Thermal history of coal wastes reflected in their organic geochemistry and petrography; the case study: The Katowice-Welnioec dump, Poland

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1. Introduction

1.1. Self-heating in coal-waste dumps

Claystones, mudstones, sandstones and rare carbonates variously intermixed with coal constitute the layers and lenses that characterize most coal-waste dumps. During coal exploitation and enrichment, it is estimated that 0.3–0.7 t of waste rock is produced in the production of 1 t of coal in Polish mines (Skarżyński, 1995). A large part of the waste ends up in dumps where oxidation of both organic- and mineral matter leads, in some cases, to self-heating and ignition of the waste. Three factors are critical for self-heating to occur within a dump, namely, the presence of organic matter, air access, and accumulation of heat (Brooks et al., 1988; Kaymakçı and Didari, 2002; Pone et al., 2007). Oxidation of sulphides, mostly pyrite, provides additional heat. Initially, immediately after deposition of the waste, oxidation causes temperatures to rise slowly without any obvious signs. If the temperature reaches 60–80 °C (Sawicki, 2004; Sokol, 2005; Pone et al., 2007), and the heat does not dissipate, the temperature may start to rise rapidly to the point of ignition that is ca 200 °C for hard coals. The temperature of burning waste can be > 1300 °C (Sawicki, 2004; Sokol, 2005). The processes taking place in what are situations of limited air access, but commonly in the presence of water (rain), include pyrolysis or/and hydrolysis (Misz-Kennan, 2010; Misz-Kennan and Fabiańska, 2011).

The factors influencing heating may be internal- or external factors. Internal factors include moisture content, the maceral composition of any organic matter and coal rank. External factors include dump shape and height, convection related to wind patterns, atmospheric precipitation (especially heavy rain), degree of material packing and isolation (Krishnaswamy et al., 1996a, 1996b; Walker, 1999; Kaymakçı and Didari, 2002).

1.2. The Welnioec dump location and history

The Welnioec dump, located in a densely urbanised area on the border of Katowice and Siemianowice Śląskie in the Upper Silesia Coal Basin (USCB), covers the area of ca 1.6 ha (Fig. 1). The deposition ~1.6 million tonnes of urban wastes started there in 1991 and continued up to June 1996. As they contained ~58.8 wt% of organic matter, it was decided in 2001 to exploit biogas (methane) from the dump (Klejnowska, 1996). 39 gas-collecting boreholes were drilled for a project planned to last 20 years but which, after only a few years, became unprofitable.

The landfill was reclaimed in 1998 after numerous complaints. The reclamation project assumed a flat top to allow a multi-barrier system to be put in place that would isolate the waste and suppress unpleasant odours. The barrier system was to comprise, from the top, (a) 0.4 m of humus, (b) 0.6 m reclamation layer of coal waste with coal content < 5%, (c) 0.3 m drainage layer of 16–32 mm gravel, (d) 0.1 m protective layer of sand, (e) 0.5 m seal layer of clays and (f) 0.3 m carrier layer of compacted coal waste (Klejnowska, 1996; Ciesielczuk et al., 2013). However, much greater amounts of coal waste were used, at least 6 m thick layer, without any packing and fire preventing measures. There was enough organic matter in coal wastes to start later heating. Self-heating had probably been occurring for some years before November/December 2009 when the first intense fire broke out on the northern slope with the maximum intensity on the eastern part of.
Fig. 1. The location of the Wełnowiec dump and sampling sites.
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