Grinlow Vein Mineralisation

Background

The Carboniferous Limestone of the Peak District is host to the South Pennine Orefield (SPO), comprising 3200 mineralised veins, karstic features and replacements of the limestones (Figure 1). The Orefield has a long history of mining for lead (mostly as galena – PbS), and more recently fluorspar (CaF_2) and barite ($BaSO_4$); crystalline calcite ($CaCO_3$) is often the most common mineral in the veins. The veins in the Orefield has been extensively studied (see Ford and Worley, 2016 for a recent review).

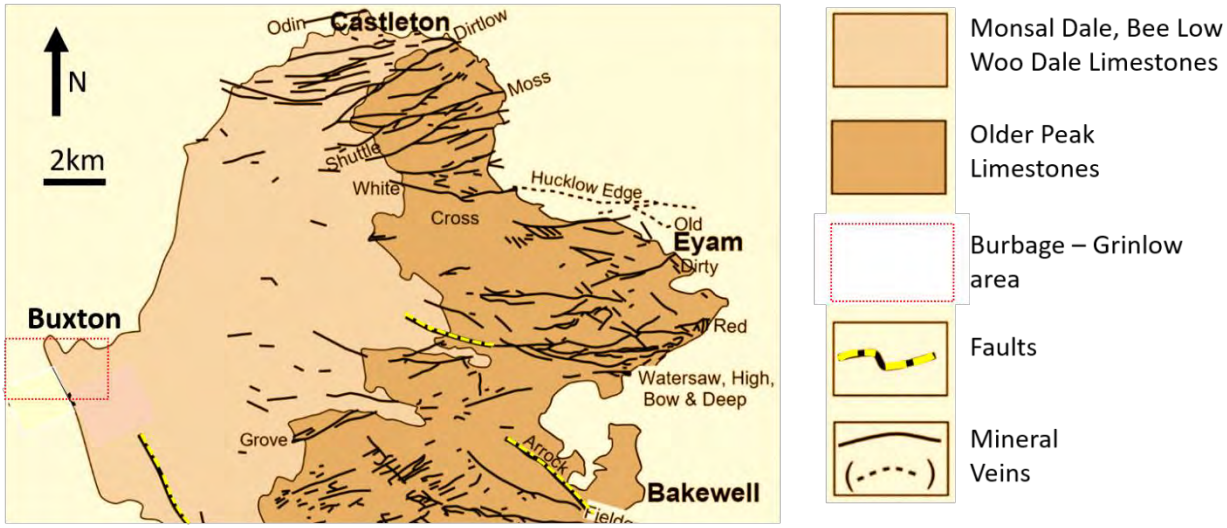

Figure 1 The northern part of the South Pennine Orefield showing the main mineral veins and the limestone outcrop (adapted from Ford and Worley 2016). Although this map shows no veins in the Buxton area, the area has several lead veins, exploited in the 16-19th Centuries.

The SPO is a type of ore deposit known either as Mississippi Valley Type (MVT) Deposits or Carbonate-hosted Pb-Zn Deposits. These are formed from low temperature (90 to 160^{0}C), saline, slightly acidic, hydrous fluids which were generated at depth in 'geological' basins surrounding limestone platforms. These fluids were either formed by dewatering of mudstones and shales under pressure during compaction in these basins, and/or groundwater driven downwards into the basins under hydrostatic pressure. Temperatures at a depth of 5km would have been approximately 150^{0}C and able to leach Pb, Ba and F out of the mudstone/shales. The rising fluids accessed fractures, became cooled, were neutralised by reaction with limestone and mixed with surface waters, resulting in precipitation of coarse grained minerals on the walls of the fractures to form veins. Metal grades (Pb-Zn) are often high (> 5% Pb and Zn). Apart from the SPO, other examples of MVT deposits in GB are the North Pennine Orefields, the Mendip Orefield and Halkyn Mountain Orefield (North Wales); all are hosted by Carboniferous (Mississippian) Limestones (Pattrick and Polya, 1993).

In the late Carboniferous (~290 million years ago) the White (limestone) Peak area was, geologically, a relatively 'high' area, with the limestone overlain by mudstones. Surrounding this limestone high were deep basins of mudstones and shales. The latter were the source of the

mineralising fluids while the overlying mudstones formed a seal to trap the rising basin-derived fluids in the limestone. The maps of the SPO show the main mineral veins (Figure 1) are mostly in the eastern side of the limestone outcrop, suggesting the mineralising fluids rose from basins to the east into faults in the limestone. However, maps of the Orefield are often not complete and, for instance, show no veins in the Burbage/Buxton area which is definitely not the case.

Burbage Pb-veins.

Lead was mined from small, marginally economic veins in the Burbage area, mainly in the 1700s, as described by Rieuwerts (2007) in a compilation derived from numerous archives (see Figures 2 and 3). Information on vein location is often sketchy and housing developments, lime workings and landscaping now obscures much of the geology of the area. These Burbage veins are hosted by the Bee Low and Monsal Dale Limestones on the western margin of the Peak District limestone outcrop (Figure 1). The limestones dip west beneath the Bowland Shale (Figure 4) with the impermeable shale making a very poor host for vein mineralisation. Thus, the trace of the veins southwestwards seen in Figures 2 and 4 represents veins hosted in limestones beneath the shale. Examination of the area has revealed no current outcrops of the veins.

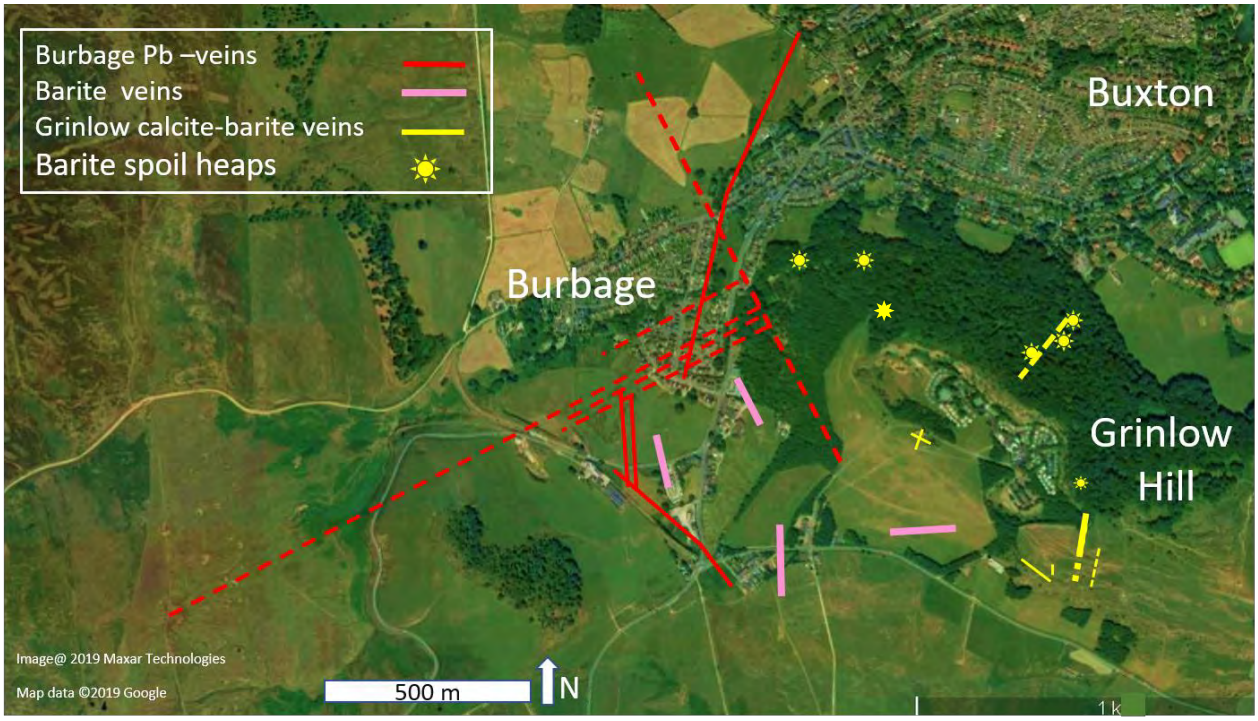

Figure 2 Mineralised veins in the Burbage-Grinlow Hill area (Burbage Pb-veins after Rieuwerts, 2007; Barite veins after Heathcote 2010; and Grinlow veins, this study).

Burbage-Grinlow Barite veins.

The mineral barite was historically mined in several veins on the west side of Grinlow Hill and Stanton Moor (southwest of Buxton) – this is detailed in Heathcote (2010) and the approximate trace of some of these veins is shown in Figure 2 and 3. However, evidence of these is also covered by developments and landscaping. The barite was produced in the mid 19th Century and was used in the paint industry including the nearby paint mills at Goyt's Clough, Whaley Bridge and Barmoor Clough, Dove Holes (Heathcote, 2010).

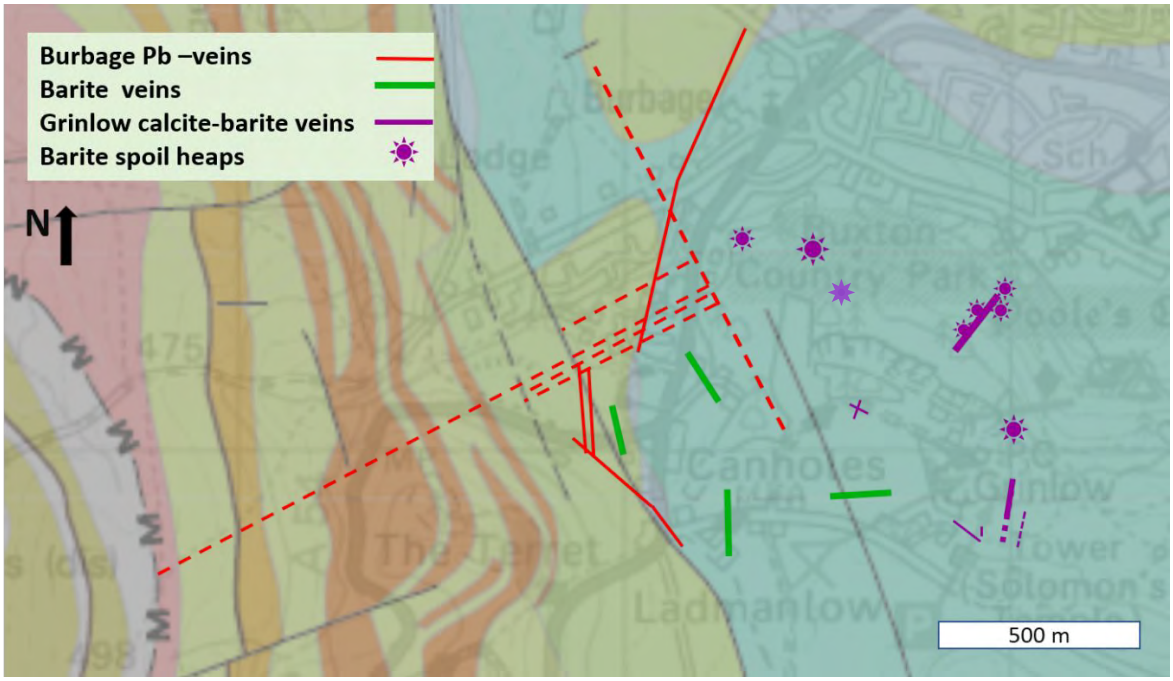

Figure 3 Mineralised veins in the Burbage-Grinlow Hill area, and the bedrock geology. Geology using Edina Digimap service: http:// edina.ac.uk.digimap downloaded 2020. Light blue = Bee Low Limestone; Pale green = Bowland shale and other shales interbedded with sandstones (brown, orange and pink).

<u>Grinlow Barite-Calcite – (Galena) veins.</u>

The Cow Vein Suite: Despite the lime working activity on both sides of Grinlow Hill, vein mineralisation has survived. The best outcrop (Figure 4, 5) is a vertical, 2m wide vein of calcite and barite which trends 010^0 and is exposed at the western end of a low (3m) cliff (53°14'35.93"N,

Figure 4 The Grinlow Hill Veins (detail of Figure 2)

1°55'34.28"W) (Figure 5) – the vein runs northwards for 100m with near continuous outcrop to Grinlow Wood where it ends abruptly (53°14'39.45"N, 1°55'32.79"W); the vein runs parallel to a small fault 3m to the west. The outcrop in the low cliff (Figure 5) reveals coarsely crystalline calcite in a breccia comprising large blocks of Bee Low limestone (Figure 6a). The crystals of calcite are often >5cm long and 2cm wide and can be seen growing into vughs (open spaces) forming a typical 'dog tooth' crystal shape (Figure 6b). The crystals can be seen growing out from the vein walls and limestone blocks, on which they nucleated. Twelve meters to the south of the low cliff, the trace of the vein is marked by a small trial and spoil heaps. A further 70m to the south a calcite-limestone breccia marks the extension of the vein. Following the vein 8m northwards towards Grinlow Wood, it is cut by a small steep path. Here, exposed in the extensive scree in the path, are yellow masses of coarse barite that are being dislodged from the weathered centre of the vein (Figure 6c). The barite masses show both platy and rosette morphologies. A further 60 northwards, the vein is cut through by a path that exposes large (10cm) brown calcite crystals (Figure 7) and lesser amounts of barite, in a vein-breccia.

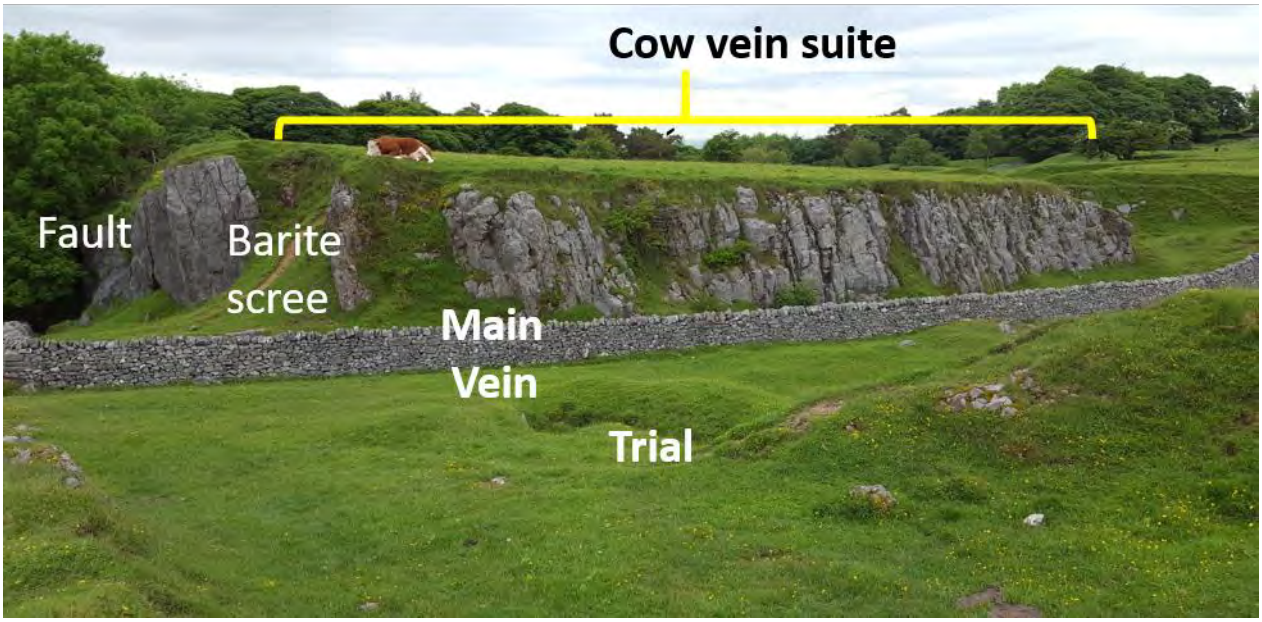

Figure 5. Outcrop of Bee Low Limestone containing calcite-barite veins and vein brecias (the Cow Vein Suite) on Grinlow Hill.

In the low cliff (Figure 5), several vertical calcite and calcite-barite veins cutting the highly jointed limestone are exposed. In one vein the margins of the vein (Figure 8) have inwardly growing calcite crystals with the centre of the vein filled with coarse (1-4 cm), white, bladed barite crystals. The east end of the low cliff is occupied by a 70 cm wide brecciated zone comprising calcite and limestone; 50 m south this vein is again exposed.

It is noted that the limestone above to the north of the low cliff was not exploited for lime burning, perhaps due to the large amount of vein 'contamination'.

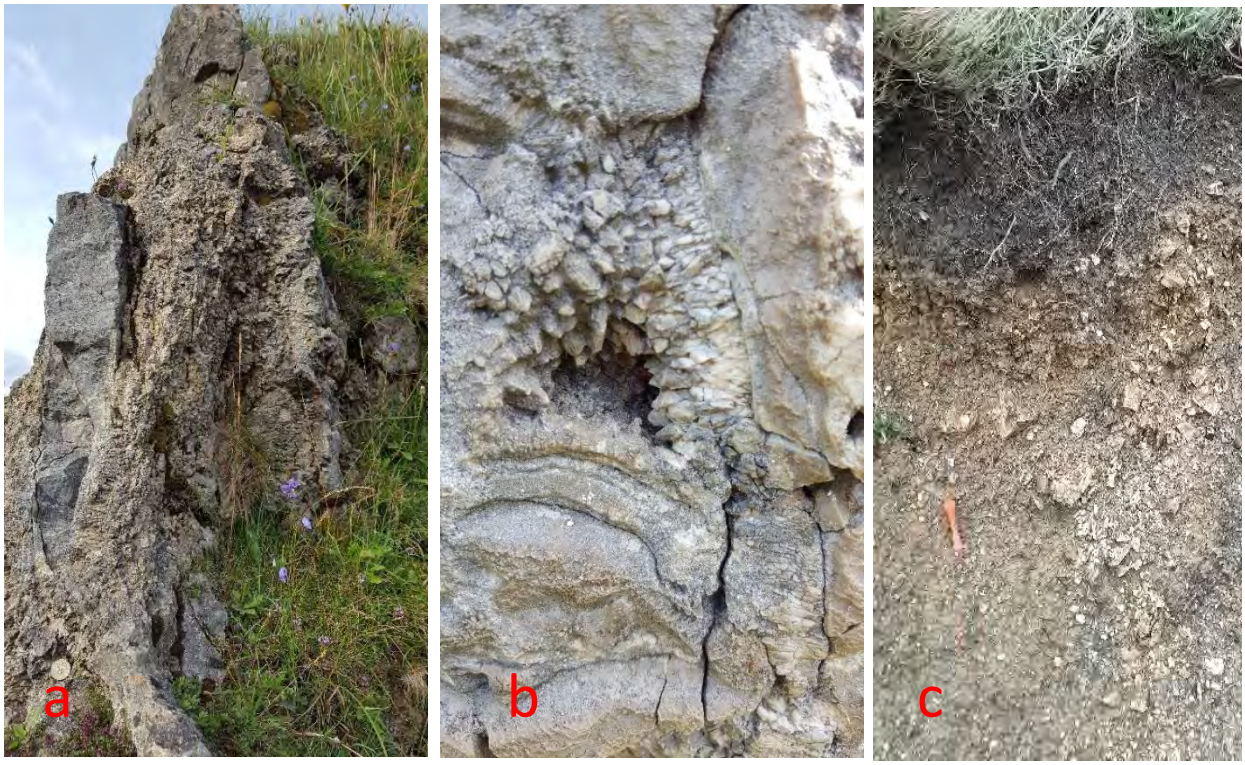

Figure 6 a) ***Vertical vein showing 'cockscomb' textures of calcite crystals grown around blocks of Bee Low Limestone.*** **(Main Cow Vein) b) Rhythmic mineral precipitation terminated with coarse calcite crystals growing into a vugh (void) in the vein c) Regolith of weathered barite above the Main Cow Vein.**

Figure 7 Large brown crystals of calcite from the Main Cow Vein in debris from the path.

Figure 8 Vein with calcite crystals growing in from the vein margins and white, bladed crystals of barite precipitated (later) in the centre.

Other Grinlow veins: There are other manifestations of the mineralisation on Grinlow Hill that have survived lime burning and restoration. On the southside of the hill, the trace of a 2m wide barite-calcite vein trending 123^0 is revealed by a trench and breccia outcrop cut by the farm track Figure 4 (53°14'34.24"N ; 1°55'40.30"W). Nearby, two small trials (trending 6^0) with associated barite debris can be found near the outcrops of the Brassington Formation (see BCA website).

In Grinlow Wood on the north side of Grinlow Hill, among the large lime heaps, the line of a barite-calcite vein (Sheila's Vein, trending 041^0) and associated spoil heaps can be traced for 150 m. The spoil comprises orange, colloform barite and coarse grained, translucent calcite crystals. Barite spoil heaps are also found in various locations in Grinlow Wood (Figures 2 - 4).

Figure 9. Barite vein in Grinlow Wood (Sheila's Vein), with small trial pits and small spoil heaps.

Figure 10 Typical pale orange barite fragments in residual spoil heaps in Grinlow Wood. The density of the fragments distinguishes them from limestone and the friable orange platy residual material from lime burning.

Many of the joint planes in the limestones exposed on the top and south facing slopes of Grinlow Hill contain barite, showing the pervasive nature of the hydrothermal fluids that mineralised this area. One of the most spectacular manifestations of this barite is on joint planes exposed in the outcrop of limestone on the top of the Grinlow Hill, adjacent to the road to the quarry (.53°14'44.60"N; 1°55'53.77"W). Here, on near vertical joint surfaces (especially those trending 114^0 and 14^0), white bladed barite forms planar rosettes which can be seen propagating from a nucleation points (Figure 11).

Summary

The veins seen on Grinlow Hill are typical of lower temperature (70-120^0C) hydrothermal veins of the South Pennine Orefield. There is no evidence of fluorite present which is associated with veins

Figure 11. Bladed crystals of barite forming rosettes, nucleating on joints surfaces in limestone exposed on Grinlow Hill.

in the east of the orefield and, although no galena is present in the visible veins, we know from Chatsworth Estate archives, that small amounts of Pb were extracted both from veins in the Burbage area (Figure 2) and unmarked veins on Grinlow Hill. The large crystals seen in these veins are typical of slow precipitation from mildly saturated fluids. These fluids will have flowed through existing joints and fractures and crystal growth will have caused widening of the vein.

The Burbage-Grinlow-Fairfield veins form a cluster that shows this western edge of limestone was pervasively mineralised. Towards Dove Holes, Peak Forest and in Great Rocks Dale there are also historical records of veins in areas quarried extensively for limestone. None of these veins appear in modern maps of the South Pennine Orefield because many in this western side of the limestone outcrop were exploited in the 17th and 18th Centuries and were low grade/tonnage in terms of Pb, thus regarded as unimportant. They do, however, contain significant barite and calcite and should be included in models for the formation of the Orefield. Although, the mineralising fluid sources for the SPO are thought to have been derived from depth to the east of the Peak District limestone outcrop (Figure 1), in the Buxton area these fluids may well have been more local, derived from shale basins to the southwest. The N-S trend of the faults on this western margin of the Peak District Limestone outcrop make an easterly source of the fluids less likely.

In terms of preservation of our natural heritage, the main issue is the outcrop of the Cow Vein Suite and the barite rosettes on joint planes on the top of Grinlow Hill; ideally these should have an enforceable protected status.

Fairfield

It should also be noted that a shaft and timbered level of a lead mine were 'discovered' at Fairfield Common, to the northeast of Buxton, beneath Buxton and High Peak Golf Course, in 1991. The 15 m shaft (53°15'58.88"N, 1°53'33.05"W) led to a 70 m long level and the shaft sits in the centre of very slightly curving line of shallow mounds trending ~80^0 (Figure 12, 13). Legal reports of mining operations in the 17th and 18th Centuries in the Fairfield Common area named 'Barms Rake' and 'Horse Buttocks Mine' (see Heathcote, 2008). Barms Rake 'may' be close to Barms Farm (Figure 12). The shaft and tunnel discovered in 1991 fit the stricter definition of a 'mine', and the 18th Century reports refer to '3 meers' or 71m of vein, so the golf course vein may well be Horse Buttocks Mine. Confirmation of this requires access to 12 relevant documents held in the Cavendish Archives at Chatsworth House – access has been granted but Covid 19 has intervened and this work will be completed when the archives reopen.

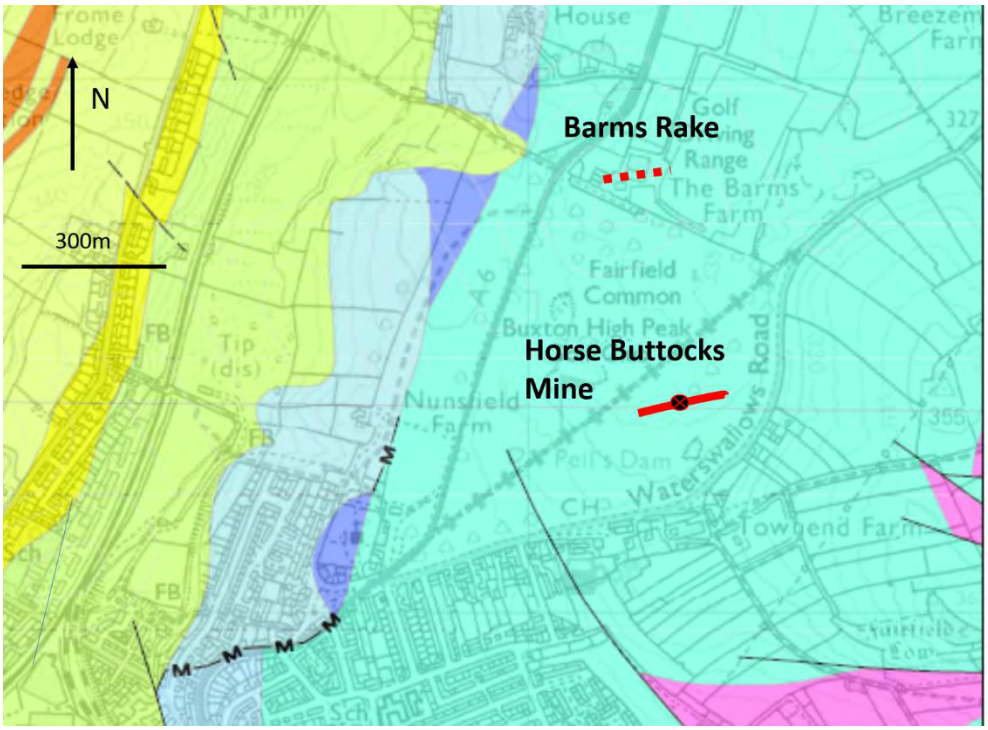

Figure 12 Geology of Fairfield Common showing the location of Horses Buttocks Mine (Trace of vein -Red, shaft ⊗). (Bee Low Limestone - light blue; Eyam Limestone - darker blues; Miller's Dale Lava - pink; Bowland Shale - pale green; Kinderscout Grit – yellow). Geology using Edina Digimap service: http:// edina.ac.uk.digimap, downloaded 2020.

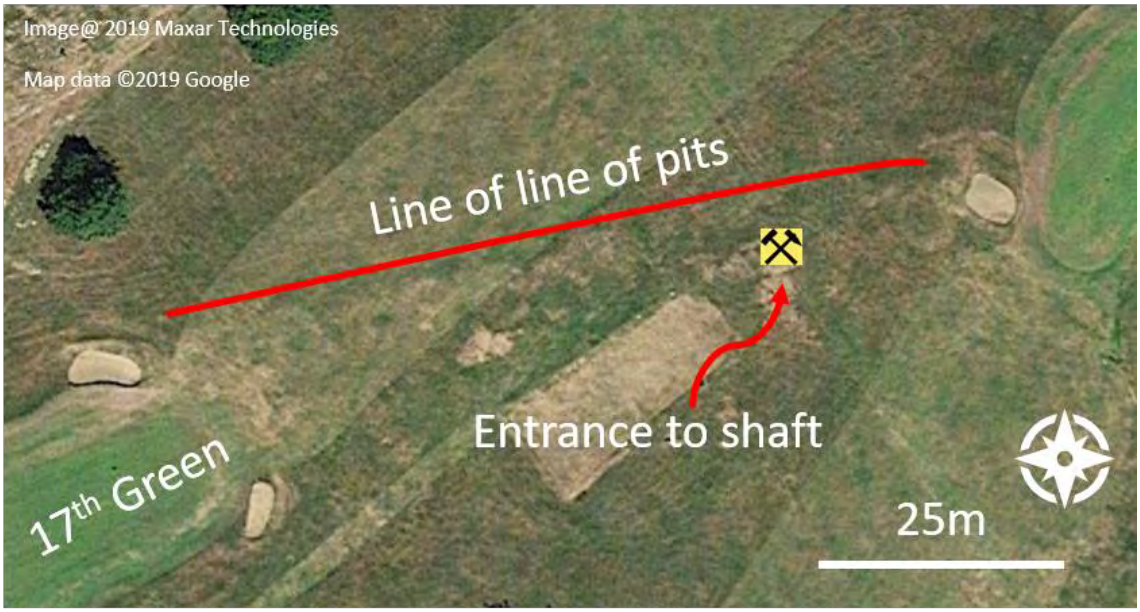

Figure 13. The mine beneath Buxton and High Peak Golf Club, perhaps Horse Buttocks Mine, worked in the 17 and 18th Centuries.

Richard Pattrick, October 2020.

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