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EVOLUTION OF THE SOUTH PENNINE OREFIELD: I. REGIONAL DISTRIBUTION OF MAJOR NON-METALLIC MINERALS

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ABSTRACT

The distribution of dominant non-metallic minerals of 138 selected ore deposits from the south Pennine orefield is examined in order to investigate the supposed regional zonation of the orefield by calcite, baryte and fluorite. Although three east to west zones of fluorite, baryte and calcite are thought to exist in the orefield, the present results show only a zone of fluorite confined to the eastern margin of the orefield and the eastern inliers. Calcite and baryte are found to have irregular distribution patterns.

INTRODUCTION

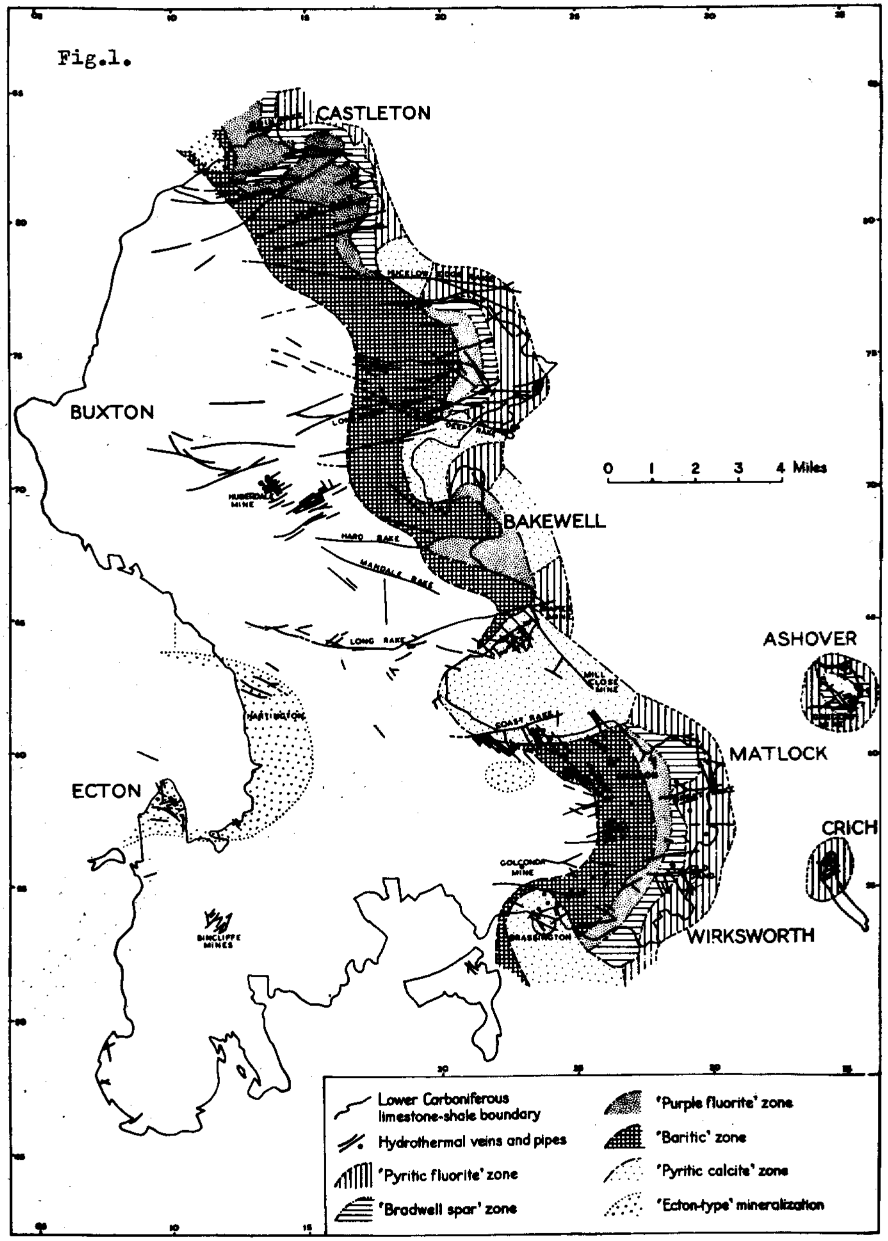
Wedd and Drabble (1908) are credited with the first recognition of regional zonation of fluorite, baryte and cacite in the south Pennine orefield. They reported that major deposits of fluorite are largely confined to a north-south zone, less than 2 km wide, on the eastern side of the orefield. To the west of this zone, baryte appears as the dominant non-metallic mineral in an irregular north-south zone less than 3 km wide and calcite was reported to be the dominant mineral to the west of the baryte zone (Wedd and Drabble, 1908). Although fluorite, baryte and calcite are often found in different proportions in each deposit, this east to west zonation was thought to reflect the relative abundance of each of these minerals (Ford, 1968).

Mueller (1951) is perhaps the only author who has provided detailed description of mineral zonation in the orefield. He suggested that the zonation of non-metallic minerals in the orefield was the result of gradual cooling of mineralising fluids as they moved from east to west. Thus he ascribed three temperature-controlled zones to the orefield which include a high-temperature fluorite zone in the east followed by cooler baryte and calcite zones (Fig. 1). Moreover he subdivided the fluorite zone into three subzones based on sulphide inclusions, transparent character and blue or purple colour of fluorite crystals (Fig. 1). Mueller (1951) claimed that these subzones are the result of minor variations of temperature in the high-temperature fluorite zone. He also recognised a pyritic calcite zone which occurred primarily in synclines and three areas of copper mineralisation which were named "Ecton-type mineralisation" (Fig. 1).

The quantitative estimates of the volumes of minerals which were used to establish the fluorite, baryte and calcite zones were given by Mueller (1954). These estimates are:

1- for fluorite zone: 10-50% fluorite, 2-10% baryte, 40-85% calcite
2- for baryte zone: 1-10% fluorite, 10-40% baryte, 80-99% calcite
3- for calcite zone: 0-1% fluorite, 0-10% baryte, 80-99% calcite

In 1954, Mueller published another version of his 1951 map in which he excluded the pyritic calcite zone and the Ecton-type mineralisation areas. Furthermore, the western boundaries of the fluorite and baryte zones in the 1954 map are geographically different from those in the original 1951 map. In 1952, Dunham produced a map showing the western limit, equal to approximately 40 percent fluorite content, of the fluorite deposits then being mined. Dunham's line was well to the west of Mueller's 10 percent western limit of the fluorite zone (Firman and Bagshaw, 1974). These discrepancies have resulted in a great confusion in the literature on the zonation of non-metallic minerals. Although a few authors, such as Firman and Bagshaw (1974) have pointed out the discrepancies associated with the reported regional zonation of fluorite, baryte and calcite, other research workers have, to varying degrees, accepted the generalised idea of an east to west change from fluorite to baryte to calcite. In recent years, the main argument has been centred on where the western boundaries of the fluorite and baryte zones should be.



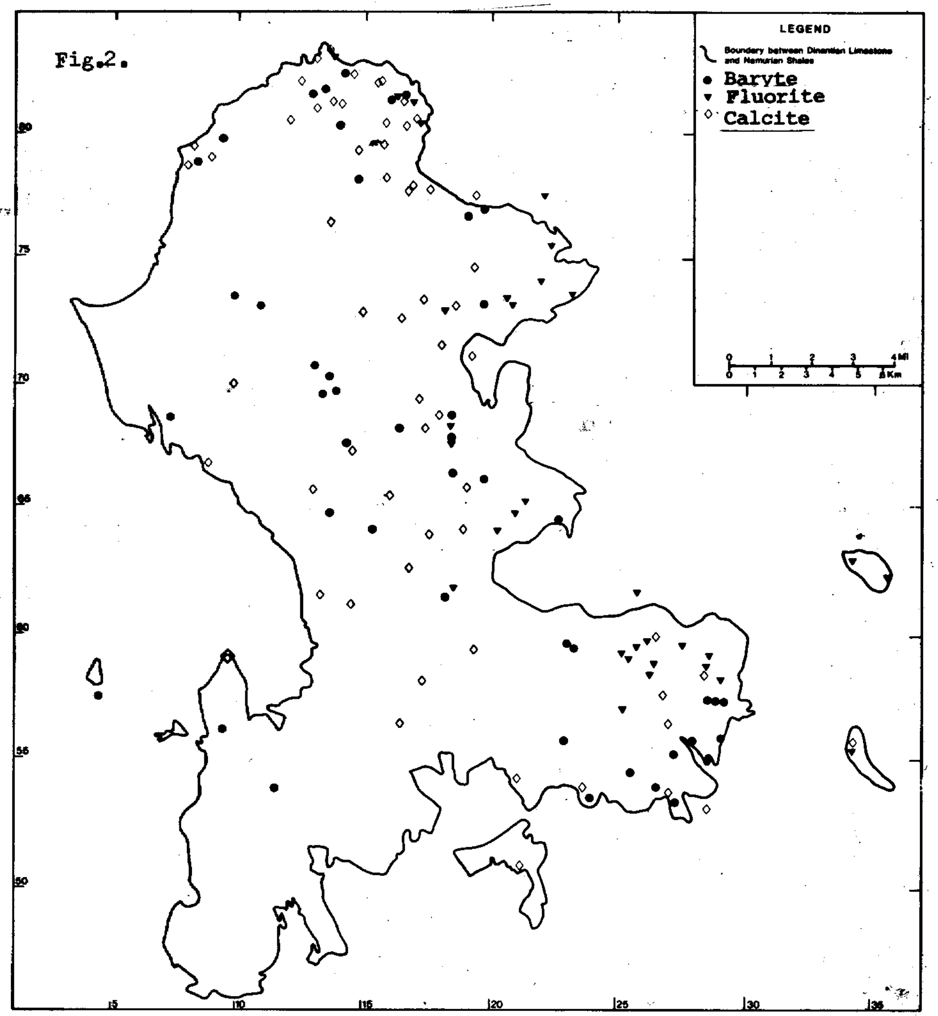


Fig. 1. Regional zonation of major non-metallic minerals as proposed by Mueller, 1951 (after Ford and Ineson, 1971).

Fig. 2. Regional distribution of dominant non-metallic minerals of 138 selected ore deposits from the south Pennine ore field.

THEORY AND PRACTICE IN DETERMINATION OF MINERAL ZONATION

The concept of regional zonation of fluorite, baryte and calcite is mainly based on the assumption that: (a) the principal cause of precipitation of the non-metallic minerals was temperature; and (b) three temperature-controlled belts existed during the entire period, or greater part, of ore mineralisation in the south Pennine ore field. In applying this far too generalised idea of ore mineralisation processes, Mueller (1951 and 1954) defined his three mineral zones by estimated percentages of each mineral in each zone. These estimates were quite arbitrary since, in many cases it is impossible to find, with any reliable accuracy, the percentage composition of a given ore deposit. Many ore deposits in the orefield were mined centuries ago when non-metallic minerals received little or no attention and only scattered information is now available on non-metallic mineral composition of these deposits. Moreover the proportion of minerals changes in different parts of an ore body or in the veins which branch out of that ore body. Firman and Bagshaw (1974) gave many examples of mineralogical changes in the ore deposits of the orefield which are contrary to the regular pattern of mineral zonation described by Mueller (1951 and 1954). Although Mueller (1954) claimed that he derived his figures from different sources including statistics supplied by mining companies and personal field examination of mines, these figures are dependant on a number of factors such as extraction methods which could give a percental mineral composition quite different from the original mineral content of the ore deposits. Moreover, based on the quantitative estimates of the proportions of minerals used by Mueller (1954), calcite could be the dominant mineral in all the three zones. According to the theory proposed by Mueller (1951 and 1954) this would indicate a prevailing low-temperature environment all over the orefield. Therefore, it seems, another approach must be used in examining the applicability and validity of the hypothesis of thermal zones. In this paper an attempt is mady to study the distribution of the non-metallic minerals on the basis of predominancy of these minerals in each individual ore deposit because, if calcite, baryte and fluorite were precipitated in different zones as the result of temperature differentiation, then it is reasonable to assume that the ore deposits in each zone should contain, as their dominant mineral, that which the temperature of that zone permitted to precipitate. Although the determination of a predominant mineral in each ore deposit may also be subjective due mainly to the extensive mining of the orefield, it is the most direct way to examine the validity of the assumptions which have formed the theoretical basis for regional zonation of the non-metallic minerals in the orefield.

RESULTS

The dominant non-metallic mineral of 138 ore deposits, selected partly on the basis of their geographical distribution in the orefield, was determined from the examination of over 4000 handspecimens and field observations. Most of the samples used in this study were collected from the "waste hillocks" of past mining developments. In situ samples were collected from a few ore deposits where access to the underground workings is still available. In determination of the dominant non-metallic mineral for each of the 138 ore deposits, the available information on the present and/or past mineral exploration of each ore deposit were combined with the data obtained from observations of the underground workings and examinations of collected samples.

The regional distribution of the 138 ore deposits with their dominant non-metallic ore minerals is shown in Fig. 2. Although fluorite and baryte are the dominant minerals in 32 and 46 ore deposits respectively, calcite is the most common mineral of the three and is dominant in 60 ore deposits. The following conclusions are inferred from Fig. 2.

1. All the ore deposits with fluorite as their dominant non-metallic mineral are restricted to the eastern margin of the orefield in a north-south zone less than 5 km wide. With one exceptipn, the dominant mineral in Ashover and Crich inliers (Figs. 1 and 2) is fluorite indicating the dominance of fluorite may continue to the east in the buried Lower Carboniferous limestones. However, a few calcite- or baryte-dominated ore deposits are also found near the eastern margin of the orefield (Fig. 2).

2. There is a sharp change from fluorite to baryte halfway between Matlock and Wirksworth (Figs. 1 and 2). Indeed, the dominance of fluorite is terminated south of Ible Mine (SK 252570).

3. The distribution of baryte is irregular with no apparent zonation. Most of the baryte-dominated ore deposits are located in Mueller's (1951 and 1954) "calcite zone".

4. Calcite has the most irregular distribution pattern of the three minerals with no apparent restriction to the western side of the orefield as has been assumed by Mueller (1951 and 1954) and other authors. It is mostly concentrated in the north near Castleton and in the central part of the orefield near Bakewell (Fig. 1 and 2).

DISCUSSION

The above conclusions do not support the threefold zonation concept of fluorite, baryte and calcite in the south Pennine orefield advocated by Mueller (1951 and 1954) and others. Although regional mineral zonation has been established in some of the orefields of the United Kingdom, in the context of the south Pennine orefield, it is inconsistent with field observations. The data presented in Fig. 2 indicate that (a) at the time of ore mineralisation in the orefield, no major variation in temperature existed in the orefield; and (b) if there were three high-, intermediate- and low-temperature zones in the orefield, the precipitation of calcite,baryte and fluorite was not related to temperature and localisation of these minerals was not controlled by variation in temperature. The most significant point shown by Fig. 2 is that all the fluorite deposits are found near the eastern margin of the orefield. This is consistent with dissolution of the limestone host rock by westward-moving fluorine-bearing mineralising fluids. The dissolution of limestone provided the necessary calcium ions needed for fluorite mineralization. The causes of fluorite precipitation, therefore, include the availability of fluorine ions and suitable depositional environments in the eastern part of the orefield; the sparsity of fluorite mineralization in the central and western parts is thus due to the lack of sufficient fluorine in the fluids there, and not to any thermal zoning effects.

Similarly the distribution of baryte is not temperature-controlled and, as pointed out by Firman and Bagshaw (1974), may be dependent on the availability of in situ sulphate-rich fluids. The irregular distribution of calcite is difficult to explain and may only be related to the composition and chemistry of the mineralising fluids. A more detailed discussion on causes of mineral precipitation and genesis of ore mineralisation in the south Pennine orefield will form the subject of a separate paper.

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