

Geochemistry and mineralogy of some British coals

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Introduction

In Britain there has been a dramatic decline in the amount of coal mined. The coal supplied to the power generators, the major users of coal, has fallen from the 1992 level of 65 mt, to 40 mt in 1993 and to 30 mt in 1994. An important factor in the decline is the composition of the coal and the high S content in particular. Elsewhere in the world, especially in India and China, the amount of coal being used for power generation is increasing and coal will continue to play a significant role as a key source of world energy for the foreseeable future. In order to reduce the environmental impact of coal combustion information on the distribution and origin of minerals and elements in coal is required.

Trace elements are known to be enriched in coal ashes, mainly from the pioneering work of Goldschmidt (reviewed in 1954). These are mainly the chalcophile elements, which may be present at concentration levels greatly in excess of those recorded for normal mudrocks. Some elements, for example Ge, are sufficiently enriched for the coal ashes to be considered as a potential source. In more recent years the interest in trace elements in coals has been concerned more with environmental considerations (Raask, 1985). Goldschmidt (1954) also made major contributions in this area,

noting, for example, the fractionation of As on combustion with As present in flue dust (fly ash) and in gaseous emissions.

Mineralogy

Present in coals from the East Pennine Carboniferous coalfields are quartz, kaolinite, illite, mixed layer clay and chlorite, which are detrital, and diagenetic minerals consisting of kaolinite, sulphides, mainly pyrite and marcasite with minor galena, chalcopyrite and sphalerite, and carbonates, including calcite, dolomite, ankerite and siderite (Spears, 1987). The diagenetic minerals range from pre-compaction framboids and nodules to later stage infilling of cleat (joints). Within the cleat there is an established sequence of mineralisation, which has been interpreted, by analogy with stages of sandstone diagenesis, as indicating continued diagenetic evolution of the peat rather than a discrete and much later epigenetic event (Spears and Caswell, 1986).

Geochemistry

The *in-situ* determination of trace elements in coal has been achieved by SEM with energy dispersive X-ray analysis (Finkelman, 1982), proton microprobe (Minkin *et al.*, 1987) and synchrotron radiation X-ray fluorescence (White *et al.* 1989). The latter work demonstrated the importance of the sulphide minerals as a location for trace elements in the coal (Table 1).

The indirect determination of trace elements in specific components of the coal has proved possible by analysing separated density fractions. The minerals are fractionated and this permits the detrital and the diagenetic mineral contributions to the geochemistry to be determined. In the low density fraction the diagenetic mineral is pyrite (finely dispersed framboids) which enables the pyrite and organic contributions to the trace element geochemistry to be resolved. The calculated concentrations for Ni, Cu, Zn and Pb in pyrite are comparable with mean values obtained from the synchrotron (Table 1). Pyrite is also established as the major location for these elements (Ni, Cu, Zn, Pb, As, Se, Mo and Tl) in the coal. The elements V, Sr, Ba, Zr and Nb

TABLE 1. Trace element composition of pyrite (ppmw)

	S XRF Analysis ^a		Calculated from XRF analysis of density fraction
	Mean	Maximum	
Ni	309	3260	530
Cu	315	8480	580
Zn	21	270	715
As	1029	1.3 ^b	-
Se	97	1250	-
Mo	107	1430	-
Ag	36	275	-
Tl	17	175	-
Pb	322	2930	505

^a White *et al.*, 1980; ^b Wt.%

appear to be either directly or indirectly associated with the organic matter. An indirect association could arise from finely dispersed mineral matter in the coal; phosphates for Sr and Ba and clay minerals for Zr and Nb, with the latter possibly originating from dispersed volcanic ash.

Origin of the enriched elements

Most of the enriched trace elements are sulphide associated and it is reasonable to assume that their origin is linked to that of the S. The S content of coals is related to the concentration of SO₄ in the depositional environment and thus to salinity (Chou, 1990). Coals would appear to differ from mudrocks in that there is greater potential for sulphide precipitation after the early diagenetic stage, due to movement of porewaters and release of ions during organic maturation. The relationship between high-S coals and marine horizons in the stratigraphic sequence may therefore be obscure. The marine black shales in the sequence are enriched in a number of trace elements compared with the non-marine shales. When these marine shales are compared with the coals comparable levels of enrichment are observed, supporting the hypothesis of a marine link for the origin of the high trace element concentrations (Spears and Martinez-Tarazona, 1993).

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