

Northern Pennine Orefield

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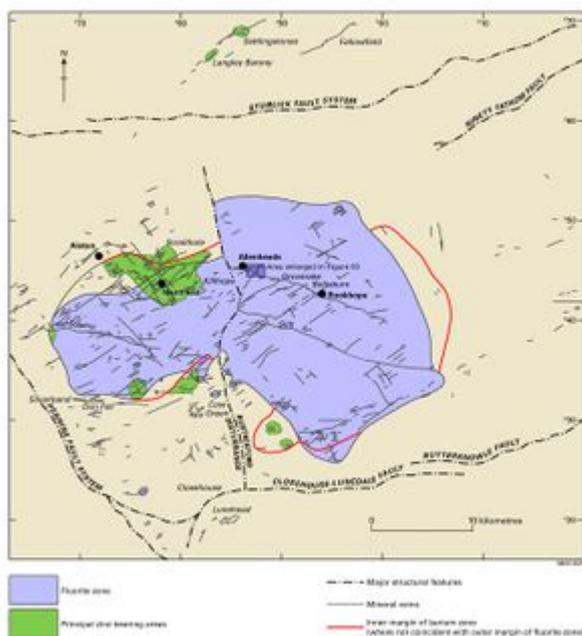
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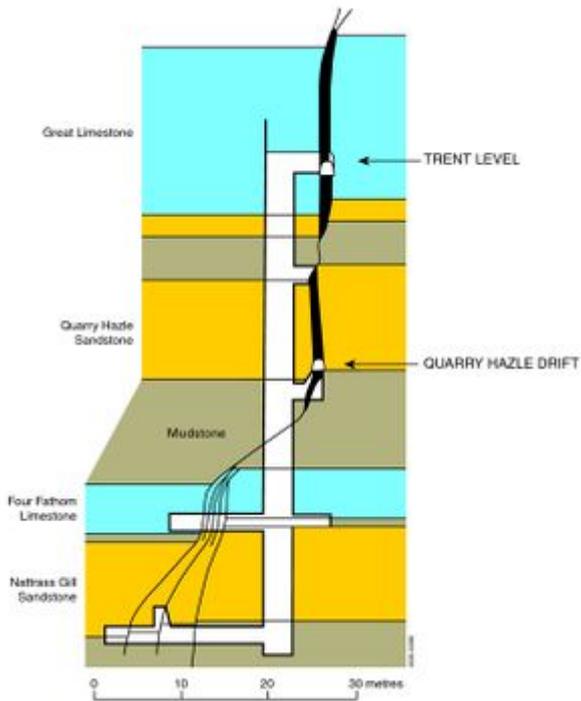
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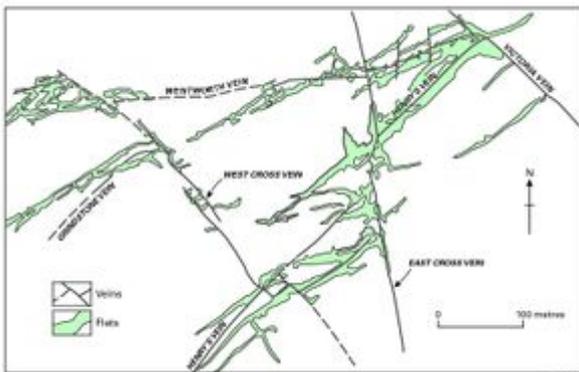
Introduction



Principal geological features of the Northern Pennine Orefield. Named localities are those mentioned in the text (after Dunham, 1990. Geology of the Northern Pennine Orefield (1). BGS Memoir). P916091.



Cross-section through the Killhopehead Vein to demonstrate the lithological control on the ore shoots. For location see Figure 61 (after Dunham, 1990. Geology of the Northern Pennine Orefield (1). BGS Memoir). P916092.



Plan view of the 'flat' mineralisation at Allenheads Mine. For location see Figure 61 (after Dunham, 1990. Geology of the Northern Pennine Orefield (1). BGS Memoir). P916093.



Purple and green fluorite with bands of white quartz and bluish chalcedony, Groverake Vein, Rookhope, Weardale, Co. Durham. Photograph taken in the sub-level above the 60-fathom level, Groverake Mine. The banding is characteristic of the Groverake Vein. The brown patches are superficial iron-staining. The compressed air pipe is about 7 cm in diameter. (P223157).



Scraithole Vein in Scraithole Mine, West Allendale, Northumberland. The vein cuts the Namurian Great Limestone, and consists

predominately of witherite with small quantities of sphalerite and numerous clasts of limestone wall rock. (Photo T F Bridges, 1983; P601083).

The comparatively thin succession of Carboniferous rocks on the Alston Block are cut by an extensive suite of veins and related deposits which collectively make up the Northern Pennine Orefield. The orefield coincides closely with the uplands of the northern Pennines, but extends eastwards to include parts of the Durham Coalfield. A group of richly mineralised faults close to the southern margin of the Northumberland Trough in the Haydon Bridge area, are generally regarded as comprising an outlying portion of the orefield. The deposits exhibit many characteristics of the worldwide 'Mississippi Valley' mineralisation type, though they should be considered as a special fluoritic subtype with similarity to the deposits of the Illinois-Kentucky fields of the USA.

Since at least the 12th century, the orefield has been a significant producer of lead and iron ores; minor amounts of copper have also been produced and a little silver has been won as a by-product of lead smelting. The peak years of metal production were during the 18th and 19th centuries. More recent years saw the rise in importance of zinc mining, together with major production of fluorspar, baryte and witherite. Commercial mining ended in 1999 with the closure of the combined Groverake-Frazer's Hush Mine (NY 890 440), the area's last major fluorspar mine (see Chapter 12). In addition to its distinguished history as a mineral producer, the orefield has contributed much to the understanding of hydrothermal deposits, from the theories of mine agents during the early years of geological science, the revision of ideas necessitated by the drilling of the Rookhope Borehole (NY 933 428), through to present-day, fluid inclusion and isotope studies.

Mineral veins in the orefield occupy conjugate sets of normal faults, which typically show maximum throws of only a few metres. Veins have three principal orientations ([P916091](#)). Most numerous, and most productive of lead ore, are those trending approximately east-north-east. A smaller number of roughly north-north-west-trending fractures are generally known as 'cross veins'. Throughout much of the orefield these are barren faults, though locally, especially in parts of Alston Moor, they are associated with significant mineralisation. A handful of roughly east-west fractures, known as 'Quarter Point' veins, complete the suite. Unlike the other vein sets, the 'Quarter Point' veins typically occupy faults with a marked sinistral transcurrent displacement. They are mostly several metres wide and are composed of spar minerals with comparatively low sulphide values. The orefield's largest fluorspar orebodies occur in 'Quarter Point' veins.

A distinctive feature of the orefield is the close relationship between the geology of the wallrock and the potential of the fault as a mineralised vein. Hard, competent wallrocks such as limestone, sandstone or dolerite of the Whin Sill-swarm provided clean open fissures favourable for the deposition of wide mineralised veins. In weak, incompetent rocks such as mudstone, fault fissures are normally tightly closed and generally poorly mineralised. In Yoredale-type sequences, this relationship results in laterally extensive oreshoots against or between hard beds, alternating with barren intervals between weak wallrocks, giving the 'ribbon oreshoots' so characteristic of this orefield and well developed at Killhope ([P916092](#)). Veins are typically filled with coarsely crystalline gangue and ore minerals, commonly as crude bands parallel to the vein walls. Vein widths vary from a few millimetres to over 10 m, though most of the worked veins appear to have been less than 5 m wide.

In addition to hundreds of fissure veins, the Northern Pennine Orefield is noted for extensive replacements of limestone wallrock by introduced minerals. Adjacent to many veins, the limestone has suffered extensive metasomatism, in places extending for many metres from the parent vein, for example in the Allenheads area ([P916093](#)). The original limestone has been wholly or partly replaced

by variable assemblages of quartz, ankerite, siderite, fluorite, baryte, witherite, galena and sphalerite, with smaller amounts of other minerals. These deposits are known locally as 'flats' because of their essentially horizontal form. Ore minerals such as galena and sphalerite are commonly more abundant in the 'flats' than in the parent veins, and some of the orefield's most productive metal mines were worked in such 'flats'. The most extensive and formerly economically important 'flat' deposits have been found in the Great Limestone, though significant 'flat' mineralisation is also present locally in the Melmerby Scar, Jew, Single Post and Tynebottom limestones. Such metasomatic replacements appear to be best developed where impervious mudstone directly overlies limestone.

Galena and sphalerite are the main ore minerals throughout the orefield, with sphalerite dominant locally, notably in the Nenthead, area. Most of the galena is silver-bearing with typical silver values of between 4 and 8 oz per ton of lead (112 to 223 ppm), though exceptional silver values of up to 90 oz per ton of lead (2511 ppm) have been identified in a few places. The sphalerite normally carries some cadmium and, in a few places, a little mercury. Chalcopyrite is common in small amounts throughout the orefield, but is abundant in a few deposits in the Garrigill area. Sulpharsenides of cobalt and nickel, and small amounts of arsenopyrite and tetrahedrite group minerals, have been identified as minute grains in many of the deposits. Pyrite and marcasite are common, locally accompanied by some pyrrhotite. Small, but significant concentrations of nickel minerals are known from Settlingstones (NY 844 683), Scordale (NY 764 228) and Lady's Rake (NY 806 342) in Upper Teesdale.

Siderite and ankerite are extremely widespread in both vein and 'flat' deposits. Supergene alteration of these minerals to goethite has produced large deposits of workable limonitic or 'brown haematite' ores. In addition to siderite and ankerite, the main gangue minerals are fluorite, quartz, baryte and witherite. The presence of the last mineral together with the local abundance of barytocalcite and the more restricted occurrence of alstonite, two unusual double carbonates of calcium and barium, is one of the remarkable, though as yet unexplained, features of this orefield. All three minerals were first described from the Northern Pennines, beyond which they are very rare.

One of the most striking features of the orefield is the marked concentric zoning of the mineralisation ([P916091](#)). A large central zone in which deposits typically carry abundant fluorite, for example at Groverake ([P223157](#)), is surrounded by outer zones in which the barium minerals baryte and witherite comprise the characteristic gangue minerals, for example at Scraithole ([P601083](#)). The separation of these zones is very sharp, with fluorite and barium minerals generally exhibiting a mutually exclusive relationship. Small concentrations of chalcopyrite, commonly accompanied by traces of bismuth minerals, and very rarely by minute amounts of synchysite, monazite and cassiterite, have been described from the innermost parts of the fluorite zone. Some major fluorite-bearing veins appear to pass downwards into veins dominated by quartz and iron sulphides amongst which pyrrhotite is common. Galena concentrations are commonly greatest in the outermost part of the fluorite zone.

The main phase of mineralisation appears to have been emplaced very soon after the intrusion of the Whin Sill-swarm in earliest Permian times. An unusual deposit in Upper Teesdale, with abundant magnetite and galena and local concentrations of niccolite, may result from reaction between metal-rich mineralising fluids and contact rocks of the Great Whin Sill while the latter were still hot. If the small concentrations of baryte, galena, sphalerite and, locally, a little fluorite within the Permian rocks of eastern County Durham are linked with the Northern Pennine deposits, the mineralisation must postdate deposition of the Permian limestones. The baryte mineralisation appears to be largely a late-stage effect, introduced during the waning stages or by the distal portions of the main hydrothermal system.

By analogy with the zonation of minerals around the granites of south-west England, and with support from early geophysical studies, a concealed Late Carboniferous ('Variscan') granite beneath the northern Pennines was postulated to account for the mineralisation. However, the proving of an Early Devonian age for the Weardale Granite in the Rookhope Borehole, drilled in 1960-61, clearly demonstrated that the mineralisation could not be the direct result of granite intrusion. Instead, as a 'high-heat-production' granite, the Weardale Granite is now considered to have driven a convective circulation of mineralising fluids long after its intrusion. From fluid inclusion and isotopic evidence, mineralising brines were derived by dewatering of adjoining sedimentary basins before scavenging metals from the rock through which they passed. Sources of the required chemical elements probably included Lower Palaeozoic basement rocks, the Weardale Granite itself, Carboniferous sedimentary rocks and the Whin Sills. Minerals were deposited in fissure veins by crystallisation from solutions which cooled as they flowed outwards from emanative centres.

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