

## Coal Mining: a unique opportunity at Clee Hill

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CRUMP, L.A. & DONNELLY, R. (1994). Coal Mining: a unique opportunity at Clee Hill. *Proceedings of the Shropshire Geological Society*, **10**, 1–3. Clee Hill Quarry is an active hardstone (dolerite) quarry in Carboniferous Coal Measures which have been intruded by a thick (*ca.* 60 m) conformable fine-grained olivine-dolerite sill.

The whole sequence is now folded into a broad synclinal structure and is extensively faulted. The area is blanketed by glacial deposits, 2–12 m thick. Historically, quarrying operations have been closely allied to the geological structure being confined to the margins of the syncline where the dolerite is devoid of overlying Coal Measures.

In 1973 a programme was undertaken to assess the viability of using Coal Measures material for the production of lightweight aggregate. This programme was initiated because virtually all remaining, albeit substantial, planned reserves of dolerite were overlain by considerable thicknesses of Coal Measures and glacial deposits. Initial results from a technical viewpoint were encouraging. The project was eventually begun and the mining phase, including the major restoration works, was completed in July 1992.

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### ORIGINS OF MINING

The area of Clee Hill in South Shropshire has been exploited for coal since the 13th century. A record from 1235 states that coal from the village of Caynham, on the flanks of the hill, was being sent to the Abbey at Cleobury Mortimer. Limestone, iron nodules and dolerite have also been worked there. By 1760 there were a large number of bell pits being worked, and aerial photos show their remains today.

By the 19<sup>th</sup> century coal extraction became increasingly important and it powered the quarry plant. Titterstone quarry employed 2000 people and produced 400 000 tons of dolerite p.a. at the turn of the century. Photographs of the time show a labour-intensive operation with rail links to Ludlow. The company was known as “The Clee Hill Granite Co.”. This quarry and the surrounding plant have never been restored. At present the quarry is a major supplier of roadstone and sends some of its production to make rockwool.

For a more substantial account of this topic, maps and sections, the reader is referred to the GSSP publication by the authors (Crump & Donnelly, 1994).

### GEOLOGICAL SETTING

Geologically, Clee Hill is an outlier of Carboniferous age with a NNE-SSW trending synclinal structure. The youngest rocks seen are

the Coal Measures which overlie the dolerite sill at least in part. The dolerite has been dated at 295 Ma (K-Ar) giving a Westphalian D age, and the Coal Measures are thought to be Westphalian A-C. This suggests that the sill intrusion is more or less contemporaneous with the rocks in which it is found. The dolerite is a blue-black colour when fresh and shows good columnar jointing in the centre. It often has a conchoidal fracture. The primary minerals of the dolerite are olivine crystals in a plagioclase-augite groundmass. Olivine may be altered to serpentine. Magnetite and titanium oxide are also present.

In many places the sill is covered by a sandy till with dolerite boulders; occasionally the till grades into the underlying Carboniferous mudstones. This latter is possibly a commutation till, made as the glacier crushed the underlying rock *in situ*.

### QUARRYING

Historically quarrying was restricted to the edge of the sill where the dolerite was exposed. Planning permission in 1947 covered 620 acres, one of the largest quarries in Great Britain, and linked the main quarries. Reserves deteriorated in the 1950s and 60s as the dolerite not covered by overburden ran out. The rock had often weathered beneath the till to an orange silty clay which infilled the joints and up to 40% of the quarried material was useless. It was evident from this weathering that the Clee Hills had stood above the most recent glaciation and have therefore been exposed at surface for a very long time. The weathering is

more typical of that found in Cornwall. and would have been tropical at times in the past.

The thickening of the overburden closed Incline and Dhustone quarries and only Belfry was in production although it too had till cover. So it was at this time that a geophysical survey was undertaken to assess the potential of the area around Belfry. Both resistivity and magnetic surveys were inconclusive as so much dolerite was incorporated into the tills. The more successful seismic survey proved Belfry to be an area of disturbance.

### RESERVE EVALUATION

In the 1970's the area between Incline and Belfry quarries was evaluated; the objective was to identify a reserve of "clean" dolerite. From the dips in the quarries the thickness of the Coal Measures could have been as much as 90 metres; however dolerite was known to be unweathered under the coal.

Thirty-one boreholes were drilled in this area, open holes in the overburden, cores in the dolerite. In total, 1200 metres of drilling was carried out at around £30 a metre. The sill was proved at around 50-60 metres and the Coal Measures were around 20 metres thick. Structurally the boreholes revealed a NE-SW trending fault that separated two basins. The cores showed the dolerite to be clean, massive and having a low fracture index, ideal for quarrying. However, removing the overburden made the cost a problem.

The Coal Measures were cored with a view to assessing them for use as a light weight aggregate. They consisted of mudstones, clays and sandstones. A shallow pit was dug to look at the beds more closely and in 1974 after some trials 15 more bores were cored in order to evaluate the area in more detail. The clay and mudstones were found to be ideal for lightweight aggregate. Coal could be used for fuel but the sandstone would be waste.

Economics finished this project in the 1970s, and the exploitation of the area continued as a nibbling of the edges of the sill. Stripping the overburden was expensive, a 30 metre advance along a 100-metre face costing £50 000 to strip. In 1981 open-cast coaling was proposed. Estimates suggested the presence of 250 000 tons of coal. The N.C.B. were consulted and information as to the quality was essential. More drilling took place.

13 open holes were drilled and down the hole logging took place. Density logs showed up the low-density coal seams. Shales contain potassium isotopes and gave gamma-ray highs.

Four main seams were identified. These were already known and had been worked in the past. They were named J, the lowest, K, L and M (originally Four-foot, Smith, Great Seam and Three-quarter). All four seams are seen only in some places. The shallow dips indicate easy working, so in 1982 another 38 boreholes were drilled and the results plotted as an overburden:coal ratio. It is possible to work a ratio of 15:1 and, as the boreholes showed a 6-4:1 ratio, the result was very favourable. The quality of the coal, especially at lower levels, was good; it was low in sulphur and therefore good for power stations.

In the end the assessment of the 26 acres was revised downwards due to the faulting, the old workings and final under extraction. The removal of 1.7 million tons of overburden plus the stripping of barren Coal Measures in order to reach the dolerite led to a 15:1 ratio. In 1986 planning permission was sought for a much smaller area between two quarries. There were plans to use the waste to restore the old quarries and a licence was needed from the National Coal Board (later British Coal).

### COAL EXTRACTION AND RESTORATION

The new phase of coal extraction began in 1988 and ended in 1991. It turned out the amount already removed by old workings had been overestimated, and the coal recovered was 320,000 tons.

Restoration of Dhustone quarry has been extensive, although the grading of very fine un lithified sediment has proved a problem with the high rainfall of the area. A network of stone-lined drains with settling tanks has proved successful. Establishing vegetation is problematical as sheep freely graze the area. However the projected restoration, not due to be completed for 50 years as quarrying continues, includes a lake and looks quite attractive.

### CONCLUDING REMARKS

Clee Hill Quarry is an active hardstone (dolerite) quarry located 5 miles to the east of Ludlow,

Shropshire. The quarry is in Carboniferous Coal Measures which have been intruded by a thick (*ca.* 60 m) conformable fine-grained olivine-dolerite sill.

The whole sequence is now folded into a broad synclinal structure and is extensively faulted. The area is blanketed by glacial deposits, 2-12m thick. Historically, quarrying operations have been closely allied to the geological structure being confined to the margins of the syncline where the dolerite is devoid of overlying Coal Measures.

In 1973 a programme was undertaken to assess the viability of using Coal Measures material for the production of lightweight aggregate. This programme was initiated because virtually all remaining, albeit substantial, planned reserves of dolerite were overlain by considerable thicknesses of Coal Measures and glacial deposits. While initial results from a technical viewpoint were encouraging, the project was abandoned for commercial reasons.

The Coal Measures sequence overlying the dolerite sill comprises in excess of 30 m of mudstones, siltstones and sandstones as well as four recognized coal seams. Piecemeal mining of this coal had taken place on the Clee Hills for centuries, and in the area for future quarrying abundant evidence was available at surface of former bell-pit workings.

In the early 1980s a decision was taken to evaluate the coal deposits at Clee Hill Quarry. The area for detailed assessment was defined using existing borehole data and evidence from old workings identified from site survey and aerial photographs. Exploration in two separate phases comprised the drilling of 44 open holes with spot coring and borehole geophysical logging. Coal quality was determined by analysing all relevant borehole core samples. Although coal reserve estimates assumed a high degree of past shallow mining activity, the economic viability of working the coal seams by opencast methods was established.

In 1986 a planning application was submitted to Shropshire County Council to work and remove all coal overlying the dolerite, over a 3 year period. The proposal would allow exploitation of a valuable mineral asset, release substantial reserves of hardstone (dolerite) and allow restoration at an early date of large areas of former mining and quarrying dereliction. Planning permission was

obtained in August 1988. Negotiations with the Opencast Executive of British Coal culminated in the granting of a licence to work both British Coal (vested) and ARC (alienated) coal. Coal mining was commenced in October 1988.

Predictions of seam thickness and faulting were consistently accurate and vindicated the site investigation programme. In two aspects more detailed/accurate information would have been useful. Firstly, with regard to coal quality, borehole core samples did not accurately reflect *in situ* moisture content. Secondly, the extent of old workings in the upper coal seams was significantly overestimated. Neither aspect significantly affected the viability of the project. The mining phase including the major restoration works was completed in July 1992.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- Crump, L.A. & Donnelly, R. (1994). Opencast coal mining: a unique opportunity for Clee Hill Quarry. *Geological Society, London, Special Publications*, **79**, 219-232.

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