THERMAL HISTORY OF COAL-WASTE DUMPS REFLECTED IN ORGANIC GEOCHEMISTRY

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Introduction

The Wełnowiec dump, located on the border between the cities of Katowice and Siemianowice Śląskie in the Upper Silesia Coal Basin (USCB), is surrounded by housing estates and a block of flats. It is a former urban dump collecting wastes from 1991 to June 1996 when the dump was closed. In 1998, it was decided to reclaim the terrain with coal waste from unidentified USCB coal mines, but most probably from the nearest Katowice Coal Mine. Despite a project planned to involve a multi-barrier system, the coal-waste rocks were dumped on the dump slopes without any structure in a layer exceeding 6 m. In 2001, equipment for biogas exploitation was installed within the dump, aerating its interior. The plan assumed biogas exploitation for 20 years, but the venture was deemed unprofitable after only a few years. The coal-waste dumping and aeration had led to self-ignition of the coal waste. Though its initiation time is unrecorded, it is very likely that the dump had been self-heating for a few years before November/December 2009 when the first intense fire broke out on the northern slope. Subsequently, several fires were recorded at different sites in the dump, all on slopes where the coal-waste layer was thickest (Ciesielczuk et al., 2013).

The aim of the research was to determine how self-heating of coal wastes is reflected in their geochemical- and petrological properties and to evaluate how the results might be applied to recognizing the thermal history of coal-waste dumps.

In the light of the dump history, 10 self-heating areas were selected as sampling sites. Coal wastes were sampled (0.5-1 kg) in (a) July 2013 (A set) when the northern slope was fully self-heated in two different areas, and (b) November 2014 (set B) during- and after firefighting carried out when the dump was opened to cool wastes and extinguish fires. Petrographic analyses carried out on polished blocks included determination of maceral composition, types of maceral transformations and random reflectance measurements. Powdered wastes were extracted with dichloromethane in a Dionex 350 device and analysed on an Agilent gas chromatograph 6890 with a HP-5 column (60 m×0.25 mm i.d.) coated by a 0.25 μm stationary phase film and coupled with an Agilent Technology mass spectrometer 5973.

Results

The wastes are mixtures of solid products from coal combustion, coal waste, organic matter altered in thermal processes in a moderate way, solid bitumen and recent organic matter. Organic matter is represented by macerals mostly of the vitrinite group, usually vitrodetrinite, collotelinite and, in some cases, collodetrinite. Macerals of the liptinite group (mostly sporinite and liptodetrinite) and the inertinite group (mostly fusinite and inertodetrinite) are less common. In some cases, the macerals are paler in colour or show cracks; moderate heating is indicated. Devolatilization pores occur in some particles that are pale grey in colour. Chars comprise < 4.3%.

Extractable organic matter (EOM) comprises a wide range of substances the coal-waste was subjected to several processes ranging from mild oxygenation during weathering through self-heating in low-oxygen conditions to rapid- and severe oxygenation during the firefighting when the dump was opened allowing the free access of oxygen to hot coal waste. Identified compounds included *n*-alkanes, acyclic- and cyclic isoprenoids, aromatic hydrocarbons, partially aromatized cyclic aliphatics, polar compounds including phenols, furane derivatives and nitrogen organic compounds.

The type of *n*-alkane distribution reflects the thermal history of the Wełnowiec dump. A narrow, pyrolytic distribution (1) comprising light *n*-alkanes predominates on the northern slope where self-heating was marked during both sampling periods. A wider Gaussian distribution characterizes sites thermally inactive at present but which underwent self-heating in the past. In some samples, lighter *n*-alkanes had been partially removed by water-washing. The distribution composed of two overlapping Gaussian types derives from two separate self-heating events differing in temperature. Samples taken in the same thermally inactive areas, but in the later sampling period, i.e. 2014, are enriched in long-chain *n*-alkanes reflecting removal of lighter compounds due to water washing and/or biodegradation. This observation indicates that even an interval as short as 18 months is sufficient to change *n*-alkane profiles in self-heated coal waste. In contrast, distributions in coal waste which was not affected by self-heating are very similar both to each other and to that of USCB coals (Fabiańska et al., 2013). The reason for this difference seems to relate contrasting modes of occurrence of bitumen substances in self-heated- and non-heated coal waste. Self-heating leads to bitumen being expelled to the grain surface and, thus, making it easily accessible to secondary processes as oxidation, biodegradation and water-washing. In non-heated coal waste, the bitumen fraction, dispersed within the grain and adsorbed on mineral- or organic matter, is protected against alteration. Despite their high variability, average values of DNR, DMPR, MPI-3, and MPyR calculated for different self-heated dump areas indicate a 2-3 times increase compared to those for coal waste sampled in areas not subjected to heating. The influence of self-heating on the organic geochemistry of coal wastes is clearly reflected in the ratios.

Conclusions

Organic geochemistry and petrography allow the recognition of significant changes in organic matter of coal-waste rocks. Variations in the overall distributions of aliphatic hydrocarbons, particularly *n*-alkanes, and of alkyl aromatic hydrocarbons, can provide insights into the thermal history of coal-waste dumps.

References

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