International Journal of Coal Geology 173 (2017) 129–141

Contents lists available at ScienceDirect

International Journal of Coal Geology

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

Distribution of As, Hg and other trace elements in different size and density fractions of the Reshuihe high-sulfur coal, Yunnan Province, China

Piaopiao Duan [a,b], Wenfeng Wang [a,b,*], Xiaohua Liu [c], Fuchang Qian [a,b], Shuxun Sang [a,b], Shaochun Xu [d]

[a] School of Resources and Geosciences, China University of Mining and Technology, Xuzhou 221116, China
[b] Key Laboratory of Coalbed Methane Resource and Reservoir Formation Process, China University of Mining and Technology, Ministry of Education, Xuzhou 221116, China
[c] Yunnan Institution of Coal Geology Prospection, Kunming 650218, China
[d] Department of Computer Science and Mathematics, Algoma University, 1520 Queen Street East, Sault Ste. Marie, Ontario P6A 2G4, Canada

ARTICLE INFO

Article history:
Received 7 September 2016
Received in revised form 18 February 2017
Accepted 18 February 2017
Available online 21 February 2017

Keywords:
High-sulfur coal
Arsenic
Mercury
Trace elements
Size fraction
Density fraction

ABSTRACT

A Lopingian coal from the Reshuihe Mine in southwestern China contains high pyritic sulfur (5.2%) and trace elements including As (10.8 μg/g), Hg (0.81 μg/g), V (98.9 μg/g), Co (15.7 μg/g), Cu (47.5 μg/g), Se (4.8 μg/g) and Th (7.2 μg/g). The variation of trace elements in coal samples of different size and density were investigated. The results showed that the vertical variation of As and Hg through the seam section is the result of hydrothermal activity. Arsenic and Hg are highly concentrated in coal layers far from the parting, roof and floor in vertical section. For example, the highest concentrations of As (44.3 μg/g) and Hg (2.8 μg/g) occur in ply 6, which is 40-cm vertically away from partings. Elements As, Hg, Co, Ni, Se, Sb and Tl occur mainly in pyrite; Be, F, Cs, Th and U are evenly distributed in clay minerals and organic components; V and Cr mainly occur in the organic portions of the coal. The As and Hg content generally increases with greater particle size and density, with content in the light fractions as low as 1.1 and 0.14 μg/g, respectively, and as high as 75.8 and 3.8 μg/g, respectively, in heavy fractions. Co, Ni, Se, Sb and Tl exhibit similar density dependence. Vanadium and Cr are more concentrated in lower-density fractions.

The genetic type and mode of occurrence of elements in coal both exert a great impact on their removability; epigenetic and coarse minerals may be readily liberated by gravity separation. Elements associated with pyrite (e.g., As, Hg, Co, Ni, Cu, Se, Sb and Tl) demonstrate high removability; F, Th, U, V and Cr, which mainly occur in clay minerals and/or organic components of the coal, show a relatively low removability. Trace elements in particle size fractions 6–13 mm and <0.5 mm are most easily removed by gravity separation. In order to fully remove toxic elements from coal, it is suggested fractions with particle sizes of 3–6 mm and 0.5–3 mm be reduced in size to <0.5 mm prior to gravity separation.

1. Introduction

China is by far the world's largest producer and consumer of coal, accounting for more than two-thirds of Chinese energy consumption (Dai et al., 2012). The southwest of the country is one of the largest coal-producing regions. However, most coals from southwestern China have high sulfur content (Li et al., 2006); combustion of this kind of coal leads to severe air pollution and acid rain, and also contains a large proportion of potentially toxic trace elements. During coal processing and combustion, toxic trace elements are released into the environment causing a range of adverse effects (Kostova et al., 2016; Li, 2006; Liu et al., 2017; Zou et al., 2014). In addition, coal from the city of Zhaotong in Yunnan Province is used for domestic cooking and heating, leading to health problems because of its high content of As and other toxic elements (Li et al., 2015; Luo et al., 2008). As a result of increased environmental pressures and restrictions on air pollution, coal must now be washed before combustion to reduce toxic environmental effects.

Genetic models as well as the distribution and occurrence of toxic elements in coal from China (Belkin et al., 1997, 1999, 2008; Dai et al., 2006; Ding et al., 1999, 2000, 2001; Kang et al., 2011; Li et al., 2002; Liu et al., 2015; Wang et al., 2011b; Zhao et al., 2003; Zheng et al., 2006), New Zealand (Black and Craw, 2001), the United States of America (Diehl et al., 2012; Hower et al., 2015; Johnston et al., 2015; Kolker, 2012; Kolker et al., 2000), Turkey (Karayigit et al., 2000), South Africa (Kolker et al., 2016), the Czech Republic

* Corresponding author.
E-mail address: wenfwang@vip.163.com (W. Wang).

http://dx.doi.org/10.1016/j.coal.2017.02.013
0166-5162/

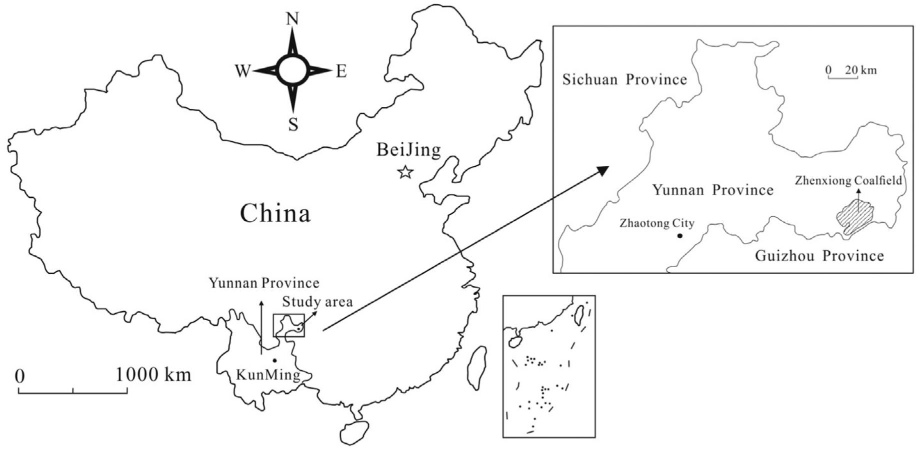

Fig. 1. Location of the Zhenxiong Coalfield (after Dai and Chou, 2007).

(Rieder et al., 2007), Bulgaria (Eskenazy et al., 2013; Kostova et al., 2013) and Malaysia (Sia and Abdullah, 2012) have been the focus of previous work. However, a few studies have been conducted to address the partition of trace elements during coal preparation. Wang et al. (2006a,b, 2008, 2009); Wang and Qin 2011a studied the relationship between the removal of trace elements and particle size, coal rank and coal preparation type; Özbayoğlu (2010) and Kolker et al. (2016) investigated the issues related to the removal of toxic elements from different coal density fractions during preparation. Wang et al. (2005) and Xie and Nie (2010) have argued that the removability of toxic elements from coal is closely related with their modes of occurrence; for example, the diversity of occurrence modes of As, Hg Se and S can lead to complex migration of these elements during coal processing and utilization (Li and Jiao, 2011).

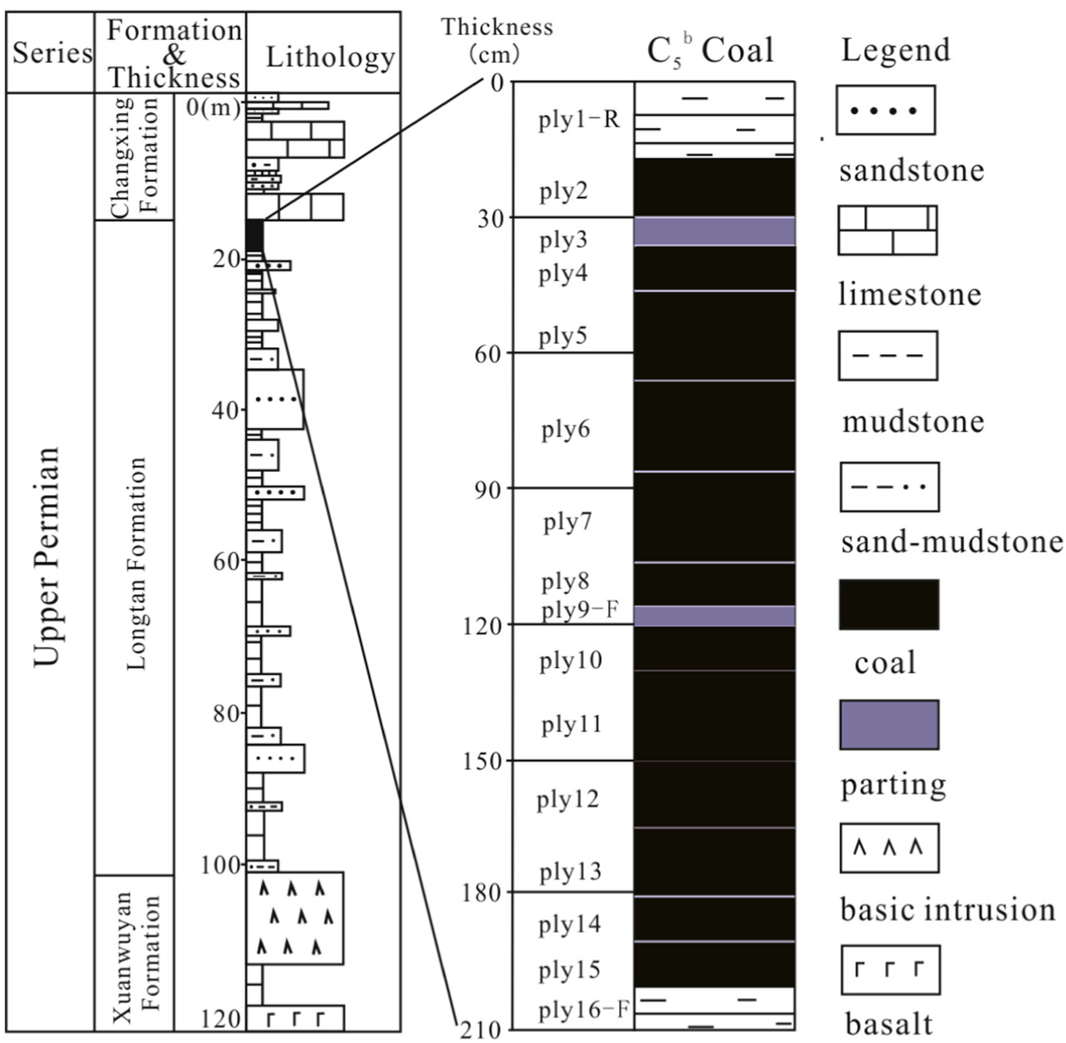

Fig. 2. Stratigraphy of the Longtan Formation in northeastern Yunnan (after Dai and Chou, 2007) and coal seam sections in Reshuihe Mine.