ASPECTS OF THE STRUCTURAL CONTROL OF FLUORITE MINERALISATION IN THE SOUTH PENNINE OREFIELD WITH NOTES ON THE MINING POTENTIAL

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Abstract

The structural geology of the South Pennine Orefield is shown to be composed of an interference pattern of folds related in part to basement features. Folds are shown to have developed with varying trends during and after the deposition of the Carboniferous limestone. It is concluded that some of the faulting, normal and reversed, is genetically related to folding. Columnar calcite is shown to be in many cases earlier than fluorite in the vein-faults and is related to early phases of movement, whilst fluorite relates to later lateral movements on the same vein-faults. The distribution of fluorspar deposits is documented and is related to the occurrence of open structures at the time of mineralisation. The flow of solutions into the preferentially mineralised anticlines is thought to be controlled by differential pressure release of solutions up through the thin shale cover to the overlying Permo-Triassic unconformity. Some of the major potential fluorite deposits are described in detail and it is concluded that there is sufficient potential to justify an exploration programme with a view to supplying a second flotation plant in the area.

The term ore as used in this thesis is potential ore in the generally accepted sense of the term. the terms possible ore ,probable ore and ore reserves are similarly used to refer to degrees of potentiality and are not used in the normal sense of the terms.

CONTENTS

FIGURES

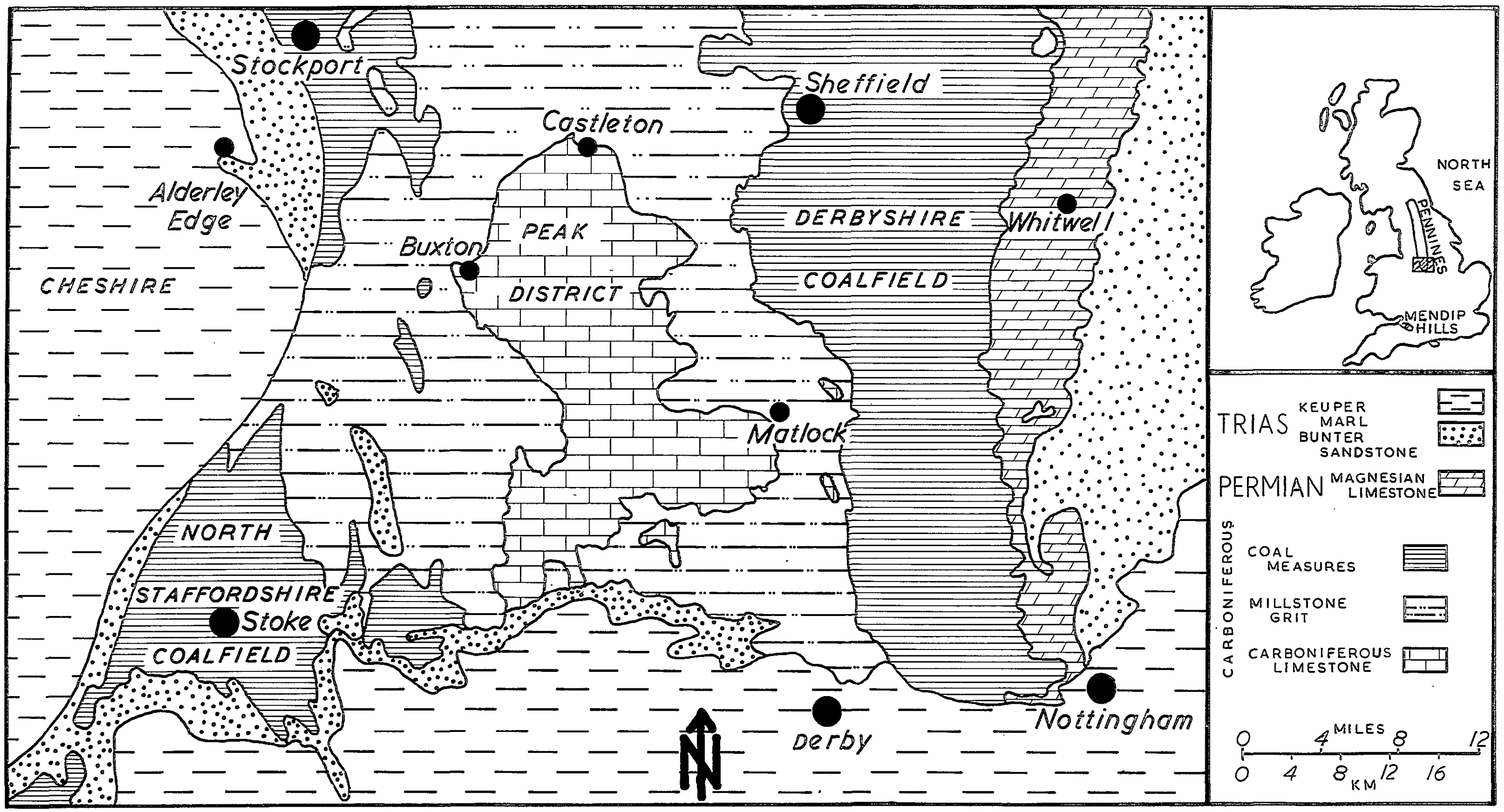
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FIG. 1.

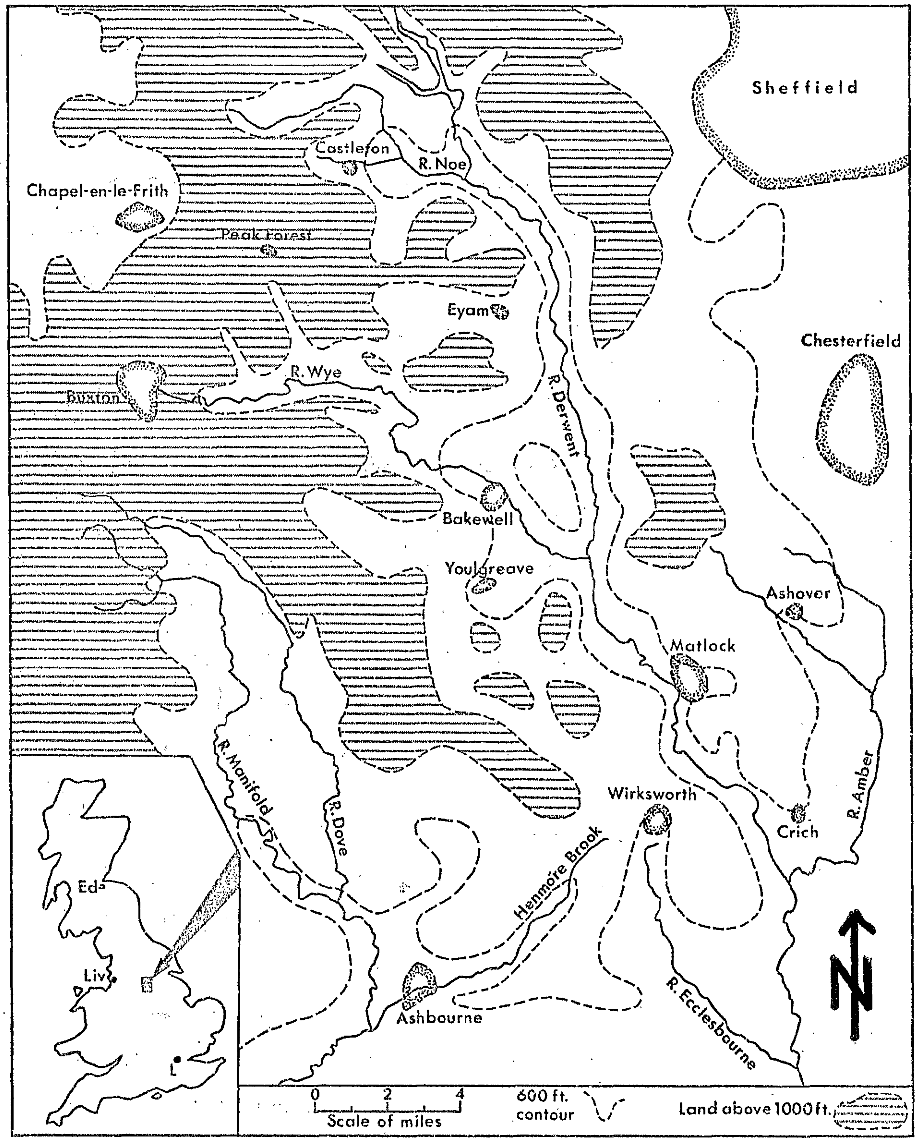

FIG. 2. After Mason Location map and physical features.

PART 1

Introduction

1. General Description and Location of the Area Studied

The area studied lies at the southern tip of the Pennine Chain, in the North Midlands. It is a limestone area sometimes referred to as the Derbyshire 'Dome', as it is geologically an area of uplift, with younger strata dipping away in all directions. It is, however, better termed the Derbyshire Massif as it is an area of quite complex folding. This is coincident with an area called the South Pennine Orefield.

The cities of Derby, Sheffield and Manchester lie a few tens of miles to the south, east and west respectively. Buxton, Bakewell and Matlock are the principal towns within the area (see Figures 1 and 2).

The area is a rolling limestone plateau, at 1000-1300 ft. O.D., deeply dissected by cliffed and wooded valleys, some of which are dry. Limestone outcrops are largely confined to valley sides. It is bordered to the north, east and west by upstanding scarps of Millstone Grit, but to the south descends to the Triassic Plain of the Vale of Trent.

2. Summary of the Geology of the Area

The Derbyshire Massif is a geologically uplifted area of limestones with dolomite, chert and inter-bedded basic igneous volcanics. These overlie a shallow basement of Lower Palaeozoic slates and volcanics of probable Pre-Cambrian age. It is surrounded by basin areas where the sediments are thicker and more argillaceous and the basement is deeper. The margins of the massif in the north, south and parts of the west are hinges across which differential subsidence occurred, as emphasised by the occurrence of monoclinal reef belts between the sediments of massif and basin facies.

Maroof (1973) on the basis of studies of gravity anomalies, has shown the massif to be composed of three east-west blocks of basement arranged in a north-south line, but inclined to the east. Sedimentation in Lower Carboniferous times was dominated by this structure, being thicker in the east than the west. The present-day gross structure reflects this basement configuration with the main axial ridge being north-south, in the west of the massif, with steeper dips to the west than to the east, i.e. an asymmetrical anticline.

The folds of the massif show mainly east-west, northwest-southeast and north-south trends which interfere to produce a complex pattern of elongate domes, lozenge shaped basins, saddles and ridges. Some folds were active during sedimentation in Lower Carboniferous times, as strata are seen to thin onto anticlinal fold crests, and facies vary from anticline to syncline.

The faults of the massif trend principally northwest, east-northeast to west-northwest and north-northwest. Some of the faults can be demonstrated to be pre-Namurian in age and intrusions of Namurian to Westphalian age occur in others. Some of the faults show relationships to the folds, reversed faults being related to the tightening phase of folding and some of the normal faults being related to the post-folding relaxation. It is clear however, that many of these early faults have been reactivated at a later date, both during and after mineralisation, by lateral stresses, which probably gave rise to the majority of the mineral veins. The mineral veins of the massif show similar patterns to the faults, indeed many of the major mineral veins in fact follow the course of faults and it is probable that most of the persistent veins have some displacement of strata on either side, although often this cannot be detected.

In the classical picture of Midland Carboniferious terrains, basement trends control tectonics in the superimposed sediments (Fearnsides, 1933).

It is therefore important to define these trends in order to recognise them in the cover rocks. Maroof (1973) and Kent (1968) have defined the trends of the edges of basement blocks as essentially north-northwest, northwest and eastwest on the basis of gravity and aero-magnetic maps. In the outcrops of Pre-Cambrian rocks in Charnwood Forest, northwest and eastwest trends are known for the folds and cleavage, whilst northwest and northeast faults occur. Thus all the trends of folds and faults seen in the Derbyshire Massif are present in the basement and this reinforces the classical concept that the folds and faults relate to basement movements.

The massif may be divided into four sub-areas on the basis of its fold and fault structure. Three of these correspond to some extent to Maroof's three basement blocks, whilst the fourth lies along their western edge. The Bonsall Fault zone SK090670 to SK300570 tends to separate these sub-areas into two groups of two, each pair with different structural patterns. Southeast of the massif, the continuation of this fault zone separates areas of the Derbyshire Coalfield, also with different structural patterns. The fault is thought to represent a fundamental line of weakness in the basement perhaps separating different types of basement.

During the late Tournaisian and early Viséan times the Carboniferous sea transgressed over the Derbyshire basement blocks. Subsidence was more rapid in the east than the west and the sediments therefore thin to the western edge of the blocks where the lowest beds (Tournaisian) are absent. The early sediments were penecontemporary dolomites with anhydrite. These were followed by more dolomites and in the higher Viséan, by limestones, indicating a change in environment from sabkha to lagoon. In all about 6000 feet of 'limestone' were deposited in the east (at Eyam; Dunham, 1973) whilst perhaps 2000 feet were deposited in the west at Woodale (Cope, 1949, 1973).

At the end of the Lower Carboniferous times, extensive uplift of the massif in the north-east and south, resulted in the erosion of much of the D_2 strata to form a limestone surface not very different from the present surface configuration. Following burial in the Upper Carboniferous period, some of this erosion surface was probably exhumed in Lower Permian times. Only a thin discontinuous cover of shales remained on the limestone. Through this, in the south and west of the massif, during the Upper Permian Zechstein transgression, magnesium-rich solutions could penetrate downwards, especially along faults and joints, to dolomitise the underlying limestones. In early Bunter times, iron-rich solutions were able to penetrate into the limestones along faults, creating small haematite occurrences in the south and west of the massif. At the same time karst cavities probably formed in the limestone, especially at the base of the porous dolomites.

Although 6000 feet of limestones and dolomites are known in the massif, only the upper 1000 feet are known to be mineralised: these beds form a sequence with many basic volcanic layers. They contain extensive ore bodies in the form of fissure and cavity fills as well as metasomatic replacements. The replacements lie on top of toadstones or in reefs immediately below the shales. All the various types of deposits are related to faults or fracture systems. The main gangue minerals are fluorite, barite, calcite, with a little quartz or other forms of silica. Commonly these gangue minerals make up the bulk of a deposit. Sulphides such as galena, sphalerite and various copper-iron sulphides, together with secondary and trace minerals, rarely make up more than a few percent of a deposit.

The gangue minerals in the veins are crudely zoned into north-south zones respectively rich in fluorite, barite and calcite, from east to west. However, ore bodies of fluorite commonly occur in the calcite zone and vice versa and thus the zonal concept is no more than a generalisation (Firman and Bagshawe, 1974). The zonation has commonly been referred to a temperature gradient with a high temperature source to the east, but fluid inclusions studies of the fluorite do not show consistent significant temperature variations in any one direction (Rogers, 1974).

It is herein suggested that from Permian to Jurassic times (Ineson and Mitchell, 1973), mineral bearing solutions driven by pressure, due to the compaction of basin sediments surrounding the massif, as well as seismic shocks, (Sibson et al., 1975) flowed up-dip and rose up the strata towards the massif.

The flow was partly driven by the hydraulic pressure gradient set up due to the leakage of solutions up through the thin shales overlying the massif, into the unconformable Permo-Triassic rocks above. The principal source of solutions was from the east due to the structure of the massif and the surrounding area, which gave a relatively long uninterrupted up-dip flow from this direction, compared with areas to the west and south. Fold and associated fault structures channelled the solutions westwards and on the massif the major anticlinal areas of the eastern margin acted as centres towards which the solutions flowed. Here, the pressure gradient was high, as the cover of shales was relatively thin and therefore leakage more intense than in the nearby synclines. Thus the mineral vein faults on the periclines of Ashover and Crich, the Hucklow Edge-Longstone Edge Anticline, the Taddington-Alport Anticline, the Long Rake Anticline and the Matlock Anticline, are all enriched in fluorite relative to the synclinal areas in between. Moreover, it was these arched areas which had open fault veins during mineralisation. Many of the fluorite deposits lying well to the west may be accounted for either in terms of open structures in dolomite, or in terms of solutions held down by impermeable toadstones until they reached a point where they could break their way towards the surface. Equally important in some of these deposits, may be the former position of the unconformable shale cover, which may have been only a short distance overhead.

Generally, therefore, it is concluded that the occurrence of fluorite orebodies relates directly to the existence of accessible open structures at the time of mineralisation. The source of the solutions, their temperature, and the effects of pressure release on distribution had only a secondary or background control on the occurrence of fluorspar deposits.

3. History of the Research Project

The project has been financed by the Italian based mining company C.E. Giulini (Derbyshire) Limited, in return for a series of geological reports on areas of interest to the Company. These are presented in Part 6.

As originally conceived, this research project was to be an intensive study of the Matlock area of the orefield. It was considered that detailed field mapping of the structure of the area should be made together with petrographic studies of the strata. The paragenesis and geochemistry of the mineralisation were to be examined from samples taken during this fieldwork. In addition, detailed studies of old mining documents were to be carried out. All these different approaches were to be integrated to create a model of the mineralisation and to use this to predict new ore bodies elsewhere. A dossier of the nature and extent of the old mines was to be compiled.

In practice the project developed along different lines. The nature of the industrial sponsor's requirements called for frequent reports, principally on the structural geology, stratigraphy and mineralisation of widely spaced, small areas, some of which lay outside the initially proposed area of study. Thus it became necessary to find a unifying theme so that the fieldwork undertaken for each of the reports could be inter-related. The area of study was therefore extended to fill in between the industrial reports and at the same time the number of techniques of study were reduced. It was decided to concentrate on refining the

KEY TO AREAS MAPPED BY THE AUTHOR

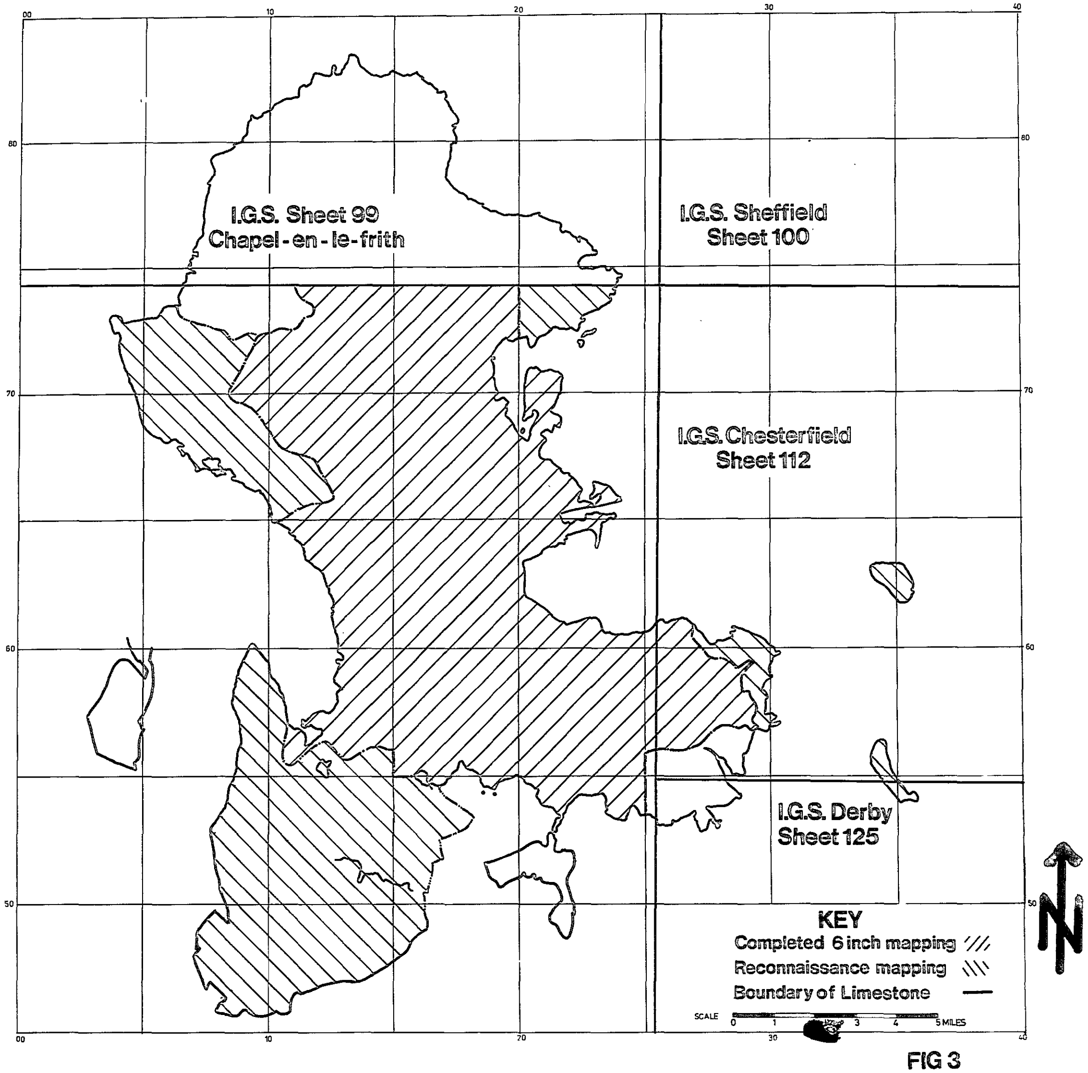

FIG 3

knowledge of structure and stratigraphy of the area in relation to mineralisation as well as to examine from old documents the nature and extent of previous mining. The study therefore became field based and the laboratory aspects of petrography and geochemistry were curtailed.

The field study has been confined principally to the ore-field south of the River Wye, since this area was less well-known geologically and from the point of view of mineralisation. Moreover, it was the area in which the sponsoring company held extensive mineral rights. Further, any examination of the northern area was limited in scope by the lack of access by the author, to the mine workings and geological information of Laporte Industries Limited, who operate two mines near Eyam.

The objective of the work has been to examine the geology of past and present workings for fluorite within the orefield and to define some of the controls on the formation of these deposits. The principles discovered have been used to predict the occurrence of new orebodies and the extensions of old ones within the known orefield and to postulate extensions of the orefield buried beneath younger beds.

The work has been financed by industry and to a great extent the areas examined and the techniques used have been dictated by their requirements. The study therefore examines the occurrence of fluorspar on a bulk or commercial scale, dealing with orebodies rather than details of paragenesis and mineralogy within a deposit.

Much of the work has involved basic mapping at scales of six inches and occasionally twenty-five inches to one mile. This has been in order to produce a modern 1:10560 map of the area of the orefield for which no modern large-scale maps were available, and to revise parts of the Chesterfield Sheet of the Geological Survey (Sheet 112), in the Matlock area (see Figure 3). Details of the structures and strata of both old and active opencast and underground workings have been recorded. Careful studies of the previous literature have been made and new information gained from the study of old mining documents in the Derbyshire Record Offices and other archives. These various types of information have been compiled as maps, sections and written reports produced for the sponsoring company (see Part 6 of the Thesis).

From the stratigraphic point of view, the research has led to the revision of the correlation of several of the toadstones (basaltic lava flows, sills and tuffs) within the area, enabling a more refined regional correlation of the limestone strata to be made. A map of the distribution of dolomite and dolomitised joints has been produced. A detailed structural map of the orefield has been constructed showing accurately the fold trends within the highly mineralised upper Visean (D_2) strata. The relationship of these folds to those of the coalfield to the east has been determined. A new map of the mineral veins for the whole orefield has been constructed. Details of the various types of fluorite ore bodies are described. The general knowledge of the distribution of fluorspar with respect to barite and calcite, has been refined and analysed with respect to structures. The occurrence of haematite within the veins has been documented for the first time. Reasons for these distributions are proposed.

4. Acknowledgements

This research project was carried out between September, 1971 and December, 1974, at the Geology Department of the University of Leicester, and was supervised by Dr. T.D. Ford.

The project was financed by the University from an industrial grand made by the former Company, G.E. Giulini (Derbyshire) Limited, the Derbyshire subsidiary of an Italian mining company.

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Thanks are also due to Mr. I.P. Stevenson and Drs. N. Aitkenhead and I. Chisholme of the Leeds Unit of the Institute of Geological Sciences for much useful information and discussions on the results of their re-survey of the area.

5. History of Previous Research

The earliest comprehensive work on the geology of the area was that of Whitehurst in 1778. "An enquiry into the original state and formation of the earth, with observations on the strata of Derbyshire". He noted the presence of certain veins in the Matlock area and discussed their stratigraphic relationships. Later, during the late 18th and early 19th Centuries, White Watson (1811) produced many inlaid tablets of the geological sections of the area, based on his detailed surface and underground observations. He theorised on the origin of the veins, noting that certain mineral products were confined to particular strata. Pilkington (1789) described the mines and geology of the area in his book 'A View of the Present State of Derbyshire'. Farey (1811) published a list of two hundred and eighty lead and zinc mines in the orefield, together with a brief description of their ores, stratigraphy and location. This was followed in the same year by his report to the Board of Trade 'A General View of the Agriculture and Minerals of Derbyshire'. The following year, he described the Derbyshire toadstones. These early works remain basic references today, as their authors had access to mines and exposures long since lost.

The first Geological Survey Maps of the area were produced in 1852 and a descriptive memoir in 1869 - 'The Geology of the Carboniferous Limestone, Yoredale and Millstone Grit of North Derbyshire' by Green et al. (2nd edition, 1887). Bemrose produced a detailed petrographic description of the Derbyshire Toadstones in 1894, and followed this in 1907 with a study of their field relationships. C.E. Parsons (1897) gave the first detailed description of an orebody, taking his example from Millclose.

Barnes (1901) discussed the nature of the limestone-shale contact at Castleton, arguing that it was an unconformity. This provided the basis of much controversy in the coming years. Wedd and Drabble (1908) pointed out, for the first time, the zonal pattern of the Derbyshire gangue minerals in their short memoir 'The Fluorspar Deposits of Derbyshire'. In 1915, the first Geological Survey's Special Reports on Mineral Resources 'Barytes and Witherite' was published. Here Carruthers et al. described the occurrence and working of barite throughout the orefield. In 1916, this was followed by 'Fluorspar' in the same series, written by Carruthers and Pocock. Spurr (1917) wrote a general paper on lead-zinc chimneys in limestone, describing the Millclose Mine example, and Stuckey wrote a detailed description of the veins in Millclose, showing them to be both cavity linings and fissure fillings. L. Parsons (1922) described the dolomitisation of the area, publishing various analyses and noting that it was an essentially superficial and secondary alteration of limestone. Carruthers and Strahan described the occurrence of lead and zinc in the orefield in a Geological Survey Special Report in 1923, and in the same year Dewey and Eastwood reported on the copper ores of the area, in the same series. Jackson (1925) described the unconformable relationship of the Edale Shales to the Carboniferous Limestone in North Derbyshire, showing that the complex boundary fault system to the limestone of the old Geological Survey Maps was imaginary.

In 1932, Fearnsides gave an address to the Geologists Association with the title 'The Geology of the Eastern Part of the Peak District', and Wilcockson added notes on the mineralisation. Fearnsides noted the east-west subfolds of the Derbyshire Massif and commented briefly on the facies changes across them. In 1933 he published his address to the British Association, 'A Correlation of Structures in the Coalfields of the Midlands Province'. This presented results of years of experience as a coalfield consultant in the form of two maps, one of the folds of the area, the other of the faults. His paper remains a fundamental work on the structure of the region. In it he discussed the sinuous fold pattern of the region, but failed to recognise it as an interference pattern between components with different trends. Fearnsides linked the subfolds of the Derbyshire Massif directly with those of the Coalfield, but later work by the Institute of Geological Sciences, and by the author, shows that whilst the patterns are essentially similar the individual folds are not directly continuous. He concluded that the complex fold and fault pattern was due to adjustments of the cover rocks to movements of the basement at depth, along pre-existing fractures and weaknesses - a conclusion with which the present author is in complete agreement. Fearnsides concluded that the massif as a whole had been moved to the northwest during the Hercynian orogeny, on the basis of the northward curve of east-west folds around the north end of the massif. Structure contour work by the author and the recent work of the Institute of Geological Sciences has modified the fold pattern and this hypothesis of a northwest movement is no longer tenable.

In 1933, Hudson and Turner described the sequence and nature of early and Mid-Carboniferous earth movements in Great Britain, noting that in Derbyshire several pulses of movement occurred from C_2S_1 times to late D_2. Hudson and Cotton (1943, 1945) developed the first ideas of massif and basin facies, as a result of their work on the Alport, Gun Hill and Edale boreholes. Traill (1939) amplified Varvills work by producing two classic descriptive papers on the Millclose Mine - 'The Geology and Development of Millclose Mine, Derbyshire', and 'Notes on the Lower Carboniferous Limestones and Toadstones of the Millclose Mine, Derbyshire'. These gave the first really clear picture of the importance of toadstones as stratigraphic and structural ore controls in the Derbyshire mineral deposits, and they have been quoted frequently with and without misinterpretations. Traill compared the rise up the stratigraphy, from north to south, of the Millclose orebody with the 'manto deposits' of the limestones of Mexico, described by Prescott (1926).

In 1942, Pocock described the occurrence of ochres and umbers in a Wartime Pamphlet of the Geological Survey. Dunham and Dines (1945) produced another Wartime Pamphlet of the Geological Survey on the occurrence of barite within the orefield. Shirley and Horsfield (1945) related stratigraphy, structure and ore deposits together in their study of the Eyam District of Derbyshire, noting the occurrence of some major veins along anticlinal folds. In the same year, Schnellmann and Wilson reviewed lead-zinc mineralisation in North Derbyshire, pointing out concealed potential orefield extensions east of the massif. In 1949, Shirley revised the stratigraphy of the Millclose Mine, correlating the toadstones thereof with those of the surrounding areas, based on his observations in 1940, just before the mine closed down. He showed the toadstones to occur on many discontinuous horizons and hence the difficulties of using them for long-distance correlations. In the same year Cope described briefly the Woodale borehole showing that dolomites of C-S age lay on a basement of probable Pre-Cambrian volcanics.

In 1951, Mueller completed his Ph.D. Thesis on 'Genetical and Geo-chemical Survey of the Derbyshire Mineral Deposits', with a new zonal map of the orefield, based on the colour of fluorite and the proportions of fluorite, barite and calcite in the veins. Parts of his thesis were published in 1954. In one, on the 'Genesis of Oil by the Hydrothermal Alteration of Coal Type Substances', he sought to show that the temperature of hydrothermal solutions could be estimated from the melting points of coal-like bitumens. On this basis, he estimated the temperature of formation of the Derbyshire mineral deposits to be about 300°C. His other papers were on the colouration of fluorite and on inclusions in gangue minerals.

Dunham's Geological Survey Report on fluorspar (1952) described occurrences and workings in the orefield. In the same year his paper on 'Age Relations in the Epigenetic Mineral Deposits of Britain' pointed out that the secondary dolomitisation of Derbyshire was pre-mineralisation and probably Permian in age. In 1953, Dennison and Varvill described 'Prospecting with the Diamond Drill in the British Isles', outlinging early use of this technique on the Great Rake at Matlock. Schnellmann again drew attention to the possibility of concealed lead-zinc orefields east of Derbyshire in 1955, while Ford described the occurrence of Blue John fluorspar. In 1958, George described the Lower Carboniferous palaeogeography of the British Isles, outlining the Derbyshire situation. Varvill reviewed the state of the Derbyshire orefield in the 1959 Institution of Mining and Metallurgy Symposium on 'The Future of Non-Ferrous Mining in the U.K.'; wherein he proposed a series of northwest to southeast lead rich and lead poor belts cutting across stratigraphy, structures and facies. The belts were constructed by joining up a few mines known to be 'rich' in lead and the present author can find no justification for this. Many 'rich' mines are known in the 'lead poor' belts and the concept is most unsatisfactory. In the same year, Shirley described the stratigraphy and structure of the Monyash-Wirksworth district producing a small scale structure contour map showing the relationship of some of the veins.

In 1961, Ford reviewed recent studies of mineral distribution in Derbyshire and commented on the fact that whilst authors derived their mineral solutions from the east, no source granite was known. In 1962, Varvill wrote on 'Secondary Enrichment by Natural Flotation' drawing on his Derbyshire consultant experience. While this contains some unacceptable ideas, it has many useful sections on geologically recent enrichment of older ore bodies in Derbyshire. George's review of 'Tectonics and Palaeogeography in Northern England' in 1964, emphasised that the doming of the South Pennines was a purely Tertiary feature. Ford and King in 1965, described the layered galena-barite ores of Golconda Mine, pointing out that they occurred in ancient karst caverns at the dolomite-limestone interface, as did many of the Matlock fluorite flats. Ford and Sarjeant (1964) compiled a Peak District Mineral Index, listing all the known minerals of the orefield and outlining their distribution.

In 1966, King reviewed the occurrence of mineralisation in the rocks of the East Midlands suggesting that mineralisation in the Trias occurred due to the re-circulation of brines through the pre-Triassic basement. These brines carried, both upwards and downwards, certain mineral components which were enriched in the basement and cover-rocks respectively. This was a major step, linking the origin of the epigenetic deposits in the Lower Carboniferous Limestones with the later episyngenetic mineralisation of the Trias.

In 1966, Sadler and Wyatt described the S_2 inlier at Hartington. In 1967 Ford and Brown outlined the geology of the Magpie Mine as then known. Dunham gave a review of the 'Mineralisation in Relation to Pre-Carboniferous Basement Rocks in Northern England' noting that the mineral fields were developed on basement highs. Greenhough (1967) described the history and development of the Riber Mine on the Great Rake at Matlock. Kirkham and Ford (1967) reviewed the geology and mines of Ecton Hill. Morris described the E_1-E_2 strata and structure of the Waterhouses-Cauldon area, North Staffordshire. The Chesterfield-Matlock Memoir (for Sheet 112) produced by Smith et al. for the Institute of Geological Sciences in this year, contained brief descriptions of the more obvious orebodies of the Matlock-Wirksworth and Ashover and Crich areas.

In 1969, Coffey described the geology of the Mixon-Warslow area. Roedder published the first fluid inclusion temperature studies from Derbyshire, showing the ore fluids to be much cooler than postulated by Mueller, around 100°C as opposed to 300°C. Ford published a note on the Blue John deposits in relation to the newly recognised boulder bed at Treak Cliff and also described the 'Stratiform Ores of Derbyshire' in the Inter-University Geological Congress Memoir.

In 1970, Dunham reviewed the creation of mineral deposits by deep formation waters, pointing out the application of this concept to the Pennine Orefields. Gower carried out studies of fracturing and mineralisation at Matlock, concluding that two directions of stress were responsible. White studied the mineralisation and structural setting at Ashover, showing two phases of mineral fills. In the same year, Ineson and Al Kufaishi deduced five phases of fluorite-barite mineralisation on the Long Rake at Raper Pit. Ineson also wrote on trace element dispersion haloes around the mineral veins in Derbyshire, concluding from the distribution of Zirconium that the source of the fluids was magmatic.

In 1971, Ford and Ineson wrote on 'Fluorspar Mining Potential of Derbyshire' reviewing the then known and postulated deposits and producing structural and stratigraphic compilation maps. Stevenson and Gaunt of the Institute of Geological Sciences produced the Chapel-en-le-Frith Sheet 99 Map and Memoir with descriptions of the principal mineral deposits. About one-third of the orefield is now covered by the New Series 1" Geological Maps and Memoirs. In 1972, Butcher and Ford described the stratigraphy and structure of the Monsal Dale area, giving evidence of syndepositional folding.

In 1973, Firman and Bagshawe gave a reappraisal of mineral zoning in Derbyshire at a Research Colloquium at Leicester University, pointing out many discrepancies in the simple east-west thermal theory. In the same year, Ineson and Mitchell's paper on potassium-argon age determinations of clay minerals from lavas and tuffs in the vein walls of Derbyshire, indicated that the mineralisation was multiphase over a period of one hundred million years from the Permian to the Jurassic. Dunham summarised the results of the deep Eyam borehole, which proved a very much expanded sequence of C_2S_1 beds and Tournaisian limestones (including evaporites) to a depth of 1703 metres, resting unconformably on Ordovician slates. Cope gave details of the 1949 Woodale Borehole later in the same year, noting that 4500 feet of beds at Eyam were equivalent to 1400 feet at Woodale. This suggested a condensed sequence at Woodale with considerably greater subsidence to the east.

Farrell and Wilmott carried out soil geochemical work in 1973, over the southern part of the orefield concluding that the observed background geochemical anomalies closely related to mineral distribution known to the present writer and that a few anomalous areas were untested by the old miners. The approach was extended to the north of the orefield by Woodbridge in 1974, with similar results. In the same year, Walid traced the distribution of copper anomalies around the Ecton area. Mason reviewed the geology of Derbyshire fluorspar deposits based on his experience in the Laporte Industries group's mines. In the same year, the first Institute of Geological Sciences dyeline Provisional Editions of the 6 inch:1 mile maps of the Buxton Sheet (No.111) became available. Brown (1974) noted the existence of the north-south Bakewell anticline and the rapid thinning of strata onto it. In the same year, Firman and Bagshawe re-appraised the controls of non-metallic gangue mineral distribution in Derbyshire, recognising an early and late phase of calcite mineralisation and noting many inconsistencies in the distribution of gangue minerals. They postulated that faults may act as hydrological barriers to mineralisation as well as channel ways and concluded that the mineralisation was consistent with generally laterally and up-dip moving fluids whose flow was controlled by aquicludes and the permeability of the host rocks.

In 1975, most of the rest of the 6 inch sheets of the Institute of Geological Sciences Buxton 1 inch:1 mile Sheet No. 111, became available. These fill a notable gap in the available coverage of the orefield. In the same year Weaver published a study of systematic joints in South Derbyshire, concluding thearea was subject to an east-west maximum principal compressive stress during the Hercynian Orogeny. The north-south and east-west joints of the Manifold-Dovedale area were produced in Variscan times as a result of movements in a Charnian basement. Late in 1975, Firman gave a paper on wrench faulting in Derbyshire. He based his analysis on the theoretical work of Chinnery (1966). Chinnery developed the theory of wrench faulting including the nature of patterns of secondary faulting at the termination of the primary faults. Firman showed that the Derbyshire patterns do not form a simple complementary pattern as described by Anderson (1951). Only short lengths are 'primary', the majority are Chinnery's 'type A' secondary faults. The faults have often propagated from west to east in an opposite direction to the supposed flow of the mineral fluids. Mineralisation was probably insignificant in the initial stages of fault formation, but later strike-slip movement and brecciation provided a little space for mineralising fluids; however, tensional stress was resonsible for most of the spaces for mineral infill.

fig 4

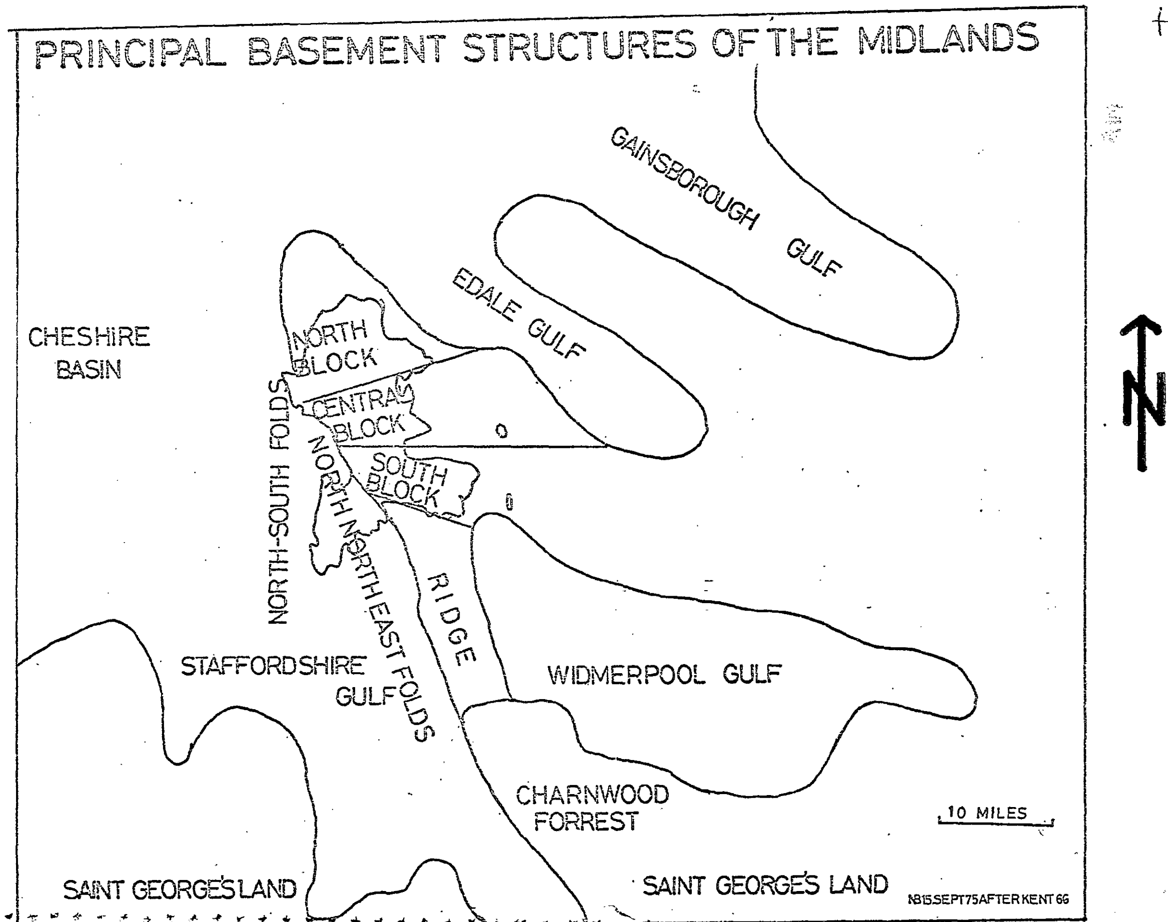

PRINCIPAL BASEMENT STRUCTURES OF THE MIDLANDS
CHESHIRE BASIN
GAINSBOROUGH GULF
EDALE GULF
NORTH BLOCK
CENTRAL BLOCK
SOUTH BLOCK
NORTH-SOUTH FOLDS
NORTH NORTH EAST FOLDS
RIDGE
STAFFORDSHIRE GULF
WIDMERPOOL GULF
CHARNWOOD FORREST
SAINT GEORGE'S LAND
SAINT GEORGE'S LAND
10 MILES
N
NB 15 SEPT 75 AFTER KENT 66

FIG.4.

PART 2

Stratigraphy

1. Geological and Structural History

At the end of Devonian times, the eroded Caledonian land mass broke up into fault blocks. Areas that had been intruded by granites and others that were relatively light remained as upstanding massifs, whilst the denser areas in between foundered. (Bott 1974 and Arab 1973). These downfaulted areas or gulfs received large amounts of fanglomerate deposits eroded from the massifs, as is known from boreholes towards the east end of the Widmerpool Gulf (Falcon and Kent, 1960). The general distribution of these massifs and basins is shown in Figure 4 for the area around the South Pennine Orefield.

Maroof (1973), has shown that the Derbyshire Massif is made up of three upstanding east-tilted blocks of basement, over which gravity and magnetic readings are high (see Figure 4). The northern two of these blocks have culminations in west Derbyshire along a north-south line. The central area is an east-dipping graben, corresponding to the central fold belt at outcrop (see Part 3). In the north of the massif a second east-dipping block is present, not so deeply buried, and this is overlain by sediments with little folding. In the south, the third block occurs. Here the basement is very shallow and has a gentle easterly dip. This corresponds to the little folded southern area of limestone west of Matlock and Wirksworth. The southern block continues into the folded basin area to the southwest of the massif, where gravity and magnetic readings are still high, indicating shallow basement. However, the nature of the outcropping rocks (basin facies) and the intensity of folding, suggests a thick sedimentary succession with basement at depth. One explanation could be that there is a layer of very incompetant material overlying a shallow basement, here, which would account for the intense folding. The southern block extends east and south-east towards Nottingham and is also connected by a narrow ridge of upstanding basement, southwards to Charnwood Forest. East of this ridge lies the Widmerpool Gulf and to the west the Staffordshire Gulf. North-east of the massif, lies the Edale and to the west the Cheshire Basin (Kent, 1966).

The Lower Carboniferous seas transgressed across this irregular surface During the time of the C and S zones, the massif was an area of shallow water with possible land along the western edge at first. The tilted block was, however subsiding. Dolomites with some evaporites at first, were deposited up to 4200 ft. thick at Eyam in the east (Durham, 1973) but less than 1300 ft. thick at Woodale near Buxton, in the west (Cope 1973). This condensed sequence in the west, indicates a tilting of the block implying considerable differential subsidence to the east. To the south of the massif, in the Widmerpool Gulf, fanglomerates* were deposited in the east, from St. George's Land, whilst to the west, evaporites were deposited around its margins (130600 to 160550) and Cauldon Low (080490), mixed reefs on the rising backs of north-south folds (Prentice 1951; Ludford 1951). At this time the massif continued north of the Alport borehole (136910) as a positive feature (Stevenson and Gaunt 1973).

About the end of C-S times, strong north-south folding occurred in the shaley basin limestones of the south-west and the Kniveton inlier (220500). In late S_2 or early D_1 times, uplift along the margins of the massif, initiated the apron reef of the north, west and southern edges (Stevenson and Gaunt 1973) and caused an unconformity at the base of the D_1 in the south-west of the massif.

Within the massif, the D_1 beds are a monotonous succession of poorly bedded to massive calcarenites, showing little sign of variation or indication of disturbances other than regular subsidence, although it is

* conglomerate fans

postulated that the Dirtlow Rake Fault at Castleton (160825) moved at this time (Stevenson and Gaunt 1973). Around Kniveton, the D_1 beds are seen to only be gently warped and unconformably overlie the highly folded C-S strata (Ford 1968). Towards the end of D_1 times, a major outpouring of lava occurred resulting in the formation of the Miller's Dale Lower Lava. This implies deep fractures intersecting the mantle. Frequent thin ash beds throughout the D_1 strata suggest that mild explosive volcanic activity was common in D_1 times. Also towards the end of D_1 the massif north of Castleton subsided and this area was henceforth overlain by shaley basinal sediments. This implies that the massif became restricted to the area of outcrop seen today.

In D_2 times, there is much more evidence of tectonic activity. The tilt block effect still applied, at least to the northern and central blocks, where the D_2 strata thin from 1200 ft. in the east on Longstone Edge (220736) to 300-400 ft. in the west, with unconformities developed around Buxton. In addition, the limestone facies change from massif (massive-thick bedded pale calcarenites) in the west to basinal(dark limestones with thin shale beds and chert) in the east.

At this time there is the first evidence of movement on the later (Upper Carboniferous) fold axes. Thinning of the strata onto anticlines of various trends occurs. At Lees Bottom (170706) at the foot of Taddington Dale, thinning is seen onto a north-east-southwest anticline (Butcher and Ford 1973). At Bakewell thinning is seen onto the north-south Bakewell anticline (Brown, 1974). In Cressbrook Dale (173744), the first movements of the Longstone Edge Anticline are seen as thinning of the D_2 strata south from Wardlow Mires (180757), (Butcher and Ford 1973). These three sets of folds created an early forerunner of the Ashford Basin in which laminated beds formed at several horizons in a temporary brackish lake cut off from the sea (Brown 1974). At Matlock thinning of the strata occurs onto the east-west Matlock Anticline between Matlock Bridge (294603) and Tearsall (264600).

In the later D_2 in Cawdor times, the major east-west folds were well differentiated. Reefs and unconformities occur on the crests of the anticlines, whilst basinal shales and dark limestones without unconformities occur in the syncline. Throughout D_2 times, there were numerous extrusions of basalt and tuffs, again suggesting fractures penetrating the mantle (see below for details).

In pre-Namurian times faulting occurred west of Dove Hole s (075762) (Stevenson and Gaunt 1973) and around Chrome Hill (075762) in Upper Dovedale (I.G.S. 1974). It is probable that some of the general fault and joint patterns of the massif were initiated at this time. At both these sites the faulted ground is transgressed unconformably by the Namurian shales. Associated with this, uplift occurred in the north,west and south of the massif, so that here the Namurian shales rest with marked unconformity on strata well down into the D_1. It is probable that the pre-Namurian erosion cut out much of the D_2 strata west of a line from Wirksworth to Newhaven (166602) and Hartington and on the crest of the Matlock Anticline. This is suggested by large quantities of residual chert gravels found between foundered shale masses and the walls of the Tertiary sandpits, suggesting an origin of pre-Namurian solution of the cherty D_2 limestones. Karst features probably formed at this time. It is thought that the limestone surface at the end of this erosion was only perhaps a short distance above the present summits (Ford 1975). In the central eastern area, from Bradwell (174810) south to Cromford (295568) deposition was probably more continuous from D_2 into E_1 times. This is certainly true in the synclinal areas although minor unconformities occurred over the anticline.

East-west folding can be traced into Namurian times as the thickness of Edale shales over the anticlines is much less than in the intervening synclines. The massif was gradually overwhelmed by the Millston Grit Delta and buried beneath thousands of feet of Upper Carboniferous sediment. The folds gradually tightened during the Upper Carboniferous and east-west faulting occurred, as is shown by the east-west alignment of dolerite intrusions of Namurian-Westphalian age (Stevenson and Gaunt 1973) in the north of the massif. The main Hercynian orogeny caused the final tightening of the folds in pre-Upper Permian times as rocks of this age in East Derbyshire are unaffected by folding.

In late Carboniferous and Lower Permian times, during and after the Hercynian orogeny, the cover of Upper Carboniferous rocks was eroded rapidly during epeirogenic uplift in rock desert conditions, so that by Upper Permian times sufficient of this cover had been removed to allow magnesium-rich brines to penetrate beneath the bed of the transgressive Zechstein Sea and to dolomitise the upper parts of the Carboniferous limestone (Dunham 1953). If the sub-Permian unconformity is projected westwards and depressed to the Manchester area it cannot have been far above the present limestone summits of the Southern Pennine hills. The dolomitisation does not necessarily mean that the limestone was exposed at this time, just that the shale cover was thin enough to allow the penetration of brines especially along joints and faults which were clearly already in existence. The massif would be a shallow shoal at this time.

In the relatively short time interval, between the Mid-Permian and the deposition of the Triassic sediments, there was further epeirogenic up-warping and the Magnesian Limestone, if deposited, was removed from the Peak District, so that today, Triassic Bunter Pebble Beds rest directly on the limestome near Ashbourne. It is probable that extensive karst development occurred in the limestones at this time, especially at the base of dolomitisation (Ford and King 1966)

Northward projection of the base of the Bunter suggests it was deposited at no great height above the present southern and south-western parts of the massif. How much shale remained between the Permian and later the Bunter rocks and the limestone, is not clear. All the available evidence suggests that in places such as on the crest of the Matlock Anticline, it was absent whilst over most of the rest of the southern part of the Peak District it reached a maximum of perhaps 200 feet. The presence of Carboniferous Limestone pebbles near the base of the Triassic at Leek, suggests that some parts of the massif were subject to strong sub-aerial erosion. Possibly the Ecton, Mixon and other nearby copper occurrences were formed by downward penetration of leaching solutions from the Bunter Sandstones, at this time. Some of the many small haematite bodies may have been created similarly. A consideration of the hydrology of the hydro-thermal mineralisation of the orefield indicates that to flow, the mineral fluids must have been able to escape upwards through the limited shale cover into the overlying sandstones.

During the Jurassic and Cretaceous the area was probably overlain by sediments. None show clear evidence of a nearby land mass, suggesting that the Pennine Chain was not then emergent. Mineralisation last occurred in the Carboniferous Limestone in Jurassic times (Ineson and Mitchell 1973).

In early Tertiary times the Mesozoic rocks were eroded off the area which was once again probably subject to karst erosion. By Miocene-Pliocene times sediments of the Brassington Formation derived from the Bunter were laid down across the area and these included some freshwater lake clays. In Pliocene-Pleistocene times a final phase of uplift occurred, giving rise to the erosion surfaces preserved today on the higher peaks and pre-dating the glacial erosion phases. At this time karst subsidence began preserving foundered masses of Namurian shales and Pliocene sands (Walsh et.al. 1972). This erosion has gradually stripped off the remaining shale cover of the orefield and cut deep gorges into the limestone. This final uplift is linked to the downwarping of the North Sea and Cheshire Basins. A hinge line lies east of the Peak District with consequent upwarping of this area as far as the margin of the down-faulted Cheshire Basin.

The effect of these Tertiary and later movements has been to oxidise and cavernise the orebodies producing secondary minerals and deposits of cerussite ($PbCO_3$), anglesite ($PbSO_4$), hemimorphite ($Zn_4Si_2O_7(OH)_2 \cdot H_2O$), smithsonite ($ZnCO_3$), pyromorphite ($Pb_5Cl(PO_4)_3$), geothite ($FeO(OH)$) and wad.* There has also been redistribution of the gangue and sulphide minerals in solution and mechanically as sands, gravels and pebbles in caverns. Pleistocene erosion has also given rise to residual deposits of fluorspar, barytes and galena on the surface.

2. Summary of Geological and Structural History

The Derbyshire Massif is a geologically uplifted area of limestones and dolomites overlying shallow basement. It is surrounded by gulf areas where sediments are thicker and more shaley and thebasement is deeper. The massif is composed of three east-west blocks of basement in a north-south line, inclined to the east. They are therefore tilt blocks and sedimentation in Lower Carboniferous times was dominated by this structure, being thinner in the west than in the east.

The main fold trends of the massif were active during the Lower Carboniferous times as strata are seen to thin onto the anticlinal fold crests and facies vary from anticline to syncline. The occurrence of a few demonstrably pre-Namurian faults and the evidence of alligned intrusions of Namurian to Westphalian date, suggests that at least some of the other faults are also of early date, whilst others probably relate to the tightening and relaxation of folds during and after the Hercynian orogeny. The presence of horizontal slickensided and brecciated Triassic to Jurassic mineral fills in the faults shows that these faults have continued to be active or to be re-activated by lateral stresses in subsequent events. These lateral stresses gave rise to the majority of the non-faulted mineral veins.

At the end of Lower Carboniferous times extensive uplift of the massif in the north, west and south, eroded much of the D_2 strata in these areas to a level not all that much higher than the present landscape. This means that

* hydrated oxides and hydroxides of iron and manganese

DIAGRAM TO SHOW CHANGES IN THICKNESS OF THE D2 SUCCESSION AND SOME CORRELATIONS OF SOME OF THE TOADSTONES IN THE SOUTH PENNINE OREFIELD

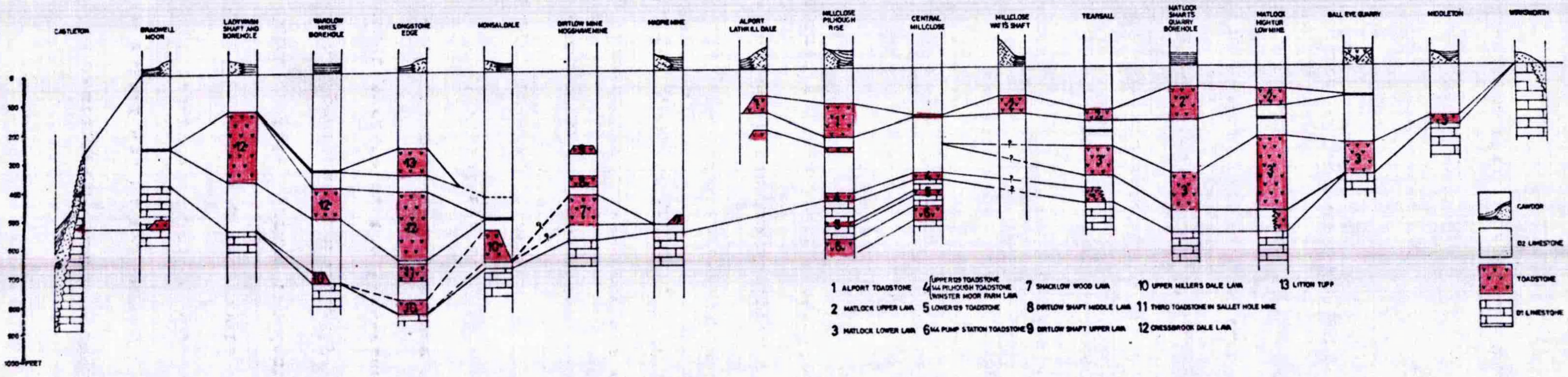


FIG.5.

the Namurian shales rested with marked unconformity on the limestones in these areas. The massif was buried during Upper Carboniferous times under a thick sequence of impermeable shales and sandstones but uplift and erosion in the early Permian left only a thin shale cover, over the southern part of the massif. Through this, during the Zechstein Sea transgression, magnesium-rich brines penetrated especially along faults and joints, to dolomitise the upper surface of the limestone. In early Triassic times, extensive karst cavities formed at the base of the porous dolomite and these, together with the fault/joint systems, were infilled by mineralisation during Triassic and Jurassic times.

During Jurassic to Cretaceous times, the area was covered by sediments but by the late Tertiary, the limestone was once again exposed. Extensive karsts formed in the south of the area with solution collapse preserving remnants of the early Tertiary cover. This was the beginning of the modern erosion cycle which has gradually stripped off the shale cover of the north and east of the orefield and led to the oxidation and cavernisation of the ore bodies.

3. Details of the D_1-D_2 Strata

(a) Introduction

During the course of detailed mapping of the orefield by the writer, the horizons of many of the toadstones (basaltic lava flows, sill and tuffs) have been located more accurately and their stratigraphic positions redefined. As these are aquicludes controlling the flow of mineral solutions, an accurate knowledge of their position and extent within the stratigraphic sequence is important. They act as a framework by which the limestone strata can be sub-divided. The results of this work are presented in the form of a columnar correlation chart (Figure 5).

(b) Details of the Succession

In the Matlock area, the Lower Lava occurs within the D_2 strata to the north of the Bonsall Fault. From Bonsall Moor (250595) westwards to Gratton Dale (210612) a sequence of some 70 feet of dark limestones, with some volcanics, is present between it and the underlying Hopton Wood Limestones, whose top is defined by the base of the Winster Moor Farm Lava.

The strata between the Matlock Upper and Lower Lavas, thin to the south-west onto the Masson Anticline, between the Smart's Quarry borehole at Matlock (293604) where the sequence is 185 feet thick and the Tearsall areas where it is 86 feet thick, as proved in boreholes (at 264601). The dark limestone facies 80 feet thick in the Smart's Quarry borehole, is only 10-20 feet thick at Tearsall again thinning onto the anticline.

In the vicinity of the Bonsall Fault, in the Pitchmastic Quarries at Ball-Eye (287573) an abnormally thick sequence of D_2 limestones with several lavas, is present, suggesting local movement along the fault. The detailed structure of this ground and hence the stratigraphy is uncertain, as is described in Part 6 of the Thesis.

West of Elton, the Matlock Lower Lava and the Gratton Dale Lava can be mapped 'into' each other and are hence equivalent. This is contrary to Shirley's (1959) interpretation. The thickness of overlying strata is considerably reduced, being 300 feet at Gratton Dale as opposed to 400 feet at Smart's Quarry borehole at Matlock.

Correlations of the Matlock Lower Lava, north into the workings of Millclose Mine (260624) are in agreement with Shirley (1948) and Traill (1939). At outcrop, the Lower Lava can be seen to lie on a sequence of 50 feet of dark limestones, with tuffs and ashes, around Bonsall Moor and westwards into Gratton Dale. These are probably equivalent to the lower 70 feet of the Second Main limestone of the mine judging by lithologies. The Lower Lava is equivalent to the Passby Wayboard in the Mine (Traill 1939). At outcrop, the Winster Moor Farm Lava lies at the base of these dark limestones, probably resting on Hopton Wood Limestones. This is a discontinuous lava flow, represented by tuffs in Gratton Dale and it is probably equivalent to the Upper 129 toadstone of the mine. It is known as a lava at depth on the Coast Rake at Portway Mine (232612). The lower lavas of Millclose are probably equivalent to tuff-beds seen to outcrop lower in the sequence on Elton Common (210600). The 103 Lava of the mine, judging by its position in the sequence, is probably equivalent to the persistent group of wayboards some 50-80 feet above the Matlock Lower Lava, traceable from Tearsall into the Matlock Gorge.

Traill's un-named highest toadstone in the Pilhough Rise (250650) in the Millclose Mine is the same as the Alport toadstone, as both can be shown to lie about 150-180 feet below the base of the Edale shales. This bed is known in the workings of Wheels Rake (227648) and the Broadmeadow Mines (225645) at Alport, and was recently discovered at Raper Pit (217653) and Conksbury Pit (208650) to the north. This is also the toadstone proved by drilling north of Stanton-in-the-Peak (235645) by Allied Chemicals, which also outcrops in Bradford Dale (202638), Lathkill Dale (205664) (the upper one), on Ditch Cliff south of Bakewell (210670) and is perhaps the lava present in the core of the Bakewell Anticline (210690). At all these localities the position relative to the base of the shales is correct. This lava is perhaps also present as the highest one in the Dirtlow shaft near Sheldon (Green, 1865) (192685) and as a clay bed found in the east end of the Mogshawe opencasts (193678) although these correlations are speculative. The Alport toadstone lies roughly at the same horizon as the Matlock Upper Lava. A lower toadstone occurs in the Wheels Rake Shaft at Alport and in Lathkill Dale. This is possibly the same as the 103 toadstone of Millclose Mine the top of which lies at the right horizon.

Two other toadstones are known in the Bakewell-Sheldon area. These are seen in the Mogshawe workings and the Dirtlow Shaft on old mine sections. The lower one is probably equivalent to Shacklow Wood Lava (I.G.S. 1975) of the Monsall Dale area (Upper Fin Cop Lava of Arnold Bemrose (1897) and Butcher and Ford (1973)). The upper one outcrops only as a thick wayboard which is also seen in shafts around the Sheldon-Taddington area and correlations are uncertain. The Shacklow Wood Lava could be equivalent to the Miller's Dale Upper Lava (Butcher and Ford 1973) although the Institute of Geological Sciences believe it to be higher in the succession.

The Litton Tuff dies out to the south into the Monsal Dale region at Wardlow Hay Cop (178740). To the south of here is is represented by a wayboard at the horizon of the base of the Hob House landslip (175714). The Litton tuff can be followed north to Tideslow (150780) at outcrop, and is known as wayboards in shafts in the Bradwell Moor area. It is probably present in the Mill Dam Mine (177779) on Hucklow Edge Rake and could be the highest toadstone in the workings in the Sallet Hole Mine on Longstone Edge (223743). The Cressbrook Dale Lava lying a little below it in the succession, is also probably present in Sallet Hole Mine and is known across Stoney Middleton Dale to the Hucklow Edge Rake. In Sallet Hole Mine, two other lower lavas or tuffs are known, the lowest of which could be the Miller's Dale Upper Lava. To the north, at outcrop, the Miller's Dale Upper and Lower Lavas can be followed to Dirtlow Rake (135811) and the Lower Lava is known to Cavedale. The Lower Lava underlies much of Bradwell Moor to the east, but the Upper Lava is absent.

The variations in thickness of the strata are summarised in Figure 5. From the point of view of the overall D_2 succession, several major variations in thickness occur. On the extreme south-east of the Matlock Anticline, the succession totals 500 feet, yet at the east end of the Matlock Bridge Anticline four miles to the north, the thickness approaches 700 feet, including lavas. This thins onto the Matlock Anticline to 500 feet at Tearsall and maintains this thickness to Gratton Dale and across the Stanton Syncline to the north end of Millclose Mine. To the north in Monsal Dale, the thickness reaches 700 feet and expands to the east on Longstone Edge to 1200 feet. In the north of the area, around Bradwell Moor, the D_2 strata are only 460 feet thick.

THE OCCURRENCE OF SECONDARY DOLOMITIZATION IN THE SOUTH PENNINE OREFIELD

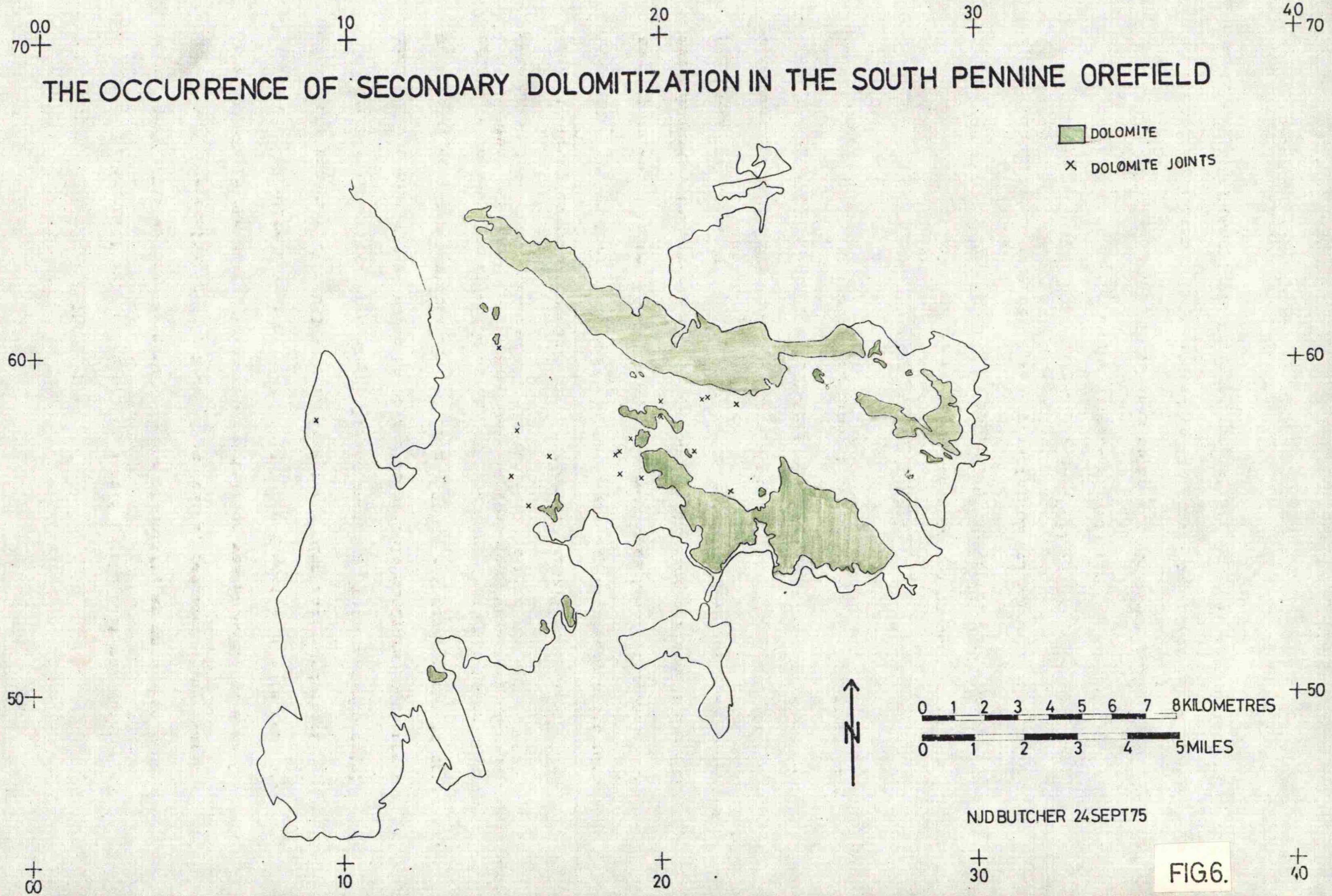


FIG.6.

(c) Summary of D_1-D_2 Stratigraphy

The differential subsidence of the massif to the east was maintained in D_2 times. The western axis was an area of uplift, at this time, as here the D_2 succession is only 2-300 feet thick, compared with a maximum of 1200 feet in the east. This eastward tilting was probably at a maximum in the central eastern area of the massif. The deposits of this area are of basinal aspect - thin-bedded dark limestones with shale and chert.

The northern (Castleton-Bradwell) and southern (Matlock-Wirksworth) areas of the massif, are shown to have a relatively condensed sequence of D_2 strata, compared with the central area. The early development of some of the folds has also affected strata thicknesses, locally causing thinning onto anticlines. It is concluded that there was a tendency for igneous rocks to erupt contemporaneously from different emanative centres. Thus the Matlock Upper Lava and the Alport Lava, are approximately contemporaneous as they may be with the Litton Tuff/Cressbrook Dale Lava. Similarly the Matlock Lower Lava appears to lie on roughly the same horizon as the Miller's Dale Upper Lava towards the base of the D_2 strata. These may also be on the same horizon as the Shacklow Wood Lava although this is not certain. Several toadstones in the Bakewell-Sheldon area, known from mine-shafts can be correlated with surface outcrops only with a degree of uncertainty.

4. The Extent of Dolomitisation in the Orefield

Two principal outcrops of dolomite occur as can be seen in Figure 6. One is to the north of the Bonsall Fault and the other to the south. The northern zone extends furthest west parallel to and down-dip of the line of the Bonsall Fault. From Parsley Hay (145639) in the north-west, to Gratton Dale, the dolomitisation affects strata from low in the D_1 to the top of the D_2 succession. It is seen to be largely superficial, however, as windows of limestone are exposed in the floors of deeper valleys such as Long Dale (190604). In Gratton Dale, at the southern end, adjacent to the Bonsall Fault (202596) the dolomitisation is seen to be over 300 feet thick. Yet at the northern end of the Dale the dolomite is only 25 feet thick and is restricted to the highest 25 feet of limestones immediately below the shales. In Gratton Dale, in limestones below the base of dolomitisation, the Wasp Pipe is seen to be surrounded by a halo of dolomite. To the east, the Portway Pipe, at Elton (230613) is said to lie at the base of the dolomite at the junction with the limestone. Further east, at Winster, the dumps of the Plackett Mine (239612) worked below the shales, show some dolomite as well as limestone and the Yatestoop Pipe (243615) is said to be in dolomitised ground below the shales. These occurrences suggest that magnesium-rich solutions could penetrate well down-dip under the shales and it seems possible that they did this especially along the joint systems which control the pipe development. It is reasonable to suppose that earlier Permian sub-aerial solutions could penetrate to similar depths, creating karst cavities along these controlling joint systems. These openings would provide channel-ways for the later dolomitising fluids and the combined effects of the cavities and dolomitisation, provided channel-ways and suitable ground for replacement by the later ascending mineralising fluids.

As the number and thickness of toadstones increases east of Gratton Dale, the dolomitisation becomes essentially restricted to the D_2 strata above the Matlock Lower Lava, although a few small areas of dolomite are known below the lava on the north end of Bonsall Moor. The dolomite gradually fingers out to the east around Tearsall (264601) and Northern Dale (268605). The general occurrence of the dolomite here, suggests that penetration has been both down-dip from the Bonsall Fault and along the strike between the lava flows. Further east, in the Matlock area, the dolomite is seen to have been separated from the main northern outcrop by erosion between Tearsall and Masson (285592). Here the dolomite is seen to finger out to the west, becoming restricted to the higher strata between the two lavas, immediately west of Masson Pit. A definite down-dip base to the dolomite is seen in the Masson Cavern and Devonshire Mines. Dolomitisation is then restricted to the D_2 strata above the Lower Lava and is generally most extensive between the Upper and Lower Lavas. Much of the dolomitisation is confined to the up-throw side of the Bonsall Fault, the area on the down-throw side having been protected by thick shales. Adjacent to the Fault, however, the down-throw side is dolomitised along an elongate strip stretching from Cromford to Bonsall. Adjacent to the fault at Blakelow Lane Pit (263589) strata below the Lower Lava are partially dolomitised. In the Ball Eye-Harp Edge section of the fault, on the up-throw side, dolomitisation affects strata above the Upper Lava, in a very faulted section of ground. Here it is noticeable that whilst dolomitisation completely replaces the lighter beds and reefs, darker thin-bedded cherty limestones are only ~~patchily~~ partially replaced.

It seems likely that the Matlock Anticline crest penetrated the shale cover at the time of dolomitisation so that magnesium rich solutions could penetrate along the anticlinal crest as well as along the Bonsall Fault.

The area south of the Bonsall Fault, which is dolomitised, is somewhat skeletal in form, since erosion has almost cut through it completely, especially in the western outcrops. The occurrence of dolomitised joints in the limestones between areas of dolomite, give some indication of its former greater areal extent. Dolomitised joints are marked as crosses on Figure 6. The cutting by erosion of the dolomite underlines its superficial nature. Shafts sunk in areas of dolomite usually intersect limestone below, but the base of dolomitisation may vary by hundreds of feet over distances of half a mile or so. For instance, at Golconda Mine (249552) (Ford and King 1966)., the dolomiteis over 300 feet thick, whereas half a mile to the west, at Manystones Quarry (236552), only 25 feet of dolomite is present. Changes in depth of dolomitisation probably occur in this area along north-northwest joints along which deeper penetration of dolomite can be seen. The reef-belt along the southern edge of the limestone, appears to have been resistant to dolomitisation. Probably this was due to it both being still shale-capped and of fine grain size. To the east, dolomitisation is cut off along a northwest-southeast front northwest of Godfrey Hole. East of this, the base of dolomitisation must have risen considerably or eastern penetration ceased, as higher hills to the east, such as Middleton Moor, have not been affected. These appear to have been cut off from magnesium solutions by a northwest fault, mapped by the Institute of Geological Sciences northwest of Broxendale Farm (273545). This must have acted as a hydrological barrier (c.f. Bagshawe and Firman 1974) preventing magnesium-rich solutions penetrating to the east into the Middleton Moor horst.

The extent of dolomitisation gives us some idea of the areas of the massif which were in close hydrological contact with the floor of the Permian Limestone Sea (Dunham 1952). This lends support to the concept, based on the projection of the base of the Magnesian Limestone westwards from its outcrop in Nottinghamshire and East Derbyshire, that the base of the Magnesian Limestone was not far above the present crests of the Southern Pennine Hills. The unconformity probably lay on a discontinuous cover of shales on the Carboniferous Limestone. Further evidence of the apparent ease of the downward penetration of solutions is provided by the occurrence of many small haematite bodies (see section on haematite deposits).

All the known relationships of dolomite to mineralisation show that the mineralisation post-dates the dolomitisation. Ixer (1974) has suggested that it is an early phase of the hydrothermal mineralisation. Dolomitised limestone has a much greater porosity than ordinary limestone which is permeable only along fractures. Therefore solutions may pass bodily through dolomite but on reaching the limestone are dammed back and a series of caverns tends to form along the interface. Bagshawe and Firman (1974) have suggested that whereas in the limestones mineral solutions were ascending and restricted to faults and joints and other cavities, on intersecting dolomite solutions were able to spread out, permeating the rock bodily and mixing with pre-existing pore waters. This caused cooling and precipitation so that in the dolomites, solutions could be descending in places. This could account for the episyngenetic cavern-lining deposits described by Ford and King (1966) at the base of dolomitisation in the Golconda Mine and Manystones Quarry.

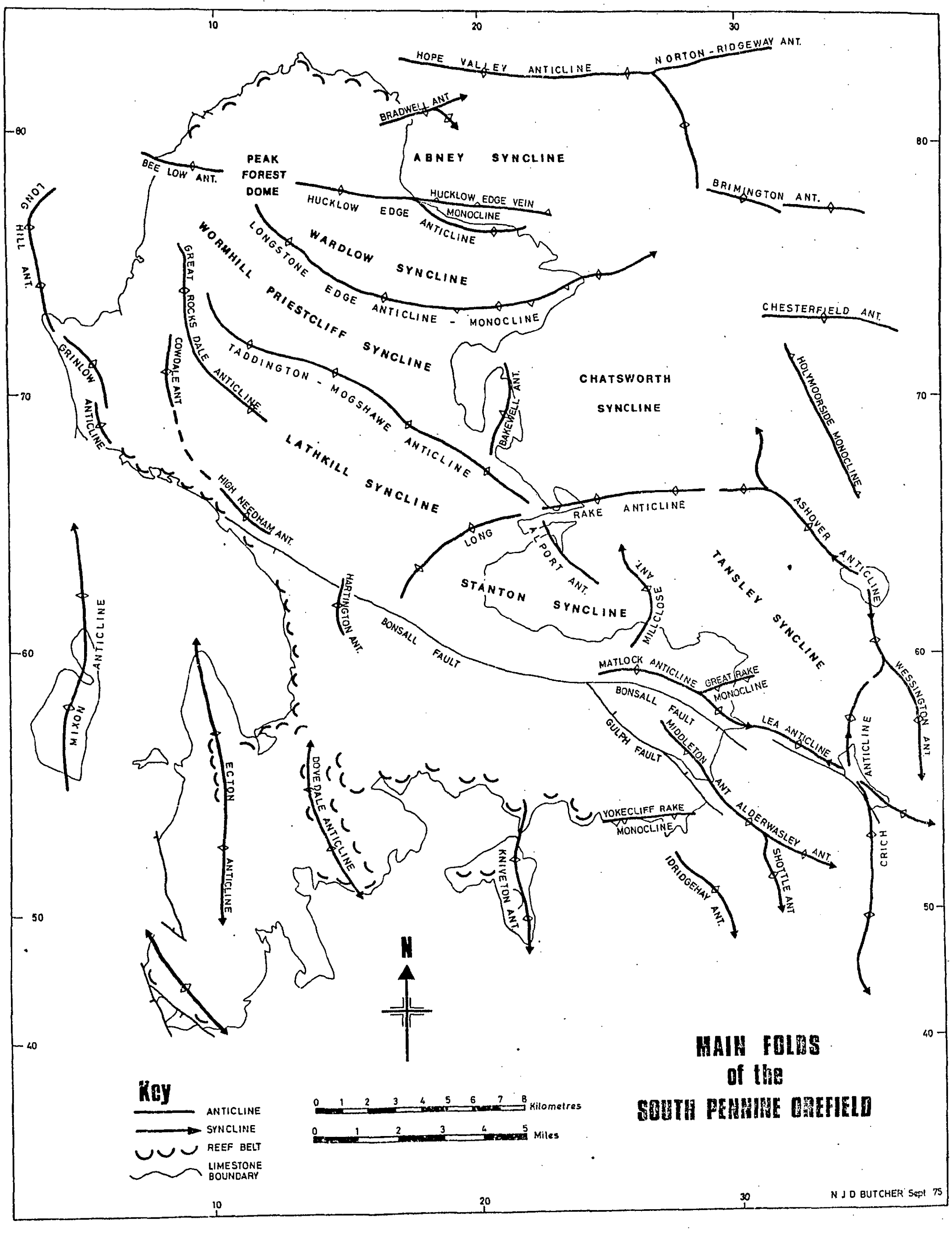

MAIN FOLDS
of the
SOUTH PENNINE OREFIELD
HOPE VALLEY ANTICLINE
NORTON - RIDGEWAY ANT.
BRADWELL ANT.
ABNEY SYNCLINE
BEE LOW ANT.
PEAK
FOREST
DOME
HUCKLOW EDGE VEIN
MONOCLINE
HUCKLOW EDGE ANTICLINE
BRIMINGTON ANT.
LONG HILL ANT.
WARDLOW SYNCLINE
LONGSTONE EDGE ANTICLINE - MONOCLINE
WORMHILL PRIESTCLIFF SYNCLINE
GREAT ROCKS DALE ANTICLINE
COWDALE ANT.
TADDINGTON - MOGSHAWE ANTICLINE
GRINLOW ANTICLINE
BAKEWELL ANT.
CHATSWORTH SYNCLINE
CHESTERFIELD ANT.
HOLYMOORSIDE MONOCLINE
LATHKILL SYNCLINE
HIGH NEEDHAM ANT.
LONG RAKE ANTICLINE
ALPORT ANT.
STANTON SYNCLINE
MILLCLOSE ANT.
TANSLEY SYNCLINE
ASHOVER ANTICLINE
HARTINGTON ANT.
BONSALL FAULT
MIXON ANTICLINE
MATLOCK ANTICLINE
GREAT RAKE
MONOCLINE
WESSINGTON ANT.
BONSALL FAULT
GULPH FAULT
MIDDLETON ANT.
LEA ANTICLINE
CRICH ANTICLINE
ECTON ANTICLINE
DOVE DALE ANTICLINE
YOKECLIFF RAKE
MONOCLINE
ALDERWASLEY ANT.
SHOTTLE ANT.
KNIVETON ANT.
IDRIDGEHAY ANT.
N
Key
ANTICLINE
SYNCLINE
REEF BELT
LIMESTONE BOUNDARY
0 1 2 3 4 5 6 7 8 Kilometres
0 1 2 3 4 5 Miles
N J D BUTCHER Sept 75
10
20
30
40
50
60
70
80

FIG. 7.

PART 3

Details of the Structure of the Orefield

1. Introduction

The South Pennine Orefield is broadly coincident with an area of uplifted Lower Carboniferous Limestones known as the Derbyshire Massif. The margin of this is a steep, monoclinal reef zone in the north, much of the west and most of the south of the area, whilst to the east it dips more gently below the younger strata.

It is flanked to the north, east and west by a horseshoe of upstanding sandstone cuestas separated by shales of the Millstone Grit Series whilst to the south the limestones dip below Namurian Shales and the Triassic strata of the Vale of Trent.

The limestone area has often been called the 'Derbyshire Dome'. Whilst this term is true in the broadest sense, it is the aim of the following account to show that the structure is far more complex and the term 'dome' is a misleading over-simplification (see Figure 7).

2. Outline Structure of the Area

This is dealt with under three separate headings: (a) Fold Pattern; (b) Faults, Fractures and Mineral Veins; (c) Structural Conclusions. The patterns of folds and faults are examined both within the orefield and in relation to the surrounding areas.

(a) The Fold Pattern

(i) General Description

The structure of the Derbyshire Massif is the result of the complex interaction of three fold patterns. To the south-west of the area, northeast-southwest and north-south fold trends of the Staffordshire, Warwickshire and Shropshire coalfields, converge and merge northwards into a group of essentially north-south folds (Fearnsides 1933). These affect the west side of the massif around Buxton and parallel the west margin. They are reflected in reef-facies limestones along elongate culminations in the Dove and Manifold Valleys, and in massif facies limestones at Cauldon Low, causing an extension of the limestone outcrop south-west of the massif proper. Synclinal areas between the culminations contain basin-facies limestones often highly contorted as at Ecton.

South of the area, the north-northeast fold trends of Charnwood Forest and the South Derbyshire and Leicester Coalfields (Fearnsides 1933) pass under the Vale of Trent affecting the southern margin of the massif.

East of the area lies the Yorkshire, Derbyshire and Nottinghamshire Coalfield with its north-south, east-west and northwest-southeast fold trends giving rise to an interference pattern of domes and basins, sinuous elongate anticlinal ridges and saddles. This pattern is reflected in the east and centre of the massif,north of the Bonsall Fault where a series of east-west, north-south and north-west folds interfere, giving rise on a smaller scale to a similar series of basins, elongate domes, saddles and ridges. This pattern is typical of the coalfields to the east (Fearnsides 1933; Kent 1968) but contrary to Fearnsides assertation it is not possible to demonstrate direct continuity of the east-west and northwest-southeast folds of the Coalfield and the massif.

The net effect of the interaction of these trends in the massif gives rise to a series of fold culminations along the west side from Peak Forest (115793) in the north via Buxton to Hartington in the south. The primary structure of the northern two-thirds of the block, therefore is an approximately north-south asymmetric anticline with a gentle easterly dip and a steeper westerly one.

In the area north and west of Buxton the axis is formed by a wide zone of broad north-south folds, but to the south, towards Hartington, it is better defined and runs along the western part of the limestone outcrop.

In the south-west however, an extension westwards of the limestone outcrop, in mixed reef and basin facies, is caused by the culminations of a series of strong, north-south folds and here the simple asymmetric structure of the massif is lost.

East of a line from Hartington to Alsop-en-Dale and south of the Bonsall Fault, the beds, although faulted in places, dip gently east to north-northeastwards, with occasional minor, discontinuous, rolling folds of various trends. West of this line lies the belt of north-south folds and faults. The axis is not a fold in its own right, but a line joining together a series of culminations on different folds.

From this axis, groups of anticlinal folds, with intervening synclines, break away to the east or south-east. From north to south these are the Hope Valley Anticline, the Bradwell Anticline, the Abney Syncline, the Hucklow Edge/Longstone Edge Anticline, the Chatsworth Syncline, the Taddington/Alport Anticline, the Lathkill Syncline, the Long Rake Anticline, the Stanton Syncline and the Matlock Anticline. These are compound, complex features, which make up the secondary structure of the massif, causing the sinuous outcrop of the Carboniferous Limestone-Millstone Grit boundary on its east side (see Figure 7).

Superimposed on these secondary structures, are a series of generally relatively small north-south folds. Locally, however, in the Bakewell and Ashover-Crich Anticlines these are large, severe structures. These folds cross the secondary structures giving rise to elongate domes and saddles along the secondary anticline crests and to elongate basins and ridges in the secondary synclines. A classic interference pattern is thus developed.

The southern margin of this area and the massif is crenulated by north-south folds superimposed on the essentially east-west reef monocline, the largest of which gives rise to the Bradbourne-Kniveton inlier. These north-south folds generally increase in amplitude to the south into the Widmerpool Gulf.

A GEOLOGICAL STRUCTURE MAP OF THE SOUTH PENNINE OREFIELD DERBYSHIRE

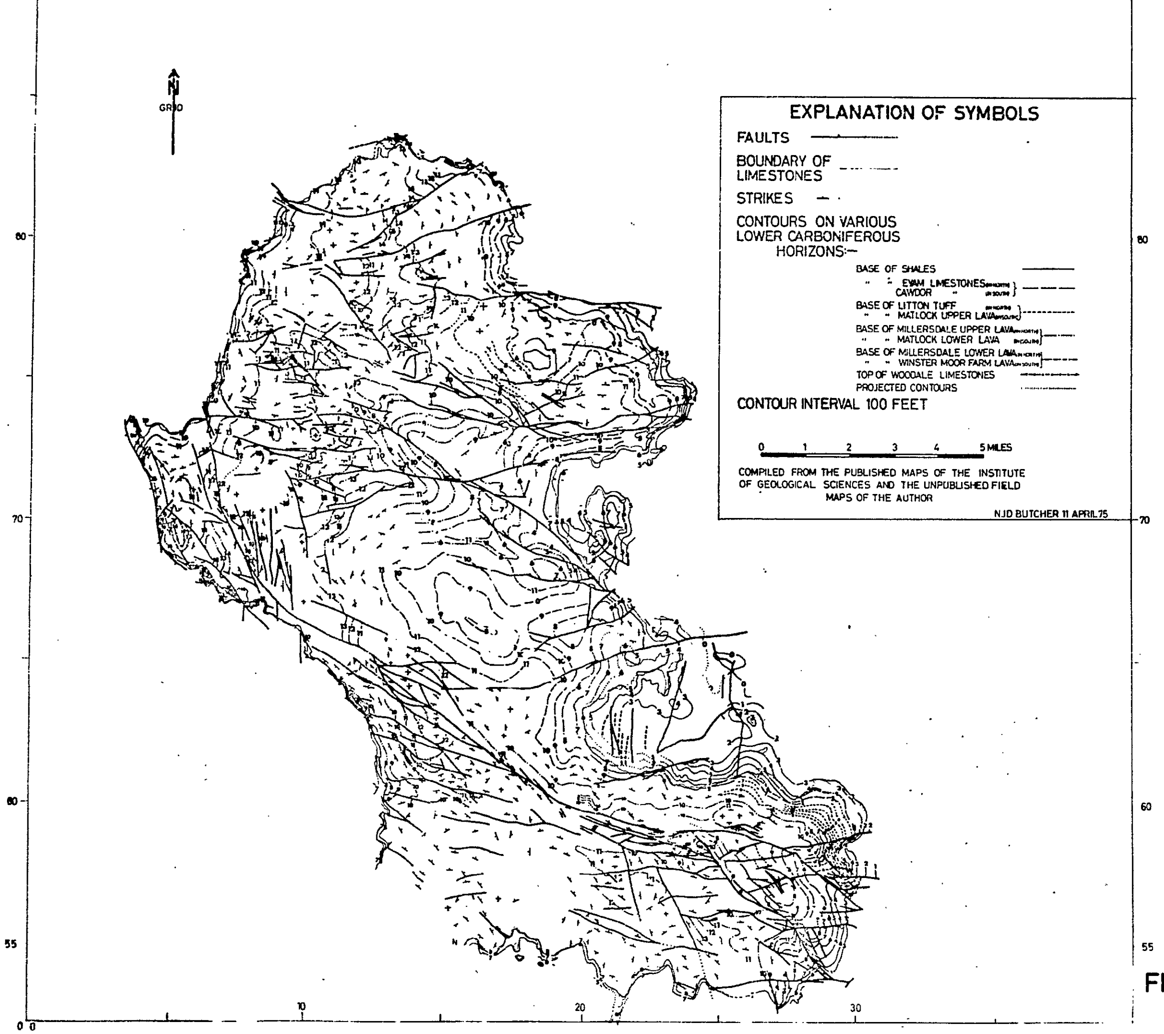


FIG8A

+38B

STRIKE LINES ON VARIOUS MILLSTONE GRIT HORIZONS

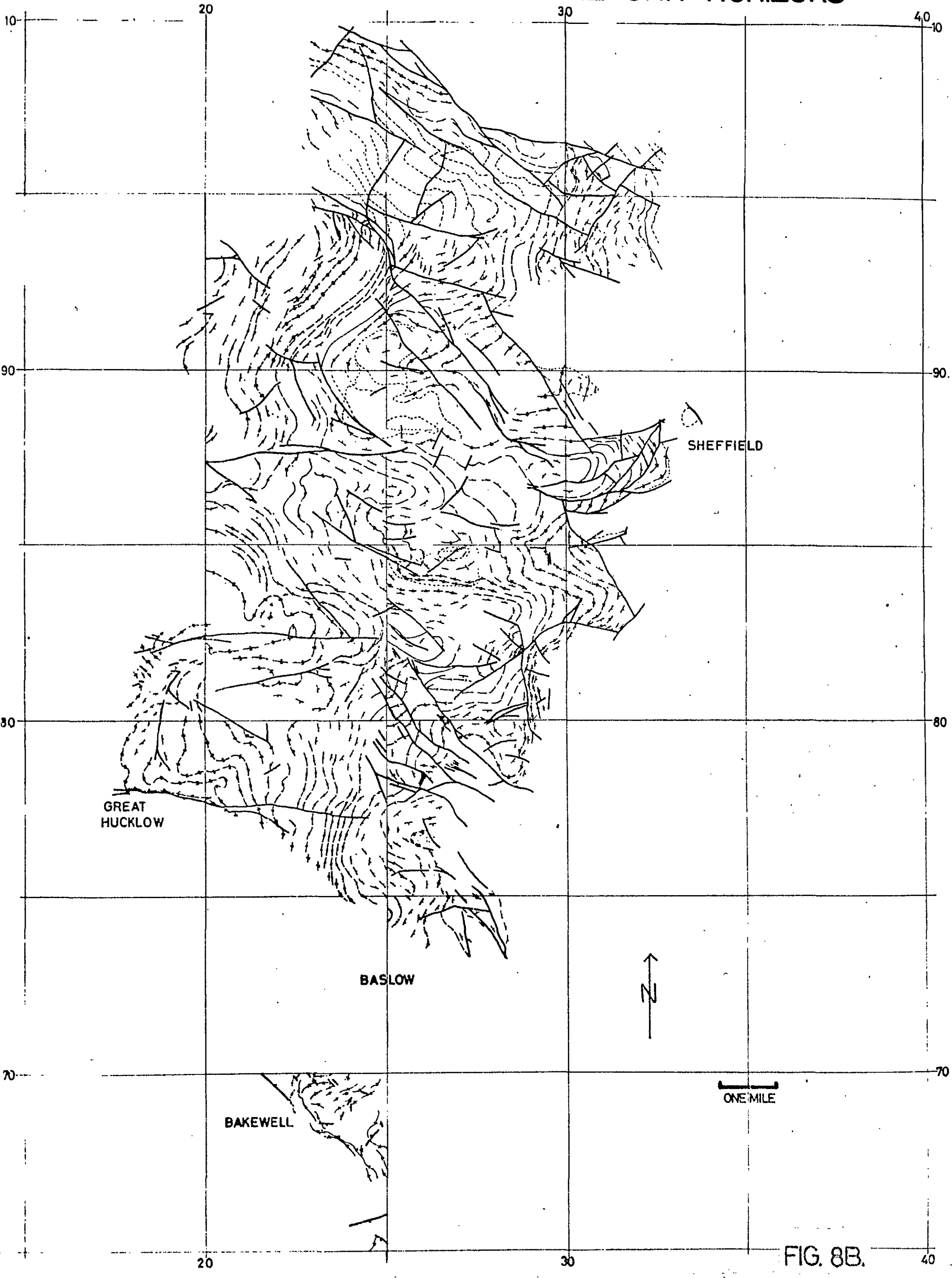
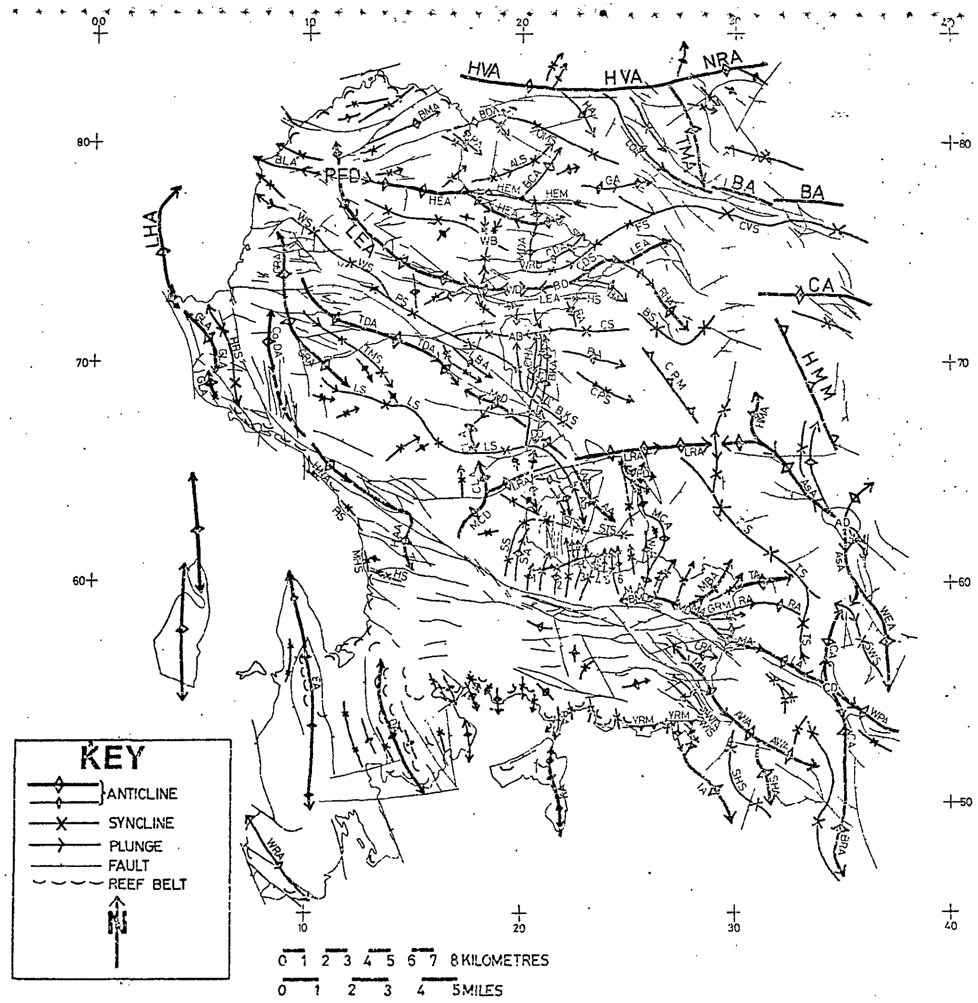
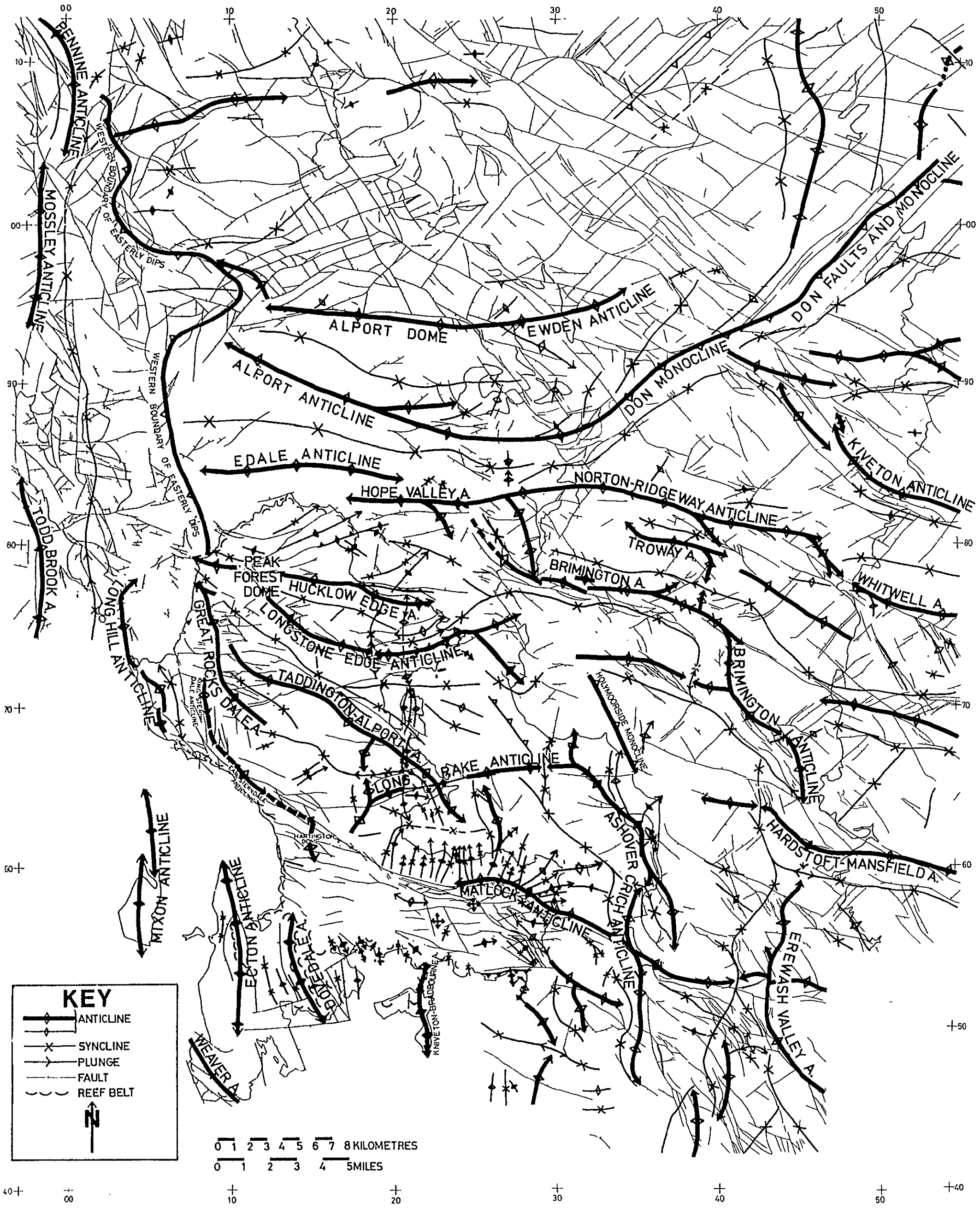


FIG. 8B.



A STRUCTURAL OUTLINE MAP OF THE SOUTH PENNINE OREFIELD

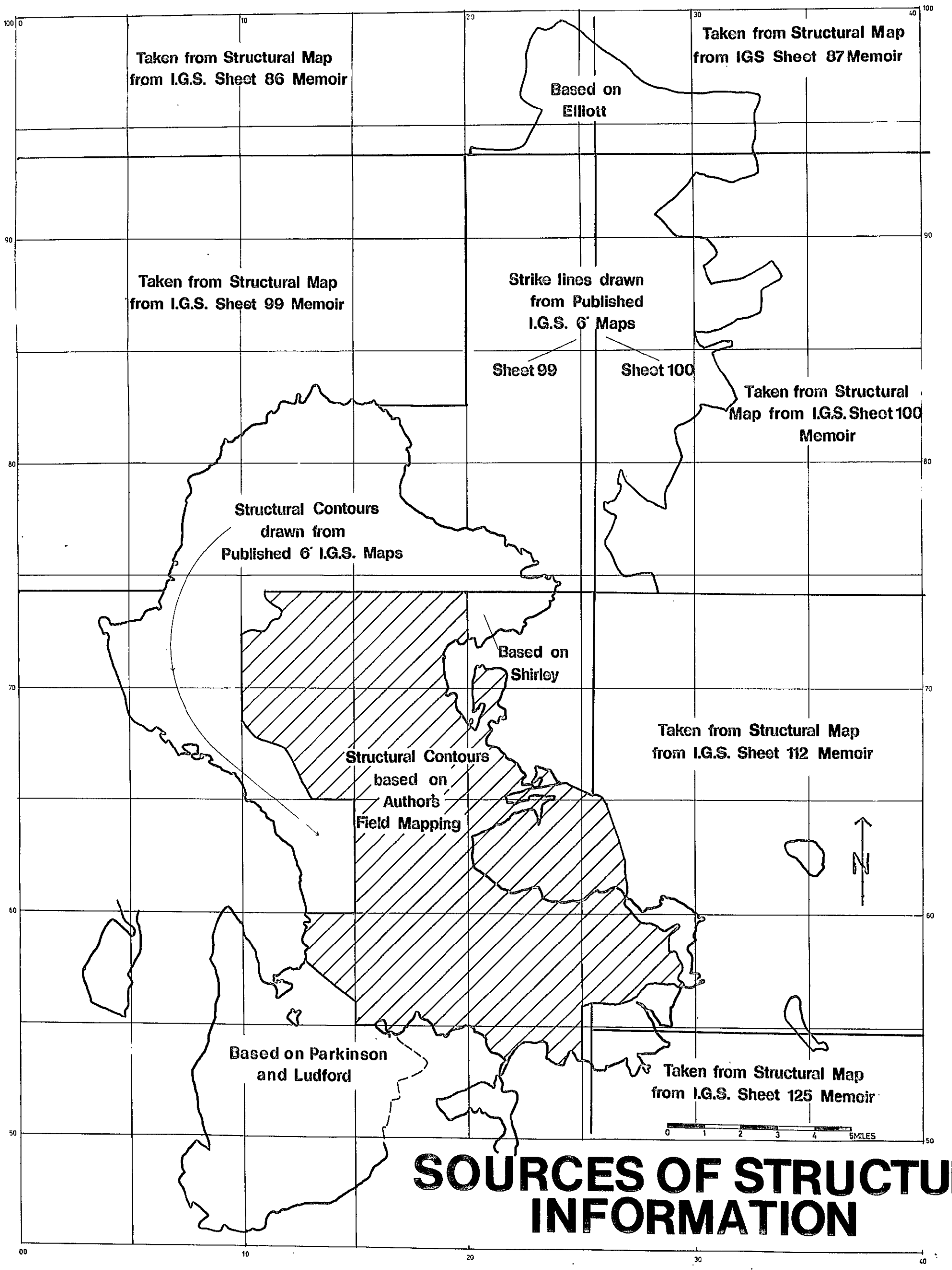
FIG 9A



STRUCTURAL MAP OF THE OREFIELD AND ADJACENT AREAS

N J D BUTCHER AUG. 75

FIG. 9B



SOURCES OF STRUCTURAL INFORMATION

FIG 10

The three trends of fold give rise to the complex sinuous and crossing fold pattern; shown in Figures 8A and B as contours and analysed in Figure 9A by means of axial traces. Regional correlations of the folds with the coalfield to the east are shown on Figure 9B. Sources of structural information are shown in Figure 10.

Although the major folds of the Derbyshire Massif mentioned above have long been named, the occurrence on, or within, them of minor and in some cases quite strong previously unobserved folds, necessitates a careful review of the fold nomenclature. This has resulted in the retention of some of the previous names for the major structures and the creation of many others with a more specific meaning. The author has attempted to do this rationally so as to reduce confusion to a minimum.

Method of Construction of the Structure Contour Map (Figure 8A) and Strike Line Map (Figure 8B)

The author carried out basic 6 inch:1 mile revision mapping of those parts of the orefield previously only mapped on the 1 inch:1 mile scale by the Geological Survey from 1854 onwards (Green, 1869) and by Shirley (1943 and 1959). The objective of this work was to map in those parts of the orefield not covered by the Institute of Geological Sciences New Series 6 inch:1 mile mapping of the Chapel-en-le-Frith and Chesterfield Sheets (Sheets 99 and 112). Some parts of their mapping of the Matlock area of the Carboniferous Limestone on the Chesterfield sheet were also revised on the 6 inch and 25 inch:1 mile scales. The distribution of the author's mapping is shown on Figure 3.

Structural contours were then drawn at 50 and 100 foot intervals on all persistant traceable horizons in the limestone (fossil marker beds, toadstones, etc.). These were produced on 6 inch:1 mile tracing overlays for each of the author's field maps. The same was done for the available 6 inch:1 mile maps of the orefield, published by the Institute of Geological

Sciences. The resultant 6 inch:1 mile structural overlays were photo-reduced to 1 inch:1 mile and retraced as a montage. The resultant contour map was considered too complex and confusing so that the number of contoured horizons was reduced and some linking interpolation carried out using dip-arrows. The horizons contoured are those shown on the key to Figure 8A which is the net result of process outlined above. The author has resisted the temptation to carry out long-distance projections of contours based on assumed thicknesses above or below other known horizons. This is because the objective of the work has been to prove the actual outcrop structures and relate these to known orebodies. Further, the study has emphasised the relatively large and sometimes rapid variations in thickness of strata in the limestone sequence. Hence the results are presented in the form of contours and multiple horizons rather than on one or two calculated surfaces.

In order to link the structures of the orefield to the structures of the coalfield to the east, strike lines were constructed on the base of various gritstone beds in the Millstone Grit for parts of the Chapel-en-le-Frith and Sheffield Sheets (99 and 100), (Figure 8B). These were analysed together with the contour map of the orefield, in terms of fold axes and this resulted in Figures 9A and 9B. The various sources of structural information are given in Figure 10.

1 inch to 1 mile verisons of Figures 8A, 8B, 9A, may be found in the wallet at the end of the thesis.

Explanation of Symbols on Figure 9A

AA	Alport Anticline	AB	Ashford Basin
AD	Ashover Dome	ASA	Ashover Anticline
ALS	Abney Low Syncline	AWA	Alderwasley Anticline
BA	Bleaklow Anticline	BA	Brimington Anticline
BCA	Bretton Clough Anticline	BD	Bentney Cop Dome
BDA	Bradwell Anticline	BKA	Bakewell Anticline
BKS	Bakewell Syncline	BLA	Bee Low Anticline
BMA	Bradwell Moor Anticline	BMD	Bonsall Moor Dome
BRA	Belper Anticline	BS	Baslow Syncline
CA	Chesterfield Anticline	CA	Crich Anticline
CD	Crich Dome	CDA	Coombs Dale Anticline
CDS	Coombs Dale Anticline	CDS	Coombs Dale Syncline
CHA	Church Dale Anticline	CoDa	Cowdale Anticline
CLA	Calling Low Anticline	CPM	Chatsworth Park Monocline
CPS	Calton Pastures Syncline	CVS	Cordwell Valley Syncline
DA	Dovedale Anticline	EA	Ecton Anticline
FS	Frogatt Syncline	GLA	Grin Low Anticline
HA	Hathersage Anticline	HAD	Hartington Dome
HEA	Hucklow Edge Anticline	HEM	Hucklow Edge Monocline
HHS	Harpur Hill Syncline	HMA	Harewood Moor Anticline
HMM	Holymoorside Monocline	HS	Hartington Syncline
HVA	Hope Valley Anticline		
IA	Idridgehay Anticline	KA	Kniveton Anticline
LA	Lea Anticline	LBA	Lees Bottom Anticline
LEA	Longstone Edge Anticline	LHA	Long Hill Anticline
LRA	Long Rake Anticline	LS	Lathkill Syncline

(Explanation of Symbols on Figure 9A - continued)

MA	Matlock Anticline	MB	Monyash Basin
MCD	Middleton Common Dome	MD	Masson Dome
MBA	Matlock Bridge Anticline	MHS	Moat Hall Syncline
MIA	Middleton Anticline	MOD	Mogshawe Dome
NRA	Norton-Ridgeway Anticline	OHB	Over Haddon Basin
OMS	Offerton Moor Syncline		
PD	Peak Hill Dome	PFD	Peak Forest Dome
PS	Priestcliff Syncline	PIS	Pilsbury Syncline
PPA	Pigtor Pipe Anticline		
RHA	Robin Hood Anticline		
SA	Smerrill Anticline	SHA	Shottle Anticline
SHS	Shottle Syncline	SS	Smerill Syncline
STS	Stanton Syncline	SWS	South Wingfield Syncline
TA	Tideslow Anticline	TDA	Taddington Anticline
TMA	Totley Moss Anticline	TMS	Totley Moor Syncline
TS	Tansley Syncline		
WA	Warrencarr Anticline	WB	Wardlow Basin
WD	Watersaw Dome	WEA	Wessington Anticline
WIA	Wirksworth Anticline	WIS	Wirksworth Syncline
WPA	Wingfield Park Anticline	WRD	White Rake Dome
WS	Wormhill Syncline		
YRM	Yokecliffe Rake Monocline		
1.	Un-named Anticline	2.	Cowclose Pipe Anticline
3.	Portway Pipe Anticline	4.	Plackett Anticline
5.	Drakes Pipe Anticline	6.	Yatestop Pipe Anticline

(b) Detailed Description of the Major Folds

The Hope Valley Anticline

This apparently does not affect the outcrop of the limestone. The fold develops about 1 mile east of Pindale (175825) and increases eastwards towards Hathersage (235815), for three miles, where it has a maximum amplitude of about 250 feet, and a width of 1½ miles. At Hathersage a branch to the southeast is the plunging Hathersage Anticline, which dies out after 1½ miles. The covergence is the Hathersage Dome, a site favoured for mineralisation at depth in the limestone (Schnellmann and Wilson 1947). The Hope Valley Anticline continues east of here as a western extension of the Norton-Ridgeway-Whitwell Anticline which may be traced to the east for many miles across the coalfield (Fearnsides 1933). A mile east of Hathersage, this fold throws off a low amplitude spur to the south-east and three miles further east, the strong asymmetric north-south Totley Moss Anticline splits off to the south. The two branches noted above coalesce and become the east-trending Brimington Anticline which also may be traced across the coalfield (Fearnsides 1933). The junction of the Totley Moss and Norton-Ridgeway Anticlines may well be an area favoured for mineralisation in the limestones at depth. The Norton-Ridgeway Anticline is coincident with a major fault zone (Fearnsides, 1933) which could have been one of the major feeders of mineral solutions to the orefield to the west.

The Bradwell Anticline

This is a somewhat diffuse structure at outcrop. It develops along the line of the Moss Rake Fault and becomes more distinct to the northeast under the shales. Here it has an amplitude of 100 feet and is half-a-mile wide. After a mile, it splits throwing off a branch to the southeast about 1 mile long. Both splits die out into the Abney Syncline. Associated with the structure but lying to the south, is the southeast-trending Pic Tor Anticline with an amplitude of 100 feet and a width of about a third of a mile. The amplitude is accentuated by reefs and the structure only persists for 1 mile, plunging into the Abney Syncline and apparently dying out.

One mile north of these lies the minor Bradwell Moor Anticline. This has an amplitude of 50-100 feet and can be followed for three miles, dying out to the northeast before the shale boundary.

The Hope Valley Anticline lies to the north of these features and is not obviously related to them, contrary to Fearnsides (1933) map.

The Abney Syncline

The northern boundary of this is the Bradwell and Hope Valley Anticline, whilst the southern boundary is the Hucklow Edge Monocline. The syncline has a complex structure due to the incursion of numerous anticlinal spurs which die out into or lie within the syncline. (See the section on the Bradwell and Hope Valley Anticlines for spurs from the north and west). To the south, the principal intruding spur is the north-northeast trending, two mile long Bretton Clough Anticline. This has an amplitude of 150 feet and a width of two-thirds of a mile. West of this, lies the north-northeast trending Abney Low Syncline, which runs into the east-west Offerton Moor Syncline to the north. East of the Bretton Clough Anticline, the syncline is disturbed by a short minor east-west anticline and the longer east-west Grindleford Anticline which has an amplitude of 50-100 feet and a width of half-a-mile. This runs into the Brimington Anticline to the east.

The Hucklow Edge Anticline

The Hucklow Edge Anticline begins on the east side of the Peak Forest Dome (107798) and may be continuous with the Beelow Anticline to the west. From the Dome the anticline runs east-southeast for 5 miles to Great Hucklow (178778). In this section, the fold has an amplitude of 2-300 feet and a width of 1½ miles. East of Windmill it becomes markedly asymmetric with a steep face to the north, down into the end of the Abney

Low Syncline. East of Great Hucklow the fold may split, the northern branch continuing the asymmetry in the form of a monocline facing north along the line of the Hucklow Edge Vein Fault. This monocline marks the southern edge of the Abney Syncline. The southern branch runs east-southeast with a maximum amplitude of 100 feet and width of 1 mile. The monocline emphasises the northern limb of this fold. The fold may be followed through a saddle at Foolow (195765) and east for three miles to a half dome, open to the south, with an amplitude of 150 feet, west of Eyam. Here a north-south fold, the Middleton Dale Anticline, with an amplitude of 150 feet and a width of half-a-mile crosses, creating the half dome by interference. East of this, the Hucklow Edge Anticline plunges to the east and dies out (Shirley 1945). Associated with the Middleton Dale Anticline is the tight parallel north-south anticline outcropping near Watergrove Mine (192758) and a similar trending minor fold in the Delph at Eyam (216760) (Beck pers.comm.). The Middleton Dale Anticline may continue north to join with the Bretton Clough Anticline. This anti-cline plunges to the north-northeast for two miles from the Hucklow Edge Anticline near Bretton (203780). It has a maximum amplitude of 150 feet. The fold dies out into the Offerton Moor syncline. The Hucklow Edge Anticline may have been active during D_2 times, as D_2 strata thin rapidly north from 1200 feet on the east end of Longstone Edge to only 550 feet at the Ladywash Mine on Hucklow Edge (219775).

The Wardlow Syncline

South of the Hucklow Edge Anticline in the west, lies the Wardlow Syncline. This is traceable for five miles eastwards from the Peak Forest Dome, where it has an amplitude of 200 feet and a width of 1½ miles into the Wardlow Basin (180757). Here it is crossed by, and terminates in, a north-south syncline. This is traceable from the Longstone Edge Anticline in the south, in which it forms a saddle, to the Hucklow Edge Anticline, in the north, where it also forms a saddle, near Foolow. The interference of synclines creates the Wardlow Basin, which is 300 feet deep and preserves the outlier of Edale Shales at Wardlow Mires. To the east, the Wardlow Syncline is terminated by the north-south Middleton Dale Anticline, and strata above the Cressbrook Dale Lava thin to the east onto the Middleton Dale Anticline, between the Wardlow Mires and Hanging Flat boreholes, suggesting that the anticline was active in D_2 times.

The Coombs Dale Anticline and Syncline

The east-west Coombs Dale Anticline branches east off the north-south Middleton Dale Anticline (196736). It plunges east with an amplitude of 100 feet and plunges east for three miles. It passes east into the Froggatt-Cordwell Valley Syncline. At the junction with the Middleton Dale Anticline, the Coombs Dale Anticline forms a dome, whilst the syncline forms a saddle between the Dome and the Longstone Edge Anticline to the south.

The Longstone Edge Anticline

The Longstone Edge Anticline is traceable from the Peak Forest Dome in the west, southeastwards and eastwards for thirteen miles. From the Dome to Tideswell Dale (4 miles) it has a southeast direction and an amplitude of 300 feet over a width of 1¾ miles. A small anticline parallels the fold to the south in this section and on it, in Monksdale, are two volcanic vents (130754). East of here, over a distance of 2½ miles, the fold gradually trends more east-west. The southern flank of the anticline is gradually replaced by a north-hading, reversed fault along this section. In Tideswell Dale (154740) the fold has a slight saddle on its crest. East of here, it has a slight dome, towards Cressbrook Dale. By Cressbrook Dale (172734) the fault throws down 200-300 feet to the south. East of Haydale (180733), the anticline becomes markedly asymmetrical, as part of the reversed motion on the fault is taken up in a steep southern limb. The section east of here is often called the Longstone Edge Monocline, for this reason. Around Haydale the anticline has a second saddle in its crest, partially created by interference with the north-south branch of the Wardlow Basin and partially by a down-faulted block. In this section, the anticline has an effective amplitude of 400 feet over a width of two miles. East of here, the anticlinal crest is a dome - the Watersaw Rake Dome (195733), followed by a saddle at the crossing point of the Great Londstone-Foolow Road (205732). East of here is a third elongate dome, the Bentney Cop Dome (210734). East of this, the markedly asymmetric anticline with its steep limb facing south gradually turns east-northeast with a fourth elongate dome on its crest, the Bleaklow Dome (220735). South of here, the minor Bleaklow Anticline splits off to the south-southeast for 1½ miles, before dying out into the Chatsworth Syncline. The northern branch of the main fold continues the asymmetry to the east-northeast. Here the fold has an amplitude of 300 feet but this decreases as it plunges below the shales and gritstones east of Calver Peak (230750) and it dies out after 2 miles. It throws off a south-east branch, traceable as the Robin Hood Anticline, which runs for three miles before dying out into the Baslow Syncline. The base of the D_2 strata overlap onto the D_1 beds to the south of Cressbrook Dale, suggesting that the Longstone Edge fold was active at this time. It is not possible to trace the Longstone Edge Anticline south to Ashover as Fearnsides (1933) suggested. A distinct syncline cuts off the Robin Hood Anticline from the northwestern extension of the Ashover fold.

General Notes

Parts of the Hucklow Edge Anticline, the Wardlow Syncline, the Coombs Dale Anticline and Syncline, and the Longstone Edge Anticline have been described by Shirley (1945). Whilst his work defined the east-west trends he failed to recognise the importance of north-south trends and the interference patterns of domes, basins, saddles and ridges, created by the intersections of the two trends.

The Chatsworth Syncline

South of the east-west Longstone Edge Anticline and north of the Taddington-Alport Anticline is a generally synclinal area, the Chatsworth Syncline. This begins in the west in the narrow Wormhill Syncline, south of the Peak Forest Dome, where it has an amplitude of 200 feet, and a width of one mile. From here it extends south-east into the Priestcliffe Syncline (135720) where it has an amplitude of 450 feet and a width of 2 miles. East of here the floor of the syncline is expanding in width, so that at the foot of Taddington Dale (170706), it is over 2½ miles wide. Here the floor of the syncline is complicated by the Lees Bottom Anticline which plunges south-east for 1½ miles with an amplitude of 100 feet. This minor fold was forming during sedimentation as strata thin onto it from the north and south. East of this the floor of the syncline is very wide and made up of two downfolds, the northern one trending east as the Longstone Syncline and the south one continuing as the Priestcliffe Syncline, southeast towards Bakewell (210690). The two synclines are crossed by a north-south syncline, extending from Longstone Edge to south of Ashford and this creates the elongate Ashford Basin by interference. The two branches of the Chatsworth Syncline cross to the east a north-south complex of folds known as the Bakewell Anticline and the Churchdale Anticline. This creates two sets of saddles in the anticlines, one in the north near Hassop (210710) and one immediately south of Bakewell (210680). These north-south anticlines have an amplitude of 200-300 feet to the north of Bakewell and can be traced northwards in association with faulting onto Longstone Edge, where they may be the cause of the Bentney Cop Dome, and they could be the same fold as the Middleton Dale Anticline (see above). To the south of Bakewell, they may be traced as a line of fold-fault disturbances into Lathkill Dale, at Over Haddon (205665), and southwards towards Youlgreave (200638), where in Bradford Dale, an inlier of toadstone outcrops in a relatively tight anticlinal core. On the crest of the anticline, north of Bakewell, the Cracknowle

Volcanic Vent occurs. Here, Brown (1974) has shown the strata to thin onto the anticline indicating that it was active during sedimentation.

East of the Bakewell Anticline, the main Chatsworth Syncline is split into two parts by the east-west Endsor Anticline. This trends east-west for three miles from the northern end of the Bakewell Anticline, near Hassop Station (218707).

At the east end of the Chatsworth Syncline is the north-south Chatsworth Park Monocline which drops the strata down to the east. The syncline is almost crossed and terminated by the northwest to southeast Robin Hood Anticline (branching off the Longstone Edge Anticline) and the north end of the Ashover Anticline but there is a three mile synclinal gap. The south side of the syncline is emphasised by a long system of faults throwing down to the north traceable from near Wormhill (115737) to Ditch Cliff (215667) south-east of Bakewell.

The Taddington-Alport Anticline

The Taddington-Alport Anticline lies south of the Chatsworth Syncline. It splits off the Great Rocks Dale Anticline (100730) and can be traced via the Calton Hill Vent southeast towards Sheldon (170690), a distance of eight miles. It has an amplitude of 500 feet and a width of two miles. At Sheldon, the anticline has a saddle in its crest. Southeast of here is the Mogshaw Dome (185678) which has a steep, almost monoclinal, northeast face which is faulted down to the northeast, along the northwest trending Arrock Fault. The Mogshaw Dome forms by the interference of the main fold with the north-south Calling Low Anticline, which cross the Lathkill Syncline to the south and has an amplitude of 100 feet. East of Mogshaw (205675) the main fold is indistinct in very disturbed ground where the north-south Bakewell Anticline crosses the axis (see above). It is next seen clearly as a dome again with a monoclinal northeast face to the northeast of Over Haddon (210667). The fold dies down to the southeast of here towards the Long Rake Anticline where it has a maximum amplitude of only 50 feet (225655). It picks up again to the southeast of this as the Alport Anticline. This has an amplitude of 200 feet and can be traced two miles southeast of the Long Rake Anticline before dying out into the Stanton Syncline. The overall length of the anticlinal system is twelve miles. The Taddington section of the anticline was described by Cope (1937).

The Lathkill Syncline

The Lathkill Syncline lies south of the Taddington-Alport Anticline and north of the Long Rake Anticline. In the north-west the Great Rocks Anticline dies out southeastwards into it (120700). The northwest-trending Taddington Moor Syncline, amplitude 100 feet, lies to the north, while the east-west Lathkill Syncline, amplitude 50 feet, is to the south. The two synclines merge at Flagg (136685) and the axis of the Lathkill Syncline continues southeast and then east along the River Lathkill, where it has an amplitude of 300 feet. To the west of Over Haddon it is crossed by the north-south Calling Low Anticline (180655) which creates a saddle west of Over Haddon, dividing the syncline into the western Monyash Basin and the eastern Over Haddon Basin. The Calling Low Anticline has an amplitude of 100 feet and is three-quarters of a mile wide, extending northwards from the Middleton Moor Dome (175635) on the Long Rake Anticline to, and creating the Mogshaw Dome on the Taddington-Alport Anticline. The Lathkill Syncline continues eastwards to Over Haddon where it crosses the southern extension of the Bakewell Anticline as a shallow saddle (200660) (see above). It then turns southeast to cross the Long Rake Anticline again as a shallow saddle (220655). To the southeast the fold becomes more pronounced as a fairly tight (50 feet deep) syncline dying out into the Stanton Syncline and complementing the Alport Anticline. Shirley (1959) described the southern part of the syncline but failed to recognise the north-south Calling Low Anticline and the southern end of the Bakewell Anticline.

The Long Rake Anticline

This begins in the Middleton Common Dome (175635) in the west which is formed by its intersection with the north-south Calling Low Anticline. Here the Long Rake Anticline has an amplitude of 400 feet and plunges steeply to the east. The plunge is reduced to almost zero where it is crossed by the Bakewell Anticline, one mile west of the River Lathkill. The amplitude is low to the east, so that at the Lathkill River, where it is crossed by the Lathkill Syncline, it is barely noticeable and it continues east as a very low amplitude structure across the Taddington-Alport Anticline. However, towards Pickery Corner (240658) the amplitude increases to about 150 feet and this continues east through Rowsley (255658) as a broad, elongate ridge up to 2½ miles wide and with an amplitude of 200 feet. This separates the northern end of the Tansley Syncline from the southern end of the Chatsworth Syncline. Four miles east of Pickery Corner, it is crossed by the continuation of the Tansley Syncline which makes a broad saddle, and one mile east of this intersects the north end of the Crich-Ashover Anticline. The structure east of Rowsley is coincident with a series of east-west faults which are perhaps the eastern continuation of Long Rake, and which could be well mineralised in the limestone. The Long Rake Anticline was described by Shirley (1959), although he did not recognise the continuation of the structure east of Pickery Corner. He also failed to detect the Alport Anticline, mainly because he had limited access to old mine records.

The Stanton Syncline

The Stanton Syncline lies to the south of Long Rake Anticline and north the the Bonsall Fault and the Matlock Anticline. It is separated from the Tansley Syncline to the east by the north-south Millclose Anticline and Pilhough Dome. The syncline has quite a complex minor structure. Its north limb is characterised by anticlines plunging southeast. The main one of these is the Alport Anticline which plunges south, almost crossing the syncline and divides it into eastern and western basins. The southern rim is characterised by north-plunging minor anticlines of a maximum amplitude of 50 feet. The syncline therefore has a crenulated form. These folds are described in section 4 below. In addition the southern limb of the syncline is complicated by an east-plunging, north-facing, monocline along the Coast Rake. The main syncline has an amplitude of 600 feet. Shirley (1959) described the syncline as relatively flat bottomed, but this is clearly not so from the above details. He did not detect the minor north-south folds which are so important in controlling the position of pipe orebodies along the south rim of the syncline, the prime example being the anticline along much of the Millclose orebody. This shows that even the Millclose orebody lying 'exceptionally' in a syncline, in fact, is controlled by an anticline, as are most of the major Derbyshire veins.

<u>The Matlock Anticline</u>

The Matlock Anticline is a double crested elongate dome with an amplitude of about 600 feet, relative to the Stanton Syncline to the north. To the south its amplitude is less as along its southern boundary is the Bonsall Fault. This acts in part as the southern limb of the anticline, downthrowing the strata by several hundred feet to the south. There is no complementary fold to the south of the fault. The more westerly of the two domes is at the north end of Bonsall Moor (255595) and the eastern dome is on Masson Hill (286586) where the Bonsall Sill intrudes the core. The western dome is a result of the intersection of the east-west Matlock Anticline with the north-south Millclose Anticline. The eastern dome is at the intersection with the Matlock Bridge and Tansley Anticlines. These latter plunge and die out the northeast and east respectively, after a couple of miles. The southern margin of the eastern dome is a highly asymmetric east-west fold - the Great Rake Monocline - which plunges to the east and dies out. It is continued to the east as the Riber Anticline under the shales. The main Matlock Anticline swings from east-west to northwest, southeast here. Its southwestern limb is effectively the Bonsall Fault, which also changes direction in sympathy. Towards Scarthin Nick, the anticline bends off to the east along the line of the Moletrap Vein (296575) and the amplitude decreases. Under the shales, to the southeast, the Matlock Anticline is traced as a long ridge, fault-bounded on the south-west side. This is about one mile wide and has an amplitude of 400-600 feet. It forms the southern boundary of the Tansley Syncline, which it divides from the Whatstandwell Basin to the south. The anticline continues to Crich (345555) which is a dome-like culmination formed at its intersection with north-south Ashover-Crich Anticline. The description of the area southwest of Scarthin Nick is based on the structural contour map in the Institute of Geological Sciences Chesterfield Memoir. This, and Shirley's 1959 structural map, adequately describe the main structures of the Matlock District, but they do not show some of the secondary details.

The Ashover-Crich Anticline

This begins as the north-south Belper Anticline six miles south of Crich, where it has an amplitude of 200 feet increasing to the north. At Crich, it intersects the northwest to southeast Matlock Anticline, which is continued southeast of Crich as the steeply plunging Wingfield Park Anticline. The latter has an amplitude of 100 feet increasing to the northeast. This intersection is the cause of the Crich Dome, which has an amplitude of about 1000 feet. North of Crich the fold turns northeast, and a branch of the Tansley Syncline crosses it making a col. Here the amplitude is reduced to 300 feet. North of this the fold intersects the north-south Wessington Anticline. This has an amplitude of 500 feet. From this junction, the main fold axis turns north again to Ashover (350630), its amplitude rapidly increases to 900 feet. At Ashover, a northwest fold intersects the axis, giving rise to the Ashover Dome. The north-south fold continues for about only one mile, with an amplitude of 200 feet and then swings and plunges steeply north-east and dies out. The northwest fold becomes the dominant trend. It throws off a north-northwest branch at the north end of the dome, with an amplitude of 150 feet. This gradually swings north-south, plunging and dying out into the Holymoorside Fault/ Monocline (320690). The main northwest fold continues with an amplitude of 600 feet decreasing northwest to join the eastern end of the Long Rake Anticline (315660). Across this, it is continued by a broad, short, north-south fold, which plunges and dies out after one mile. This fold is only three miles from the Robin Hood Anticline, which branches south-east off the Longstone Edge Anticline, but they do not connect as a strong synclinal area lies in between. The whole of the Ashover/Crich Anticlinal system north to the Holymoorside Monocline, is a markedly asymmetric feature with a steeper and longer limb on the eastern side. Superimposed on the regional dip, it is therefore one of the principal structures, which brings up the Carboniferous Limestone to outcrop in the massif, a few miles to the west. It may represent a fault-zone in the basement at depth.

(Note: Amplitudes on the Crich-Ashover fold given above, refer to the western side rather than the steeper and higher eastern limb. The description is based on the structure contour map in the Institute of Geological Sciences, Chesterfield Memoir).

<u>The Middleton Anticline</u>

This runs down the core of the Gulf Fault-Bonsall Fault graben. It trends and plunges southeast with an amplitude of 150 feet. Under the shales to the south, it splits to give two vaguely outlined anticlines, the Alderwasley Anticline continuing east-southeast for two miles, and the Shottle Anticline trending south for two miles before plunging and dying out. Parallel to the Middleton Anticline lies the minor Wirksworth Anticline and Syncline traced in the limestone west of the Gulf Fault with an amplitude of 50 feet.

The Southern Margin of the Massif

This is formed by a south-facing Yokecliffe Rake Monocline which terminates the outcrop from Wirksworth (286540) to Carsington (252534). On it, at Hopton (258533) is a large volcanic vent. At Godfrey Hole (274537) a roughly north-south pair of sinuous anticlines bring up limestone south of Yokecliffe Rake. These merge and plunge southeast below the shales forming the Idgridge-Hay Anticline with an amplitude of 200 feet. This can be traced to a saddle after two miles, south of which it is seen as a north-northeast trending and plunging fold. West of Carsington, the southern margin of the massif is an east-west reef belt which is crenulated by probably syndepositional north-south folding and faults. At Bradbourne, the area is strongly folded on north-south lines. The main fold continuing south of the reef belt as the axis of the Kniveton Inlier. The reef belt may be followed west to Alsop-en-le-Dale.

The Area between the Southern Margin and the Bonsall/Gulf Fault

This is an area of massive D_1 limestones. It is heavily faulted along north-south, east-west and northwest to southeast lines, but there are few large folds. What folds have been discovered are slight rolls along north-south and east-west lines. In general across the area the beds dip gently east, or north-east, so that the oldest strata outcrop between Hartington and Alsop-en-le-Dale in the southwest.

The Southwestern Area

Here the main folds are north-south and are the Dove Valley Anticline and the Manifold Valley-Ecton Anticline. In the extreme southwest is the northwest trending Weaver Hills Anticline. Much of the area is basin limestones with shales which give rise to many tight minor folds on the
See Ludford (1951), Prentice (1951)
limbs of the main anticlines. The area has not been studied in any detail by the author.

MINERAL VEINS OF THE SOUTH PENNINE OREFIELD WITH FAULTS IN ADJACENT AREAS

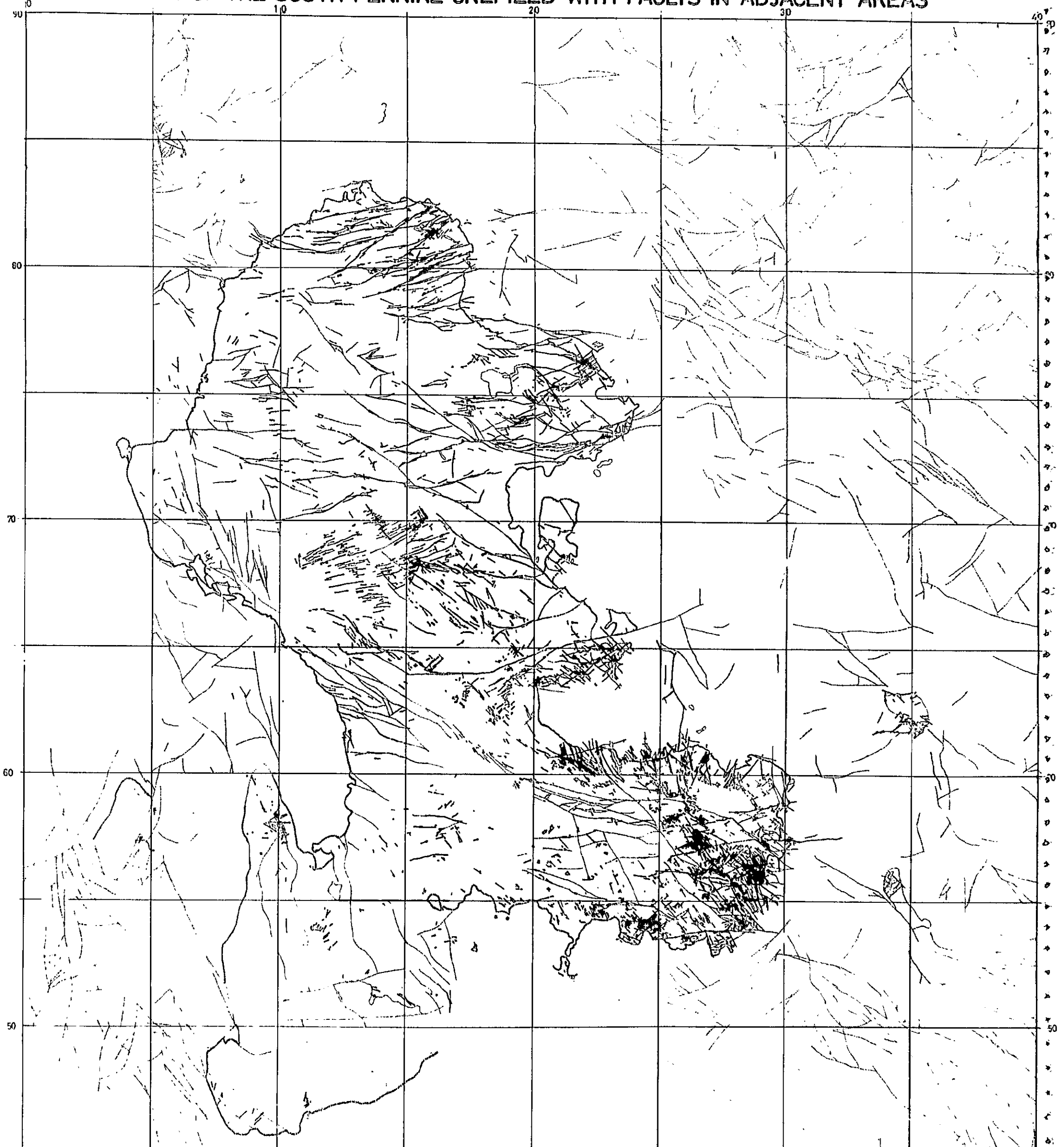


FIG.11A.

The Axis of the Massif

This runs from a culmination in the Hartington Dome, north to the High Needham Anticline and from this further north is poorly defined in a series of north-south anticlines including the Cowdale Anticline, the Long Hill Anticline with its southern extension - the Grinlow Anticline - which make the axis a broad zone of folds. These folds lie outside the area studied by the author.

To the east of the Cowdale Anticline is the Great Rocks Dale Anticline. This is north-west, south-east in its southern part where it divides and dies out into the west end of the Lathkill Syncline. It gradually swings north-south to the north, and merges with the Taddington Anticline. Here it has a culmination which forms part of the axis of the massif. From here the axis of the massif continues north to the Peak Forest Dome which lies at the junction of the Hucklow Edge, Longstone Edge and Beelow Anticlines and is formed by the interference of these features. It is a broad culmination from which the folds splay radially. The Beelow Anticline is a short east-west feature extending west for two to three miles from the Peak Forest Dome, plunging steeply below the shales as it does out to the west.

The so-called axis of the massif is not a fold in its own right, but rather a line joining a series of culminations in which older S_2 strata outcrop. Generally the strata to the east dip east and those to the west dip west.

(c) Faults, Fractures and Mineral Veins

(i) The Fault Structure of the Orefield

The principal faults of the massif run in a spread from east-northeast to east-southeast, and in a northwest to southeast direction, as shown on Figure 8. A subsidiary set run in a spread from north-northeast to north-

Method of Construction of the Fault/Mineral Vein Map (Figure 11A)

Aerial photographs about 6 inch/- mile were studied and visible lines of dumps and other lineations were plotted on 6 inch:1 mile maps for the whole orefield. These were checked with published maps of the Institute of Geological Sciences for sheets 99 and 112, Chesterfield and Chapel-en-le-Frith. In addition worked veins were plotted from the Barmaster's 25 inch:1 mile maps. In some areas with the Institute of Geological Sciences map coverages, the veins were checked again in the field and the pattern amended and extended in conjunction with the aerial photographs. Areas not covered by Institute of Geological Sciences maps were surveyed on the ground. Whenever possible the veins shown on old plans were incorporated after checking in the field. In all some fifty old plans were studied. The resulting maps were drawn on tracing overlays and photoreduced to a scale of 1 inch:1 mile. There were retraced as montage to give the map shown on Figure 11.

A 1 inch to one mile verison of Figure 11 may be found in the wallet at the end of the thesis, together with a map naming the principal veins.

northwest but are generally of minor displacement. Although northeast mineral veins and joints occur, few can be shown to be faulted. In the southwest in the basin area, the principal faults are east-west and north-south with northeast and northwest mineral veins. Whilst southwest of Buxton the faults are dominantly north-south. In general, where a movement can be proved, the faults show vertical displacement, but horizonal slickensides. All the faults seen by the author are mineralised to some extent.

The principal fault of the massif is the Bonsall Fault zone which can be traced generally northwest across the orefield from near Buxton to Crich. North of Grange Mill (243576) the fault has a dominant northwest trend, but the section from Bonsall (279582) for three miles westwards to 210594 on Bonsall Moor, is more east-west. Gower (1970) has suggested that the east-west Great Rake Monocline is an eastern continuation of this trend. Here the fault runs along and acts as the southern limb of the Matlock Anticline with a displacement of 200 feet down to the south. The Matlock Anticline is folded against the fault on the south limb. No complementary syncline occurs to the south. The fault zone gradually becomes west-northwest to the west and is more complex, being paralleled by four or five faults in a three-quarter of a mile strip to the south, for several miles, in the Aldwark area. These parallel faults may well continue west-northwest, fanning out across the Hartington Anticline and reaching the western limestone boundary. The main Bonsall Fault swings to the northwest and breaks up into several branches which intersect the west end of the Long Rake Fault system. The northwest trend continues to Earl Sterndale, where the Bonsall Fault dies out into the area of north-south faults south of Buxton. It is interesting to note, however, that if the general northwest trend of the Bonsall Fault is projected into Upper Dovedale, it coincides with the back of the Reef belt from Crowdecote

(100654) to the northwest and early strong pre-Namurian faults do occur here, with northwest trends. Perhaps the trend of the reef belt here is the result of fault control.

The Bonsall Fault Zone continues southeast of Crich across the coalfield towards Nottingham, perhaps to join with east-west faults along the northern margin of the Widmerpool Gulf. The fault separates areas of different structural pattern. To the northeast, the coalfield has a regular pattern of northwest and northeast faults with east-west, north-south and northwest folds, but to the southwest, northwest and north-northwest faults, in a slender reversed 'S' form, and north-south folds predominate. In the ore-field, the area to the north is well folded and faulted along east-west and north-west lines with occasional north-south structures. The area to the southwest is folded only by slight rolling folds, but has many west-northwest, east-west and north-northwest faults. The Bonsall Fault, probably represents some fundamental line of weakness in the basement of the area and may separate areas of different basement rigidity. Thus the area to the south of the fault is rigid and yields by faulting rather than folding, whilst that to the north is more ductile and is well folded.

North and east of the Bonsall Fault some faults can be in part related to folding. This includes the Bonsall Fault along the east-west section, whereit acts as the southern limb of the Matlock Anticline, along which the fault has an appreciable displacement down to the south. It may, in part, be a high-angled thrust dipping north along this fold (see Part 6).

The Hucklow Edge and Old Edge Vein faults probably occur along an east-west north-facing monocline. The faults hade south and are reversed, which suggests they are genetically related to the folding. Similarly the High Rake on the crest of the asymmetric south-facing Longstone Edge Anticline, is north-hading and reversed, as is a fault inferred at the foot of the Edge. The Monocline passes west into a reversed fault with a 200 foot throw to the south. The Long Rake, on the crest of the weaker Long

Rake Anticline, is also reversed, hading north at least in the section east of Raper Pit, although to the west the hade reverses with depth. Similarly, the Great Rake, at Matlock, on the crest of the Great Rake Monocline is also a reversed fault perhaps the continuation of the east-west section of the Bonsall Fault to the west. There is evidence that these folds were forming during sedimentation so it is possible that some of the faults could be of similar age, although it is more likely that they relate to the end stages of tightening of the folds during the Hercynian Orogeny. This theory is supported by the occurrence along other east-west faults of large dyke-like dolerite intrusions, dated as Namurian to Westphalian (Stevenson and Gaunt, 1972), however, some faults are of pre-Namurian age (see Chapter on Structural History).

The hade and throw of many of the faults in the interior of the massif is unknown as they are traced only as zones of smashed and disturbed rock across country and are rarely exposed in the vertical plane. The faults west of Wirksworth and around Aldwark, trending east-west, northwest and north-south, appear to all be normal faults as do those mapped by Sadler and Wyatt (1966) in a northwest direction at Hartington and the north-south faults mapped by the Institute of Geological Sciences (1975) around Buxton. Similarly, the east-west and northwest faulting exposed in the Great Rocks Dale quarries and around Tideswell also noted by the Institute of Geological Sciences, is also normal with the exception of the west extension of High Rake and the Hucklow Edge Vein.

Some of the least of these normal faults, such as Dirtlow Rake and the Arrock Fault near Sheldon, parallel the local fold trend. These then, may in part be the result of post-compressional relaxation of the folds. The area between the Gulf and Bonsall Faults at Wirksworth is a graben with an anticlinal core with marginal downthrows of 200-400 feet. Within this is a second graben between the Gulf and Ranter Faults. Grabens suggest a tensional origin and the collapse of an uplifted structure in post-compressional relaxation.

ROSE DIAGRAMS OF MINERAL VEINS/FAULTS

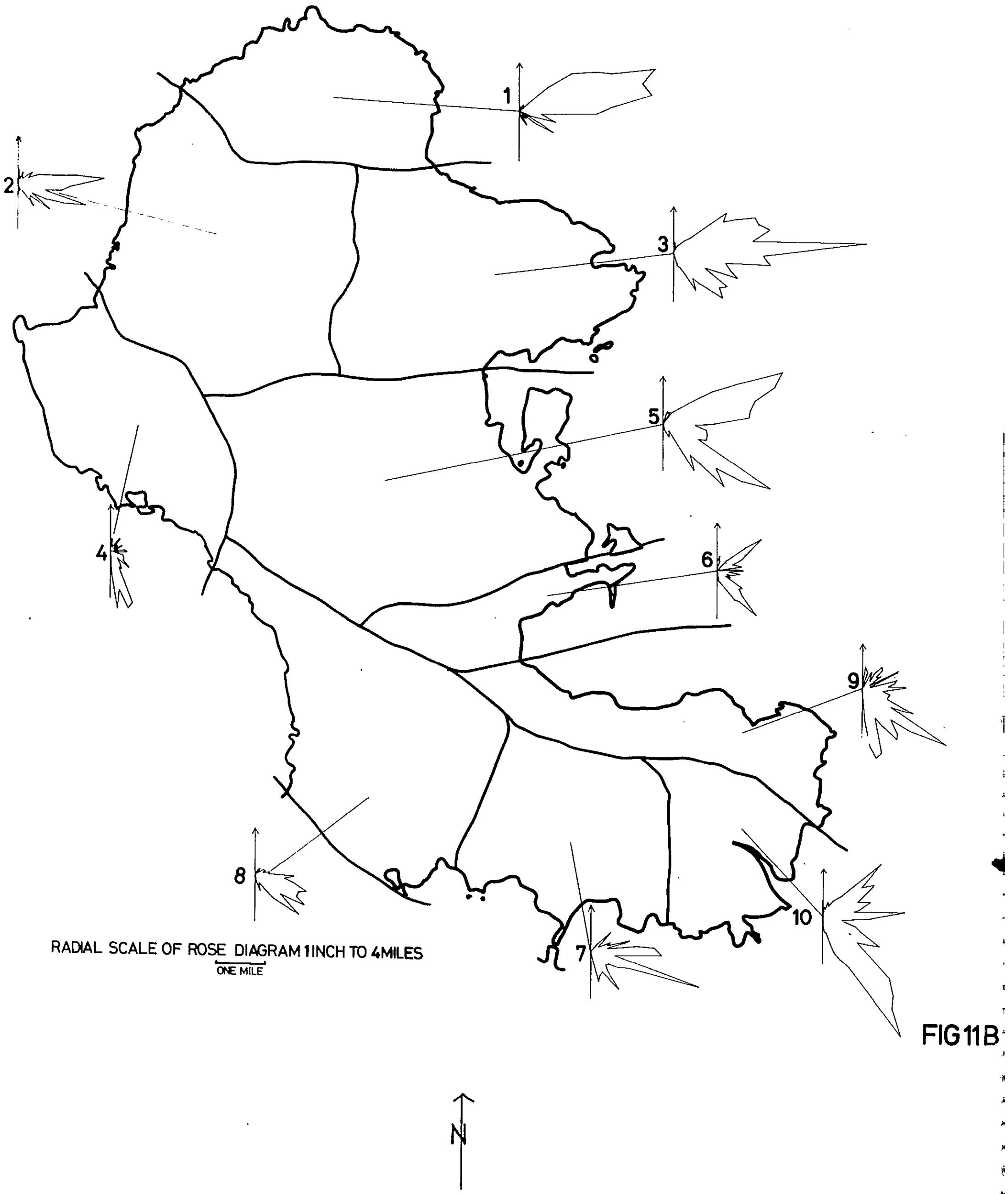


FIG 11 B

Many of the east-west mineral veins show little vertical displacement, but much horizontal slickensiding. This is true for most of the veins north of the Hucklow Edge Vein, except the Dirtlow Rake at Castleton, which is known to be a normal fault with a throw of a hundred feet down to the south, but which still shows horizontal slickensides. Indeed many of the veins further south, such as those on Longstone Edge, and the Dirtlow and Mogshaw Rakes and even those with appreciable vertical displacements such as the Lathkill Dale Rake and Long Rake, show dominantly horizontal slickensides on the walls and cutting through the mineral fill. These must be the result of a late phase of lateral compression, superimposed on the early normal compressional and tensional phases which created the fault displacements. This lateral compression took place during and after mineralisation as the veins show brecciated and recemented infills which are cut through by horizontal slickensides. Further details of the faults and their infills are dealt with in the section on mineralisation below.

(ii) The Pattern of Mineral Veins

The mineral vein map (Figure 11A) was divided into sub-areas with different patterns by visual inspection. A rose diagram of length against direction was plotted for each sub-area. The results are presented on Figure 11B and described below:

Area 1: Bradwell-Castleton: This is dominated by veins trending between 050° and 090°. The main directions within this are 070° to 075° and 080° to 085°. By inspection of the map a persistent set of veins on 050° is seen. Minor trends are present on 110-115°, 125-130° and 145-150°. The pipe deposits in the area develop on trends of 095-110° and on 150°. By inspection of the map, the pattern is seen to become dominated by east-west and west-northwest trends in the west, where the pattern is more like the Peak Forest area to the southwest.

Area 2: Peak Forest: The dominant vein trend lies between 060° and 100° with a peak at 085° to 090°. A secondary peak is developed from 105° to 110°. Minor trends are present on 005° to 010°, 025° to 030°, 050° to 055°, 110° to 115°, 125° to 130°, 145° to 150° and 170° to 175°. The majority of these mineral veins in the Peak Forest area can be shown to be faults.

Area 3: Longstone Edge-Hucklow Edge: The dominant trend is 085° to 090° and secondary trends occur on 075° to 080° and 095° to 100°. The majority of these three trends are faults. The elongation of these trends along which the fault-veins occur reflect the east-northeast to west-northwest trends of the folds of the area. Other trends occur on 050° to 055°, 060° to 065°, 125° to 130° and 145° to 150°.

Area 4: Buxton: The dominant trends are 160° to 165° and 170° to 175° paralleling the dominant fold trend of the area. Secondary trends occur on 050° to 055°, 075° to 080°, 085° to 090°, 110° to 115°, 125° to 130° and 145° to 150°. Minor trends are developed on 035° to 040° and 000° to 005°.

Area 5: Lathkill: The principal trends are 065° to 070° and 120° to 125°. Secondary peaks are developed on 110° to 115°, 135° to 140°, 145° to 150° and 030° to 035°. The strong south-east trend reflects tension over the main southeast folds of the area as perhaps does the 110° to 115° peak. Pipes are developed on the 145° to 150° and 165° to 170°.

Area 6: Alport: The principal trends are 055° to 060° and 130° to 135°. These appear to be equivalent to the dominant trends of the Lathkill area, but lie at a less acute angle. Trends are also developed on 075° to 080°, 085° to 090°, 095° to 100°, 115° to 120°, 120° to 125° and 010° to 015°. The 085° to 090° trend and the 130° to 135° trend parallel the local folds. Pipes are developed on the 095° to 100° trends.

Area 7: Carsington-Aldwark: The dominant trends are 090° to 095° and 105° to 110°. Secondary trends are developed on 045° to 050°, 060° to 065°, 070° to 075°, 140° to 145° and 160° to 165°. The 125° to 130° trend, present in all areas to the north and east is absent and northeast trends are poorly developed. The presence of the 160° to 165° trend suggests some affinities within the Buxton area. The Golconda pipes are developed on this trend.

Area 8: Southwest: The principal trends are on 090° to 095°, 105° to 110°, 120° to 125°, 130° to 135°. Minor trends are present on 035° to 040°, 055° to 070°, 075° to 080° and 160° and 165°. The 145° to 150° and the 125° to 130° trends of the areas to the north and east are replaced by the 130° to 135° and 120° to 125° trends in this area.

Area 9: Matlock: The principal trends are 120° to 125°, 140° to 145°, 165° to 170°. These reflect the north-west and north-northwest fold trends of the area. Other minor trends are developed on 005° to 010°, 025° to 030°, 035° to 040°, 055° to 060°, 060° to 065°, 075° to 080°, 085° to 090°, 100° to 105°, and 115° to 120°. This is a very complex joint pattern and to some extent it is a combination of the Lathkill pattern and the Buxton pattern. Pipes are developed on 130°, 145° and 025° trends.

Area 10: Middleton-Wirksworth-Cromford: The principal trends are developed on 045° to 050° and 145° to 150°. A secondary trend is developed on 085° to 090°. Other trends are developed on 000° to 005°, 010° to 015°, 055° to 060°, 065° to 070° and 110° to 115°. The general pattern is quite similar to the Lathkill area.

Area 11: Ashover: This area has been dealt with in detail by White (1970) and the present author has made no further observations. White showed veins to occur on east-west,north-west and north-east trends. Two phases of compression were involved, related to two phases of mineralisation.

Area 12: Crich: The number of mineralised joints measured here are too small to justify any conclusions about trends.

Area 13: Ecton and Bincliffe: The number of mineral veins measured here is too small to justify many conclusions. It is clear, especially at Ecton, that 160^{o} to 170^{o} trends are developed parallel with the main local folds. At both Ecton and Bincliffe, some east-west, northwest and southeast mineral veins are also present.

Summary of Vein Pattern Analysis

The pattern of mineralised fissures appears to reflect the local fold structure to some extent. Thus on the Longstone Edge and Hucklow Edge areas the east-northeast, east-west and the west-northwest trends are elongated, parallel to the main local folds. In the Lathkill-Alport and Wirksworth-Middleton-Cromford areas, northwest trends are elongated, again parallel to the local folds. On the Matlock Anticline, where northeast, north-northeast and north-northwest minor folds are developed, joint trends develop parallel to these directions. In the Buxton area, the dominant north-northwest faulted mineral veins parallel the local fold trend.

There is a general overall pattern to the mineral veins in the orefield. This consists of sets of northwest, east-west and north-east veins which are developed to varying extends in each area. The pattern of the Bradwell-Castleton area contains these trends, but is made distinctive by being dominated by northeast trends. The Buxton area forms another distinctive unit with strong north-northwest trends which dominate the basic pattern noted above. The Carsington-Aldwark area and the southwest area are dominated by east-west and west-northwest trends. The presence of north-northwest trends suggest some afficinities with the Buxton area. However, to the south in the Wirksworth-Cromford-Middleton area, the basic pattern is again expressed.

Without thorough joint analysis in the field, it is impossible to know how representative the located worked mineral veins shown on the map are, of thetotal joint pattern. It is not possible to know how many trends of uneconomic veins have never been worked in a given area. It does, however, seem reasonable to suppose that in the more intensely worked areas of the orefield, representatives of all the veins are present and have been mapped. In many cases, the major veins are faults, but it often is impossible to know whether an individual vein is a fault or a joint. The author is convinced that it is impossible to give a proper tectonic interpretation of these mineral vein rose diagrams without first establishing the overall joint pattern of the area concerned and deducing the tension and shear directions from their surface morphology. This is a major research task which is becoming necessary.

(3) Structural Conclusions

From the foregoing detailed description of the folds, the area is seen to be a complex interference pattern created by the intersection of north-south, east-west and northwest to southeast folds. These create domes, basins, saddles and ridge fold forms on the main anticlines and synclines. Clearly the description of the area as a whole as the 'Derbyshire Dome' grossly over simplifies this situation and the use of the term 'Derbyshire Massif' is preferable.

The area is shown to lie on a relatively shallow east-tilted basement the subsidence of which has on the gross scale, controlled sedimentation. Three phases of folding and five of uplift and erosion are deduced for the structural history of the area, beginning in mid-Dinantian times. It is concluded that the present surface of the limestone is only 300 feet or so below its position at the end of erosion in pre-Namurian times and that this surface with a progressively more discontinuous shale cover, has been repeatedly re-exposed to the effects of sub-aerial erosion during ensuing periods of uplift. It is concluded that uplift and erosion in pre-Namurian times probably initiated some of the joint and fault pattern of the massif and that this was accentuated and extended during the uplift and re-emergence of the limestone in both the post-Hercynian, Permian and later, Triassic erosion phases. Some unmineralised joints may belong to the Tertiary uplift and erosion phase.

Two types of fault may be related directly to the folding. The first are reversed faults parallel to and along the crests of asymmetric, anticlinal or monoclinal axes. These probably formed during folding towards the end of the Hercynian orogeny. The second type of fold-related fault is normal faults parallel to anticlinal axis, the result of post-compressional relaxation. Some faults may be shown to be Lower Carboniferous in age, whilst others are Namurian or Westphalian. The early faults referred to above have been reactivated by lateral stresses during and after mineralisation but some of the calcite therein, relates more to the early movements than to the later mineralisation.

The area may be divided into four sub-areas on the basis of its fold and fault pattern. North of the Hucklow Edge Anticline is an area of east-west, north-east and east-northeast, mineral vein faults with few folds, where only the Dirtlow Vein shows significant vertical displacement. South and west of this, to the Bonsall Fault, lies an area of east-west and north-west folding and faulting with occasional strong north-south trends, such as in the Crich, Ashover and Bakewell Anticlines. South of the Bonsall Fault is an area where north-northwest, east-southeast and east-west faults are dominant, with only broad low amplitude rolling folds of similar trends, present. Along and to the west side of the massif is an area where north-south fold and fault trends with some east-west faulting are dominant.

If these four sub-divisions are compared with the geophysical work of Maroof (1974) on the basement of the area, it would appear that the central folded belt lies over the western end of his central basement graben where the sedimentary cover is thickest. The relatively unfolded zones to the north and south lie over areas of shallower basement and thinner sediments, whilst the north-south trends in the west lie over the north-south shallow western edge of the blocks.

If the trends of the fold-fault features are considered it appears that the north-south trends are generally confined to the south and west of the area, where perhaps the Carboniferous lies on a north-south fractured Malvernian, or Charnian type of basement. To the north and east, the dominant trends are east-west and northwest with fewer north-south features. This is a pattern similar to the coalfield to the east. Perhaps here the Charnian is overlain by a sequence of lower Palaeozoic slates as proved in the Eyam borehole (Dunham, 1973) damping the effects of the north-south trends of the basement below.

The fold-fault pattern of the ore-field, therefore, reflect those of adjacent regions. Derbyshire is a nodal point for three styles of faulting and folding. In the west and north-northeast to north Malvernian trends of the West Midlands converge with the north-northwest to north Charnian trends of the East Midlands and these trends are reflected in the structure of the ore-field west and south of the Bonsall Fault. To the north and east of the fault the orefield has more the style of the coalfields to the east.

THE DISTRIBUTION OF FLUORITE MINERALISATION IN THE SOUTH PENNINE OREFIELD

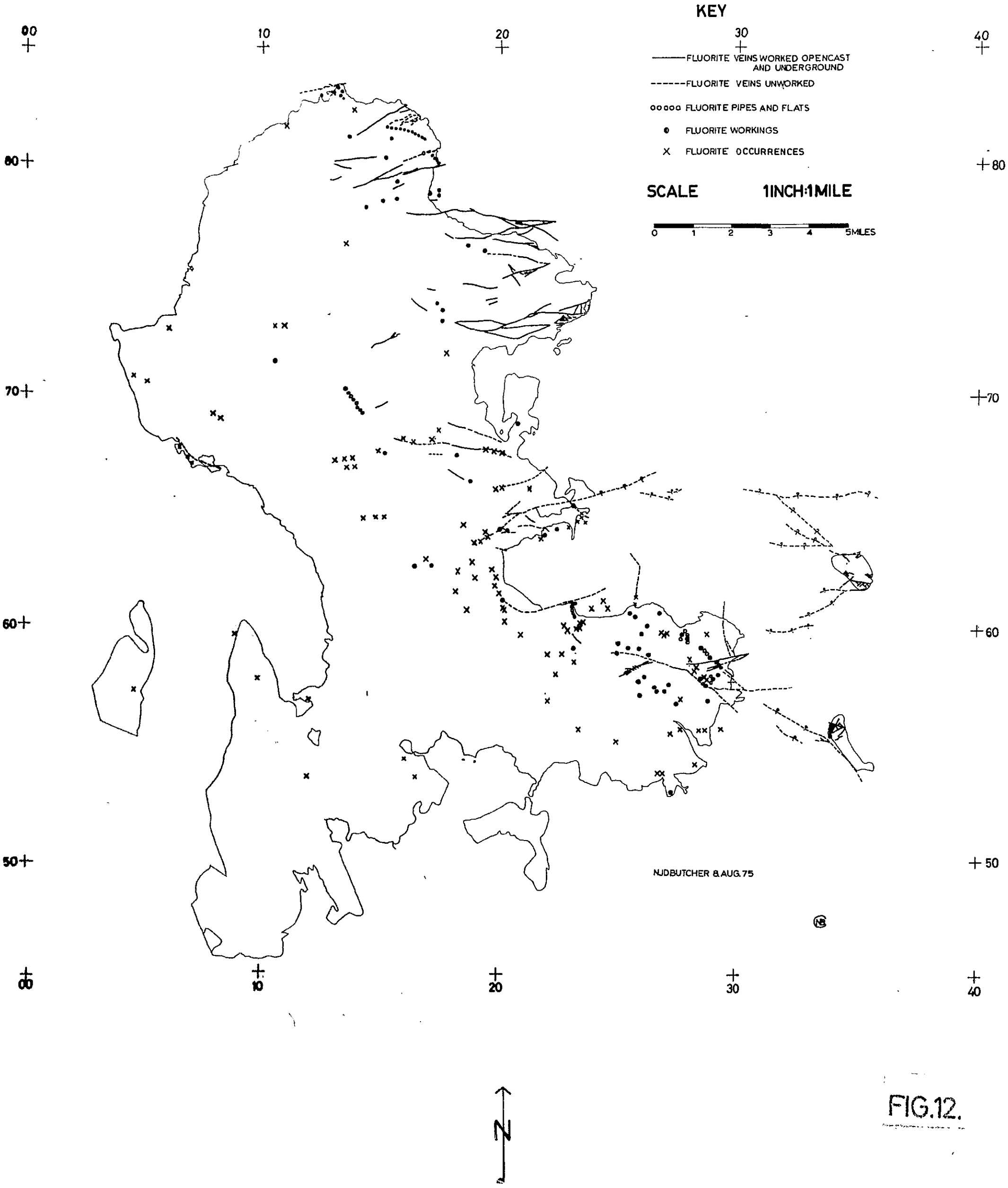


FIG.12.

PART 4

Fluorite Mineralisation of the South Pennine Orefield

1. Introduction

In this Chapter the distribution of fluorite is described in outline by vein and area, from north to south, for the eastern part of the massif. Outlying deposits in the west of the massif are also described. Greater details of some of the individual ore bodies can be found in Part 6. Known occurrences are shown on Fig. 12.

In 1908, Wedd and Drabble showed that fluorite occured in a zone along the eastern edge of the orefield. Known deposits were thought to be restricted to the strata above the highest local toadstone. In 1945, Shirley and Horsfield demonstrated that within the Eyam part of this zone most, but not all, of the principal veins occurred along the crest of anticlines. In 1952, Dunham produced a zonal map of the orefield with fluorite, barite and calcite zones which he believed were thermally controlled. In 1952 and 1954, Mueller produced a subdivision of the orefield, based on zones of fluorite, barite and calcite from east to west and also related this to a decreasing temperature of formation. He further subdivided the fluorite zone into a high temperature pyritic zone in the east, followed by an intermediate temperature clear fluorite zone and a low temperature purple fluorite zone in the west. He considered the temperature and formation of the deposits to be around 300°C. His subdivision of the orefield has been much used as a basic reference by subsequent authors, although that of Dunham appears to have been more accurate in representing the situation known at that time.

Roedder, in 1969, working on fluid inclusions, was able to demonstrate that the temperature of formation of the fluorite was more in the order of 100°C. Firman and Bagshawe, in 1974, showed that there are so many exceptions to the Mueller zonal system, that the concept of subdivisions of the fluorite zone should be abandoned. They showed that the concept of the three zones, calcite, barite and fluorite, needs to be reconsidered in the light of new deposits of fluorite found since the 1950's; they also showed that different phases of mineralisation either overlap or do not, and that local structure, at least to some extent, controls the distribution of the deposits. They also noted that Wedd and Drabble's assertion that fluorite tended to occur above the highest local toadstone was invalid. Since their 1908 survey, many deposits have been proved to carry fluorspar below one or more toadstones.

The aim of the following account is to describe the present occurrences and workings for fluorite and to discuss some of the details of the effects of structures, dolomitisation, karst features and the facies of the limestone on the development and distribution of the orebodies and occurrences.

2. Details of the Fluorite Mineralisation of the Orefield

This section is a brief outline of the geology and extent of fluorite mineralisation in the main veins and flats of the orefield.

Odin Vein (135834 to 123832)

This east-west vein occurs in D_1 limestones of reef facies immediately below the shale unconformity. The vein has been worked for galena over a distance of two miles, mainly below the shale cover, which plunges steeply to the east and west. The principal gangue is fluorspar which can be seen underground and in the old dumps at the Odin Gorge and to the west along the flank of Mam Tor. Substantial reserves must be present, but it is unlikely that they can ever be worked.

Treak Cliff Caverns (136831)

These are pipe deposits developed in D_1 reef limestones and in a boulder bed immediately below the shales. The fluorspar lines karst cavities in the reef and gaps between boulders in the boulder bed. It was probably fed at least in part from the Odin Vein.

Veins between Odin Vein and Dirtlow Rake

These veins are dominantly calcite although near the west end of Oxlow Rake, in Jack Pot, small veins with fluorite are present. East of Eldon Hill the Portaway Mines have been worked for barites in the dumps. The veins are in D_1 limestones generally of massif type, although close to the shale boundary they enter D_1 reefs.

The Dirtlow Vein (097812 to 161825)

This is one of the major fault-veins of the orefield throwing down to the south by about 100 feet. There is evidence that it was active in Lower Carboniferous times offsetting the reef belt at its east end (Stevenson and Gaunt, 1972). The vein is traceable under various names from Perry Foot (Coalpit Hole Rake) where it trends west-northwest, to Pindale where it is east-northeast. This latter trend is continued to the Peak Forest area by the Oxlow Rake branch to 115795. The vein is dominantly calcite, but east of, and at, Hazard Mine (139813) some fluorite and barite occurs. At the east end, in Pindale, in D_1 reef limestones, where the vein breaks up into several parallel veins, it is fluoritic and much small scale opencasting has occurred. The dumps and fluorite-rich lenses in the vein have been worked for fluorspar and barites as far west as Hazard Mine. The Oxlow Rake branch has been worked for calcite east of Peak Forest and some fluorite occurs here as well. The vein is principally in D_1 massif limestones, but a short section from Hazard Mine, east to 153822, is in D_2 massif limestones at surface.

Veins between Dirtlow Vein and Moss Rake

To the south of Dirtlow Rake is a large area of silicified and fluoritised blocks representing a replaced bed of limestone let down by solution collapse and which was probably fed from the Dirtlow Vein. In Earle's Quarry, a series of northeast fluorspar veins cause problems with quality control in the plant. These veins become calcitic to the west of

Bird Mine (156813). This system of northeast fractures is crossed by the northwest Smalldale Pipe at Bradwell. This is a linear system of cavity linings and marginal replacements of coarse, crinoidal limestone along a north-west joint system. One of the cavities at 165814 contains shales perhaps let down by solution subsidence, but possibly sedimented in a pre-Namurian, pre-mineralisation, karst cavity. The pipe may be followed for 2½-miles northwest of Bradwell, in massif type crinoidal Monsal Dale Beds (173813-160817).

<u>Moss Rake</u> (175810 to 110792) (see Report 5 in Part 6)

The main vein is east-northeast, and is dominantly massive columnar calcite. Fluorite stringers occur near the walls which are fluoritised in places. Fluorite was clearly deposited later than the calcite, in which fluorite lines cavities.

West of Eidson's plant (150803) some parallelveins and an east-west branch are principally fluorspar with some barite. The veins have been worked for 1½-miles to the west, over the crest of Bradwell Moor and are in massif type D_2 limestones above the Upper Miller's Dale Lava.

<u>Harthill Rake</u> (170805 to 158801) (see Report 5 in Part 6)

This is a calcite-fluorite vein, traceable from Bradwell Dale west to the boundary of Hazlebadge, a distance of two miles in D_2 limestones of massif type. Here it coalesces with the Earl Rake system. At 168804, to the south of the vein, a replacement deposit of fluorspar occurs in a north-west joint system in off-reef and reef Eyam Limestones.

<u>Earl Rake</u> (176804 to 147794) (see Report 5 in Part 6)

This is a major east-west calcite vein in D_2 limestones of massif type, carrying some fluorite in places. At the crossing with Pic Tor Pipe in the Cawdor reefs (172804) it is fluoritic and occasional fluorite can be seen westwards towards the junction with Harthill Rake (158801). West of here the vein carried ribs of fluorspar up to three feet wide in otherwise calcitic veins. These have been worked by drag-line. The vein gradually merges with Shuttle Rake to the west at 147794.

Shuttle Rake (173798 to 111787) (see Report 5 in Part 6)

Shuttle Rake and associated veins have been worked for fluorspar west of the junction with Earl Rake. Here the vein carries much calcite, but residual de-calcitised gravels and some fluorspar ribs have been worked extensively in the D_2 massif limestones as far west as the outcrop of the Upper Miller's Dale Lava. Below the lava, west towards Peak Forest, in massive D_1 limestones, the vein is calcitic, or is barren in toadstones. East of the split-off, of Earl Rake, Shuttle Rake becomes a zone of tight fractures which have been intermittently and shallowly opencast for fluorite. In Intake Dale (164795) large fluoritic washing dumps have been removed. East of Hazlebadge Farm (172800) on the Lawrence Grove section of the vein, large dumps of fluorspar from mines below the shales have recently been worked. These workings are associated with the intersection of the south-east end of Pic Tor Pipe in the Eyam Reef Limestones.

Pic Tor Pipe (175800 to 172805) (see Report 5 in Part 6)

This is a fluorite rich cavity lining and marginal replacement deposit in Eyam Reef Limestones. Large caverns are present, some of which are pre-mineralisation in age, whilst others of recent origin. The pipe cavities appear to be developed along a series of north-west joints. The cavities are infilled by layers of barren mud with layers of sandy and gravelly fluorspar in places. These are often covered with layers of collapsed limestone blocks and subsided shale masses. Pleistocene animal remains are found from time to time. The deposits extend to a depth of 150 feet and appear to plunge to the southeast beneath the shales. They are crossed by the Earl Rake calcite vein. The deepest workings may extend down into the top of the massif type Monsal Dale Beds.

Veins between Shuttle Rake and Hucklow Edge Vein (see Report 5 in Part 6)

At Nether Water Farm (172791) trials were made in the 1950's along an east-west vein in Eyam Reef Limestones. The objective was to discover pipe and flat deposits similar to Pic Tor Pipe, but underneath the shales. The trials were unsuccessful, but some limited stoping for fluorspar was carried out. The vein has been worked from a shaft just to the west of the Tideswell-Bradwell Road at 167788 in massif type Monsal Dale Beds. At 158792, a parallel vein has been opencast for fluorspar on a small scale, in massif type Monsal Dale Beds. Further south Maiden Rake, the continuation of the Netherwater vein, west of Great Hucklow has been worked on a small scale (155755). Below Hucklow Edge, dumps on the May Mine, worked below the shales, carry much fluorspar (172787).

The Hucklow Edge-Old Edge Vein Systems (122786 to 244773)

This vein system is one of the principal fluorite producing veins of the orefield. Production has been continuous since the 1940's. A total length of about 3 miles has been developed and stoped for fluorsar, in the D_2 limestones above the Cressbrook Dale Lava and below the shales. The surface dumps were worked and removed for gravel-fluorspar in the 1920's. Towards the east end of the Old Edge Vein (225770) the veins are said to become calcitic and are dying out (Ridgeway - personal communication 1975). Fluorite has been proved in the D_2 limestones below the Cressbrook Dale Lava by boreholes. To the west of Slater's Engine Mine (195779) the vein becomes calcitic and although it has been worked for fluorspar at outcrop, west of Little Hucklow, as far as Wash House Bottom (161779) the workings have been intermittent and very selective. To the west, over Tideslow (150780), the vein is largely calcite above and below the Litton Tuff in massif type Monsal Dale Beds, but in and below the Miller's Dale Lavas, a vein of very high grade fluorspar was discovered in the 1960's at 144782. This occurrence well to the west of most deposits is quite anomalous. However, many of the veins mentioned above lying to the north pass through the same stratigraphical situation and these should also be examined for fluorspar. West of the deposit, the vein is once again calcite in massif type Miller's Dale Beds.

Little Pasture Vein-Crosslow Rake-Middle Field Rake (215767 to 180767 - General Reference)

These veins have been worked for fluorspar underground from the Glebe-Ladywash Mine and the Black Hole Mine. Opencasts have taken place on the Crosslow Rake from near Dusty Pit Mine (205772) towards Foolow (192768) and high grade fluorspar has been worked for 1½-miles to the west of Foolow to 180767. The east-west Middle Field Rake and associated replacements at its east end (215766) were worked from Glebe Mine in the 1940's and have been opencast across the fields for 1 mile east of Eyam to 200767.

Streaks Vein (222757 to 195762)

This east-west vein is worked for fluorspar in the Hanging Flat Mine (204760) which produces a 60% fluorspar ore. Near the head of Stoney Middleton Dale, an opencast has produced fluorspar intermittently on this vein at 195762. At the east end at the junction with Main Rake (222757) a replacement deposit has been worked underground.

Main Rake-Dirty Rake (222757 to 205753)

This east-northeast vein has been worked for fluorspar in a replacement deposit at the junction with Streak's Vein, in Middleton Dale. It has also been opencast amongst the cliffs on the south side of the Dale. Several medium scale opencasts for fluorspar were developed in the 1960's, on the Dirty Rake section of the vein, towards the site of Laporte's Cavendish Mine.

White Rake (214746 to 170751)

This vein has been worked by small-scale opencasts for fluorspar as far west as Seedlow Mine (194747), but west of here it becomes calcitic. It runs along the crest of the Coombs Dale Anticline and the change to calcite occurs more or less at the crossing point of the north-south Middleton Dale Anticline.

Blagdon Great Vein and Cacklemackle Mines (205740 to 190740)

Small opencasts for fluorspar have taken place from time to time on these veins.

Longstone Edge; Deep Rake; High Rake, etc. (237744 to 135743)

This long system of veins is the second most important fluorspar deposit of the orefield. It has been worked in the D_2 limestones mainly of basinal type. The principal vein is the High Rake-Deep Rake system. This has been worked opencast for fluorspar from the 1940's. A total length of 5 miles has been opencast, from Cross Dale Head Mine (183733) in the west, to the Red Rake Vein (237741) in the east. The Red Rake Vein was worked for fluorspar underground in the 1920's. Morerecently, the Sallet Hole Drift was driven south into the vein at a higher level from Coombs Dale (223744). The vein has been stoped out for about $\frac{3}{4}$-mile either side of the adit intersection and some of the branch veins have been stoped out for a short distance. At Bow Rake (214735) where a large rider breaks the vein, a major replacement has been worked. Fluorspar has been proved below the toadstone in the east half of the mine and by both deep drilling and a development incline and sub-level. To the west, the base of fluorite mineralisation appears to rise and it has been possible to work out the full depth of fluorite mineralisation by a 220 foot deep opencast at 206732. West of there the vein splits. The northern branch, Watersaw Rake, has been opencast by dragline to a depth of 100 feet to 192735. By Crossdale Head Mines, the vein is calcite and was worked for this mineral by an ornamental stone company, in the 1920's. The southern branch (High Rake) hades steeply north and descends the escarpment to the foot of the Edge (197728) where it intersects the Ash Nursery vein. It then re-ascends the Edge, still hading steeply north, to the Crossdale Head Mine. The deposit on parts of this section is poorly defined, being a linear stockwork of fluorite stringers. Several similar veins run east-west along the face of the monocline between High Rake and

Watersaw Rake. Below Longstone Edge, the Ash Nursery Vein has been opencast by Turners of Great Longstone, for fluorspar (200727 to 210726). Further east the Harry Becca Mine worked fluorspar underground at the foot of the Edge (223732). West of Haydale (179733), the main High Rake vein is calcite and hades steeply north. West of Cressbrook Dale, it is a reversed fault and this has been worked for calcite at 170734. The vein may be traced as a fault-carrying calcite, as far west as Monk's Dale. To the west of Haydale, a north-west vein branches off and crosses Cressbrook Dale towards Litton. This carries fluorspar which in the absence of Upper Miller's Dale Lava, extends down into the massif type D_1 limestones and this has been opencast to the south of Litton in the 1960's (168738).

<u>The Bull Tor Vein</u> (173734 to 148723)

This vein branches east, south-east off the High Rake system in Cressbrook Dale, It crosses Cressbrook Dale and the River Wye in the D_1 massif limestones where it is dominantly calcite. At Bull Tor (154725), the vein has been worked for fluorspar and barites by opencasts which extend towards Priestcliffe. These are high in the D_2 strata which are of interdigitated massif and basinal type.

<u>Putwell Hill-Grove Rake Vein</u> (212724 to 099700)

This east-west vein is traceable from east of Great Longstone, westwards to a point west of Chelmorton. The author has not examined the east end of the vein, but in Monsal Dale, at Putwell Hill Mine (178718) in the D_2 basinal strata, the vein was worked for calcite, in the 1920's. However, there are many stringers of fluorspar in the wall rocks. West of Taddington, on the Wham Rake section of the vein, above the Upper Miller's Dale Lava, the hillocks have been washed for fluorspar and barites. Near Chelmorton, low down in the massif type D_1 beds, below both Miller's Dale Lavas, the vein has been worked for calcite (099700).

The Arrock-Taddington Dale-Priestcliffe Fault (115737 to 209674)

This 8 mile long northwest fault system is principally calcite. It can be traced from Flagg Dale (115737) southeast for 8 miles to a point at its junction with the Mogshawe Vein, south of Bakewell (209674). West of Ashford, it has been worked for calcite and a short stope occurs (184699).

Dirtlow Vein (162700 to 198683) (see Paper on Geology of Magpie Sough and Mine)

Northwest of Sheldon, in Deepdale (164698) and also to the north of Sheldon, in Magpie Sough (177691) the vein is calcite. However, east of Sheldon, near Kirkdale (182688), in opencasts, the foot-wall of the vein is calcite, while the hanging wall is fluorspar and has been worked by drag-line. East of Kirkdale to 188687, trial opencasts proved some fluorspar, but the vein is dominantly baritic here. The vein occurs in D_2 strata of basinal type.

MogshaweVein-Magpie Mine-Hard Rake (209674-157682) (see Report 14 in Part 6 for details and plans)

This vein has been worked extensively for lead inthe 19th Century. On The Mogshawe section of the vein (203676 to 173678) the gangue is fluorspar and barite in D_2 strata of basinal type. Above the first toadstone barite increases along the vein to the west. Fluorite grades of up to 60% have been obtained from deep opencasts for 1 mile west of Green Cowden Farm (196678) and fluorite can be traced in old workings for ½-mile east of Green Cowden. The Mogshawe section of the vein is thought to have mining potential for a mixed fluorspar-barites ore. West of the Kirkdale Road (178678) the hillocks have been worked for low-grade fluorspar and barites towards Magpie Mine (173682). In this mine, at 560 foot level, the vein is calcitic, but reports from workings in the 1950's suggests that as the workings proceeded east towards Trueblue Mine (178680), rises up off the 560 foot level, intersected a good fluorspar vein in D_2 basinal strata. Some of the shallower workings on minor veins around the Magpie Mine, carry fluorite. The main Mogshawe-Hard Rake vein appears to pass south of the Magpie Mine, splitting into a vein complex to the west and eventually becoming Hard Rake and associated parallel veins. At the west end of Hard Rake Plantation, fluorspar was worked from an incline put in during the 1950's (157682). In all, a total length of 4 miles is known to carry at least intermittent fluorspar in D_2 strata. Traces of fluorite occur in D_1 strata, but no ore is known. The author's detailed account 'The Geology of Magpie Sough and Mine' was published in 'The Bulletin of the Peak District Mines Historical Society', vol.6, No. 2, October, 1975, and is submitted as part of this thesis.

The Mandale Vein (160700 to 195660)

This north-west vein is traceable for 3 miles from Lathkill Dale towards Hard Rake. The vein is dominantly barites, but fluorspar occurs. A mixed low-grade fluorspar-high barites residual ore has been opencast from the vein, near Haddon Grove (184666) although at depth the vein is principally calcite and barite. The vein occurs in D_2 limestones of basinal type.

The Lathkill Dale Vein (182658 to 207664)

This east-west vein is dominantly calcite with haematite and ochre in Lathkill Dale. From a point just west of Over Haddon (199660) it becomes fluorite bearing and this may continue to the east, where in Haddon Fields, the vein has never been worked. The change to fluorite occurs at the crossing point of the east-northeast Bakewell Anticlinal system. The vein occurs in D_2 limestones of basinal type.

Other Fluorite Occurrences in the Lathkill Drainage Basin

Fluorite-rich silica rock boulders have been ploughed up along a north-west vein, to the northwest of Over Haddon (198688).

Low grade fluorspar barites ore has been worked on Crotie Rake near Wheel Farm, on a series of northeast veins (153697). On the Hubberdale Pipe, a northeast cross vein at 137704 proved a rib of fluorspar in an otherwise baritic vein. Recent exploration show that fluoritisation of the wall of the pipe could be very extensive. The pipe occurs below wayboards, but above the Upper Miller's Dale Lava in the D_2 limestones of massif type. Near Monyash at 149677, an east-northeast vein carries fluorite which is exposed in a small quarry in the Cawdor Reef limestones. In Ricklow Quarry (165663) in Cawdor reefs, a pre-mineralisation solution cavity largely filled with calcite and calcite sand, contains a 1-inch purple fluorite layer. West of Monyash around the Whin 137666 and 137674, east-northeast calcite veins carry a little fluorite in the dumps. These occurrences are in the D_2 limestones of massif type.

<u>The Long Rake Vein System</u> (270665 to 132646) (see Reports 1, 2, 3, in Part 6 for details)

This is the longest vein system of the orefield, traceable for 12 miles, from east of Rowsley westwards to Coates Field Farm near Parsley Hay. The vein is dominantly fluorspar in D_2 Cawdor limestones of reef and basinal type from its emergence from beneath the shales at Pickery Corner (240658) westwards to Conksbury Pit (207650) north of Youlgreave. Here, and at Raper Pit (217654) the vein and associated replacements have been worked for fluorspar in D_2 limestones above the Alport toadstone in large scale open; casts (see Report 3 in Part 6). At Conksbury Pit the vein splits throwing off a southwest branch which carries fluorite for 1½-miles. The main vein continues west-southwest carrying fluorspar for about 1000 feet from the junction. The vein gradually breaks up to the west of the pit into several branches still carrying fluorite. For 3000 feet to the west of these, the vein has never been worked and then the east end of a series of opencasts and stopes for calcite and lead are intersected (199647). West of these the vein has been worked for calcite at the Long Rake Mine (182640) in the east, and the Arbor Low Mine (172640) in the west, for a length 3 miles and to a depth of 400 feet. The change in the vein from fluorite to calcite occurs at the crossing of the north-south Bakewell Anticline in the unworked section of the vein. All the known fluorite occurs above the Alport toadstone which dies out to the west in the unworked area west of Conksbury Pit. Whether the vein is calcite or fluorite below the toadstone, east of, and under, Conksbury Pit, is unknown. West of Arbor Low Mine, the vein throws off a northwest branch (165640). This carried fluorspar and barites and after 1 mile intersects a major east-west calcite vein (152646) which can be traced for 2½-miles to the west of Cotesfield Farm. Some fluorite replacement occurs in dolomitised wall rocks at 154646. The main Long Rake continues west of Arbor Low Mine for 1 mile before swinging north-west to intersect the same calcite vein at 138647. A few showings of fluorite are present, but it is mainly calcite here. West of Raper Pit the workings are in D_2 Monsal Dale Beds, principally of massif type.

The Alport Mining Field (see Report 4 in Part 6 of thesis for details and plan)

This is an area of northeast, northwest and eastwest veins and pipes. Many of these carry fluorite above the Alport toadstone but the nature of the veins in depth is unknown. Fluorspar has been worked from the dumps of the Blythe Mine (225643), Guy Vein (221639), Harthill Dale Pipe (218644), Pynet Nest Shaft (216638) and Kirk Meadow Shaft (234644) to the south of the rivers Bradford and Lathkill. North of the Bradford towards Long Rake and north of Youlgreave, several northwest and one northeast vein have been worked for fluorspar by small scale opencasts around 213647. The various workings are in Cawdor limestones of reef and basinal type and in the upper Monsal Dale Beds of massif type.

Middleton by Youlgreave

The southwest vein off the Long Rake, at Conksbury Pit, carries fluorite into this area as far as 194639. This is in Upper Monsal Dale Beds of massif type and Cawdor reef limestones. Parts of the Cawdor limestone reefs at 188636 are fluoritised from minor veins. To the west on Middleton Moor, several

PIPES AND VEINS OF THE WINSTER ELTON AREA

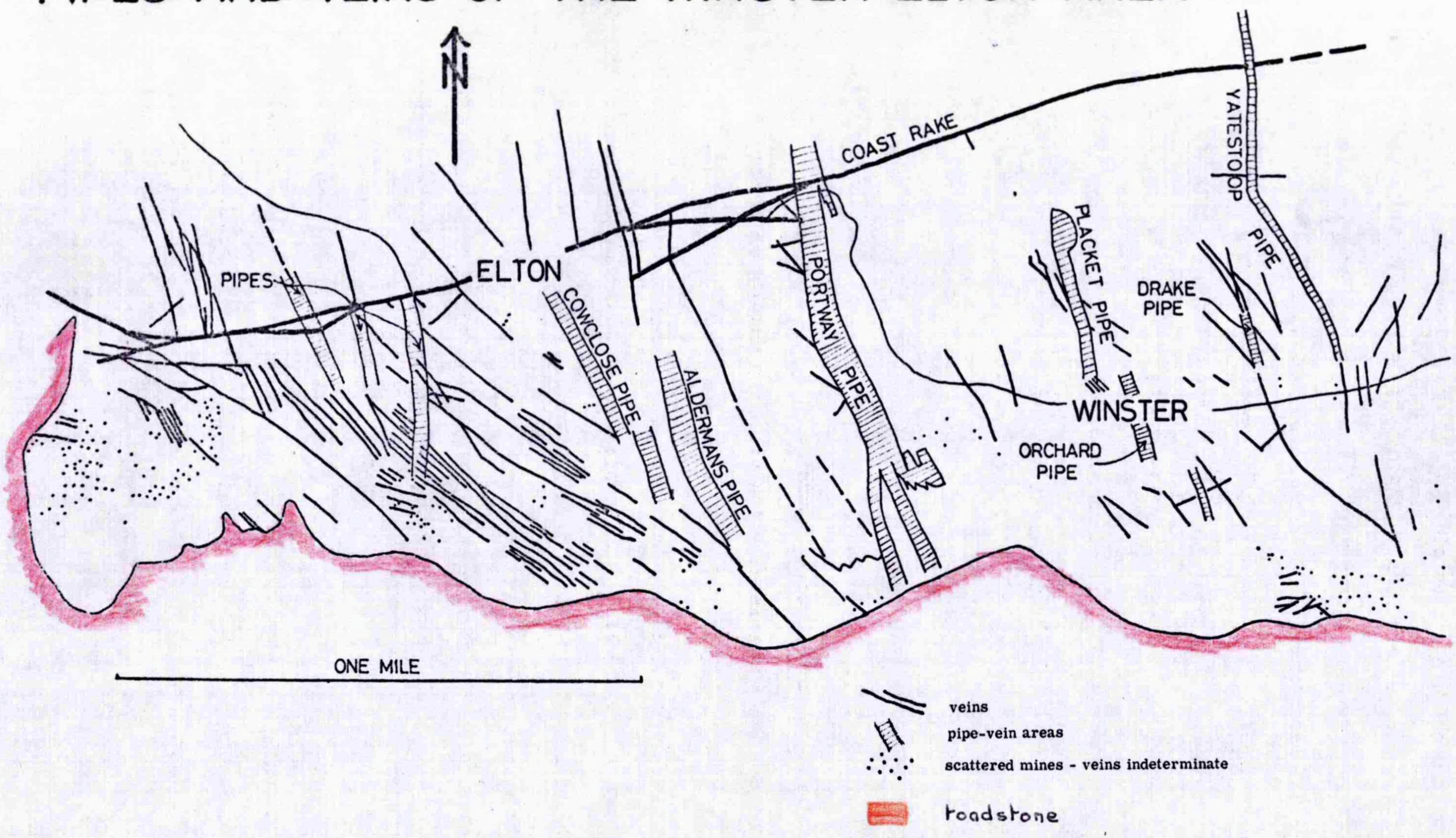


FIG. 13.

minor fluorspar deposits occur as stockworks and replacements in dolomitised Monsal Dale limestones near Mere Farm (180630, 168630 and 173627) and at Green Lane Pit (166626). Fluorite stringers are known in similar dolomitised strata at Kenslow Pit (183616). Near Smerrill, small north-east and north-west veins carry fluorite around 198623 in massif type Monsal Dale beds. The Timperley and Wenley Hill veins carry fluorite east of the River Bradford in Cawdor reef limestones (203635, 208637 respectively).

The Coast Rake and Associated Pipes (246616 to 202613) (see Fig. 13 for plan)

This east-northeast vein carries fluorite from east of its intersection with Yate Stoop Pipe (246616) (east of here the vein dies out) to west of Gratton Dale (202613), a distance of 4 miles, in D_2 limestones of massif and basinal type. On the east end, east of the Portway Pipe intersection (230613) the Allied Chemical Company has proved a major fluorite ore body stretching below the upper toadstone (the Matlock Lower Lava). The vein is probably fluoritic through Elton village (225610) to Gratton Dale (210610) although this section has not been examined by the author. On the west side of Gratton Dale, trials have proved a strong fluorite vein above the Matlock Lower Lava and this can be followed as a northwest branch of the Coast Rake for ¾-mile to a shallow open pit worked for fluorspar at 202613. Here the vein is only a series of stringers. To the south of Coast Rake, in Gratton Dale, a series of northwest minor veins carrying fluorite cross the dale. At the north end of the dale, the hilltops on either side are intensely dolomitised while the lower slopes are limestone.

Passing south up the dale, the dolomite descends abruptly to the valley floor along a small vein at 205603. Here on the north side of the valley a fluorite flat is exposed in the D_2 dolomite. Extensive drilling and trenching by Alcoa on the hilltops to the northwest of the dale, proved many showings of fluorite replacement in dolomite, but failed to locate an orebody. East of Gratton Dale, on the flat hill tops of Elton Moor, are

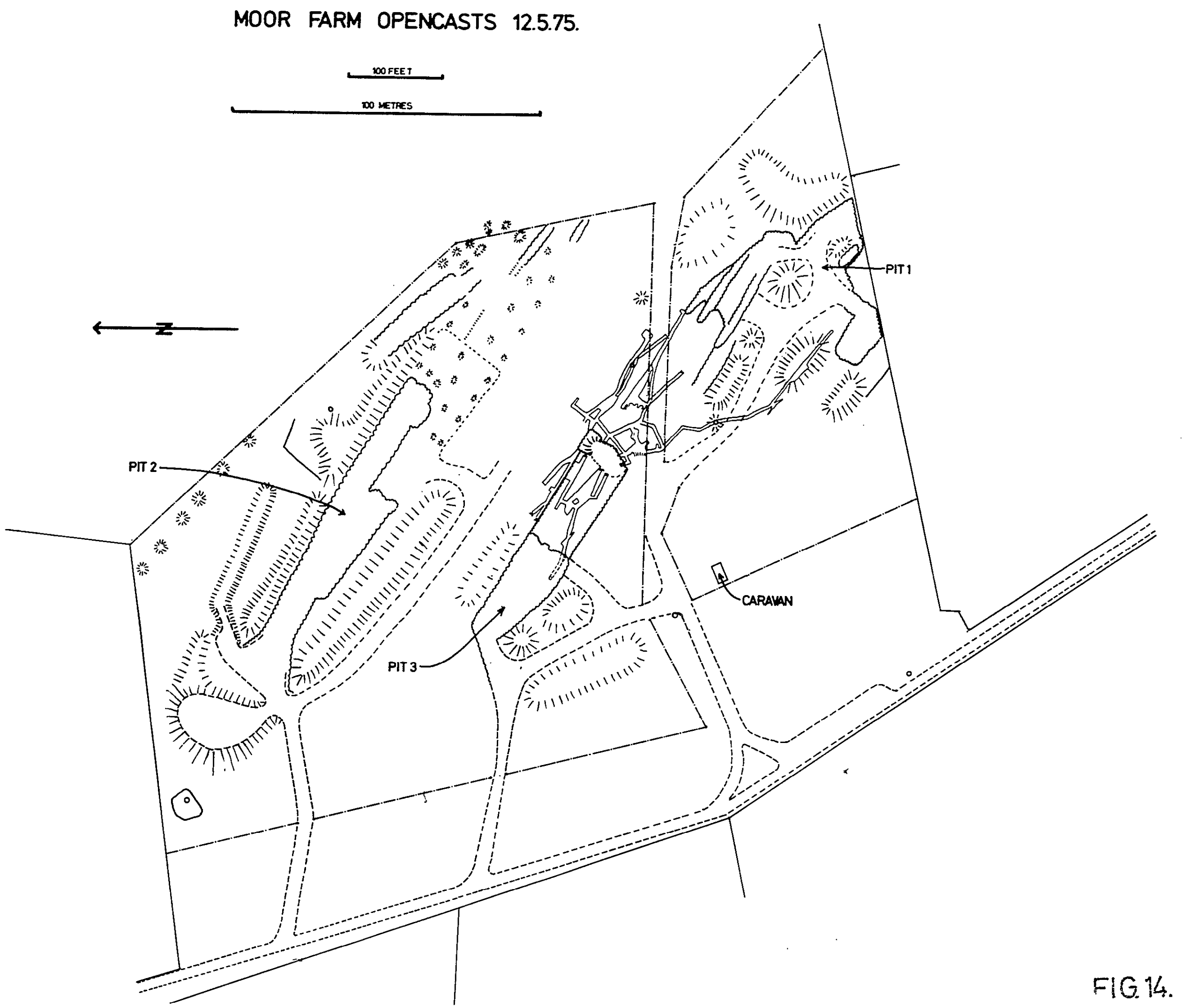

MOOR FARM OPENCASTS 12.5.75.
100 FEET
100 METRES
N
PIT 1
PIT 2
PIT 3
CARAVAN

FIG. 14.

GENERALISED SECTION OF THE MOOR FARM PITS

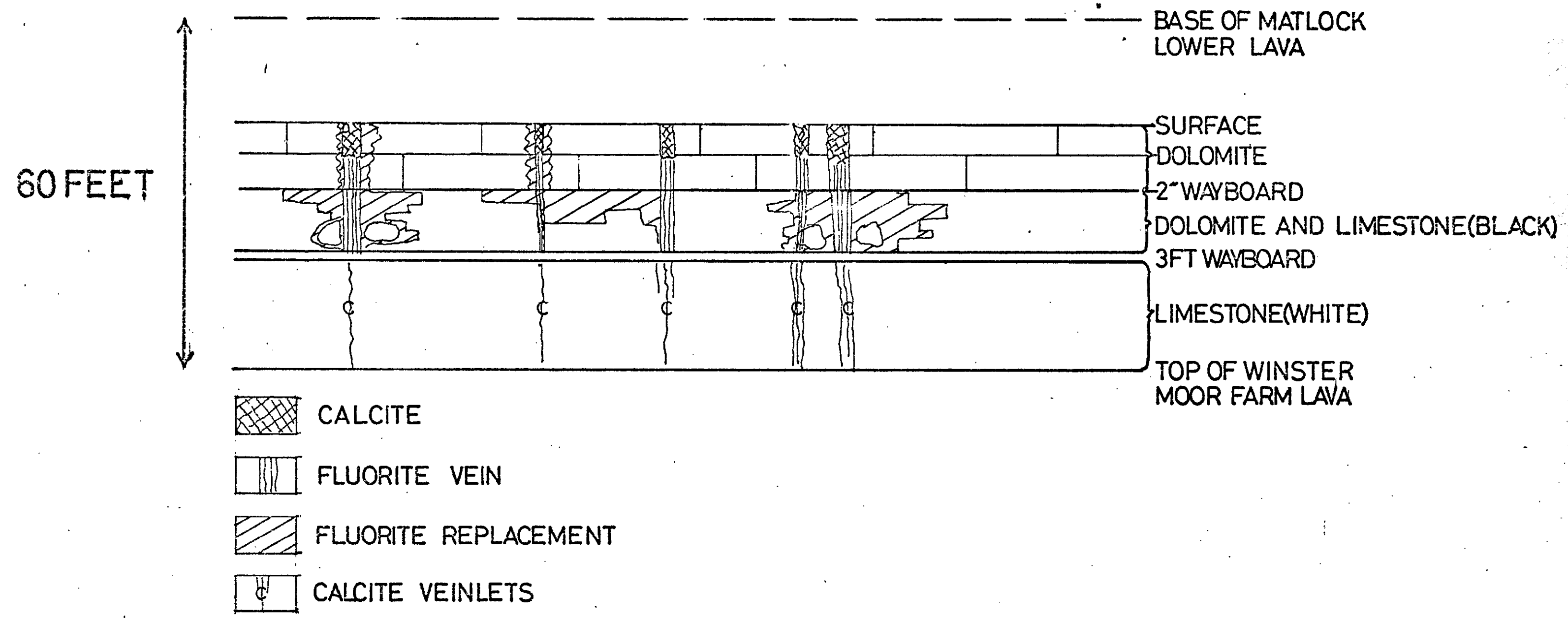


FIG.15.

TEARSALL OPENCASTS

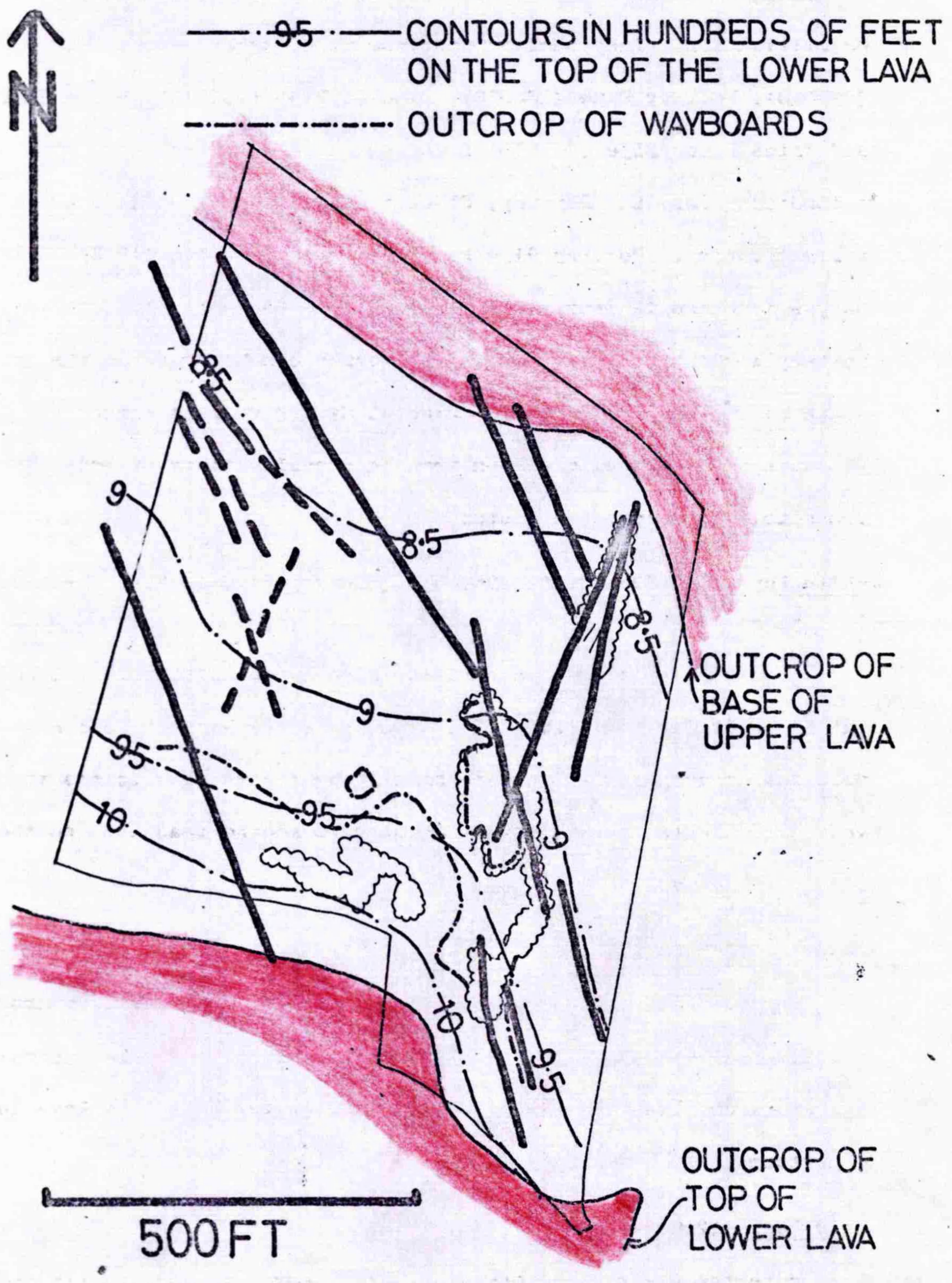


FIG.16.

a swarm of northwest veins, which need to be tried for fluorite especially below the Matlock Lower lava.

Running south-southeast, updip off the Coast Rake, are a series of pipe ore bodies. These lie above the Matlock Lower Lava, possibly at the base of dolomitisation. They include Cowclose Pipe (225609), Alderman's Pipe (228610), Portway Pipe (230613), Placket Pipe (239612), Drake Pipe (242610) and Yates Stoop Pipe (243615) from west to east. They were all rich galena orebodies. Only the Portway, Placket and Yates Stoop Pipes are known to carry fluorite. Portway Pipe was described by Dunham (1952) as having a baryte core and fluoritised margins on the 360 foot level of Fisher's Portway workings. Some fluorite epimorphs can be found on the dumps to the south at 230600. The dumps at Placket Mine have been worked for fluorspar. At Yates Stoop Mine, dumps on the old dressing floor at 244613 have been found to contain some fluorspar.

White Low Rake (234595 to 226604) (see Report 6 in Part 5 for details and plan)

This northwest vein is baritic in dolomite above the Matlock Lower Lava but below it for a distance of ½-mile above the Winster Moor Farm Lava, in dolomitised ground, it contains high grade fluorspar. In the toadstone the vein was calcitic. Its content below this second toadstone to the south-east is unknown.

Sacheverall Farm (230594)

Here a zone of many narrow parallel veins in dolomitised ground, carries fluorspar, which replaces the walls in places. The deposit bottoms on limestone and lies immediately below the Winster Moor Farm Lava in D_1 limestone.

Moor Farm (250594)

Here the walls of a zone of parallel north-west veins are patchilly dolomitised in two places (see Figs. 14, 15 for plan and section). The deposit consists of fissure fillings and marginal replacements and cavity fills of fluorspar in the dolomite. Adjacent limestone areas are weakly mineralised. The deposit lies immediately below the Matlock Lower Lava and above a 3 foot thick wayboard, 30 feet above the Winster Moor Farm Lava. It is probable that similar ore bodies lie to the west towards the Whitelow Rake fluorspar deposit which is at the same horizon.

Blakelow Lane-Beans and Bacon Mine (262593 to 255593)

A network of east-west and north-south tight veins and ramifying stringers carry fluorspar here in silicified limestones. The deposits include some toadstone clay and are calcitic in places. They are in probably D_2 limestones below the Matlock Lower Lava and above the Winster Moor Farm Lava.

Tearsall (264601)

A replacement fluorite ore body is developed amongst and is capped by wayboards, half-way between the Matlock Upper and Lower Lavas. The deposit occurs on an intersecting north, northwest and northsouth minor fault system on the crest of a north-trending and plunging minor anticline (see Fig. 16 for plan). The deposit is also developed at the base of dolomitisation. The basal Matlock beds here, are very dark, bituminous basinal limestones. These have not been replaced on top of the Matlock Lower Lava, as at the Masson Flat, where in contrast, the basal Matlock beds are coarse, white calcarenites, receptive to replacement. To the west at 259601, a similar deposit occurs but here only surface dumps have been worked. Extensive dumps of low grade fluorspar at 256607 suggest that there may be deposits at depth here, below the Matlock Upper Lava. One high grade fluorspar vein trending north-south occurs to the south of the Big Dungeon (259607) above the Matlock Upper Lava. These ore bodies lie updip of the Millclose manto. This deposit however, lay above the Upper Lava, whereas most of the Tearsall deposits lie beneath it. To the north-east of Tearsall, at 267605, west of Northern Dale, a swarm of north-east veins and pipes have been worked for fluorspar in narrow opencasts in Cawdor reef limestones. Further east along the crest of the hill, above the Matlock Upper Lava, large dumps carry fluorite at the junction of north, northwest and northeast veins (272598).

The Millclose Mine (258617 to 249650)

Large dumps of low-grade fluorite ore occur at Watt's Shaft (258617) probably derived from workings to the north above the Matlock Upper Lava. To the south of the brook, large dumps with fluorite occur towards Wensley. A system of fluorite-rich pipes of north-south trend is known here below the shales and above the Upper Lava. Recently, the major tailings ponds from the main Millclose workings at Warrencarr Shaft, have been reprocessed for an average of 24% fluorspar (263624). Fluorspar was the main gangue of the 1920's Millclose workings above the Upper Lava, but below this the fluorspar occurred only as a replacement of the wall rocks and calcite was the dominant gangue.

Oxclose Mine (276598)

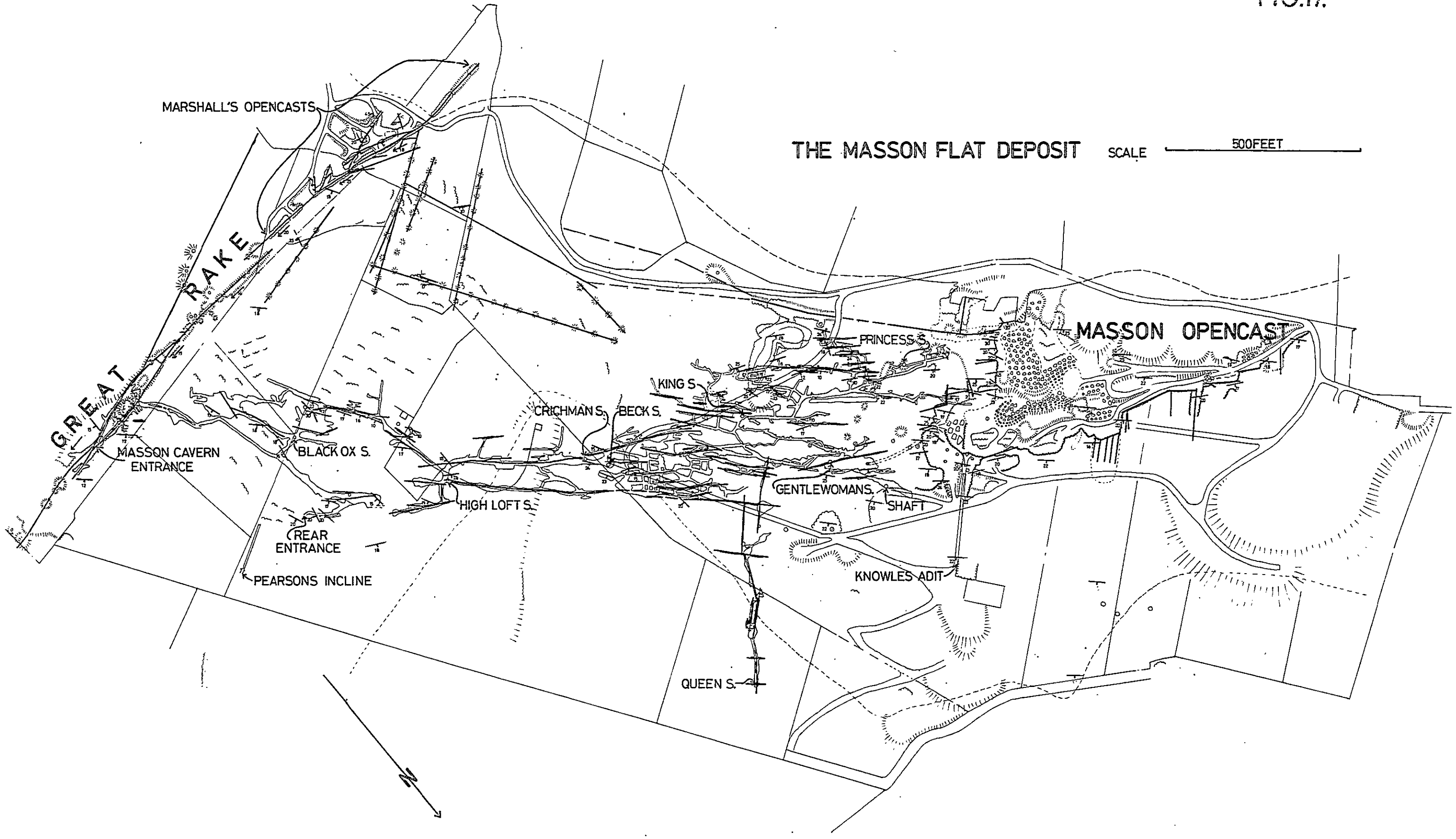
This worked a flat deposit of fluorspar in massif limestones below the Matlock Upper Lava and a second one on the Matlock Lower Lava. Extensive ramifying workings in pipes and flats extend updip, controlled by northeast joints and veins. These outcrop between the Upper and Lower Lavas near Lee Wood (275595) and here the dumps carry much fluorspar. Further to the west at 273596, a parallel series of veins outcrops between the lavas and these too carry fluorite.

Jugholes Mine (279595)

This lies on a series of north-south veins and minor faults. The deposit is a fluorspar flat associated in its upper parts with dolomitisation. The lower part lies below a 1 foot wayboard about 15 feet above the Matlock Lower Lava. This has been worked both by undergound and opencast methods and is a replacement of coarse, white calcarenitic limestones.

FIG.17.

THE MASSON FLAT DEPOSIT SCALE 500FEET



Masson Flat (284592 to 289590)

This is a flat deposit varying between a metasomatic replacement and a cavity lining. It is developed along the north-west series of joints, many of which are minor fault monoclines. These throw down to the north-east. Northeast cross joints occur and pipe-like cavity linings extend down dip along these at Queen Mine (289592). The flat occurs generally in D_2 massif limestones from 10-20 feet above the Matlock Lower Lava, but some joints have wall-like replacements and joint intersections have chimney-like continuations, both of which may rise as much as 70 feet above the lava to a thick 1 foot wayboard. The deposit occurs partially at, and below, the base of dolomitisation in coarse calcarenites and appear to have been fedd from the Great Rake to the south-east. It lies on the same zone of fractures as the Rutland Cavern and Station Quarry veins to the south-east (see below) (see Fig. 17 for plan).

The Seven Rakes-Slit Rake-High Tor Rake (295610 to 300588)

The north-south Seven Rakes has been worked for fluorspar in D_2 massif limestones and Cawdor Limestones above the Upper Matlock Lava from Cawdor Quarry (295603). The vein was drilled here by Johannesburg Consolidated Investments during the 1950's in an attempt to prove fluorspar below the Upper Lava, but this was unsuccessful. The vein splits to the south. The eastern branch, the Slit Rake was worked for fluorspar above the Upper Lava from a shaft at 297593 in the 1950's. The western branch, the High Tor Rake, carries a fluorite, but has not been worked.

The Great Rake (305590 to 280585) (see Fig. 17 for details of vein - see Reports 8,9,10 in Part 6 for details and plans)

East of the Derwent, this east-west vein has been worked during the 1950's for fluorspar in D_2 massif limestones and Cawdor Limestones above the Upper Lava at Riber Mine (300588). The vein lies on the crest of an east-plunging, south-facing monocline, but this dies out to the east and becomes the Riber Anticline. At the same time the vein breaks up, becomes calcitic and is lost. Below the Upper Lava, a trial shaft proved the vein to be calcite. West of the River Derwent the vein has been worked for fluorspar in places in D_2 massif limestones, between the Upper and Lower Matlock Lavas. Some parts of the vein are very calcitic however. Above the Lower Lava at 288587, in dolomitised ground to the south of the vein, is a replacement deposit, associated with minor faults. Below the Lower Lava, the vein has been worked in D_1 massif limestones for high grade fluorspar at Low Mine (284585) to a depth of 240 feet, below which the vein is calcitic. Workings did not proceed very far to the east, so the nature of the vein there below the toadstone is unknown. A recent drilling programme by Ex-Sud Limited, did not sufficiently prove the ground here. The base of the deposit is on the Bonsall Sill in the west, the eastern extent of which is not known. From the sill to Low Mine, the vein has been worked open-cast for fluorspar between massive silicified walls to an unknown depth.

<u>Rutland Cavern-Nestus Mine</u> (292586) (see Figs 2, 3 in Report 9, Part 6 for details of veins)

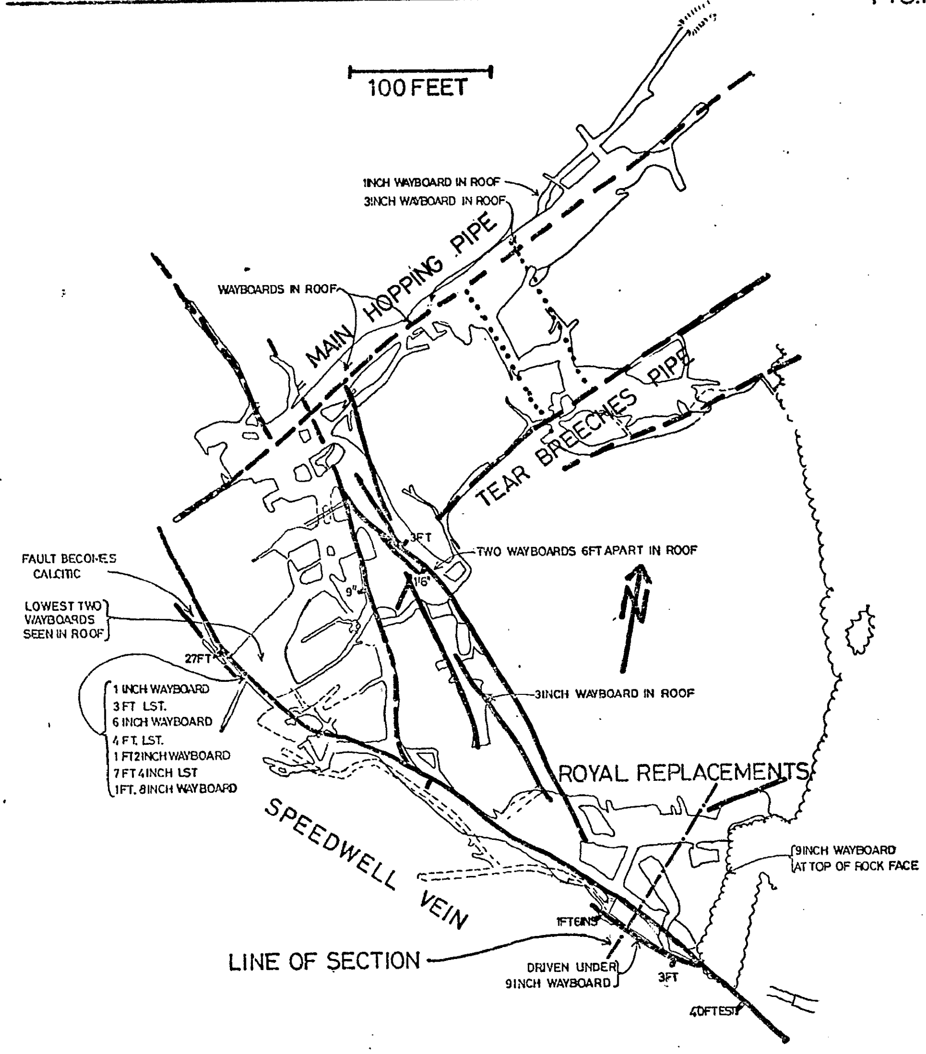
This is a series of pipe caverns lined and replaced with fluorite. They rise up the dip in a northwest series of joints on the face of the Great Rake Monocline in D_2 massif limestones between the two Matlock Lavas. It seems to be on the same system of joints as the Masson Cavern (but somewhat offset to the east) and the Station Quarry veins east of the Derwent. The system is crossed by the east-west Coalpit Hole Vein at the foot of the monocline.

<u>The Coalpit Rake</u> (283586 to 301589) (see Figs. 2,3 in Part 6, Report 9 for plan and details)

This east-northeast vein runs along the foot of the Great Rake monocline. It is a relatively tight series of minor fluorspar veins worked in dolomitised D_2 limestones between the two Matlock Lavas, both underground in the

THE ROYAL MINE HOPPING PIPE COMPLEX

FIG.18.



SURVEY BY R. FLINDALL

SECTION OF THE SPEEDWELL VEIN

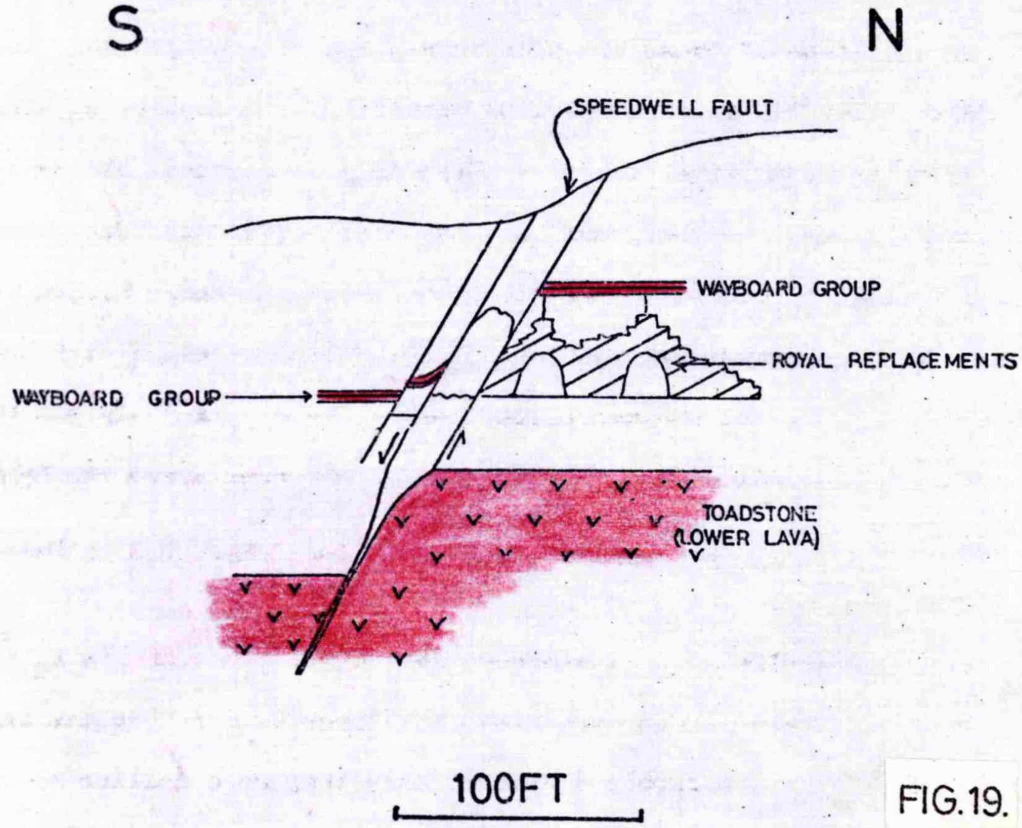


FIG.19.

Devonshire Cavern (289583) and in opencasts to the west, towards Ember Farm (287583). In Devonshire Cavern, fluorite flats are developed amongst a group of wayboards, but they become calcitic when followed down the dip. West of Ember Farm, below the Lower Lava in D_1 massif limestones, the vein system is continued by the Superfine Vein. This has not been worked. Between the Coalpit Hole vein and Great Rake, on the steep face of the monocline above the lower Matlock Lava, a whole series of tight, parallel, fluorite veins occur. Some of these are seen in depth at the Longtor Grotto Mine (296586). Below the Lower Lava in D_1 massif limestones east of Bonsall (284584) these veins give rise to a large area of massive, silica rock and fluorite replacement. The ground has been drilled and trenched by Acmin and a few rich pockets were found, but the area as a whole proved uninteresting. To the east of the Derwent, the Coalpit Hole vein coalesces with the Great Rake in Riber Mine and the monocline dies out here. The vein has been worked for fluorspar from Riber Mine in D_2 massif limestones above the Upper Lava.

The Station Quarry Veins (296583 to 289581) (see Figs. 2,3 in Part 6, Report 9 for plan)

These two parallel veins have been worked for fluorspar in D_2 massif limestones and Cawdor Limestones above the Upper Lava from adits in Station Quarry (299581) in the 1950's. At this time they were drilled by Johannesburg Consolidated Investments below the Upper Lava, but no developments resulted. To the south, towards Moletrap vein a series of northeast, northwest and eastwest minor veins carry fluorite.

The Speedwell Vein (292579) (see Fig. 18 for plan, Fig. 19 for section)

This northwest vein has been stoped for fluorspar in the Speedwell Mine at Upperwood in dolomitised D_2 limestone, between the Upper and Lower Matlock Lavas. The vein is a fault, throwing down 60 feet to the southeast at the entrance to the mine, but decreasing to the northwest and southeast. Northeast of the vein a series of flat replacements have developed on minor

THE WAPPING MINE COMPLEX

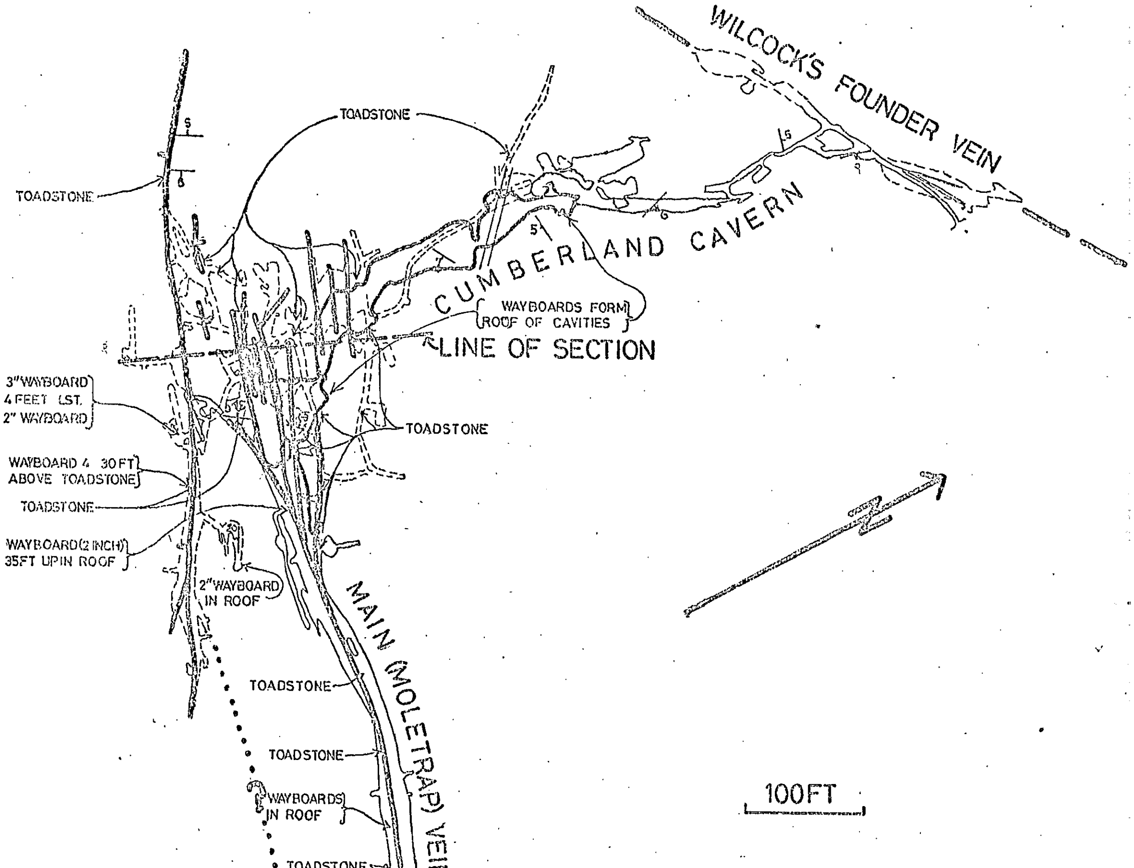


FIG. 20.

WAPPING MINE SECTION

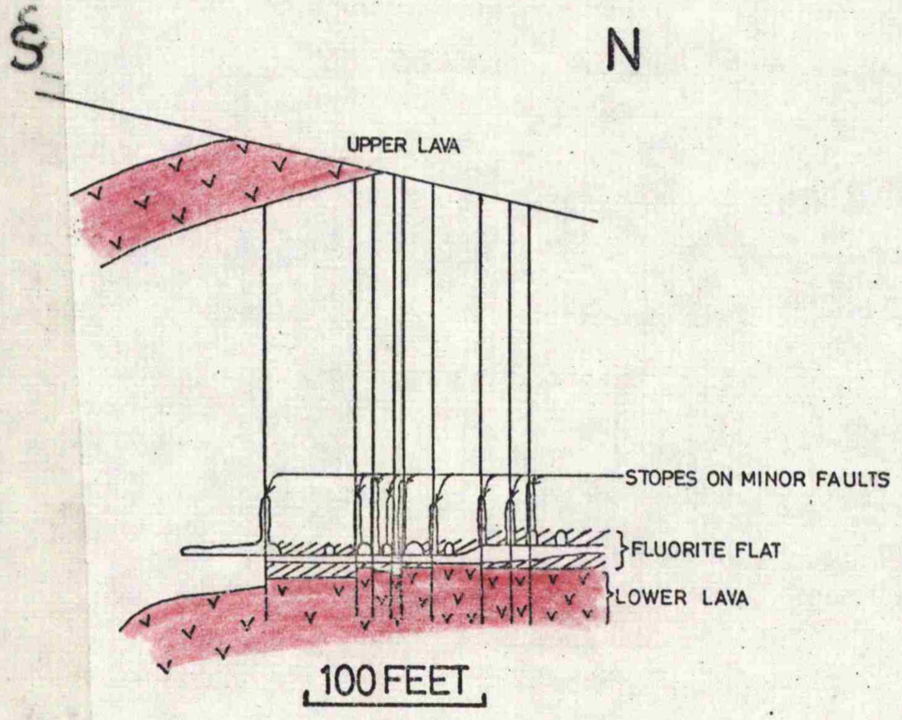


FIG. 21.

BLAKELOW PITS, BONSALL MOOR, SECTION

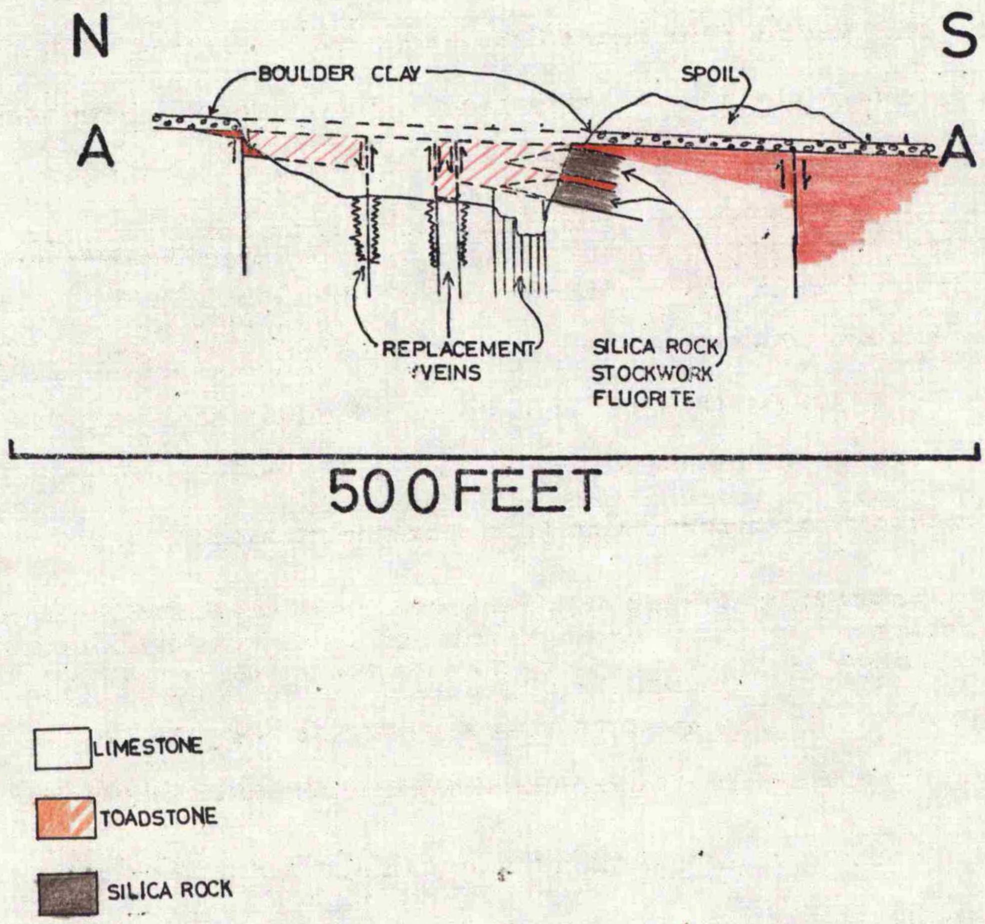


FIG.23.

faults splaying off the main vein and along northeast joints. Nearby, other small flats have been worked at Temple Pipe (293581) and Owlet Hole Mine (293580) and small areas of replacement can be seen between these and Speedwell Mine. The flats are confined between the Lower Lava and a group of wayboards some 60 feet above it.

Wapping Mine-Moletrap Vein (292575 to 321574) (see Reports 8,9 in Part 6 for details and plans)

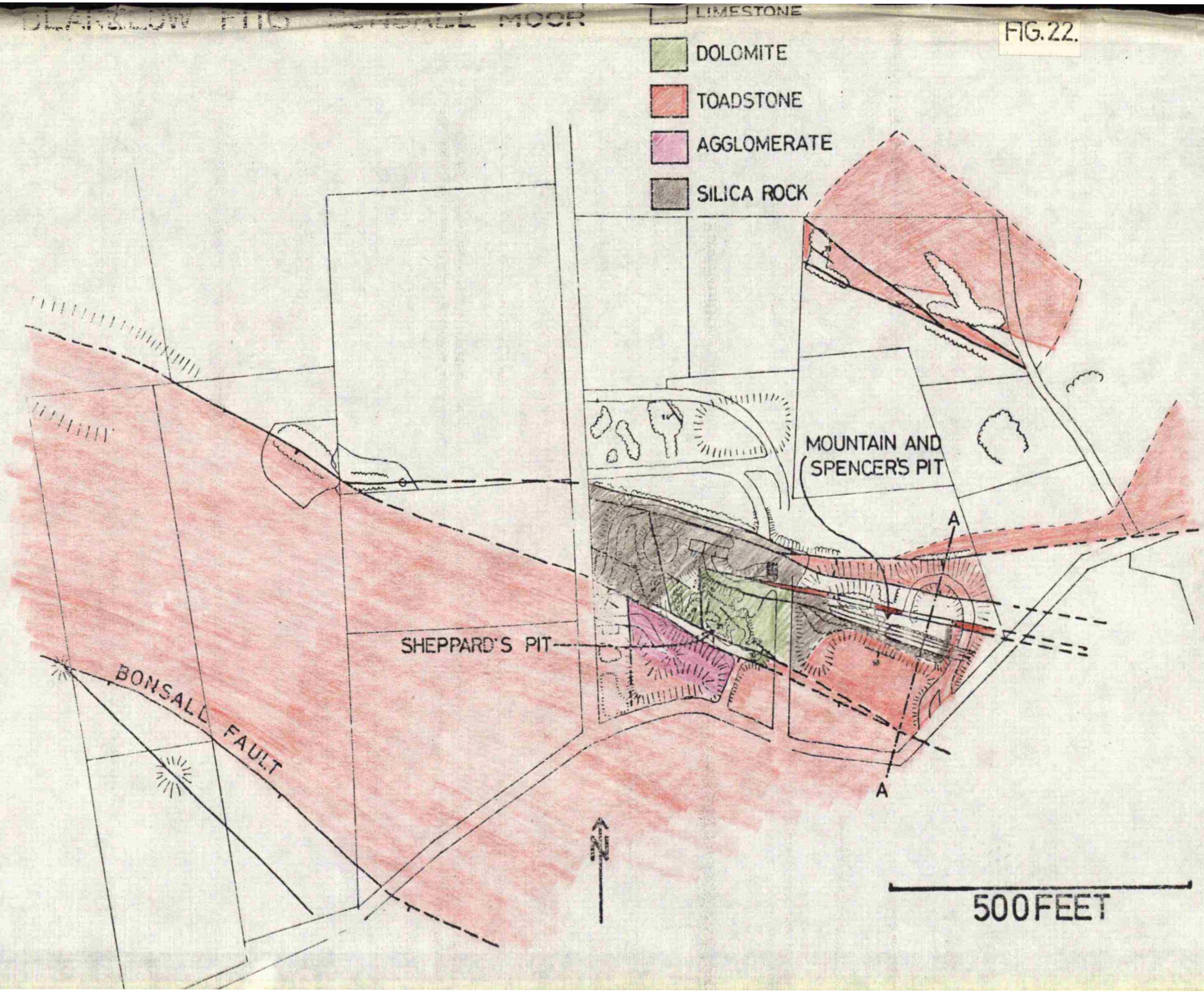
The eastwest Moletrap Vein can be followed from Lea Mills (321574) in the east, across the gritstone country where it is seen as two faults, to the New Bullestree Shaft, the easternmost working at 306575, east of Cromford Station. The fault throws down to the north here, and the vein emerges from beneath the shales in the grounds of Willersley Castle (300574). It is reported to be rich in fluorspar and about 10 feet wide beneath the shales. The vein outcrops south of Cat Tor on the east bank of the Derwent (297575) as a 20 foot wide zone of fluorite replacement and silicification between the two Matlock Lavas. The vein throws down 60 feet north at the river, but displacements decrease to the west, so that the throw is only 15 feet down to the north at the entrance to Wapping Mine (293574). (see Figs. 20, 21). Here the vein has been stoped between the Upper and Lower Lavas for fluorspar. To the west it breaks up into a series of northwest parallel minor faults and between them, on the Lower Lava, a fluorspar flat develops. The vein system is probably the same as the Ball Eye Rake, immediately to the west, across the Bonsall Fault and this is probably the same vein as the Great Rake of Bonsall Moor to the west.

The Bonsall Fault Zone

Harp Edge to Ball Eye Quarry (292573 to 287575) (see Report 15 in Part 6 for details)

The Bonsall Fault Zone is a heavily mineralised fault vein trending northwest here. At Harp Edge (291574) to the north of Ball Eye Quarry, several

FIG.22.



LIMESTONE
DOLOMITE
TOADSTONE
AGGLOMERATE
SILICA ROCK
MOUNTAIN AND SPENCER'S PIT
SHEPPARD'S PIT
BONSALL FAULT
A
A
N
500 FEET

parallel veins have been worked opencast for fluorspar in the Cawdor Limestones. Replacement occurs below the upturned Upper Lava in the main fault zone. To the west of Masson House (292573) a zone of fluorite veins 30 yards wide, is present below the Upper Lava, in the Matlock Limestones.

In Ball Eye Quarry (288574) Cawdor Limestones are faulted against Matlock beds to the north-east and a zone of faulting some 90 feet wide is present. The limestones here are dolomitised and a fluorite stockwork with replacement is developed. This varies from high to low-grade ore from place to place. In addition, some high grade veins are present. The ground has been worked while removing overburden from the quarry for a distance of ¼-mile. At the northwest end of the workings, Namurian shale can be seen, probably not quite in-situ, and let down by solution collapse. The belt of mineralisation may be followed to the northwest to Bonsall Village, through a series of small fluorspar trials at 285578. Here trenching has proved several parallel veins to the northeast, in dolomite. The structure of this area is described in report 15 in Part 6 of the thesis.

Bonsall Village (276583)

Here fluorspar has been worked on the Bonsall Fault, which throws toad-stone of the Bonsall Sill against D_1 Hopton Wood limestones. The workings are now backfilled.

Blakelow Pits (263589) (see Figs 22, 23 for plan and section)

An extensive ramifying fluorspar replacement deposit is developed on west-northwest joints and minor faults, in D_1 Hopton Wood limestones below a toadstone,perhaps the Bonsall Sill. This dips to the south here, into the adjacent main Bonsall Fault. The fluorspar ore lies below a silica rock cap, which in places is a fluorite stockwork. Immediately to the southwest of the main pit, is a second deposit again lying below the Bonsall Sill, but this is a fluorite replacement stockwork in dolomite. It occurs agains a faulted mass of agglomerate. It is probable that extensions of the deposit lie to the east and west of the workings.

Pit to the West of Moor Farm (249590)

This pit lies west of Moor Farm and is a de-calcitised siliceous fluorite replacement below thin wayboards. It is of low uneconomic grade as at present exposed. It is reasonable to expect that a siliceous fluorite ore body extends to the east to Blakelow Pit, below a thin toadstone on the up-throw side of the Bonsall Fault.

Sacheverell Farm

To the south of this, trials have been made in two fluorite-bearing calcite veins in D_1 limestones at 226590 and 223588. Only low-grade material was produced and the trials were quickly abandoned. These are the westernmost occurrence of fluorite known tothe author on the Bonsall Fault system in the Matlock area.

The Bonsall Fault Southeast of Matlock (307573 to 353540)

The Bonsall Fault trend is taken up by two parallel north-west faults in the shales of the Derwent Valley. The more northerly of these is the Crich Fault and both throw down to the southwest. They follow the crest of the shallowly buried south-east extension of the Matlock Anticline towards Crich and they could be fluorite-bearing in the limestone.

Crich

The Crich Dome is mineralised with fluorite mainly at the northern end. Here northwest, northeast and north-northeast trending scrins form an intersecting network. The principal vein is the Great Rake which was proved to be fluorspar above and calcite below the Matlock Lower Lava at Glory Mine (342559) and Old End Mine (346556). Along the western margin of the system runs the north-south Wakebridge Pipe. It is not clear why only the northern area is mineralised. The vein minerals are unoxidised and no dolomitisation occurs so that it seems the area has been covered by shales until a relatively recent geological period.

Ashover

This is characterised by a series of northwest, northeast and eastwest fluorite veins mainly in the south of the inlier. The most important of these was the Gregory Vein (343617) which dipped west under the shales for 1 mile. As it was worked down-dip it became calcitic. Most of the veins on being worked down-dip under the shales, became tight and died out. The main concentration of fluorspar occurred therefore where the flexure on the Dome was at its greatest in the south and southwest. At the northend of the inlier is the Town Head-Westedge vein system (344633) which was worked for fluorspar mainly below the shales. To the north of this, for three or four miles, are several northwest and east-west faults in the shales and grit-stones. It is reasonable to suppose that these may carry fluorite in lime-stones below the shales, at least along the extension of the Crich-Ashover Anticline.

The Ball Eye Mine (286574) (see report 15 in Part 6 for details and sections)

Three types of deposit occur here in the D_2 Matlock beds above the Lower Lava. Firstly there is the east-west Ball Eye vein, which is dominantly calcite. On either side of this, the Ball Eye fluorspar flat is developed on top of the Lower Lava, on a series of north-northwest joints. Finally there is the Ball Eye Pipe, a series of purple fluorite-lined caverns, descending down the dip of the beds towards the Bonsall Fault. To the north-west towards Bonsall a series a northwest trending pipe caverns is developed. These lie above the horizon of the Matlock Upper Lava and contain fluorspar.

Whitelow Rake (Bonsall Moor) (257583)

This strong east-west vein has been worked in the D_2 massif type Matlock limestones, by shafts and opencasts for high-grade fluorspar for a length of ½-mile and to a depth of 90 feet. To the west the vein breaks up and becomes more baritic. At Shepherd's Pit (264583) a large decalcitised fluorspar replacement deposit occurs at the junction with several northwest vein.

Bonsall Moor Veins (see reports 6, 11, in Part 6 for details)

An intense plexus of northwest and northeast and east-west scrins and veins have been worked intermittently for fluorspar and barites in massif type D_2 Matlock Beds above the Lower Lava. Several larger west-southwest veins cross this system, such as the Great Rake and the Parson's Rake. It is probable from the intensity of veins in the centre of the moor that many others await discovery in the less intensely worked parts of the area. Dunham has suggested that a major fluorspar flat may be developed on the Lower Lava here. The veins are dominantly fluorite-barite above the lava, but are calcitic below it, as seen in deep adits driven from Via Gellia, such as Thunder Mine (273572). Some fluorite is present below the Lower Lava, at Goodluck Mine (270565) and at 277570 on the south side of the Via Gellia but generally only calcite-barite scrins are developed in the D_1 Hopton Wood limestones here.

The Aldwark Area (see Report 7, in Part 6 for details)

Three occurrences of fluorspar are known here. In Ivonbrook Quarry (233585) fluorite occurs in massif type D_2 Matlock limestones above the Lower Matlock Lava on an east-west fault filled mainly with calcite and haematite. At Greenlow Farm (223581) excavations proved fluorite, a little above the Matlock Lower Lava. Excavations at Slipper Low Farm (220569) proved fluorite below the Matlock Lower Lava, adjacent to an east-west fault.

South of the Via Gellia, East of the Gulf Fault

Structurally this area is the continuation of the Bonsall Moor area, but the veins are more baritic. At 274567, some northeast-trending veins have been opencast for fluorspar above the Lower Lava. At Bowlpit Mine

(277570) 2 feet of fluorite is present on a northwest vein below the Lower Lava. Minor fluorspar can be also found in the Goodluck Mine (270565). At Slinter Wood (285571) a series of pipes associated with dolomitisation occur in the cliffs and are lined with fluorite and barite. These are in the Matlock limestones. To the south on the hilltop above the valley, a series of east-west veins and associated pipes have been worked for fluorspar and barites amongst reef and off-reef Cawdor limestones (285569). Further south, fluorite is present on the dumps of the Upper Tenth Mere Shaft on the Gang Vein (294557) but the gangue is dominantly calcite. Some fluorite is present on the vein further west at 286557.

West of the Gulf Fault

Fluorite is known as solution cavity fills in the massif D_1 Hopton Wood limestones of the Middleton Mine (276556). This is associated with east-west faults branching off the north side of the Gang Vein which trends south-west here. At Golconda Mine (249552) a little fluorite is known in the dolomitised upper levels. Further west at 237557, near Longcliffe a 3 foot joint carries fluorite in dolomite. Fluorite is said to occur on Costa Rake somewhere on Carsington Pastures.

Yokecliffe Rake (286538 to 252535)

This vein is dominantly calcite, but in D_1 limestones north of Godfrey Hole, fluorite is said to be present (267537). To the south of Godfrey Hole, near Dream Mine, fluorspar was worked briefly in the D_1 limestones in the 1950's (273529).

Occurrences of Fluorite in the West of the Orefield

Fluorite occurs as late infilling in vughs at Ecton Mines (100580). Thin stringers are known at the Bincliffe Mines to the south-west (117539). Fluorite lines vughs at the Mixon Mine (045574). The author has noted fluorite north of Alstonfield at 121569. Bagshawe (personal communication) reports fluorite in the dumps around Newton Grange Farm (165535). Fluorite occurs as a zone of stringers at 062735 in D_2 limestones in Buxton, and there are reports of a strong vein in the town as well. Fluorite stringers are known to the east in S_2 limestones at Great Rocks Dale Quarries on an east-west fault at 108729. On Chrome Hill (070674) many stringers of fluorite are present in D_2 limestones and some of these are associated with a major northwest pre-Namurian fault to the east of the hill. This is not exposed and there could be a major deposit here. To the east, in the quarries south of Harpur Hill (079694), fluorite lines vughs in north-south calcite veins in the D_1 limestones. Further north, west of Buxton, fluorite occurs at Anthony Hill in D_1 limestones (046710) and at Burbage (037727).

3. Types of Fluorite Deposit

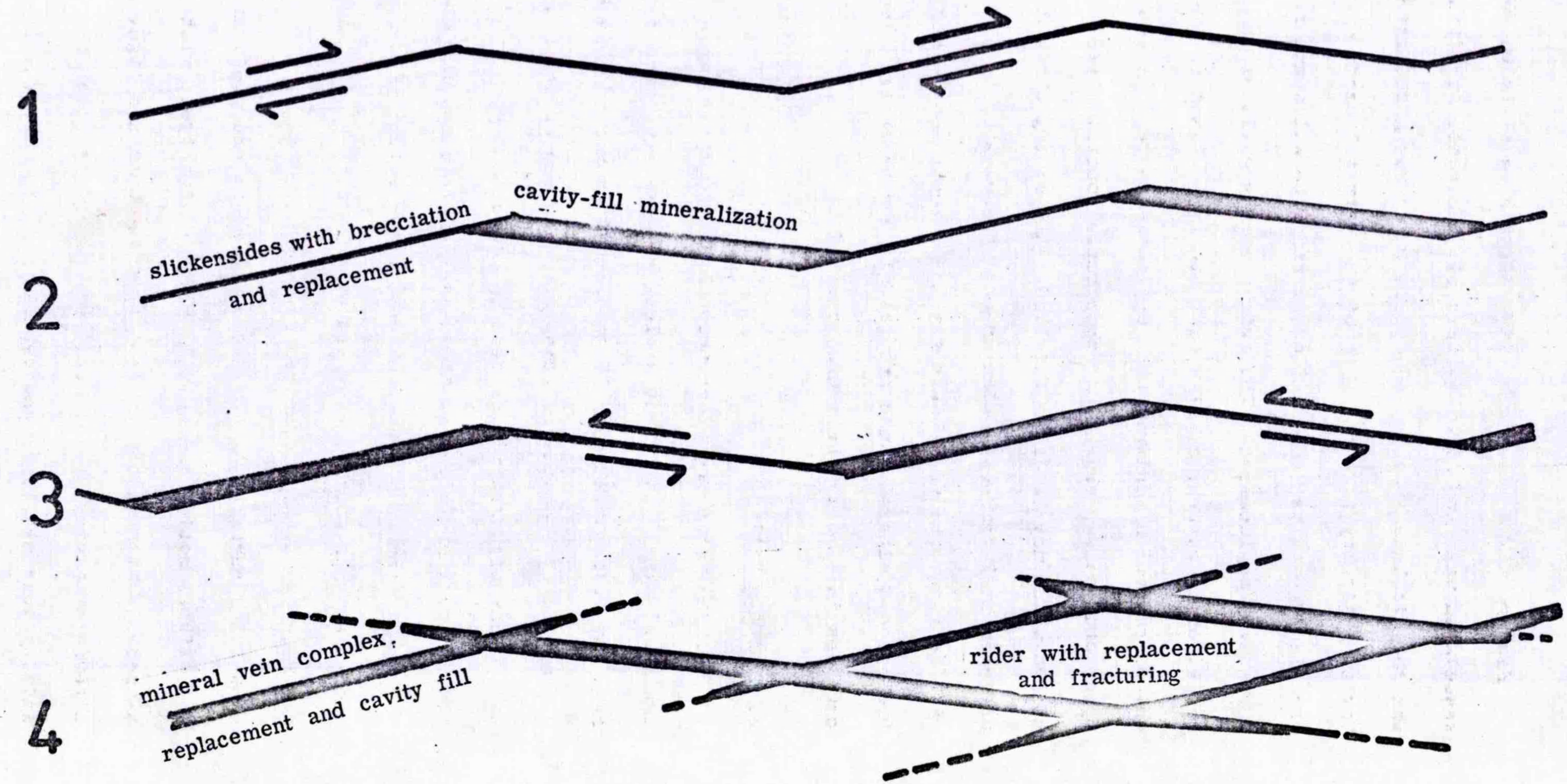
a. Introduction

Historically, the Derbyshire deposits have been divided by the old miners into rakes of veins, scrins, flats and pipes. Rakes are large, nearly vertical, fissures, traceable for one or more miles across country and which are infilled with minerals. These grade down to scrins which are the narrower fissures, shorter in length. Flats are orebodies of greater lateral extent than height whilst pipes are semi-horizontal and of greater length than width or height. These simple definitions and divisions need some modification when dealing with gangue minerals, especially when it is seen that any one ore body can show evidence of vein, flat, or pipe development in different parts or at different stratigraphic levels.

The Derbyshire mineral deposits may also be sub-divided in a different way into four basic types. These are fissure fills, cavity fills, replacements and detrital or residual ore bodies. In practice, any ore body may again be a combination of all these, one type often being dominant in one part of the deposit whilst another is dominant elsewhere.

FIG.24.

THE FORMATION OF A MINERAL VEIN



Fissure fills vary from simple single veinlets to multiphase veins with associated wall and rider (wedges of limestone, splitting a vein) replacement, and they include stockwork deposits which may grade into replacements. Cavity fills may take the form of the detrital sands on the bottom of the cavities or may be encrustations lining the walls and roofs with or without associated replacement. The origin of the cavities may be as pre-existing karst, or as caverns created by a pre-mineralisation solution phase, or during volume reduction replacement. Replacements vary between 'volume-for-volume' types and 'volume reduction' type replacements, where cavities form in the ore bodies which may be later infilled. Any of the above deposits may be affected by later weathering processes such as decalcification. This gives rise to fluorspar sand/barites gravel, residual ore bodies, at surface. Underground, mineral sands and gravels may be sorted and washed into karst cavities in or near the source ore body.

b. Fissure Fills

Mineral veins are often shown as straight lines on maps, but in fact they are rarely straight on any scale. The plans of Long Rake and the more detailed ones for Great Rake (Fig. 17 and Fig. 2 in Report 4 in Part 6), make this quite clear. The mineral veins are composed of sectors at acute angles to each other and within each sector the veins may also be sinuous, both in plan and vertical profile. If the variation in hade with depth on passing through different strata is also considered, the effect of any net offset of the two walls, whether normal, reversed or lateral, is to produce a series of lens-shaped, open areas, separated by lengths of highly fractured rock which acted as bearing surfaces. The latter are tight and yield little mineral. If the lateral motion has been of a to-and-fro type, with a small net offset, as seems common in Derbyshire, then the open and tight sectors will alternate, giving a semi-continuous vein with brecciated zones of cavity-filling vein material, and replacement areas in the tighter parts (see Fig.24).

Moreover, at the ends of the bearing sectors of veins, joints or minor faults tend to lead off as shown in Fig. 24. These may be virtually unmineralised, but commonly replacement occurs in the acute angle between the main vein and the side fracture. This can occur on almost any scale and one large example of this is the Conksbury Quarry Opencast, where the South-West Vein branches off the Long Rake (see Report 3 in Part 6). The branches may lead to the splitting of the vein either side of a rider, beyond which they rejoin. This can again be on any scale. Examples of large-scale developments of this type are the Bow Rake on Longstone Edge, and the Raper Pit on Long Rake (see Fig. 1 in Report 2 in Part 6). Such riders on the large and small scale, form sites favourable for replacement as they become very broken up during faulting. Riders are also three-dimensional. They may die out in depth as the two bounding faults converge and coalesce. This is the case at Bow Rake on Longstone Edge, where the 'foot' of the large rider is intensely replaced. Such a feature presents an interesting mining problem. The nature of a vein is to some extent the result of the strata through which it passes. Thus in the thin-bedded dark limestones of the face of the Longstone Edge Monocline, some of the veins are broad stockworks of fluorite stringers, rather than the usually single, well-defined, vein found in more massive strata.

In Derbyshire, mineral vein faults generally show semi-horizontal, slickensided walls and multi-phase mineral fills indicative of lateral faulting. The fill often show further slickensided surfaces. Many of the major veins, however, show vertical displacements of strata across the veins and although it is arguable that in inclined beds such displacements are the result of lateral movement, it is rarely possible to demonstrate significant lateral offsets of cross-veins on either side of the fault. In the only case known to the author, the sinistral offset of thirteen yards on the Bowers' Rake at its crossing with Long Rake, is not enough to account for the observed downthrow further west in such gently dipping strata. On the Great Rake at Matlock, which has a throw of 15-20 feet, to the south, whilst most slickensides are semi-horizontal some are steeper than 45^{o} again suggesting normal or reversed faulting.

As has been noted above, fluorite can be seen to cut calcite in several of the major veins of the orefield. The author postulates that many of the fault veins of Derbyshire originated as normal and reversed calcite and galena fault veins, and werelater reactivated by repeated backwards and forwards lateral stresses, during later periods of movement, partially during fluorite mineralisation. Some, at least, of the early epigenetic calcite-galena mineralisation could be thus as old as Lower Carboniferous in date.

c. Flat Deposits

These are replacements of receptive horizons of strata generally of coarse grained white limestones. In all the deposits seen by the author they are controlled by a feeder system of fractures, often minor faults and usually with a series of cross-fractures. The fractures may also be economically mineralised. Commonly, pre- and post-mineralisation cavities are also developed.

The replacement varies between the volume-for-volume type which produces massive fluorspar rock to the volume-reduction type which creates a fluorspar rock with bands of cavities. Generally replacement appears to have occurred from a stockwork of joints into the body of the rock. The degree of penetration of the body of the rock appears to be controlled by the facies of the limestone. Thus, thin-bedded dark limestones may form no more than poorly mineralised stockworks while more massive coarse-grained white limestones are often totally replaced. In dolomitised rocks stockworks may form and fluorite may then occur in the many pores in the rock, giving rise to large low-grade deposits.

Commonly, replacement may only occur adjacent to the feeder joints or faults so that strips of replacement are present on either side of these. The overall pattern is net-like in form. Walls of replacement may extend up the controlling joints whilst chimneys and columns of replacement may extend up the joint intersections. Pre-mineralisation solution cavities may occur along the fracture system. Their origin may be in a pre-existing karst or in solution by early flushes mineralising fluid. These cavities may be lined with fluorspar or marginally replaced. Commonly, post-mineralisation solution cavities are present, infilled with mineral sands and gravels.

Thus a flat is a complex area of mineralised rock, partially a replacement of a particularly receptive group of beds, partially a replacement on and up joints and partially an infill or marginal replacement of pre-existing cavities.

d. Pipe Deposits

These are linear zones of mineralisation with a large proportion of open cavities. It is clear from old descriptions that pipe deposits developed in a stratum favourable to solution along a narrow zone of joints or minor faults. These joints or faults may have been worked in their own right as a vein and only later when the workings reached the favourable horizon did the deposit become known as a pipe. This can lead to some confusion in the old literature with references to an 'X' vein and an 'X' pipe referring to a single geological feature. The cavities are usually lined with minerals and may sometimes be marginally replaced by fluorspar (cf. Portway Pipe - Dunham 1952). Commonly, post-mineralisation solution has taken place along the cavities and these are filled with clays and sands, often containing detached galena blocks as a residuum of the former ore. The term 'pipe' really described two features - a linear zone of mineralisation on a favourable horizon - the pipe deposit; the other is the pipe cavity - any pre-mineralisation cavity lined or infilled by minerals. These latter may occur in association with a vein, flat or pipe deposit.

e. Residual and Detrital Deposits

Residual and detrital sedimentary infills of cavities in pipes and flats have already been noted. These may also occur at surface in the form of insoluble residues at the outcrop of a vein. The general effect of weathering is to decalcitise the vein and residual fluorite-barite-goethite sand and gravel deposits are formed. The process tends to upgrade the fluorite-barite content, which can then be worked. Sulphide are usually in the form of carbonates or in the case galena arsenophosphates as well. Good examples of the types of deposit occur on the Mandale Rake and Shuttle Rake.

PART 5

Factors Controlling the Distribution of Fluorite in the Orefield
(Conclusion to Part 4 and Overall Conclusion)

1. Zoning

Figure 12 documents fluorite deposits and occurrences in the orefield, as known to the author; these have been described in Section 4(2). The description confirms that fluorite occurs principally in the east of the orefield in the fluorite zone first noted by Wedd and Drabble in 1908. However, there are many occurrences of fluorite in other parts of the orefield. Many of these are just minor stringers or small cavity linings in calcite veins but some are deposits of ore grade such as those on Middleton Common. Others such as those occurrences on Chrome Hill in Upper Dovedale are associated with major fault structures and there may be hidden deposits of substantial size. Any attempt to explain the origin of the main deposits must also take into account and explain these other occurrences.

The author agrees with Bagshawe and Firman (1974) that the western boundary of the fluorite zone, if one needs to be drawn, should be further west than shown by Dunham (1952). He defined the western limit of the fluorite zone as by the then 50% CaF_2 cut-off line. The 20-25% CaF_2 line would be more suitable to include all the known worked deposits today. Mueller's (1954) map purporting to show a fluorite zone with greater than 10% CaF_2 has so many errors and missed deposits of much higher grade (known at that time) as to be regarded as very dubious. The author agrees with Bagshawe and Firman (1974) that it is difficult to draw a line for this 25% boundary when the exploited grade of a fluorspar ore depends as the method of working the orebody.

2. The Effects of Structure

The principal fluorite ore bodies - veins and associated flats as opposed t o mineral occurrences and small workings - are generally restricted to the crests and flanks of the main east-west and north-west anticlines of the area, often along the more extreme local folds within the generally anticlinal zones. Good examples of this structural control are the Great Rake on the crest of the Great Rake Monocline, lying on the flank of the Matlock Anticline. Here at outcrop, where the structure shows its greatest amplitude, the vein is fluorspar, but as the structure decreases down-dip to the east, the vein became calcitic. At Ashover, the Gregory Vein was fluoritic on the crest of the dome but became clacitic down-dip into the Tansley Syncline to the west. Other veins, at Ashover, which have been worked down-dip under the shales for fluorspar, are known to die out as they were worked away from the crest. The Coast Rake, near Elton, lies in part along a monocline, marking the southern boundary of the Stanton Syncline and this is a major fluorspar vein. The High Rake carries fluorspar along the monoclinal section of the Longstone Edge Anticline. The important Hucklow Edge fluorspar vein lies along a postulated monocline marking the southern boundary of the Abney Syncline and becomes calcitic to the east where the fault and possibly the monocline are dying out. Other veins lie on or cross obliquely the crests of the major anticlines. This is true of Long Rake which carries fluorite along the crest of the Long Rake Anticline. Similarly, the Dirtlow and Mogshawe Veins carry fluorspar on the crest of the Taddington-Alport Anticline. White Rake, north of Longstone Edge, carries fluorspar at the crossing point of the Middleton Dale and Combes Dale Anticlines.

Clearly, many of these major fluorite deposits occur in faults developed along areas of folds under tension as noted by Shirley and Horsefield (1945). Such areas would tend to be open and receptive to mineralisation. However, several of these structures are reversed faults associated with monoclines, features developed originally under a state of compression. It seems likely that later lateral movement on the same faults, for which there is so much evidence in the form of horizontal slickensides, created tension due to the irregularities in the plane of the faults (see Figure 13). Thus a system of opening zones and tight zones with intense fracturing could develop along such veins. These could act both as channel ways for mineralisation and as sites suitable for infill (the tensional areas) or replacement (the tight fractured areas).

Some deposits cannot be readily accounted for as a result of faulting related to folding. Notable amongst these are the many deposits along the Bonsall Fault. It is true that to some extent it does act as the southern limb of the Matlock Anticline and downthrows several hundred feet to the south along this feature. The fault carries fluorite as far west as Aldwark and appears to have acted as a feeder for many deposits to the north and south as far west as Sacheverall Farm. It may be traced southeast into the coalfield and northwest across the orefield separating areas of different tectonic style. It may therefore be the surface expression of some fundamental basement feature and it is suggested that it may be one of the main feeders of mineralisation into the massif, updip from the basin and gulf areas to the south and east. A similar function may be ascribed to the Brimington Anticline-Fault system, which Fearnsides (1933) considered so important a feature of the coalfield. This appears to terminate close to the end of the Hucklow Edge-Longstone Edge fault vein systems which it could have fed.

Many of the sporadic occurrences in the west and south of the area are replacement pipe ore bodies lying on joint swarms associated with dolomitisation. Moor Farm is a good example of this on Bonsall Moor. Here, at the base of dolomitisation, a replacement cavity lining deposit has formed on a zone with very many small stringers. Fluorite is much less common in the undolomitised sections of the veins. The dolomitised sections appear to have been more open and the rock more porous and hence receptive to dispersed fluoritisation. Other similar deposits include the Masson Flat, Jug Holes, and Tearsall Pipes as well as those west of Middleton-by-Youlgreave.

Another type of deposit occurs in dolomite as an infilling of pores in the rock. This usually occurs where major fluorite veins intersect dolomite. A complex of fractures branching off the vein affecting the dolomite is necessary to feed in the mineral solution. Examples of this occur on the south side of the Great Rake on Masson Low, on the Bonsall Fault at Pitchmastic's Ball Eye Quarry and west of Elton on Coast Rake near Gratton Dale.

In summary it appears that fluorite mineralisation occurs wherever there was a suitable open structure to receive it at the time of mineralisation. This could be in the form of a tensional zone or a sheared zone in a vein fault, a pre-existing solution cavity, or in a fractured, porous, dolomite rock. Therefore, whilst the fundamental control was proximity to the eastern edge of the massif, i.e. to the main sources of the fluids and heat, equally as important was the occurrence of an open structure to be infilled or replaced. This explains some of the many exceptions to the simple thermal zonal concept of Dunham (1952) and Mueller (1954).

3. The Relationship of Calcite to Fluorite

If the relationship of calcite to fluorite is examined in the veins, it is found that in many cases calcite is cut through by the fluorite and therefore pre-dates the latter. This is true for example in Moss Rake near Bradwell, Dirtlow Rake near Sheldon, Mandale Rake near Over Haddon, in the Tearsall Group of mines near Matlock and the veins in the quarries at Hindlow, south of Buxton. It is thus argued that much of the columnar calcite in the veins relates to early phases of normal and reversed faulting preceeding fluorite mineralisation (see section on faulting above).

In several cases, for instance, on the Long Rake west of Conksbury Pit, on Lathkill Dale Rake west of Over Haddon, on the High Rake of Longstone Edge west of Crossdale Head mine, and on the White Rake near Seedlow Mine south of Stoney Middleton, the veins change rapidly from fluorite to calcite on moving westwards. This change occurs close to the crossing point of transverse (north-south) folds and faults. Thus it can be argued that at these points of weakness, fluorine-bearing solutions escaped vertically to the Permo-Triassic unconformity along a steep pressure gradient up through any Millstone Grit cover. Further, the occurrence of the main fluorite deposits along the main anticlinal areas could be explained by their proximity to this erosion surface and hence the increased likelihood of leakage upwards. This would tend to draw mineral solutions towards the anticlines as they travelled up dip from the east. The shales over the intervening synclines were much thicker both due to deposition and the effects of Permian erosion. It is probable that the unconformity at the base of the Namurian was such that the Ashover Grit rested on the limestone on the Matlock Anticline. Blocks of barite covered grit are known in the workings of the Whitelow Rake at Elton. Similar baritic grit occurs at Shottle Edge on the eastern projection of the Yokecliffe Monocline.

The author believes that the prime example of the effects of pressure release is the Mill Close manto. Here solutions travelling from east to west deep in the limestone along the Long Rake, have been drawn off along a rising pipe system ascending the strata towards the crest of the Matlock Anticline to the south (Traill, 1939). This was the most easily penetrable structure with respect to the shales and the unconformity in the south of the orefield. A similar effect appears to have supplied the rich north-south pipes south of Coast Rake from Winster to Gratton Dale (the Yate Stoop, Plackett, Portway and Cowclose pipes). These trend up dip towards the Bonsall Fault, another structure which would allow upwards pressure release of solutions to the unconformity. The Coast Rake appears to have been linked to the Millclose System by the Chapel Fault. Pressure release around the southern and western sides of the Stanton Syncline helps explain why the Millclose ore bodies lay on the up dip side of the main joints or feeder fault.

On the Matlock Anticline the general disposition of the orebodies is consistent with the flow of mineral solutions up dip along joint systems towards the crest of the anticline to leak up to the Triassic unconformity. The occurrence of fluorspar at Low Mine on Great Rake below the Lower Lava is probably the result of fluorine bearing solutions travelling northwest along the Bonsall Fault system, held down by the toadstones and the shales on the downthrow side of the fault, being drawn to the east and upwards by pressure release on the crest of the Matlock Anticline at Masson Low.

4. Other Controlling Effects (Aquicludes)

Stevenson (1973 - verbal communication) has suggested that many of the fluorite deposits lying well to the west of those previously reported, did not lie very far below the former position of the base of unconformable Edale Shales and that the existance of this former cap has had an important effect in holding down solutions and pushing them to the west. Thus, some of these westerly deposits may be as much related to this effect as to the presence of toadstones holding down the solutions to the east as often invoked in the past.

5. Other Sources of Solutions, West of the Orefield

The occurrences of fluorite in the extreme west of the area, at Buxton, Chrome Hill, Ecton, Mixon, etc., suggest that there may have been a separate source of mineralising solutions to the west of the massif, perhaps in the Cheshire Basin.

THE OCCURRENCE OF HAEMATITE IN THE SOUTH PENNINE OREFIELD

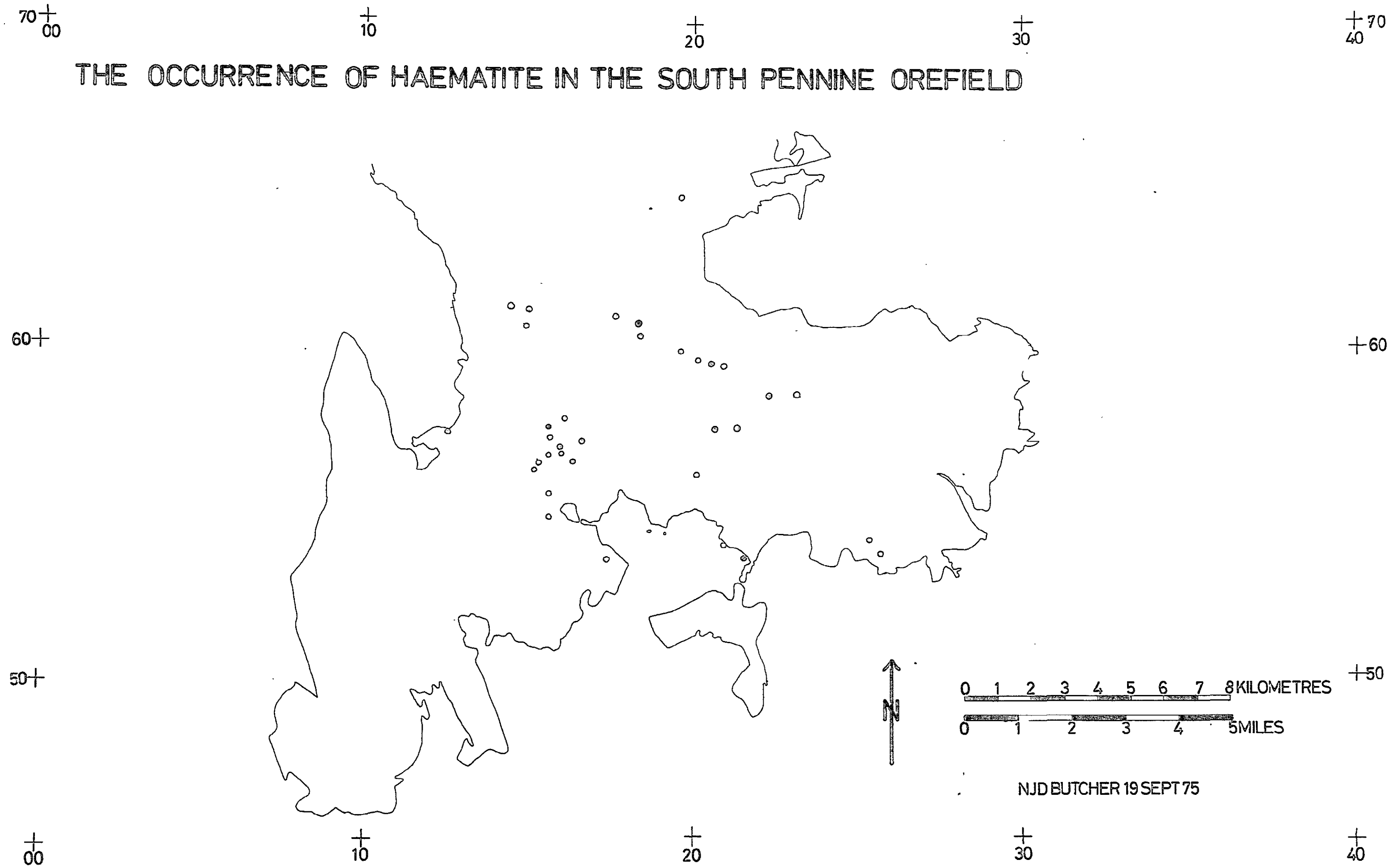


FIG. 25.

The Occurrence of Haematite in the Orefield - A Short Note

The known occurrences of haematite are shown on Figure 25. The haematite occurs in two environments and is generally restricted to the south and west of the massif. One set of deposits is associated with the southern reef complex, such as the Dog Low Mine (257537) near Hopton Village and those near Ripley Hill at Ballidon (210540). The other deposits occur in large calcite fault veins. These may be haematite disseminations or pink calcite-sand sediments, sometimes with travertine in cavities on the veins. It is here considered that these deposits represent the effects of downward percolation solutions leaching iron from the formerly unconformable cover of Permian or Triassic Sandstones. It could then result from desert weathering at surface. The origin of the reef association deposits is less certain as some where probably under moderately thick shales during Permo-Triassic times, but down dip migration of iron bearing solution could have taken place in most cases.

The deposits have been mined from time to time as a source of red pigment for the paint industry.

PART 6

Reports on Certaining Mining Prospects in the South Pennine Orefield

General Introduction

The following fifteen reports on the mining potential of various areas of the South Pennine Orefield were originally submitted to the sponsoring company, C.E. Giulini (Derbyshire) Limited, between October, 1971 and December, 1975. The research work and compilation was carried out by the author. Although co-author to all of them Dr. T.D. Ford acted in a supervisory and editorial capacity only. The reports have been up-dated to give the situation as known in December, 1975. Together they give a description of much of the remaining Fluorspar mining potential of the Orefield, excluding Odin Vein and Coast Rake.

REPORT I

LONG RAKE, NEAR PICKORY CORNER. 14th DECEMBER, 1971

The course of the rake is clearly marked by a line of old hillocks from a point immediately south of Nutseats Quarry, westwards to Raper Mine. The most easterly hillocks close to Nutseats Quarry appear to be very largely of shale, and there must be some doubt as to whether the vein was worked here or whether the hillocks merely follow Black Sough. The first hillock to show limestone and vein-stuff is about 150 feet west of the quarry. This has a concrete cap and so was probably open until recently and if the cap was removed it is possible that some workings might be accessible for examination. If open the shaft will be 120 feet deep beneath the cap.

A shaft hollow and mound a few yards to the south of this are entirely in shale and suggest that the vein is here on the line of a fault downthrowing the shale to the south, by some 80 feet, as limestone is briefly exposed north of the vein. Several other shafts to the west are also apparently in shale, and it seems likely that the "old man" sank his shafts through the softer shale either to reach the sough or by cross-cutting to reach the vein, which is said to hade north.

A short line of hillocks marks a vein branching north at the crest of the rise where there is a large hillock of fluorspar and further west a very indefinite line marks the apparent course of Sellers Vein. An open shaft (though covered with large slabs; it could be accessible with a few minutes work) is also near the crest. In this the vein is hading north at 70°, with the north wall limestone and the south wall of shale. The vein is barren probably because of the presence of shales.

Between this shaft and the wood the hillocks contain a substantial proportion of fluorspar, in contradiction to the findings of Ineson & Al-Kufashi (1970).

The intersection with Bowers Rake is in the wood, and it is very overgrown. No vein was seen but there are large hillocks containing a substantial proportion of fluorspar and four open shafts. Bowers Rake trends southeastwards towards the river but little could be seen of the vein. An opencut just above the road showed a little fluorspar in the walls, and most of the hillocks contained fluorspar. West of the wood the hillocks on Long Rake contain a lot of shale again, though some fluorspar was seen. It seems likely that the "old man" encountered the cover of boulder clay (as seen in Shining Bank Quarry) over the vein, and that he was only able to work the vein from a few widely spaced shafts.

The intersection with Wheels Rake is marked by a large hillock with an open shaft covered by a concrete cap. This has been descended about 200 feet to water within recent years, but no details of the workings are known to us.

From surface evidence alone it seems that there is a strong vein throughout this length. The vein is a fault throwing down to the south and hading north. At the east end of Raper Pit the vein downthrows 120 to 140 feet to the south and hades 80° to the north.

A downthrow of 60 feet to the south was recorded at Wheels Rake Shaft and the vein hades north. The old Memoir notes a throw of 84 feet south but the site of this is uncertain. Reconnaissance mapping suggests that a throw of 60 to 80 feet is maintained all along the fault except near the junction with Bowers Rake where the throw is less. This means that this height of vein will have shale on the south wall and limestone on the north, as in Raper Mine openpit. This will undoubtedly cause roof-support problems in underground mining.

Also, Shining Bank Quarry shows up to about 20 feet of Boulder Clay lying indiscriminately on shale or on limestone. This appears to be present along much of the middle reaches of Long Rake so that the two walls may well show the following sections at the intersection with Wheels

Rake (taking mining records into account):-

South	North
Boulder Clay 20 ft.	Boulder Clay 20 ft.
Shale 20-40 ft.	Limestone 160-180 ft.
Limestone 160-180 ft.	1st Toadstone 102 ft.
1st Toadstone 102 ft.	2nd Limestone 45 ft.
2nd Limestone 45 ft.	2nd Toadstone either 56 ft. or 56 ftms
2nd Toadstone either 56 ft. or 56 ftms (see below)	

This estimate was modified on the results of boreholes subsequently carried out. See Report 2.

Old mining records are few and, as usual, tantalizing in their incompleteness as far as Long Rake is concerned. An important feature is the presence of Black Sough. The tail of this was a bolt (= covered trench) on the bank of the River Wye some 200 yards SE of Pickory Corner, in line with Long Rake. The last 50 yards of this have obviously fallen in and a shallow trench in the field marks the course. The sough is recorded as having been driven up Long Rake, to and along Wheels Rake. Its tail still has a pipe trickling water into the river. If this could be entered by removing the concrete cap from the shaft behind Nutseats Quarry it might be possible to explore part of the vein. The tail is at about 345 ft. O.D., i.e. about 100 feet down the capped shaft.

Adits are also known to have been driven up Sellers Rake, Bowers Rake and Wheels Rake from about river level either from the river bank or as branches from Rhainstor Sough. No records are known as to how far they went, and nothing is visible on the ground now. Adits in Sellers and Bowers Rakes would have been at altitudes of about 365 ft. O.D. and in Wheels Rake at about 395 ft. Branches of Hillcarr Sough are known to have been driven up both rakes as far as near the river, but there is some evidence that the Wheels Rake branch went almost to Long Rake in the 1880s. The altitudes of these at the river would be about 320 ft. O.D.

Two toadstones are present at about 180 feet below the top of the limestone in Lathkill Dale west of Raper Mine. The upper toadstone is 60 feet thick and it is separated by around 140 ft. of limestone from the lower one. Neither is recorded in the Spar (calcite) mines north of Youlgreave, though there are wayboards. Both mines are around 400 ft. deep. The toadstones appear to increase in number and vary in thickness both under Alport and towards Pickory Corner. Diagrammatic sections of the available records are appended (fig. 1/2) and the nature of the variation in thickness and spacing of toadstones can be seen thereon. In particular the thickness of the lower toadstone in Wheels Rake Shaft deserves comment. It is based solely on a note in the 1887 Geological Survey Memoir, which says that 56 fathoms of toadstone were bored through. A boring of this depth in toadstone seems an unlikely though not impossible proposition at that period, and it is possible that someone misread 56 ft. as 56 ftms! Alternatively if it is taken at face value it may be that they bored into a buried volcanic vent, as was once done at Hucklow! An attempt to sink into this second toadstone at Wheel Shaft was abandoned after 18 fathoms (108 feet), indicating that the toadstone is more than 56 feet thick.

The northern end of Millclose Mine penetrated several toadstones, and it does seem that there is a complex of several lava flows spreading out from a buried vent somewhere in this area - some lavas spread further than others, hence the very varied stratigraphic sections.

Interpreting these old records and linking them with Millclose Mine raises many problems so that any conclusions herein are necessarily speculative. Firstly, a contour map has been prepared showing the probable position of the top of the upper toadstone. This should be regarded as very approximate and generalized.

It will be seen that there is a marked flat area in the centre, and this seems to coincide in part with the concentration of veins in the Alport Mines. It appears to extend as far as Long Rake, but nothing is known of the detail there. Secondly, the thickness of limestone above the upper toadstone is variable, owing to the development of small reefs (some are visible in the higher parts of Shining Bank Quarry giving very lenticular bedding). The thickness is probably between 150 and 180 feet. Some of the upper beds have been removed by erosion both before the shale was deposited and since. Making some allowances for this, for the faulting and for the variable cover of boulder clay, means that the height of vein with both walls in limestone above the upper toadstone may be about 100 feet. An increase in the height of mineralized ground varying between 40 ft. in the west and 80 ft. in the east, will have with one wall in shale near the surface, or at depth an increase in height of about 60 ft. will have one wall in toadstone. As no underground inspection has been possible it is not known whether there are replacements in the wall rocks.

The limestone between the upper toadstone and next below is again variable in thickness, but it is generally less than 100 feet, and if the faulting is again taken into account most of the vein here will have one wall in toadstone and the other in limestone, with consequent support problems. It is not known whether this part of the vein was reached by the "old man" though there is a mention of a water-wheel connected with and working below Black Sough. This was close to Nutseats quarry and worked to 120 ft. below the Wye, i.e. to 225 ft. A.O.D. Workings are recorded to 15 fathoms below Black Sough at Bowers Rake. Wheels Rake Whim Shaft apparently worked its rake in the 2nd limestone close to Shining Bank Quarry.

In conclusion, it seems that the proposal to drive an adit along the vein from Nutseats Quarry will certainly find a substantial vein of fluorspar all along Long Rake in the uppermost limestone, but mining will lead to serious problems of wall and roof support - in particular I do not suppose the Duke would delight in having caving to the surface, which could well happen with the shale and boulder clay cover. The vein will be dry down to more or less river level, but any attempts to go much below about 310 ft. O.D. (height of tail of Hillcarr and Yatestoop Soughs) may well break into the same system of joints as fed so much water from the Alport Mines into Millclose Mine and there will be a possibility of back-flow from the flooded workings there.

Continuation of Long Rake eastwards under the shales has been proved by geochemistry but boreholes will be necessary to prove the strata first.

The main recommendation is that the vein should be explored as far as possible by temporary re-opening of the capped shafts, particularly that behind Nutseats Wood. The decision on an exploratory adit from Nutseats Quarry should be postponed pending the findings of such an exploration. It should be noted, however, that the "old man" did very little in the vein at Raper Mine and so even if he did work galena from the vein near Nutseats Quarry, he probably left the bulk of the fluorspar gangue behind!

A final comment is that virtually nothing is known of the ground to the north of the Long Rake, and it seems unlikely that the numerous veins of the Alport area, some of which intersect the Long Rake on its south side, have no counterpart in the area masked by boulder clay to the north. An adit along Long Rake could well find several veins shooting off and continuing to the north. In this connection the potential of the eastwards continuation of the Lathkilldale Vein to the north should be considered.

Notes on the figures

1/1. Key map to the Long Rake area.

1/2. Diagrammatic sections of the strata along Long Rake, Pilhough Joint, Bowers Rake and Wheels Rake. Correlation with the four toadstones seen in the Pilhough Joint of Millclose Mine with the strata known around Long Rake is highly speculative except for the topmost toadstone.

1/3. Correlation chart of major sections of strata known in Millclose Mine, Wheels Rake and Lathkill Dale. The discrepancies in the relationship of the second toadstone are obvious.

1/4. Contours interpolated on the top of the Upper Toadstone. These can be taken as being roughly 180 feet below the stratigraphic top of the limestone, or by comparison with present topographic contours the depth to the toadstone may be estimated at any point. The contours suggest a broad arch or anticline trending southeast from Broadmeadow Shaft. It is notable that many of the known veins are either along the axis of this anticline or parallel its trend. None were worked south of Hillcarr Sough owing to water problems - if these can be overcome it is likely that there is over a mile of virgin veins at depth below Stanton Moor southeast of the Alport Mines.

THE LONG RAKE, YOULGREAVE, PICKERY CORNER TO ARBOR LOW MINE

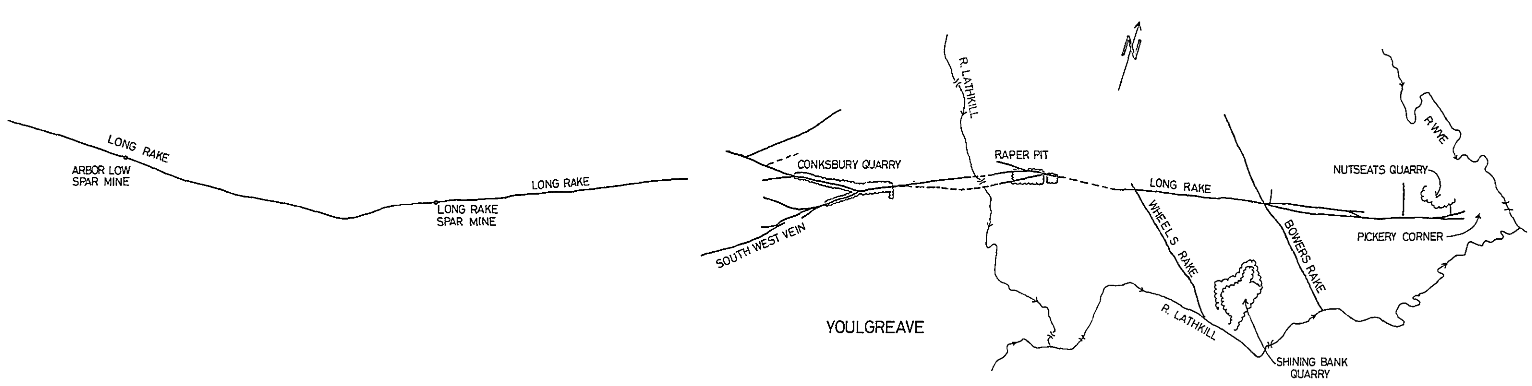


FIG.1.

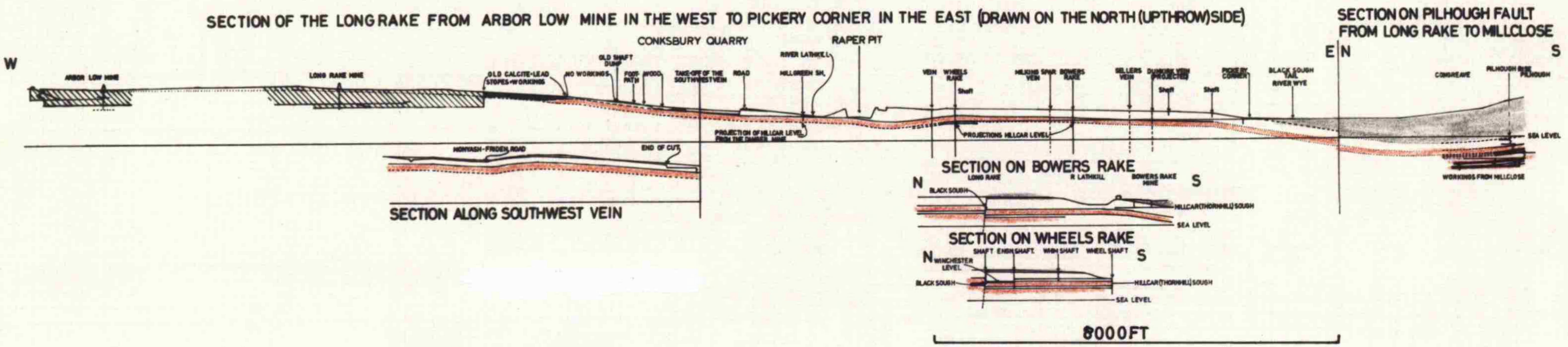
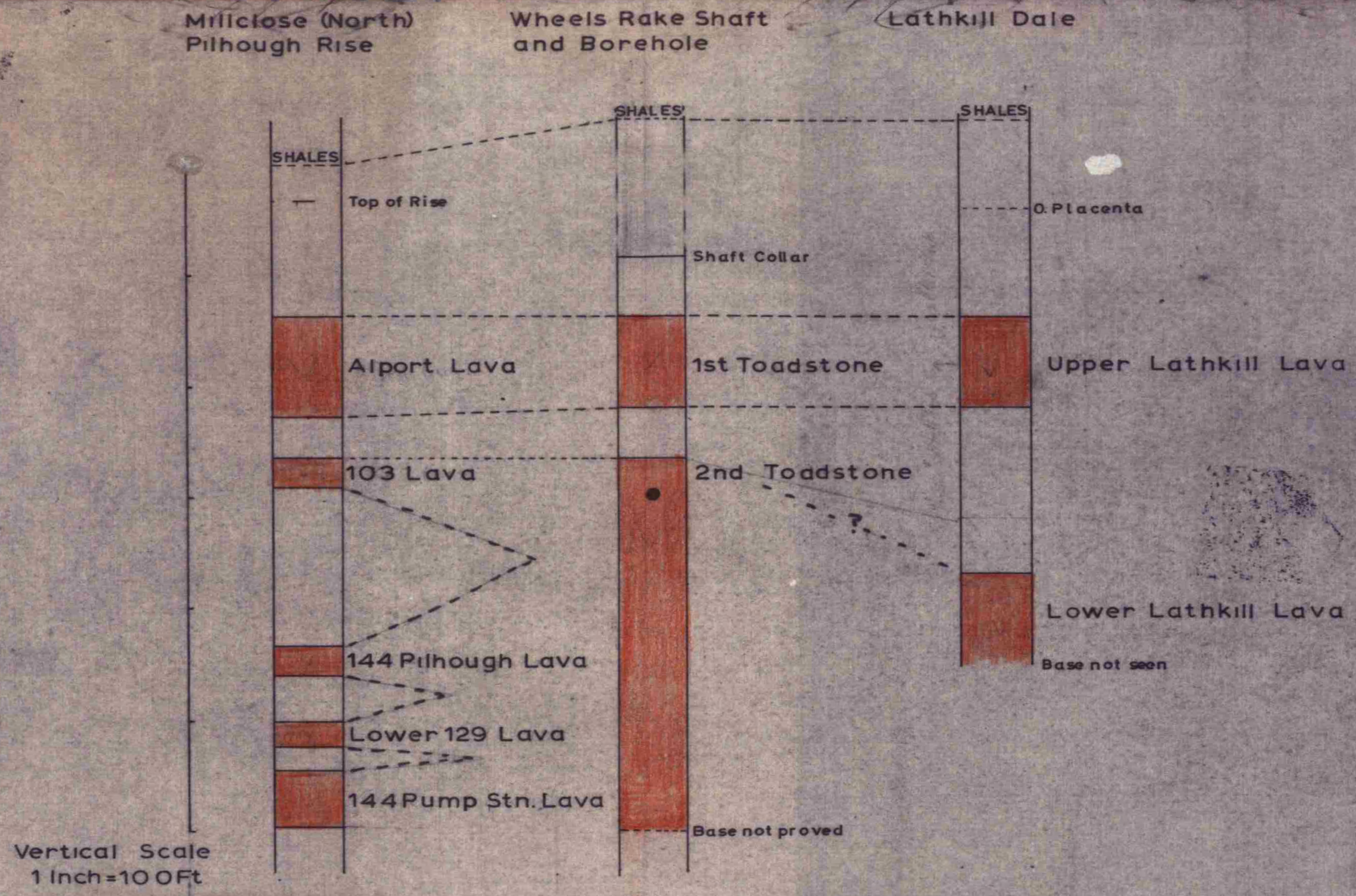

SECTION OF THE LONG RAKE FROM ARBOR LOW MINE IN THE WEST TO PICKERY CORNER IN THE EAST (DRAWN ON THE NORTH (UPTHROW) SIDE)
CONKSBURY QUARRY
RAPER PIT
W
E
SECTION ON PILHOUGH FAULT FROM LONG RAKE TO MILLCLOSE
N
S
SEA LEVEL
WORKINGS FROM MILLCLOSE
SECTION ALONG SOUTHWEST VEIN
SECTION ON BOWERS RAKE
N
S
SECTION ON WHEELS RAKE
N
S
SEA LEVEL
8000FT

FIG.2.

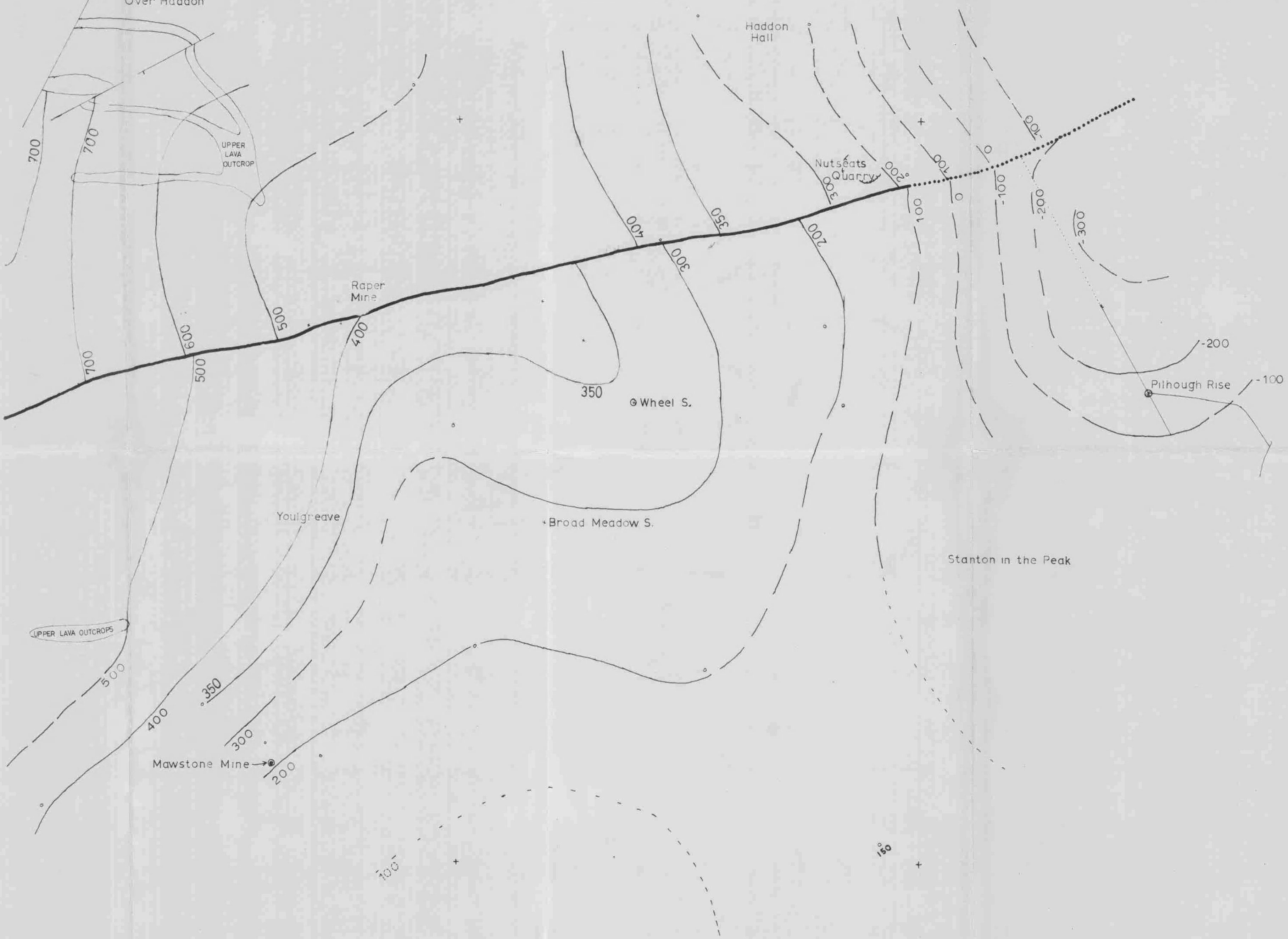
FIG.3.



DETAILS OF MAJOR SECTIONS

CONTOURS AT 100FT INTERVALS ON THE HORIZON OF THE ALPORT LAVA TOP

SCALE 6 Inches = 1 Mile



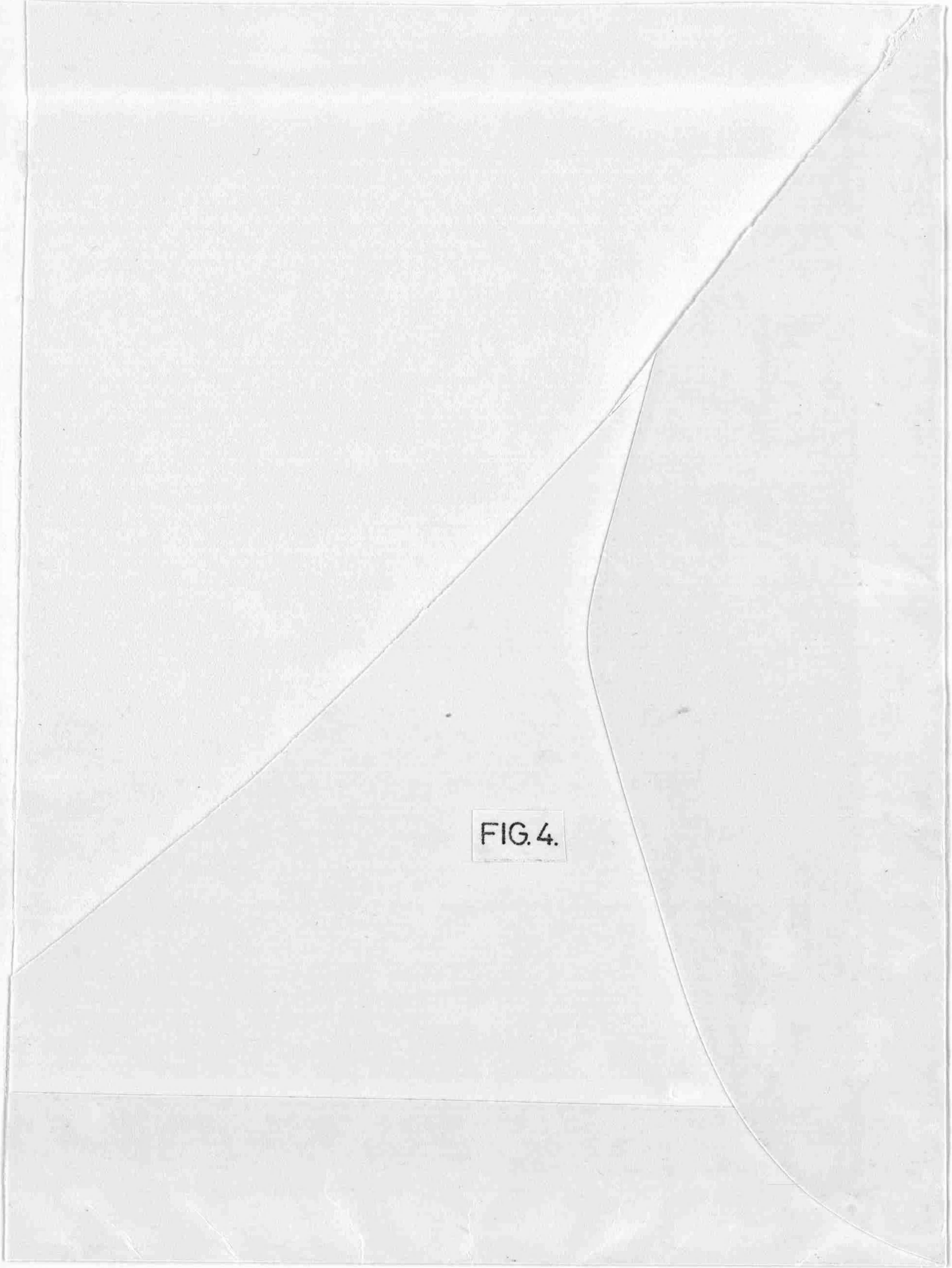


FIG. 4.

REPORT 2

PROPOSAL FOR BOREHOLES TO BE SUNK IN CONNECTION WITH THE EXPLORATION OF LONG RAKE AND BOWERS RAKE. 29th FEBRUARY, 1972

Summary

A pattern of four boreholes is suggested to prove the stratigraphic sequence and thus the faulting. It is proposed that these should be sunk in each of the four quadrants at the intersection of Bowers Rake and Long Rake. Two of these (B.H.s 1 & 2) need only be shallow to about 130 feet; the third (B.H. 3) should be of moderate depth to about 230 feet; whilst the fourth (B.H. 4) should be deep enough (about 450 feet) to prove strata to the base of the Second Toadstone.

It is proposed that two additional boreholes (B.H. 5a & 6a) should be sunk near Nutseats Quarry, to prove the extent of lateral change in the strata, and to prove whether or not the displacement of the faulting along Long Rake is still the same. B.H. 5a would need to be about 150 feet deep, and B.H. 6a a minimum of 290 feet. Alternative sites (5b & 6b) are suggested screened from view if this is necessary.

It is suggested that B.H.s 4 & 6 should be cased and sealed for possible future deepening to prove lower strata.

Some possible programmes of trenching and other exploration are suggested.

Since the report of 14th December 1971 the geology of the area between the rivers Wye and Lathkill, south of a line from Over Haddon to Wigger Dale, has been mapped in detail (Fig.2/1), and the stratal sequence in Shining Bank Quarry has been measured in detail. Your drilling

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Subsequent to submitting this report it was found that the boreholes at the BowersRake-Long Rake intersection had already been sunk. (Boreholes 1-4 above), though not to our specifications. The report is modified to include the findings of these holes.

programme at the Bowers Rake-Long Rake intersection has been carried out and the results are interpreted below.

The uppermost beds in the quarry section show "reef" development and the base of the shale may be quite an irregular surface. A structural contour map on the base of the shales has been prepared (Fig.2/2). This work has lead to a revised picture of the strata at the Long Rake-Bowers Rake intersection (Fig.2/3).

The surface attitude at this point is about 550-560 ft. A.O.D. and an adit from Shining Bank Quarry would intersect this region at about 150 ft. below the surface. Boulder clay is up to 40 ft. thick although only 25 feet is seen at the north end of Shining Bank Quarry. It would appear that there is little or no shale on the south side (downthrow side) of Long Rake at this point. From the positions of the toadstone to the north and south of the fault it appears that there is a downthrow of 80 to 100 feet to the south here. The adit would intersect the vein at the horizon of the top of the first toadstone on the upthrown (north) side of the vein.

On Fig.2/3 the fault has been shown hading to the north at 80°. The direction is valid (at least in the upper strata) but the value is dubious being an estimate derived from measurements in Raper Pit and observations in shafts. It is likely that the hade varies considerably as the walls of the fault vary from limestone against shale to limestone against limestone, limestone against toadstone, etc. The hade may reverse with depth as it does in the calcite mines further west on Long Rake.

Long Rake should not be thought of as a single fault line, but as a zone of disturbance mineralized in part or as a whole. Raper Pit shows this well as four faults are present. Three of these are strongly mineralized on the fractured limestone between walls variably replaced by fluorite. A zone of mineralization perhaps 100 ft. wide on Long Rake is suggested by the double line of workings up to 1800 ft. east of the

Long Rake-Bowers Rake junction (A-A on Fig. 2/4).

To prevent vertical boreholes intersecting the zone of faulting at depth the deeper holes to prove strata should have been sited to the south of the fault, and all boreholes set back from the line of the veins by at least 20 yards to miss ground disturbed by faulting. The most easterly of your boreholes north of Long Rake could have intersected the vein hading north or a parallel fracture from 126 ft. to 132 ft.

Bowers Rake may also be fault throwing down to the northeast. As B it shows no displacement, but it is thought that north of Long Rake displacement may increase. There is evidence from dump samples that Bowers Rake along with other N.W.-S.E. veins in the area especially Wheels Rake may carry a much larger baryte to fluorite ratio than Long Rake.

East of Bowers Rake the exact throw of Long Rake is unknown, though it is to the south and probably over 100 ft. with the vein hading at 70° north. It will be necessary to know accurately the position of the limestone-shale boundary south of the fault, the throw of the fault and the position and thickness of the first toadstone in this area, if any adit, incline, or sublevels are to be driven more than about 2000 ft. east of Bowers Rake along Long Rake. Moreover any future work that might be proposed on the basis of this exploration would need accurate location of deeper strata. Bearing in mind the Filhough Fault section of our previous work it is likely that the number of toadstones increases eastwards along Long Rake.

Bearing these factors in mind two further boreholes are proposed (5a & 6a) to prove the throw of the fault by drilling to at least the top of the first toadstone (6a preferably to the base of the second toadstone) to the north and south of the rake. In positions 5a & 6a these bores would be very obvious from Haddon Hall, and they could be moved to positions 5b & 6b screened by Nutseats Quarry Plantation. Here although slightly less useful for the present project, B.H. 6b might well be ideally situated to yield information as the correlation of strata to the Pilhough Fault section. Whilst this bore (6b) need be no deeper than 6a at this stage it is suggested that with B.H. 4 it should be lined and sealed so that they might both be deepened later on if exploratory work justifies this.

B.H. 5a **Object** to prove the position of the top of the first toadstone and in conjunction with 6a the displacement at Long Rake

Location SK 2356 6570

Altd 475 ft. A.O.D.

Depth c 180 ft.

Anticipated Succession

65 ft.	Dark well bedded limestone - shaley at top
1-2 ft.	Grey wayboard
100 ft.	White poorly bedded limestone
10 ft.	1st toadstone
	base of hole

B.H. 6a **Object** see B.H. 5a and possibly to prove strata to the base of the second toadstone

Location SK 2363 6560

Altd 500 ft. A.O.D.

Depth 290 ft. to 1st toadstone ? to be taken deeper

Anticipated Succession

	120 ft.	Shale
	65 ft.	Black limestone well bedded, shaley at top
	2 ft.	Wayboard (grey)
	c100 ft.	White poorly bedded limestone
		possible base
	80-102 ft.	1st toadstone
	45 ft.	2nd limestone
presence and thickness uncertain		2nd toadstone

B.H. 5b **Object** Alternative to 5a

Location SK 2380 6580

Altd 375 ft. A.O.D.

B.H. 6b	Object	alternative to 5b - also a possible site for a deep borehole
	Location	SK 2387 6567
	Altd	380 ft. A.O.D.
	Succession	similar to 6a but shale perhaps 160 ft?

Trenching etc.

We suggest that whilst the boreholes are being sunk some other work might usefully be put into operation:-

Trenching: Along the line E-E' we suggest a trench about 100 feet long and up to 15 feet deep, to prove the width of the vein and its contents, and the presence or otherwise of parallel subsidiary veins. It should also be possible to prove the attitude of the vein, i.e. whether it dips to the north or not.

A further trench at Point B should prove the width and contents of Bowers Rake. This trench need only be about 20 feet long and 10 feet deep.

Descent of Old Shafts: If possible the various shafts mentioned in our previous report should be explored. Some will need the removal of concrete caps. Permission for access will be required.

Bulk Sampling: We also suggest that you should carry out bulk sampling of old dumps, particularly those at the intersection of Bowers and Long Rake.

Other Comments

Several other points of interest have emerged from mapping and research in old mine documents.

1) Black Sough - has been driven west along Long Rake at least as far as Wheels Rake where a branch - Winchester Level was driven S.E. to the Engine Shaft.

2) It seems very probable from the depth of working of this shaft (288 ft.) that a branch of Hillcarr Sough was driven at c340 ft. O.D. N.W.

up Wheels Rake as far as Engine Shaft and in view of the present insignificant flow from Black Sough this may effectively drain Long Rake to this level.

3) A series of veins have been mapped in the western end of Haddon Fields north of Raper which lie in line with Wheels Rake. One shaft on Wheels Rake lies c100 ft. north of Long Rake and it seems probable that the former continues to the north and may have been worked at depth but not on the surface. The general absence of veins north of Long Rake is attributed to the thick (15-30 ft.) cover of boulder clay.

4) If Bowers Rake is projected northwestwards it lies in line with the Arrock Fault at Ashford, and there is much evidence that this line is a monoclinal fold dipping to the northeast and probably with associated faulting, though the latter has not yet been proved. This line intersects the projections of Lathkilldale Vein, Mogshaw Vein, Dirtlow Vein and others to the northwest. To the north of Meadow Place Grange, Lathkilldale Vein shows a substantial fluorite content on dumps, whilst at Over Haddon a fault is seen displacing the toadstone. The course to the east is uncertain - the blank triangular area on Fig.2/2 shows the uncertainty, whilst the dotted lines are merely a preferred location. This concealed vein has the same direction as Long Rake and may be as significantly mineralised - its intersection with Bowers Rake (projected N.W.) is a locality of potential interest.

5) The "Bowers Rake" of Millclose Mine lies parallel to the Pilhough Fault and its projection is to the east of Bowers Rake proper. However it is not impossible that they are the same vein if some curvature is allowed.

6) Figs. 2/8, 2/5, 2/6, 2/7 are large-scale diagrams of sections of the strata on the Pilhough Fault, Long Rake, Bowers Rake and Wheels Rake respectively.

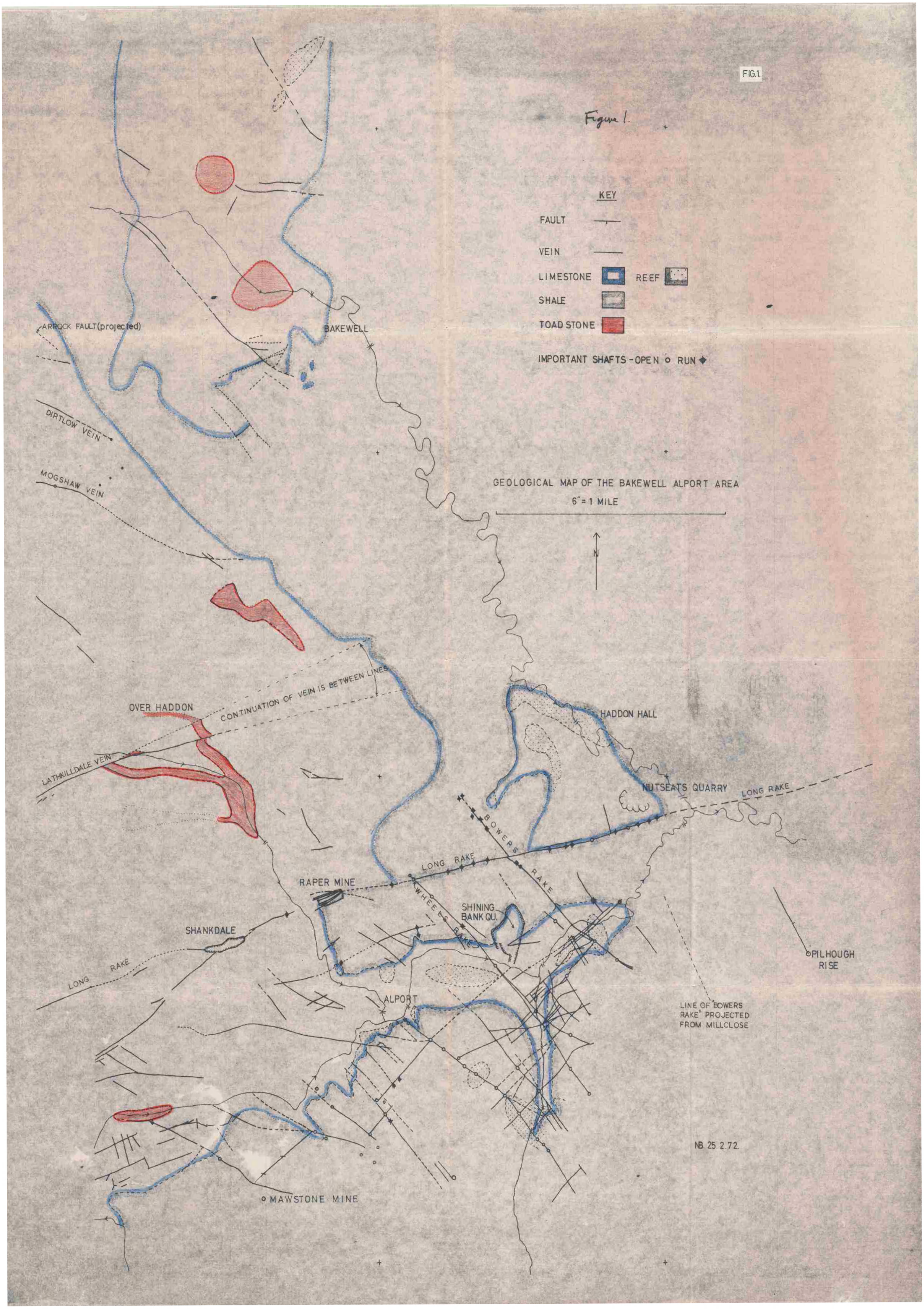


FIG.1.

Figure 1.

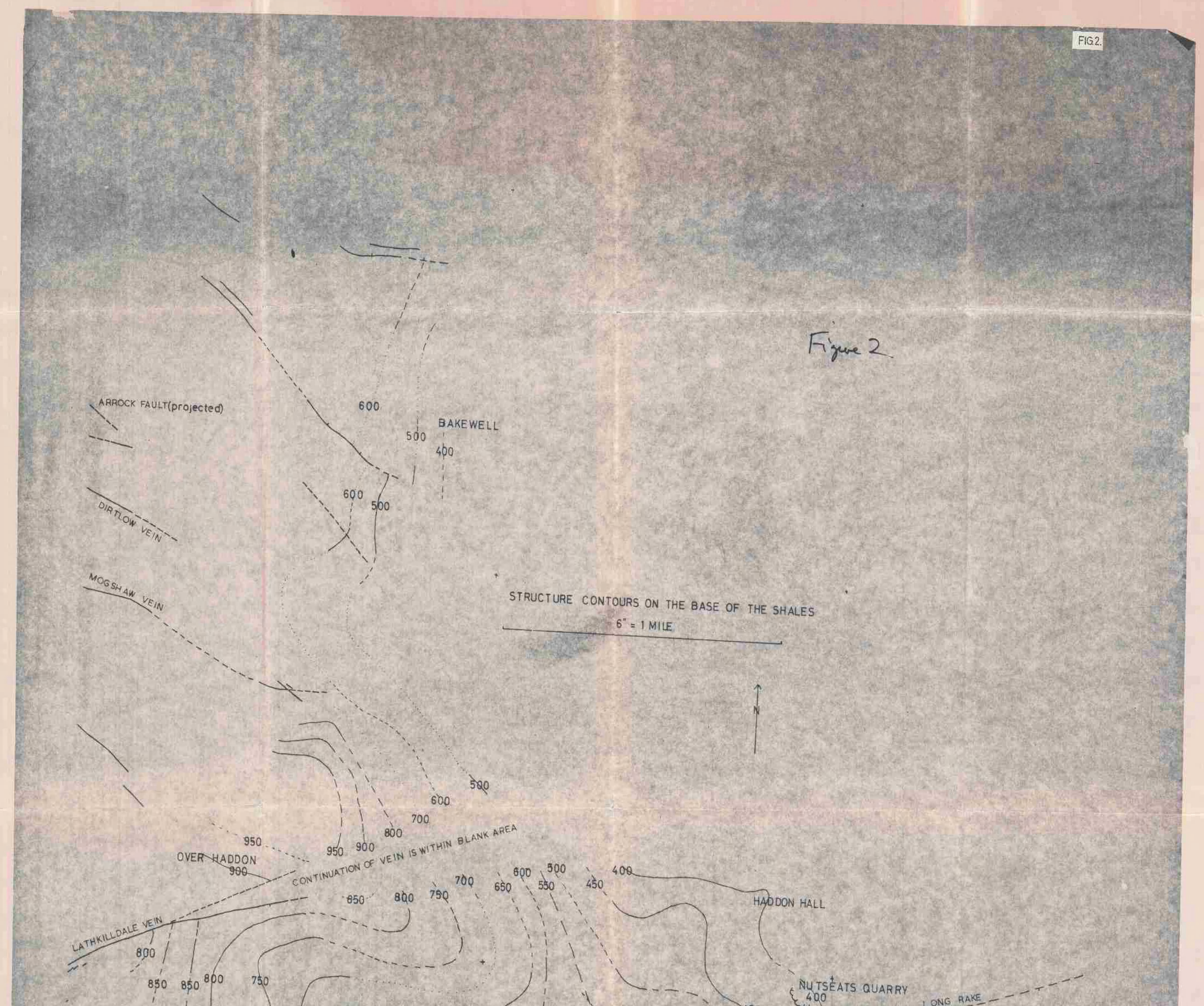
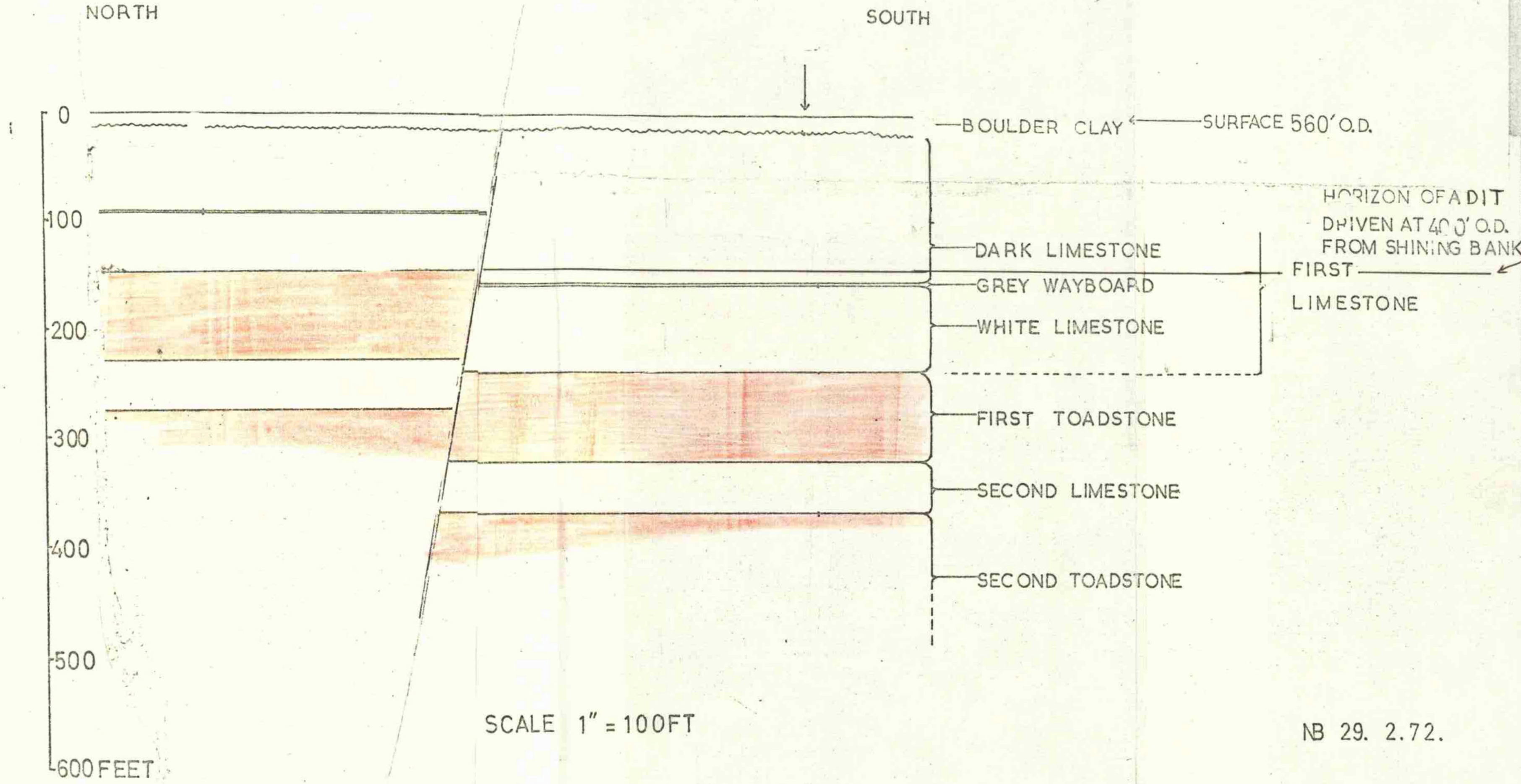


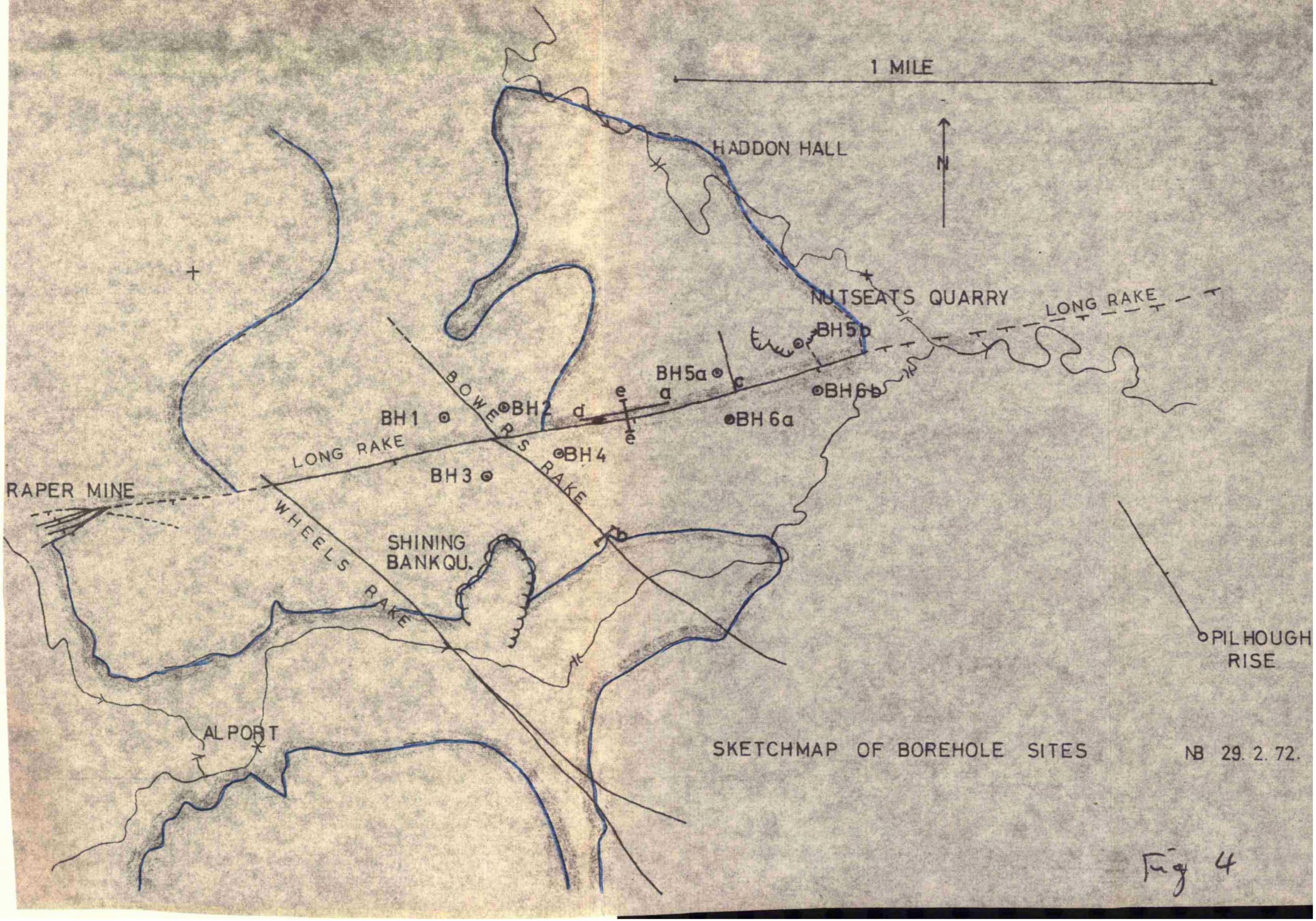
FIG.2.
Figure 2
ARROCK FAULT(projected)
BAKEWELL
DIRTLOW VEIN
MOGSHAW VEIN
STRUCTURE CONTOURS ON THE BASE OF THE SHALES
6" = 1 MILE
N
OVER HADDON
CONTINUATION OF VEIN IS WITHIN BLANK AREA
LATHKILLDALE VEIN
HADDON HALL
NUTSEATS QUARRY
LONG RAKE
BOWERS RAKE
RAPER MINE
SHINING BANKOU
WHEELS RAKE
LONG RAKE
SHANKDALE
PILHOUGH RISE
ALPORT
MAWSTONE MINE
NB. 25.2.72

LONG (LADIES) RAKE - BOWERS RAKE INTERSECTION   REVISED CROSS SECTION WITH BOREHOLES



SCALE 1" = 100FT

NB 29. 2.72.

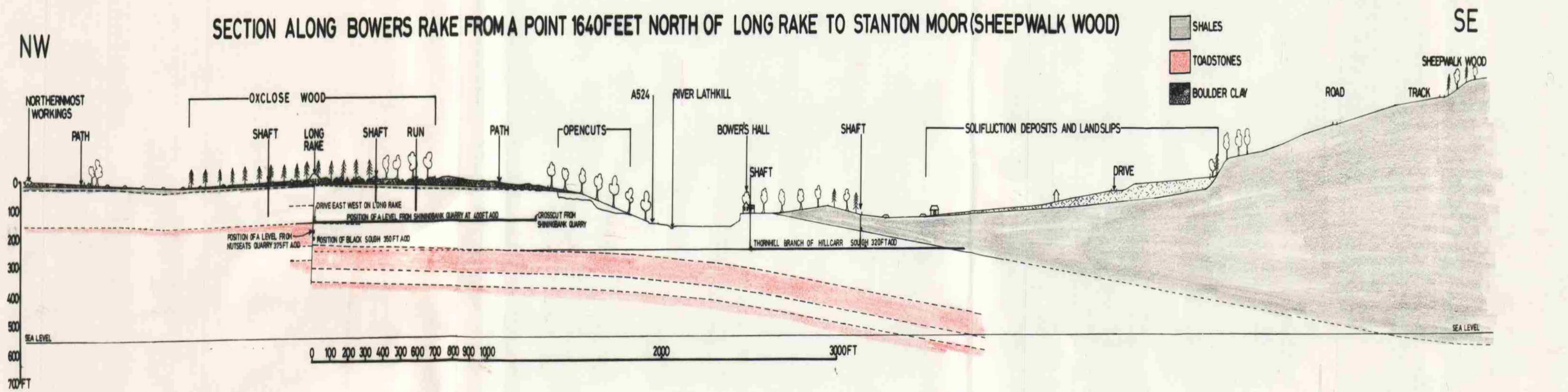


SKETCHMAP OF BOREHOLE SITES

NB 29. 2. 72.

Fig 4

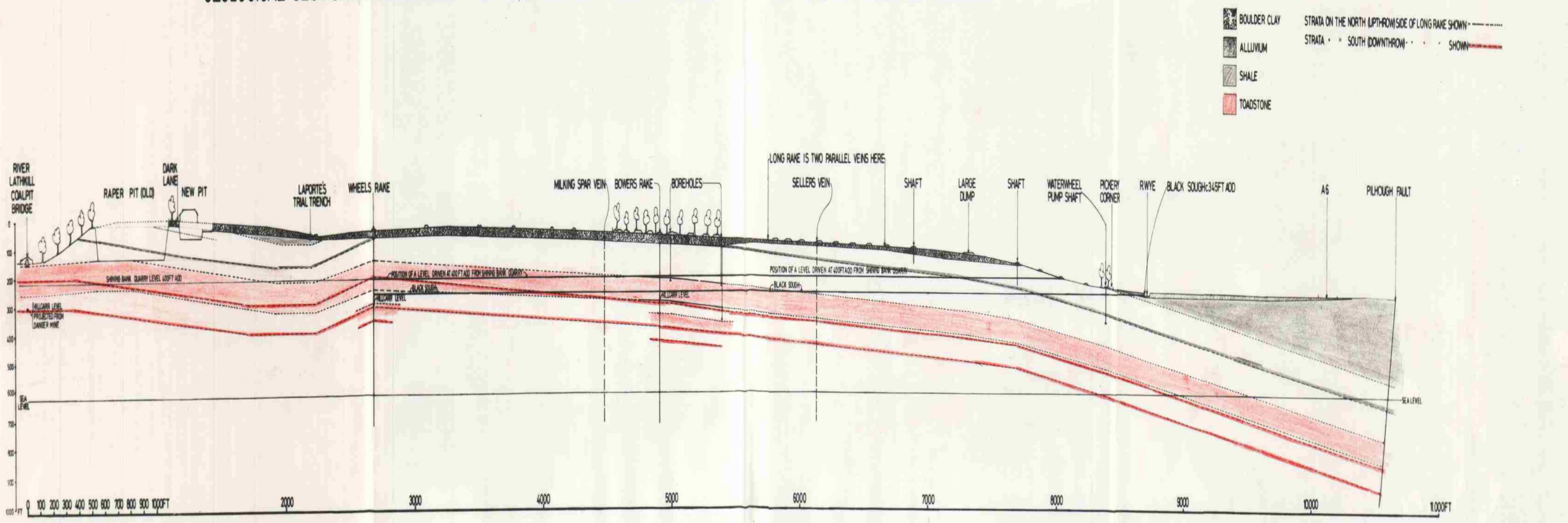
3/6



SECTION ALONG BOWERS RAKE FROM A POINT 1640FEET NORTH OF LONG RAKE TO STANTON MOOR (SHEEPWALK WOOD)
NW
SE
SHALES
TOADSTONES
BOULDER CLAY
NORTHERNMOST WORKINGS
PATH
OXCLOSE WOOD
SHAFT
LONG RAKE
SHAFT
RUN
PATH
OPENCUTS
A524
RIVER LATHKILL
BOWER'S HALL
SHAFT
SHAFT
SOLIFLUCTION DEPOSITS AND LANDSLIPS
DRIVE
ROAD
TRACK
SHEEPWALK WOOD
DRIVE EAST WEST ON LONG RAKE
POSITION OF A LEVEL FROM SHININGBANK QUARRY AT 400FT AOD
CROSSCUT FROM SHININGBANK QUARRY
POSITION OF A LEVEL FROM NUTSEATS QUARRY 375FT AOD
POSITION OF BLACK SOUGH 350 FT AOD
THORNHILL BRANCH OF HILLCARR SOUGH 320FT AOD
SEA LEVEL
SEA LEVEL
0
100
200
300
400
500
600
700FT
0 100 200 300 400 500 600 700 800 900 1000
2000
3000FT

FIG.5.

GEOLOGICAL SECTION OF LONG RAKE FROM THE RIVER LATHKILL IN THE WEST TO THE PILHOUGH FAULT IN THE EAST



SECTION OF WHEELS RAKE AND AMOS CROSS VEIN FROM LONG RAKE TO ANNALEES SHAFT NEAR STANTON IN PEAK

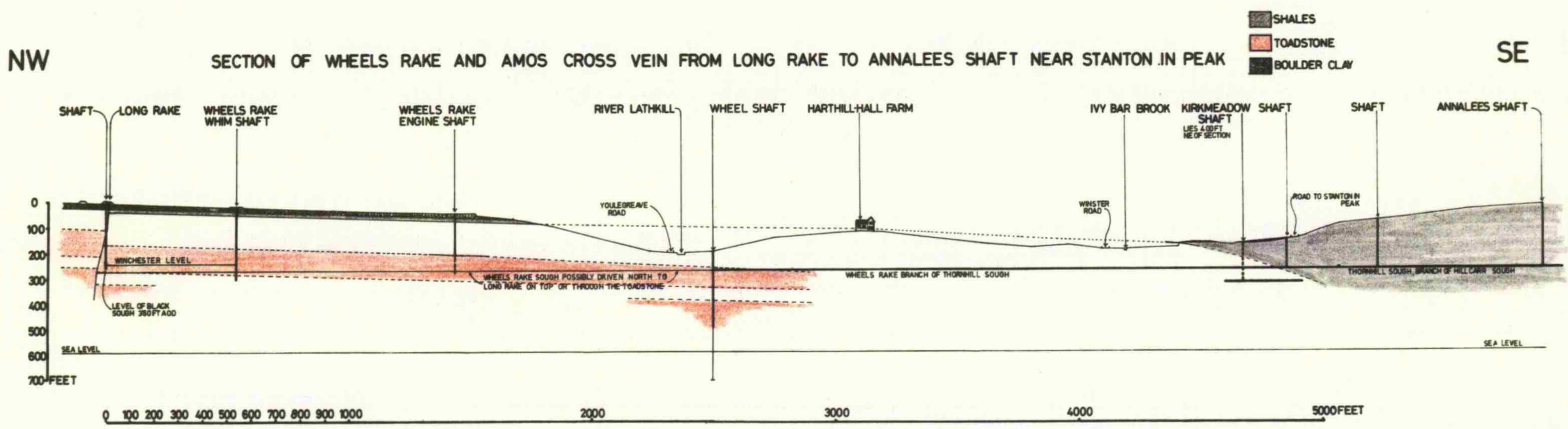


FIG.7.

SECTION OF THE PILHOUGH FAULT FROM LONG RAKE TO THE MILLCLOSE MINE

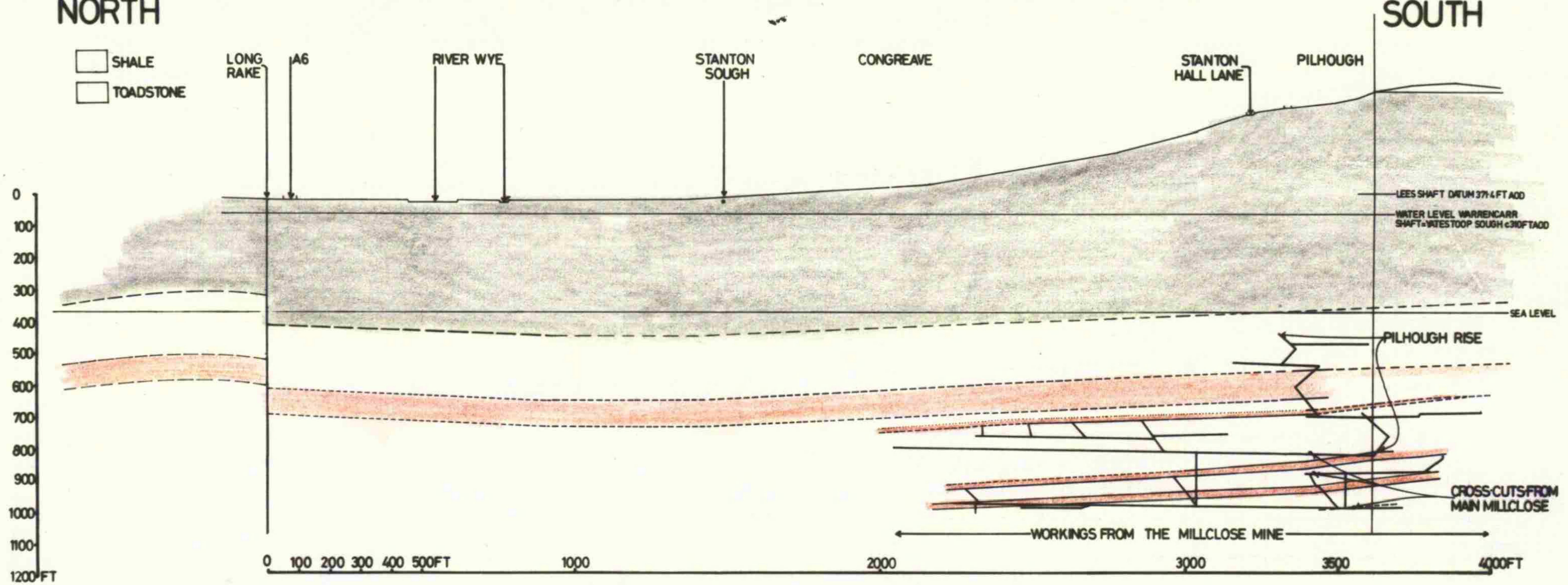


FIG.8.

REPORT 3

LONG RAKE FROM RAPER PIT TO THE LONG RAKE MINE CALCITE WORKINGS. DECEMBER, 1975

The section of Long Rake east of Raper Pit towards Pickery Corner has been described in the two previous reports. Fig. 1/1 in Report 1 shows the various sections of Long Rake and the main worked and potential deposits.

Details of Raper Pit See fig. 3/1

The Raper Pit is a vein and replacement orebody proved by underground drives in the 1940s and by opencasting in the 1950s and 1960s by R. Bacon and Sons. This led to the development by Laporte Industries of a large open pit between 1972 and 1974, reaching a depth of 140 feet: it was 400 feet long and 150-200 feet wide. The orebody is on a fault downthrowing to the south by 140 feet and this brings in 120 feet of shale in the south wall.

The pit works the eastern end of a large replaced split in the Long Rake Vein thought to extend westwards under the Lathkill River towards Conksbury Quarry. Only about one-quarter of the possible strike length has been exploited in the Raper Pit. West of the river along the footpath a deep sewer trench proved a broad zone of fluorite mineralisation in continuation with the Raper Pit deposit.

In Raper Pit the main workings are in a replacement between the two branches of the Long Rake Fault. The replaced beds are Upper Lathkill Limestones which form a horst bounded by the two faults at the west end of the pit (see Fig.3/2 Section B). At the east end of the pit the main replacements lay in a fault-bounded mass of Cawdor Reef Limestones (see Fig.3/2 Section A). On the north face of the pit a minor northwest fault branches off the main vein. This forms a graben with Cawdor Limestones preserved north of the main deposit. (See Fig.3/2 Section B). The northeast wall of this fault was not proved, but the fault contained downfaulted shales. The main Long Rake Fault has a throw of 120-140 feet down to the south and is the southern fault of the complex. The replacement was seen to extend under the shales on the downthrow side of the fault. This was in Cawdor limestones which in places have been turned almost to a vertical attitude by the fault, which hades 80° to the north.

To the east of Dark Lane, a trial pit proved the Long Rake where the two faults bounding the replacement had converged to form a single fracture. Towards the eastern end of this pit the fault was lost and a trial trench 400 yards to the east also failed to prove it, although this may have been sited too far to the south.

In all, about 300,000 metric tons of fluorspar have been extracted from Raper Pit in the beds above the Alport toadstone. This was proved at a depth of 120 feet in the western end of the pit. No exploration has been carried out below this toadstone (probably about 100 feet thick here) despite the fact that the broad zone of faulting suggests a potential deposit there.

East of the junction of Bowers Rake with Long Rake, the Long Rake splits for a strike length of 1800 feet. This could indicate a Raper Pit type orebody here as well.

Details of Conksbury Quarry

The Conksbury Quarry orebody was developed at the junction of Long Rake and 'Southwest' Veins. (See Figs.3/1, 3/2). Near their junction these ran almost parallel for several hundred feet. At the surface the fluorspar veins were relatively narrow, but at depth below a group of wayboards extensive replacement of the wall rocks occurred to the north, giving a zone of mineralisation up to 100 feet wide. Above the wayboards the pillar of rock between the two veins was also extensively replaced.

The replacement orebody below the wayboards tapered downwards towards the Alport Lava 80 feet below. Figure 3/2 Section C shows the situation west of the junction.

The main Long Rake Vein west of the junction with the South-West vein, was well defined on the south wall of the pit, where the vein was barite and fluorspar, but to the north the vein merged with a zone of replacement up to 30 feet wide below wayboards. Thus replacement became baritic and then siliceous towards the unaltered wall rock. In this section the Long Rake vein threw down some 20 feet to the south as judged by the displacement of the wayboards, but at the east end of the pit a horst of toadstone was present on the south side of the excavation about 120 feet below the surface, suggesting a more complex fault. The vein was 12-25 feet at the east end of the pit.

The southwest vein hades south at 80° and the vein was worked to a depth of 80 feet where it became tight. At the southwest end of the cut the vein, still carrying fluorspar, split into three branches. The northerly branch hades north at 75°. A borehole 300 feet southwest of the last workings proved limestone resting on toadstone at a depth of 120 feet.

Workings to the west on the main Long Rake Vein proved toadstone at a depth of 84 feet below surface so that it is rising at about 10-15° in this direction. Boreholes in the floor of the pit penetrated 90 feet of toadstone without bottoming it. The toadstone, despite rising to the west, is not known to outcrop. It is not present in the Long Rake Calcite Mine workings to the west so that it appears the flow must have a front somewhere just to the west of the pit, and is probably represented by thin clay wayboards further west. The nature of the vein below the toadstone is unknown and it could be either fluorite or calcite. A programme of diamond drill cored holes was put down below the toadstone by A.L.C.O.A. but no results are available to the author.

West of the present quarry the Long Rake splits and the northern branch is intersected by two fluorspar-bearing northeast veins (see Fig. 3/1). In this complexly veined piece of ground there is the possibility of large scale replacement both above and below the lava. Detailed long sections of the Long Rake and Southwest Veins are given in figs. 3/3 and 3/4 respectively.

PLAN OF LONG RAKE FROM RAPER PIT TO CONKSBURY QUARRY

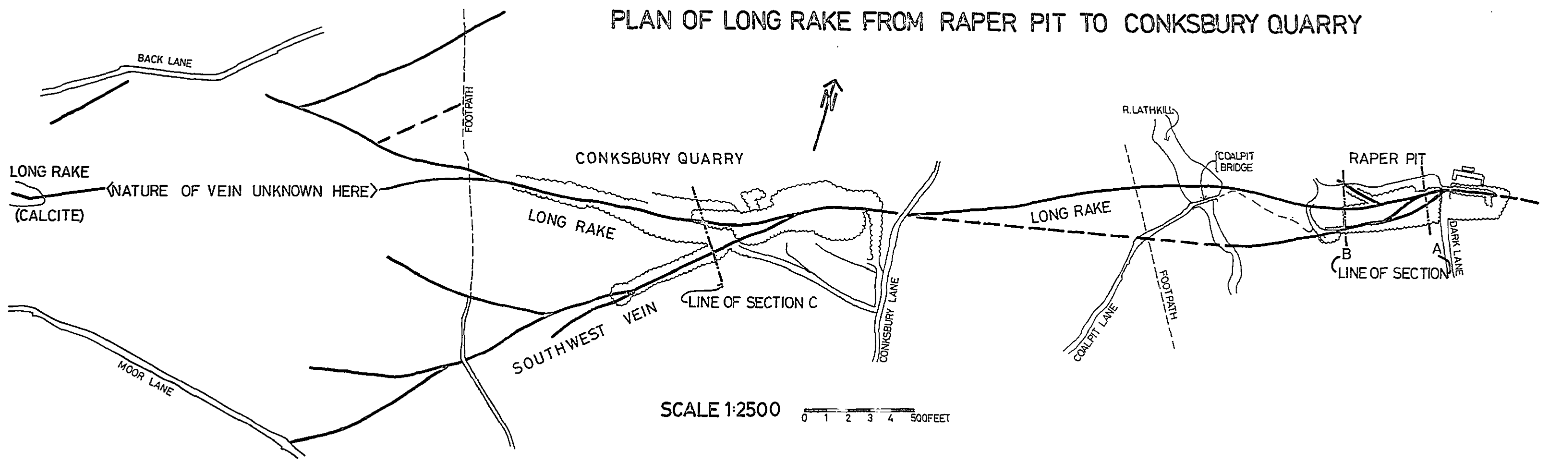


FIG.1.

SECTIONS ON THE LONG RAKE

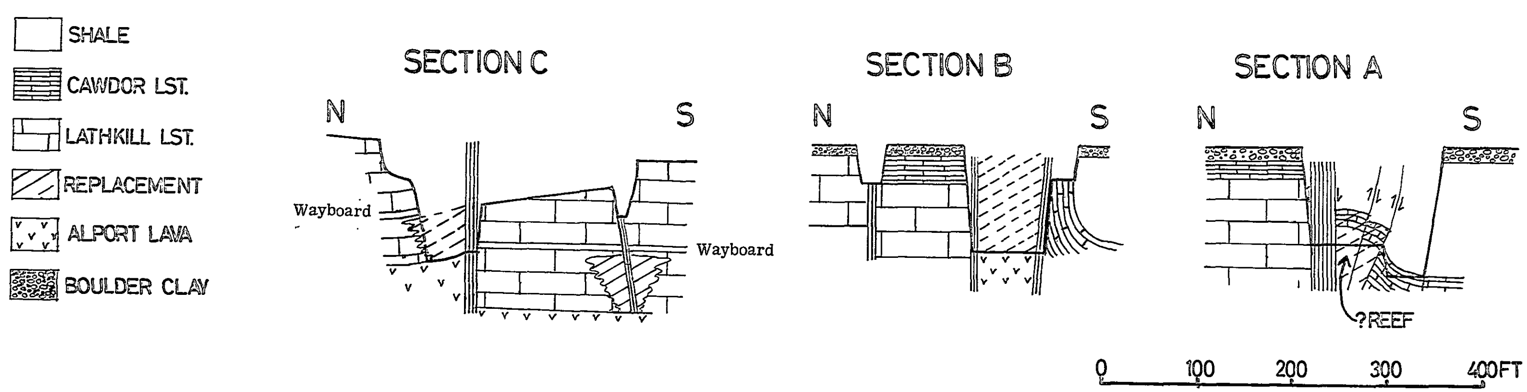


FIG.2.

SECTION ALONG LONG RAKE AT CONKSBURY QUARRY SHOWING THE MINERALS AND THE TOADSTONE

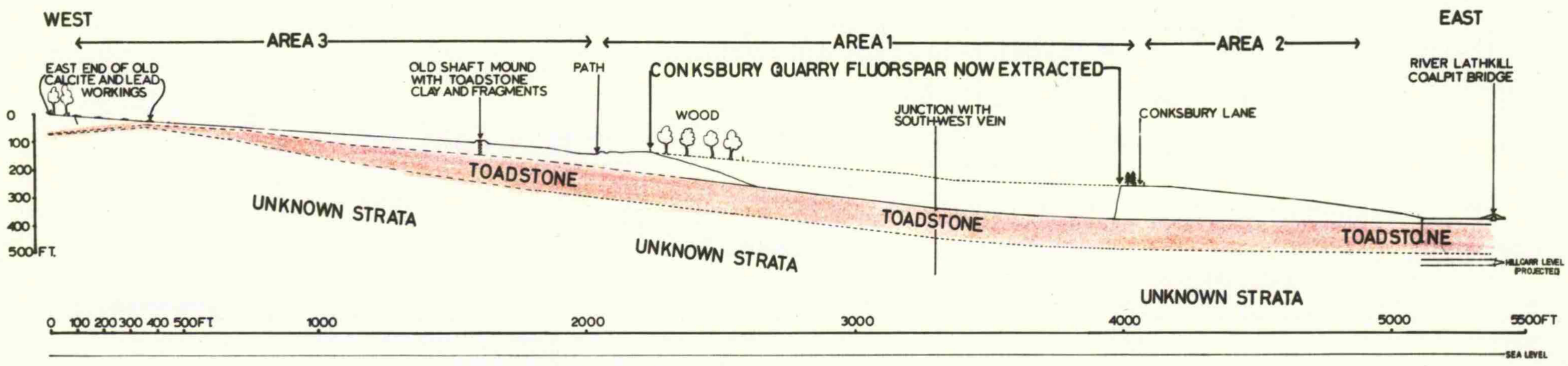


FIG.3.

SECTION OF SOUTH-WEST VEIN FROM THE YOULGREAVE-FRIDEN ROAD TO THE LONG RAKE JUNCTION

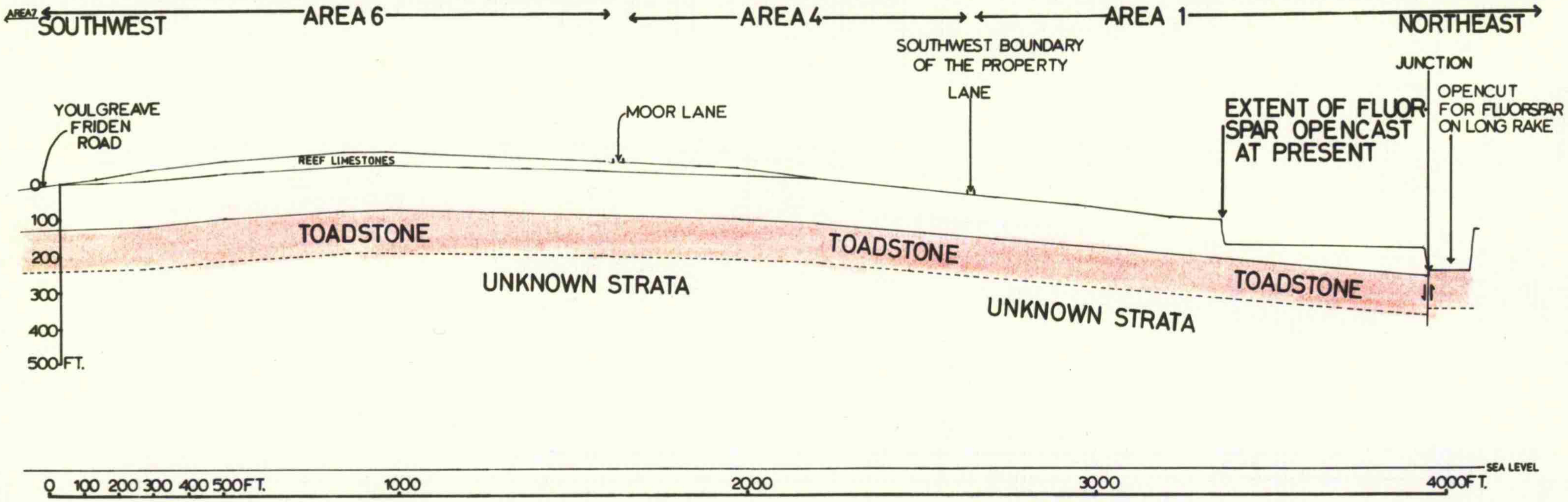


FIG. 4.

REPORT 4

THE HARTHILL SECTION OF THE ALPORT MINING FIELD. DECEMBER, 1975

This is a very old mining area worked extensively for lead from the 16th Century onwards. Nearly all the veins have been discovered and worked down at least to river level. Several major drainage projects, the main one of which was the Hill Carr Sough driven between 1766 and 1787 have lowered the water table to 100-140 feet below river level, i.e. to 310 feet A.O.D. The veins south of the Lathkill-Bradford area have been worked to this depth in the 18th and 19th Centuries. North of the river the workings are generally shallower and older.

Several shafts have been worked below the Hill Carr level. These are Mawstone Mine, Old Engine Shaft, Pynet Nest Shaft, Guy Shaft, Broadmeadow Shaft, Bacon Close Shaft, Wheels Rake Shaft and Stoneylee Shaft. At these shafts various hydraulic engines, water wheels and steam engines worked to depths of between 4 and 23 fathoms below the Hill Carr level, i.e. to about 180 feet A.O.D. at the deepest. The workings at Broadmeadow and Mawstone Mines bottomed on the local highest toadstone (Alport lava). At Wheels Rake this toadstone was passed through and a second deeper toadstone was found. Details are given in the sections of the Long Rake Report 2, Fig. 7.

The Alport workings were centred on the crest and flanks of a southeast minor anticline plunging into the Stanton Syncline to the south. In general as the workings proceeded down the flanks away from the crestal area they became tight and impoverished. This suggests that the veins were tensional in origin and more open over the fold crest. All the workings (except at Wheels Rake) were developed between the base of the shales and the top of the first toadstone. The main productive beds were a middle group of thick bedded coarse grained pale limestones (Upper Lathkill limestones). In the overlying thin-bedded dark shaley and cherty beds mineralisation was weak, except in the 'Great Shell Beds' or reefs. The lowest beds on top of the toadstone were also thin-bedded and dark, and weakly mineralised.

From the old accounts it is clear that galena occurred in the veins both as persistent stringers as well as richer pipe-like masses of ore, which were a source of a considerable proportion of the output. Often these areas were worked out by hand pumping below the sole of the workings for up to 120 feet. Where shafts were deepened in later times and levels driven out, quite often the richer ores had been 'robbed out' by the "old man" from above.

The Hill Carr Sough was a successful venture because it unwatered the white limestones on the anticlinal crest. The majority of the later 19th Century pumping engines were sited off the axis or pumped out the lowest unfavourable black limestones on the crest. Thus, 19th Century mechanisation was a financial disaster of major proportions never covering the running, let alone the investment, costs.

Fluorspar occurs on many of the old dumps and workings notably on Blythe Pipe, Guy Vein, Pynet Nest Vein and Ditch Vein. In general the veins are narrow, with a maximum of 6 feet, but they lie under a shale cover, where it is possible that small replacements may occur in places. Many of the old workings are still accessible and a systematic programme of exploration is necessary to determine their potential. Any workings below the Hill Carr level would encounter considerable water problems from old workings.

The crest of the anticline below the toadstone has never been examined by mining. The principal veins - Old Cross, Oldfield Pipe, Guy Vein, Bacon Close Vein, Ditch Vein, Blythe Pipe and Bakers Vein would be good exploration targets for fluorspar and sulphides below this toadstone, using the analogy of the structures of Millclose Mine. The only piece of vein worked below the toadstone was Wheels Rake which worked with steam engines into the 1880s suggesting that a reasonable return on capital was being made.

Details of the veins and workings are given in fig. 4/1.

THE HARTHILL SECTION OF THE ALPORT MINING FIELD

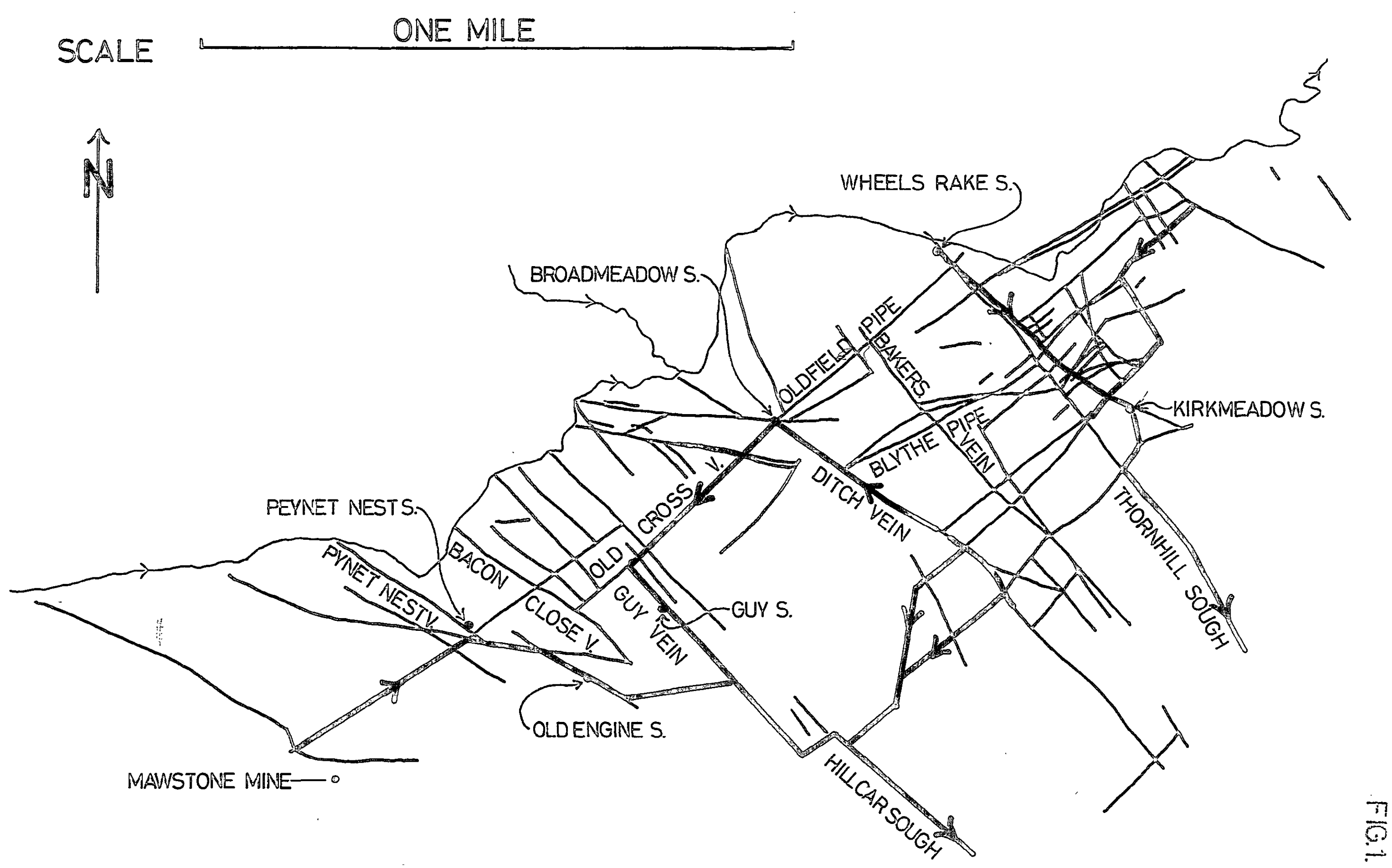


FIG.1.

REPORT 5

PRELIMINARY GEOLOGICAL REPORT ON FLUORSPAR DEPOSITS IN HAZLEBADGE PARISH

OCTOBER, 1972

The Geology of the Area

The geology of the area, modified slightly from the Geological Survey (I.G.S.) maps, is shown in fig. 5/1. The area lies in an east-dipping limestone block, bounded to the north by Moss Rake - a strong calcite vein-fault, downthrowing to the north, and High Rake - Tideslow Rake to the South, also downthrowing north and associated with north-facing monocline.

There are three main geological controls on mineralisation in the area - the base of the Edale Shales; the presence or absence of reefs in the uppermost Eyam Limestones and the presence or absence of any of three toadstones. The general succession is shown in the column at the side of fig. 5/1.

Shales

Structural contours on the base of the shales have been produced on rather limited evidence in attempting to predict the position of the shale base east of the outcrop (fig. 5/2).

Reefs

These irregularly bedded, vuggy limestones are susceptible to replacement or cavern formation with voids later infilled with minerals. Pic Tor Pipe and the workings at SK 169804 are examples, whilst the shaft and workings at Nether Water Mine hoped to intersect similar deposits but apparently failed.

Toadstones

To the west and south of the area, three horizons of toadstone are known - The Cressbrook Lava - Litton Tuff and the Upper and Lower Millers Dale Lavas.

a) The Litton Tuff

This outcrops at Tideslow and is known to the east in High Rake Mine and Mill Dam Mine shafts and in the Derwent Valley Water Board's Great Hucklow Borehole. It was probably intersected in Laportes' inclined borehole at Washhouse Bottom but we have no data. The Water Board's Broadlow and Little Hucklow boreholes are not quite deep enough to prove the presence or absence of this toadstone.

The horizon appears to die out northwards and will probably only be of significance in the extreme south of the Hazlebadge area, around Virgin Mine. However, it should be borne in mind that a tuff or clay wayboard at an appropriate horizon is known as far north as Long Rake Mine on Bradwell Moor.

b) Upper Millers Dale Lava

This outcrops west of the area but its presence in the Hazlebadge cannot be closely defined. Deep Shafts on Earl Rake, Chance Mine and on Shuttle Rake Mine are about 360 ft. deep and have toadstone on the dumps. Such a depth is consistent with the horizon of the top of the Upper Lava. The Upper Lava is apparently absent on Moss Rake, Long Rake and Earle's Quarry to the north.

c) Lower Millers Dale Lava

The Lower Lava outcrops west of the area and is known to the north in Cave Dale and in boreholes at Earle's Quarry. It is reached at 450 ft. by Kittycross Shaft on Moss Rake and is apparently a toadstone "passed through" according to the Geological Survey, in the 480 ft. deep Silver Cross Shaft on Moss Rake. The toadstone has recently noted at 520 feet depth in Long Rake Mine.

General

On the basis of this slender information, it would appear that the Lower Millers Dale Lava may underly the whole area at a depth of 650 ft.

stratigraphically, below the shales, its top being at about 630 ft. A.O.D., in the west and a little below sea level in the east. The Upper Lava may be absent in the north and east of the area. However its horizon would be at about 750 ft. A.O.D., in the west and around sea level in the east. The Litton Tuff/Cressbrook Lava is probably only of significance in the extreme south of the area.

Drainage

Moss Rake Sough, Pic Tor End Sough and Bagshawe Cavern resurgence control the water-table of the area. Their courses are shown on fig. together with unexplored but dye-tested connections with the Bagshawe Cavern. The three outfalls are in Bradwell at 580 ft. A.O.D. Any attempt at deep mining will affect the solids content and outflow volume of these outlets and therefore the flow of Bradwell Brook. A quarter of a mile north of Bradwell this has the Derwent Valley Water Board take off point for the Winhill Tunnel supply to the Derwent Dams.

Pic Tor End Sough

In the 1800s, a waterwheel and steam engine pumped from below the sough, where it crossed Earl Rake and the discharge ran north along the sough. The level was intended to be extended southwards to Mill Dam Mine, Hucklow, but this was not completed. When entered by Professor Shotton about 1950 via Pic Tor End Shaft, no evidence of this extension was found. The water level was accurately measured as 587.2 ft. A.O.D. A branch on Earl Rake reaches Water Shaft in the Dale bottom about 70 ft. below the road.

In the west of the area, the water-table position will be controlled by the highest local toadstone. Each of these will tend to funnel water eastwards towards the soughs and/or cavern systems and any deep mining below the water-table in the east will find considerable volumes of water.

Details of Individual Veins

The veins of the area have been walked to get a preliminary idea of their content, width and degree of previous working for fluorite. It seems likely that all the major veins have been worked by the old man for galena down to the water-table or the highest local toadstone. Only the east end of Earl Rake has any historical evidence of working for lead below the water-table.

Hartle Moor Farm Rake is a small vein reaching 3-4 ft. wide runs across the upper end of Hartle Dale, just below Hoveringham's quarry tip and under Hartle Moor Farm. On the east side of the Dale, a shallow shaft and adit were sunk in the 1950s and small-scale stoping carried out, but the vein cannot be seen now. It has not been worked west of the Dale.

Hartle Dale Rake and Associated Veins show a consistent fairly high proportion of fluorite all along the length. The Rake appears to break up into a zone of fractures towards Bradwell Dale. Here the southernmost fracture is exposed in the old quarry, showing 2-3 ft. of 30-50% fluorite with calcite. On the east side of the Dale, the vein is a barren stringer but under the shales further east, it may expand, as a shaft mound is present. The vein and dumps have not been worked for fluorite except immediately adjacent to the road at the west edge of Hazlebadge.

At SK 169805 a mineral deposit lies immediately south of the vein. The working is in a complex replacement of dark, cherty Eyam Limestones, about 60 ft. by 30 ft. Large clay and fluorite block-filled vertical solution pits pass through it. The degree of replacement is variable. The west wall of the pit appears to be the edge of the deposit but the east wall still has an appreciable fluorite content. It is possible that further pitting might reveal extensions or new deposits. One problem will be the extent of unreplaced chert nodules.

Earl Rake is apparently the longest and strongest vein in the area. It only averages 3-4 ft. wide, reaching 10 ft. occasionally and closing down to 1 ft. in one place. The dumps show a high calcite proportion in the coarse fraction but fluorite is in higher proportion among the visible fines. Extensive dumps remain all along the Rake west of Bradwell Dale. Judging by the present opencuts west of Hazlebadge, 20-40% of fluorite may be present in the western end, perhaps increasing to the east. The vein is suitable for small scale open pitting. East of Bradwell Dale large open stopes are present and open working for fluorite in conjunction with the intersecting Pic Tor Pipe has been carried out. This section of the vein has not yet been fully examined.

Shuttle Rake is a single large fracture in the west of the area worked by Laportes in a shallow open pit. It breaks up into a zone of fractures, each rarely exceeding 3 ft. wide as it enters Hazlebadge. West of Intake Dale shallow open pits for fluorite have been backfilled. In Intake Dale, a large fines dump, associated with a deep shaft, has been completely removed. From here to Top Hole Road some dumps have been removed and a little shallow pitting carried out. East of here and to the south of Hazlebadge Farm, the vein appears to be much stronger but it lies below the shales. The dumps have been worked for low grade fluorite here.

Barnes Flat Vein is west of Top Hole Road/New Road junction. Although flattened the vein may be traced but its content and width cannot be determined. Parallel and close to New Road, although the dumps remain, they are grassed and the contents unknown.

Maiden Rake - Nether Water Vein has not yet been examined.

Virgin Mine - May Mine: the length of vein in Hazlebadge is quite short and lies below the shales. The dumps show a dominantly fluorite gangue.

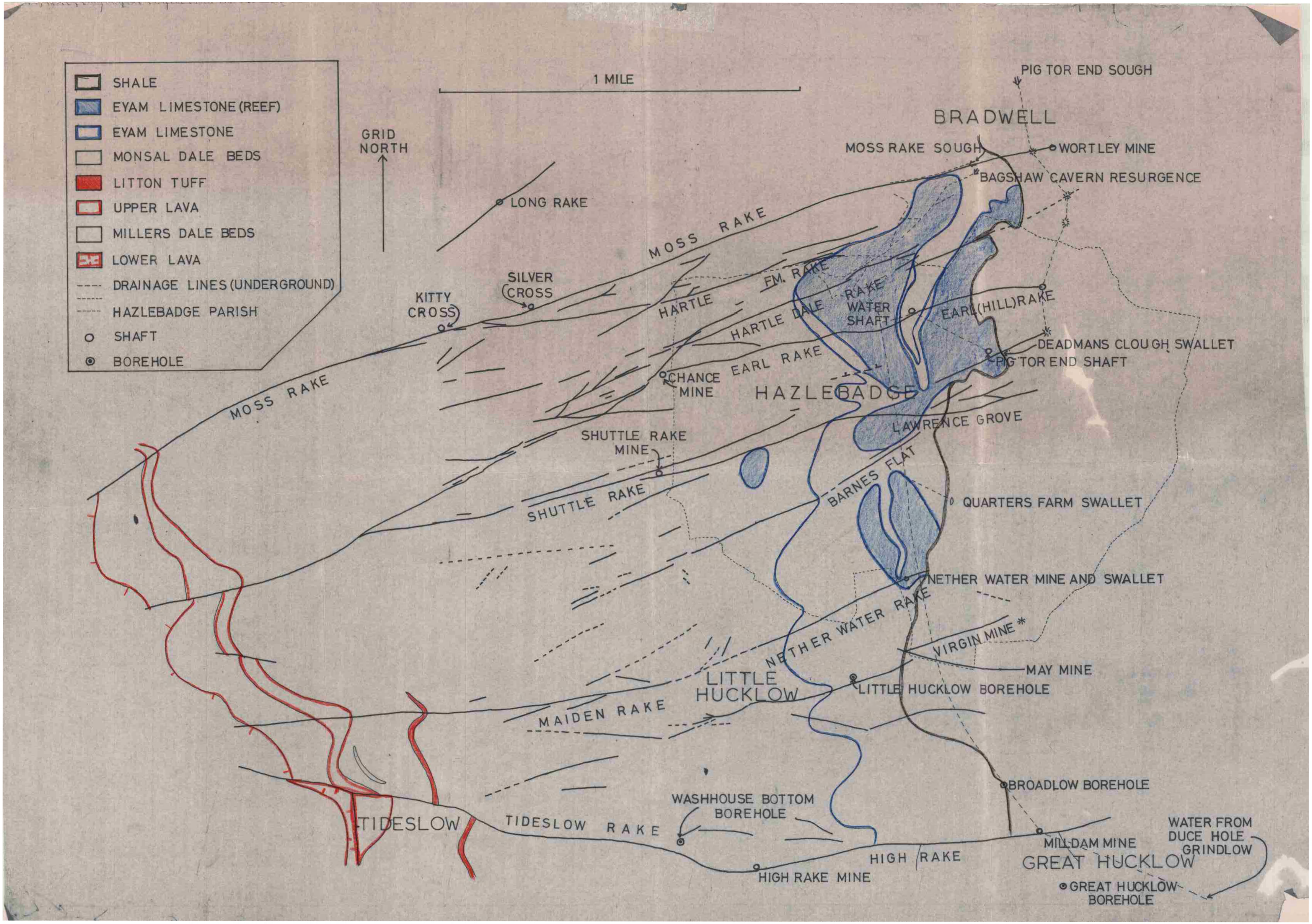
Pic Tor Pipe consists of a linear series of NNW pipe-replacements and cavern-fill mineralisation which have been worked from surface down to

120 ft. The deposits are in Eyam Reef limestones. Their extreme irregularity, clay fills and variable limestone overburden, make them unattractive for more than small scale work. Other deposits of this type may occur.

General Conclusions

A systematic programme of dump sampling to prove the fluorite content of the fines, is required mainly in Hartle Dale and Earl Rakes. A series of pits and trenches is necessary to prove the widths and contents of each of the veins detailed above (except those below the shales). A few shafts within and adjacent to the area could be usefully descended.

Any attempt at deep-mining will require a borehole programme to prove the strata - particularly the toadstones. Deep mining potential is probably confined, on the basis of vein widths and contents, to the eastern half of the area, under the shales, although little is known of the vein widths/contents at depth in the west. Any attempt to mine in the east will find shale dipping to the water-table within a few hundred yards, except in the south of the area, where greater lengths may be available. Any attempt to mine below water-table (and perhaps above) may pollute or upset the supply to the Derwent Valley Water Board's take-off point on the Bradwell Brook.


SHALE
EYAM LIMESTONE (REEF)
EYAM LIMESTONE
MONSAL DALE BEDS
LITTON TUFF
UPPER LAVA
MILLERS DALE BEDS
LOWER LAVA
DRAINAGE LINES (UNDERGROUND)
HAZLEBADGE PARISH
SHAFT
BOREHOLE
1 MILE
GRID NORTH
PIG TOR END SOUGH
BRADWELL
MOSS RAKE SOUGH
WORTLEY MINE
BAGSHAW CAVERN RESURGENCE
LONG RAKE
MOSS RAKE
SILVER CROSS
KITTY CROSS
FM. RAKE
HARTLE
HARTLE DALE
RAKE WATER SHAFT
EARL (HILL) RAKE
DEADMANS CLOUGH SWALLET
PIG TOR END SHAFT
EARL RAKE
CHANCE MINE
HAZLEBADGE
LAWRENCE GROVE
MOSS RAKE
SHUTTLE RAKE MINE
SHUTTLE RAKE
BARNES FLAT
QUARTERS FARM SWALLET
NETHER WATER MINE AND SWALLET
NETHER WATER RAKE
VIRGIN MINE *
MAY MINE
LITTLE HUCKLOW
LITTLE HUCKLOW BOREHOLE
MAIDEN RAKE
BROADLOW BOREHOLE
WASHHOUSE BOTTOM BOREHOLE
TIDESLOW
TIDESLOW RAKE
HIGH RAKE
HIGH RAKE MINE
MILLDAM MINE
WATER FROM DUCE HOLE GRINDLOW
GREAT HUCKLOW
GREAT HUCKLOW BOREHOLE

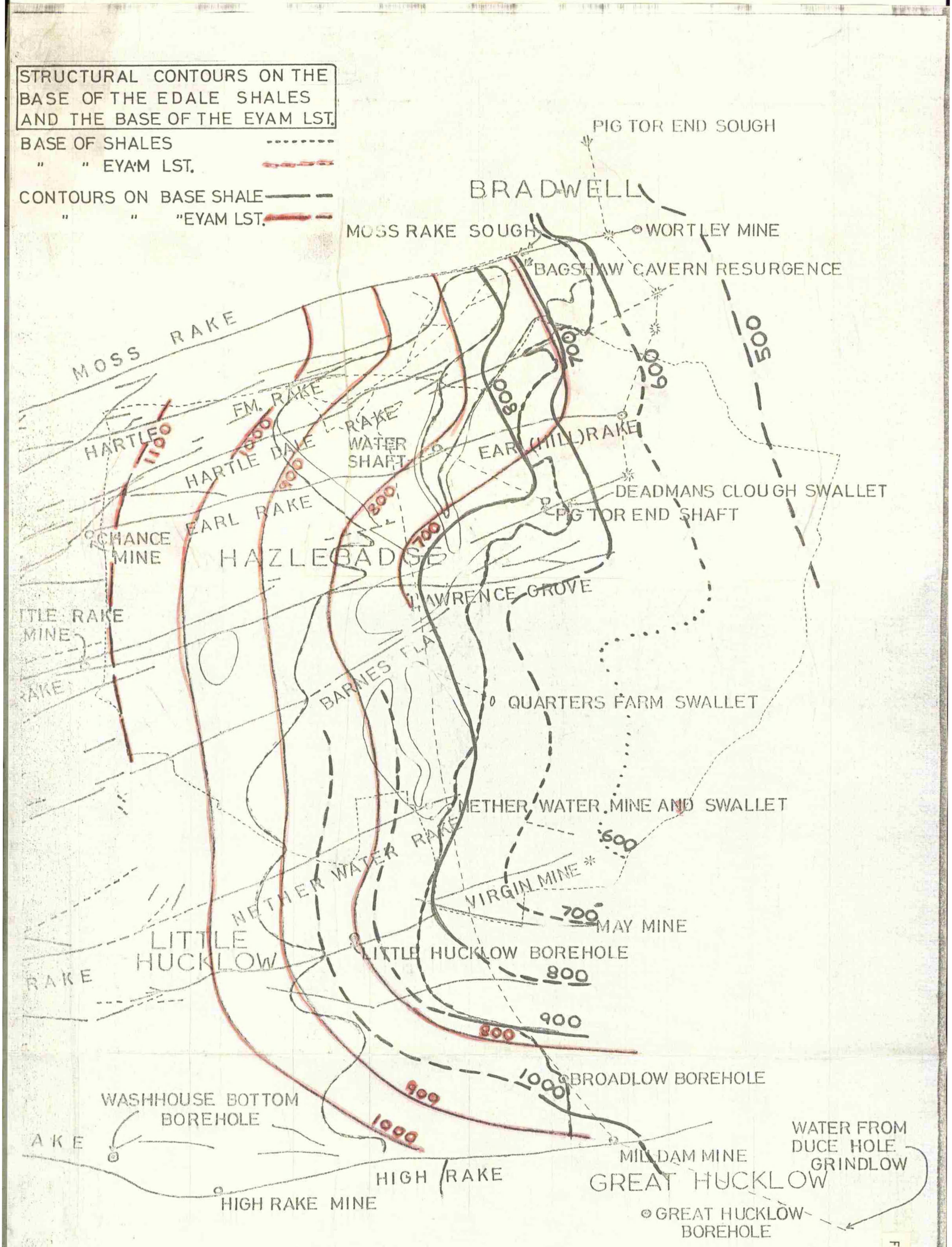

STRUCTURAL CONTOURS ON THE BASE OF THE EDALE SHALES AND THE BASE OF THE EYAM LST.
BASE OF SHALES
" " EYAM LST.
CONTOURS ON BASE SHALE
" " "EYAM LST.
PIG TOR END SOUGH
BRADWELL
MOSS RAKE SOUGH
WORTLEY MINE
BAGSHAW CAVERN RESURGENCE
MOSS RAKE
FM. RAKE
HARTLE
HARTLE DALE
RAKE WATER SHAFT
EARL (HILL) RAKE
DEADMANS CLOUGH SWALLET
PIG TOR END SHAFT
EARL RAKE
CHANCE MINE
HAZLEBADGE
LAWRENCE GROVE
ITLE RAKE MINE
RAKE
BARNES FLAT
QUARTERS FARM SWALLET
NETHER WATER MINE AND SWALLET
NETHER WATER RAKE
VIRGIN MINE
MAY MINE
LITTLE HUCKLOW
LITTLE HUCKLOW BOREHOLE
RAKE
BROADLOW BOREHOLE
WASHHOUSE BOTTOM BOREHOLE
AKE
MILLDAM MINE
HIGH RAKE
GREAT HUCKLOW
WATER FROM DUCE HOLE GRINDLOW
HIGH RAKE MINE
GREAT HUCKLOW BOREHOLE
500
600
700
800
900
1000
1100

FIG. 2.

REPORT 6

REPORT ON MAPPING OF MINERAL VEINS IN DERBYSHIRE UP TO 31st OCTOBER, 1972

Summary

Work has been concentrated on the production of a 6 inches : 1 mile geological map of the limestone area not yet covered by the recent maps of the Geological Survey. As maps are available mapping of the areas of the Matlock, Wirksworth and Darley Dale 6 inches : 1 mile sheets has been limited. In general, the programme has been to work across the area from east to west, hence the distribution of completed, semi-complete and reconnaissance mapping.

A map of veins on a scale of 6 inches : 1 mile of the whole of the orefield has been prepared for areas where aerial photos are available. This shows good agreement with the Geological Survey mapping of the Chapel-en-le-Frith Sheet but considerably amplifies the vein pattern shown on the Chesterfield Sheet.

A joint and fracture reconnaissance has been made of the area south of Lathkill Dale but interpretation is not yet complete.

Underground survey work has been carried out in the Matlock and Alport areas.

Mapping

The area has been mapped with a view to determining stratigraphy and structure, as well as defining accurately the position of mineral veins. A careful examination of dumps has been made with a view to getting a general picture of the pattern of mineralisation. No sampling or assay work has been done.

The main result of the work has been to demonstrate the more westerly extent of significant fluorite mineralisation than has been shown on the previously published maps of Gibson and Wedd, Mueller and Dunham. This is the result of the inattention of previous authors to the distribution of minerals in the fine-grained fraction on the waste hillocks. Previous work has been concentrated on the major E-W veins and there is some evidence of calcite dilution of the contents westwards. Smaller NW and NE fractures appear to have lower calcite contents and hence a higher fluorite and barite proportion. The Geological Survey record fluorite-calcite veins south-west of Buxton, whilst fluorite is also present at a number of previously unrecorded localities, e.g. in a small quarry in Buxton; at Tarmac's Hurdlow quarry; at the Burrs (Chelmorton); at Sough Top (Taddington); near Benty-Grange (Parsley Hay); in the Blake Moor sand pit; in Gratton Dale and at various localities around Aldwark. Together, these indicate that fluorite has a far less restricted distribution than previous literature suggests and that its occurrence needs more careful documentation.

Four areas of specific mineral interest are detailed later.

Fracture Analysis

The initial work on this is almost complete. It is hoped to establish the degree of correlation between minor fractures and the mineral vein pattern and to use this data to predict vein orientations in poorly exposed areas.

Underground Work

a) Masson Flat

Survey work to extend the incomplete 1940s abandonment plan has been carried out as a preliminary to studying the geology of this complex deposit. The Masson workings have been chosen as they are the most readily accessible "pipe" working and the results should be of value in understanding the mechanism of pipe formation which may then be applied to other deposits.

b) Ball Eye

Survey work has been carried out in Clatterway Sough, Ball Pie (Brogdale), Ball Eye, Rugs Hall (the Hermitage) and Cambill level, all of which show intense fluorite mineralisation. The plans will be reduced on to a common 25 inches : 1 mile scale map and the underground geological data linked to surface mapping to produce a three-dimensional picture of the geology and ore potential of the area. (See fig.6/2 for mine localities).

c) Bowers Rake

An attempt to enter Bowers Rake branch of Hill Carr Sough proved abortive as it was blocked by dead sheep. The shaft, 75 ft. deep, lies behind Bowers Hall and was cleared to the Sough in the 1930s by Millclose Mine Co. Only stopes immediately below the shale are accessible. The vein is not seen in situ but was about 3-4 ft. wide with a fluorite gangue. Galena, pyrite and sphalerite were also present.

Details of Areas of Specific Interest

Gratton Dale

A plan of the Gratton Dale area, showing the Deepwood Mining Company activities, is enclosed (fig.6/1). I understand that an adit, trending northeast out of the Dale, on Coast Rake, has been contemplated, as it appears that a promising vein is present. Further southwest, up the Dale, extensive augering has been carried out. Here, there are indications of a sugary fluorite flat deposit high up on the northwest face of the Dale.

Portway Pipe

In view of the working of dumps of Portway and Placket mines for fluorite in the fines, it would be reasonable to suppose that dumps from similar workings above the Lower Lava to the west and east of Winster, might be usefully investigated. To the east, large dumps on Back Pastures - Orchard Pipe, Yatestoop Pipe and others towards Tearsall Farm are present, whilst in the west, towards Gratton Dale, moderate size dumps are present on Aldermans, Cowclose, Water Rake and Cowlishaw Pipes and a swarm of northwest scrins and minor veins. Few of these dumps have been tried for fluorspar.

Whitelow Rake, Winster

Recently workings have exposed a strong fluorite vein between the Lower Lava and the Tearsall Farm lava. The vein has been worked northwest above the Lower Lava as an open pit (parts of this may be workable to a greater depth) but no attempt has been made to work southeast below the Tearsall Farm lava towards Shothouse Spring. At present, workings are beginning to expose the top of this lava.

Bonsall Fault (fig. 6/2)

The Bonsall Fault and/or associated veins have been worked for fluorite above Pitchmastic Ltd's Quarry, at Cromford, immediately east of Uppertown (Bonsall), in the Blakelow opencasts and Rockach shafts to the west and in a pit a few hundred yards west of Moor Farm, on Bonsall Moor. The fault or associated complex of faults, appear to be mineralised along the whole length but several significant sections have not been tried yet.

a) Pitchmastic Quarry Overburden Tip Veins

Four parallel NW-SE veins, north of the Bonsall Fault, have been worked by dragline, within the area now being filled by stripped waste. No attempt has been made to work them northwest of the dump boundary, although trials by Deepwood Mining Company, in the projected line to the northwest show moderate fluorite contents. A systematic trial of the main Bonsall Fault, northwest of the quarry, towards Bonsall Village, may also be worthwhile.

b) Uppertown to Blakelow Opencasts

Between Bonsall and Uppertown, open pitting for fluorite, up to 10 ft. wide, in limestone faulted against dolerite, is recorded by the Geological Survey. The workings are now backfilled and it is not now clear to what depth and how thoroughly the work was carried out. A similar geological situation applies to the fault west of Uppertown, all the way to Blakelow open pit and for that matter, to the Moor Farm pit. No examination by pitting of the Bonsall Fault proper, has been made.

c) Blakelow Opencasts to Moor Farm

The Blakelow Opencasts to the north of the main Bonsall Fault, the position of which is uncertain, consist of workings in a replacement deposit, associated with minor faulting below a cap rock of lava, probably the Lower Lava. Thick soil limits geological mapping outside the pits and so the true outcrop pattern cannot be determined. The zone of minor faults and replacement may well extend west of Rockarch shaft, past Beans-and-Bacon Mine, towards Moor Farm. It cannot be proved whether the northern margin of the toadstone here, is faulted or a stratigraphic contact, nor can the position of the faulted southern boundary be clearly located. Further work will be done when the relevant fields are ploughed. It would appear that a programme of fairly deep trenching would be necessary to prove both geology and minerals.

The presence of fluorite in the pit west of Moor Farm, associated with toadstone and on the line of the Bonsall fault, lends strong support to the hypothesis outlined above.

d) West of Moor Farm

West of Shothouse Spring, the Bonsall fault runs along the northern boundary of Giulini's Aldwark property. No exposures or workings are known but, in view of the fluorite in Ivonbrook Quarry, mineralisation may occur. Again, trenching and pitting will be necessary.

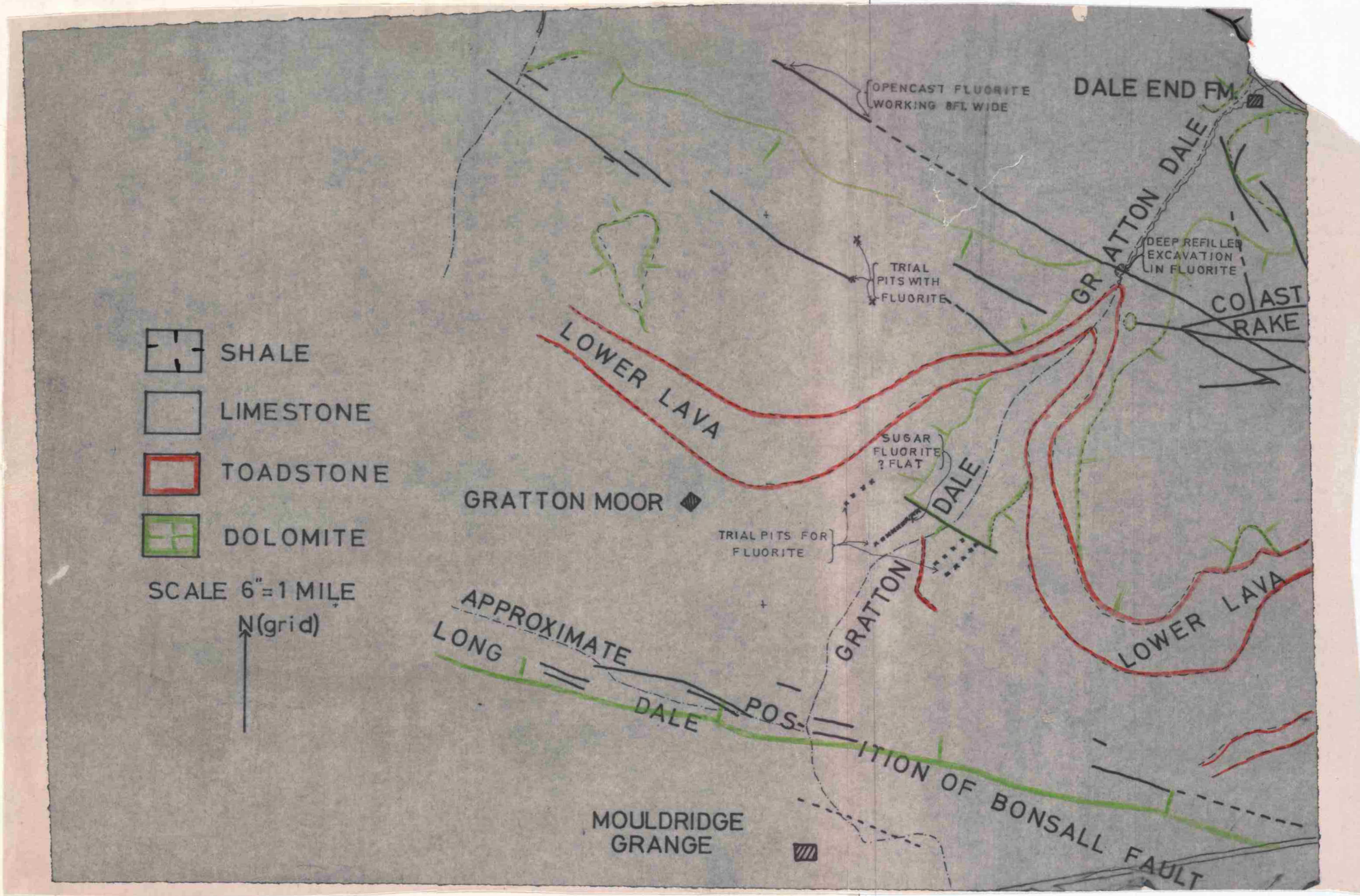
Future Work

It is proposed to complete mapping westwards to the line of the Cromford and High Peak Railway, south of a line through Chelmorton and Taddington and to remap, in detail, sections of the Matlock Sheet during the coming winter months. This should complete the 6 inch : 1 mile map of the geology and veins for the orefield south of the River Wye.

On the basis of these maps, a programme of systematic dump sampling will be devised, to give a more accurate picture of the distribution of gangue minerals across this part of the orefield.

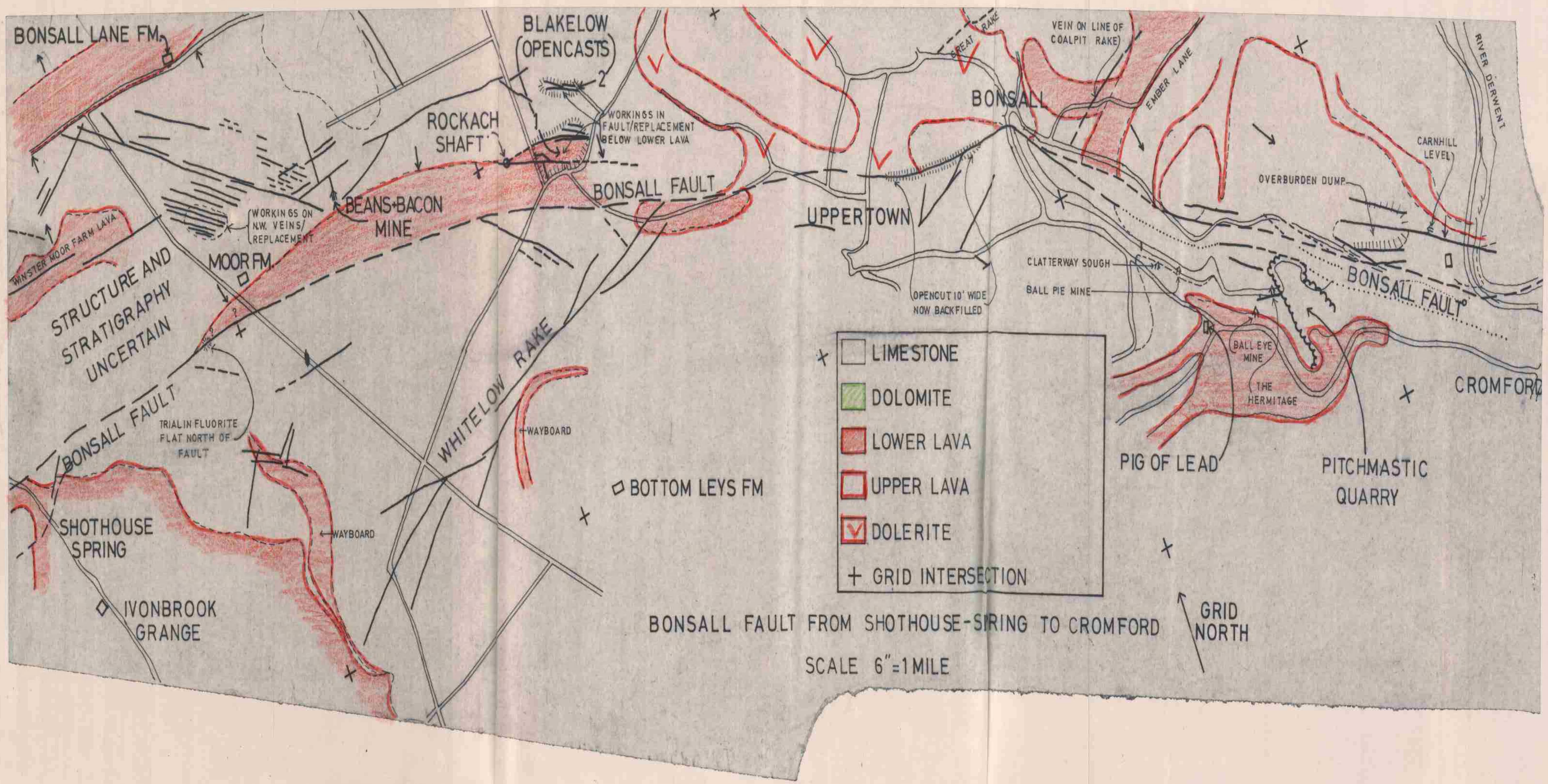
Mapping will be, at the same time, concentrated on proving details of individual deposits and areas of specific interest, once the general "background" map is completed.

FIG.1.



OPENCAST FLUORITE WORKING 8FT. WIDE
DALE END FM.
GRATTON DALE
DEEP REFILLED EXCAVATION IN FLUORITE
TRIAL PITS WITH FLUORITE
COAST RAKE
LOWER LAVA
SUGAR FLUORITE ? FLAT
DALE
GRATTON MOOR
TRIAL PITS FOR FLUORITE
GRATTON
LOWER LAVA
SHALE
LIMESTONE
TOADSTONE
DOLOMITE
SCALE 6"=1 MILE
N(grid)
APPROXIMATE POSITION OF BONSALL FAULT
LONG DALE
MOULDRIDGE GRANGE

FIG.2.



BONSALL FAULT FROM SHOTHOUSE-SPRING TO CROMFORD

SCALE 6"=1 MILE

REPORT 7

REPORT ON ORE GEOLOGY AND MINERALISATION OF ALDWARD PARISH AND ADJACENT AREAS OF 6 inches : 1 mile GEOLOGICAL SURVEY SHEET SK25NW

DECEMBER, 1972

General Introduction

The Aldwark area is divided into two structural zones by the Bonsall Fault. Aldwark Parish itself, lies immediately to the south of the Fault. North of the Fault, the beds dip moderately steeply north into the Stanton Syncline and are unbroken by faulting. However, to the south of the Fault, strata broken by several E-W normal faults, dip gently to the east. The Bonsall Fault downthrows south. At the fault, strata at about the horizon of the Lower Matlock Lava on the south, abut against beds well down in the Hopton Wood limestones on the north.

Stratigraphy

Details of the stratigraphy are given in the column attached to the map. It should be noted that the Lower Matlock Lava is laterally equivalent to a volcanic ash pile and vent complex in the Grange Mill Area. This Lower Lava is not the lowest in the area - the Winster Moor Farm Lava appears to lie about 100 ft. lower in the Hopton Wood limestones, though it is of smaller areal extent. This lava is not definitely known south of the Bonsall Fault, although it may underlie this area at depth. A thick ash seen in Prospect Quarry, Grangemill, is possibly equivalent, although it appears to be even lower in the Hopton Wood limestones. Numerous wayboards, of which one or more appear to pass laterally into ash beds or lava, are present in these limestones. Three such wayboards are exposed in Ben Bennett's quarry at Grangemill.

Faulting

The principal faults of the area run E-W and are very poorly exposed. They control the position of valleys and hence tend to be covered by thick soil. However, the exposure at the rear of Ivonbrook Quarry and the "old man's" working north of Minninglow, suggest that the faults are mineralised and that, in the areas where they are not exposed, their position and contents should be further proved.

Bonsall Fault

The work outlined below should be regarded as a logical extension of that described in the previous report on the eastern end of the Bonsall Fault. Within the present area, no convincing outcrop of the Fault has been located, though the quarry at point B shows brecciated limestone and dolomite with calcite, perhaps associated with the Fault. The Fault position on the map is drawn on the basis of the limestone-dolomite contact, topographic features and anomalously steep dips. Its position cannot be regarded as accurate and indeed the Fault may be more of a narrow zone than in individual fracture. Localities A-G are suggested as localities suitable for trenching to prove the Fault and its contents. There is, as yet, no evidence that the Fault is mineralised west of Bonsall Moor. West of locality A, the position of the Bonsall Fault cannot be properly defined until it reaches the head of Gratton Dale. There is no point in investigating this section until the results of the tests to the east are known.

Ivonbrook Fault

At the rear of Ivonbrook Quarry above the face, the Fault shows 5-10% fluorite. This occurs in a zone of calcite and haematite in a mineralised fault breccia which has been partially dolomitized. Fluorite occurs both as fracture fillings and as a replacement of dolomite. This exposure is the only evidence of fluorite mineralisation in the faults of the area. On the other hand it is the only reasonable exposure of a fault. It is suggested that an agreement be entered into with the quarry owners to open up the fault for further examination. The Fault can be traced eastwards as a zone of barite across stripped ground above the quarry, for a few hundred feet. Further east the Fault probably splits, though the presence of the southern branch is largely speculative, whilst the position of the northern branch is not clearly defined. To the west, the Fault may be traced with confidence as far as H and it is suggested that here and at I, trenching should be carried out. West of H, the Fault is located only on the basis of steep dips, topographic features and fractured rock. Work on this section should await the results of trenching and the work in the quarry.

Aldwark Grenge Fault

This fault is reasonably accurately located from J-K, at which points pitting and trenching are suggested. A fault branches to the south here but it is likely that both walls are in the lava. East of K, the fault cannot be traced accurately and may split, whilst to the west it is drawn only on the basis of topographic features. Further work should await the results of trenches at J and K.

Minninglow Fault

This fault is well defined by the "old man's" workings from L-M and on this section the fine fraction in the dumps should be examined and if successful, followed up by trial pitting. No fluorite is present in the coarse fractions. East of M, the fault is covered by valley bottom soil. Work here should await the results of dump sampling, etc., to the west.

Aldwark Fault

Although on the map the Lower Lava west of Aldwark Village is shown as a double flow with an interveining limestone layer, the observed outcrop could be equally explained by an east-west fault (dotted line on map). Further field-work is proceeding to resolve this ambiguity.

NNW Fault (SK 218577 - 216585)

This is a fault necessary to explain observed outcrops of the Lower Lava. Its exact location and orientation are not known. Augering around point N could be carried out to help this to be drawn more closely.

Other Mineral Veins

Several groups of mineral veins, apparently in fractures without faulting, have been tried or worked by the "old man". A few NNW haematite-calcite-quartz veins of only academic interest, are present, as well as NE-NW and E-W calcite-barite veins. The dumps of the latter should be checked for possible fluorite in the fines, though none has been found in the coarse fraction. Such groups of veins lie north of Minninglow and the fault (P), south and west of Aldwark (Q) and south of Grange Barn (R).

Other Fluorite Localities

At Greenlow Farm, the recent trench is now filled in. The mineralisation lies above the Lower Lava and is perhaps in a flat. Further pitting is necessary to prove the extent and nature of the deposit.

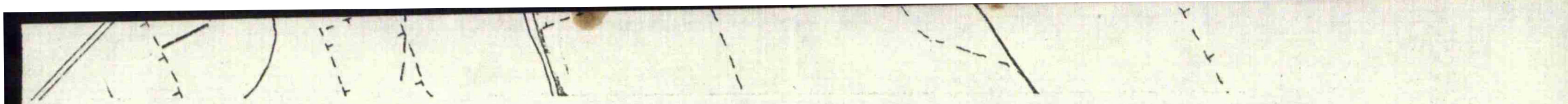
Similarly, the occurrence at Slipper Low Farm, is now built over, though it apparently lies at the base of the Lower Lava. Again further pitting is necessary.

General Conclusions

The area has previously been regarded as lying well outside the zone of significant fluorite mineralisation; however, three exposures of fluorite in recent excavations show that this designation is at least worthy of careful re-examination. A geochemical soil reconnaissance, over an area including Aldwark, was undertaken in this Department by B. Farrell. His results suggest that the north, northeast and southwest of the area lie within an area of relatively high background fluorite.

It is significant that the three fluorite occurrences lie within or close to this "high", even though the sampling (part of a larger survey of the southern half of the Derbyshire limestone) was carried out only on 1 km. grid basis. Examination of the few "old man's" dumps on unfaulted veins shows no fluorite (at least in the coarse fractions) and potential fluorite ore appears to be only in the main faults (especially if the breccia is dolomitized) or in possible flats related to the Lower Matlock Lava.

The area shows clearly the limitations of the classical field techniques used in compiling this report in areas with thick soil cover. Moreover, the same problem clearly limited exploration by the "old man". Thus, whilst it is relatively easy to demonstrate the presence of faults, their exact location and the nature of any mineral infill is still almost unknown. A limited programme of trenching is outlined above, to check the contents of these faults at points at which they have been reasonably accurately located. Assuming that these trials produce encouraging results, it is thought that a detailed geochemical soil survey to study the distribution of fluoride in the soil of the area, might give a more rigorous and inexpensive basis on which to carry out a wider pitting and trenching programme for the appraisal of the ore potential of the area as a whole.



GEOLOGICAL MAP OF ALDWARK PARISH AND ADJACENT AREAS OF
6 INCH SHEET SK 25 NW

SCALE 6" = 1 MILE

GRID NORTH

MATLOCK LIMESTONES

LOWER MATLOCK LAVA

HOPTONWOOD LIMESTONES

WINSTER MOOR FM. LAVA

OTHER LAVAS

DOLOMITE NB the NE boundary of dolomitisation is not yet accurately mapped. in the SW of the area.

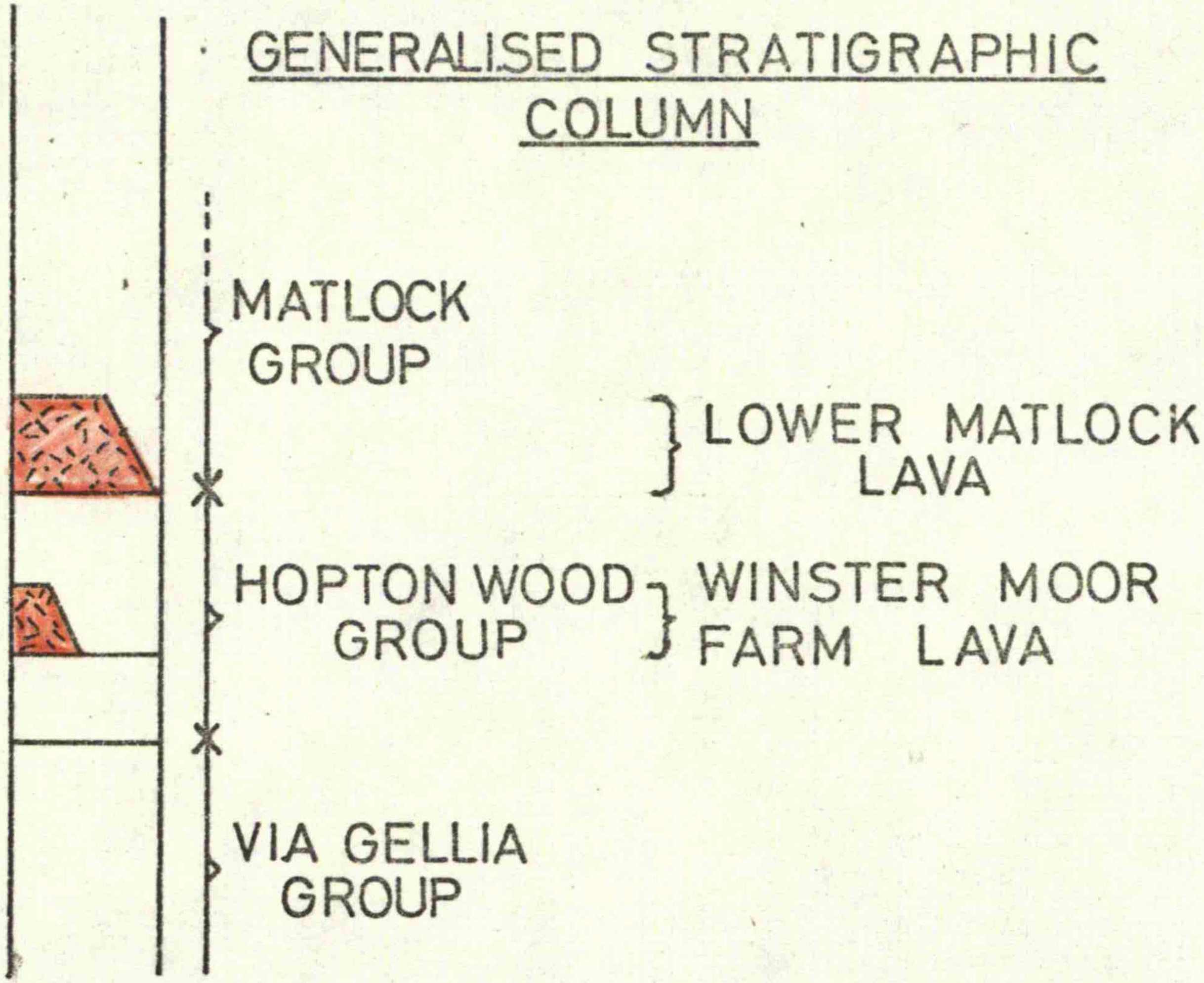
completed / unfinished — BOUNDARY OF COMPLETED MAPPING

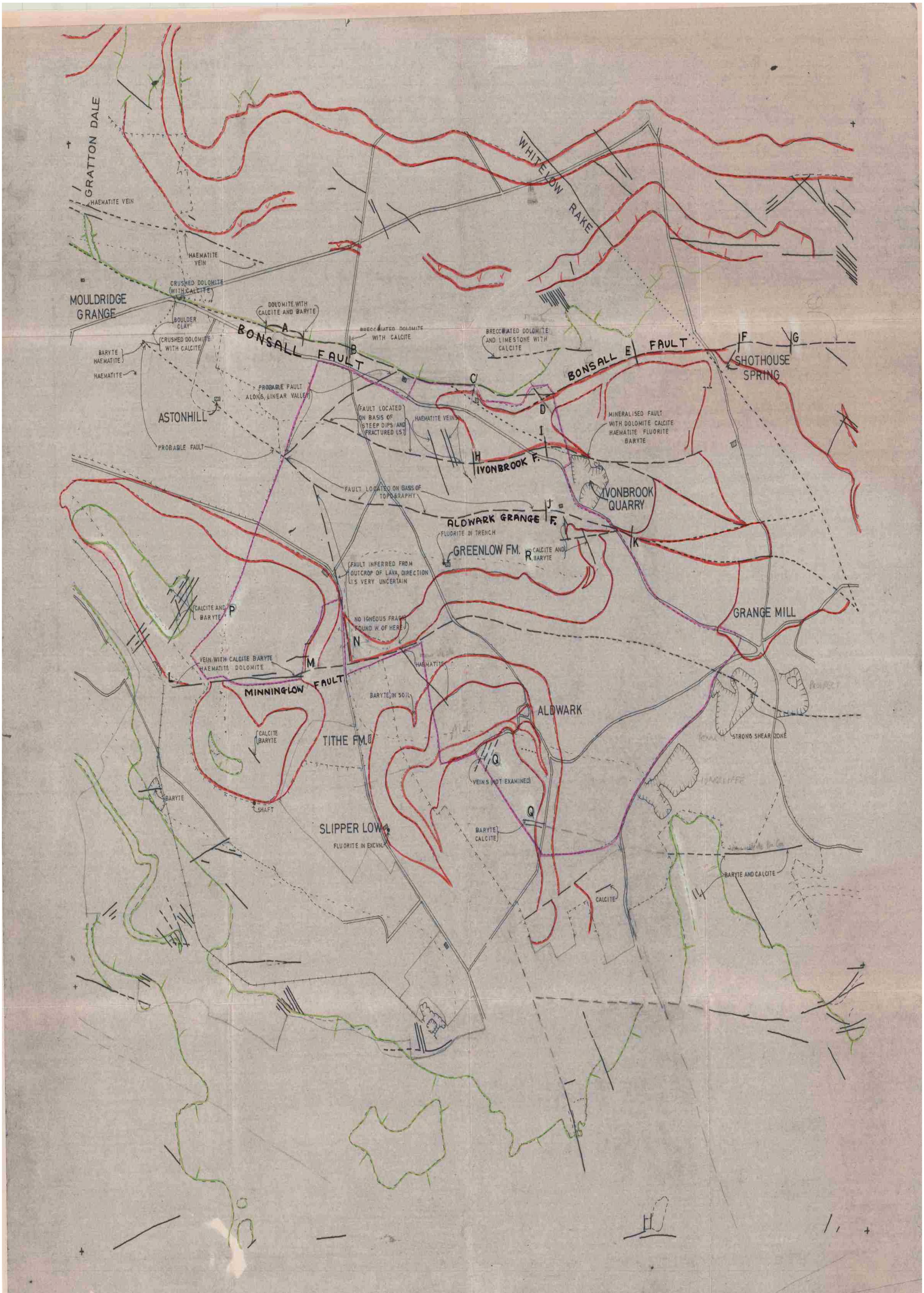
FAULTS EXACT POSITION UNCERTAIN

INFERRED FAULTS POSITION VERY UNCERTAIN

MINERAL VEINS (OLD WORKINGS)

GENERALISED STRATIGRAPHIC COLUMN





GRATTON DALE
HAEMATITE VEIN
HAEMATITE VEIN
CRUSHED DOLOMITE WITH CALCITE
MOULDRIDGE GRANGE
DOLOMITE WITH CALCITE AND BARYTE
BOULDER CLAY
CRUSHED DOLOMITE WITH CALCITE
BARYTE HAEMATITE
HAEMATITE
WHITELOW RAKE
A
B
BONSALL FAULT
BRECCIATED DOLOMITE WITH CALCITE
BRECCIATED DOLOMITE AND LIMESTONE WITH CALCITE
C
D
BONSALL E FAULT
F
G
SHOTHOUSE SPRING
PROBABLE FAULT ALONG LINEAR VALLEY
ASTONHILL
PROBABLE FAULT
FAULT LOCATED ON BASIS OF STEEP DIPS AND FRACTURED LST
HAEMATITE VEIN
MINERALISED FAULT WITH DOLOMITE CALCITE HAEMATITE FLUORITE BARYTE
I
H
IVONBROOK F.
IVONBROOK QUARRY
FAULT LOCATED ON BASIS OF TOPOGRAPHY
J
ALDWARK GRANGE F.
FLUORITE IN TRENCH
GREENLOW FM.
R
CALCITE AND BARYTE
K
FAULT INFERRED FROM OUTCROP OF LAVA, DIRECTION IS VERY UNCERTAIN
CALCITE AND BARYTE
P
NO IGNEOUS FRAGS FOUND W. OF HERE
N
GRANGE MILL
VEIN WITH CALCITE BARYTE HAEMATITE DOLOMITE
L
M
MINNINGLOW FAULT
HAEMATITE
BARYTE IN SOIL
ALDWARK
STRONG SHEAR ZONE
CALCITE BARYTE
TITHE FM.
Q
VEINS (NOT EXAMINED)
Q
BARYTE
SHAFT
SLIPPER LOW
FLUORITE IN EXCVN.
BARYTE CALCITE
CALCITE
BARYTE AND CALCITE

REPORT 8

GEOLOGICAL REPORT ON MR. HORROCKS' MINERAL RIGHTS AND ADJACENT AREAS AT BONSALL. MAY, 1973

General Introduction

The area has been worked and prospected for fluorspar both from surface and underground workings on various scales since the early twentieth century. A medium scale mine with gravity separation mill, producing 95% CaF_2 operated at Low Mine under various owners, from c1920-1935. No sections of the stopes are in the possession of the present writers. During the 1940s and 1950s, Hopton Mining Company and Derbyshire Stone Ltd., operated underground pillar and stall working at Wapping Mine and Hopping pipe (adjacent to Mr. Horrocks' ground), producing a moderate quantity of low grade ore from flats. In addition, at Wapping, stoping of the Moletrap Vein was carried out.

More recently, Marshall Bros. have obtained spar from open-cuts in Great Rake and Coalpit Rake, as well as from replacements in faulted ground adjacent to Great Rake. In 1971-2, Exsud carried out a programme of vertical bores for flats and inclined bores below the Lower Lava into Great Rake. As the area is well above river level, pumping has not been necessary in the various mines.

Notes on Report

In addition to the geological map and section of Great Rake, we enclose surveys of *Masson Flat, *Rutland Cavern, *Devonshire Cavern, *Wapping and Cumberland Mine and *Ball Eye Mine. These are from various sources on various scales and of various accuracies. We would have preferred to reduce all these onto the same 25 ins. map, and to have presented our report map on this scale but we have had such short notice. Positions of levels, etc., on the 6 ins. report map submitted, should be regarded as generalised and approximate. R. B. Flindall is preparing an accurate survey of Hopping Pipe - Speedwell Mine and a re-survey with additions of Ball-Eye workings. He will probably part with preliminary copies for a reasonable fee but will wish to retain copyright.

Our knowledge of Exsuds' bores is only from discussion and a quick view of parts of two of the cores. We cannot fully judge how representative or accurate our information is. We suggest that you should contact them yourselves.

*Not submitted for thesis.

Stratigraphy

A typical columnar section of the Matlock area is given in the Inst. Geological Sciences, Chesterfield Memoir, No 112 pg. 9. Within this columnar section, the beds just above the Lower and just below the Upper Lavas, are susceptible to replacement by dolomite and fluorite, in flats. The causes of localisation of flats are complex. Most are adjacent to minor faults, jointing, dolomitisation, cavity formation and grain size of the original limestone, as well as the presence of major toadstones and minor wayboards (tuffs) probably all play an inter-related part. The net effect is to produce patchy replacement of variable but only moderate grade, fading in and out into calcite rock, dolomite, or limestone.

No flats are yet proved in the strata immediately below the Lower Lava. Here the limestones are of different lithology, contain many wayboards and are very susceptible to silicification both as wall rock alteration and replacement of the limestone as a whole. At Blakelow Lane (west of Bonsall) south end, a fluorite replacement in fractured limestone and dolomite, associated with faulting, occurs at this horizon, so the possibility within this area cannot be ruled out.

Structure

The area northwest of Great Rake lies on the termination of the Matlock Anticline, the exact structure of which is doubtful due to the intrusion of a major dolerite sill at Bonsall and the interference of a major east-west fault - monocline (see below). The sill may underlie much of the area and there may be a variable and even multiple, unpredictable set of sills in the Hopton Wood Limestones. The evidence is far from clear.

The Great Rake - Coalpit Rake fault zone lies along the steep limb of an east-northeast plunging monocline, traceable from the Bonsall

Fault in the west, to well under the shales at Riber Mine in the east. The Bonsall Fault runs southeast across the area and is a complex zone of faulted slices and wedges of strata traceable from Bonsall to Cromford. This zone is at present exploited for fluorspar above Pitchmastic's Quarry and is being explored further west by Deepwood/Admin in Messrs. Rockarch's ground. The net effect of this fault zone is to throw the ground to the southwest down by several hundred feet. The zone is paralleled to the north by a fault seen in Hopping (Speedwell) Mine, which throws down to the southwest by a few tens of feet. The continuation of this fault outside the mine area is uncertain. Between these two faults the beds dip gently southeast. In the south of the area, an east-west fault swings out of the Bonsall fault zone, eastwards, dropping strata to the north, by several hundred feet. North of this, a parallel fault - Moletrap Vein - whose west end is last seen in Wapping Mine, drops strata to the south by 50 ft., close to the river. This fault can be traced by old workings below the shales to New Bullestree Shaft which is 400 ft. deep, half a mile east of the river, and by faults in the Millstone Grit for a further mile east towards Lea Bridge, in which section it has never been worked. Along all this section the limestone is well below river level. Gangue on the dumps is dominantly fluorite but the vein has not been explored for fluorite east of the river and is of great interest. To the south, the fault mentioned above, has a similar potential. The strata between these two faults dips steeply south. To the north, of Moletrap Vein, strata east of Speedwell Fault and south of the Coalpit Rake dip moderately steeply east-northeast under the shales. In this area, at J, boreholes were drilled into two parallel northwest veins as part of a lead-zinc exploration programme by Johannesburg Consolidated in the 1950s, but no underground exploration resulted.

Details of Mineralisation and Previous Workings

a) Great Rake

Great Rake has been worked extensively by the "old man" for lead above the Lower Lava west of the Derwent and below the shale cover but above the Upper Lava east of the Derwent to 120 ft. below the river. There is some evidence of minor lead working in the Bonsall Sill at the extreme west end of the vein.

Workings for fluorite were carried out below the Lower Lava but above the Bonsall Sill to depths of 250 ft. at Low Mine (bottoming on a toadstone, perhaps but not necessarily the Bonsall Sill) by Steel, Peach and Tozer (now part of British Steel Corporation) from 1920-30. Subsequent working was carried out underground by A. Beck and Co., and Wm. Smith (Fluor-spar) Ltd. (of Blackhole Mine, Eyam) until the shaft became unsafe in 1935. Blanchland Spa (now part of British Steel Corporation) began to explore the workings in the 1950s but this proved abortive. Stope sections may lie with any of the above firms or with the Mines Record Office in London.

At Low Mine, according to Dunham (1952) two adjacent parallel veins were worked - one 12 ft. wide, the other minor one reaching ten feet, in places. Working ceased due to excessive silica dilution of the ore, presumably from the wall-rock.

In the 1950s, Johannesburg Consolidated and later Derbyshire Stone, attempted to prove the vein east of the Derwent for Pb-Zn and later for CaF_2, at Riber Mine - on the whole, this trial was unsuccessful. Exploration of the Coalpit Vein east of the Derwent was also undertaken (Greenough, 1967).

Marshall Bros. have exploited Great Rake by shallow opencast workings and on Mr. Horrocks' ground, both above and below the Lower Lava. Above the lava, 50 ft. wide low-grade replacements have been opencast in dolomite faulted and fractured against the main vein. There may be further similar deposits here. From the outcrop of the lava to the eastern boundary of Mr. Horrocks' ground, opencuts in the vein have been worked. Towards the east of this section, there is some potential for deeper drag-line work but the fluorite is very variably diluted by columnar calcite which may reach almost 100% as seen in Masson and Rutland Caverns sections of Great Rake. Below the Lower Lava, shallow open-pitting has been carried out and fines from the dressing-plant have been fed into and apparently filled the Low Mine Shaft and workings. At A, an opencut shows 6-8 ft. of good sugary spar on its floor between clean silicified limestone walls. But at B, only 200 feet away, on apparently the same vein, a short adit, now about 20 ft. long, shows intense fluorite veinlets in silicified breccia, perhaps reaching 30% CaF_2 over a width of 10 feet. Clearly the vein is very variable in tightness and content. At C the vein appears to "bottom" on a toadstone, which may be the top of the Bonsall Sill, in which case, the latter is probably faulted down to the south on the vein at this point. The various exposures noted above also show many thin clay wayboards. In the absence of a stope section of Low Mine, there is no way of knowing how far the bottom of these pits are above the top of open or slime-filled stopes! Their potential for drag-line open-cutting, therefore, cannot be assessed.

Exsud took an option on Mr. Horrocks' area in 1971. They appear to have had an agreement with Laporte on the Hopping Pipe ground as well. A series of inclined bore-holes (nos. 8, 10 and 11) were drilled into Great Rake with an object of proving reserves both below Low Mine stopes and to the east under the Lower Lava. The intersections shown as xx's on our section have assumed a vertical vein and 45% inclinations and are based on the offset from the vein (the inclinations may have been steeper). As far as we know, no significant fluorite was found. Without a careful examination of the full cores and logs, we cannot be certain. Igneous horizons such as tuffs in the top of the Hopton Wood Limestone, prove to be more frequent than expected from the opencuts and borehole no. 11, began in a previously unrecorded outcrop of dolerite. No major igneous beds were met in depth in no. 11, suggesting that the Bonsall Sill dies out or steps down to the east. Boreholes no. 6, was a preliminary vertical borehole to prove strata. Nos. 12 and 13 were probably not sunk due to jamming of the rods in silica rock below the Lower Lava in hole no. 10, which was not completed.

b) Coalpit Rake

To the south of and parallel to Great Rake (at least in Mr. Horrocks' area) is Coalpit Rake, which has been worked for lead by the "old man" above the Lower Lava, especially at Devonshire Cavern, where associated replacements occur. In 1952, the vein was tried from Riber Mine above the Upper Lava. In Mr. Horrocks' ground, parallel to and north of Coalpit Rake and extending below and to the west of the outcrop of the Lower Lava, are a whole series of minor fault-veins (best seen east of Mr. Horrocks' ground). All these carry fluorite in dolomitised limestone. The larger ones close to Coalpit Rake, between the upper entrance of Devonshire Cavern and Ember Fram, have been deeply open-pitted by Marshall Brothers. Any future fluorspar production here is likely to be low grade. It is possible that low-grade flats and/or fluoritized dolomite might exist on the Lower Lava below the flats seen in Devonshire Cavern. Boreholes 1, 3 and 7 may yield useful data but are too widely spaced to be considered as sufficient investigation of this problem. (We do not know whether these boreholes are vertical or inclined).

c) Hopping Pipe - Speedwell Mine - Royal Mine

These workings of which there is no accurate printed survey (see below) lie to the north of a northwest minor fault. This throws down some tens of feet southwest but its continuations outside the workings are not proved. In the 1940s, Hopton Mining Company drove an incline below the old Hopping Pipe to prove a flat on the toadstone but the venture was abandoned because of water. In the 1950s, Derbyshire Stone drove a series of adits along and parallel to the Speedwell Fault, proving a moderate size, low-grade flat, about five to ten feet thick, which was extracted by pillar and stall methods. A series of trial adits were driven at the northern end of the adjacent inlier of Lower Lava, proving analogous but smaller flats on the toadstone. All these workings are now highly unstable, some being under or adjacent to occupied houses in Upperwood. The area is now owned by Laporte. Boreholes 2 and 4 seem to have been designed to prove logical continuations but single bores are useless in such circumstances. The workings appear to have stopped at the edge of the Derbyshire Stone area. A few cross-cuts and adits extend into the downthrown side of the fault but it is not clear whether these are out of the fault zone or into the continuation of the flat. Sand-filled natural cavities and "old man's workings" above and in the flat, add to the problems of this mine. A thorough sampling programme and underground geological survey is necessary to examine the grade of the flat and to determine the throw on the Speedwell Fault. The possible position of continuations of the flat may then be determined, either by further cross-cuts or boreholes. Boreholes 1 and 3 were presumably designed to prove a flat on a similar horizon. There is a possibility of flats below the Upper Lava. Boreholes 4 and 5 may yield information on this, but a thorough programme of trenching, both at the base of the Upper Lava and top of the Lower Lava, would be useful as part of a pre-borehole and cross-cut programme. The ground which has been so far worked lies within Laporte's area and clearly it would be difficult to examine the ground here without access rights or purchase.

d) Wapping Mine - Cumberland Cavern

This worked a flat on the Lower Lava north of an east-west fault throwing down fifty feet north of the river - Moletrap Vein. This was stoped for fluorite for a length of 800 ft., to a height of 30 ft., and a width of 15 ft. The throw in the mine is much less and the vein has not been traced beyond the western end of these stopes. The flat was formerly worked by the Hopton Mining Company, by pillar and stall with the workings about five to ten feet high. A series of parallel vein-faults were worked near and to the south of the western end of the main Moletrap vein stope. A cross-cut was driven southwest slightly inclined by Banks and Barton in the 1950s, from a position close to the entrance of Wapping Mine but these veins here, were only thin stringers. At the bottom of an incline, a sump was sunk but it apparently failed to find any continuation of the flat. The flat is not known to the southwest of the faults in the main mine.

Prospects lie: a'. in looking for a continuation of the Moletrap Vein westwards; b'. driving under Cumberland Cavern in the flat (which was not worked here as the Cavern above was then a tourist cave), and examining the southeast end of the Speedwell Fault; c'. attempting to prove the flat southwest of the Moletrap Vein. The entrance series to Wapping Mine lies outside Mr. Horrocks' ground, possibly in Hopton Mining Company ground.

e) Masson Flat

The area overlies a small part of Masson Flat, a section until recently used as a show-cave. Much of the high-grade ore has been extracted by hand methods in the early 1900s. Until recently the ground to the northwest has been worked by Mr. Pearson, on contract and/or lease. An abortive incline was driven approximately as shown on the large-scale plan. Without this further area there is no possibility of working the flat which lies at a depth of 80-120 feet. However, with this extra ground, Laporte might be prevented from extending their holdings down dip from the top of the hill. They clearly have the shallower and some of the higher grade sections of the flat. Whether Pearson's section is of sufficient grade or size for open-cast working through such a thickness of rock, is unknown to us. Underground mining would be very difficult because of the instability of old workings which honeycomb the flat. Some underground percussive drilling in the floors and walls of the old workings would be useful.

f) Bonsall Fault

Although we have already reported on the general possibilities of the Bonsall Fault Zone, it lies adjacent to Mr. Horrocks' ground and it is worth noting that it is within this area, west of Pitchmastic Quarries, that Deepwood-Acmin have made their recent discoveries. An extensive programme of trenching has produced many shows of fluorite. Whether this justifies their recent announcements of major reserves, is an open question. However a follow-up drilling programme (of which no announcement has been made) has been carried out. A small trial-pit at T'., is yielding an excellent quality sugar fluorspar. Mine-adits from Clatterway (Brogdale Sough) and the Via Gellia (Ball Eye Mine) pass under this and adjacent areas. Brogdale workings show small pipes of fluorite 200 ft. below Deepwoods pit at T'., but the major faults expected have not yet been recognised. An old cross-cut - Fountrabby Level in Ball Eye, on the Lower Lava apparently also fails to intersect these faults and higher workings from the Hermitage which also show minor fluorspar pipes are similarly not affected by the faults. A great deal of further underground work is needed here.

Overall Conclusions on Mr. Horrocks' Ground

The Flats

It seems probable that significant though not major reserves of fluorite exist on Mr. Horrocks' holdings. These flat deposits are likely to be patchy and of low to medium grade and only of moderate tonnage. In general, we feel that open pit extraction would be most suitable for this type of deposit except that here there is the problem of the overlying Upper Toadstone, housing and the overall thickness of superimposed strata. Underground mining would be expensive in relation to the grade of these deposits. In the case of both the previously worked localities and their possible continuation, agreements with other owners will be necessary.

Veins

We cannot judge the Low Mine potential without access to the full logs of Exsud cores and some knowledge, preferably to sections of the 1930s stopes. The vein is not as promising as its continuity and surface exposures suggest. Moletrap Vein - a western continuation of this vein should be sought for in the west end of Wapping Mine. Better prospects, however, lie on the same vein, outside the area east of the Derwent, at Bullestree.

Environment and Planning Problems

Exsud had a great deal of unwelcome adverse publicity concerning their drilling programme. Matlock Urban District Council are opposed to extraction. Bonsall residents complain of lorry traffic through the village. At Matlock Bath, many locals are worried by the possibility of landslip induced by mining on the steep ground northeast of the Hopping-Speedwell Fault. Natural slips occur here already as dolomite slides over the clayey upper surface of the Lower Lava!

FIG.1.

SECTION ON SOUTH WALL OF GREAT RAKE

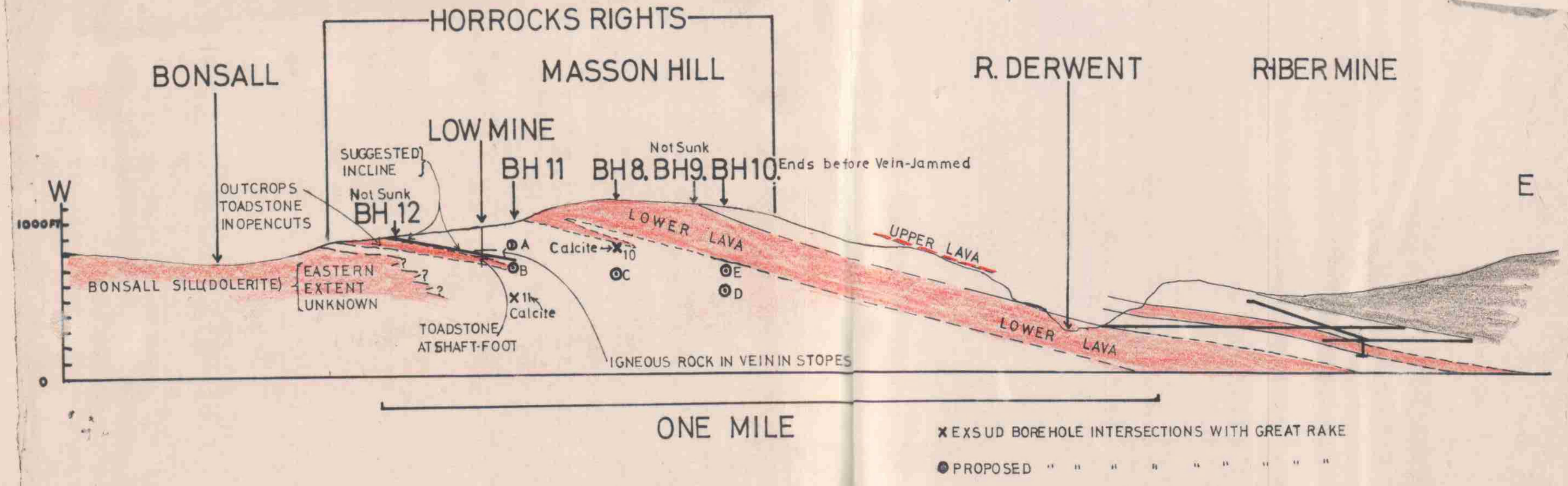
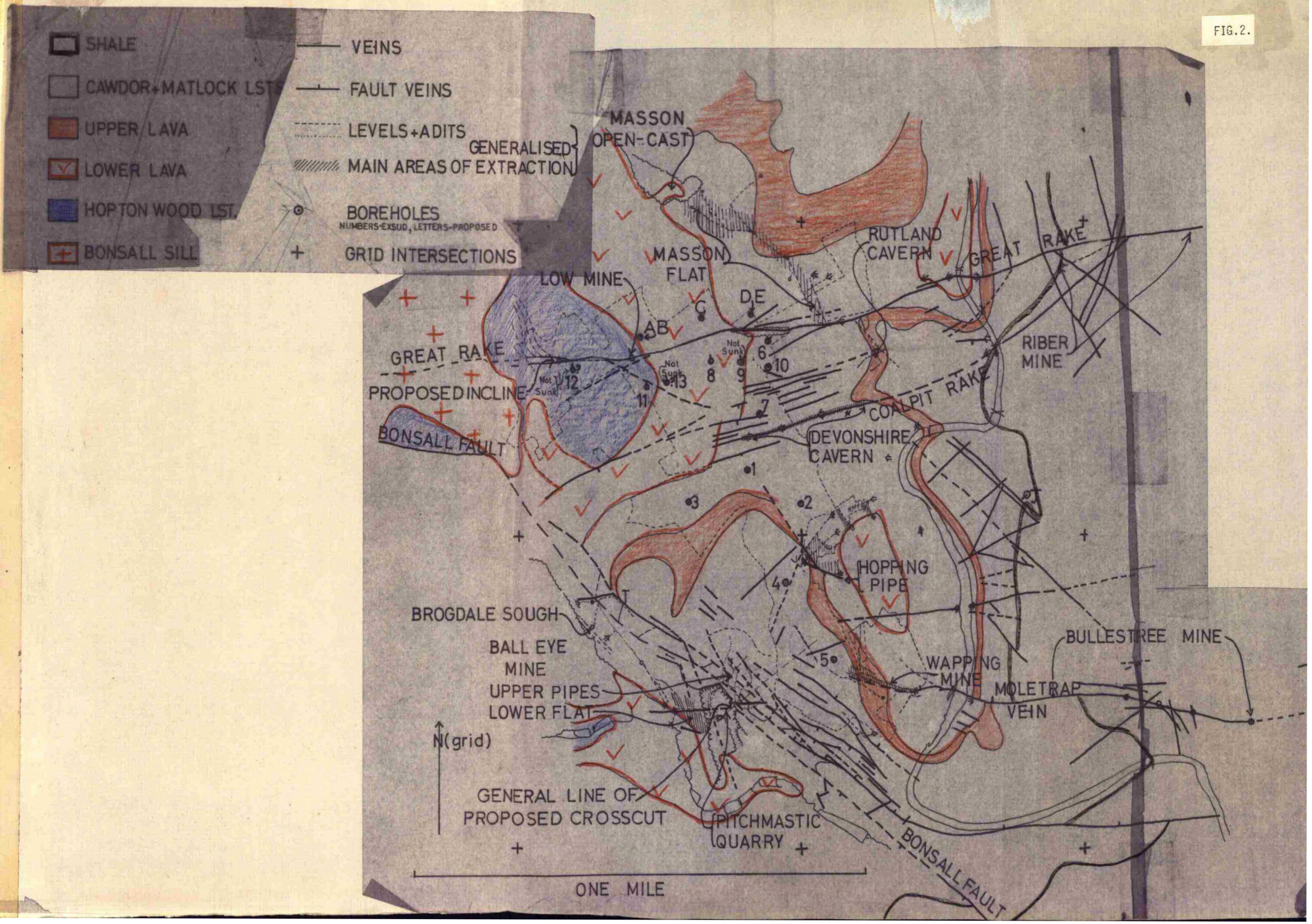


FIG.2.


SHALE
CAWDOR+MATLOCK LST.
UPPER LAVA
LOWER LAVA
HOPTON WOOD LST.
BONSALL SILL
VEINS
FAULT VEINS
LEVELS+ADITS
MAIN AREAS OF EXTRACTION
GENERALISED
BOREHOLES
NUMBERS-EXSUD, LETTERS-PROPOSED
GRID INTERSECTIONS
MASSON OPEN-CAST
MASSON FLAT
LOW MINE
RUTLAND CAVERN
GREAT RAKE
RIBER MINE
COALPIT RAKE
DEVONSHIRE CAVERN
PROPOSED INCLINE
BONSALL FAULT
HOPPING PIPE
BROGDALE SOUGH
BALL EYE MINE
UPPER PIPES
LOWER FLAT
WAPPING MINE
MOLETRAP VEIN
BULLESTREE MINE
N(grid)
GENERAL LINE OF PROPOSED CROSSCUT
PITCHMASTIC QUARRY
ONE MILE
Not Sunk

REPORT 9

FURTHER REPORT ON MR. HORROCKS' GROUND, MASSON HILL, MATLOCK, INCLUDING A REPORT ON THE LOGS OF THE "EXSUD" BOREHOLES. JANUARY, 1974

Summary.

The results of continuing work on Great Rake, including the disappointing results of "Exsud's" inclined boreholes are described herein. The vein can be shown to change from fluorite to calcite with depth. It is considered that a further programme of five inclined boreholes, to complete the unfinished "Exsud" programme, is necessary to establish the overall depth and eastward extent of fluorite east of the old Low Mine workings below the Lower Lava.

It is suggested that an exploratory incline be driven to intersect the base of and examine the Low Mine workings. This should be continued as either a level or incline further to the east, dependent on the results of the borehole programme. The vein above the incline, as far as the Low Mine, could be worked by a combination of open-pitting and stoping. This section is the most promising ground on the basis of present information.

Above the Lower Lava, open-pitting on Great Rake, could reach a maximum depth of 100 ft. (the depth of the Lower Lava) at the east end of the property, the overall depth being dependent on the width and grade of the vein as well as the stability of the walls. Marshall's replacement flat on the south side of Great Rake, above the Lower Lava, might extend further east below clay wayboards and a thin cover of dolomite, thus paying for wall-rock removal adjacent to the main vein and hence the possibility of deeper open-pitting on Great Rake.

"Exsud's" vertical boreholes were also disappointing mainly because they were poorly sited. Borehole 5, however, proved low grade but significant flat mineralisation ahead of the Wapping Flat. Hopping Pipe is considered to be an impractical proposition because of the proximity

of housing.

Some general comments on the localisation of flats in relation to geology and the futility of attempting to assess or prove a flat continuation with single "wild" boreholes are emphasised.

It is concluded that Wapping Flat mineralisation and potential extensions would be best explored by an adit driven northeast from Pitchmastic's Quarry. The possibility of some joint exploration arrangement for both Pitchmastic's fluorite deposits on the Bonsall Fault and the adjacent Mr. Horrocks' ground is discussed.

In view of the difficulties being experienced at Pitchmastic's Quarry, we feel that it will become uneconomic and it could then be worthwhile acquiring the quarry, both as a site for exploratory adits into the Bonsall Fault and adjacent flats as well as to provide access to Mr. Horrocks' ground. The quarry mights serve as a site for primary processing of production from Mr. Horrocks' ground and as a dump for the dry fines likely to be produced in the future at the Hopton Plant.

Since our first report on this area, work has been continued both on the surface and underground and we have recently acquired the logs of the "Exsud" boreholes. We have also had useful discussions with A. Marshall on the extent of the Low Mine workings and the problems which lead to the abandonment of that mine. Whilst the new information supports our previous conclusions, several modifications of detail are required.

We include both a copy of the "Exsud" borehole logs, R.B. Flindall's survey of Hopping Pipe-Speedwell Mine, as well as a modified section of Great Rake and a plan to locate proposed further boreholes.

Report on Vertical Boreholes and Flat Replacements

General Comments (Details of relevant workings/geology are given on fig.9/1,2,3,4)

In the immediate vicinity of Matlock, flats are confined to the lower part of the limestones between the Upper and Lower Matlock Lavas.

In particular, a wayboard or group of wayboards about seventy feet above the Lower Lava, appears to act as a ceiling for replacement. Replacement may occur in all the horizons between the Lower Lava and the wayboards as at Masson Pit but even here the main replacement is restricted to beds 0-20 ft. above the Lower Lava. Other favoured horizons lie in amongst the wayboard group as in Devonshire Cavern or in the limestones 0-20 ft. below these wayboards as in Hopping Pipe.

Our observations indicate that flats are always associated with zones of closely spaced minor faults or joints. These develop at points where major faults are dying out: the Wapping and Hopping Flats are good examples of this. We feel that it is pointless to sink single, cored boreholes in the random "Exsud" manner and that it is necessary first to define a suitable structure and stratigraphic horizon before carrying out an intensive drilling programme for replacements.

"Exsud" Boreholes - Wapping Mine (See Survey)

Each of the "Exsud" boreholes proved traces of mineralisation at the wayboard horizons, but only Borehole 5 proved significant flat mineralisation. This appears to indicate an extension of the Wapping replacements on the Lower Lava 250 ft. ahead of the previous flat workings and about 120 ft. from the closest workings in the mine. Two to three metres of mineralised ground was intersected, probably low grade calcitic fluoritised dolomite and limestone. We again emphasize the need for a thorough sampling of this mine, followed up by either cross-cutting northwest from the old workings, if the sampling results justify the cost of clearing access through the old workings, or alternatively, the Wapping Flat extensions could be explored by a northeast cross-cut, 1500 ft. long, from Pitchmastic's Quarry. This would pass through and prove at depth, the highly mineralised Bonsall Fault. This latter proposal is preferred if some arrangement can be made with Pitchmastic Ltd.

In Wapping Mine itself, there is no prospect of vein stoping on the scale of the entrance series on the Moletrap Vein, as the vein breaks up into multiple faults which have in the past been stoped on a small scale towards the position of Borehole 5. (See survey of Wapping Mine attached.)

"Exsud" Boreholes - Hopping Pipe (See Survey)

Investigations here show that the main Speedwell Cross Vein is dying out and breaking up to the northwest. This is confirmed by "Exsud's" boreholes. The vein runs on about 300° rather than 320° as shown by the Geological Survey. Their northwest fault extension appears to be on the line of the southeast Hopping Pipe. Borehole 2 was too far off this alignment to prove extensions. The main vein, Speedwell Cross Rake, is dying out and becomes calcitic to the northwest within the mine. The main possibilities seem to be in exploring the ground along the northwest projection of the southeast Hopping Pipe. Judging from the mineralisation in the northeast drift under Cumberland Cavern, the Hopping Flat will extend on the downthrow side (southwest) of the Speedwell Cross Rake - but this area is also overlain by housing.

The difficulties of housing over the old mine preclude any possibility of extending it from within and access for lorries is probably impossible. The only possibility of working seems to lie in extending the proposed drift from Pitchmastic's Quarry. However, this will still involve blasting very close to occupied housing and on the whole we feel that planning permission would be unlikely. The cross-cut would be in any case long and expensive.

Devonshire Cavern - Coalpit Rake

We have not yet received the full log of Borehole 7 on Coalpit Rake and will send a short note when we receive this log.

Report on Inclined Boreholes into Great Rake

Marshall's Opencasts above the Lower Lava

The replacements south of Great Rake and lying on the Lower Lava occur below the wayboard group described in the section on flats. It seems probable that similar deposits might extend further east, close to and parallel to Great Rake but under a thin dolomite cover. However, vertical Borehole 6, 100 ft. south of the vein, encountered no mineralisation. The replacements are associated with minor splay-faults branching from the main vein. Inclined Borehole 10, appears to have jammed up in silica rock associated with these fractures but below the Lower Lava.

Great Rake, at the eastern end in Mr. Horrocks' ground, has about 100 ft. of mineralised ground above the Lower Lava. Marshall has extracted the vein down to the Lower Lava only in the largest and most westerly pit. In conversation, he claimed to have descended an old shaft on Great Rake, at the extreme east end of the property, for 90 ft., in fluorite. As we noted previously, the vein which is here generally 4-6 ft. wide, has a variable calcite : fluorite ratio - evident in Marshall's disconnected workings. This section of vein is suitable for opencast by dragline. The possible marginal replacements noted above may allow deeper open-pitting by "subsidising" the removal of wall rock.

"Exsud" Inclined Boreholes into Great Rake

"Exsud's" inclined borehole programme was not very successful - only two holes - 8 and 11, reached the vein which was almost exclusively calcite in each case. Borehole 10 jammed up in silica rock.

We have plotted the intersections with strata and the vein, onto a revised section along the Great Rake (Figure 9/1). Also, according to Mr. Marshall, Low Mine stopes were worked only 15 yds. west and 30 yds. east of the shaft. Low Mine Shaft appears to have been 200-220 ft. deep, where it bottomed on toadstone. Toadstone outcrops in a corresponding position in workings about 700 ft. west of the old dressing plant at about 850 A.O.D., (where minor excavations were carried out recently). Borehole 11 failed to prove toadstone at a corresponding position a little east of Low Mine, nor did it prove extensions of the Bonsall Sill, (dolerite) which must also die out to the east. On the other hand, according to Mr. Marshall, the 140 ft. and 172 ft. levels of Low Mine, ran into toadstone in the vein, 30 yards east of the shaft and the difficulty of holding this was a principal factor in closing the mine.

It would appear from these factors as well as the outcrop of the vein, (see previous report), that it would be worthwhile to drive an exploratory incline from about 875 ft. A.O.D. (the site of the present short drift) inclined 10-15^{o} east towards the Low Mine workings and to stope out and opencast this sector of the vein. Great care will be needed adjacent to Low Mine, as the workings may be filled with poorly consolidated slimes and it might hence be best to drive in the wall rock, although this is silicified limestone and would be expensive.

East of Low Mine, the data on the vein is not sufficient and we suggest that a programme of five inclined boreholes be sunk. According to Mr. Marshall, and this is supported by Borehole 11 (which proved the vein to be calcite 100 metres below Low Mine Stopes), the vein changes sharply from fluorite to calcite on the floor of the Low Mine stopes. The programme of boreholes is designed to fix the position of this fluorite-calcite interface east of Low Mine and should be drilled before the proposed incline is carried into this area.

Proposed Programme of Cored Boreholes

It is important that the boreholes be cored in the limestone strata, as this will allow an accurate assessment of the amount of igneous material in the succession below the Lower Lava. This igneous rock is likely to affect vein widths, breccia plus clay content of the mineralisation and stability of the wall rocks. It is not necessary to core in the Matlock Lower Lava. The inclined "Exsud" Boreholes 8 and 11 proved unexpected igneous horizons below the Lower Lava. It is important that an accurate knowledge of the position of intersection of borehole and the vein is obtained, therefore inclination of the hole should be accurately recorded at intervals by dipmeter.

Details of Boreholes

Borehole A

Position SK28425863	Altitude c1000 ft. (323m.) Length c80m.
Direction 170^{o}	Inclination 45^{o}S. Objective - check calcite/
All Cored	fluorite content of Great Rake at 50 m. below the Lower Lava and examine for minor veins north of Great Rake.

Borehole B

Position as A	Altitude as A. Length 130m. Inclination 65^{o}S.
Direction as A	Objective - check calcite/fluorite content of
All Cored	Great Rake at 100m. below the Lower Lava.

N.B. Borehole 11 intersected calcite at 160m. below the Lower Lava.

Borehole C

Position SK28645870	Altitude c1100 ft. (355m.) Length 200m.
Direction 165^{o}	Inclination 65^{o}S. Objective - check calcite/ fluorite content of vein 90m. below the Lower
Cored from 70 metres	Lava.

N.B. Borehole 8 intersected the vein at 35m. below the Lower Lava.

Borehole D

Position SK28805874 — Altitude 1090 ft. (352m.) Length 250m.

Direction 180° — Inclination 70°S. Objective - examine the calcite/fluorite content of Great Rake 80 metres below the Lower Lava.

Cored from 0 to top of Lower Lava.

Cored from 90m. to 250m.

Borehole E

Position as D — Altitude as D. Length 180m. Inclination 60°S.

Direction 180° — Objective - examine the calcite/fluorite content of Great Rake 20-30m. below the Lower Lava.

Cored from 90m.

The five boreholes should determine the value of driving an exploratory adit east of the bottom of the Low Mine workings.

The main unknown area remaining after this programme would be west of Low Mine - below the level of the Low Mine stopes and the proposed incline. Here the vein will be affected by the presence of the edge of the Bonsall Sill. A vertical cored borehole on the site of the proposed "Exsud" Borehole 12 would be useful in this context, the depth being about 100m. in order to assess the eastern extent of the sill.

Other factors affecting the vein content

Three further factors not readily assessible until the ground is blocked out, must be considered. Firstly, the various igneous horizons proved by the "Exsud" Boreholes in the limestones below the Lower Lava, will mean that certain parts of the vein have a high clay content. Secondly, these igneous horizons will affect the stability of the wall rock during stoping operations and, as this is silica rock, ore dilution will occur. Thirdly, the "tight" parts of the vein are likely to be silica rock breccia with fluorite stringers again leading to dilution.

The problems of wall rock slippage on clay horizons are well illustrated in the surface opencasts!

Conclusions

Whilst there may be a significant body of fluorite ore on Great Rake below the Lower Lava, only that part of the vein west of the eastern end of the old Low Mine stopes, can be said to be in any way known. Even this bottoms on a toadstone at a depth of about 200 ft. at Low Mine. The vein can be shown to change from fluorite to calcite with depth and it is necessary to prove the position of this change east of Low Mine, before the potential of the vein can be assessed. A programme of five inclined boreholes is outlined to test this problem.

The new plan of Hopping Pipe shows that whilst this mine has not been fully worked out, the position of housing over and adjacent to the workings and the lack of access precludes further development from within the old workings.

Further potential in Wapping Flat is on the basis of a borehole intersection ahead of the workings. A proper sampling programme of the present faces is necessary before the cost of making some trial crosscuts and clearing access through the old workings (including several major falls) can be justified. Preferably a drift might be driven northeast from Pitchmastic's Quarry proving both the extension of the flat and the Bonsall Fault in depth. This could be extended to the Hopping Pipe area, but we doubt if planning permission will be granted because of the proximity of housing.

We believe that in the near future, the Ball Eye Limestone Quarry (Pitchmastic's) will become uneconomic - reserves are low - (if planning restrictions are not lifted) and considerable difficulty is being experienced in dressing due to high igneous clay content of the feed. This quarry and land includes promising mineralised ground, as well as being close to the Rocharch ground explored by "Acmin". It is well situated to put exploratory drives into the Bonsall Fault Zone, Ball Eye Flat and the probable extensions of Wapping Flat. The quarry site could be utilised for primary processing of production from Mr. Horrocks' ground or for the dry fine waste which is, in the future, to be produced at Hopton. It would also allow access into Mr. Horrocks' ground, direct from the main "Via Gellia" road, avoiding housing and this could help extensively the various problems of planning permission involved with exploitation of Mr. Horrocks' ground. In the short term, some arrangements to drive a cross-cut from some disused part of the quarry, to jointly explore for fluorite, both in Pitchmastic's and Mr. Horrocks' ground, might usefully be made!

ORDNANCE SURVEY

Scale: 1:2500 or 25·344 inches to 1 mile

PLAN SK 2858 & PLAN SK 2958

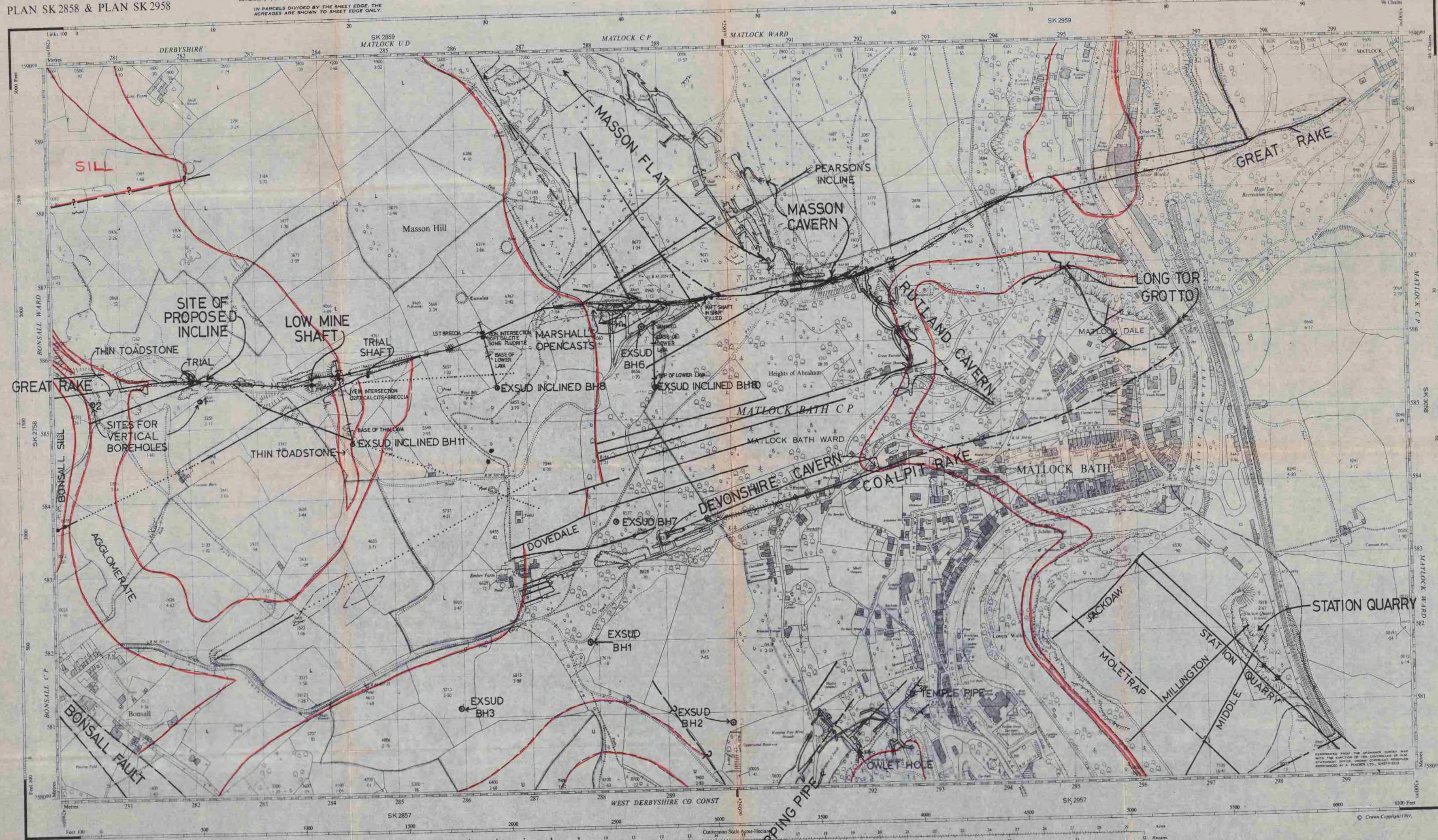
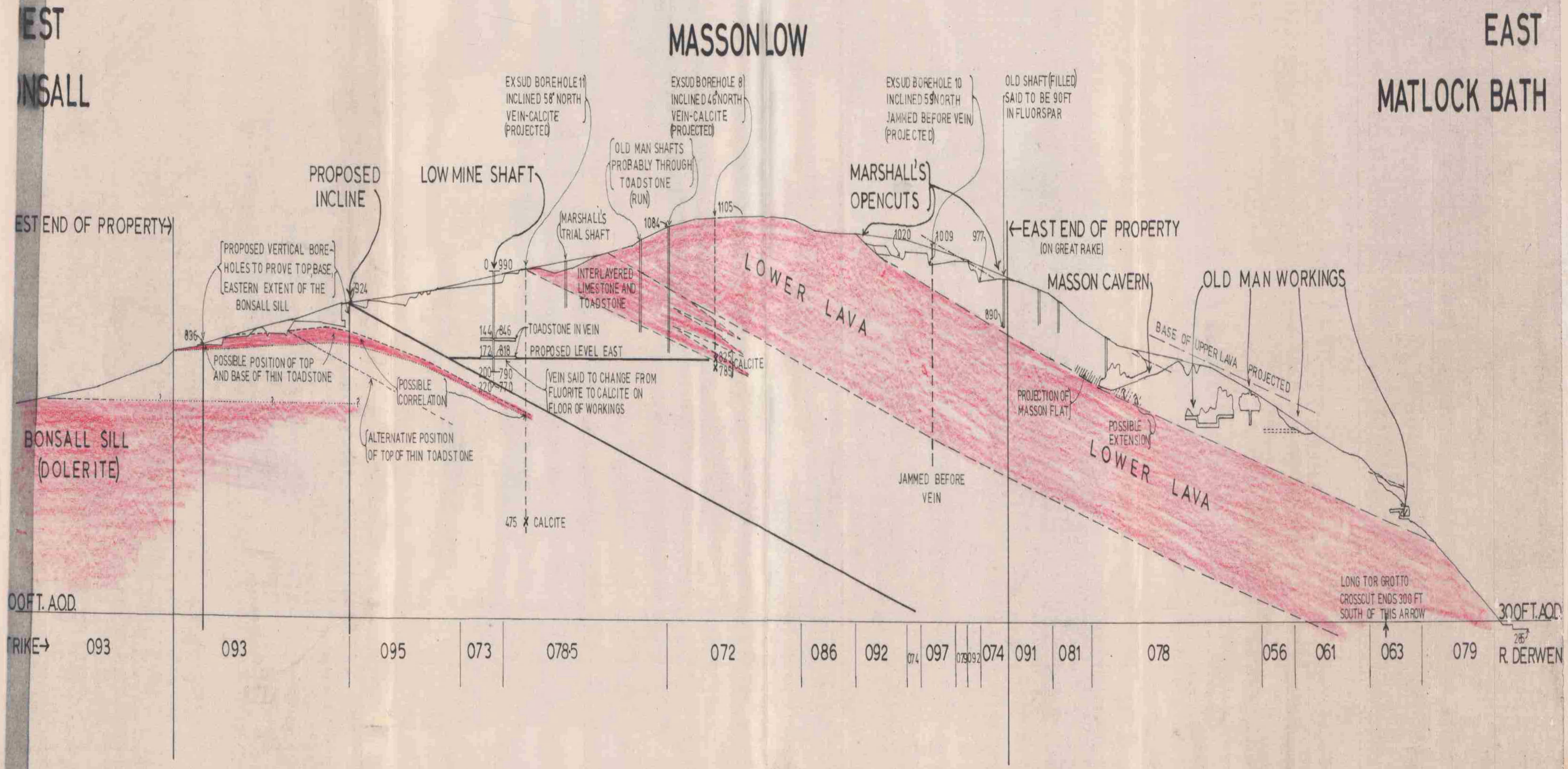


FIG. 2.

PLAN SK 2858 & PLAN SK 2958

FIG. 1.

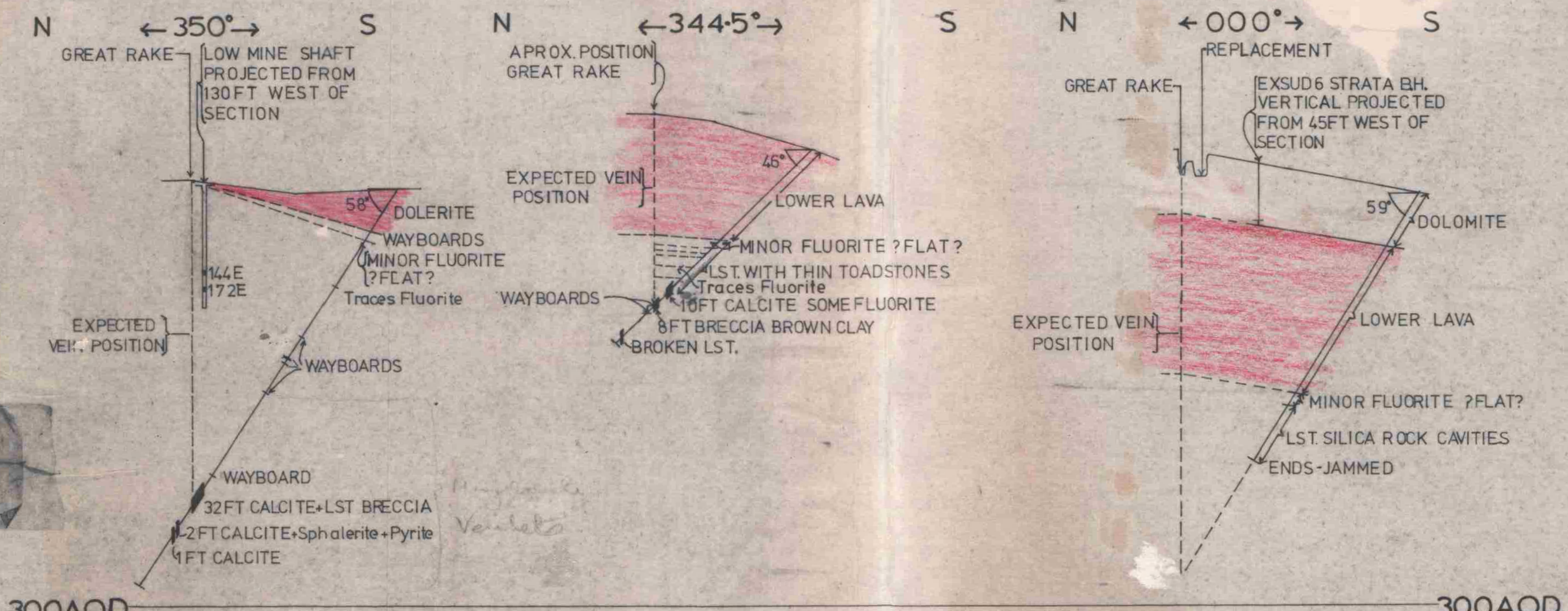
GEOLOGICAL SECTION ALONG GREAT RAKE INCLUDING THE PROPOSED INCLINE AT LOW MINE BONSALL



SCALE 1:2500

ALTITUDES IN FEET SHOWN THUS: 875.

SCALE SECTIONS OF EXSUD INCLINED BOREHOLES AT GREAT RAKE EAST OF LOW MINE BONSALL



0 100 200 300 400 500 600 700 800 900 1000FT

SCALE 1: 2500

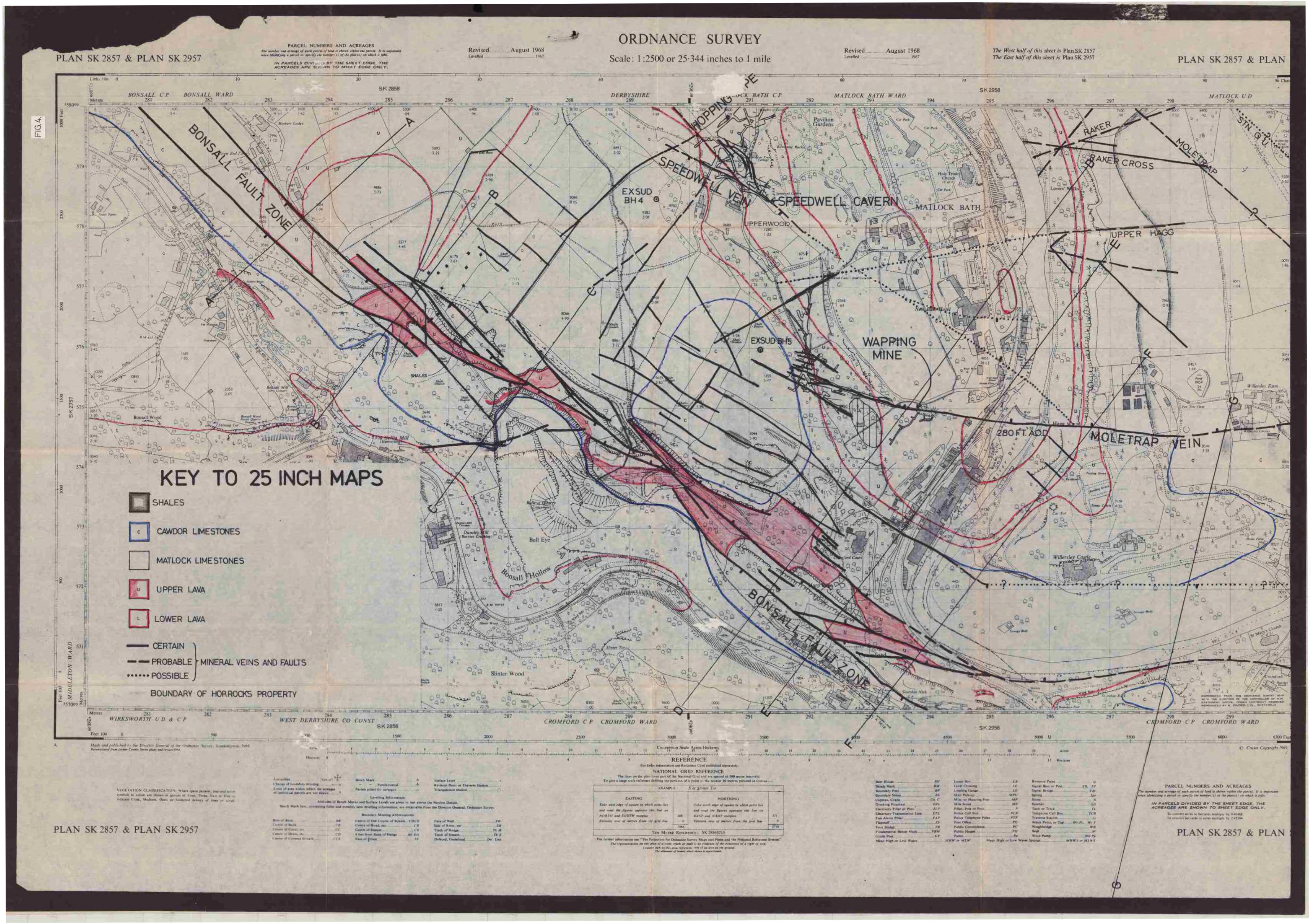

ORDNANCE SURVEY
Scale: 1:2500 or 25·344 inches to 1 mile
PLAN SK 2857 & PLAN SK 2957
Revised August 1968
The West half of this sheet is Plan SK 2857
The East half of this sheet is Plan SK 2957
KEY TO 25 INCH MAPS
SHALES
CAWDOR LIMESTONES
MATLOCK LIMESTONES
UPPER LAVA
LOWER LAVA
CERTAIN
PROBABLE
POSSIBLE
MINERAL VEINS AND FAULTS
BOUNDARY OF HORROCKS PROPERTY
BONSALL FAULT ZONE
SPEEDWELL VEIN
SPEEDWELL CAVERN
HOPPING
EXSUD BH4
EXSUD BH5
UPPERWOOD
MATLOCK BATH
WAPPING MINE
MOLETRAP VEIN
280 FT. AOD
UPPER HAGG
RAKER
RAKER CROSS
MOLETRAP
SHALES
Pavilion Gardens
Bonsall Hollow
Slinter Wood
Ball Eye
Willersley Castle
BONSALL C P
BONSALL WARD
DERBYSHIRE
MATLOCK BATH WARD
MATLOCK U D
WIRKSWORTH U D & C P
WEST DERBYSHIRE CO CONST
CROMFORD C P
CROMFORD WARD
MIDDLETON WARD
SK 2858
SK 2958
SK 2856
SK 2956
SK 2757
REFERENCE
NATIONAL GRID REFERENCE
PARCEL NUMBERS AND ACREAGES
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FIG. 4.

REPORT 10

REPORT ON PROPOSED INCLINE INTO GREAT RAKE AT LOW MINE BONSALL. MARCH, 1974

Summary

The dip of strata on Great Rake west and east of Low Mine is 15° to the east. The effect of a possible minor anticline in the toadstone clay close to the site of the proposed incline mouth is considered, and it is concluded that a few shallow trial pits in the order of 10-20 feet deep could define the position of the toadstone clay. Two possible altitudes for starting an incline at 888 and 923 ft. A.O.D. are located on the plan and sections.

There is no suitable site for a level to be driven into Low Mine from the ground at the west end of the property because of the presence of toadstones. It is concluded than an incline at 15° to the east is the most suitable for a drive passing close below Low Mine stopes. These should be examined and cleared if necessary by a level driven east to the toadstone (Lower Lava) and this sector brought into early production if suitable. But these old workings and the shaft could be filled with dangerously unstable slimes. This level, if combined with sumps, should check the position of the fluorite-calcite interface described in our previous report.

The Great Rake is divided into three sectors by changes of about 10° in strike. It is therefore not possible to drive a straight incline in the vein. Five alternatives are discussed and outlined on the plan.

1) Driving a "crooked" incline in the vein.

Advantages - early production in soft ground.

Disadvantages - expensive support problems.

- haulage problems in driving.

2) Driving a similar incline parallel to the vein

Advantages - stronger roof conditions are predictable, and old man's workings will be avoided.

Disadvantages - hard driving in silica wall rock.

- need for parallel development drives and cross-cuts for production and further haulage problems.

3) <u>Driving a straight incline well off the vein</u>

Advantages - avoidance of silica alteration and "old man" workings.

Disadvantages - need for long cross-cuts and developments.

4) <u>Driving a straight incline on the average strike of the vein</u>

Advantages - incline remains close to proposed workings but much not in weak vein; haulage problems minimised.

Disadvantages - hard rock drives in silica rock needed from place to place. Support problems in parts in vein.

5) <u>Driving a straight incline part in wall rock and part in the longest straight stretch of vein</u>

Obviously a subtle combination of the various factors mentioned above.

These factors affect the position on plan of the incline but not the altitude of the mouth nor the inclination. We favour proposals four or five.

The incline should be carried down at the same time as examining Low Mine from the level. Once a further 200 vertical feet of ground are proved by the incline two vertical boreholes should be sunk to prove the Bonsall Sill west of Low Mine. Westerly levels can then be designed to hit the sill front or explore the ground beneath. Easterly levels to the Lower Lava can be put out at suitable intervals. The water table is expected to lie from 350-300 feet A.O.D. Pumping below this may affect the Matlock Bath thermal springs. We suggest therefore that a 400 A.O.D. level east and west should be at least the temporary bottom level of the mine.

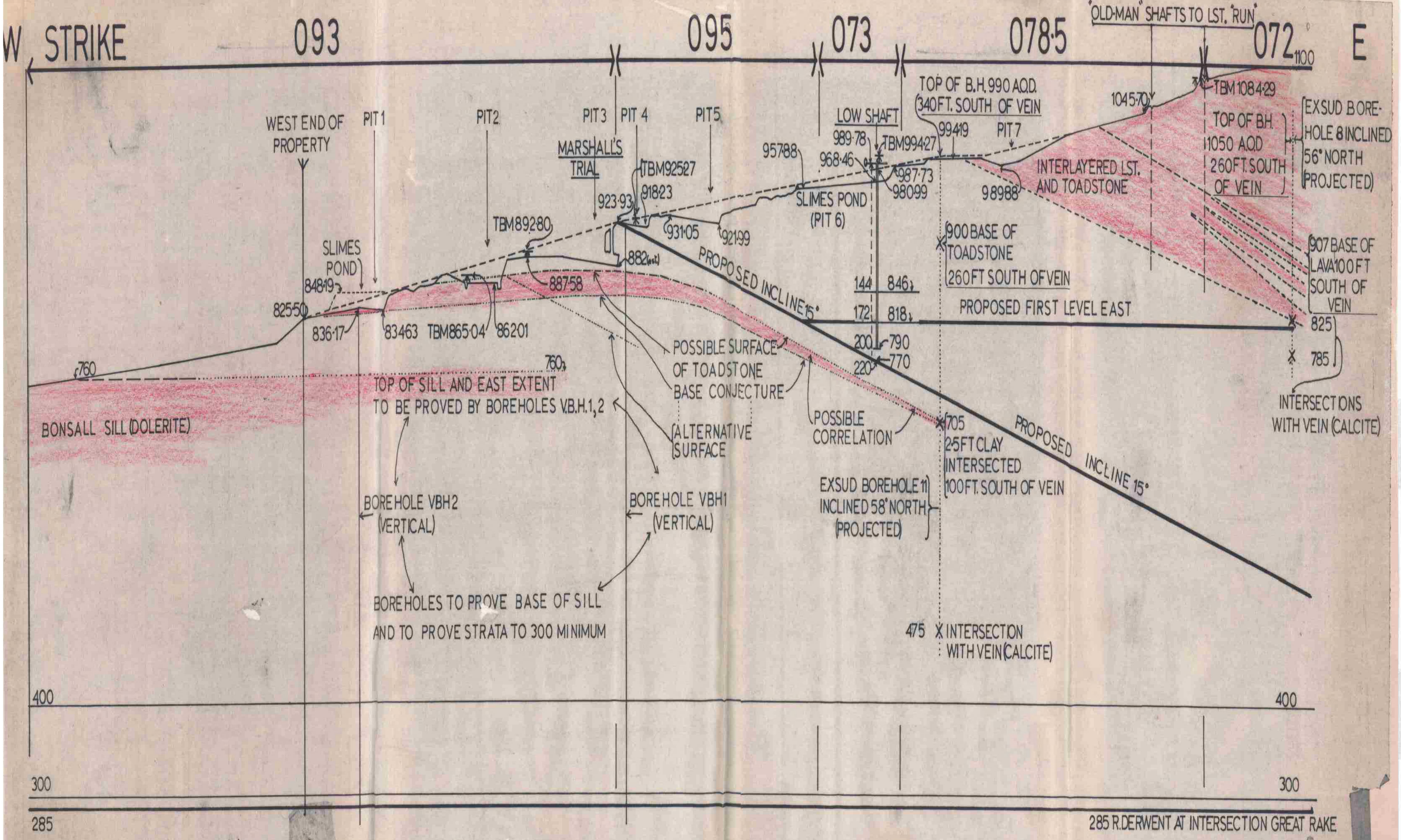
Given a suitable alignment this would allow bypass of the Matlock UDC ground to below the Masson Flat. A rise through the toadstone (c300 ft.) could allow production from the flat and from the limited height (100 feet) and length of Great Rake above the Lower Lava. This proposition is not practical unless the Sugden-Pearson property to the north on Masson Flat towards Laporte's Masson open pit is acquired. Flat production in the "old man" is low grade and expensive.

Alignments at the east end of the ground should be such as to allow bypass of Matlock UDC ground should any property at Riber be acquired.

Several minor veins defined on the plan parallel Great Rake. Those should be regularly tested by cross-cuts. A 600 ft. long southeast cross-cut should be considered when the incline reaches 700-600 feet A.O.D. to test Coal Pit Rake below the Lower Lava. This could be inclined with the bedding. There are several smaller veins in between which might expand or coalesce with depth.

We require Exsud BH 7 log and the Acmin logs to assess this cross-cut venture properly.

Details of the proposed incline are given on section figure 10/1. A plan of the area is given in figure 9/2.



DETAIL OF PROPOSED INCLINE AT LOW MINE 1:

REPORT 11

GEOLOGICAL REPORT ON TWO AREAS OF LAND ON BONSALL MOOR. 8th MAY, 1974

Northern Area

The area is crossed by the east-west Bonsall Fault south of Moor Farm. To the north the limestones are in the Hopton Wood Group and lie below the Lower Matlock Lava. These limestones include the Winster Moor Farm lava dipping at 20^{o} northwards. The latter is an effective base for extraction. The rocks are folded by the west end of the east-west "Matlock Anticline".

A swarm of north-west minor veins cross this part of the area. Where they are in dolomitized limestone they form a calcitic fluorite replacement which has been worked in two shallow pits. Both these pits and other unworked dolomitized zones have some potential for small scale low grade open pitting. The Winster Moor Fram lava lies only 30-50 ft. below these pits. A strong E-W vein (Old Dean) should also be sampled, though much of its course appears to be within the lava, and clay and silica dilution may be a problem.

The Bonsall Fault throws strata down several hundred feet to the south. In view of the old fluorite working 300 yards west of Moor Farm, (see Report October 1972) and the large pits at Blakelow Lane ½ mile to the east it is likely that the Bonsall Fault is significantly mineralized in this area. Flats may be developed below the "Lower Lava" immediately north of the fault and perhaps also in association with the Old Eye vein. Drilling or open pitting would be needed to prove this.

South of the fault the strata are in the Matlock Limestones with the Lower Lava at about 150 ft. depth. There is no outcrop, up to 25 ft. of superficial deposits being present but it seems possible that a "stock work" similar to the southern area is developed. Only one east-west vein is known and this should be sampled 200 yds. south of Moor Farm. Some open trenching through the superficial deposits will be needed.

The small detached area southwest of the main one lies at the western end of Abbott's Whitelow Rake which is breaking up to the west here. Some potential for small scale dragline work is present. Whitelow Rake in Abbott's ground to the east is a very strong vein with up to 10 ft. of clean sugary fluorspar. A trial shaft, 50 feet deep, was recently timbered up, and trenches in the floor of the open cut to the east look promising. The vein is said to be the western extension of Great Rake at Bonsall, but it cannot be followed through directly, on present evidence.

Southern Area

The area lies in the Matlock limestones which are here relatively flat-lying. Over most of the area the Lower Lava lies over 150 ft. below the surface, which must be just below the horizon of the Upper Lava (or equivalent wayboards).

The area has been worked by shallow open cuts for fluorite in the 1950s - 1960s especially in the eastern half. This part is crossed by an intense "stockwork" of small veins each only a few feet wide. Some however are stronger and more continuous and it is these which have yielded most fluorite. The veins carry much baryte with the fluorite. Several of these larger veins are probably minor faults and this supports Dunham's contention that there might be a flat developed extensively on the Lower Lava at depths up to 150 ft. It is however probable, from our work on Masson etc. (see previous reports) that flat development would be restricted to strips of limestone adjacent to the postulated minor faults.

It seems likely that the almost "veinless" western half of the area is also crossed by a similar "stockwork" but the "old man" has not explored here because of a thick cover of superficial deposits. Most of the previously worked veins could probably be opencast deeper by shallow dragline as could the postulated new ones. Proving of the flat would require a sophisticated exploration programme. Below the Lower Lava adits show only calcite in Great Rake and Parson's Rake.

The southwest boundary of the area in Hollow Church Way follows a branch of the major Gulf Fault. The content of this fault is unknown between Grange Mill and Wirksworth.

General

These areas should be viewed as part of an intention to acquire the whole of Bonsall Moor rights as a conveniently close potential low grade source.

GEOLOGICAL MAP OF BONSALL MOOR DERBYSHIRE

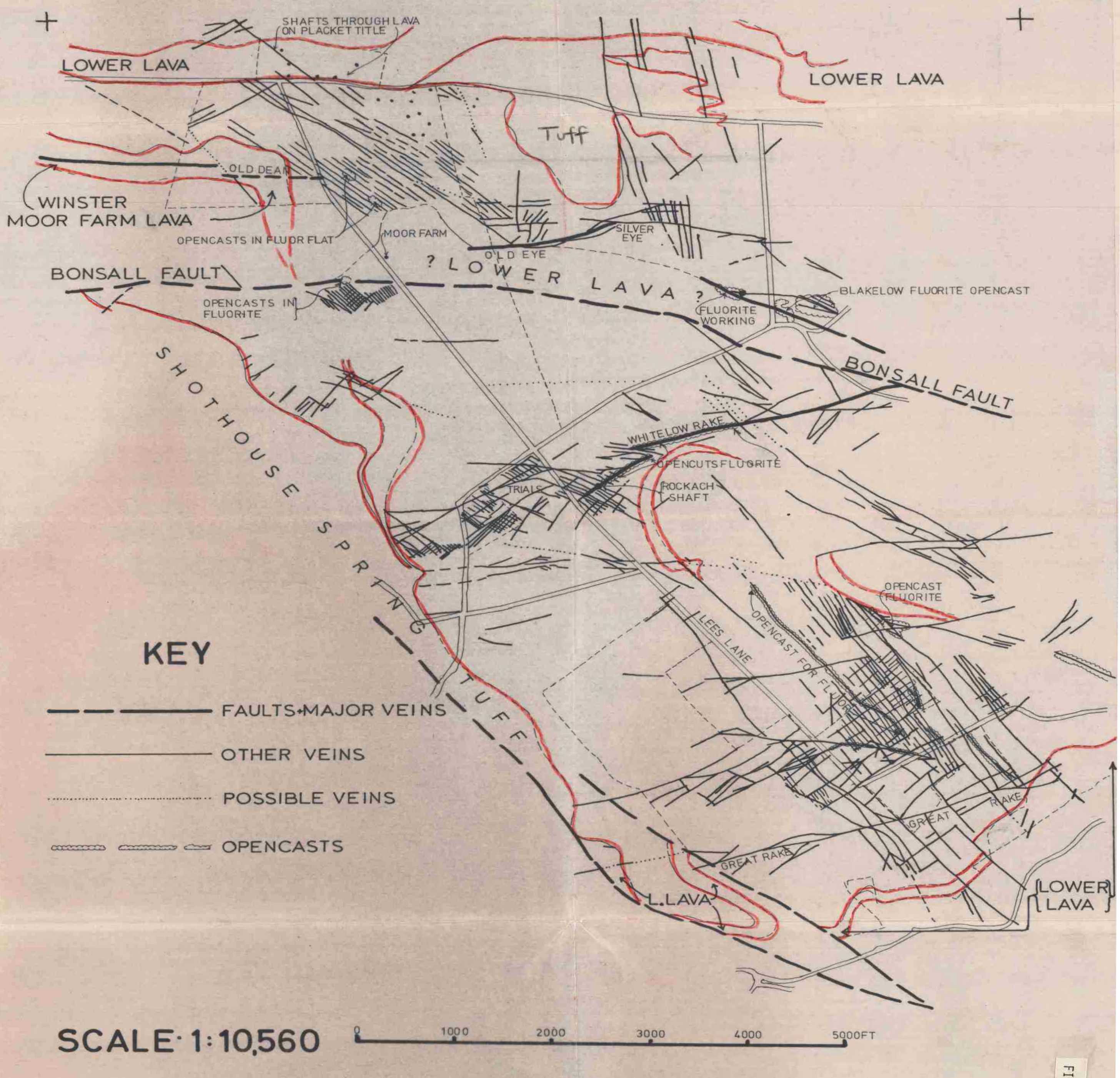


FIG. 1.

REPORT 12

REPORT ON THE MOLETRAP VEIN AND THE BULLESTREE MINE PROSPECT. 21st MAY 1974

Summary

The Moletrap vein and its extension is one of the major fault-veins of the orefield. Above the Lower Lava, it carries fluorite, from the Gulf Fault in the west, to the eastern end of the old workings from Moletrap Shaft; a distance of 3½ miles. Below the lava the vein appears to be calcite, at least at its western end. The vein may be traced for a further 1½ miles east of the probable workings from Moletrap Shaft, as a fault in the Millstone Grit.

For the Moletrap-Bullestree Prospect we have considered only that part of the vein east of Willersley Lane as viable from the point of view of planning permission; which leaves about between 100,000 - 400,000 metric tons untouchable between the lane and the River Derwent.

East of the lane about 250,000 - 1,000,000 m. tons of fluorite is likely to be present in the "old man's" deads, if a vein width of 10 ft. is maintained. A content of 330,000 - 660,000 m. tons of fluorite is likely below and east of the "old man's" workings to Lea Brook, if the content of the vein is fluorite and the width persists. Both these calculations apply to the ground above the Lower Lava. They are subject to revision dependent on the behaviour of the Upper Lava to the east of the Derwent valley, where it is only 30 ft. thick. In calculating the tonnages of the "old man's" deads we have assumed the maximum possible extent of the "old man's" workings, as shown on the section. Our information on workings is limited to that on the Geological Survey Map.

We have no information on the content of the vein below the Lower Lava (it could be calcite) nor do we know the thickness of the lava accurately - 60 to 150 feet is likely. As far as we know no workings penetrate this lava east of the Derwent but the possibility should not be discounted west of New Bullestree Shaft, which could give water problems.

Prospects could be tried by cross-cuts north and south of the main

vein. The exploration and development of the mine is very dependent on planning permission. Two factors to be considered are visibility and traffic problems. It may be possible to separate the exploration and production requirements, however. From the point of view of visibility the wooded New Bullestree Mine Yard is preferred as a production site. However, exploration will be most rapidly carried out by a temporary head gear and pumps at Moletrap Shaft, providing the shaft is stable and not jammed with old timber and rock. We emphasize the need for very careful examination of the old workings with some small scale clearance or bypass drives, so that strata, veins and water flows can be examined before any other work is carried out. New Bullestree Shaft must be plumbed from the water table, to sound for blockages, before pumps are installed. The objective of pumping and deeper exploration should be to establish the depth and eastern extent of the "old man's" workings by driving or clearing a level east to the shale from the Lower Lava at the foot of the Moletrap Shaft. These "old man" stopes should be brought into early production. A cross-cut should be driven north 400 feet after about 1,000 feet east to prove a parallel vein, which may not have been worked by the old man. Further development (on the main vein) should be either via a gentle incline on the Lower Lava eastwards to Lea Brook and beyond to prove the vein to the east. Alternatively the Moletrap Shaft could be continued through the lava. An internal drilling programme is necessary to prove the vein in depth. Levels would then be needed, driven east back through the Lower Lava, to the shale, east of Lea Brook. The latter hypothetical extension is discussed in relation to the Ashover-Crich anticlinal axis.

Production could be carried out either by the Moletrap Shaft or by a 20° or 30° incline from New Bullestree Mine Yard as planning permission dictates. An alternative site would be via a long drive on Station Quarry Vein from Station Quarry. This is held by Tarmac who may, however, have leased it to Laporte.

In this connection a check during exploration at Bullestree should be made for suitable northwest or north fractures on which to drive both the access incline from Station Quarry and to explore the eastern end (below the shales) of all the minor east-west and northwest veins in between. Similarly fractures and veins running south or southeast should be noted for drives to the south into the projection of two east-west branches of the Bonsall Fault, concealed by the Derwent at Willersley.

Longer term prospects to the southeast between Bullestree and Crich (Wakebridge) are discussed in an appended report.

Enquiries for information and old documents should be made locally. We have not had time to check with the various local record offices. Our present knowledge of the extent of workings and shafts is not satisfactory.

The known geological and mining information is plotted on fig. 1 (section) and fig. 2 (plan). Fig. 9/3 which shows the western end of the vein on the 1:2500 scale.

REPORT ON THE MOLETRAP VEIN AND THE BULLESTREE MINE PROSPECT. MAY, 1974

Extent of the Vein

The Moletrap Vein and its extensions can be traced from the Gulf Fault along Great Rake (on the south end of Bonsall Moor) eastwards, via Ball Eye and Wapping Mines (where it is disturbed by the Bonsall Fault), through Bullestree and Moletrap Mines (where the vein dips below the shales), to Lea Brook, where it is known as a fault displacing the Ashover Sandstone. It is therefore one of the major veins of the orefield being at least four miles long.

Above the lava the vein contains fluorite, below in the west it is calcitic, whilst in the east the content is not known. The vein is also a fault throwing down about 60 feet to the north. At Bullestree Mine, Willersley Lane is a likely western boundary for extraction, from the point of view of planning permission. To the east the vein can be traced by old workings for ¼ mile and then as a fault in the gritstones, indicated by the Geological Survey, for a further mile to Lea Brook. The vein may extend further east but there is no evidence.

Widths and Content - Tonnages - Moletrap below the Lower Lava

On the east bank of the Derwent the vein is seen as a six to eight foot wide rift with a wide zone of fluoritization and silicification. Under Mr. Alsopp's home, west of Willersley Lane, fluorite has been found. At New Bullestree Mine Founder a recent descent by A. Smith suggests fifteen feet of fluorite. All the old dumps east of the Lane to Moletrap Shaft show good fluorite with sphalerite, galena and calcite. An old report says that at the east end of the Moletrap Shaft workings, the vein was ten feet wide, ~~good quality~~ fluorite with sphalerite and that the vein was relatively dry. N.B. This report could refer to a point up to 3200 feet east of the shaft. We have no information on the vein content below the Lower Lava. It could be calcite. This would need to be proved by an internal borehole programme.

From the evidence above there is little doubt of substantial fluorite tonnages in the "old man's" deads. If the vein persists in width and does not change to calcite down dip, then further substantial tonnages in a virgin fluorite vein can be anticipated, above the Lower Lava.

Length of "old man's" workings (effective)	=	1235 m.
Height of "old man's" workings (effective)	=	86 m.
Width of vein	=	3 m.
Total volume	=	319,000 m^3
Volume x 3.2 x 25% to allow for tights & voids	=	250,000 m. tons
Volume x 3.2 x 100%	=	1,000,000 m. tons

i.e. there could be 250,000 m. tons fluorite in the "old man's" deads, above the level of the foot of Moletrap Shaft, as a minimum.

Length of virgin vein to Lea Brook (effective)	=	803 m.
Height of virgin vein to Lea Brook	=	86 m.
Width of virgin vein to Lea Brook	=	3 m.
Volume of virgin vein to Lea Brook	=	370,000 m^3
Volume x 3.2 x 50% to allow for tights	=	330,000 m. tons
Volume x 3.2 x 100%	=	660,000 m. tons

i.e. there could be a minimum of 330,000 m. tons fluorite in the untouched vein below and east of the "old man's" workings, as far as Lea Brook, if the vein is in fluorite.

Extent of "Old Man" Workings

Details of the old workings known to us are given by the Geological Survey Map and have been plotted on the section. We have applied logical deductions to estimate the maximum possible depth and eastern extent of the old workings from Moletrap Shaft. We have no information on the overall depth of this shaft but it would probably bottom on the Lower Lava at 650 feet. It is probable that the vein between Willersley Lane and the Derwent was worked by water-wheel pumps down to the Lower Lava. This could cause leakage problems from the Derwent during pumping. Here there may have been an attempt to sink through the Lower Lava but we have no evidence.

The Strata (Limitations)

The dip of the shales is calculated for the north wall of the vein. We only have two facts to go on - the approximate outcrop of the shale at Willersley Farm and the depth of shale at Moletrap Shaft (300 feet). The rest of the section is a projection valid to ± 100 feet or so at the eastern end. The position of the outcrop of the Lower Lava is known in the Derwent and would appear by projection to correspond to the foot of the 420 feet New Bullestree Shaft. The Upper Lava is about 30 feet or so thick in the Derwent Valley but it may break up to the east, as it is represented by a group of wayboards at Crich. This lava will affect the design of stoping and ore dilution above the Lower Lava.

The Lower Lava is of unknown thickness; 60-150 feet could be expected. An internal borehole programme would be required, before sinking through was contemplated.

Eastern Extent of Moletrap Vein

By projecting the average strike of the fault east of Moletrap Shaft the intersection with the Crich-Ashover anticlinal axis can be determined.

The Survey end their fault at Lea Brook. It could extend to the east hidden by a tributary stream valley. The extension should be considered hypothetical at this stage but if it were to cross the Crich-Ashover anticline it could be an interesting, if long term prospect.

Other Veins

a) North of Moletrap Vein

On the cliffs on the east side of the Derwent a series of east-west and northwest veins outcrop. They all carry fluorite. These include Station Quarry vein which was drilled for Pb, Zn and fluorite by Johannesburg Consolidated Investments in the 1950s, in connection with Riber Mine. The vein was worked from Station Quarry in the 50s and re-opened last year (on a small temporary scale?) by Tarmac, who hold the rights. These may be on lease to Laporte. The Station Quarry vein, when projected, intersects Moletrap vein close to Moletrap Shaft. A drive along this would check the other veins in depth. Alternatively an incline from Station Quarry could give production access to the Moletrap Vein as well; if planning permission were to be refused for production at Bullestree.

About 1000 ft. west of Moletrap Vein and 400 ft. north is a fault, traced east for 1600 ft. and displacing the Ashover Grit 40 ft. down to the north. This should be examined in depth in the limestone, as it may be unworked and of greater significance at depth.

b) South of Moletrap Vein

1000 feet south of the vein is a strong east-west fault-vein indicated as a dashed line by the Geological Survey and branching out of the Bonsall Fault. In between a second parallel fault has been postulated by Gower (unpublished M.Sc. thesis, Leicester). Both are conjectural to varying extents but if present could carry substantial fluorite deposits. They should be considered in relation to long term prospects of the area between Moletrap-Bullestree and Wakebridge, described in the accompanying short report.

These two veins could well be very wet, as they run under the Derwent valley for almost 1 mile. They would be best examined by driving a heading at depth on a north-south or northwest-southeast leader or minor vein from Bullestree Mine.

Exploration Programme

The long and short term exploration/development programme is outlined in the summary.

A) Preliminary Exploration

1) Examination of levels on Derwent opposite Masson Hill and Bullestree Sough.

2) Check if the shaft by Willersley Lane is open and descend to examine strata, vein, water.

3) Descend and check stability of New Bullestree climbing shaft - especially for access to workings to east and west, and to determine effects and degree of run in of New Bullestree Main Shaft (420 feet) and check strata and vein. Establish access to a point for examining water table during pumping between here and Willersley Lane Shaft - some clearance or bypass may be needed.

4) Examine stability of Moletrap Shaft lining (in shale to 300 ft.) to water table at 200 feet. Examine any pump way or shale gate at water table. We do not know if this shaft pumped via a north-south cross cut to the river, passing a shaft just above the road and 150 ft. east of the railway bridge, or if the pumpway was along the vein to the west and into the river via Bullestree Sough (level), 600 ft. west of the railway bridge. Moletrap Shaft should be probed and plumbed to check for any blockages by timber/rock.

B) Drainage Problems

This work should allow an initial assessment of the nature of the vein, refine the position of the base of shales, and an assessment of the pumping and access problems at Moletrap Shaft. Pumping below river level will face two problems. Firstly there is the possibility of flow from the river through the old workings and secondly the problem of local damining actions due to run ground in the old stopes. This may lead to dangerous columns of water in old workings and shafts, especially west of Moletrap Shaft - hence the suggestion of setting up access to some point between New Bullestree and Willersley Lane shafts, to monitor the drainage of the old workings in this sector. According to the only record we have the Moletrap Shaft workings to the east were quite dry considering the position, but of course at this time the older workings to the west would be in good order.

C) Second Phase of Exploration

a) Pumping and clearance of Moletrap Shaft, east west drives at the base of the old man

We are not competent to judge the relative merits of driving an incline at 20-30 degrees east from the New Bullestree Mine Yard, or reopening Moletrap Shaft, from the point of view of production. However, we consider that an incline would have to be driven in wall-rock north of the vein, to avoid the "old man's" stopes. If the vein were to be dewatered via the incline, cross cuts would be frequently necessary, fraught with problems on intersecting the water filled vein. Therefore from the point of view of dewatering and exploration, we believe it is necessary to equip Moletrap Shaft for at least temporary access and for permanent pumping. The question of an incline could be considered, from the point of view of production, at a later date. The situation would however be different if the Moletrap Shaft is blocked with rock or old timbers for any great depth, dependent on the difficulties of clearing, bearing in mind that the pumps will require a working head, for cooling, over the debris that must be cleared.

5) Equip Moletrap Shaft for access, pumping, shaft clearance, clearance of old workings, driving of bypasses, and extraction of driving much to 6-700 ft. below surface, either for temporary exploration, or for

potential permanent production facilities, if planning permission allows and you prefer shaft to an incline from New Bullestree Mine Yard.

6) Pump at shaft, bearing in mind the water problems noted above and frequently checking the relative levels from shaft to western monitoring point.

7) Examine old workings as reached - clearance, short bypasses, anticipated major level at about 550 ft. Shaft probably reaches second major level at about 660 ft. This is likely to be the lowest working level of the mine but hand pumped sumps could continue down about 100 ft. to the east from place to place.

8) Explore east to shale by level from Lower Lava at shaft foot. Either clear "old man's" anticipated level and bypass falls, or drive in wall rock and cross-cut to vein. This level could act as a divide for stoping between the vein above, worked by the old man, and that which is virgin ground, below and to the east. It would also prove the eastern extent of the "old man's" workings from the foot of Moletrap Shaft.

9) At the same time as 8 drive an incline west on the Lower Lava from the shaft foot in the wall rock 1400 ft. to Willersley Lane. Beware of water in old workings and shafts.

10) When 8) reaches 1000 ft. east of Moletrap Shaft, drive a cross-cut north about 400 ft. to the parallel vein-fault noted above and drive east and west as decided by content/strength of vein.

Phasing in of Production

At same point in 8), 9), 10) it should be possible to phase in production from the ground above the opened levels. Method of stoping will presumably depend on the vein width and grade and how much of the vein width has been slit by the "old man". Sometime before this stage it will be necessary to decide on the relative merits of shaft and incline production, so that the necessary incline or shaft capacity is ready.

Note, all the above discussion depends in its details, on the assumptions of the depth of Moletrap Shaft and the eastern extent of workings, as defined in the "Extent of "Old Man's" Workings" above and on the section. The general principle of an eastern and western drive from the foot of Moletrap Shaft, at whatever depth this is, is the best initial exploration method whatever the circumstances.

D) Third Phase of Exploration

a) Examination of the vein below the "old man"

It will be necessary to determine the thickness of the Lower Lava and the nature of the vein content below the lava by inclined drilling from cross-cuts within the mine. A major factor to be assessed would be the strength of the Lower Lava relative to sinking the Moletrap Shaft deeper, and driving east through the lava. There would be a permanent increase in water to be pumped. This could be very large when the likely drained area is considered and could have side effects on the Matlock Springs.

These factors will need to be assessed, as the alternative is to concentrate, at least initially, on extracting the vein above the Lower Lava. This could be via a gentle incline east to Lea Brook, from the shaft foot on the Lower Lava, or by a steeper incline driven at 20-30° from the east level, say 1500-2000 ft. east of Moletrap Shaft. This would give about 200 ft. of stopable ground below the "old man's" level, if a level were driven east from the foot of the incline. This assumes that the vein is still in fluorite as work proceeds down dip. The possibility of a change to calcite down dip cannot be ruled out. This work could be progressively extended deeper and further east to prove any extension of the vein above the Lower Lava but east of Lea Brook. (See section on eastern extent of Moletrap Vein above). It would perhaps become worthwhile to consider further access by shaft or incline from Lea Brook at some stage.

b) Examination of veins north and south of Moletrap Vein

See the notes on this above in the section "Other Veins". Much more detailed geological information is required before we can give specific recommendations for location of cross-cuts. See the note on planning permission below in relation to the veins to the north. The veins to the south are considered also in a short appended report on the potential of the ground between Moletrap-Bullestree Prospect and the Crich-Wakebridge Prospect.

Long Term Exploration

Forward exploration for the Moletrap vein on the Ashover to Crich anticline is noted on the section on the eastern extent of Moletrap Vein above.

Exploration southeast of Moletrap-Bullestree Prospect is noted in Report 13 on the prospects between here and Crich-Wakebridge.

Problems of Planning Permission

We feel it is unlikely that planning permission would be allowed for more than a temporary headgear during exploration on Moletrap Shaft, although there is, so far as we can see, no objection to its use as a pumpway.

New Bullestree Mine Yard is a better site so far as visibility is concerned but shaft clearance would be slow, expensive and not give such deep access as Moletrap Shaft. A 20 or 30 degree incline to the east from here would be preferred but dewatering and exploration would still need to be via Bullestree Shaft.

Both these possibilities mean mining and vehicles close to adjacent housing and heavy lorry traffic over Cranford Bridge and might well be strongly opposed.

A third possibility is to drive down Station Quarry Vein from Station Quarry on a southeast direction by level/incline. This vein and quarry are owned by Tarmac but fluorite may be leased to Laporte. This prospect is more acceptable except that traffic would be routed through the Matlock Bath Station Car Park and through Matlock Bath on the A6.

Unfortunately, Cromford Station and Willersley Tunnel occupy the most acceptable site for an incline! Some enquiries with British Rail might be worthwhile.

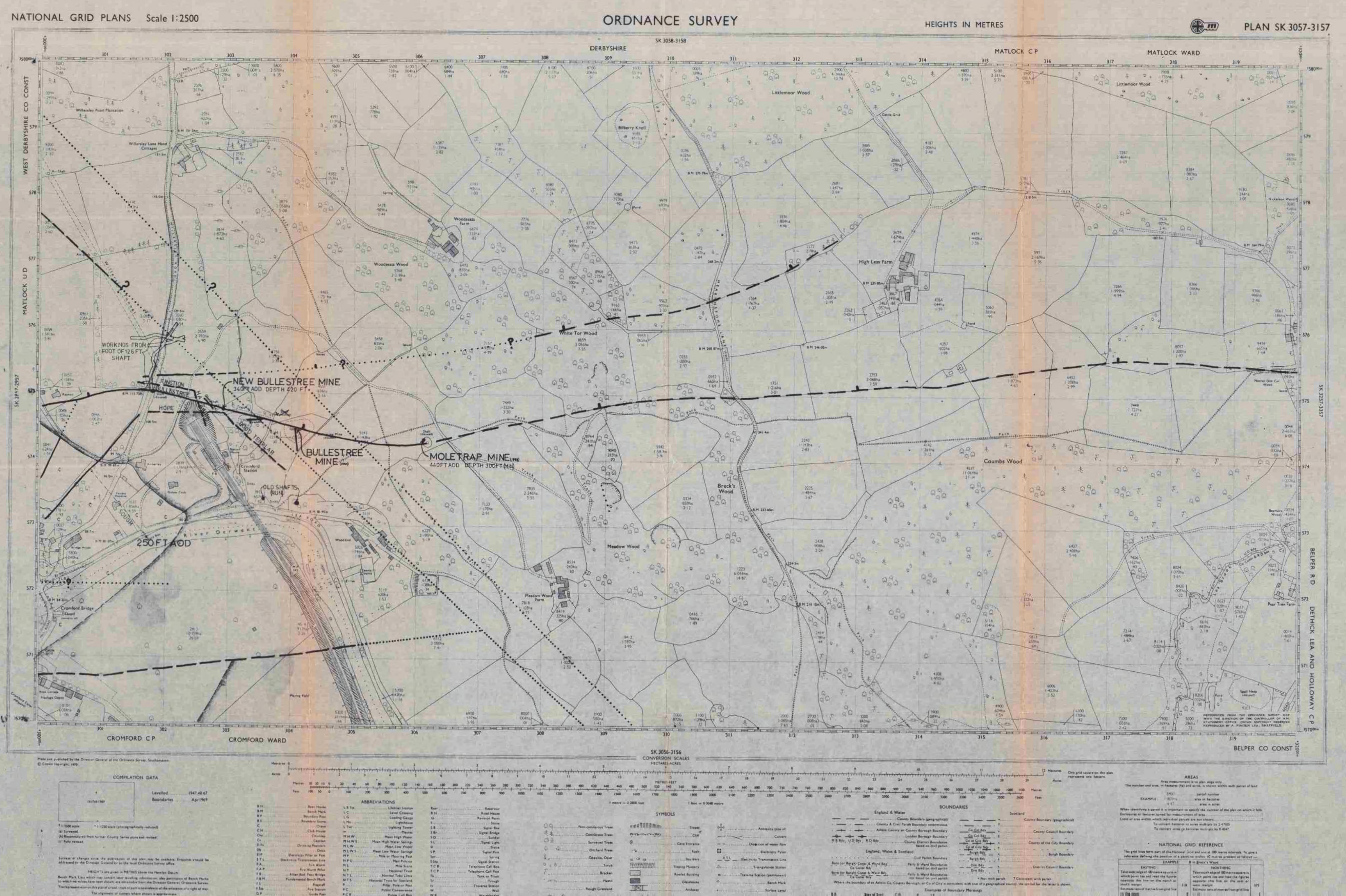

NATIONAL GRID PLANS Scale 1:2500
ORDNANCE SURVEY
HEIGHTS IN METRES
PLAN SK 3057-3157
DERBYSHIRE
MATLOCK C P
MATLOCK WARD
WEST DERBYSHIRE CO CONST
MATLOCK U D
BELPER R D
DETHICK LEA AND HOLLOWAY C P
BELPER CO CONST
CROMFORD C P
CROMFORD WARD
NEW BULLESTREE MINE
340FT AOD DEPTH 420 FT
BULLESTREE MINE
MOLETRAP MINE
440FT AOD DEPTH 300FT
WORKINGS FROM FOOT OF 126 FT SHAFT
OLD SHAFTS RUN
250 FT AOD
High Lees Farm
Coumbs Wood
Breck's Wood
Meadow Wood
White Tor Wood
Woodseats Wood
Littlemoor Wood
Willersley Road Plantation

FIG. 2.

REPORT 13

REPORT ON THE WAKEBRIDGE OPTION AND THE NORTHERN PART OF THE CRICH INNER AND ADJACENT AREAS. DERBYSHIRE. 23rd MAY, 1974

Introduction

This report is based principally on a survey of the available written accounts* - only a limited amount of personal observation is involved.

The property is critically situated to examine four significant prospects only parts of which lie within the option area. It will be advisable to acquire exploration or mineral rights or options on the whole of the north end of the Crich limestone inlier and the surrounding areas to east and west under the shales. Cambro Quarries and Clay Cross Co., have significant holdings in this area. Exploration rights and options should be acquired for longer term work along the Crich-Ashover anticlinal axis to the north and for the full extent of the southwestern Crich boundary fault and associated east-west faults from Crich Village to Bullestree Mine. If the faults in this area are mineralised with fluorite then we believe that there could well be very large reserves. For these various factors we have extended our report to cover the whole of the northern part of the Crich Inlier. ~~The parts referring to the Wakebridge Option are paralleled by two red lines in the margin for convenience.~~ An appended outline report describes the prospects between Wakebridge and Bullestree Moletrap mines.

The southeast extension of the boundary fault is overlain by Crich village. The southern end of the Crich inlier is apparently less mineralised than the north. The presence of the village, thick soil, and the nature of the outcropping limestone may mask a similar vein network to that in the north, at depth, however.

Fluorite mineralisation is confined to the strata above the Matlock Lower Lava. Below this several very deep shafts passed through 500-600

*Lead Mining at Crich, Derbyshire, (Kirkham N.) Manchester Assocn. of Engineers, Session 68-69, No 5
Chesterfield Memoir, 112. (Institute of Geological Sciences).

feet of calcite in the vein. Just below the lava the vein has a higher galena content but this faded with depth.

The four principal prospects wholly or partially contained within the Wakebridge Option are as follows:-

1) The Wakebridge - Bacchus Pipe complex - a north-south fluorite pipe at the west side of the limestone inlier (wholly within the option area).

2) Great Rake - a major northwest to southeast fluorite vein towards the north of the limestone inlier (partially within the option).

3) A Postulated east-west vein - seen as a fault projecting into the option (postulated as partially within the option).

4) The Southwest Boundary Fault - a major northwest to southeast fault zone seen principally in the Millstone Grit which extends towards the Bullestree-Moletrap Prospect (partially within the option).

In addition a whole series of smaller fluorite veins intersect these deposits within and outside the option and could be worked in conjunction.

Wakebridge-Bacchus Pipes, and Great Rake have been worked for fluorite in the 1930s, 40s and 50s. Baryte was also produced. The extent of the workings of this period are poorly known so that local enquiries will be vital. Some plans of the far more extensive 19th Century lead workings are known at record offices, in the Devonshire collection, and Mr. Eric Fisher of Winster has several. We have not seen any of these. Only with a careful assessment of this data can the potential of these two prospects be gauged. It will be necessary to enter all the open shafts and workings. In general at present we have only details of shaft depths and strata. There is little or no information on the vein widths.

The workings above 250 ft. A.O.D. are drained by Ridgeway level

(Whatstandwell or Wakebridge Sough). At present this is inaccessible because of a bricked up entrance at the foundry north of Whatstandwell Bridge, where the level discharges into the Derwent. There are also internal blockages and CO_2 gas. Most of the level (except the entrance?) lies within the option. It is an important and critical asset.

Outline of Exploration work required

This is work needed before any equipping of shafts or driving is begun.

1) Further field observations, examination of the old records, verbal contacts with miners to determine the extent of the 20th Century fluorspar workings.
2) Descent and survey of all accessible workings - Great Rake, Wakebridge 1, 2, Bacchus, Jingler-Rolley, etc.
3) Compilation of data on sections - plans to determine details of geology, which shafts to equip for exploratory drives, siting of inclines or levels.
4) Clearance of Whatstandwell (Wakebridge or Ridgeway) level to assist or extent 2) as found necessary.

Details of workings, tonnages on Great Rake and exploratory drives on the four prospects, insofar as they can be suggested at present, are given in the full report.

General Considerations

1) Structure

The Crich Inlier is an elongate dome formed by the intersection of a north-south anticline from Ashover, and a less obvious and poorly documented anticline running northwest to southeast from Matlock. This is bordered on its southwest side by a major northwest fault, which throws down to the southwest. The northern part of the Inlier is crossed by a complex of fluorite-barite veins the most important of which are the northwest to southeast Great Rake and the Wakebridge-Bacchus Pipe running north to south down the western boundary of the limestone. There is probably a second major east-west fault-vein, concealed by shale 1,500 feet north of the north end of the limestone outcrop according to the Institute of Geological Sciences 1:10,560 map.

2) Strata

Three hundred feet of limestones overlie the Matlock Lower Lava (60-120 feet thick). In this limestone a group of wayboards about 120 feet down are probably equivalent to the Matlock Upper Lava. Below the Lower Lava 600 feet of Hoptonwood limestones were proved in the Glory and Old End Shafts.

3) Stratigraphic Control on Mineralisation and Topography and Soil Cover

A glance at the Geological Survey's Map shows that the veins are confined to the northern part of the inlier, principally to the outcrop of the Matlock Limestone. In the Cawdor Limestone the veins are not seen so frequently and in this connection appear to be absent from the southern part of the outcrop, where outcrop is largely in the Cawdor Group. Here there are old quarries which provide exposure down into the Matlock Limestones but reveal no veins. Their area is, however, very small. A few workings are known from old documents in the Crich Village area but have not been located.

It can be argued that the absence of workings does not necessarily indicate an absence of veins. The southern half of the inlier is thickly covered by soil and boulder clay because of topography and it may be that the lack of exposure conceals a similar complex to that in the north. We have no fixed opinion, and the quarries need further examination.

4) Details of the Four Principal Prospects

A) Great Rake

This is the main vein at Crich. It runs northwest to southeast and has been worked for a length of at least 3,000 feet. We have no information on the width of the vein at any point. It is said to hade south at about 1 in 5. Above the Lower Lava the vein is in fluorite with barite. Below the lava it is calcite, as proved for 600 vertical feet at Glory and Old End Shafts.

The vein is drained by Ridgeway (Whatstandwell or Wakebridge) Sough or level to 240-250 feet A.O.D., at the western end, and by Fritchley level to 340 feet A.O.D., in the east. Glory Mine shaft continued down below Ridgeway level to 60 feet A.O.D. and Old End Mine below Fritchley level to 150 feet below A.O.D. The ground either side of these workings has been worked for galena but we have no idea of the lateral extent. All the ground above the Ridgeway and Fritchley levels, from their intersection with the shale to the northwest and southeast has probably been worked for galena.

Fluorite has been worked both by shallow opencuts and shafts along the vein and by shallow inclines, levels, and reopening deep shafts. Our information on these deeper workings is very scanty and we are left with the impression that large sections of the vein are untouched, i.e. that there will still be considerable tonnages in the "old man's" deads. It is essential that local information and old plans of these fluorite workings be gathered together and assessed. Below are the details at present available.

Old End Shaft was reopened in the 1940s to 300 feet and a level driven as shown on the section. The "old man" proved unstable and the venture was abandoned. The vein was then worked by opencuts in conjunction with Church Rake, and a shaft 125 feet deep, 175 feet west of Old End produced good fluorspar in Great Rake.

Glory Mine Shaft was reopened in the 1950s for fluorspar at least to the lava. We have no information on the extent of workings. At present an incline is being driven into the western end of the Glory Mine in search of fluorspar but no significant reserves have yet been proved, as the incline is not in the vein?

Wakebridge No. 2 shaft is on the junction of Great Rake and Wakebridge Bacchus Pipe within the Wakebridge Option. This was worked for fluorite by the Hopton Mining Company in the 1950s. There were levels at 540 and 450 feet A.O.D. but it is not clear whether Wakebridge Pipe and/or Great Rake was worked. The principal Hopton Mining Co. work was in Wakebridge Pipe at this time however. Below 450 feet A.O.D. the vein has probably not been worked for fluorite. In the early 1900s a level was driven east at Great Rake from the surface adjacent to this shaft to prove fluorite. We have no other details.

Possible Reserves on Great Rake

It must be understood that we have no information on the width of Great Rake at any point. Making an assumption of 2 metres, as the minimum economic vein width, the following tonnages could be expected, above the Lower Lava.

1) Within the Wakebridge Option

i) Below 240 feet A.O.D. (Ridgeway level) probably unworked for fluorite or galena.

Length (effective)	=	300 m.
Height	=	100 m.
Width (assumed)	=	2 m.
Volume	=	60,000 cu m.
Volume x 3.2	=	192,000 metric tons
x 50% for tights	=	96,000 metric tons

There could be 96,000 to 192,000 metric tons fluorspar in a virgin vein below Ridgeway level in the Wakebridge option, assuming a 2 m. vein, continuing across the option in the limestone above the Lower Lava, and that its content is fluorspar. The vein has not been proved more than

650 feet west of the eastern boundary of the Wakebridge Option.

ii) Above 240 feet A.O.D. (Ridgeway level) below 450 feet A.O.D. (base of Hopton Co's. possible workings)

This has been worked by the "old man" for galena.

Length (effective)	=	150 m.
Height	=	62 m.
Width (assumed)	=	2 m.
Volume	=	18,400 m^3
Volume x 3.2	=	59,000 metric tons
Volume x 3.2 x 25% to allow for tights and voids	=	14,750 metric tons

There could be 14,750 - 59,000 metric tons fluorspar in deads in a vein worked for galena by the "old man" assuming a 2 metre vein and above the Lower Lava.

iii) Above 450 feet A.O.D. to Surface

This has been worked for galena and may have been stoped by Hopton Mining Co. for fluorite in the 1950s.

Length (effective)	=	111 m.
Height (effective)	=	77 m.
Width (assumed)	=	2 m.
Volume	=	17,100 m^3
Volume x 3.2	=	55,000 metric tons
Volume x 3.2 x 25% to allow for tights and voids	=	13,750 metric tons

There could be 13,750 - 55,000 metric tons fluorspar in a vein worked for galena by the "old man" if this has not been stoped by Hopton Mining Co. in the 1950s.

Overall tonnages in the Great Rake in the Wakebridge Option

96,000 to 192,000 metric tons, in a probably virgin vein west of Wakebridge No. 2 shaft, above the Lower Lava and below Ridgeway level.

14,750 to 59,000 metric tons, in a vein worked for galena by the "old man" but not for fluorspar, above Ridgeway level but below Hopton Co. workings

13,750 to 55,000 metric tons above 450 ft. A.O.D. to surface if this was not stoped by the Hopton Mining Co. in the 1950s.

Note that the vein has only been proved for 650 ft. west into the Wakebridge Option and there may also be extensions west of the option.

2) To the east of the Wakebridge Option

These calculations refer to ground above the Lower Lava and ignore the effects of earlier fluorspar workings. They assume a 2 metre vein.

i) To Glory Shaft

Length (effective)	=	197 m.
Height (effective)	=	62 m.
Width (assumed)	=	2 m.
Volume	=	24,400 m^3
Volume x 3.2	=	78,000 metric tons
to allow for tights and voids x 25%	=	19,500 tons

There could be 19,500 - 78,000 metric tons fluorspar in "old man's" deads from Wakebridge Option to Glory Shaft, assuming a 2 metre vein and no significant stoping for fluorite from Glory Shaft.

ii) Glory Shaft - Old End Mine

Length (effective)	=	340 m.
Height (effective)	=	78 m.
Width (assumed)	=	2 m.
Volume	=	53,000 m^3
Volume x 3.2	=	170,000 metric tons fluorite
x 25%	=	42,250 metric tons fluorite

There could be 42,250 - 170,000 metric tons fluorite from Glory to Old End Mine Shaft, in the "old man's" deads, above the Lower Lava, if there has been no significant stoping of fluorite from the two shafts.

iii) Old End Mine to the shales above 340 ft. A.O.D. (Fritchley level)

Note the vein has apparently not been proved or worked east of a point 450 ft. east of Old End shaft. This is surprising and it could be that no records have been kept.

Length (effective)	=	438 m.
Height (effective)	=	93 m.
Width (assumed)	=	2 m.
Volume x $\frac{1}{2}$ (triangular)	=	40,700 m^3
Volume x 3.2	=	130,000 metric tons
to allow for tights and voids x 25%	=	32,500 metric tons

There could be 32,500 - 130,000 metric tons fluorspar in the Great Rake in the "old man's" deads, above the Lower Lava, east of Old End Shaft and above Fritchley level (340 ft. A.O.D.). Part of this section may be unworked, in which case the tonnages will be higher.

iv) Below and to the east of Fritchley level.

Here the vein has not been proved. Further large tonnages may be present in an unworked vein.

Total Tonnage at Great Rake

This refers to fluorite above the Lower Lava, above Whatstandwell and Fritchley soughs, in the "old man's" deads and assumes a 2 metre vein with no significant stoping for fluorite at any point on the rake.

There would appear to be 125,000 - 500,000 metric tons of fluorite in the "old man's" deads.

On the same assumptions, if the vein continues to the west there could be an additional 96,000-192,000 metric tons in the Wakebridge option in an unworked vein below Whatstandwell Sough, and also considerable tonnages to the east of the Old End workings and below Fritchley level, assuming the vein continues in fluorite.

Outline Method of Exploration on Great Rake

1) Descend and examine Wakebridge No. 2 shaft to determine back up of water (if any) on Ridgeway level/Long Gate and the stability of shaft.

2) Descents of Glory Shaft and any other open shafts on Great Rake to examine workings. Is Old End Shaft open, run or sealed?

3) Check the inclination and extent and alignment of the present trial incline, west of Glory Shaft.

4) Search for the 1900s level east from the surface near Wakebridge No. 2 shaft; open, enter and examine workings.

5) Equip Wakebridge No. 2 shaft for exploration and driving to the west on Great Rake.

6) Decide as a method of exploration for Great Rake east of the Wakebridge option and above the Lower Lava. By shafts, level, or incline(s). Development drives and inclines would need to be in the wall rock to avoid the "old man". Old End Shaft, if open, is in a poor state and the Glory Shaft is also very loose.

B) Wakebridge Pipe - Bacchus Pipe

General

The pipe body runs north-northwest and north-south on the western margin of the inlier at depths of about 250 ft. It begins at Pearson's Venture Shaft and then runs north via Jingler or Rolley Shaft through Bacchus Shaft, Wakebridge No. 1 Shaft, to the Great Rake at Wakebridge No. 2 Shaft, a total distance of 3000 feet. There are also links to workings and shafts on the many minor veins intersected.

The nature of the workings and their extent is not known in detail. The mineralization appears to be a pipe-replacement-stockwork deposit in respect of fluorite. There is also much baryte. The workings are dry and lie above the Lower Lava.

Drainage

The system is drained by Ridgeway level (Whatstandwell or Wakebridge Sough) to 240 feet A.O.D. This begins at the foundry 2000 ft. north of Whatstandwell Bridge and forks at Jingler shaft, one branch going to Pearson's Venture Mine and the other proceeds along the line of the pipe to Great Rake, perhaps being driven along this as far as Old End Mine (the Long Gate). The level is bricked up in the foundry yard and water issues from a pipe. There is at least one blockage between here and Jingler Shaft, from quarry debris thrown down an air shaft. The level contains CO_2. We do not know the state of the level north of Jingler Shaft (see comments under individual shafts to the north).

Details of Shafts and Workings

Pearson's Venture Shaft

This shaft lies outside the option and the site is covered by landslip and quarry debris. The shaft was 690 feet deep passing through 60 feet of lava below 420 feet depth. We have no further details.

Jingler or Rolley Shaft

This shaft worked the southern end of the deposit in the 1920s. At this time the shaft was opened to 246 feet and was said to be flooded below. In the 18th Century this shaft was worked to 420 feet. It is intersected by Ridgeway level (Whatstandwell or Wakebridge South) at 370 feet down. It seems likely that the shaft is flooded to the 240 foot level although there may be some back up on the level behind run shafts. The mine is linked to Lees Shaft on the opposite side of the road behind the houses. In the 1920s it was worked for fluorite with some baryte. We have no details of the workings. The shaft is sealed by a concrete slab.

Wakebridge No. 1 Shaft

The shaft is 660 feet deep and is 372 feet to Ridgeway South, at about 240 ft. A.O.D. It probably passes through the Lower Lava and was worked for galena by E.M. Wass in the 19th Century. Fluorspar and barytes were worked by the Hopton Mining Co. from this shaft above the sough level in the 1920-30s. The workings are linked to the Bacchus Pipe and Shafts. The shafts were descended in the last year and are in good condition. Extensive workings were entered but we have no details. The shaft is open.

Bacchus Shaft

This worked the north-northwest Bacchus Pipe parallel to Wakebridge Pipe. The shaft passed through 120 feet of toadstone (?) to a depth of 450 feet. This shaft was the ladderway for Wakebridge No. 1 workings. It is still open but the ladders are rotten. The pipe was worked for fluorite and barytes by Hopton Mining Co. in the 1920-30s. The shaft is capped.

Wakebridge No. 2 Shaft

This is on the intersection of the pipe with Great Rake, being sunk to the Ridgeway level. The Wakebridge Pipe was worked from this shaft in the 1950s by the Hopton Mining Co. Levels were driven at 168 feet and 246 feet. They worked a north-south fluorite replacement orebody as a stockwork of northwest and northeast fractures.

Exploration

We have so little information on the mineralization and such scanty knowledge of the workings that the first priority must be to gather as much information locally as well as old plans, and visit the record offices. Hopton Mining Co. must have records. This should be followed up by a rigorous inspection of the old accessible workings and unbricking and entry of Ridgeway level which lies mainly within the option. (The entrance is in the foundry property). With the information obtained we can then make specific recommendations on clearing access or exploratory drives in the old workings.

C) Jingler-Rolley Shaft and the Southwest Boundary Fault

The southwest boundary of the Crich inlier is a major northwest to southeast fault. This throws down to the southwest. Its exact position and extent are not well defined. There is no information on the fault content in the limestone. Further surface mapping is needed to confirm the situation defined by the dotted line on the Geological Survey's Map.

800 feet south of Jingler Shaft the Geological Survey shows the fault splitting into three branches. It may be followed southeast along the limestone boundary for $1\frac{1}{4}$ miles from this point. To the northwest the main branch is marked for two miles towards Bullestree-Moletrap Mines. These extensions are dealt with more fully in an appended report. The Wakebridge Option includes the fault near the point of splitting. We consider it is very important to check the content of the fault in the limestone at this point. There is only limited data on the depth of the limestone here (it must be below 240 ft. A.O.D. as Ridgeway level is in shale to near Jingler Shaft). Using the figures calculated by the Geological Survey we estimate that an incline 900 ft. long at 1 in 6 from the foot of Jingler Shaft at 240 ft. A.O.D. (Ridgeway level) should intersect the faults in the limestone. Much more preliminary geological work is necessary, possibly including strata boreholes.

If this sector of the fault were to prove significantly mineralised above the Lower Lava then a very major deposit might well be developed to the northwest and southeast. The wider aspects of this are considered in the appended report.

Exploration

1) Descend Jingler/Rolley shaft determine back up on Ridgeway level.
2) Clear access into Ridgeway level to locate fault smash zone in the shales. (This will have beneficial effects in drainage and access as far as Great Rake).

3) Decide on best position 'to drive incline' into the fault in the limestone.

D) <u>The Postulated East-West Vein North of the Inlier</u>

1500 feet north of the inlier, striking into the Wakebridge Option, the Geological Survey mark an east-west fault displacing the Millstone Grit. The portion of the fault as drawn by the Survey should be checked by trenching. The postulated extension into the option should be sought by trenching and/or geochemistry. We expect the postulated vein to lie 250 feet below the surface below the shales at its shallowest point and inclined diamond drilling and some preliminary strata boreholes will be necessary.

Alternative methods would be to drive a level/incline on the shale limestone contact from the surface near Wakebridge No. 2 shaft - this would also check the intervening ground. A similar level could be driven north from the foot of No. 2 shaft on the Lower Lava as an alternative. A sketch section of the likely geology is provided. ~~A strike length of 1400 feet of postulated vein lies within the Wakebridge option.~~

<u>Prospects for the Area between Crich (Wakebridge) and Moletrap (Bullestree) Vein</u>

The Geological Survey indicate a major northwest fault along the southwest boundary of the Crich inlier and extending over two miles to the northwest towards Moletrap Mine. The fault is indicated as a dashed line and its exact position is therefore not known. Rigorous geological mapping is required all along its length.

If Ridgeway level (Whatstandwell or Wakebridge Sough) were to be cleared to Jingler Shaft the fault could be located accurately by the smash zone in the shales. A 1 in 6 southwest incline 900 ft. long would check the fault in the limestone above the Lower Lava at a point where it splits into three branches, within the Wakebridge Option. This should be driven from the foot of Jingler Shaft. (See the main Crich report for details).

To the southeast the fault has been traced by The Survey and approximately located. Its content could be checked at outcrop (in limestone (one wall)) by trenching, for about 1000 feet just northwest of Crich village, if planning permission could be obtained. To the southeast of here it lies under the village.

To the northwest the fault runs across the syncline between Crich and Cromford. This syncline is crossed by a little known anticline extending from Crich. The fault runs along the crest of this and effectively forms the southwest limb, by downthrowing 200 feet to the southwest. It is paralleled to the southwest by a similar fault for one mile, under the Derwent.

Between Lea Lead Works and Moletrap the fault or its projected line under landslips intersects three major east-west faults which can also be regarded as important prospects in the concealed limestone.

Between Wakebridge and Lea Lead Works the limestone on the northeast side of the fault lies at 300 feet A.O.D. according to the Geological Survey. Therefore at the Lead Works it cannot be far below the surface, although we believe it may be somewhat deeper than The Survey suggest. At some stage a strata borehole will be necessary here, followed up by inclined boreholes or an incline.

If parts or all of this system of faults were mineralized with fluorite in the limestone above the Lower Lava then a major deposit would be present. There is also good potential for Pb-Zn to greater depths than fluorite.

We strongly recommend that the relevant exploration rights or options or purchases are made soon. Once the Wakebridge and Moletrap work begins it will become very obvious where developments are heading and this will adversely affect your interests.

Sketch outline of proposed work

1) Surface rigorous geological mapping - trenching (especially near Crich village).

2) Clear Ridgeway level, locate fault in shales, and equip Jingler Shaft.

3) Drive incline from foot of Jingler Shaft into the fault zone and develop.

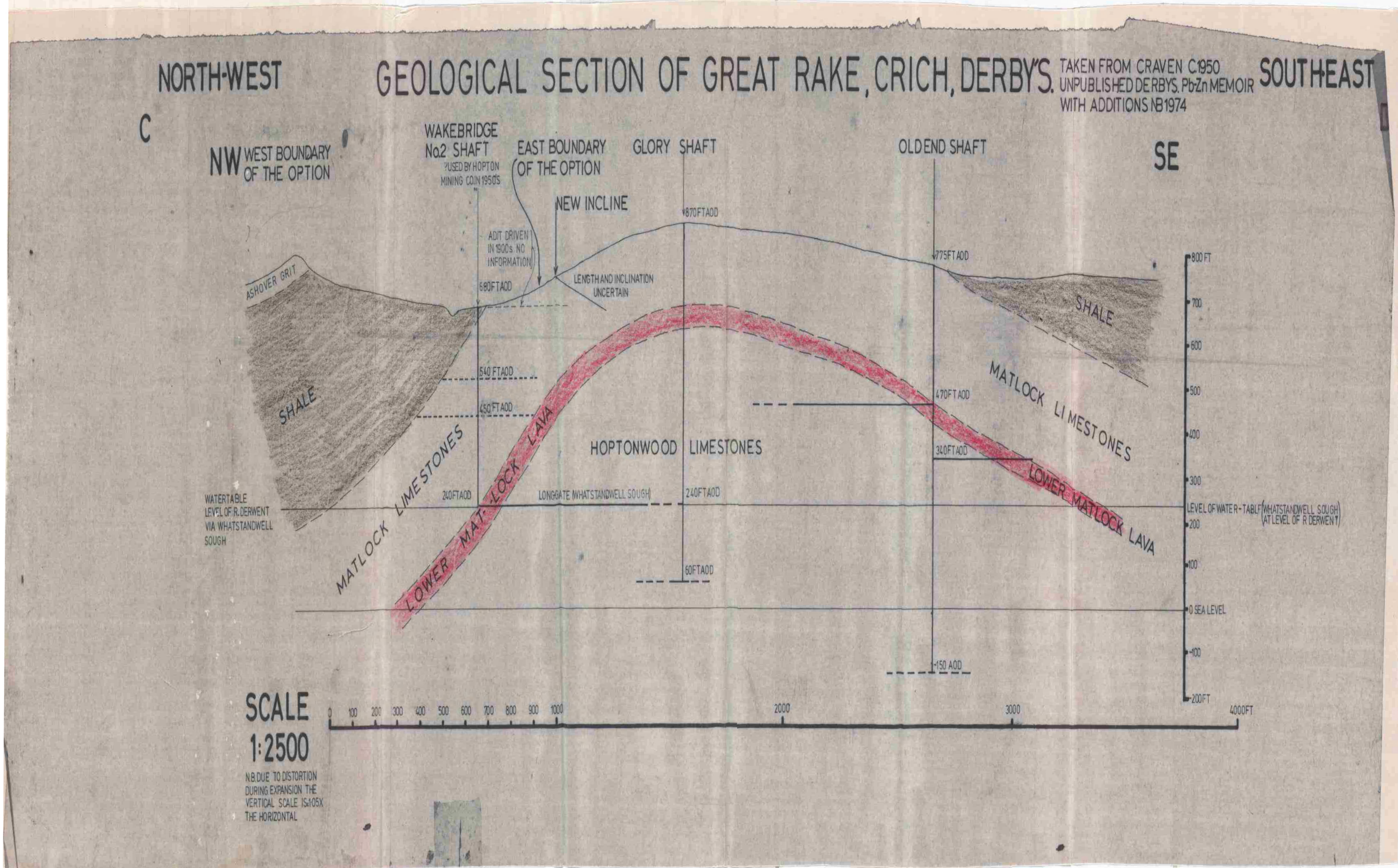
4) Strata boreholes at Lea Lead Works.

5) Inclines boreholes at Lea Lead Works.

6) ?Inclined drift into vein at Lea Lead Works.

These developments will of course be proceeding at the same time as work at and from Bullestree-Moletrap Vein.

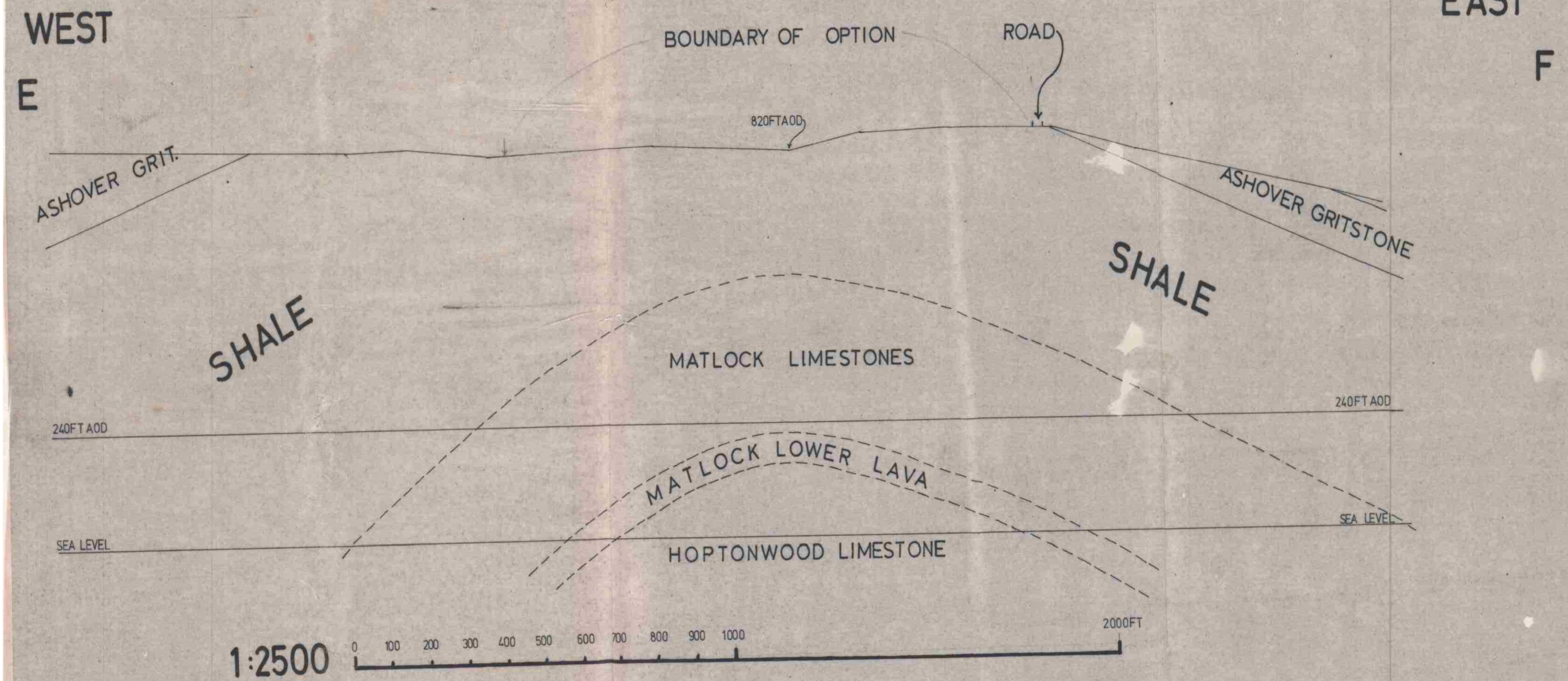
For a plan of the area refer to the Geological Survey's 6" sheet.



NORTH-WEST
GEOLOGICAL SECTION OF GREAT RAKE, CRICH, DERBY'S.
TAKEN FROM CRAVEN C1950 UNPUBLISHED DERBYS. PbZn MEMOIR WITH ADDITIONS NB 1974
SOUTHEAST
C
NW WEST BOUNDARY OF THE OPTION
WAKEBRIDGE No.2 SHAFT
?USED BY HOPTON MINING CO.IN 1950'S
EAST BOUNDARY OF THE OPTION
GLORY SHAFT
OLDEND SHAFT
SE
NEW INCLINE
ADIT DRIVEN IN 1900's. NO INFORMATION
LENGTH AND INCLINATION UNCERTAIN
ASHOVER GRIT
SHALE
680FT AOD
870FT AOD
775FT AOD
540 FT AOD
450 FT AOD
470FT AOD
340FT AOD
240FT AOD
240FT AOD
60FT AOD
-150 AOD
HOPTONWOOD LIMESTONES
MATLOCK LIMESTONES
LOWER MAT-LOCK LAVA
LOWER MATLOCK LAVA
LONGGATE WHATSTANDWELL SOUGH
WATERTABLE LEVEL OF R. DERWENT VIA WHATSTANDWELL SOUGH
LEVEL OF WATER-TABLE (WHATSTANDWELL SOUGH) (AT LEVEL OF R DERWENT)
800 FT
700
600
500
400
300
200
100
0 SEA LEVEL
-100
-200FT
SCALE 1:2500
0 100 200 300 400 500 600 700 800 900 1000 2000 3000 4000FT
N.B. DUE TO DISTORTION DURING EXPANSION THE VERTICAL SCALE IS 1.05X THE HORIZONTAL

FIG.2.

GEOLOGICAL SKETCH SECTION OF A POSSIBLE EAST-WEST VEIN IN THE NORTHERN PART OF THE WAKEBRIDGE OPTION



REPORT 14

REPORT ON MOGSHAWE PROSPECT. OCTOBER 1974

Summary

The known geological and mining information has been plotted on 1:2500 and 1:10560 plans and section (figs. 1, 2, 3).

The stratigraphic succession consists of dark cherty limestones up to 300 ft. thick underlain by two toadstones with intervening white limestone and unknown limestones below.

Generalised correlations of the strata have been made west to Magpie Mine and north to Dirtlow Vein, but these are very speculative. However, an anticlinal area in the centre of the lease is apparently indicated. To prove this and to locate the toadstones in the centre and west of the lease, three vertical strata boreholes are proposed and are located on the 1:2500 plan and section (figs. 1, 3).

In view of the zone of fracturing parallel to the main vein, the occurrence of toadstones with intervening white limestones in an anticline on the vein, and assuming the presence of fluorite at depth, it is possible that there is significant replacement of the wall rock between the toadstones and perhaps in the unknown strata below. The black limestones are not usually favourable to replacement.

Relevant details of Nash's descents of the Mogshawe Shafts are abstracted and his shaft names corrected. His assays are appended and show persistent presence of fluorite at depth, in workings or veins from one to thirteen feet wide. The assays vary from 2.9 - 64.7% CaF_2. Their variability suggests that they are from very small and perhaps unrepresentative samples. Most have a high silica content. Assay diagrams from deep workings at Wilkinson's Shaft made in the 1890s also suggest a narrow vein of fluorspar at depth.

A rough calculation suggests a tonnage of 540,000 tonnes of

fluorspar are from Green Cowden to Kirkdale if a vein 2 metres wide and 100 metres high is assumed. There is a ~~good~~ content of baryte increasing to the west and the anticlinal area may have sulphide potential below the toadstones. The calculation takes no account of possible replacements in the walls as these are speculative and unpredictable.

Possibilities east of Green Cowden and northwest to and including the east end of Dirtlow Vein are discussed. It is concluded that a thorough programme of trenching to rock and sampling is needed. This applies to the fractures parallel to Mogshawe Vein also. In general all the veins marked on the 1:10560 map (fig. 2) should be sampled and or trenched with a view to removing dumps or draglining.

We conclude that the vein will be dry above 500-600 ft. A.O.D. There is some vague evidence that a level was driven from Bakewell at 400 ft. A.O.D., to the east end of the vein, in the 1880s. Whether this was merely a proposal or was not completed is not known.

The prospect should be developed by an incline driven at 15-30° east in the wall rock off the vein. When Capt. Waterhouse drove the level from Kirkdale in the vein, it was so loose that it was abandoned! Levels off the incline should be designed to intersect, utilise and explore the "old man's" workings at depth.

There are two alternative sites for inclines. A preferred site is in the centre of the prospect, and the other is the Kirkdale Site in the west, for which planning permission already exists. In either case trenching will be necessary to locate the portal off the vein and determine the optimum alignment.

The relative merits and details of the two incline sites are discussed. It is concluded that, whilst the pre-existence of planning permission favours the Kirkdale site, the strategic position of the central site relative to the more promising east end of the vein and the anticline below the toadstones favours this latter alternative. This central site crossing the vein is indicated west of Middle Buddle Yard Shaft (fig. This anticline below the toadstones should be an exploration target. Because of the toadstones and uncertainties of their position, three strata boreholes between Middle Buddle Yard Shafts and Kirkdale will be needed - the locations are detailed below and on the plan.

The Vein

The vein is a zone of parallel smaller fractures and branch veins developed either side of the main vein. At the surface these are in thinly bedded dark cherty limestones but at depth below the toadstone (the upper one?) "white limestone" occurs. Noting the zone of fractures and assuming the presence of fluorite below the toadstone, these beds could be replaced. Therefore, these beds, especially in the anticline, increase the potential of the vein as an ore-body.

At the surface only the main vein has been worked in a series of 6-10 feet wide dragline opencuts. The parallel veins have never been examined. Turner has operated this, directed by Laportes, between Green Cowden Farm and Kirkdale. The content became more barytic to the west. Commercial dump fluorite has been worked almost to Magpie Mine. No information has been available on the assays of these opencast workings.

Underground Exploration

Doug Nash carried out exploration of the open shafts for Laportes.

a) Green Cowden Engine Shaft

Nash entered east-west levels at 165 ft. and found narrow stopes. The shaft was blocked by a collapse at the 200 ft. level, though it was originally 291 ft. deep. No assay of the vein was made.

b) Middle Buddle Yard Shaft

117 ft. deep to cross-cut south to the vein, which ends in a run-in stope. Run is 15.6% CaF_2 (see assays attached).

178 ft. deep to cross-cut south to the vein, which had been stoped

is situated in a hollow surrounded by trees. It is altogether less conspicuous than the Kirkdale site. Access is downhill onto the Bakewell-Monyash road. The Peak Planning Board has a policy being gradually introduced to divert traffic from the Kirkdale Road. It is therefore concluded that there will be little problem in "trading" planning permission for the conspicuous Kirkdale site for the "hidden" central site.

A summary of the suggested exploration programme is at the end of the report.

Report on Mogshawe Prospect

General

Both the geology of and the extent of workings on Mogshawe vein are poorly known. The available information is compiled on figures 1 and 3 (plan and section).

The Succession

The east end of the section is based on a reliable 1840s section, showing dark cherty limestones over 300 ft. thick, underlain by two toadstones with white limestone in between them. This compares favourably with the Dirtlow succession 2500 ft. to the north, which shows a third, higher, thinner toadstone in the middle of the black limestones. This is perhaps equivalent to "shale" bands recorded in these beds by Nash while exploring Mogshawe Shafts.

The toadstone recorded at the foot (384 ft.) of Wilkinson's Shaft is perhaps equivalent to one of the toadstones at the east end of the rake. Toadstone is also recorded below True Blue Shaft west of the Kirkdale Road.

Correlation and Structure

The dashed correlation line on fig. 3 is very speculative and only illustrates the general form of the structure. An anticlinal feature

1-13 ft. wide. Samples in the stope assayed 55% CaF_2.

Blocked at 235 ft. 6 inches on top of the higher toadstone. The shaft may well have been 416 ft. deep if a projected scheme shown on the 1840 section was carried out.

c) Waterhouse's Shaft

70 ft. deep to cross-cut north to vein. The latter is timbered, 11 ft. wide.

d) West Shaft

150 ft. southeast of Kirkdale incline. A very loose shaft, south of the main vein.

At 100 ft. level into flats - unstable, assay 84% $BaSO_4$, 10.9% CaF_2.

At 125 ft. narrow 18 inch - 3 ft. wide vein, stoped.

At 150 ft. cross-cut north to main vein, not completed, shows vein 6-9 inches wide fluorite in 3 ft. vein calcite, assaying 61.1% CaF_2.

N.B. Doug Nash miscorrelated the open shafts with the 1840s section in his report.

Samples taken by Doug Nash on Mogshawe Rake for Laportes

Name on Plan (...)	Description		$CaCO_3$	SiO_2	$BaSO_4$	Pb	CaF_2
Green Cowden Engine Shaft			NO VEIN SAMPLE TAKEN				
West Shaft	150 feet Southeast	100 ft. level	1.96	1.02	84.08	0.17	10.90
	Kirkdale Incline	150 ft. level	15.79	2.22	19.33	0.30	61.10
Middle Buddle Yard Shaft	Random Samples		10.20	63.60	0.48	1.30	21.80
			12.06	29.47	0.77	7.49	54.00
			4.84	6.20	0.10	23.41	64.70
	Surface		76.61	16.72	0.78	0.0	2.90
	113 foot level		45.35	27.35	4.25	0.061	15.60
	178 foot level		29.27	11.62	0.51	0.0	55.50

e) Wilkinson's Shaft

On the 384 ft. level of Wilkinson's Shaft scale drawings for assay purposes in the 1890s show a vein of fluorspar only 9-12 inches wide between 572 and 605 ft. east. East of this to 750 ft. east 7 pencil sections suggest a somewhat wider vein but these are too indistinct to determine the contents

General Impression of vein and tonnages

On the whole it appears that the vein is not so strong at depth; however this may be a distorted impression as the access points are limited. It is not fully clear whether all the workings entered are on the main vein or are parallel fractures. All the workings described above are in the black limestones which are less favourable to wide vein development.

If a 2 metre vein is assumed, with 100 metre high stopes, for a length of 850 metres, from Kirkdale to Green Cowden then a tonnage of 540,000 tons fluorite ore could be expected. This is a conservative estimate and takes no account of possible replacements in the walls, nor of the substantial baryte content. The amount of open stoped out ground cannot be estimated.

East of Green Cowden Farm

East of the Bakewell-Monyash road in Moor Edge Plantation (to a point 600 ft. southeast of the new water-tank) are a series of old workings and recent trial pits. These show much silica-rock and fluorite, and indicate a continuation of, or a significant branch from Mogshawe Vein. Other possible continuations east of the Green Cowden Engine Shaft are indicated as dashed and dotted lines on the 1:10560 plan (2). The postulated intersections of these with northwest faults and the Dirtlow Vein are discussed below.

Water

The water table in the vein is controlled by Magpie Sough, to the west of the property. There are alleged to be two other levels, the Haredale level draining north to Ashford and a sough eastwards to Bakewell, but very little is known about these, and even their existence is uncertain. A trickle of water emerges from one at the possible outfall near Ashford. The toadstones probably restrict the draining effects of the Wye at Bakewell. As far as we know all the old workings indicated on the section (fig. 3) were dry or drained into natural cave systems (e.g. on the "fault east of Green Cowden Engine Shaft). We therefore expect no problems with water until about 500 ft. A.O.D. However, the water may be higher say 600 ft. A.O.D. at the Green Cowden end of the vein.

Proposed Method of Exploration

Two possible sites for inclines are shown. One is at the west end of the site in Kirkdale. The other lies in the centre of the site. The principal problem of inclining will be rock stability. It is strongly advised that the inclines be driven in wall rock as the vein contents and walls are very deeply weathered and weak. Moreover, the "old man's" workings are unpredictable. Waterhouse's ring-arched level failed because they could not support the roof. Moreover any drives in toadstone will be difficult unless they are away from the rotted and faulted zone near the vein.

Kirkdale Incline

We have not located this in plan, only in section: It will be necessary to carry out some trial pits in order to site it a little way from the vein. It is suggested that the incline be at 15-30° to the east. This should intersect the south 'hading' Wilkinson's Shaft workings as shown. These could be utilized if open. Wilkinson's Shaft was filled due to instability in 1969-70 on the orders of the Mines Inspectorate. The shaft top is in the deep opencast opposite the ruins of the engine house (which contains Waterhouse's 1950s shaft). It is probably no longer of any value unless the top can be located and rebuilt and the fill drawn from below. The incline could be expected to intersect toadstone at the 384 ft. level of Wilkinson's Shaft and it would be logical to drive out east and west a little above this. An extension of the incline could then await the results of inclined diamond drilling through the toadstone from these exploratory levels. This incline siting will require a very long drive and haulage to explore the east end of the vein (over 5000 ft.). This might lead to premature abandonment if the results at this west end of the vein were disappointing.

Central Incline Site (Alternative)

This could be also inclined at 15-30° E. Again the site is located on the section but not on the plan. Pitting and trenching is recommended so that the alignment can be sited a little way from the vein(s) to avoid unstable rock conditions. This incline site would allow the development of the mine from a point at the centre of the lease and closer to the more promising eastern end. It also allows a direct approach into the postulated anticlinal zone below the toadstones. If the Engine Shaft at the east end of the property were cleaned and stabilized (3600 cu. ft. material, 115 ft. deep rubble) it might be possible to rehabilitate the west drive from the Old Shaft foot (290 ft. deep) and extend and link this to the incline.

Prospects East of Green Cowden Farm

There is no information on the vein at depth east of the Engine Shaft and our knowledge of the strata especially the toadstones is shaky. This ground is structurally complicated - it will be seen from the 1:10560 plan (3) that three fault trends intersect here. If the main Mogshawe Vein (wherever it trends!) were to bear significant fluorite for 3000 ft.

east of Green Cowden Engine Shaft, then it could be that the northwest fault zone and the east end of Dirtlow Vein also carry fluorite.

Planning Permission

Although there is long standing planning permission for the Kirkdale Incline it is felt that this should be exchanged for the Central (Alternative) Site which is more hidden in a hollow and surrounded by trees and is of greater strategic value for exploration. It also allows downhill access onto a better road. The Peak Park Planning Board has a policy for diverting lorry traffic from the Kirkdale road due to be phased in over the next few years.

Summary of Exploration Recommendations

Method

1. The prospect should be explored by means of an incline driven dipping at 15-30° east, either from the Kirkdale Site or preferably from the Central (Alternative) Site (see figs. 1, 3).

2. The incline should be driven in the wall rock for stability especially as it passes through toadstone.

3. For the Kirkdale Site - the incline should be driven to intersect the Wilkinson's Shaft workings on the 384 ft. level which level should be reopened and extended east and west on the toadstone involving a long drive to the more promising east end of the property.

4. For the Central Site - the incline should be carried down through the toadstone. It would be useful to drive a level west to the Wilkinson 384 ft. level and a lower one east to intersect the deep "old man's" level driven west from Green Cowden Engine Shaft. This shaft should be cleared and the level examined before or during inclining.

5. Strata Boreholes Preceding the Inclines - it is recommended that three cored boreholes for strata (perhaps steeply inclined to intersect

the vein well below the toadstones) should be sunk to depths of about 700 ft. These are located on the plan. They are designed to locate the position of the toadstones so that both the inclines and projected levels can be suitably aligned. In general it will be better to prove the vein below the toadstones and "old man" by internal cored boreholes from the levels at a later stage.

6. Trenching and Sampling

All the veins marked on the plans should be sampled with a view to either removing the dumps or small scale dragline work. The following are the main points:

a) Trenching to rock at regular intervals across Mogshawe Vein will help locate the incline portals and check the unworked parallel adjacent veins.

b) Trenching to rock on the Dirtlow Vein at regular intervals for 950 ft. east of Dirtlow Farm. This section of the vein has never been examined for fluorite.

c) The Mogshawe veins east of Green Cowden Farm should be trenched to rock to locate any unobvious continuations.

d) The Mogshawe(?) vein in Moor Edge Plantation east of the Bakewell Monyash road should be trenched to rock to examine the width and content.

7. People who have worked in the mines in the 1950s

a) Frank Barton - miner, drove Waterhouse's level in the 1950s, works in Long Rake mine. He has worked self-employed throughout the orefield.

b) Don Birds (Senior) - miner, worked in shafts on Mogshawe in the 1950s.

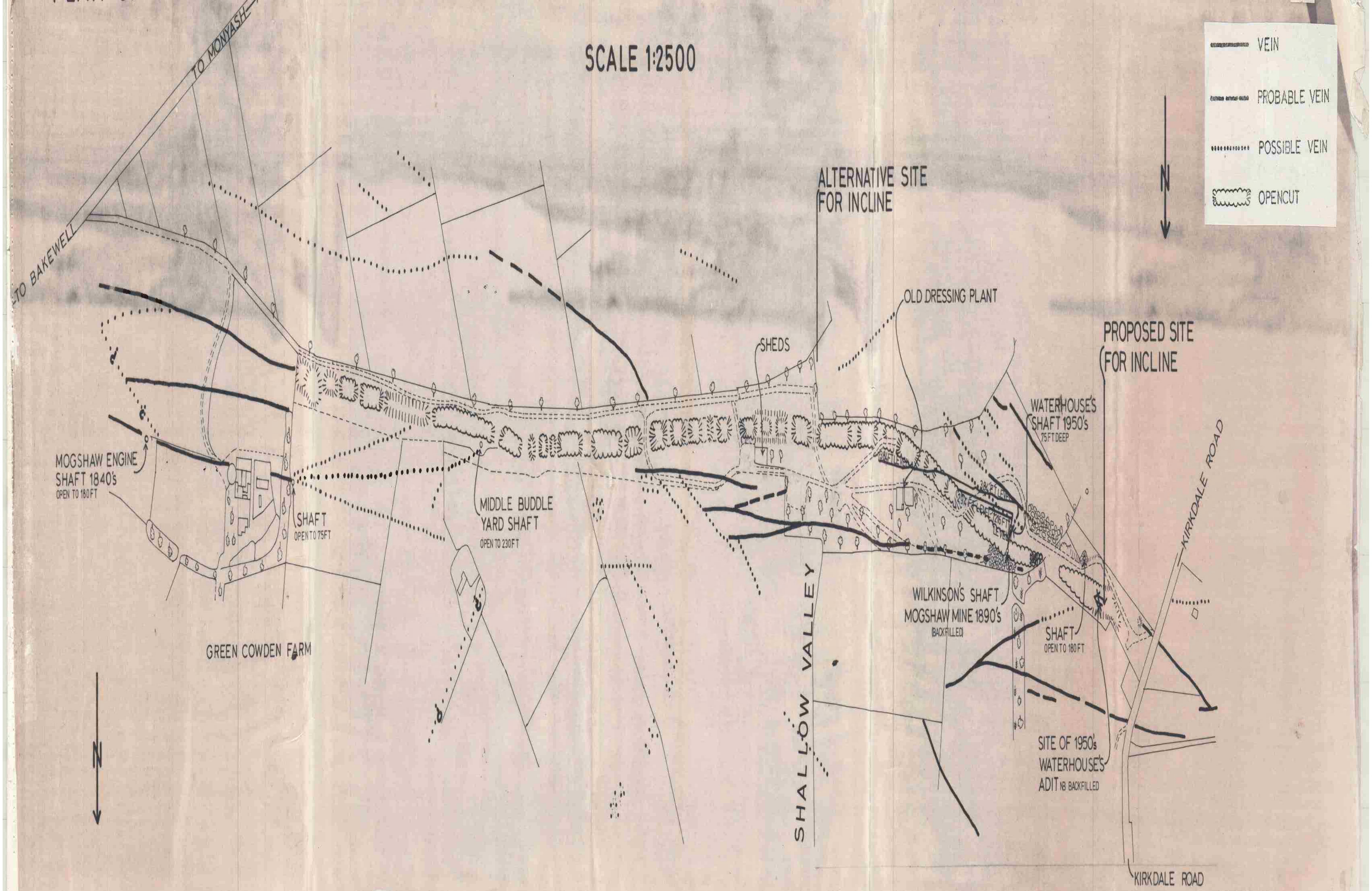
c) Ken Steeple - miner, Youlgrave, worked in rises above east end of the Magpie 560 ft. level in the 1950s.

These men may have much useful practical information on the workings and veins and should be interviewed.

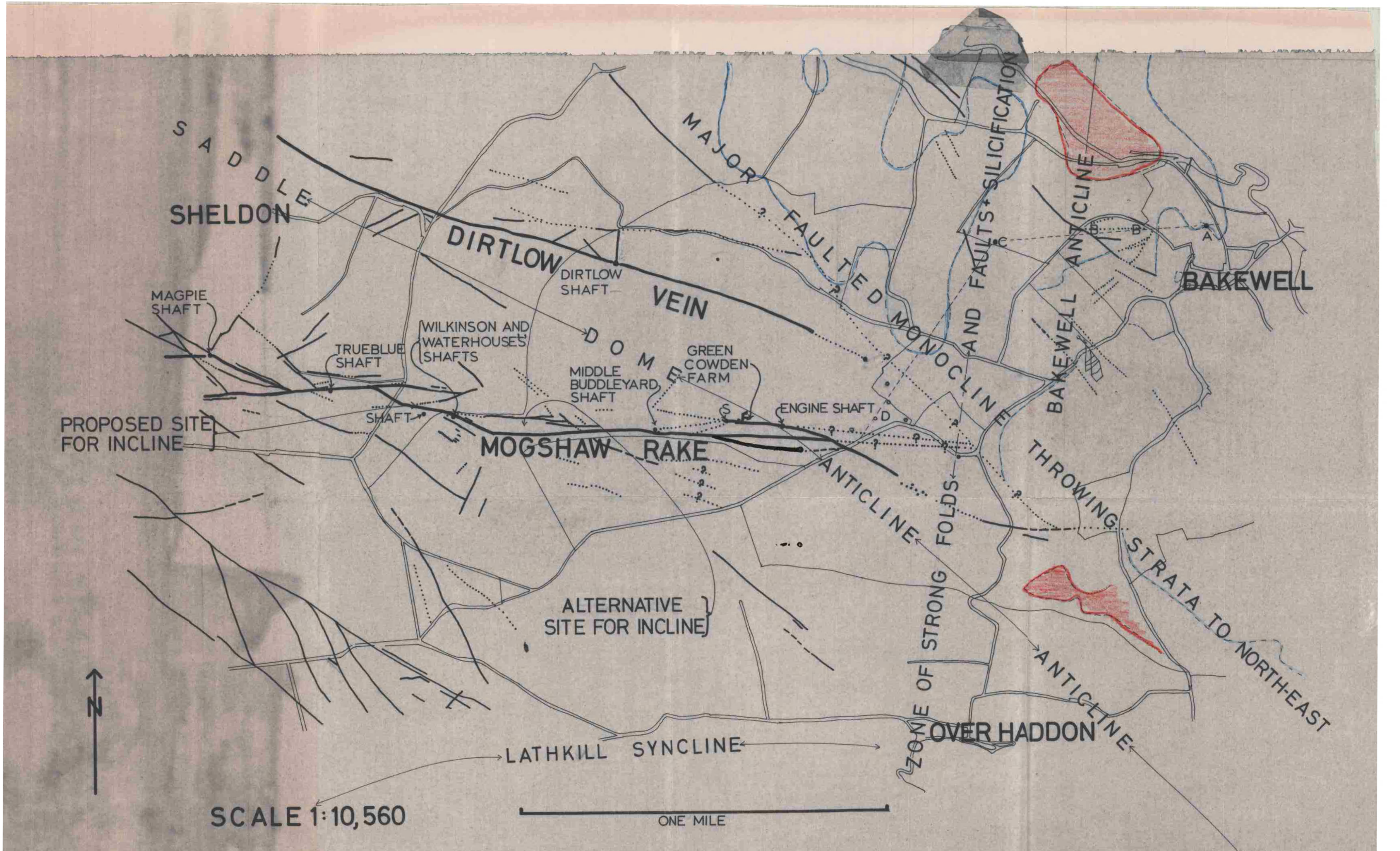
PLAN OF MOGSHAW VEIN FROM KIRKDALE TO GREEN COWDEN FARM SHOWING SITES FOR PROPOSED INCLINE

FIG. 1.

SCALE 1:2500

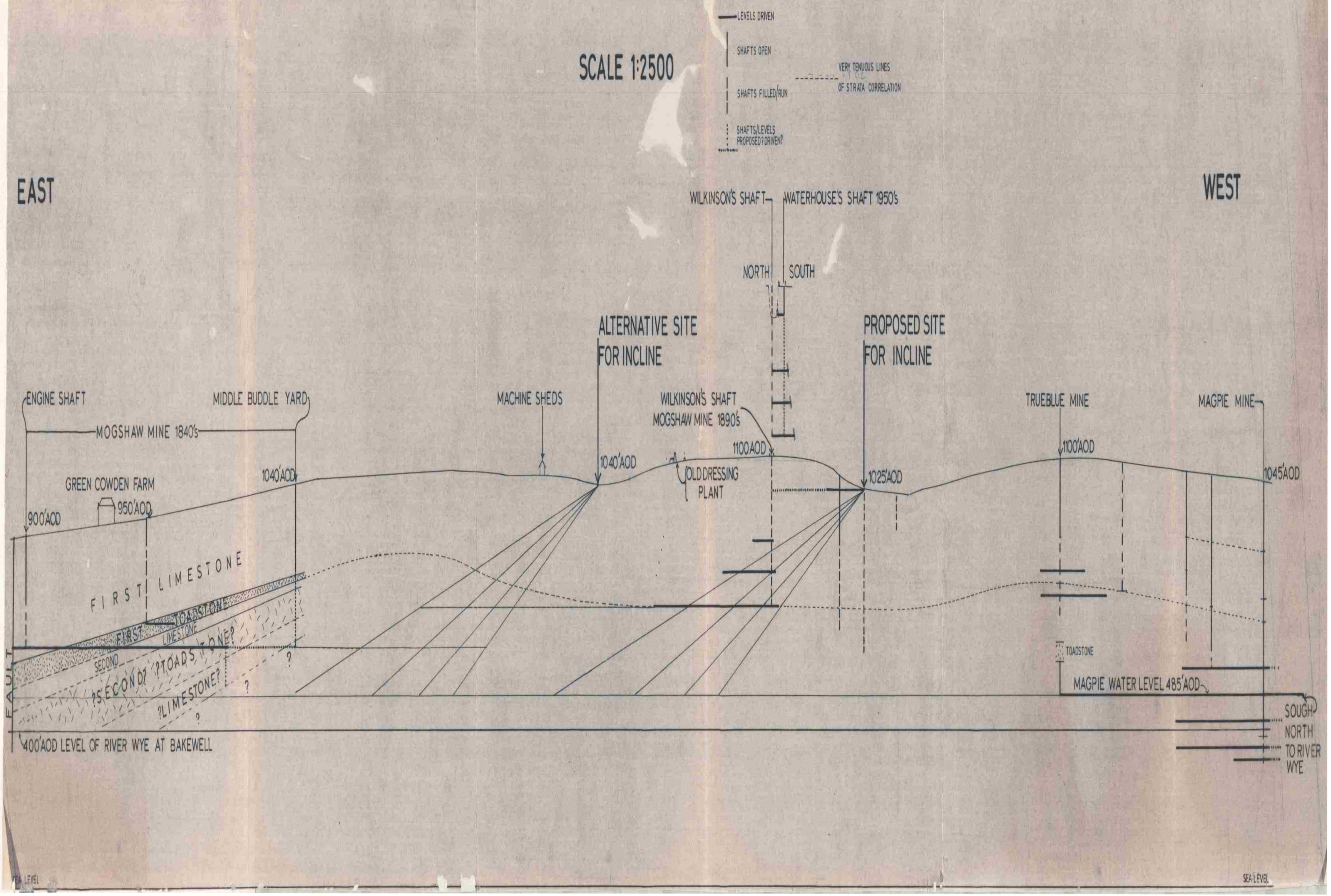


NB 1.10.74



GEOLOGICAL SKETCH OF THE MOGSHAW PROSPECT

SECTION ALONG THE MOGSHAW VEIN FROM MAGPIE SHAFT TO GREEN COWDEN FARM SHOWING GEOLOGY AND KNOWN OLD WORKINGS



REPORT 15

THE BALL EYE QUARRY SECTION OF THE BONSALL FAULT (BONSALL TO CROMFORD).

DECEMBER, 1975

The Bonsall Fault trends northwest to southeast in this section. It is a zone of faults with a net effect of throwing down strata to the southwest by several hundred feet, at least in the section northwest of Ball Eye Quarry (see Fig.15/1 Sections A.A, B.B). Southeast of the quarry the structure becomes more complex along Harp Edge, an intricate zone of faulting between the southernmost Bonsall Fault and the east-west Moletrap Vein Fault (see Sections D.D to F.F). Here the northern components of the Bonsall Fault swing to east-west to be lost in the shales east of the Derwent Valley. The southern component proceeds through Cromford to the south-east, dying out into the shales (see Section G.G).

An initial appraisal of the fault zone from mapping suggests a complex of normal faults with intervening horsts and grabens of dolomitic limestone and toadstone. However, at Ball Eye Quarry a different interpretation is required. In the quarry a full sequence of the Matlock limestones from the Lower Lava upwards is exposed. This is overlain by thin bedded dark Cawdor Limestones about 100 feet thick, which form the top of the limestone succession. These are, however overlain by 'mounds' (reefs?) of dolomite in turn overlain by toadstone. This toadstone in turn is overlain by bedded dolomite and toadstone appears to fill in channels between the 'reef' masses.

The interpretation of this 'anomalous succession' is difficult partly because the critical exposures are inaccessible in the quarry face. It appears, however, that there is a thrust fault bringing the Matlock Upper Lava over the top of the Cawdor beds. The 'reef masses' appear also to have moved on a clay lubrication horizon at their base. In the light of these exposures faulted outcrops to the northwest may also be interpreted as thrusted (see Sections A.A, B.B).

The presence of a thrust in this section gives rise to the question of whether the whole of the Bonsall Fault is a thrust structure in this area. Near Ball Eye Quarry old mine workings can be explored northeastwards beyond the position of the normal faults at the surface without encountering more than a few fractures. A deep cored borehole almost at the northeastern edge of the fault zone near the quarry passed down through bedded dolomite and toadstone for 139 feet before reaching a normal succession of Cawdor Limestones on Matlock Beds. These facts suggest that the main structure of the fault here may be a thrust, although only the definitely thrusted sections are shown as such on the sections (Fig. 15/1). The principal mineralised veins here are all normal faults, and if they are floored by a thrust there may be an offset continuation below the thrust plane as yet undiscovered.

The sections are located on Fig. 9/4.

GEOLOGICAL SECTIONS OF THE BONSALL FAULT BETWEEN BONSALL AND CROMFORD DERBYS.

BASE LINE 200FT A.O.D. SCALE 500 FEET

SEE ACCOMPANYING MAP FOR LOCATIONS

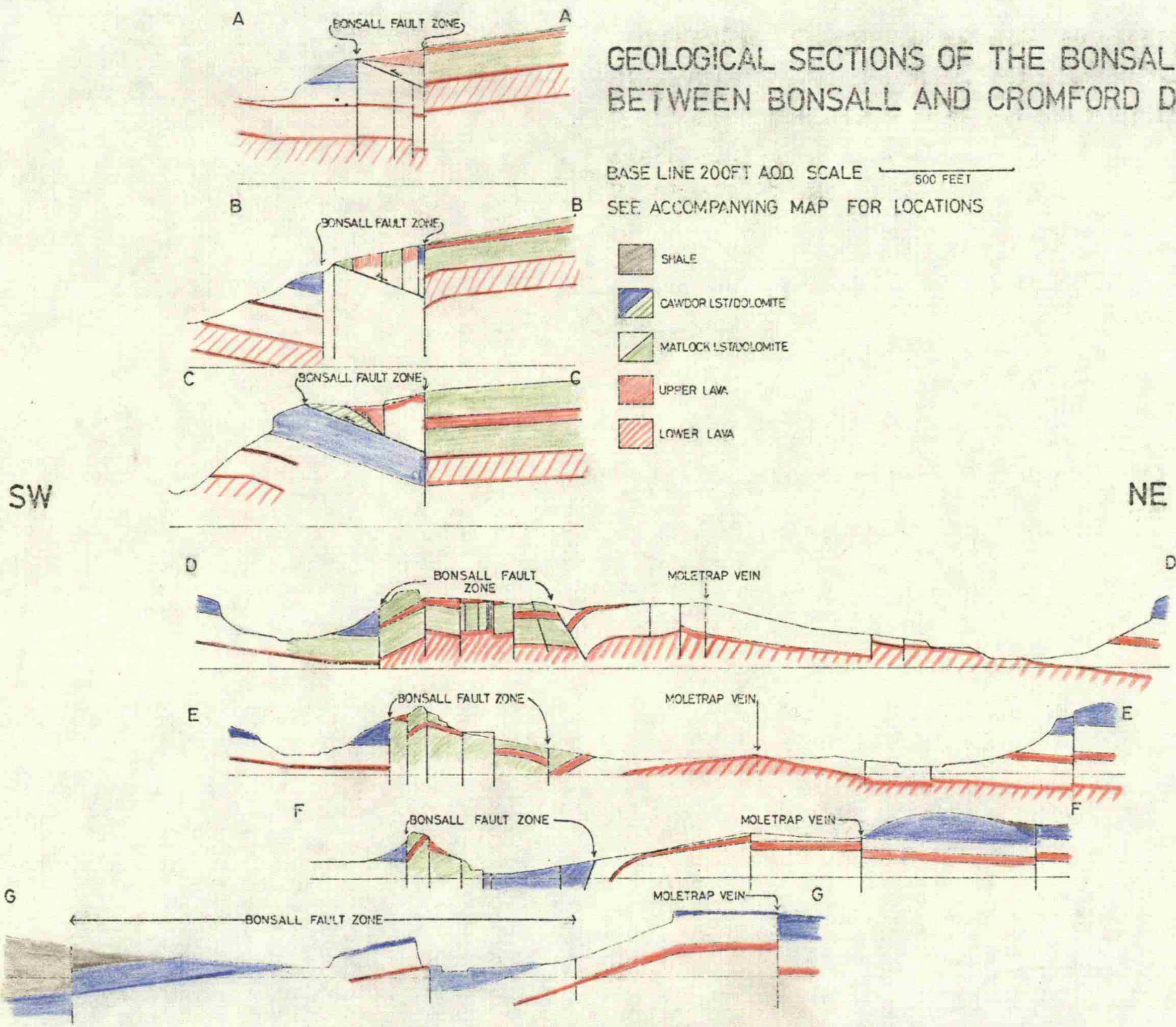


FIG.1.

GENERAL CONCLUSIONS ON MINING PROSPECTS

Overall Conclusions on Fluorite Distribution in Relation to Economic Mining

The principal potential fluorspar deposits for underground mining still unproven lie on the eastern edge of the orefield, and occur in veins associated with anticlinal or monoclinal fold structures. The main factors affecting their suitability for mining other than width, grade, presence of toadstones and water problems, are the vertical extent of fluorite mineralisation down the strata and the lateral extent of fluorite mineralisation down dip under the shales. Both these factors are 'unknowns'. On the one hand the occurrence of fluorite below toadstones in the Ladywash and Sallet Hole Mines suggests that fluorite mineralisation can persist to considerable depths, but on the other hand the finding by the 'old man' that fluorite gave way to calcite below toadstone at Crich and gave way down dip to calcite under the shales at Gregory Vein, Ashover, suggests limited vertical and lateral persistance. This is supported by the situation proved in the Riber Mine in the 1950's, in Millclose at Darley Dale in the 1930's and by drilling at Low Mine at Bonsall in 1972. The proving of the vertical extent and lateral persistance under the shales of fluorite in the deposits noted below, should be the principal factors influencing the design of an exploration programme.

The Potential for a New Mining Operation in the South Pennine Orefield

The Mogshawe Vein near Bakewell, the Long Rake near Youlgreave (including its possible eastern extensions to the north of Ashover) the Coast Rake near Winster, the Great Rake at Matlock, the Moletrap Vein at Cromford (including the Crich area as a whole) are the principal potential locations for new fluorite mining ventures. They have possible reserves of 3 million metric tons (not including some probable extensions, and not including the extensions bracketed above). These alone are sufficient to supply a 1000 ton/day flotation plant for 8 years. It would appear therefore that a thorough exploration programme to prove the full extent and grade of the reserves of these deposits (other than Coast Rake which has already been proved) is justified.

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