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Karst development and surface water management in the West Cumbrian iron Ore Field, Cumbria, UK.

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The hematite ore deposits hosted within the Dinantian (Lower Carboniferous) limestones that fringe the western edge of the coast of the Lake District massif, North West England (herein referred to for convenience as the 'west Cumbrian iron ore field') occurred as either veins (mineralised faults and fractures) or flats (replacement deposits parallel to the bedding) (Figure 1). Although now exhausted and no longer worked for iron ore the huge high-quality low phosphate 'red hematite' deposits were formerly of enormous commercial value (Dodd 2010, Hewer and McFadzean 1992, Kelly 1994). The industry was at its peak in the 1870s and 1880s but fell victim to cheaper imports and the working out of many deposits in the mid-20th century. Major mining ceased in the 1960s but the Florence mine at Egremont was the final mine to close in 1988. In the Furness and Lonsdale ore fields to the south the hematite deposits are intimately associated with paleokarsts and some may well be cavity infills (Rose and Dunham 1977, Murphy and Moseley 2010) though no such deposits are recorded in the West Cumbria area.

The limestone succession in the area was traditionally divided into a number of subunits separated by clastic deposits. Seven such subunits were recognised by the iron ore miners numbered in descending order (Eastwoods et al. 1931). The first to the sixth limestone corresponding to the Urswick and Park Limestones of the Furness area to the south (Rose and Dunham 1977) now formalised as the Urswick Limestone Formation and the Park Limestone Formation of Brandon et al. (1998). The seventh limestone being considered in part equivalent to the Dalton Beds of Rose and Dunham (1977). In a more locally based study the seventh limestone has been renamed the Frizington Limestone Formation by Barclay et al. (1994).

Karst Features

Only one accessible cave, Goosey Tyson's Cave, is known in the region consisting of 60 m of passage containing a small stream. It is in a small outlier of limestone 4 km east of Egremont near the village of Wilton. (Proctor 1971, Brook et al. 1994, Carradice 2005). Sediment filled cavities are exposed in the walls of disused quarries indicating the presence of relict karst in the area (Figure 2). As surface water gathered on the high ground of the Lake District massif is channelled onto the limestone outcrop the possibility of other caves existing in the region does appear promising however both caver searches (Proctor 1971) and geological survey work (Akhurst et al.1997) have found no evidence of any significant cave system. The presence of such a high number of non-carbonate beds in the sequence may have impeded subterranean drainage development. Surface karst development does occur as shown by the presence of limestone pavements near Kelton Head north east of Rowrah (NGR NY068186).

Mine Water Control

When mining in fractured and karstified carbonate strata the problems caused by surface water entering the underground workings can cause considerable engineering,

and safety problems. Water ingress also has financial implications as the water needs to be removed from the workings. In order to avoid such problems surface engineering to prevent water ingress is not uncommon. The use of masonry lined channels and iron pipes to prevent water entering the iron mines in the limestones of the Forest of Dean is described by Bowen (1992) however the complex and major engineering works undertaken to prevent water ingress into the mines of the west Cumbrian iron ore field have received little attention. The remoteness of the area and limited development has resulted in the survival of a number of these structures to the present day. This report provides descriptions and details of surviving examples where the local surface geomorphology has been altered in order to control the ingress of water into the mine workings.

1 (NGR NY013130) -Longlands Mine, located 2 km to the south of Cleator Moor, was situated on low lying ground near the point where the Rivers Ehen and Keekle meet. The deposit outcropped beneath unconsolidated deposits and great care had to be taken in workings near the outcrop to avoid an inrush of glacial and river gravel. The area was inundated by floodwaters in 1909 and on one occasion gravel was washed all the way to the base of the shaft (Smith 1924). A meander loop of the River Ehen was removed and an embankment built to separate the river from the mine area. This did not prevent water ingress during times of spate so the river was boxed in. The concreted section of the river is referred to locally as The Dub (Figure 3). After abandonment in 1924 the low lying ground flooded and is now Longlands Lake country park nature reserve. Longlands Lake is signed as a tourist attraction from the A5086 on your right hand (west) side 1.5 km north of Egremont. Free car parking is provided and the footpath to the lake crosses the River Ehen on a footbridge from which the concrete engineering works can be seen in the banks and bed of the river.

2 (NGR NY013136) -Cleator Glebe Mine was situated to the west of Cleator village. A meander loop was removed and the River Keekle straightened to divert the surface water away from the mine. The area of the diversion is now occupied by Cleator Cricket Club. To visit Cleator Cricket Clubs ground turn left into Church Street from the A5086 in Cleator, cross the River Keekle and the ground is on your right.

3 (NGR NY006150) -West of the town of Cleator Moor the River Keekle was proving a flood hazard for the Montreal Mine. This mine produced both iron ore and coal from the same shaft as deposits were juxtaposed by faulting. Sixty yards of the river bed was boxed in in 1878. Eventually 528 yards were completed by the Whitehaven Shipbuilding Company. The project became known as the back ship and is still referred to as such by the locals. The metal box work was later covered with concrete. When the mines were active wooden troughs were widely used to control water ingress from other surface streams crossing the area (Smith 1924). On the B5295 leaving Cleator Moor in the direction of Whitehaven turn left onto Crossfield Road. Follow the road for a kilometre until the road becomes an unsurfaced track after passing beneath a disused railway bridge. The track continues to a concrete bridge across the River Keekle from which the scale of the engineering undertaken to the river bed can be appreciated (Figure 4).

4 (NGR NY035165) -Lingla Beck flowed through the site of High House Mine at Parkside, 1 km north east of Cleator Moor. Iron box work was constructed to contain

the beck waters. It still functions today and can be seen behind the bends warning signs on the sharp bend where the A5086 passes beneath a disused mineral line railway bridge at Parkside to the north of Cleator (Figure 5). The misaligned masonry on the bridge buttresses shows the effects of mining subsidence in the area.

5 (NGR NY045167) -East of Frizington the waters of Windergill Stream caused problems in the workings of both the deep Agnes mine and the shallower Margaret mine. This area was very prone to subsidence to such an extent that the railway had to be diverted from the eastern side of the valley on to the western side. In order to prevent water ingress the stream was diverted into a length of cast iron piping (Fig 6). Although no longer carrying the stream this impressive and lengthy construction is known locally as the boilers.

Conclusion

The limestone outcrop of west Cumbria do show some evidence of both karst and paleokarstic development though they show increased sedimentological and structural complexity compared to other areas of lower Carboniferous outcrop in the north of England. However the area retains some excellent examples of engineering works deployed to control the ingress of groundwater into hematite mines within the lower Carboniferous carbonate succession and illustrates the extent to which mining can alter the surface as well as the underground geomorphology.

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Figures.

Figure 1. Location map.

Figure 2. Sediment filled cavities in the east wall of Salterhall Quarry, Frizington.

Figure 3. The Dub. Concrete box work containing the River Ehen, Longlands Lake Country Park.

Figure 4.The Black Ship. Concrete box work containing the River Keekle, Cleator Moor.

Figure 5. Iron box work containing Lingla Beck, Parkside.

Figure 6 The cast iron pipework which was used to contain the waters of Windergill east of Frizington.