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MINERALISATION WITHIN THE IGNEOUS ROCKS OF THE SOUTH PENNINE OREFIELD

by

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ABSTRACT

In spite of the long-standing tradition that ore is poor or non-existent within the toadstone of Derbyshire, a list has been compiled of some sixty localities with minerals of the hydrothermal suite within lavas or tuffs. Some of these were noted by Farey in 1811. Both these and other recorded occurrences have been checked as far as possible in the field. More localities have been added from field observations.

INTRODUCTION

The Carboniferous igneous rocks of the South Pennine Orefield constitute a varied assemblage of contemporary basaltic lava flows, tuffs, vents and a few intrusive dolerite sills emplaced within the Dinantian limestones. The igneous rocks are known locally as 'toadstones'. It has long been thought that this old mining term may have been derived from the German 'Todt stein' meaning dead or unproductive rock. This derives from the general belief that all toadstones were devoid of exploitable mineral deposits (Firman and Bagshaw, 1974). This tradition has not been supported, however, by the investigation of early mining literature and manuscripts. Examples of mineralisation within toadstones have also been recorded from recent exploration of old mines and from some recent boreholes.

The mineral deposits of the orefield are subdivided into rakes,scrins, pipes and flats (Ford, 1977). Pipes and flats are mineral infills of solutionally enlarged pre-mineralisation pathways in the limestones, i.e. along bedding planes and joints. This complex paleokarstic 'plumbing system' only developed in the carbonate host rocks and therefore, such solutional features are absent from the toadstones. Rake veins are major mineralised faults displacing toadstones and creating 'belts' of open fractures. Scrins may be in minor faults, or in solutionally enlarged joints. In many instances both scrins and rakes were infilled with a clay gouge of decomposed toadstone.

During the propagation of a rake vein from limestone into toadstone the vein often underwent a marked change in character. Whereas 'limestone mineralisation' occurred as single,or a small number of thick veins with distinct vein-walls, in toadstones these veins may split into a swarm of interconnecting veinlets (Fig. 1). Such a change in character was well documented in Seven Rakes Mine, Matlock by De Villiers et al. (1826). Veinlets produce a well-defined zone of bleaching and alteration in the basaltic host rocks similar to, but often more intense, than the 'toadstone-clay' type of alteration developed at the upper and lower contacts of toadstones with limestones (Garnett, 1923).

Pipe veins may be localised above or below lava horizons. Examples of a pipe vein above a lava are from Oxclose and Masson Hill, while at Millclose Mine pipes were developed below a lava. In both these situations the lavas are intensely bleached and intersected with minor veins. Thus the presence of bleached toadstone on a mine dump does not necessarily imply that a vein had been worked 'in the toadstone'. However, in pipes under toadstones, collapse during or after mineralisation may result in adventitious blocks within the ore deposit. A few localities determined from blocks of altered toadstone in the waste dumps may be of this category.

Toadstones are usually regarded as impermeable aquicludes that controlled the flow of mineralising fluids in the limestones (Firman & Bagshaw, 1974). However, the presence of open fractures transgressing some toadstones could have allowed leakage of fluids from one limestone horizon to another. In some instances this phenomenon was a major factor in the localisation of orebodies, as exemplified at the 'boil-up' in Millclose Mine (Traill, 1939), where the rich 129 fathom orebody suddenly ascended through an open fracture in the Upper 129 Toadstone and continued into the overlying limestones.

Such spectacular control cannot be demonstrated easily elsewhere. In the majority of cases thin veinlets in toadstones were infilled with an early-phase of calcite. The rarity of vugs in these veinlets suggest that from a very early stage in the history of mineralisation the fracture zones were effectively 'sealed' and the toadstones reverted to acting as aquicludes. This early infill would account for the 'barren spar leaders' in toadstone often referred to in mining documents. Only the largest fractures remained open long enough to permit the passage of the main phase of mineralisation as in High Rake at Sallet Hole Mine.

In the early mining literature the Rake veins are often depicted as being continuous in limestones above and beneath toadstone layers but cut off by the toadstone, e.g. Whitehurst (1778). Although Pilkington (1789) considered that veins were generally barren in toadstone he noted a vein with a rib of galena 10 inches (25 cm) thick in a mine in toadstone on Tideswell Moor. Farey (1811) noted that during the continuation of a vein through a toadstone it became 'pinched' and was squinted or refracted from its expected position in the underlying limestone (Fig. 1). He also commented that "the vein underneath a toadstone bed, is seldom nearly of the same width, or of the same nature exactly, as that above it".

Farey was the first to recognise that the toadstones were not totally 'unproductive' and in his list of mines (1811) he gave nineteen localities where veins carried ore in the toadstone (although in two of these he misidentified clay and sand bodies around Brassington as decomposed toadstone). He commented ".... doubtless the instances are more numerous". He also listed thirteen mines 'in toadstone' but not specifically working ore in toadstone. A possible logical explanation in these cases is that veins had been followed into toadstones but had proven to be impoverished in galena. Watson (1813) also recorded a number of mines as "very productive in the toadstone".

The strong belief, prior to Farey, that toadstones did not host mineralisation, seems puzzling given these occurrences. However, the unwillingness of the miners to test their veins in the toadstones is less surprising when it is remembed that only some of the larger rake veins carry ore in toadstone. As a percentage of the total of all the other types of mineral bodies in the orefield, scrins, flats, etc., these occurrences appear to be so few as to discourage any trials within toadstone. Practical difficulites of working veins in toadstones would also discourage such ventures. As De Villiers et al. (1826) noted, decomposed toadstone was difficult and expensive to support. Where the toadstone was fresh its hardness and lack of jointing were a major obstacle to the early miners. Whereas miners would drive long distances on thin, barren veins in limestone in the hope of encountering rich bellies or pipes, veins in toadstone were unlikely to strike rich ore suddenly. When a vein had been worked down to a toadstone horizon it was easier to drive crosscuts in search of new veins in the limestone than to attempt to follow the vein down into the toadstone even though it might appear promising. Sinking and driving in toadstone would also be fraught with problems of drainage.

Despite this apparent lack of interest in mineralisation within toadstones nearly sixty instances are given which range from the occurrence of rich, orebearing veins to swarms of barren calcite veinlets.

The list does not include instances where one wall only of the vein is in toadstone, owing to faulting. In cases other than those of Farey's list, that cannot be confirmed, where swarms of barren calcite veinlets are noted these have produced strong wall-rock alteration in the toadstones. This distinguishes them from calcite veins present in toadstones which are the product of deuteric activity, and which show no alteration features. Those mines given in Farey's (1811) list (reprinted in Vol.1,part 7, of the Bulletin, 1962, pp. 38-47) have been located (Fig. 2) and their various 'toadstones' identified in terms of a modern stratigraphic nomenclature. Mineralisation in lavas, dolerites and vents have all been recognised herein.

The stratigraphy of the igneous rocks in the orefield has recently been reviewed (Walters and Ineson, 1980 a & b) and the reader is referred to these accounts for further details of nomenclature and correlation.

At present, the authors do not feel that there is any point in categorising the occurrence into different types, although clearly a partial separation is possible into: (a) adventitious, faulted-in mineralised toadstone; (b) adventitious due to collapse into pipe cavities; (c) replacement of calcitised toadstone; (d) deuteric mineralisation; and (e) epigenetic, but not part of the Pb-Zn-F-Ba ore suite.

The authors realise that their list is incomplete and would welcome news of further localities.

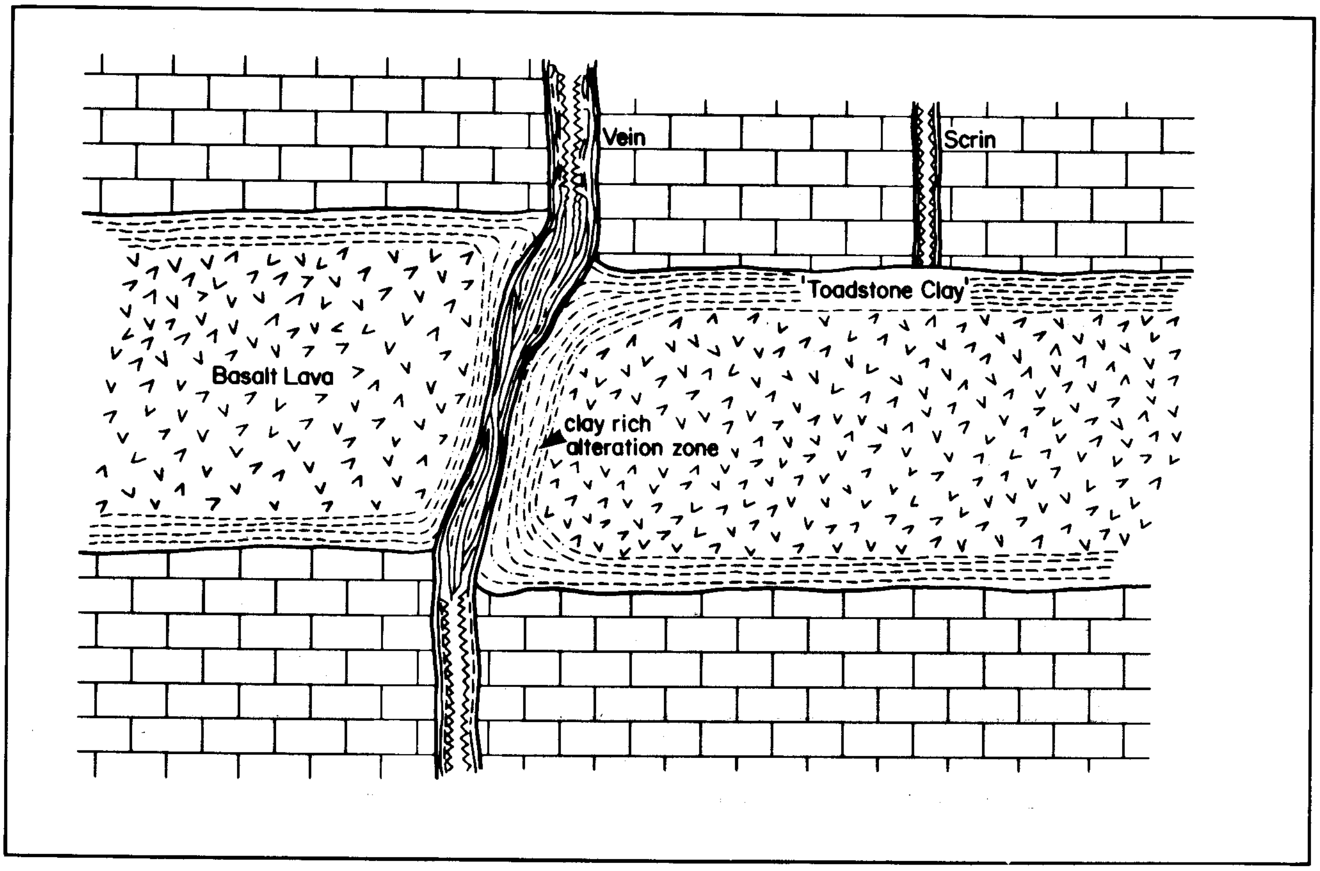

Fig. 1. A typical example of vein - lava relationships.

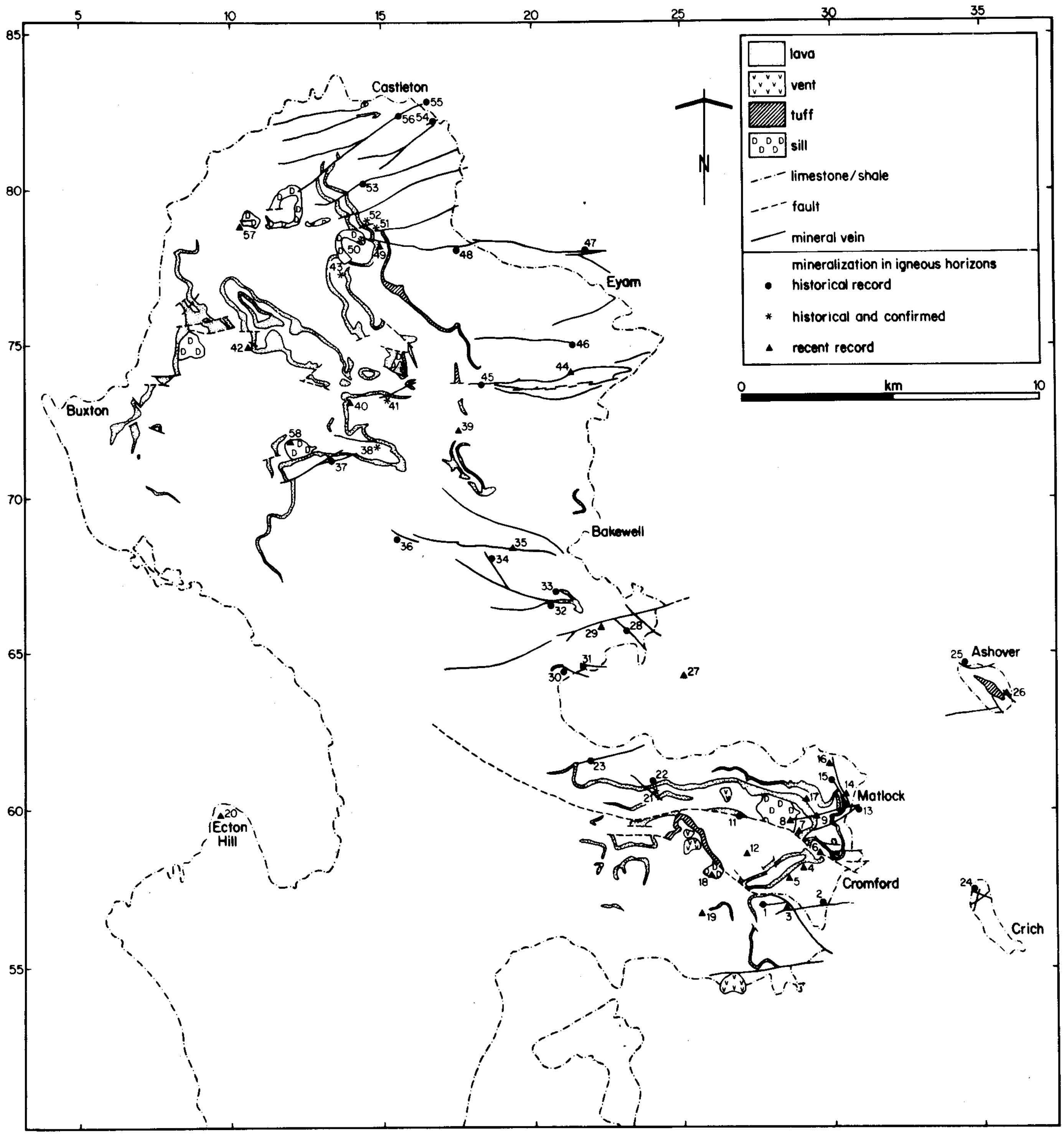

Fig. 2. Mineral localities within the igneous rocks of the South Pennine orefield.

SPECIFIC OCCURRENCES OF MINERALISATION WITHIN IGNEOUS OREBODIES

(Numbers refer to locations given in Fig. 2)

1. Bondog-Hole (or Dog Holes) Middleton by Wirksworth: An E-W rake that crosses Middleton Moor and intersects the Gulph Fault to the north of Middleton. It was an important ore producer in the latter part of the 18th century (Flindall et al., 1973). Bondog Hole Mine is situated at the western end (SK 266.560) and intersects the Matlock Lower Lava, approximately 10 m thick, at a depth of 30 m. Bondog Hole workings in a small rake and associated pipe caverns have been intersected in Middleton Limestone Mine, and both show fallen blocks of the overlying Lower Matlock Lava.

2. Gang Vein: A powerful E-W mineralised fault ranging from Middleton by Wirksworth to Black Rocks, Cromford. Farey (1811) gave no specific indication where the vein carried ore in toadstone. The vein crosses the 'Great Clay'; the clay has been equated with the thin and deeply weathered Matlock Lower Lava (Alsop, 1845). Farey (1811, p.250) however, referred to the "hard 1st toadstone" in the Gang Mine without mentioning clay. It seems likely that as the thickness of the lava will not be in excess of 5 m in this area that even when freshly exposed in a hard state, it would rapidly weather to the 'great clay' lithology, especially adjacent to the vein.

3. Middleton Limestone Mine, Wirksworth: The so-called western extension of the Gang Vein has been intersected and old man's lead workings encountered in a number of places. The limestone workings are in the Hoptonwood Limestones beneath the Lower Matlock Lava, and in places it appears that both walls of this fissure vein are in altered toadstone, much of which has fallen into the old workings giving a spurious effect of toadstone 'in' a vein. Elsewhere in the mine veins have been worked in thick wayboards (1-2 m) along minor faults.

4. Groaning Tor Adit (or Hallicar Wood Sough), Via Gellia: Extension to the adit have recently provided a section in the Matlock Lower Lava and its overlying tuff. Within the coarse, doleritic central portion of the lava occur a number of clay-rich, green, bleached zones associated with calcite veinlets. Tracing thin amygdaloidal horizons across these zones show that they are small mineralised faults with displacements up to 0.4 m. Pyrite is the only other mineral present and no stoping has taken place. These alteration zones lie on the strike of the SW-NE Goodluck Sough veins (Flindall, Hayes and Rieuwerts, 1977).

5. Jacob's Dream Mine: This adit high on the south side of Via Gellia is driven along a scrin through a 'wall' of toadstone some 5 m thick, with short workings along the two contacts of the dyke-like toadstone body. In spite of its shape the toadstone mass is a faulted-in slice and the mineralisation is mainly along the contacts with only stringers of calcite in the bleached toadstone.

6. Ball Eye Quarry: High at the back of the quarry a rake vein has been worked for fluorspar along the line of the Bonsall Fault or one of its branches, in a thick altered toadstone. The vein had a fill with a high content of fluorite and had diffuse calcitic walls in bleached and altered toadstone.

7. Superfine Vein, Bonsall: This locality constitutes the only case recognised to date of mineralisation within a vent. The vein lies on the extrapolation of Coalpit Rake westwards beneath the Matlock Lower Lava. A line of old workings extends across the area of the Ember Lane Vent (Walters and Ineson, 1980) and shaft spoil (SK 283.582) includes blocks of agglomerate. Some of the agglomerate blocks show the replacement of the calcareous matrix and limestone clasts by fluorite and quartz.

8. Great Rake, West of Low Mine: The Great Rake continues into the eastern edge of the Bonsall Sill. It appears that the sill interfingers with the limestone in this region and the vein transgresses one of these leaves. Trenching has exposed the sill at the western end of the Rake and the vein has been worked opencast for a short distance in the dolerite. Blocks of variously bleached and altered dolerite can be found in the opencast walls. In extreme cases it has been converted into an almost white rock consisting of calcite, kaolinite with minor albite, similar to the 'white trap' of the north Pennines.

9. Great Rake, East of Low Mine: On Masson Hill the vein has been worked opencast for a width of 3 m in the upper part of the Matlock Lower Lava. Both vesicular and non-vesicular basalts are exposed and are intensely bleached adjacent to the vein.

10. Porters Mine, Bonsall: Noted by Farey (1811) as being 'in toadstone'. According to Pilkington (1789) the mine was "about 2 miles south of Snitterton", this places it north of Ball Eye Mine. Pilkington (1789) also referred to the "uncommonly strong dip of the measures" which could indicate a position close to the Bonsall Fault Zone, while Watson (1813) placed Porters Shaft to the south of Masson Hill..

11. Salters Way, Brightgate: According to Whitehurst (1778), this was a "fissure, part filled up with toadstone and in part with minerals, etc.". Farey (1811) referred to "chance toadstone beds, and filling fissures?". Whether this represents a true instance of ore within a toadstone is not clear. The mine lay on the Bonsall Fault, west of Bonsall and has also been referred to as Blackstone Shaft (Watson, 1813).

12. Slaley Sough, Via Gellia: This exploratory adit was driven to test veins beneath the Lower Matlock Lava on the north side of the Via Gellia. In its further reaches, the adit was driven along the E-W Parsons Rake. Rises in the vein up into the lava have allowed blocks of lava to fall into the level. These blocks are often strongly altered and veined with calcite which carries minor galena and pyrite in some blocks. This is inferred to represent the continuation of Parsons Rake through the lava.

13. Side Rake, Matlock: A SW-NE vein off the Great Rake in the Riber Mine area yielded ore in toadstone (Matlock Upper Lava) according to Farey (1811).

14. High Tor Rake, Matlock: A NNW-SSE rake that parallels and connects with the Seven Rakes/ Slitt Rake system. High Tor Rake crosses the outcrop of the Matlock Upper Lava below High Tor (SK 296.593) and has been worked in a series of shallow opencasts within the lava.

15. Seven Rakes Mine: 16. Smarts Quarry Borehole, Matlock: Seven Rakes is one of the most widely quoted and best documented cases of the occurrence of ore in toadstone. Workings at Seven Rakes Mine in toadstone were referred to by Pilkington (1803), Farey (1811) and Watson (1813), who also noted ore in toadstone at Dickeye Mine on the Seven Rakes further south. De Villiers et al. (1826) gave an account of a visit to Seven Rakes Mine to examine the workings in toadstone.

At its northern end, the vein was intersected within the Matlock Upper Lavas by an inclined borehole in 1957, at Smarts Quarry (Smith et al., 1967). Mineralisation was present as a 20 cm thick vein containing galena, zinc blende, fluorite, calcite and pyrite.

17. Masson Opencast: The complex system of fluorspar replacement pipes and flats is in dolomitised Lower Matlock Limestones resting on the Lower Matlock Lava. These limestones carry several clay-wayboards which are variably mineralised with fluorite, or which merge into the replacement ore so as to lose their identity.

18. Ible Sill, Via Gellia: A shaft was sunk in the floor of the old dolerite quarry in the 1920's following leads of thin calcite and quartz stringers alleged to carry gold. Samples have revealed only chalcopyrite.

19. Golconda Mine, Brassington: A thick clay wayboard in the roof of a stope near the start of the northeast decline carried large numbers of euhedral calcite scalenohedra, which appear to have grown freely in the altered tuff.

20. Salt's Level, Ecton: A thin steeply dipping clay wayboard (altered tuff) about 5 cm thick carries galena and calcite crystals in the clay near the end of the level.

21. Whitelow Rake, Winster: A NW-SE vein that crosses the outcrop of the Matlock Lower Lava. Ore was worked in the toadstone (Green et al., 1887). The vein has been opencast within the lava in recent years (Butcher, 1976).

22. Mossey Meer Mine, Winster: Situated on one of the series of veins parallel and to the east of the Whitelow Rake that also cross the outcrop of the Matlock Lower Lava. These veins are also known as the Lickpenny Veins (Green et al., 1887).

23. Old Isaacs Venture, Elton: Situated on the Raithe Rake portion of the Coast Rake east of Gratton Dale. It yielded ore in lava (Matlock Lower Lava) according to Farey (1811).

24. Wakebridge Mine, Crich: Stoping for lead in lava (probably, the Matlock Lower Lava) was described by Bemrose (1894). He noted that the ore was "as good as that in the limestone" and gave a brief description of the alteration of the lava adjacent to the vein.

25. Westedge, Ashover: In a strong E-W mineralised fault which bounds the northeast side of the inlier. Lead ore occurred in toadstone (Farey, 1811) which is inferred to be the northern continuation of the Ashover Tuff and associated lava flows.

26. Fall Hill, Ashover: A large fluorspar ore-body has been worked in the limestone overlying the Ashover tuff, along a NW-SE rake. Replacement 'wings' extend into the limestones on each side, and recently one has been worked in the highly altered upper part of the tuff, which may have been very calcareous before mineralisation.

27. Mill Close Mine: The occurrence of ore in toadstone at the 'boil up' has already been mentioned. Traill (1939, p.866) whilst noting that open fissures were much less common in toadstone than limestone nevertheless asserted that at Millclose ".... several instances have been found where the existence of an open channel on a fault (in toadstone) has permitted ore solutions to rise from below a bed of toadstone to a higher horizon".

28. Wheels Rake, Alport: This is one of the major NW-SE veins of the Alport mining area. Watson (1811) noted Wheels Rake as "very productive" in toadstone (the Conksbury Bridge/Upper Alport Lava). This rich vein appears to be that discovered in 1786 in toadstone, at the forefield of Wheels Rake Old Sough (Kirkham, 1964). As the sough was driven along Wheels Rake, the vein in the forefield probably equates with one of the NE-SW cross veins in the Baltic Wood area. Although the sough was eventually driven in toadstone to the Long Rake, it is improbable that this was the rich vein mentioned as the sough was still being driven after 1786. Kirkham (1964) also included a section (dated 1836) which depicts the Amos Cross branch of Wheels Rake persisting through the lava into the underlying limestones.

29. Long Rake, Conksbury: Recent exploratory boreholes sunk in connection with the opencast workings around Conksbury have intersected the Long Rake within the Conksbury Bridge Lava. The vein comprised two zones of intense bleaching and calcitisation which show evidence of polyphase movement and shearing.

30. Nick Sough, Youlgreave: Noted by Farey (1811) as "in toadstone". Nick Sough was driven along the NW-SE Nick Vein from Bradford Dale. The sough tail is situated on the outcrop of the Bradford Dale/Lathkill Lodge Lava.

31. Black Shale Pits, Youlgreave: Another mine "in toadstone" from Farey's (1811) list. It is located on a WNW-ESE vein close to Nick Vein and the toadstone referred to is likely also to be the Lathkill Lodge Lava.

32. Dale, Over Haddon: The Lathkill Dale Vein Sough, being driven in 1743 (Rieuwerts, 1973) passed beneath the river at Lathkill Lodge. The sough was initially in the Lathkill Lodge Lava and followed the vein in this lava for a short distance.

33. Robinstye Flat Work, Over Haddon: Probably situated to the north of Lathkill Dale Sough tail (Rieuwerts, 1973). Ore occurred in the Lathkill Lodge Lava (Farey, 1811).

34. Warm Bath, Sheldon: A NW-SE rake branching from Mandale Rake, north of Lathkill Dale, and trending towards the Magpie Mine area. According to Watson (1811) this was a particularly rich vein and in a section he depicted the vein descending into the upper part of the toadstone. Farey (1811) also noted the vein as carrying ore in toadstone. In the Magpie area the vein transgresses the ground underlain by the Shacklow Wood Lava and it is probable that this is the toadstone referred to by Watson and Farey.

35. Mogshaw Rake, Sheldon: Recent borehole information has supported the statement that major faults are often mineralised within lavas. Mogshaw Rake has been intersected in the Shacklow Wood Lava. It is represented by a zone of intense bleaching and calcitisation. Vuggy veinlets carry calcite and green fluorite together with minor amounts of marcasite, pyrite and chalcopyrite.

36. High Low Pipe, Sheldon: Noted by Farey as "in toadstone" the western end of this WNW-ESE rake is underlain by the Upper Millers Dale Lava. For the mine to have intersected this horizon it would have to have exceeded a depth of 200 m.

37. Wham Rake, Taddington: The NW-SE Wham and Grove Rakes intersect and displace the outcrop of the Millers Dale Upper Lava. Lines of hillocks cross the lava outcrop suggesting the veins were worked in this horizon. Farey (1811) also noted their continuation into toadstone.

38. Horse Steads Mine, Taddington: An E-W vein,that transgresses the outcrop of the Upper Millers Dale Lava at Horse Steads Mine (SK 143.716). Farey (1811) noted the presence of a lower toadstone (Lower Millers Dale Lava) and that the vein was followed down through both these lava horizons.

39. Putwell Hill Mine, Monsal Dale: Once worked for lead, this vein was extensively worked for calcite in the 1920's and the lowest workings, in the Monsal Dale Limestones, worked down into the top of an underlying toadstone, without substantial change in the vein.

40. Basalt Quarry, Millers Dale: In a small quarry above Millers Dale (SK 134.731) an E-W zone of alteration is exposed within part of a coarse non-vesicular, central flow unit of the Upper Millers Dale Lava. The alteration zone is 1.0 m wide and is associated with a swarm of calcitic veinlets with a central, thicker vein with vuggy dog-tooth calcite and pyrite.

41. Maury Mine, Millers Dale: This locality is one of the few mines from Farey's list that is accessible and provides an excellent example of the nature of the continuation of a rake vein in toadstone. Maury vein can be observed in limestone beneath the disused railway track where it is a single thick vein with sharply defined walls, slickensided in places. Columnar calcite is the main fill.

Above the railway track an excavated entrance (SK 150.731) allows access into a section of adit where the vein can be observed in the Upper Millers Dale Lava. Within the lava the rake continues as a swarm of thin calcite and quartz veinlets. These are associated with a well-defined zone, up to 3 m wide, of intense bleaching and argillisation which has a central zone of almost white, kaolinite-rich clay alteration produced in the most intense area of leaching. Some 60 m of adit are currently accessible but over this distance the veinlets have not been observed to carry lead or zinc mineralisation. However, the dumps yield abundant blocks of mineralised and altered lava. Sphalerite and smithsonite predominate with lesser amounts of galena, pyrite and bravoite.

42. Calcite Vein, Tunstead: A 4.9 m wide calcite vein is exposed near Tunstead Quarry (SK 104.748) within the Lower Millers Dale Lava. The vein comprises a number of closely spaced columnar calcite-filled veins each separated by a thin and highly altered segment of lava. There is a bleached and altered zone developed in the lava adjacent to this set of veins. Disturbed ground suggests that the vein was investigated by the old lead miners; however no ore minerals were observed in the present exposure.

43. Edge Rake, Wheston: This E-W vein transgresses and displaces the outcrop of the Upper Millers Dale Lava. Surface spoil contain blocks of bleached and mineralised lava and support Farey's (1811) statement that ore was worked in toadstone.

44. Sallet Hole Mine, Coombs Dale: This modern mine driven into High Rake and its branches beneath Longstone Edge, has confirmed William Wager's early 19th century reports of a vein in toadstone. The vein, carrying mainly fluorspar, has been stoped out in both limestone and toadstone, in some cases showing little change in its character even when both walls of the fissure were in toadstone, here a bedded tuff carrying much dispersed pyrite, and subordinate amounts of other sulphides such as bravoite, chalcopyrite, etc.

45. Robin Wash, Longstone: Situated in Hay Dale on the western end of the Longstone Edge vein system (SK 180.732), this locality was referred to by Farey (1811) as "in the 1st toadstone". The complex volcanic stratigraphy of this area is far from clear but Robin Wash may be part of the lava exposed at the foot of Cressbrookdale. This lies at the same stratigraphic horizon as the Upper Millers Dale Lava, but appears to be unrelated to it with an extrusive centre in the Longstone Edge area.

46. High Field, Stoney Middleton: Situated at the eastern end of the White Rake (Wardlow) vein. Farey (1811) noted High Field Sough as driven from Coombs Dale and intersecting toadstone. Which toadstone this refers to is uncertain. The area is underlain by the Cressbrook Dale Lava, but the toadstone may be the northern extension of a tuff horizon located above the horizon of Cressbrook Dale Lava in the Longstone Edge area.

47. Ladywash Mine, Eyam: According to Farey (1811) ore was worked, from the continuation of the powerful Hucklow Edge vein into the top of the Cressbrookdale Lava. Modern workings have confirmed this, as parts of the vein have been stoped with both walls in lava.

48. High Rake Mine, Hucklow: This constitutes one of the most thoroughly documented cases of the occurrence of exploitable mineralisation in toadstone on part of the Hucklow Edge/White Rake mineralised fault system. Three main periods of working in the toadstone can be recognised around 1757, 1784 and 1834 (Rieuwerts, 1964). Only the earliest episodes in 1757

and 1784 could have been noted by Farey (1811). As early as 1757 toadstone had been penetrated to the remarkable depth of 49 fathoms (89.6 m) giving a total depth to the shaft of 96 fathoms (175.6 m). Plans (Bagshawe Collection No. 587/18 in Sheffield City Library) from the second period of working clearly state that payable ore was located at a depth of 62 m in the toadstone and the vein could be traced even deeper in the toadstone to a depth of 74.9 m as a thick 'barren spar vein'. A further, parallel, vein was discovered north of the main vein toadstone but this was uneconomic to work.

The High Rake Mining Company was formed in 1834 with the express intention of bottoming the toadstone. In 1846 the shaft foot was standing at a depth of 98.8 m in toadstone. Borings from the shaft bottom to an unknown depth also failed to locate limestone and the attempt was finally abandoned as a financial disaster in 1852. During this period the vein was stoped in the uppermost 55 m of the toadstone to the east of the engine shaft (Bagshawe Collection 203).

The minimum thickness of 100 m for the toadstone in High Rake Mine is exceptional, the most likely explanation being that the Cressbrookdale Lava had been intruded by a thick dolerite sill at this locality.

49. White Rake Opencast, Tideslow: Recent opencast workings on the western end of the Hucklow Edge vein system has exploited a fluorite-rich portion of the vein where the Upper and Lower Millers Dale Lavas have been juxtaposed by faulting. The vein also contains calcite, marcasite and galena with secondary goethite, pyromorphite and cerussite. The geology of this locality and localities 50, 51 and 52 have been described in detail by Walters (1980).

50. Black Hillock Mine, Tideslow: The White Rake, at its western extremity, continued into the outcrop of the Potluck Sill as far as Black Hillock shaft (SK 141.783). The vein was traced to a depth of some 80 fathoms (146.3 m) within the dolerite. The interaction of mineralisation on the dolerite produced a highly altered white rock consisting of kaolinite and calcite with albite.

51. Chapmaiden Mine, Tideslow: Situated on Maiden Rake to the north of White Rake opencast (SK 147.784). Blocks of altered toadstone with veins of calcite-fluorite-galena-baryte are common on the dumps. The geology of the area is complicated by the 'chance toadstone beds' of Farey (1811).

52. Calvestones, Tideslow: A small parallel rake north of Chapmaiden Mine (Whitehurst, 1778). This was also mentioned by Watson (1811) as 'very productive' in toadstone. The rake transgresses the outcrop of the Upper Millers Dale Lava and at its western end there is a much overgrown opencast in the lava.

53. Rake Head Mine, Bradwell Moor: This lies on Moss Rake (SK 143.800) and both the Upper and Lower Millers Dale Lavas are present. Ore was found both in and under the toadstone (Green et al., 1887).

54. Nunleys (Nunlowend) Mine, Castleton: This is situated on the eastern end of Long Rake, to the west of Hope Cement Works. Faujas de St. Fond (1799), in describing a visit to Nunleys Mine, noted the continuation of the rake into 'channel'. This 'channel' is the Pindale Tuff formerly exposed in the Hope Cement Quarry. The vein carried some ore in the tuff but was apparently uneconomic to exploit. The mine was also visited by De Villiers et al. (1826).

55. Ashton's (Pindale) Mine, Castleton: Ashton's Mine (SK 163.825) exploited the eastern extremity of the Dirtlow Rake System beneath the Namurian shale cover. According to Green et al. (1887) a "greenish variety of toadstone was found to underlie the shale, without any limestone intervening". The rake could be traced in the toadstone as a network of veinlets that carried small quantities of galena.

56. Dirtlow Mine, Castleton: Situated further west on Dirtlow Rake north of Pindale (SK 175.822), Dirtlow Mine extracted ore within the Pindale Tuff, some 22 m thick at this locality (Green et al., 1887).

57. Vein near Blacklane Farm, Peak Forest: An E-W vein can be traced as a line of disturbed ground and old hillocks into an isolated outcrop of the Peak Forest Sill. In the spoil heaps blocks of bleached dolerite, often strongly veined and brecciated occur together with columnar calcite and minor amounts of galena. This suggests that the vein was exploited within the dolerite.

58. 'Calton Hill Type' Mineralisation: This occurrence of mineralisation differs from all the previous recorded instances in that it cannot be related to a continuation of vein type mineralisation in toadstones. In its classic development - the lava, intrusive dolerite and vent complex at Calton Hill large vugs in unaltered basalt and dolerites are lined with well crystallised quartz, often of amethystine colour. Calcite and baryte occur as overgrowth on this quartz lining. Pyrite and haematite are the only associated metallic minerals. A zonal distribution

of quartz/calcite/baryte infills was at one time evident (Mueller, 1954; Ford, 1967) and suggested a close genetic relationship between the site of the extrusive vent and subsequent silica-rich hydrothermal activity. During the present survey an additional occurrence of this type of mineralisation has been noted from vugs within coarse, non-vesicular basalt of the Upper Millers Dale Lava in a small quarry above Millers Dale (SK 134.730). This occurrence cannot be directly related to the proximity of a vent.

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