Chapter 4 South Pennine Orefield: Cheshire, Leicestershire and Shropshire

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Introduction

The sites described in this chapter are geographically dispersed around the Midlands of England, and range in geological age from Precambrian to Triassic. They have in common a history of exploitation, as mines and quarries, which in some cases extends back many centuries. Alongside commercial activity, they have attracted the attention of scientists by virtue of their geological characteristics, which include the type locations for certain (rare) minerals, and the occurrence of hydrocarbons within mineralized rocks. Many of these locations have played a very significant role in the historical development of the Earth sciences, and whilst interest in them may now be dormant, they have achieved international exposure through their past contributions to our understanding of mineralizing processes. Although some of the locations no longer show features that were recorded in the past, the bibliography recorded here is quite substantial and allows them to be placed into context.

Four GCR sites in Leicestershire (see (Figure 4.1)) are related spatially to the Precambrian-Lower Palaeozoic basement rocks and their uncomformably overlying Triassic sediments. At the Newhurst Quarry GCR site, near Shepshed, the unconformity between granodiorites intruded into a Charnian hornfels and overlying Mercia Mudstone Group (Keuper) marls carries distinctive mineralization. High-temperature copper sulphides occur within veins within the basement granodiorite, whilst native copper and secondary copper-vanadium minerals occur within the basal Triassic or along fractures close to the unconformity. Similarly, the unconformity between basement and Triassic rocks is exposed at the Croft Quarry GCR site (an isolated inlier of dioritic rock, 10 km south-west of Leicester). Here, alteration of the diorite has led to the formation of a suite of zeolites including analcime, and unconformity-associated mineralization within the overlying Mercia Mudstone Group includes manganese minerals. At Warren Quarry, the unconformity was exposed in the past during quarrying, and this is the only British locality that shows formation of palygorskite ($Mg_2Si_8Al_2O_{20}(OH)_6.4H_2O$) during weathering in the Triassic. Granodiorite from basement rocks is exposed at the Castle Hill Quarry GCR site, at Mountsorrel near Loughborough, where it contains mineral veins carrying a high-temperature assemblage including molybdenite and topaz. Here, Carboniferous dolerite dykes carry bitumens in association with a low-temperature hydrothermal suite of minerals, including dolomite. The spatial association of bitumens with igneous rocks at this location was used in the 1970s as evidence for an abiogenic origin for hydrocarbons, and so contributed significantly to debates concerning the origin of life and the possible development of life in extraterrestrial systems.

Farther from the unconformity, the Keuper sediments at Gipsy Lane Brick Pit (north-east of Leicester) contain uranium and vanadium minerals in association with bitumens, within gypsum.

Evidence of deep mantle systems is afforded by the occurrence at the Calton Hill GCR site near Buxton, in Derbyshire (see (Figure 4.1)) of Lower Carboniferous volcanic rocks that contain olivine nodules. These originated deep beneath the Earth's crust and represent the only known examples found in England. The Calton Hill volcano is believed to have produced the Miller's Dale volcanic rocks which provide a control on the distribution of mineralization in the Carboniferous sequence of the Peak District. At the Masson Hill Mines GCR site (south-west of Matlock), mineralization within the Carboniferous succession is clearly controlled by the distribution of the volcanic rocks and by dolomitization of the limestones. Here pipes and other, planar, replacement fluorite(-galena) orebodies occur within dolomitized limestone sandwiched between two volcanic horizons.

The South Pennine Orefield is important as an example of Mississippi Valley-type mineralization within the British Isles. One of the best examples of vein mineralization in this area is seen at the Dirtlow Rake and Pindale GCR site, located to the south of Castleton, in Derbyshire (see (Figure 4.1)), which is a major hydrothermal fissure-vein that can be traced for over 6 km in a general ENE–WSW direction. Between 3 m and 12 m in width, it carries fluorite and galena mineralization, and shows extensive silicification of the host limestones. This vein has played a major role in the development of our understanding of the mineralization processes that have taken place within the zoned orefield, in which high-temperature lead (galena)-fluorite veins are surrounded by lower-temperature barite-bearing veins. On exposure of these mineral veins to the surface, secondary minerals form by weathering of primary sulphides; these commonly include sulphates and carbonates. The Bage Mine GCR site, at Cromford, near Matlock (Figure 4.1) contains a remarkable assemblage of secondary minerals, and is the type locality for the lead chloride minerals cromfordite (properly known as 'phosgenite': $Pb_2CO_3Cl_2$) and matlockite (PbFCl).

Importantly, the South Pennine Orefield is hosted by anticlinal features of which the largest is the Derbyshire Dome. Peripheral smaller anticlinal structures have created inliers of Carboniferous limestone surrounded 'by younger, clastic-dominated Carboniferous rocks. Although scales vary, the occurrence of hydrothermal mineralization at the crests of anticlinal structures is an important constraint on models of their genesis. In many cases, crestal mineralization is accompanied by hydrocarbons, leading to conceptual overlaps with models of petroleum migration into structural traps. The Fall Hill Quarry GCR site at Ashover (Figure 4.1) exposes part of the Ashover Anticline, which is an example of a microcosm of the Derbyshire mineralization story. Here, fluorite veins cutting limestone carry small amounts of sphalerite and nickel and cadmium sulphides, including millerite, greenockite and hawleyite. Hydrocarbons occur within the fluorite, suggesting a link with petroleum hosted farther to the east, in similar buried structures.

On a much larger scale, the 'crest' of the Derbyshire Dome contains fluorite mineralization, as seen at the Treak Cliff and Windy Knoll GCR sites (Figure 4.1). Treak Cliff is host to the unique deposits of Blue John fluorite that occur within a boulder bed at the contact between the Carboniferous limestone reef and overlapping Namurian mudstones. At Windy Knoll, at the crest of the reef structure, fluorite mineralization is accompanied by the occurrence of a variety of solid bitumens. As in the case of the Croft Quarry GCR site examples, the Windy Knoll bitumens have been used as evidence for abiological hydrocarbon formation by virtue of their spatial association with mineral deposits.

Geographically located on the summit of the Derbyshire Dome and close to Dirtlow Rake, the Portway Gravel Pits GCR site shows evidence of the collapse of a pipe structure with barite mineralization, and the later infill by Pleistocene sediments. Farther south in Derbyshire, the Kirkham's Silica Sandpits GCR site has a Pliocene–Pleistocene sedimentary fill, with the clay mineral metahalloysite ($Al_2Si_2O_5(OH)_4$). Importantly, the Pliocene–Pleistocene fill at these locations provides evidence of uplift and erosion of the South Pennines and adjacent areas, by up to 450 m in 2 million years.

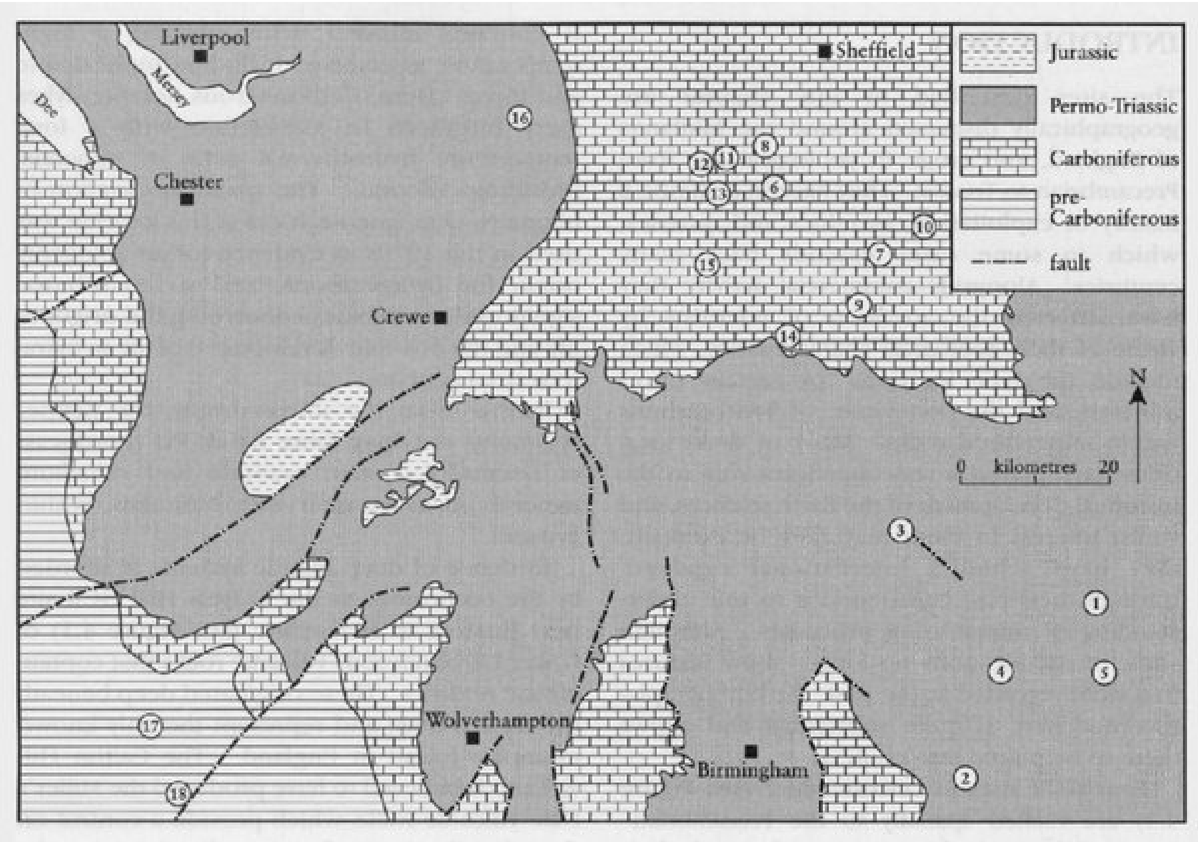
To the west of the Derbyshire Dome, a flanking anticlinal structure at the Ecton Copper Mines GCR site (Figure 4.1) introduces mineralization dominated by copper sulphides. Again, hydrocarbons are present. These deposits are unique in the United Kingdom, as they are the only copper deposits that were mined from within Carboniferous limestones. They occur on the flank of the Cheshire Basin, within which the Triassic sandstones contain a number of occurrences of copper mineralization. At the Alderley Edge District GCR site (Figure 4.1), copper mining has taken place over several centuries, recovering copper from an assemblage of secondary minerals (principally copper carbonates) associated with faulting within Triassic sandstones. These deposits also contain vanadium and cobalt minerals, and were the source of the material used by Roscoe (1876), who discovered vanadium. The geological relationships of the copper and associated barite mineralization at Alderley Edge are typical of those associated with elastic petroleum reservoirs.

The mineralization of the West Shropshire Orefield is represented by the Snailbeach Mine GCR site, which was the largest lead-zinc mine in the orefleld, dating back to Roman times. The lead-zinc veins occur within Ordovician rocks, with a dear stratigraphical control. A further association between copper and barite mineralization is found at the Huglith Mine GCR site, near Habberley in Shropshire (Figure 4.1). Here vein mineralization occurs In basement (Neoproterozoic) quartzites. The characteristics of the vein mineralization suggest an origin from basinal brines, probably during early Carboniferous times.

The locations described in this chapter share a number of common features. With the exception of Calton Hill and Kirldiam's Silica Sandpits, they all describe hydrothermal mineral deposits associated with geological boundaries between basement or host-rocks and unconformably overlying impermeable strata. Without exception, all locations have made significant contributions to geological knowledge during a long history of study, extending back to the early 1800s in some cases. The story they tell is one of migration of ore-bearing fluids into fractured rocks within which precipitation takes place, followed by uplift, erosion and modem exposure to the atmosphere which has generated suites of secondary minerals. The occurrence of bitumens in spatial association with igneous or hydrothermal rocks within many of the localities has been used in the past as evidence of an abiological origin for hydrocarbons, and comparisons have been made between these materials and organic matter from extraterrestrial sources, with a view to supporting models for the origin of life. However, as geochemical analysis has become more sophisticated, combined with improved understanding of petroleum migration and biodegradation, reexamination of hydrocarbons from these locations now favours a secondary, petroleum-related origin. Thus the mineral deposits of the Midlands region form part of a much larger story of the evolution of sedimentary basins and how they interact with basement highs.

In this context, the individual descriptions that follow provide a view of the — historical record of the geological investigations of each site. Each has been studied at different times with different geological paradigms in mind, and so individual descriptions vary greatly in the quality and quantity of work that is available. With these limitations in mind, the site reports provide an opportunity not only to focus on the individual merits of each site, but to consider more broadly the contribution that all of the sites, taken together, can make in the future to our understanding of the geological evolution of the Midlands region, and hence to similar geological environments elsewhere.

References



(Figure 4.1) Map of the geological sites reported in this chapter showing simplified major geological boundaries and faults. 1- Castle Hill Quarry; 2 — Croft Quarry; 3 — Newhurst Quarry; 4 — Warren Quarry; 5 — Gipsy Lane Brick Pit; 6 — Calton Hill; 7 — Masson Hill Mines; 8 — Dirtlow Rake and Pindale; 9 — Bage Mine; 10 — Fall Hill Quarry; 11 — Treak Cliff; 12 — Windy Knoll; 13 — Portway Gravel Pits; 14 — ICurkham's Silica Sandpits; 15 — Ecton Copper Mines; 16 — Alderley Edge District; 17 — Snailbeach Mine; 18 — Huglith Mine.