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From threat to future asset—The legacy of opencast surface-mined coal in Scotland

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ABSTRACT

The recent economic collapse of the opencast surface coal mining industry in the Midland Valley of Scotland has left behind a number of abandoned voids that reveal stunning 3D exposures in strategically important strata. A strong case can be made for retaining these large-scale, often continuous and very detailed geological sections that might otherwise have been lost to us, along with their relevant digital geological and geotechnical datasets and other social and industrial records. In particular, Spireslack and Mainhill Wood opencast workings might be seen by some as industrial scars on the Scottish landscape, but they can instead both be turned into national assets for multidisciplinary Geoscience research and learning in general, supporting high-quality international research into Carboniferous geology. Such opencast sites can also provide a rich visitor and/or learning experience for the wider public in coal geology, illuminating aspects of a former way of life of previous generations.

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1. Geological introduction

Rocks of Carboniferous age occupy much of the bedrock crop in the Midland Valley of Scotland but are commonly obscured at surface by Quaternary deposits. The Carboniferous succession lies within an ENE-trending graben bounded by the complexes of the Highland Boundary Fault to the northwest and the Southern Upland Fault to the southeast (Fig. 1). Onshore, the graben is about 90 km wide and extends some 150 km from the Ayrshire coast and Glasgow in the west to the east Fife, Edinburgh, and the East Lothian coast in the east (Fig. 1). The Highland Boundary and Southern Upland faults were active and helped control sedimentation, initially during the Tournaisian as sinistral strike-/oblique-slip faults and subsequently in the Viséan to Westphalian régime of regional-scale dextral strike/oblique-slip deformation (Brown and Monro, 1989; Ritchie et al., 2003; Underhill et al., 2008). Carboniferous rocks in these basins are more than 6 km thick (Dean et al., 2011); the Midland Valley of Scotland was separated from basins farther south (Tweed and Solway Firth basins and the Northumberland Trough in north-east England) by the Lower Palaeozoic rocks of the Southern Uplands block, a positive, mainly emergent structural high throughout the Carboniferous. In the Scottish Highlands, Lower Palaeozoic and Precambrian rocks to the north of the Highland Boundary Fault were similarly a positive, mainly emergent area with only limited outcrops of Carboniferous.

Most of the stages of the Carboniferous are present in the Midland Valley of Scotland, but this account is concerned with the coal-bearing

Namurian strata assigned to the Clackmannan Group that is predominantly Mississippian in age; the upper part of the group (the upper Passage Formation) is assigned to the Pennsylvanian (Fig. 2).

Namurian strata extend across the Midland Valley of Scotland (Fig. 1) from Glasgow (c. 700 m stratigraphic sequence), via Clackmannan (1400 m) to Fife (1100 m), with structurally isolated outcrops in the vicinity of Edinburgh (800 m), in central and north Ayrshire (450 m) and to the north of the Southern Upland Fault in east Ayrshire (Muirkirk Coalfield sub-basin) and around Douglas (together up to 650 m) in south Lanarkshire. The last two areas are the principal interest here. Following on from the preceding Viséan heterolithic clastic and non-marine carbonate and fluvio-deltaic succession (and associated major eruptive centres), marine influence reached its peak during the deposition of the mixed shelf carbonate and deltaic succession of the Namurian Clackmannan Group. Syn-sedimentary tectonic movements were prevalent from the late Viséan, and especially during Namurian times, and are associated with N-S and NNE-SSW striking major growth folds such as the Midlothian–Leven Syncline (Underhill et al., 2008). In Ayrshire, Namurian rocks are associated with ENE-trending faults controlling marked changes in thicknesses of the deposits across the fault lines. Disconformities within the Passage Formation at the top of the Namurian have also been identified.

2. History of opencast surface coal mining in Scotland

Starting from small-scale 13th century operations, coal mining activity in Scotland expanded slowly until the 18th century when, with the onset of the Industrial Revolution in the UK, steam engines created a

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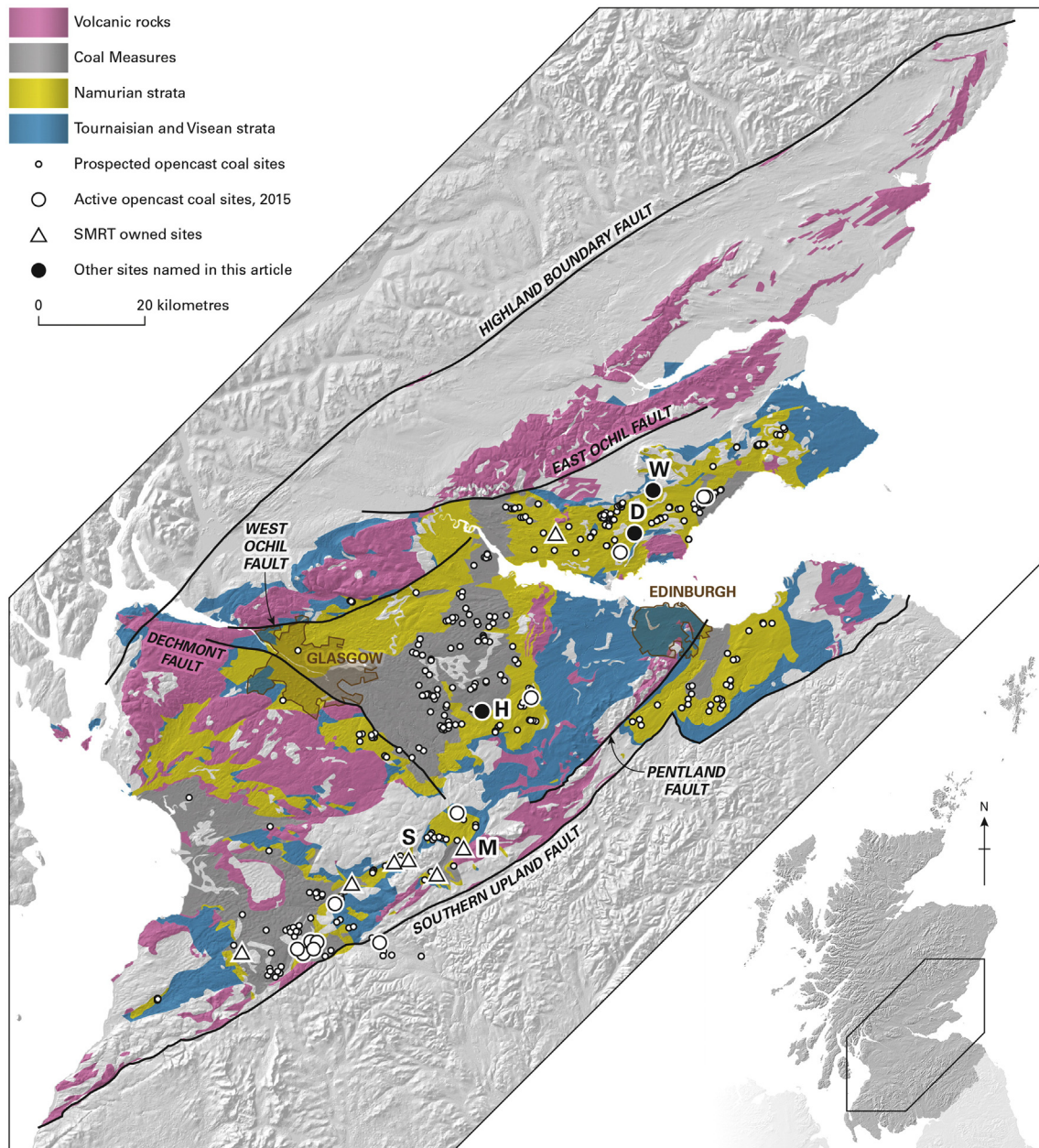


Fig. 1. Generalised Carboniferous geology of the Midland Valley of Scotland. The map shows the locations of prospected and still active (at end-2015) opencast surface coal mine sites in those strata. Sites now owned by the Scottish Mines Restoration Trust are also highlighted and include Spireslack (S) and Mainhill Wood (M). The now inactive sites at Dora (D), Headlesscross (H), and Westfield (W) are also highlighted on the map and discussed further in the text.

near insatiable demand for fuel. Much of Scotland's industrial growth and prosperity in the late 18th to mid-20th century depended upon the extensive underground exploitation of Central Scotland's Carboniferous bituminous to locally anthracitic coal resources, in concert with workings for ironstone, oil shale, limestone, sandstone, fireclay, and mudstone—the last for brick-making. Underground working of coal ceased in Scotland in 2002 with the closure of Longannet Mine in west Fife. Arguably, an entire generation of Scots has now lost touch with the coal that provided employment, income, energy, and a social structure for their parents, grandparents, and older generations.

The history of opencast coal mining in Great Britain was described by Grimshaw (1992) in a publication celebrating the first 50 years of significant activity, following on from the final full implementation of the 1938 Coal Act. In the early years, opencast surface mining of Scottish coal was not particularly important, but some 16 sites were listed as active (or consented) in Scotland by Grimshaw (1992). Perhaps one of the

best known of the earlier generation of Scottish Surface Coal Mines (SCMs) was Westfield SCM in Fife, first opened in 1956 and, at the time, the largest in the UK (Fig. 3).

By the end of the 20th century, a snapshot of the then Scottish Opencast Industry by Friends of the Earth Scotland (1999) reported 104 working and approved sites (with 23 in Ayrshire alone)—effectively 39% of UK surface-mined coal production (cf. Fig. 1). That level of output was maintained for a decade with a third of UK surface-mined coal production at sites across central Scotland until 2010. Since then, however, environmental constraints and weak world coal prices (standing at £30/tonne in October 2015) precipitated the financial collapse of two of the then main operators of Scottish opencast surface coal mine sites by April 2013. That failure left seven 'orphaned' sites in Ayrshire and Lanarkshire, all lacking the necessary funding for 'muck shift and levelling' restoration programmes that would have backfilled excavations with the opencast waste rock materials. Although some surface mining for coal

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