THE DISTRIBUTION OF BARITE IN PERMO-TRIASSIC SANDSTONES AT BRAMCOTE, STAPLEFORD, TROWELL AND SANDIACRE, NOTTINGHAMSHIRE

by

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Summary

The geographical and stratigraphical distribution of barite, in an area to the west of Nottingham, is described. The association of the mineralisation with faulting is considered significant. Other locally occurring minerals are mentioned and it is concluded that there is a restricted region of intense barite mineralisation in a severely faulted area. The origin of the barite is still in doubt.

Introduction

The knowledge that barite is to be found in the sandstones of Bramcote and Stapleford Hills (SK 500387) dates from papers by Clowes (1885 - 1893). Most references, for example, Blake (1892), Gibson (1908), Lamplugh (1910), Edwards (1951) and King (1966), are merely records of its occurrence and give little evidence for its geographical and stratigraphical distribution. The discovery of barite in sandstones excavated from a trench for a mains water pipe, near Swancar Farm, Trowell, led to a review of the literature and the realisation that there was little detailed information published. Using the Bramcote and Stapleford Hills area as a centre, a wide search was undertaken of all exposures available at the time, to determine the geographical and stratigraphical distribution of the mineral. At the same time, other geological evidence was assembled, much of it already known, with the hope that something new would turn up to shed light on the origin of the barite in this area. The work was stimulated by the account of the mineralised Triassic sandstones of Alderley Edge, Cheshire, by Warrington (1965).

Detection of barite

This section is included mainly to assist Members of the Society to look at Permo-Triassic sandstones and observe even small amounts of barite in the rocks and perhaps record the data for a wider survey of the distribution of this mineral.

Sandstones containing over 25% barite are easily recognised in hand specimen (Plate 13 fig. 2), tabular crystals up to 20 mm. in length standing out on the weathered surfaces. On freshly broken surfaces, there is a characteristic reflection from the crystal and cleavage faces, varying in intensity on rotation of the specimen, the well known phenomenon of 'lustre-mottling'. Most of the crystals are pink, but some are buff or white. The specific gravity of the sandstone is high, between 3.2 and 3.7, compared with 2.6 for a sandstone without barite. The mineral is almost insoluble in normal ground water and the soils derived from these sandstones have a characteristic rubbly or nodular appearance.

Mercian Geol. Vol. 4, 1973, pp. 171-177

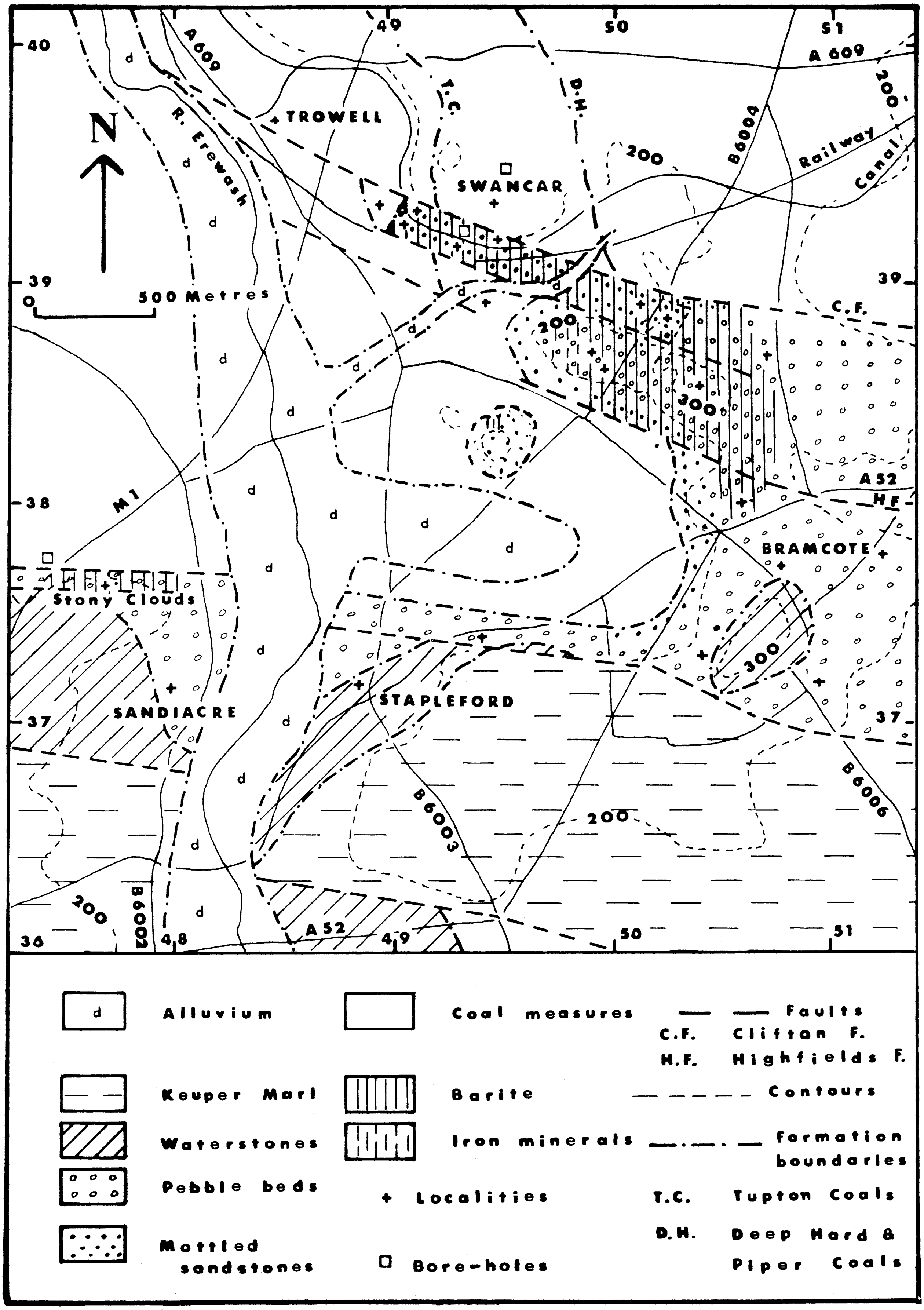

Figure 1. Geological map of the Bramcote, Stapleford, Trowell and Sandiacre area, to show the distribution of barite in Permo-Triassic sandstones.

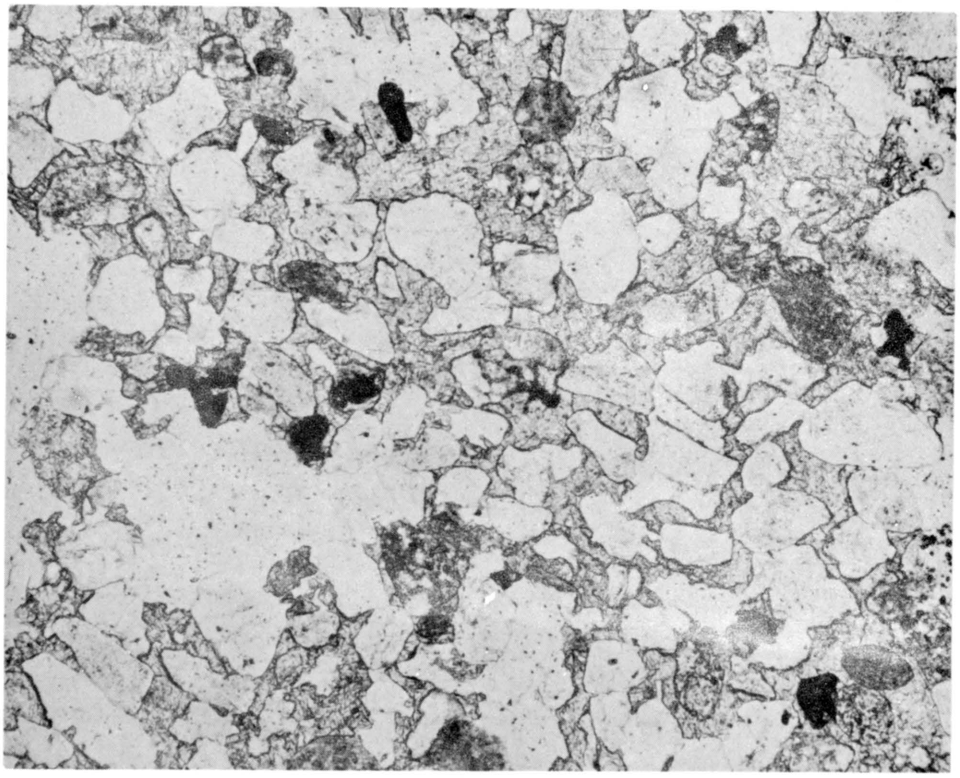

Figure 1 Photomicrograph of thin section of sandstone cemented with barite. Note the sharp crystal boundaries and the barite which appears grey.

Figure 2 Block of sandstone with 30% barite, developed in the rock as large tabular crystals, standing out on the weathered surface.

The mineral is less obvious in sandstones with between 25 and 10% barite. When the bedding is well developed, the sandstones are flaggy. Barite fills the pore spaces and encloses quartz grains in large irregular crystals. The sandstone is well cemented compared with rocks without barite and possess a characteristic pinkish colour. In this section (Plate 13 fig. 1 and cover of Mercian Geologist Vol. 1, No.4), the well marked boundaries of the crystals are due to the high refractive index of barite compared with quartz, whereas the polorisation colours (birefrigence) are about the same as quartz. The specific gravity of the rock is now between 3.0 and 3.2 .

A barite percentage, less than 10%, was more difficult to determine. Initially specimens were analysed for barium using the Philips X-Ray Fluorescence Spectrometer at the Department of Geology, University of Nottingham. For speed of operation, known high and low percentage barite sandstones were used as standards. In addition specific gravity determinations were made for many of them, although values below 2.8 may not be of significance, since iron oxide coating the sand grains may produce a similar result. Thin sections were made of a number doubtful samples. Eventually, with experience, it was possible to detect in hand specimen as little as 5% barite.

It is realised that strontium sulphate, celestine, has similar density and optical properties to barite. Investigations are progressing to determine the possible extent of celestine in the sandstones or the substitution of strontium for barium in the barite.

The distribution of barite

Geographical distribution

The areal extent of barite (text-fig.1) lies mainly between the Clifton and Highfields Faults, but there are small outcrops to the south of the Highfields Fault at Crow Hill (SK 505380) and a small outlier (SK 496384) 560 metres south-west of Stapleford Hill, where a small hill is being developed as the Albany Housing Estate. In the first case, weathered sandstones contain abundant barite material and in the second, flaggy sandstones in house foundation trenches in the northern part of the outlier, only, contained a small amount of barite. In the main area of Bramcote and Stapleford Hills, sandstones rich in barite form the higher ground, the best samples being obtained above the British Industrial Sands' Quarry, Bramcote (SK 504387) and close to the summit of Bramcote Hills. Two small abandoned quarries (SK 501385) on the west flank of Bramcote Hills, about midway in the Pebble Beds sequence contain sandstones with large barite crystals. These quarries are at about the same horizon as those forming the Hemlock Stone, which also has layers of sandstone well cemented with barite.

South of Derby Road (A.52), sandstones of the same type, outcrop at Bramcote Village (SK 509372), Bluebell Hill (SK 505375) and in Stapleford at quarries below Bob's Rock (SK 492373), but barite has not been found. These exposures are adjacent to the Beeston Fault, a major dislocation comparable with the Clifton and Highfields Faults to the north. The sandstones are not mineralised in the vicinity of the Beeston Fault and no barite was observed in a temporary exposure of the fault, south of Bramcote Village. Many other exposures have been examined, including quarries and roadside exposures in the vicinity of Sandiacre Church (SK 480372) and road cuttings at Cow Lane (SK 512378) and Moor Lane (SK 508388), both near Bramcote. In none of these localities do the sandstones contain any significant amounts of barite. A record of this mineral at Bramcote Hall, (Gibson, 1908), has not been confirmed. It is possible that there may be confusion here with the new Hall built on the south side of Bramcote Hills, where barite is seen, and the old Hall in the village. The same author recorded barite as far east as Wollaton Vale, but the present work records the distribution only as far as Moor Lane (text-fig. 1).

On the west side of the Erewash Valley, sandstones containing up to 10% barite have been found at Stony Clouds (SK 477377). The Pebble Beds at this locality dip steeply to the south and there is extensive faulting (Dunham 1969). A northern boundary fault is similar in effect to the

Clifton Fault downthrowing to the south, against Lower Coal Measures to the north. The southern boundary fault is a small structure, separating the Pebble Beds from the 'Keuper Basement Beds' (Taylor 1965) and also downthrowing to the south. A number of cross-faults divide the sandstones into small outcrops. There appears to be no continuity of outcrop across the Erewash Valley and the structures may be more complex than is shown in text-fig.1.

Stratigraphical distribution

Of all the Coal Measures rocks in the vicinity, coarse grained sandstones were thought most likely to contain barite. The nearest exposures of such sandstones are the north-east face of Swancar Quarry (SK 491393) and the old quarry (SK 489393), immediately to the west near Swansea Cottages. The first is a coarse sandstone below the Tupton Sandstone, whilst the second is probably the Tupton Sandstone itself (Taylor & Houldsworth, 1972 fig.1). Acting on information received from Mr. R. Moss, the remaining sections of a bore-hole core drilled in 1934 were discovered under a hedgerow at Swancar Farm. The bore-hole passed through the Tupton Sandstone north of the Clifton Fault. None of these samples, from close to the Clifton Fault, contained barite, nor did other samples from close to the southern boundary fault or those from further afield, as far north as the type locality of the sandstone near Chesterfield, Derbyshire. The only Coal Measures sandstones that contained a small number of barite crystals occurred immediately below the unconformity in Swancar Quarry. Barite was located on joint surfaces on the north-east face of this quarry at a point closest to the Clifton Fault.

Barite is found in the Permo-Triassic sandstones immediately above the unconformity. The Mottled Sandstones are mainly fine-grained with thin marl seams. The barite occurs as a cement in the sandy layers, in thin seams up to 20 mm. thick and is best developed in the coarser beds. The mineral can be found in the Mottled Sandstones throughout the area between the Clifton and Highfields Faults wherever the beds are exposed, but the best locality is at the north end of the Bramcote Sand Quarry. The rocks, here, are close to the Clifton Fault, although it is not exposed in the quarry, and are much less friable than is usual for the Mottled Sandstone Formation. Elsewhere, the mineral occurs impersistently, binding the grains together and imparting a pinkish tinge to the rock at maximum concentration.

As the grain size of the sandstones increases, the Mottled Sandstones pass upwards into the Pebble Beds. Large barite crystals are developed in the coarser beds. Pebble Beds with well developed barite crystals occur midway in the sequence, at the Hemlock Stone and two small quarries on the west side of Bramcote Hills; higher in the sequence at the top of the Bramcote Sand Quarry. The top bed of the Pebble Beds contains the largest number and biggest pebbles and has been shown by Swinnerton (1948) and others, to contain a calcite cement in many places. Barites occurs immediately below this bed. The Hemlock Stone illustrates the irregular vertical distribution of the barite which accounts for the stark weathered appearance of this isolated stack (cover of this issue) and of quarry faces which have been left to weather for a number of years. Wind, rain and frost action, remove the finer, softer, uncemented beds, leaving the well cemented layers projecting as ledges (Taylor & Houldsworth, 1972 Plate 13 fig. 2).

It is concluded that porosity of the sandstones, increasing with grain size, is a controlling factor in the occurrence and growth of barite crystals.

Barite and sedimentation

As seen at the present time, the Mottled Sandstones and Pebble Beds are essentially arenaceous deposits, with thin beds of marl. Swinnerton (1948) records a marl bed near Blidworth, Nottinghamshire, over 1 metre thick, but this thickness is exceptional. In our area, marl occurs in the Mottled Sandstones in thin seams only a few mm. thick, well displayed on the north side of Stapleford Hill, and in the Pebble Beds, mainly as marl fragments. These fragments are all that remain of, formerly, more extensive layers, which may have included evaporite minerals, that were eroded with deposition of succeeding sandstone layers. Most of the sandstones are cross-bedded (see cover of this issue) but more regularly bedded sandstones are present in the Mottled Sandstones. No detritial grains of barite have been seen and it is concluded that the mineral developed within the sandstones after deposition. This results in the flaggy sandstones characteristic of parts of the Mottled Sandstones and the more massive beds within the Pebble Beds Formation. Barite fills the available pore spaces enclosing quartz grains and in the coarser sandstone with maximum porosity tabular crystals are formed. A fibrous form of barite, from a locality to the south of Swancar Farm, (Taylor and Houldsworth 1972) was interbedded with marl layers. Infilled dessication cracks in the marl underlying the barite were preserved. It is possible that his form of barite is a pseudomorph after gypsum.

Barite and structure

The maximum development of the barite mineralisation is restricted to the area between the Clifton and Highfields Faults in the Stapleford and Bramcote Hills area (text-fig. 1). Both the faults can be traced for a considerable distance between the Trent and Erewash River Valleys, yet the barite mineralisation is largely restricted to the area under consideration. The Clifton Fault hades to the south, whilst the hade of the Highfields Fault is to the north. It is possible that at depth the two faults meet and become a single fracture. There are a number of subsidiary faults in the same area, some of which have been described by Taylor and Houldsworth (1972). Stapleford Hill and Bramcote Hills are separated by an erosion hollow and similar topographical features occur on Bramcote Hill, all of which may be controlled by faults. Although some of the mineralisation can be found to the south of the Highfields Fault, it very quickly dies out in that direction. Unfortunately, in the Bramcote area there are no Permo-Triassic rocks north of the Clifton Fault and the only evidence that this structure may be connected directly with the mineralisation is the occurrence of barite on joint surfaces of the sandstone noted on p.174. There is a complete absence of barite in any of the fault planes seen in the Bramcote Sand Quarry although sections of the two main faults have not been available for study, in the Bramcote - Trowell area. The Stoney Clouds area, Sandiacre, with 10% barite in the sandstone, is again situated in a faulted locality.

Comparison with Alderley Edge, Cheshire

The mineralisation of the Lower Keuper Sandstones of Alderley Edge, Cheshire, is described by Warrington, (1965) and Warrington and Thompson (1971). A further visit was arranged to study barite mineralisation of this area in detail. Although the age of the mineralised rocks of Alderley Edge differs from that in the Bramcote and Stapleford Hill area, the barite mineralisation shows many similarities. The development of crystals in the most porous sandstones is identical in the two areas and there are also large faults present. On Alderley Edge there is extensive copper mineralisation, traces of which can be located throughout the area at the present time. These minerals are largely absent from the Bramcote area. Warrington (1965, p.127) considers that the Alderley deposits are epigenetic in character, possibly from an acid igneous mass at depth.

Other minerals

Calcite is significant as a cementing mineral in some of the Permo-Triassic sandstones. It has been found in fault planes often accompanied by dolomite lining the cavities of geodes. Calcite is the more common cementing mineral of the top bed of the Pebble Beds Formation.

Various iron minerals occur as principal cementing materials but excessive amounts can be found on the west face of Stapleford Hill, in the form of limonite. Some sandstones possess a green iron mineral, not identified, although tested for copper.

Because of the record of a copper mine in the area, (Gibson 1910) on the north side of Stapleford Hill, a careful search was made for copper minerals without success. Gypsum has only been recorded in a bore-hole drilled close to the fault north of Stony Clouds at the side of the M.1. Motorway (Midland Road Construction Unit, Matlock, M.42 exploratory bore-hole) on joint surfaces of the Crawshaw Sandstone. It is common in the Keuper Marls to the south. (Taylor 1965). Its presence may be inferred in marls within the Pebble Beds, from the occurrence of fibrous barite.

Origin of the barite

Although mineralisation of the Hemlock Stone was known before 1880, Clowes (1889 - 1895) was the first to test the mineral and identify it as barium sulphate. In his papers, he drew attention to the insolubility of barite in ground water and concluded that the mineral must have been precipitated from a chemical reaction, suggesting the oxidation of barium sulphide, a more soluble mineral, or the double decomposition of barium carbonate and calcium sulphate, both soluble. Warrington (1965, p.127) considers that the Alderley deposits are epigenetic in character, migration of the mineralising solutions being assisted by faulting. The syngenetic origin of minerals, including barite, deposited from hot springs and brines has been reviewed in papers by King (1966) and Dunham (1970) and with reference to modern examples by Degens (1969).

We have found no new evidence which can be used to assist in the choice between any of these possible origins for the barite. There is some calcium carbonate in the rocks which would favour Clowes' hypothesis of double decomposition if the calcium carbonate could be proved to be the result of this reaction. There would still be the need to account for the source of barium carbonate. There are two possible sources of calcium sulphate. The first is the Keuper Marl, which almost certainly covered the area above the Pebble Beds prior to erosion but it is possible that gypsum was precipitated in the marl layers of the Pebble Beds and became incooperated with the succeeding sandstones on resumption of normal sandstone deposition. Our fragments of fibrous barite is the sole evidence for this idea.

Conclusions

In the Permo-Triassic sandstones, west of Nottingham there is a concentration of barite in the Bramcote and Stapleford Hills area. Barite occurs throughout the sequence, but is particularly well developed in the coarser sandstones of the Pebble Beds. The Bramcote and Stapleford Hills are bounded by two important faults with a number of smaller ones, one of which has been shown to contain iron and carbonate minerals, but no barite. The absence of barite in the sandstones associated with the Beeston Fault emphasises the restricted distribution. Similar mineralisation at Stony Clouds, is well developed and may be independent of that of the Bramcote area. The presence of copper minerals at Alderley Edge, Cheshire, reduces the development of barite to secondary importance in most accounts, but the barite mineralisation is comparable with that at Bramcote.

The origin of the barite is still in doubt, but its occurrence in well faulted areas suggest that the faults are not incidental but have aided the migrating mineralising solutions. Calcium sulphate was possibly available and may have been one of the minerals involved in the formation of barium sulphate but there is even less evidence for barium carbonate (Clowes 1889) or barium chloride (Dunham 1970) as a source of the barium.

Acknowledgements

The authors would like to thank Mr. E.R. Allen, manager of the Bramcote Sand Quarry (British Industrial Sands) for permission to visit the quarry on numerous occasions. Beeston & Stapleford U.D.C., have allowed access to parts of Bramcote & Stapleford Hills not normally open to the public and their help in this way is gratefully acknowledged. We would like to thank the technicians at the Department of Geology, University of Nottingham, who carried out analytical techniques.

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