International Journal of Coal Geology 88 (2011) 1–23

Contents lists available at ScienceDirect

International Journal of Coal Geology

journal homepage: www.elsevier.com/locate/ijcoalgeo

Application of organic petrology and geochemistry to coal waste studies

Magdalena Misz-Kennan *, Monika J. Fabiańska

University of Silesia, Faculty of Earth Sciences, ul. Będzińska 60, 41-200 Sosnowiec, Poland

ARTICLE INFO

Article history:
Received 30 March 2011
Received in revised form 30 June 2011
Accepted 3 July 2011
Available online 23 July 2011

Keywords:
Coal wastes
Macerals
Self heating
Organic biomarkers
Geochemical indices
Thermal alteration

ABSTRACT

Coal wastes produced during mining activities are commonly deposited in nearby dumps. These wastes mostly composed of minerals and variable amounts (usually 20–30%) of organic matter start to weather immediately after deposition. Oxidation of the organic matter can lead to self heating and self combustion as a result of organic and mineral matter transformations. The degree of alteration depends on the properties of the wastes, i.e., the maceral and microlithotype composition of the organic matter and its rank.

Alteration of wastes also depends on the heating history, i.e., the rate of heating, final heating temperature, duration of heating, and the degree of air access. Although air is probably necessary to initiate and drive the heating processes, these usually take place under relatively oxygen depleted conditions. With slow heating, color of organic matter particles changes, irregular cracks and oxidation rims develop around edges and cracks, and bitumen is expelled. As a result, massive and detritic isotropic and strongly altered organic matter forms. On the other hand, higher heating rates cause the formation of devolatilization pores, oxidation rims around these pores and along cracks, vitrinite-bands-mantling particles, and bitumen expulsions.

Organic compounds generated from the wastes include *n*-alkanes, *iso*-alkanes, alkylcyclohexanes, acyclic isoprenoids, mainly pristane, phytane and, in some cases, farnesane, sesquiterpanes, tri- and tetracyclic diterpanes, tri- and pentacyclic triterpanes, and steranes, polycyclic aromatic hydrocarbons (mostly with two- to five rings, rarely six rings), and phenols. The compounds formed change during the heating history. The fact that phenols are found in dumps where heating has not yet been completed, but are absent in those where heating ceased previously suggests the presence of water washing. The organic compounds formed may migrate within the dumps. However, when they migrate out of the dumps, they become a hazard to environment.

This paper is a review on transformations of organic matter (both maceral composition and reflectance and chemical composition) in coal wastes deposited in coal waste dumps. Immediately after deposition the wastes are exposed to weathering conditions and sometimes undergo self heating processes.

Contents

* Corresponding author. Tel.: +48 32 3689546; fax: +48 32 2915865.
E-mail address: magdalena.misz@us.edu.pl (M. Misz-Kennan).

0166-5162/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.coal.2011.07.001

1. Introduction

Coal wastes are generated during the preparation of coal seams for exploitation (mining wastes) and as slurry wastes. The origin of mining wastes is connected with preparatory mining works and coal seam exploitation. Individual fragments of these wastes are up to 500 mm. Slurry wastes are generated during coal separation. They are commonly divided into (a) coarse grained (10–250 mm) wastes produced from suspension plants, (b) fine-grained (0.5–30 mm) wastes produced from sedimentation processes, and (c) very fine-grained (<1 mm) slurries (tailings) resulting from flotation processes (Skarżyńska, 1995).

Constituent elements of wastes vary in size and composition. Mineral matter, the main component, typically occurs as fragments of sandstone, shale, mudstone and, less often, conglomerate and carbonate (Skarżyńska, 1995). Organic matter, usually comprising 3–30% of the waste material (Skarżyńska, 1995), occurs as laminae and lenses of variable length and width, and as dispersed organic matter. When they come in contact with oxygen, these wastes start to oxidize and may generate fires.

In general, two types of fires occur in coal-waste dumps. Exogenic fires are caused by some external source of heat, such as dumped hot slag and badly protected welding works (Urbański, 1983). Endogenic fires are uncontrollable and occur as the end result of self heating processes (Itay et al., 1989; Krishnaswamy et al., 1996a,b; Lu et al., 2004; Sensogut and Cinar, 2000; Shi et al., 2005; Singh et al., 2007; Urbański, 1983; Walker, 1999). In this paper, endogenic fires and their origins will be discussed. Although much research (Beamish, 2005; Beamish et al., 2001; Brooks et al., 1988; Clemens and Matheson, 1996; Kaymakçi and Didari, 2002; Krishnaswamy et al., 1996a,b; Liu and Zhou, 2010; Walker, 1999) has been conducted, the origin of endogenic fires is not understood completely. However, it is clear that these fires occur in coal wastes that contain organic matter of various rank, such as bituminous coals (Misz et al., 2007; Misz-Kennan, 2010; Misz-Kennan and Fabiańska, 2010; Misz-Kennan et al., 2011a) and anthracites (Ribeiro et al., 2010a,b,c).

Immediately after deposition in coal-waste dumps that are usually sited close to the source mines, the coal wastes undergo a process of oxidation that, in some cases, can lead to self heating and self combustion (Fig. 1). For self combustion to take place, three key conditions are required to co-exist at the same time. These conditions are the presence of organic components and pyrite that easily react with air, easy access for air into the interior of the dump, and the conditions for heat to accumulate (Barosz, 2002, 2003; Brooks et al., 1988; Kaymakçi and Didari, 2002; Pone et al., 2007; Szafer et al., 1994; Tabor, 1999, 2002; Urbański, 1983).

Two critical stages are involved in self heating. During the first stage no change in temperature is observed (Sawicki, 2004; Walker,

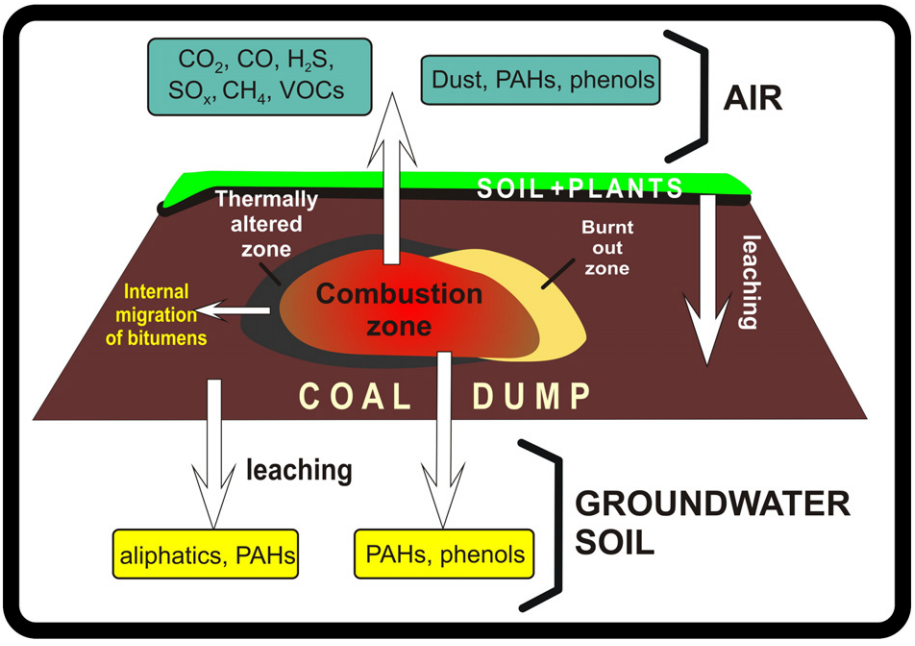

Fig. 1. The main processes that occur in a coal-waste dump.