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Control of Trace Elements During the Increasing Development of Coal For Energy

Bobby G. Wixson
Missouri University of Science and Technology, wixsonb@mst.edu

Ernst Bolter
Missouri University of Science and Technology

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Bobby G. Wixson and Ernst Bolter
University of Missouri-Rolla
Rolla, Missouri

1. INTRODUCTION

The question of an energy crisis continues as many people in the United States have difficulty and become confused with what seems to be a continuing excess of gasoline, oil products and questionable reporting of price increases and profit margin by energy companies. However, the majority of the scientific and engineering community, knowledgable politicians and the general public realize that the energy crisis is real. Fortunately there still remains time to practice conservation and the development of alternative and new sources of energy if the United States can unite and implement a viable energy plan.

On 29 April, 1977 President Carter presented a National Energy Plan to the American people outlining the energy problems and possible solutions (1). It is hopeful that the public will respond positively to this challenge while the opportunity still exists for the selection of several various options, rather than exhausting or being denied oil and natural gas energy sources without the benefit of alternate fuels. However, many technical and social problems remain to be solved before alternative or new energy sources are available for utilization.

The continuing energy crisis coupled with the proposed United States energy policy, designed to achieve independence from imported oil products, has projected the increased utilization of coal which is our most abundant fossil fuel source. The problems are that coal is known to be a rather impure fuel source which varies with composition, energy values, sulfur, ash and toxic trace element concentration dependent upon its type and geographic location.

The electric utilities are the major consumer of coal and used 403,249,000 tons in 1975 (2). The U. S. Bureau of Mines has projected a usage figure of approximately 1000 million short tons by 1985 with coal meeting the greatest portion of increased energy needs in the United States (1).

There are many environmental and health problems associated with increased coal production. Mining (underground and surface) problems are leaching, water contamination and possible burning while transportation and open storage present other problems. The ultimate combustion of coal presents particular problems in the release of sulfur dioxide along with various trace or fugitive elements into the environment.

2. REGIONAL DISTRIBUTION OF TRACE ELEMENTS

Regionally the United States may be divided into three major coal producing regions: the eastern; midwest; and western coal regions as illustrated in Figure 1. The trace element content of these coals is given in Table 1.

By geographic distribution some of the more volatile or potentially dangerous trace element concentrations of lead, zinc, and mercury are found to be highest in the Eastern Region. Arsenic, antimony, beryllium, cadmium, and selenium concentrations are found to be elevated in the Western coals with the Appalachian region also containing high beryllium concentrations. Lower concentra-

MAJOR COAL REGIONS

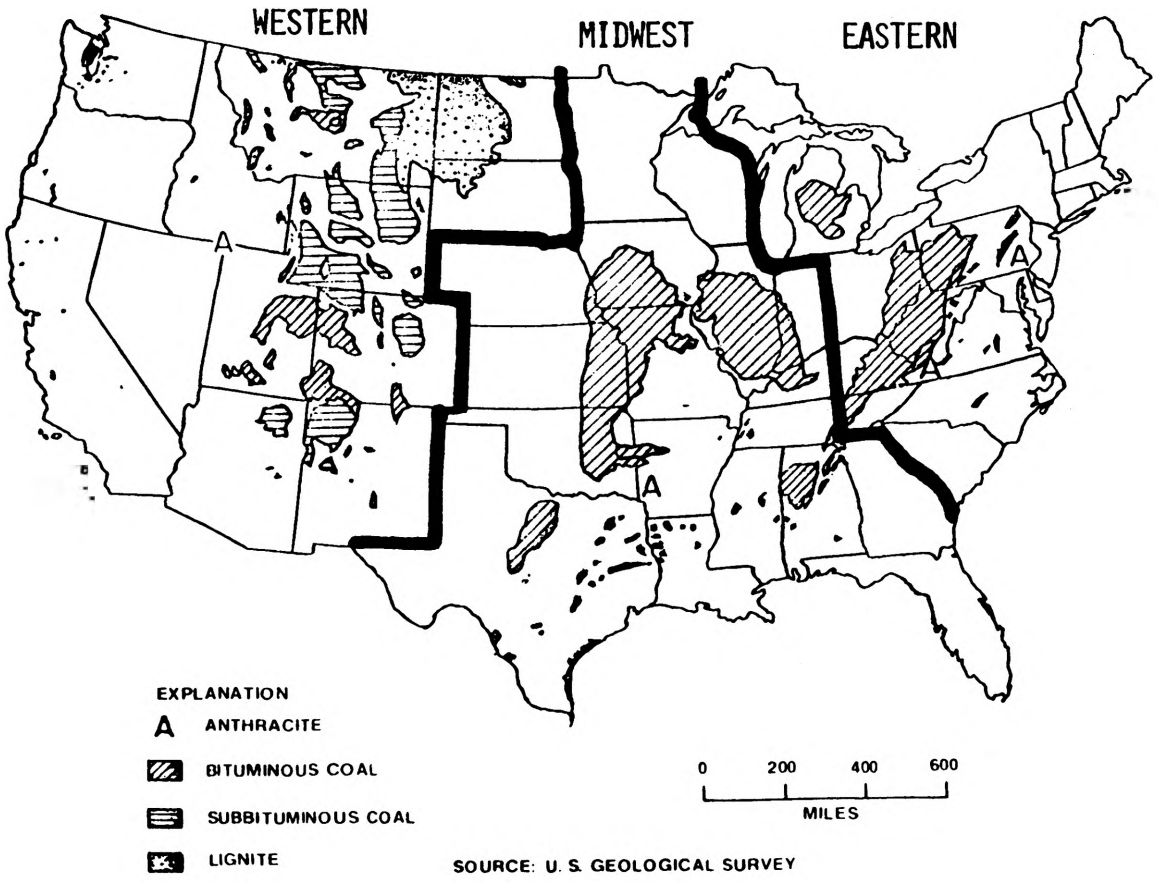

FIGURE 1. COAL FIELDS OF THE UNITED STATES

tions of these elements are also found in the Powder River Basin of the Northern Great Plains or Western Region (Table 2).

TABLE 1. TRACE ELEMENT CONTENT OF U.S. COALS (3) IN PARTS PER MILLION (PPM)

	REGION		
Element	Western	Midwest	Eastern
Beryllium	1.1	2.5	2.5
Boron	33	96	25
Titanium	250	450	340
Vanadium	18	35	21
Chromium	13	20	13
Cobalt	4.6	3.8	5.1
Nickel	14	15	14
Copper	11	11	15
Zinc	108	44	7.6
Gallium	2.0	4.1	4.9
Germanium	5.9	13	5.8
Molybdenum	3.1	4.3	3.5
Tin	1.3	1.5	0.4
Yttrium	7.4	7.7	14
Lanthanum	6.5	5.1	9.4

TABLE 2. DISTRIBUTION OF ENVIRONMENTALLY HAZARDOUS TRACE ELEMENTS IN COAL (PPM) (4)

	REGION		
Element	Western	Midwest	Eastern
Antimony	3.5	1.3	1.2
Arsenic	16	14	18
Beryllium	2	1.8	2.0
Cadmium	20	2.3	0.2
Mercury	0.13	0.19	0.16
Lead		34	12
Selenium	5.7	2.5	5.1
Zinc		250	13

3. ENVIRONMENTAL CONTAMINATION FROM TRACE ELEMENTS IN COAL

Problems associated with the development of coal may be divided into the four main categories of mining, preparation, (washing), transportation, and utilization (combustion, liquefaction, gassification, and others). Each of these categories may serve to either release or remove (control) certain trace elements from coal. Various concerns for each procedure are discussed below.

I. Mining

Coal mining is considered as either surface (strip) or underground mining. Both contribute to:

A. Particulate contributions in dust from operations.

B. Possibility of acid mine drainage or leaching through refuse piles associated with mining.

C. Air pollution by dust from refuse piles or fires.

II. Preparation

The coal preparation may take several forms during which many of the trace elements are removed. One of the most popular concepts is that it is more economical and environmentally sound to remove trace elements, sulfur and other products by washing rather than to rely on precipitators or scrubbers during the combustion process (5).

Trace elements in coal preparation wastes have been reviewed by Wewerka, Williams, Wanek and Olsen (6) and the various coal-cleaning methods are presented in Table 3.

TABLE 3. COAL CLEANING METHODS (6)

Washer Type	Fraction of coal cleaned by equipment type (%)			
	1942	1952	1962	1972
Jigs	47.0	42.8	50.2	43.6
Dense-Medium processes	8.8	13.8	25.2	31.4
Concentrating tables	2.2	1.6	11.7	13.7
Flotation	---	---	1.5	4.4
Pneumatic	14.2	8.2	6.9	4.0
Classifiers	7.4	8.5	2.1	1.0
Launders	13.1	5.2	2.2	1.0

Additional research remains to be done on trace-element removal during the washing process since trace elements differ in their susceptibility of removal by the density separation process.

Table 4 illustrates the trace elements removed by the coal cleaning process. Trace element research by the Bituminous Coal Research Inc. has indicated that coal cleaning represents a potential method for controlling many harmful constituents found in coal (7). These findings also illustrate that one of the major

TABLE 4. PERCENT OF TRACE ELEMENTS REMOVED BY COAL CLEANING (7)

Trace Element	Coal Sample Number							
	2847	2856	2860	2881	2889	2900	2926	2928
Arsenic	21	67	67	59	15	39	11	45
Lead	28	53	63	37	8	19	16	34
Manganese	16	53	76	58	39	9	24	18
Mercury	23	64	68	44	3	15	4	20
Selenium	9	61	55	39	19	10	2	29

problems remaining is the treatment or proper disposal of the wash water or residues remaining from these processes containing a higher concentration of trace elements than was present in the feed coal. The residues are of particular concern since some are landfilled thereby increasing the potential hazard of leachates. More research is needed in this area.

III. Transport of Coal

Presently coal is transported by railroad, trucks, barges, conveyer belts and pipeline slurries. Each of these methods lend themselves to potential environmental contamination by blowing dust, leachates from rain or the disposal of excess water used in the slurry process. Additional work is needed to determine what types of trace elements might be released during transport and what control methodology might be employed to minimize these problems.

IV. Combustion or Utilization

Coal may be burned to produce heat, gasified or liquefied to produce a fuel. Also the in-situ gasification of coal, where the coal is ignited underground under pressurized air and steam, is receiving renewed interest as a more environmentally sound method. Environmental concerns are the problems of sulfur removal, corrosion of materials and the disposal of wastes. All of these processes have been examined in detail and extensive reports compiled by groups such as the Oak Ridge National Laboratory concerning the environmental health and control aspects of coal conversion (8) and trace elements in coals and other fuels (9). Other groups have investigated the health impacts of environmental pollution in energy development impacted communities (10).

Similar concerns for trace elements in Australian bituminous coals has been reported by Swaine (11). Additional research is continuing throughout the world to understand these problems and to develop more effective control measures.

4. SUMMARY

The increasing development of coal resources to meet our energy crisis has resulted in new environmental concerns, especially in the trace element area. There is a need for more knowledge on the geochemical composition and concentrations of potentially hazardous trace elements associated with the mining, processing, transport, and energy conversion of coal. Such research will allow for the development of needed coal resources through the prevention, control or recovery of trace elements that might otherwise present environmental and health problems.

5. ACKNOWLEDGMENTS

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6. REFERENCES

(1) The National Energy Plan Executive Office of the President, Energy Policy and Planning, Washington, D. C. (April 1977).

(2) Asbury, J. G., Kim, H. T., and Kouvalis, A., "Survey of Electric Utility Demand for Western Coal", Argonne National Laboratory, Argonne, IL. Report ANL/ES-58 (Jan 1977).

(3) Ensminger, J. T. "Coal: Origin, Classification, and Physical and Chemical Properties", In: Environmental, Health and Control Aspects of Coal Conversion: An Information Overview. Braunstein, H.M., Copenhaver, E.D., and Pfuderer, H.A., (editors) Oak Ridge National

Laboratory, Oak Ridge, Tenn. ORNL/EIS-94, p 2-34, (April 1977).

(4) Zubovic, P. Geochemistry of Trace Elements in Coal, U. S. Geological Survey, Reston, VA (1975).

(5) "Coal Use: Which of Three Choices?" In: Environ. Sci. & Technology, Vol. 11, No. 8, p. 750-751 (August 1977).

(6) Wewerka, E. M., Williams, J. M., Wanek, P. L., and Olsen, J. D., Environmental Contamination From Trace Elements in Coal Preparation Wastes. Prepared for the U. S. Environ. Protection Agency and the U. S. Energy Res. and Development Admin., ERDA LA-6600-MS, EPA-600/7-76-007, Washington, D. C. (August 1977).

(7) Ford, C. T., Care, R. R., and Bosshart, R. E., "Preliminary Evaluation of the Effect of Coal Cleaning on Trace Element Removal". Trace Element Program, Report No. 3, BITUMINOUS COAL RESEARCH INC., Monroeville, PA (July 1976).

(8) Braunstein, H. M., Copenhaver, E. D., and Pfuderer, H. A. (editors), Environmental, Health and Control Aspects of Coal Conversion: An Information Overview. Oak Ridge National Lab., Oak Ridge, Tenn., ORNL/EIS-94, Two volumes (April 1977).

(9) Trace Elements in Coals and Other Fuels, Part I and II, Toxic Materials Info. Center, Oak Ridge Natl. Lab., Oak Ridge, Tenn., (February 1975).

(10) Health Impacts of Environmental Pollution in Energy-Development Impacted Communities. Final Report, U.S.E.P.A. Contract No. 68-01-1949, Copley International Corp., La Jolla, CA (September 1976).

(11) Swaine, D. J. "Trace Elements in Coal" In: Recent Contributions to Geochemistry and Analytical Chemistry, Tugarinoo, A.I. Editor. John Wiley & Sons, Inc., New York (1975).