone Workings, Cowshill [NY 857 410]

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

Frazer's Hushes, Rookhope [NY 885 445]

Boltsburn Mine, Rookhope [NY 9368 4279]

Shildon Mines, Blanchland [NY 959 510]

Farnberry and Holyfield Mines, Alston [NY 731 448]

Cornriggs Mine, Alston Moor [NY 7178 3724]

Noonstones Hill, Alston Moor [NY 742 382]–[NY 750 380]

Great Sulphur Vein, Crossgill [NY 7396 3830]

Sir John's Mine, Tynehead [NY 7616 3782]

Smittergill Head Mine, Alston Moor [NY 6739 3896]

Windy Brow Vein, Dorthgillfoot, Tynehead [NY 7610 3806]

Hard Rigg Edge, Melmerby Fell [NY 658 390]

Dun Fell Hush, Great Dun Fell [NY 712 318]–[NY 720 319]

Grasshill Mines and Highfield Hushes, Harwood Common, Upper Teesdale [NY 819 355]

Cowgreen Mines, Upper Teesdale [NY 810 310]

Wynch Bridge, Teesdale [NY 905 275]

Pike Law Mines, Newbiggin Common, Teesdale [NY 902 313]

Coldberry Gutter, Teesdale [NY 924 290]–[NY 939 291]

Greenlaws Mine, Daddry Shield [NY 887 367]

Augill Beck, Brough [NY 8219 1564]

High Longrigg Mine, Kirkby Stephen [NY 7985 0950]

Mineral veins in Great Britain

Concentrations of mineral veins of many different types are found across Great Britain. 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 contribute to interpreting the deposits of an area and help to inform and guide exploration for similar deposits worldwide.

Mineral veins in the AONB

The veins, and associated 'flat' deposits, of the North Pennines AONB comprise the large group of deposits collectively known as 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 as a by-product during the smelting of many lead ores. The non- metallic minerals fluorspar, barytes and witherite were also mined, especially in more recent years.

Veins within this area mostly occupy normal faults, typically with a maximum displacement, or throw, of only a few metres. Veins in the North Pennines may be up to 10 metres wide, though most of those worked have been less than 5 metres wide. The area's veins typically exhibit crude bands of largely 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 wall rock or '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'. Where one or both walls of a vein are composed of weak, or 'incompetent', rocks such as shales and soft sandstone, 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 the North Pennines, where the veins occur in alternately strong and weak rocks, the long, wide oreshoots between vein walls in strong beds are often termed 'ribbon oreshoots'.

Reaction the mineralising fluids and limestone wall rocks has locally created extensive 'flat' deposits. In most 'flats' within the North Pennines the main mass of the original limestone has been replaced by a compact aggregate of 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. Several 'flats in which the iron carbonate minerals ankerite and siderite were abundant were workable as iron ores, especially where later weathering had converted these carbonate minerals into oxidised, or 'limonitic' ores.

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 barite, witherite, and locally, barytocalcite. This outer zone includes much of the Nent Valley, West Allendale, parts of Teesdale, Lunedale and the Pennine escarpment.

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 to give large workable deposits of 'limonitic' iron ores.

Impact on the landscape

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

The North Pennine Orefield is celebrated for the remains of the early form of opencast mining and prospecting 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. Although it has commonly been supposed that these water torrents alone created the hushes, this is extremely unlikely, as the amounts of water available were almost invariably insufficient to dislodge and remove the large volumes of material necessary. It seems most probable that 'hushing' was employed as a convenient means of 'flushing' away rock loosened by previous manual excavation. Large elongated trenches, or hushes, are conspicuous features of the AONB landscape.

Impact on biodiversity

An important feature of the area is the widespread occurrence of a number of specialised plant species and communities which exhibit a preference for 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. Concentrations of metal-rich soils, together with their associated rich metallophyte plant communities, adjoining many streams and rivers reflects the downstream erosion of such metal-rich sediments. Concentrations of metallophyte plants almost certainly served as important guides to the presence of ore deposits to early prospectors.

Several areas of mine spoil, which are contaminated either through elevated heavy metal concentrations or adverse soil pH values, remain virtually devoid of continuous vegetation cover, even after over a century. Severe heavy metal contamination is also a feature of soils close to a number of former lead and zinc smelting sites.

Most of the area's mineral deposits were worked from 'adit levels', driven into hillsides, or from shafts. Stone-arched adits are common landscape features. Many of the area's open adits are today protected by steel gates, though many have collapsed or 'run in'. They 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 'run in' circular depressions, sometimes filled with water, or may be covered by distinctive protective stone 'bee hives'. Such unprotected shafts, adits or areas of collapsed ground may present significant safety hazards.

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

One of the most widespread landscape impacts of the area's mineral veins 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 uneconomic hillside and the development of scattered, isolated settlements. The area has a rich legacy of remains relating to the minerals industries. These remains comprise opencast workings, including hushes, spoil heaps, mine entrances, mine buildings and many miles of underground workings. All have considerable historical interest. Many are scheduled, or proposed for scheduling, as historical monuments.

Miner-farmer landscape, upper Weardale. © Elizabeth Pickett/NPAP

Mine water discharges may carry high levels of contaminants which can affect land immediately surrounding the discharge. Where mine waters discharge into streams and rivers, these can have an adverse effect on the biodiversity of that watercourse. Notable examples of such heavy metal concentrations in surface streams include the River Nent and the Rookhope Burn. In the former, particularly high levels of zinc which may be related to mine and natural groundwaters passing through heavily mineralised ground, results in a severe restriction in the biodiversity of the river. In Rookhope Burn, significant contamination, including iron and zinc, has occured since the cessation of mine water pumping following the closure in 1990 of the Groverake–Frazer's Hush fluorspar mine near Rookhope.

Whereas the term 'contamination' is commonly used for such concentrations of heavy metals in soils and waters, it is important to appreciate that not all such concentrations are necessarily the result of the mining and processing of metal ores. The natural weathering and breakdown of locally abundant mineralisation may result in numerous entirely natural concentrations of very high levels of heavy metals. Entirely natural occurrences of heavy metal 'contamination' may be at least as widespread as anthropogenic concentrations.

Economic use

The mineral veins and flats have, over several centuries, provided the foundation for much of the area's economy. Available records indicate that over 4 million tonnes of lead ore, one third of a million tonnes of zinc ore, over 2 million tonnes of fluorspar, almost 1.5 million tonnes of barytes and several thousand tonnes of witherite and very large, but unrecorded, tonnages of iron ore have been mined from the hundreds of veins and associated flat deposits.

Large scale mining for vein minerals ended in 1999 with the final closure of the combined Groverake-Frazer's Hush fluorspar mine. At the time of editing (January 2010), working for minerals 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.

In common with many of the world's disused mineral mines, the end of mining in the North Pennines owes more to the fluctuation in world metal prices 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. The large-scale working of fluorspar, which to a small extent helped to offset the effects of the collapse of lead mining, prospered during parts of the 20th Century. However, the availability of cheap fluorspar from countries such as China, brought about the demise of fluorspar mining in the North Pennines during the 1990s. Whereas there are good grounds for supposing that significant reserves of lead and zinc ores and fluorspar may be present within the area, any serious interest in commercial exploration depends on a significant rise in world mineral prices and would have to be undertaken in line with national planning regulations for AONBs.

Wider importance

The area's mineral veins and flats exhibit a number of features which give them national and international importance. Similar orefields within the USA have given the name 'Mississippi Valley Type (MVT)' to these orefields worldwide. The Northern Pennine orefield is one of the worlds finest, and best known, examples of such an MVT orefield.

Whereas many aspects of the mineralisation have clear parallels with broadly similar orefields elsewhere, the North Pennines exhibits several distinctive or unique features. 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 vital importance in understanding similar orefields across the world.

The orefield is remarkable for the abundance of carbonates of iron, magnesium, managenese and calcium as the minerals dolomite, siderite and ankerite, which occur widely in veins and flats. These mineral assemblages still offer considerable research potential which is 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 (see Minerals and Mineralogy).

The veins and associated deposits of the North Pennines have long been a source of beautifully crystallised examples of many of the constituent minerals. In addition, observations, practical experience, interpretations and theories which flowed from the activities of generations of miners have been crucial to the understanding of not only the North Pennine deposits, but of similar deposits across the world.

Conservation issues

Although many important surface exposures of mineral veins and flats remain, many of the finest exposures lie underground in long-abandoned workings. Although many of these remain accessible with appropriate care, such workings must always be regarded as potentially unstable.The continued accessibility of such exposures can thus not be guaranteed.

In addition to surface and underground exposures of mineral veins and flats, material within the numerous spoil heaps at many of the mines across the North Pennines provides 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 serious threats to these resources.

Uncontrolled collecting of mineral specimens at the surface and underground, both by amateur and commercial collectors, poses a significant threat to the integrity, research and heritage value of many sites across the AONB.

Selected references

Bevans, et al, in press; British Geological Survey, 1992; British Geological Survey, 1996; Dunham, 1990; Dunham and Wilson, 1985; Dunham et al , 2001; Forbes, Young, Crossley and Hehir, 2003; Stone et al , 2010; Symes and Young, 2008; Young, 1997, 2003

Figures

(Figure 39) Outcrop of mineral veins.

(Figure 40) Witherite vein, Scraithole Vein, Scraithole Mine, Carr Shield © BGS P601083.

(Figure 41) Slitt Vein and worked — out ironstone flats, West Rigg, Westgate, Weardale © B. Young, BGS, NERC.

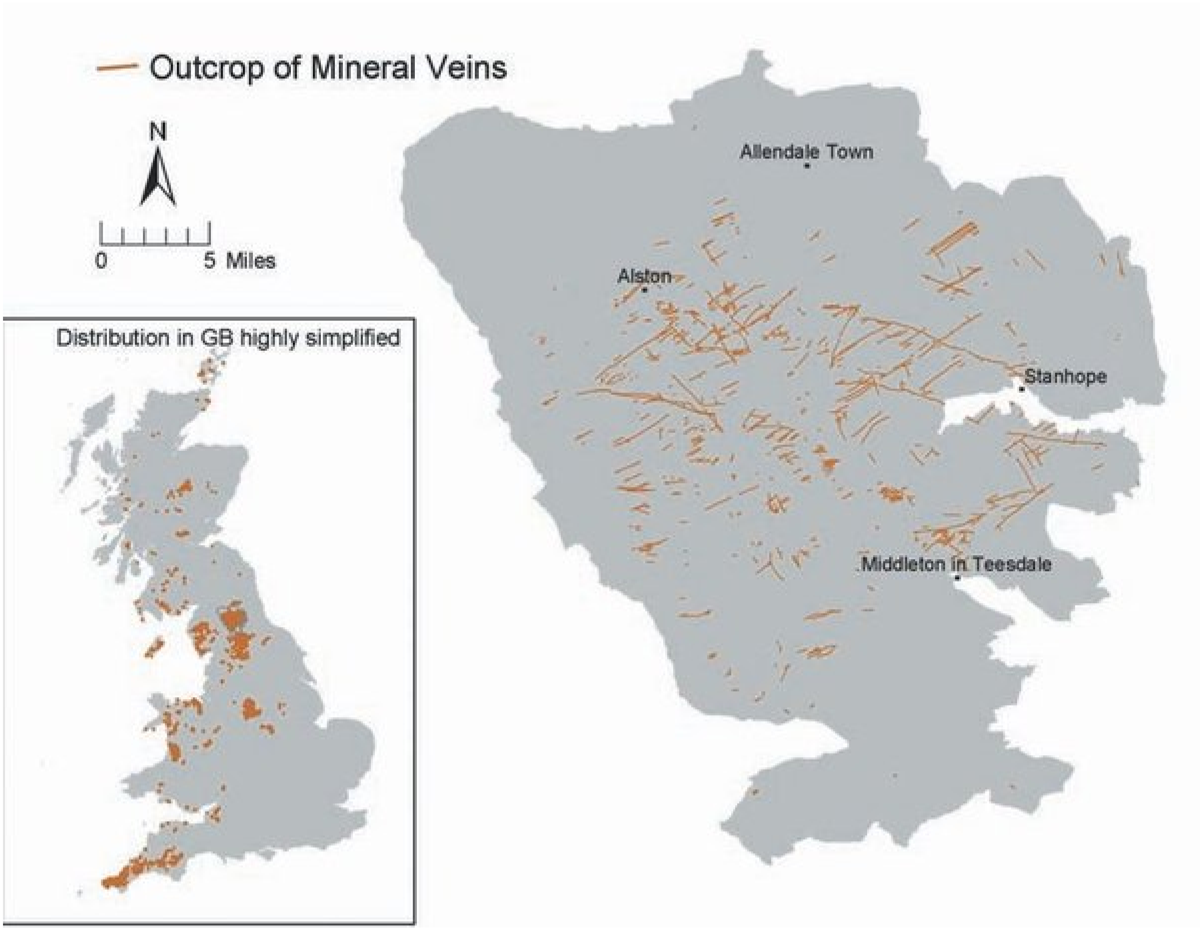
(Figure 42) Miner-farmer landscape, upper Weardale. © Elizabeth Pickett/NPAP.

(Figure 43) Spring Sandwort © B. Young, BGS, NERC.

(Figure 44) Discharge of brown iron-rich minewater entering Rookhope Burn near Ripsey Mine, 2007. © B. Young, BGS, NERC.

(Figure 45) Lady's Rake Mine, an extremely important mineralogical site with mining history interest. © B. Young, BGS, NERC.

Full references



Outcrop of mineral veins

Witherite vein, Scraithole Vein, Scraithole Mine, Carr Shield © P601083. BGS.

Slitt Vein and worked – out ironstone flats, West Rigg, Westgate, Weardale © B. Young, BGS, NERC.

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