

## Arsenic concentrations in Chinese coals

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### Abstract

The arsenic concentrations in 297 coal samples were collected from the main coal-mines of 26 provinces in China were determined by molybdenum blue coloration method. These samples were collected from coals that vary widely in coal rank and coal-forming periods from the five main coal-bearing regions in China. Arsenic content in Chinese coals range between 0.24 to 71 mg/kg. The mean of the concentration of Arsenic is  $6.4 \pm 0.5$  mg/kg and the geometric mean is  $4.0 \pm 8.5$  mg/kg. The level of arsenic in China is higher in northeastern and southern provinces, but lower in northwestern provinces. The relationship between arsenic content and coal-forming period, coal rank is studied. It was observed that the arsenic contents decreases with coal rank in the order: Tertiary>Early Jurassic>Late Triassic>Late Jurassic>Middle Jurassic>Late Permian>Early Carboniferous>Middle Carboniferous>Late Carboniferous>Early Permian; It was also noted that the arsenic contents decrease in the order: Subbituminous>Anthracite>Bituminous. However, compared with the geological characteristics of coal forming region, coal rank and coal-forming period have little effect on the concentration of arsenic in Chinese coal. The average arsenic concentration of Chinese coal is lower than that of the whole world. The health problems in China derived from in coal (arsenism) are due largely to poor local life-style practices in cooking and home heating with coal rather than to high arsenic contents in the coal.

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### 1. Introduction

Coal plays an important role in the energy consumption of China. About 75% of China's energy needs come from coal combustion and this reliance is not expected to change over the

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next several decades. However, coal is not a clean energy. It contains many harmful compounds, such as arsenic and mercury. During mining and combustion, these toxic substances may be transferred to ambient environment and affect human health (Swaine and Goodarzi, 1995; Matschullat, 2000; Finkelman et al., 2002). Arsenic presents a high potential of environmental impacts. The potential arsenic contamination of water, air, and food from coal is a significant environmental health concern (Bencko and Symon, 1977; Zheng et al., 1999; Ng et al., 2002). In Guizhou Province, China, more than 3000 people have suffered from arsenism due to burning high arsenic coal (Zheng et al., 1999). The arsenic contents of many coals can be reduced by up to 70% by cleaning (Finkelman, 1994); however, in 1997, only about 20% of the coal mined in China was subjected to cleaning (Chen, 2001). In many regions in China, raw coals are burned directly.

Although widely distributed in the natural environment, arsenic is generally present in very low concentrations. Concentrations of arsenic in most of coals range from 0 to 80 mg/kg and the mean is 5 mg/kg (Swaine, 1990; PECH, 1980). But some coals contain especially high-arsenics in certain regions in China (Zheng et al., 1999; Ren et al., 1999a,b). Thus, knowing the distribution of As in coal is very important. With respect to production of a clean utility coal, coals of low arsenic content will be most desired because coals with high arsenic contents will have to be cleaned before combustion. The concentration distributions of arsenic in Chinese coals have received much attention (Chen et al., 1989; Ren et al., 1999a,b; He et al., 2002; Zhang et al., 2004). However, their results of the average arsenic content of Chinese coals are not quite precise due to insufficient samples from the limited areas, and a study of more coal samples from larger areas in China is required to obtain a more representative mean value of arsenic in Chinese coals.

In this study, 297 representative coal samples were measured by molybdenum blue coloration method. The average and geometric mean of arsenic in Chinese coals are reported, and the relationships between arsenic content and coal-forming period, coal rank are examined.

## 2. Sampling and analysis

### 2.1. Samples studied

Our nationwide sampling program was based on the following: (1) the coal reserves of five main coal-bearing areas, (2) the production of 26 provinces in 2000, (3) coal rank and coal-forming period. In China, six coal-bearing areas can be identified, namely Permo-carboniferous (C-P) coal-bearing area in northern China, Late Permian (P<sub>2</sub>) coal-bearing area in southern China, Early-Middle Jurassic (J<sub>1-2</sub>) coal-bearing area in northwestern China, Late Jurassic (J<sub>3</sub>) coal-bearing area in northeastern China, Mesozoic-Cenozoic (M-C) coal-bearing area in Yunnan Province and Tibet, and Tertiary (T) in Taiwan Province (Wang et al., 1992). The coal reserves in Yunnan Province and Tibet are less than 20 billion tons and exploitation is not yet well developed. Consequently only one coal sample was taken from this area. There are no coal mines in Shanghai and Tianjin Cities. The production of coals in Zhejiang Province, Hainan Province and Tibet is very low. Thus, there are no sampling sites in these regions. Coal sampling sites are shown in Fig. 1. The samples were collected from coal seam and the weight of every sample is about 5 kg. The samples were prepared by grinding, and screening through 200-mesh sieve. To avoid contamination and weathering, all samples were stored in plastic bags.

### 2.2. Reagents

Stock solution of 100  $\mu\text{g ml}^{-1}$  As was prepared by dissolving As<sub>2</sub>O<sub>3</sub> 0.1320 g into the mixture of 2 ml 6 mol l<sup>-1</sup> NaOH and 50 ml de-ionized water. Then 2.5 ml 6 mol l<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub> was added into the solution, followed by being diluted to 1000 ml with de-ionized water. 50 ml of the stock solution was diluted to 500 ml to make standard solution.

KI solution was prepared by dissolving 3 g KI into 17 ml de-ionized water before being used.

SnCl<sub>2</sub> solution was prepared by dissolving 8 g SnCl<sub>2</sub> into 12 ml 36.5% HCl.

I<sub>2</sub> solution was prepared by dissolving 9 g KI and 1.5 g I<sub>2</sub> into de-ionized water and being diluted to 1000 ml.

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