Characterization of a Channel Sample of the Phalen Coal Bed, Sydney, Nova Scotia, Canada

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The Sydney Basin is located in northeastern Cape Breton Island, Nova Scotia and is of unknown offshore extent. The Carboniferous strata of the basin include 600 m of productive coal measures within the Morien Group (equivalent to the Cumberland Group: Ryan et al., 1991), which ranges in age from Westphalian C to Stephanian (Hacquebard and Donaldson, 1969; Duff et al., 1982; Rust et al., 1987). The coal beds are restricted to the Sydney Mines and South Bar Formations. The three major beds in the Sydney Mines Formation are the Hub, Harbour, and Phalen, which are up to 4.3 m thick and present the major accessible coal resources in eastern Canada. Fauna of the bituminous shales and limestones within the Sydney Mines Formation are regarded as non-marine, and the paleoimages are inferred to have formed in an alluvial and coastal plain paralic environment (Hacquebard and Donaldson, 1969). According to vitrinite reflectance measurements, the Phalen bed is classified as high volatile bituminous A (0.9 to 1.0 % R₀,random) (Stach et al., 1982).

This report presents preliminary petrographic, chemical, mineralogical, and sulfur isotope characterization of a channel sample collected from a working face in the Phalen Colliery, a unique coal mine under about 17 m (50 feet) of Atlantic Ocean sea water. The channel sample was collected in 24 sub-samples or benches, ranging in thickness from 2.5 cm (1 inch) to 23 cm (9 inches). The total thickness of the coal bed at the point of collection was 2.7 m (8 ft 8 in). Nine of the coal benches plus a sample of the roof rock were selected for analysis. The ash yield, total sulfur, and moisture content of the bed are 5.9 wt %, 2.2 %, 4.3 %, respectively.

White light petrographic analyses were conducted on polished pellets prepared from -20 mesh coal. For each sample, five hundred point counts were made on each of two pellets. The results appear in Table 1. High temperature (525° C) ash from each sample was analyzed by inductively coupled plasma atomic emission spectroscopy and inductively coupled plasma mass spectroscopy. Mercury was determined by cold vapor atomic absorption spectroscopy, selenium by hydride generation, and chlorine by ion chromatography. Because of the unexpectedly low ash yields for samples 9, 11, and 16 (2.3, 1.5, and 1.0 wt % ash, respectively), there was insufficient material for complete chemical analysis (Table 2). The low-temperature ash mineralogy of four samples (1, 9, 13, and 19) was determined by semi-quantitative X-ray diffraction (XRD). Polished blocks of all samples were analyzed by scanning electron microscopy with an energy dispersive X-ray analyzer (SEM-EDX) and with an electron microprobe. Sulfur-forms were determined by ASTM procedures and sulfur isotopic analyses were conducted by the method described by Bates et al. (1993).

Table 1 illustrates the distribution of volume percent of the maceral groups vitrinite, inertinite, liptinite, and mineral matter within the vertical profile of the Phalen coal bed. Except for some samples in the middle and lower part of the bed (samples 9A & B, and 24), all samples are rich in vitrinite, a majority of which is composed of telocollinite. Three forms of pyrite were observed: a) fine-grained framboids usually associated with vitrinite; b) large framboids within vitrinite and inertinite; and c) fracture-filling pyrite. The coarse-grained, fracture-filling pyrite may have caused some sample inhomogeneity, resulting in some inconsistencies in the analytical results.

There appear to be two distinct suits of inorganic constituents with little intermixing (Table 2). One suite represented by samples 6, 13, and probably 9 and 11 is dominated by lithophile elements (Si, Al, K, Ti, Cr, Cs, Li, Nb, Rb, Ta, Th, V, Zr, Hf, Ni, Sc, Ga, and the LREE) and is almost devoid of sulfides. The other suite, represented by samples 3, 19, 22, and 24, is dominated by siderophile and chalcophile elements (Fe, As, Cd, Mo, Sb, Tl, Zn, Hg, Se, Ge, and the HREE) with a very sparse silicate component. In addition, this sample suite contains relatively high concentrations of elements (Ca, Mn, Sr, P) that could have been derived from nearby evaporite deposits (Gibling et al., 1989). The stark chemical differences between the two sample suites may be due to the detrital source material alternating between silicate-rich and sulfate-rich rocks resulting from a change in geographic location or stratigraphic position of the source material. The concentrations of several elements (Be, Co, Cr, Cu, Ga, Ge, Ni, V, Y, and possibly W) are highest in the low-ash samples, possibly indicating an organic association.

Preliminary SEM and electron microprobe data for the two stratigraphically highest samples (1 and 3) and the lowest sample (24) identified pyrite as the primary sulfide phase. Arsenic content determined for sample 3 is relatively low and uniform (150-800 ppm; 28 points; highest value - 2200 ppm). For pyrite in sample 1, arsenic is also relatively low (500-600 ppm; 10 points; highest value - 5800 ppm). Arsenic in sample 24 pyrite was higher...