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A Geological Trail around Hawkstone Park

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RAYNER, C. (2007). A Geological Trail around Hawkstone Park. *Proceedings of the Shropshire Geological Society*, **12**, 70-78. Hawkstone Park lies at the south-east edge of a shallow elongated basin extending through the North Shropshire and Cheshire Plains. The sandstones, being stronger than the intervening mudstones, stand up from the general low-lying landscape as prominent ridges faced by escarpments. These escarpments were displaced in the Jurassic Period, some 60 million years later, by a series of important faults.

Copper mineralisation is present, dating from the Tertiary Period, some 100 million years after the faulting, when there was igneous activity associated with the opening up of the North Atlantic. The effect of this locally was to produce hot fluids, rich in copper and barytes, which moved within the groundwater and crystallised out in the sandstones, particularly along fault planes.

A geological trail is presented, enabling the visitor to the Park to better appreciate the influence of this geology on the landscape and the features enhanced over the last two hundred years by the Hill family.

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GEOLOGICAL BACKGROUND

During the Triassic Period, about 230 million years ago, the area of what is now Hawkstone Park would have been located between 20 and 30 degrees north of the Equator, within an enormous continent known as Pangaea.

Because it was far from any ocean, the rocks of Hawkstone were formed from sediments deposited on land rather than in the sea. Thus two similar sandstones are seen: the Wilmslow Sandstone (mostly a distinct red colour) and the Helsby Sandstone (also known locally as the Grinshill sandstone, which is generally pale with some reddish colouring in places).

The climate during the Permo-Trias was arid or semi-arid, rather like that of the Sahara Desert today. The sands were laid down by braided rivers or by the wind, building up as dunes.

Hawkstone Park lies at the south-east edge of a shallow elongated basin extending through the North Shropshire and Cheshire Plains. The sandstones, being stronger than the intervening mudstones, stand up from the general low-lying landscape as prominent ridges faced by escarpments (Figure 1). These escarpments were displaced in the Jurassic Period, some 60 million years later, by a series of important faults. For instance, Hawkstone was moved in the third shift north-eastwards (Figure 2).

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Much of the low-lying ground was then overrun by glaciers during the Pleistocene, draping the landscape in moraine (Superficial Deposits, formerly known as ‘Drift’).

Throughout the Park there are clues to its geological past, seen in the rocks themselves, thereby opening ‘windows’ into a Shropshire long vanished and enable the imagination to conjure up landscapes so different from today.

A glossary of geological terms appears at the end of this paper. Readers may also wish to refer to Peter Toghill’s *Geology of Shropshire* (2006) to benefit from his detailed knowledge of the local geology.

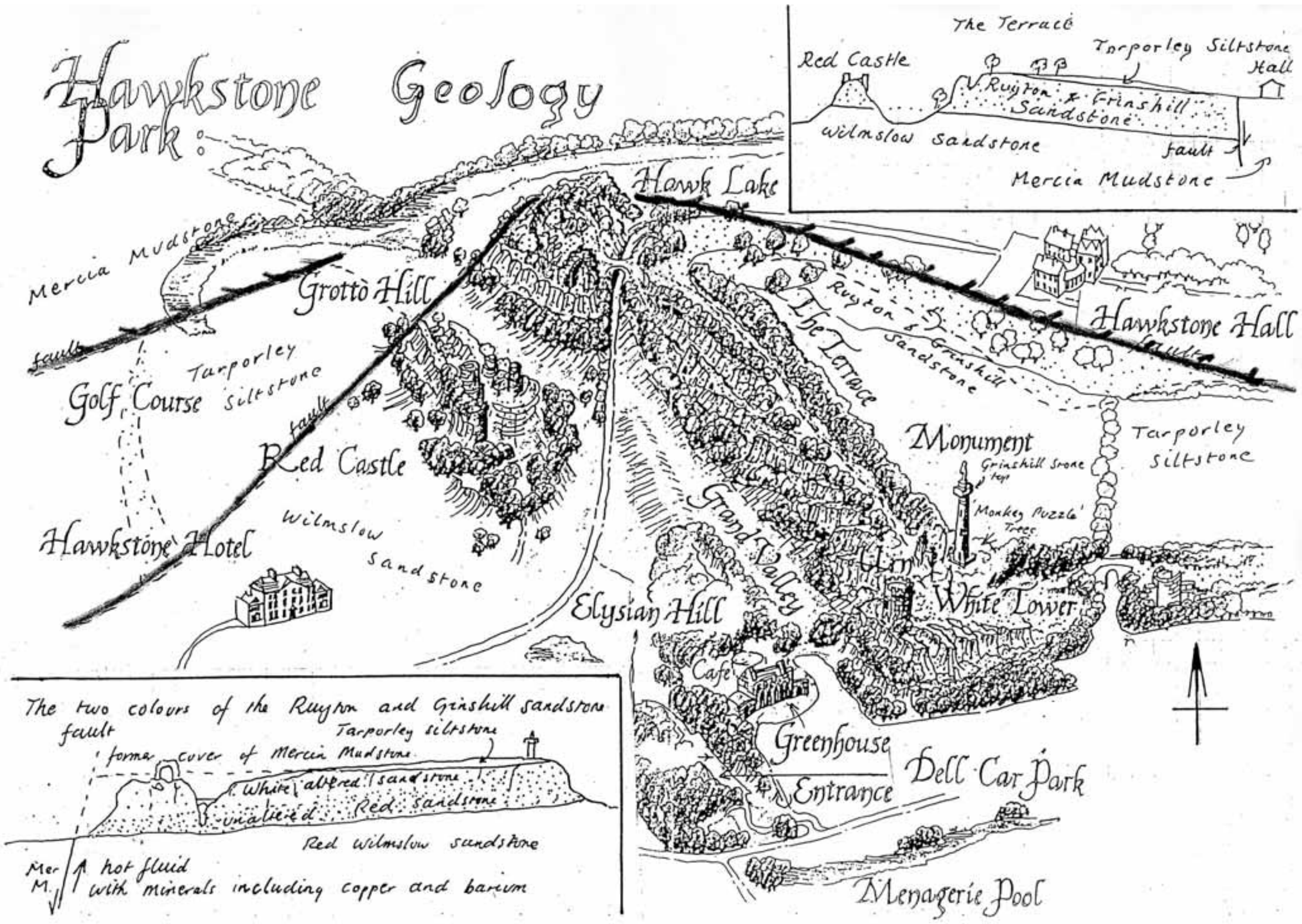

Figure 1. An overview of the landscape at Hawkstone Park. The geological trail commences at the entrance marked in the lower centre and finishes at the café nearby. The route is clearly marked, and takes the visitor anti-clockwise around the Park. *[Sketch taken from “Hawkstone: a short history and guide” published by Hawkstone Park Leisure, 1993; geological insets drawn by David Pannett.]*

HAWKSTONE PARK IN CONTEXT

Hawkstone Park can be placed in its regional geological context with reference to the North Shropshire and Cheshire Basin. The following is based on the paper by Chadwick (1997) in the Geological Society Special Publication No. 124 entitled *Petroleum Geology of the Irish Sea and adjacent areas*.

“The Cheshire Basin developed during a period of E-W regional crustal extension associated with the development of the Arctic-North Atlantic rift system to the north and the Tethys-Central Atlantic-Gulf of Mexico rift-wrench system to the south. The Cheshire Basin lies within a complex N-S Permo-Triassic rift system extending for more than 400 km from the English Channel Basin in the south, to the East Irish Sea Basin. These basins are bounded by major normal faults which formed during sediment deposition.

“Initiated in Permo-Triassic times, the Cheshire Basin marked a particularly rapidly subsiding segment of the rift system, forming an asymmetrical half graben with preserved fill of more than 4500 m Permo-Triassic red beds. It is roughly elliptical in outline, 105 km long and 30 to 50 km across, the long axis trending NE-SW. Sub-surface information has been obtained from detailed seismic reflection data. It is deepest close to the Wem-Bridgemere-Red Rock Fault System (WBRRFS), the southern end of which passes through the Hawkstone-Wixhill area.

“The steeply dipping WBRRFS is 110 km long, forms the eastern margin and was a dominant influence on the development of the basin. A significant branch of this important fault is the mineralised Brockhurst Fault. The western margin is relatively unfaulted, forming a ‘feather edge’ characteristic of depositional on-lap. (See cross section in Figure 3).

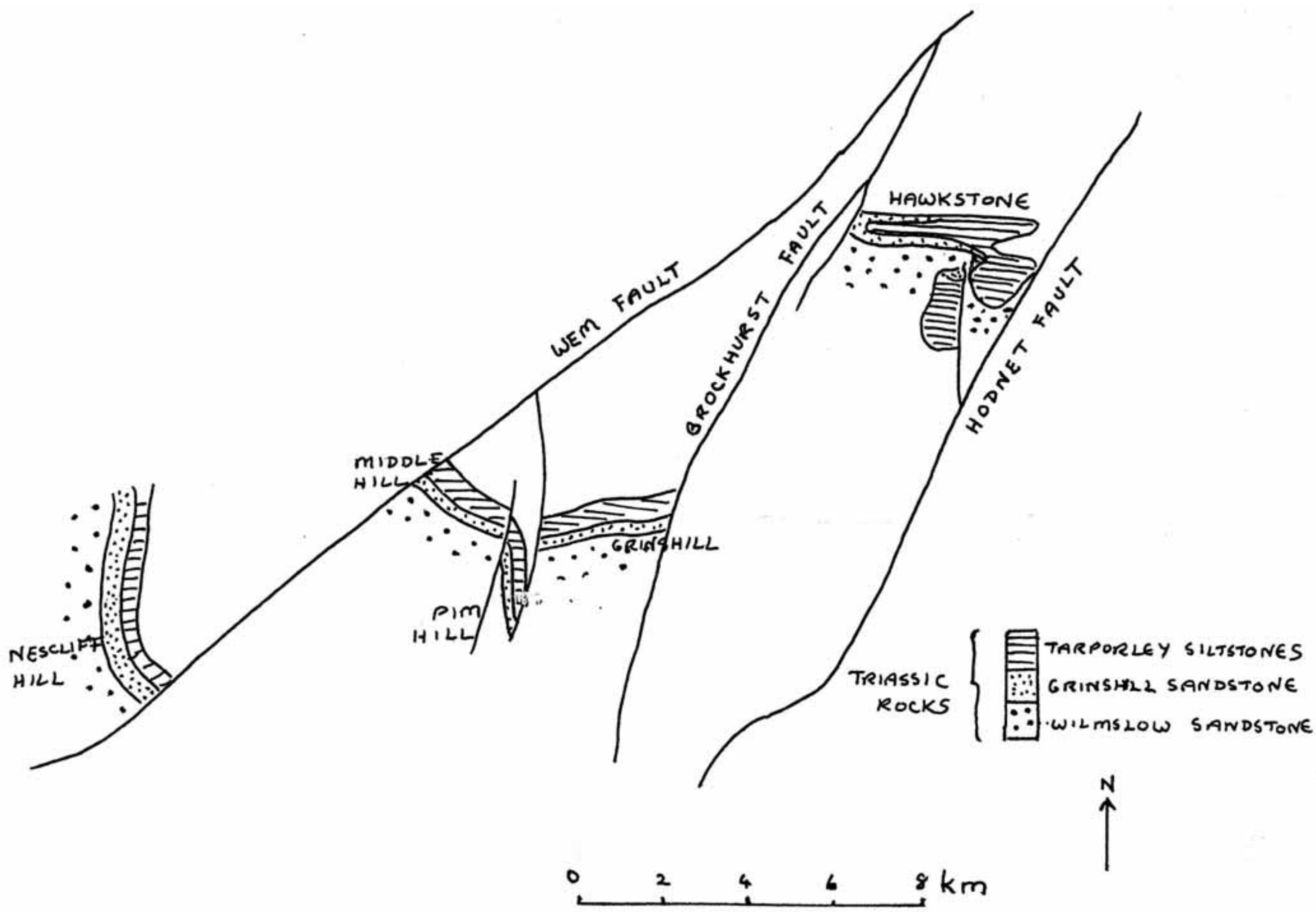

Figure 2. Simplified sketch map to show how the Permo-Triassic geology has been offset by faulting, resulting in discontinuous sandstone ridges.

THE GEOLOGICAL SETTING.

Hawkstone Park lies on fault-bounded scarps formed by the outcropping Triassic sedimentary rocks, mainly sandstones. The succession is shown in Table 1. Only the Wilmslow and Helsby (Grinshill) Formations are seen within the Park, although the succeeding Tarporley Siltstones are present, and indeed are exposed, in a small valley just outside the area normally accessible to the public. Beyond the Park, Hawkstone Hall sits on the low ground of the Bollin Formation of the Mercia Mudstone Group.

Table 1. Geological Succession.

Bollin Mudstone Formation Tarporley Siltstone Formation	Mercia Mudstone Group
Helsby Sandstone Formation (Grinshill sandstone) Wilmslow Sandstone Formation Chester Pebble Beds Kinnerton Sandstone Formation	Sherwood Sandstone Group

Permo-Triassic boundary transitional

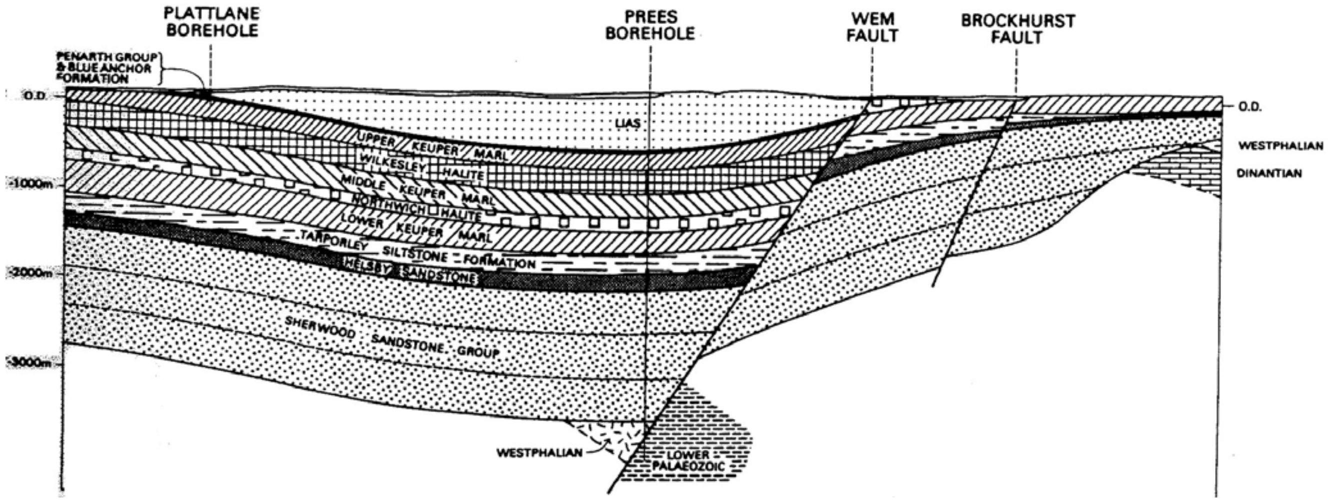

Figure 3. The Bedrock geology in cross-section *[from Plant et al., 1999]*.

HAWKSTONE GEOLOGY: A GEOTRAIL AROUND THE PARK

The story of the rocks of Hawkstone Park can be discovered as a walk, described below as a geotrail that will take 2 to 3 hours. Go back not merely to the 18th century to enjoy the exciting historical features created by the Hill family, but to the age when dinosaurs (small ones!) were just beginning to roam the North Shropshire Plain, some 230 million years ago.

1. The Urn

As you walk from the Visitor Centre towards the Urn, you will notice exposures of weak, red/brown sandstone. There are steps cut into natural stone and, near the seat, tree roots can be seen growing around the rock. This is the first of the two main sandstones found in the park, the Wilmslow Sandstone.

Standing at the safety rail near the Urn, you can appreciate the good view of the cliffs opposite, which form the Terrace. The red and white sandstones look blocky in places and are fragmented by joints (joints are cracks in rocks across which there has been no movement, and thereby differ from faults where the rocks have been displaced). Joints are sometimes filled in with minerals or with later sediments. The red colouration is due to iron oxides, from weathering of the sandy sediments.

The paler coloured sandstones have resulted from reducing fluids circulating through the sediments and subsequent chemical alteration causing ‘bleaching’. The nature of these fluids is subject to debate (see remarks on mineralisation). Such alteration has changed colours from red to white or yellow and caused some strengthening of the rocks.

Notice the lack of vegetation on faces where there have been recent rock falls. The holes along the layers behind the Urn were probably excavated by bees, wasps or other insects; an iron oxide deposit (haematite) is visible there.

2. The White Tower

En route to the White Tower the weakness and workability of the sandstones are obvious.

Vertical and curved markings indicate the pick marks of stone masons in the quarries. The rounded alcoves show how easily the rock could be shaped as well as how easily it was naturally eroded. Notice the hollows in the steps leading to the White Tower, resulting from many human feet in combination with some water erosion.

3. The Monument

The white top of the Monument, made of best quality Grinshill stone, contrasts with the red stone of the rest.

The comer stones are much newer and it can be seen that the markings on these are regular and vertical, made by a later machine-cutting technique rather than by hand.

The climb of 152 steps to the top of the Monument is well worth the effort. Magnificent views of both near and more distant features can be seen in all directions. As you emerge into the daylight at the top, you are looking approximately north. Hawkstone Hotel, nearly straight ahead, helps to get your bearings. This is where the viewpoint diagram (Figure 4) can help you to see some of the features you'll meet later in the walk. Also, note in particular the curving, wooded sandstone ridges sweeping away to the east and west before fading into the lowlands of the North Shropshire Plain. Also the second ridge, with the Bury Walls rampart to the south.

Looking beyond The Citadel it is just possible to see the Grinshill ridge. Perhaps it is a good idea to refer to the map showing how faults have caused these ridges to be off-set.

On a clear day, the distant mountains and hills form almost a ring around this part of North Shropshire. These are made of a variety of rocks millons of years older than those of Hawkstone.

The collection of conifers surrounding the Monument include 'Monkey Puzzles' (Araucaria) from Chile, one of the oldest conifer families, dating back to the Triassic Period, the same as the rocks!

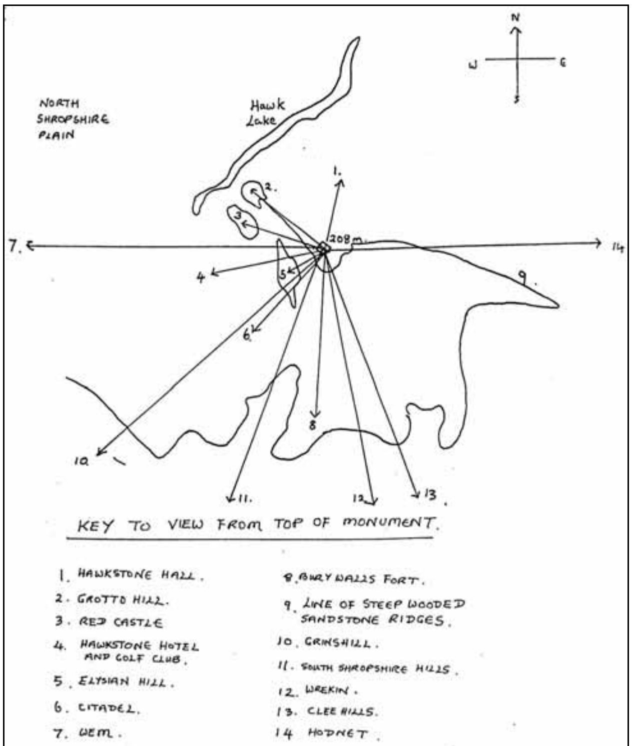

Figure 4. View from the top of The Monument.

4. Swiss Bridge

Crossing this narrow bridge is exciting and you can 'enjoy' the steep drop and impressive gorge below as well as the striking view of Grotto Hill.

To appreciate the geology further, go down to the lower route which goes under the bridge. You find yourself in a shady, narrow gorge where the rock walls are covered in moss and algae. This gorge is probably eroded along a line of weakness known as a fault. Whether this is completely natural or whether it has been artificially widened during the construction of the features in the Park is not known.

There are many examples of both fault and joint planes at Hawkstone. One can see a possible fault plane at close hand here in the gorge. Or is it a joint? Look on the left at the bottom of the steps by the barrier. Set back a metre or so is some light coloured sandstone. A diagonal crack separates this from some red and white sandstone. This crack seems to be a fault or joint plane. Can you see any displacement? This feature crosses the path and can be traced again on the right hand side of the gorge about 5 metres downhill.

5. Weston Bridge and Gingerbread Hall

As you cross Weston Bridge on the way to Gingerbread Hall, you may be able to see, especially in winter, grooves and polished flat surfaces on the rock faces below. These markings are known as slickensides and have been produced as one rock face slides past another during faulting. These are difficult to see in summer when there is much vegetation.

6. The Cleft

Here is another good example of how a natural feature has been used by the Hill family to make something more dramatic.

The steps have been cut into the underlying sandstone and the Cleft deepened to allow a way through for visitors. The Cleft was originally either a major joint or a fault line partially widened by erosion and weathering processes. There is evidence to show how it has been modified by human effort (*look for the chisel marks; these are visible towards the bottom of the rock faces but missing at the top, suggesting artificial deepening*).

7. The Grotto

You can't examine the rocks in the Grotto easily, even with a torch, as it is so dark but the mysterious atmosphere soon becomes apparent as you wander through the fascinating network of chambers, pillars and passageways.

These are old mine tunnels which have partly been used along with some more recently excavated passageways. There are many clues to the mineral which was formerly mined there. Look for green staining on the surfaces: evidence of malachite (a copper carbonate), a minor ore of copper which was formerly mined here, possibly as early as Roman times. This staining is best seen near the exit.

At Hawkstone the copper deposits were less rich than at nearby Clive and therefore not worked so extensively. Note that this mineralisation, as in other places in the area, is associated with fault planes. A model for this mineralisation is presented in Table 2 and Figure 5.

Table 2. Metallogenic model for the mineralisation in the North Shropshire and Cheshire Basins *[from Plant et al., 1999]*.

STAGE 1 Permo-Triassic
Metals held on iron oxides and clays formed by the breakdown of detrital ferromagnesian minerals in red beds
Sandstones cemented by evaporites from $CaSO_4$-saturated fluids derived from the overlying mudstones of the MMG
STAGE 2 Late Triassic to early Jurassic
Metals stripped from recrystallised oxides and clays into brines in MMG halite-mudstone sequence
Density-driven metalliferous brine flow into sandstones with partial dissolution of evaporite cement
Mixing with reducing fluid from greater depth near basin margin faults, biogenic sulphate reduction and precipitation of sulphide ores
Downward baryte sealing of channelways and cessation of sulphide precipitation
STAGE 3 Tertiary to Recent
Dissolution of remaining evaporite cement and oxidation of sulphides by fresh groundwaters

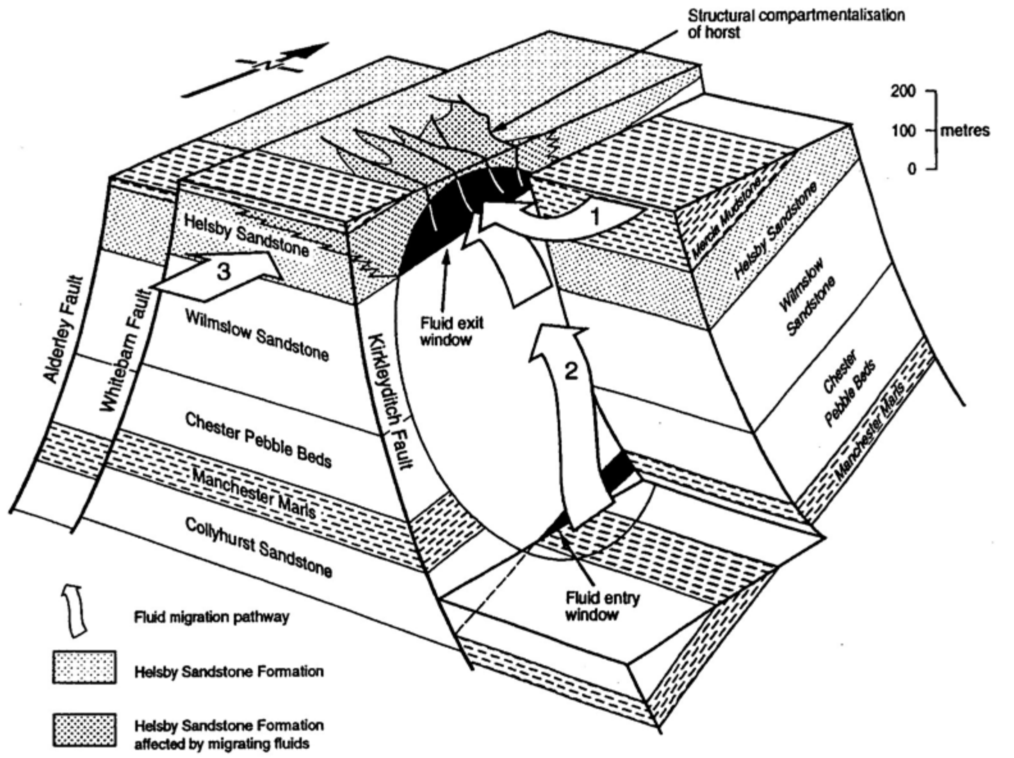

Fig. 14. Conceptual model of the probable fluid migration pathways responsible for the mineralization at Alderley Edge. Migration pathway 1 is for cross-formational flow of a saline, sulphate-rich chloride brine expelled from the MMG in the Kirkleyditch Fault Block. Pathway 2 is for overpressure valving of fluids from deeper stratigraphic horizons in the Kirkleyditch Fault Block. Example of a sulphate-rich chloride brine sourced from the Mancheter Marls is shown, but a similar vertical migration route is possible for a reducing fluid expelled from the underlying Carboniferous. Pathway 3 represents a regional flow of reducing fluid through the uppermost sandstones of the Sherwood Sandstone Group, sourced from the Carboniferous juxtaposed across the Red Rock Fault to the south. In all cases the fluids are trapped and ponded on the crest of the Alderley Horst. Fluid entry window and fluid exit window concepts based on Knipe (1993). Vertical exaggeration ×2.

Figure 5. Conceptual model for the mineralisation [copy of Figure 14 in Rowe & Burley, 1997].

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An exposure of barytes-rich sandstone can be seen if one walks through the main cave and out at the back.

From the platform outside the Grotto is a magnificent view across to the Red Castle, built on a small outlier of white Grinshill Sandstone that caps a hill formed of the red sandstones of the Wilmslow Group.

The same rock sequence occurs beneath your feet, seen clearly in the cliff below Raven's Shelf. Notice how the light-coloured Grinshill Sandstone forms the top of Grotto Hill, changing to the red sandstones at its base. There is some striking green copper staining near the top of the cliff. Also an overhang which indicates weaker rock below it.

It is worth a closer look beneath your feet as the rock shows wavy structures. These were formed when the sandy sediments were deposited. It also contains irregular white crystals of barytes scattered throughout the rock, giving it an interesting texture; this can also be found filling small joints (Figure 6).

Figure 6. Barytes just outside The Grotto *[photograph courtesy of Mike Rosenbaum]*.

It is interesting at this point to climb up to the arch on the top of Grotto Hill and look at the building blocks there. There is much variety of colour, size of grains, and hardness, even though they are all the same kind of rock: sandstone.

8. Hermitage and Retreat

As one follows the signs along the path, look up to the left and notice the excellent joint (or are they fault?) planes parallel to each other. These once again reveal the tell-tale copper staining and produce a most attractive green and orange coloured feature in the rock.

Next to the path weathering has added another variation: beautifully rounded boulders of different sizes.

At the Retreat it is possible to sit down, pick up loose sand and pretend you are on a beach somewhere hot! The sand probably originated not from a beach, though, but within a desert, far from the sea! Do you recognise the white crystals again?

9. Fox's Knob

Fox's Knob is a pinnacle of Grinshill sandstone with a flat slab on top. It is a remnant left after the erosion of a much larger rock formation. You should, by now, readily recognise the mineral (barytes). This forms discontinuous layers, 20 mm thick, standing proud from the surface.

The most interesting and important feature here is seen as you emerge on the far side and look back (Figure 7). Thin, striped, curving beds sweep across the rock face, made more distinctive by the black iron oxide present as alternating layers. What is seen here is cross-stratification ('cross bedding'), a sedimentary structure produced by shifting sands moved by current action on shallow river beds or migrating dunes, blown by winds across the desert. Both processes result in inclined beds at varying angles, but how could they be distinguished? (*Think of how steep a bank of sand can stand; when dry it could be quite steep, but when wet it readily slumps*).

Figure 7. Cross-bedded sandstone below Fox's Knob *[photograph courtesy of Mike Rosenbaum]*.

10. Reynard's Walk and The Terrace

From Fox's Knob onwards, a red sandstone makes its appearance beneath the pale rock. There is no clear break between the two but the red sandstone seems to belong to the underlying Wilmslow Formation, already seen at the base of Grotto Hill and outcropping widely over a large area in the east of Hawkstone Park, especially at Elysian Hill. Or is it merely a lower red facies of the Ruyton/Grinshill formation of the Helsby Sandstone?

The path along Reynard's Walk and at the foot of the Terrace Cliffs displays perhaps the most impressive and, indeed, beautiful sandstone faces in the park. Turning one corner, a high vertical cliff of red, then white, rock with thinner slabs at the top exhibits an excellent section through the Wilmslow and Grinshill formations (or just the Grinshill?). Further along, magnificent, sweeping, high angle dune bedding comes into view. Closer examination reveals 'flows' of barytes up to a metre long, looking like miniature waterfalls.

The Triassic sand dunes did not all accumulate at once and perhaps there were considerable gaps in time between one dune and the next. It has been suggested (Mike Rosenbaum, *pers. comm.* 2004) that the exposures beneath the Terrace appear to provide good evidence of the presence of relict soils developed on the older dunes. Evidence includes discolouration of the sand, leaching of the reddened iron oxides, a laterally extensive bedding plane beneath the overlying dune, and preservation of plant rootlets, now by barytes, but probably originally by gypsum (Figure 8).

Figure 8. A possible relict soil with plant rootlets now preserved in barytes, Reynard's Walk *[photograph courtesy of Mike Rosenbaum]*.

Here then is the place to take an imaginary trip 230 million years back in time, to feel the dry heat, wipe the grit from your eyes, and gaze upon the sand dunes and dried up river beds of the seemingly endless desert landscape. After all this, it will be a relief to find yourself approaching the Urn again and the promise of refreshments back at the Visitor Centre.

GLOSSARY OF GEOLOGICAL TERMS

BARYTES: Barium sulphate, a white mineral common in Hawkestone Park

BEDDING PLANE: The boundary between each layer in a sedimentary rock.

BRAIDED RIVER: A river that divides into numerous channels that branch, separate and rejoin, becoming a tangle of islands, channels and sand bars.

CROSS-BEDDING: Sedimentary layering within a bed inclined at an angle to the main bedding plane. Mainly formed by the migration of sand dunes or sediment in the bed of a stream.

EROSION: The wearing away of the earth's surface by natural agents, e.g. wind, ice, rivers.

ESCARPMENT: A ridge of land with one side steeper than the other.

FAULT: A fracture in the earth along which rocks have been displaced. The surface where the movement occurs is a *fault plane*.

HAEMATITE: Iron oxide, a potentially valuable iron ore.

OUTLIER: Area of rock completely surrounded by older rocks.

MALACHITE: Copper carbonate, a green ore of copper.

SLICKENSIDE: A rock surface which has mineral growths that feel smooth to the touch in one direction but rough in the opposite, formed by the growth of minerals along a fault plane as the rocks slide past each other. Sometimes refers to a surface that has become polished and grooved from the sliding motion along a fault plane.

ACKNOWLEDGEMENTS

The author would like to thank the owners of Hawkstone Park for their encouragement in producing this guide.

Readers may also wish to know of the associated paper, which is written for the younger visitor (Rayner, 2007).

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Disclaimer - The information contained in this Trail Guide has been prepared following a summary of the geological literature of the area and visits to all the locations described. Its sole aim is to give visitors to the area an insight into its geology and the links between it and past and present industry. It should not be used for any other purpose.

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