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Vertical variations of mercury in Pennsylvanian coal beds from Indiana

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Abstract

Twenty-three in-situ coal sections were sampled in Indiana mines to investigate mercury (Hg) concentrations, with a special reference to in-seam vertical variations in Hg distribution. In addition to raw coal, corresponding float fractions were also analyzed to evaluate the effectiveness of Hg reduction during conventional pre-combustion washing. Hg content in Indiana coals in the locations studied averages 0.11 mg/kg, which after recalculation into equal energy units corresponds to 9.2 lb Hg/10^{12} Btu (~39.5 kg Hg/10^{10} MJ). Hg content is reduced after washing to 0.07 mg/kg on average, corresponding to an equal energy Hg loading of 5.2 lb Hg/10^{12} Btu (~22.3 kg Hg/10^{10} MJ). A large portion of Hg appears to be associated with pyrite, as in the Springfield Coal Member of the Petersburg Formation (Pennsylvanian). In the samples from the Danville Coal Member of the Dugger Formation (Pennsylvanian), Hg is associated to a larger extent with organic matter. Large differences in Hg content may exist between different portions of a coal bed in a single location, indicating that very careful, complete sampling is necessary to get representative Hg concentration data.

Keywords: Mercury; Coal; Pennsylvanian; Illinois Basin; Indiana

1. Introduction

Inorganic constituents in coal have a significant effect on almost every aspect of coal utilization, as well as major impacts on the environment. Mercury is one of the elements of special environmental concern; being highly volatile (it volatilizes at temperatures as low as about 150 °C; Finkelman, 1981), it poses a special problem for utilities. The Clean Air Act authorized the U.S. Environmental Protection Agency (EPA) to regulate mercury emissions form electric utilities. On December 15, 2003, the EPA issued a proposal to permanently cap and reduce mercury emissions from power plants, and in its supplemental proposal of February 24, 2004, provided rule language for a model cap-and-trade approach that will reduce Hg emissions by 70% when fully implemented (EPA, 2004).

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Emissions from coal-fired power plants are considered the largest anthropogenic point source of mercury released to the atmosphere (EPA, 1998a,b, 2000). About 48 tons of mercury are emitted annually in the U.S.A as a result of fossil fuel combustion, mostly from coal-fired power plants. Although exposure to the elemental mercury emitted to the atmosphere from coal-fired power plants is not considered harmful, transformation of this mercury to methylmercury in the aquatic environment results in elevated concentrations in fish. Fish consumption is the primary source of human exposure to mercury.

Mercury is a difficult element to remove from coal during the conventional cleaning process. Available data indicate that usually 25 to 50% of mercury can be removed, but the range of Hg removal is very broad and often unpredictable (Akers and Despoy, 1992; Junk et al., 1986; Cavallaro et al., 1978). Therefore, it is important to identify coal beds and coal zones having the lowest mercury contents.

The purpose of this paper is to investigate the distribution of mercury within selected coal beds in Indiana, with special emphasis on the vertical variations within individual beds. The two major objectives of this study are to (1) better understand depositional and postdepositional factors that influence mercury concentrations in the coals, and (2) determine to what extent mercury can be reduced by conventional coal washing. To address the second objective, float fractions of all coal samples were analyzed for their mercury contents, in addition to the corresponding whole coal samples.

2. Geologic setting

Coal-bearing rocks in Indiana are part of the Pennsylvanian System of the Illinois Basin. The Illinois Basin is a broad, shallow, trough-like structural depression. The source of sediment is generally thought to have been the southern part of the Canadian Shield and, possibly, the highlands of the Northern Appalachians (Potter, 1962, 1963). For many decades, the depositional environment of the Pennsylvanian in Indiana was considered as a dominantly fluvial-deltaic setting punctuated with short-term marine transgressions and regressions. Such an interpretation was the basis for the so-called "cyclothem" concept, developed for the Pennsylvanian System in the Illinois Basin (Wanless et al., 1969; Wanless and Wright, 1978). More recently, a tidally dominated coastal setting has been proposed for various Pennsylvanian intervals in Indiana, based on

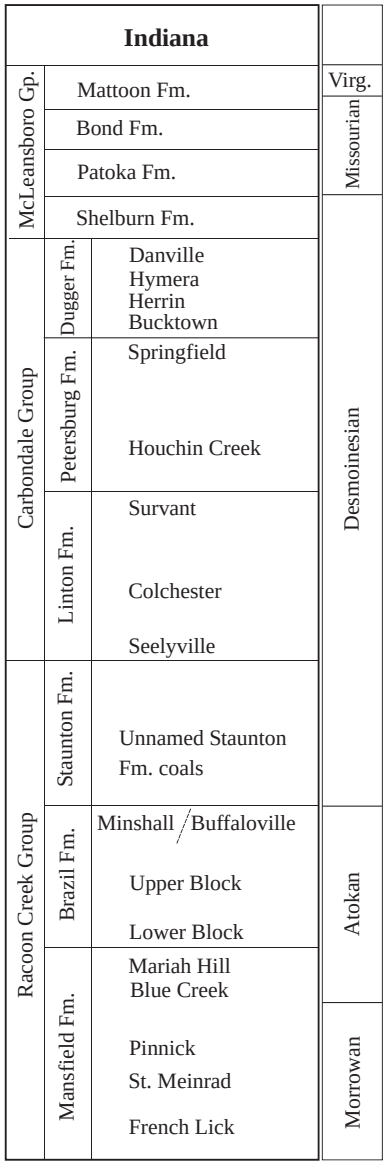

Fig. 1. Lithostratigraphy of the Pennsylvanian System in Indiana (modified from Mastalerz and Harper, 1998; The TriState Committee on Correlation of the Pennsylvanian System in the Illinois Basin, 2001). The chart shows the relative position of major coal beds.