ILLINOIS BASIN COAL SAMPLE PROGRAM AND ACCESS TO INFORMATION ON ILLINOIS BASIN COALS

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ABSTRACT

The Illinois Basin Coal Sample Program (IBCSP), was established in 1983 at the Illinois State Geological Survey (ISGS) to facilitate comparisons of results among laboratories conducting basic and applied research on Illinois Basin coal. The sizes of samples available to the individual user and the focus on Illinois Basin coals are distinguishing characteristics of this program. The unit sizes provided to most requesters have been 1/256th of a 55-gallon barrel of coal (nominally 1.5-pound), 1/16th of a barrel (nominally 20-pounds) or one barrel (approximately 400 pounds). The Illinois Coal Development Board (ICDB) and the State of Indiana fund the IBCSP through the Center for Research on Sulfur in Coal (CRSC). The program makes samples available not only to CRSC contractors, but other research groups as well. Additionally, the CRSC supports a computerized information system through which on-line access to data bases on compositions of the IBCSP samples at the ISGS and on research being conducted on these samples is available.

Six Illinois Basin coals, designated IBCSP-1 through IBCSP-6, are available. Three mine-washed Illinois coals became available in 1983: IBCSP-1, a Herrin (Illinois No. 6); IBCSP-2, a Colchester (Illinois No. 2); and IBCSP-3, a mixture of a Springfield (Illinois No. 5) and a Herrin (No. 6). A fourth coal, IBCSP-4, a tipple (run-of-mine) Herrin (No. 6) coal, was added to the program in 1984. The fifth sample (IBCSP-5), a 3-ton channel sample of a Herrin (No. 6), was collected in 1985 and processed into 1-pint cans, 1-gallon cans and 5-gallon cans by Argonne National Laboratory (ANL). This sample is of higher quality than the other five; it was maintained under argon from the mine to the processing facility and all processing was carried out in ANL's inert atmosphere facility designed for the Premium Coal Sample Program (PCSP). IBCSP-5 matches the Illinois coal in the PCSP (PCSP-3). Because the replacement cost for this sample will be very high, charges are made depending on the quantity requested. The sixth sample, provided by the State of Indiana in December 1986, is a mine-washed sample of Springfield (No. 5) Coal from Southwestern Indiana. Multi-ton quantities of the five samples (3/8" x 0) are being maintained in 55-gallon barrels under a low pressure of nitrogen gas at the Applied Research Laboratory of the ISGS in Champaign, Illinois.

Characteristic properties -- maceral composition, reflectance of vitrinite, size and maceral association of pyrite grains, mineral matter composition, and minor and trace element compositions -- were determined on the samples. The informational data base comprising these and other data was established on a mainframe computer at the University of Illinois. The name, address, sample numbers, project title, and project objectives for each project using one or more of the IBCSP samples are included in this data base. To date more than 156 uniform splits of the first four samples in the program have been provided to 67 researchers, 34 located in Illinois. The remainder are in other states and Canada. Telephone requests for information on the IBCSP are received at 217-333-5161.

INTRODUCTION

Coal sample programs, frequently called sample banks, facilitate coal research not only by providing a source of samples but also by simplifying comparisons of results among laboratories that use representative fractions of the same coal. A number of sample programs are in operation in the United States -- the most widely known is the Penn State Coal Bank -- but few provide multi-pound quantities to their users. Additionally, few programs concentrate their efforts on coals from one basin.

In Illinois, the Gas Research Institute, Argonne National Laboratory, Southern Illinois University and the Illinois State Geological Survey are leaders in the development of coal sample programs. The Gas Research Institute (GRI) and the U. S. Department of Energy (U.S.DOE) sponsored a Coal Sample Bank Workshop in March of 1981 to resolve some of the technical problems of establishing a premium coal sample program [1]. The goal was the collection and storage of coal under conditions calculated to preserve as many of the physical and chemical properties as possible. With GRI funding, R. R. Dutcher at Southern Illinois University (SIU) began a study in 1981 on techniques for field acquisition, transporting, processing and storage of premium coal samples. The results are available in the final report [2]. The ANL initiated the Premium Coal Sample Program (PCSP) in late 1982 to meet nation-wide, small-scale, basic-research needs of the research community. A rigid-wall facility was constructed for processing barrel quantities of coal in a nitrogen environment with remote-control equipment [3]. Exceptional care was taken in collection, transport, processing, and storage of the channel samples stored in this program. The relative humidity of the nitrogen atmosphere was controlled to avoid changes in the moisture level. The samples are now available in 5 and 10 gram quantities, hermetically sealed in glass ampules [4].

The Illinois Coal Development Board (ICDB) funds a variety of coal research projects in the State of Illinois. To provide continuity in succeeding years, the ICDB at its first meeting in 1982 expressed interest in funding a project to collect and store reasonably large samples of coal. The board desired to assure the availability of a few of the same coals used by the first year's ICDB contractors for research in subsequent years. The Minerals Engineering Section of the ISGS agreed to collect additional coal and store it at room temperature in a nitrogen atmosphere. The maintenance of samples together with the distribution of samples has become the Illinois Basin Coal Sample Program (IBCSP). The State of Indiana joined the effort in December 1986 by supplying a sample and becoming a partner in sharing the maintenance and distribution costs.

Five of the six coals in this program have undergone some oxidation before leaving the mine site, during transport to Champaign by truck, and during the time required to crush, riffle and package the samples. For the five coals in question, homogeneity from barrel to barrel was assured by a series of rifflings. For the three-ton lots, the coal was passed through two riffles in succession to produce four sets of four barrels each, each set being equivalent in composition to the other sets. The composition of barrels within a set was not equivalent. In the next stage of riffling, each set was riffled through two riffles in succession to homogenize the four barrels within the set. Added exposure to air was the offsetting cost for this assurance of sample uniformity. For many types of tests, applied bench-scale process testing in particular, the degree of oxidation which occurred is acceptable because all coals entering a commercial process have undergone some degree of oxidation during mining and cleaning. The units delivered to users have been approximately 0.7 kilogram and 11 kilograms (1.5 and 20 pounds). They are produced by riffling a barrel of coal to produce representative fractions. The particle size distribution of the smallest units (1/256th of a barrel) is minus 8 mesh by zero and that of remaining units (1/16th of a barrel or larger) are minus 3/8" by zero. Larger quantities have been supplied to a few projects.

THE SIX COALS AVAILABLE

The six coals now available are described in Table 1. The results of most of the standard ASTM tests are shown in Table 2. The minor and trace elements were also determined (Table 3).

Chemical analyses

Barrel to barrel variations in the initial composition are small based on the analyses of fractions taken during a pilot testing of the homogenization procedure and by the analyses shown in Table 4 (column 1) from riffled fractions of four barrels of IBCSP-4 at the time of the initial packaging. Variations are not more than expected for the analysis of a given sample by different analysts or by different laboratories. Periodic proximate and ultimate analyses show excellent uniformity. Analyses over a two year period for IBCSP-4 in Table 4 are typical. All samples except IBCSP-5, which was specially prepared and prepackaged under nitrogen, can be expected to contain the trace amounts of elemental sulfur shown to accompany oxidation [5].

Minor and trace element analyses

Comparison of the results of minor and trace element analyses with the average of concentrations found in channel samples collected by the ISGS from the Herrin and Springfield seams in Illinois for many years [6], (see Table 3) indicates IBCSP-4 is notably rich in SiO_2, MgO, Na_2O, F, and Rb. The reason for these high values is the relatively high abundance of mineral matter in this run-of-mine sample. It should also be noted that IBCSP-2 contains a relatively high amount of As, Ge, and Pb compared to the average. Germanium is probably associated with the organic matter in the sample, while As and Pb are probably in pyrite.

Petrographic Analyses

On a mineral matter free basis, all six samples are rich in vitrinite (85 to 90 vol %). On this basis, IBCSP-5 contains the most inertinite group macerals (10 vol %). The reflectance of vitrinite (maceral telocollinite) is highest for IBCSP-3 (0.74 %, mean-maximum) and the other samples range between 0.46 to 0.67 percent. Complete analyses were reported by Harvey, et al. [7].

Mineral matter analyses

The total amount of mineral matter is most abundant in IBCSP-4 because this sample is a run-of-mine product and it contains some shale from the mine roof. A trace of marcasite, an orthorhombic form of FeS_2, was detected in all samples except IBCSP-4. Two different carbonates, calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$), occur in IBCSP-5. The differences in the mineral phases in the samples may affect the outcome of desulfurization or cleaning processes applied to these coals. Complete analyses are given in Harvey, et al. [7].

Pyrite size and maceral association

The mean diameters for pyrite grains in the six IBCSP samples range from 4 μm (IBCSP-3) to 9 μm (IBCSP-4). The distribution of particle sizes in each sample is much wider than one might project from these mean values and significant differences exist in the way pyrite is distributed among the particles. These differences determine the effectiveness of physical methods for removing pyrite. Approximately 25 percent of the pyrite in IBCSP-5 occurs within macerals-rich particles versus 80 percent in IBCSP-3 [4].

Table 1. Samples available (ash and sulfur on a moisture-free basis)

Sample no.	Product	Seam	Location	Rank	Ash[1] %	Sulfur[1] %
1	Prep plant	Illinois No. 6	W. Central IL	HVCB	10.3	4.3
2	Prep plant	Illinois No. 2	Western IL	HVCB	6.7	3.2
3	Prep plant	80% Illinois No. 5 20% Illinois No. 6	Southern IL	HVBB	8.4	2.3
4	Run-of-mine	Illinois No. 6	Southwestern IL	HVCB	38.1	4.2
5	Channel	Illinois No. 6	Southwestern IL	HVCB	18.0	4.6
6	Prep plant	Indiana V[2]	Southwestern IN	HVCB[3]	9.0	3.8

[1] Analyses in February 1987

[2] The Springfield (Illinois No. 5) Coal is called Indiana V in Indiana

[3] Borderline between HVBB AND HVCB

Table 2. Average[1] analyses[2] of the six coals in the IBCSP (values reported on a moisture-free basis except for moisture)

/Sample number	1	2	3	4	5	6
Moisture	14.14	13.62	5.36	10.21	9.47	10.42
Volatile matter	44.12	43.34	39.20	30.56	40.38	39.56
Fixed carbon	45.62	49.92	52.48	31.36	41.61	51.44
H-T ash	10.28	6.66	8.36	38.10	18.00	9.00
Carbon	67.66	73.31	73.82	45.97	63.26	71.64
Hydrogen	4.86	5.21	4.94	3.46	4.40	4.73
Nitrogen	1.18	1.47	1.68	0.80	1.23	1.78
Oxygen (by difference)	11.63	10.09	8.75	7.43	8.39	9.05
Sulfatic sulfur	0.06	0.10	0.09	0.10	0.00	0.0
Pyritic sulfur	1.20	2.34	1.03	2.33	2.55	1.83
Organic sulfur	3.00	0.92	1.16	1.76	2.08	1.94
Pyritic/organic S ratio	0.40	2.53	0.89	1.32	1.23	0.92
Total sulfur	4.26	3.23	2.27	4.19	4.63	3.77
Chlorine	0.13	0.03	0.18	0.05	0.09	0.03
Calorific value (Btu/lb)	12606	13526	13437	8492	11522	13248
Free swelling index[3]	4.5	4.3	5.2	2.1	3.8	4.7

[1] Average of all analyses through December 1986 for IBCSP-1 through IBCSP-5. Average of 10 analyses in February 1987 for IBCSP-6

[2] All values are percent except for pyritic/organic sulfur ratio, calorific values and FSIs

[3] FSIs are normally reported to the nearest 0.5 unit

Table 3. Minor and trace elements

Oxide/element	IBCSP sample number 1	2	3	4	5	Average IL coal*
Minors (%)						
SiO_2	4.6	1.8	4.1	22.1	8.2	5.5
Al_2O_3	1.6	0.9	1.8	6.5	2.9	2.5
Fe_2O_3	1.7	2.8	1.5	3.8	3.4	2.7
MgO	0.09	0.038	0.073	0.529	0.185	0.046
CaO	0.5	0.2	0.1	1.4	1.2	1.0
Na_2O	0.139	0.0182	0.0297	0.337	0.168	0.0987
K_2O	0.21	0.11	0.2	0.99	0.33	0.22
P_2O_5	0.02	0.01	0.03	0.09	0.02	0.02
TiO_2	0.08	0.03	0.09	0.31	0.15	0.11
Traces (ppm)						
Ag	<1	<1	<1	<1	<0.2	0.06
As	2	32	16	5	2.6	11
Ba	32	14	28	135	73	140
Be	1.4	3.3	1.2	2.7	1.0	1.5
B	193	109	71	317	179	118
Br	6	3	12	3	6.5	12
Cd	1.1	0.8	0.1	<0.4	-	1.5
Ce	6	2	10	21	19	14.7
Co	3	6	5	9	3.8	5
Cr	31	7	16	44	19	18
Cs	1.1	0.8	1.2	4	1.9	1.0
Cu	9.7	21.9	8.0	14.4	9.5	12.5
Dy	0.6	1.5	0.9	1.7	-	1.1
Eu	0.2	0.2	0.2	0.5	0.2	0.3
F	63	26	56	460	-	68
Ga	3	3	3	10	3.4	3.9
Ge	<5	30	<5	<5	5	5
Hf	0.4	0.2	0.5	1.7	1.0	0.6
La	4	2	7	16	5.9	7
Li	11.3	18.1	29.9	38.9	8.2	16.3
Lu	0.1	0.1	0.1	0.3	0.08	0.1
Mn	31	16	13	112	71	55
Mo	15	4	13	6	9	9
Ni	11	22	14	23	15	18
Pb	8	149	57	28	6	28
Rb	9	5	11	63	20	16
Sb	0.2	3.4	1.1	0.3	0.3	1.0
Sc	2.1	2.1	2.6	6.4	2.4	2.7
Se	1.5	1.3	2.2	2.2	2.4	2.4
Sm	0.9	0.9	1.4	2.9	1.2	1.4
Sn	<1	<1	<1	1.7	<5	-
Sr	25	12	33	58	29	34
Ta	0.1	0.1	0.1	0.4	0.25	0.2
Tb	0.1	0.2	0.2	0.2	0.13	0.2
Th	1.2	0.7	1.3	3.9	3.2	2.2
Tl	<2	<2	<2	<2	1.0	1.0
U	<2	<1.5	<4	<3	1.2	1.5
V	25	22	26	50	23	31
W	<0.5	<0.5	<0.7	0.9	1.5	0.6
Yb	0.4	0.6	0.5	1.0	0.5	0.6
Zn	172	99.8	45.1	175	77	248
Zr	16	13	23	51	28	35

* Calculated from data on channel samples from the Herrin (No.6) and Springfield (No. 5) Coals (Harvey, et al., 1983).

Table 4. Analyses of IBCSP-4[1]
(values reported on a moisture-free basis except for moisture)

Analysis[2]	C22538-41 July 84 Av. (Std. Dev.)[3]	C23924 Sept 85	C24450-51 March 86	C24893 July 86
Moisture	10.2 (0.05)	10.2	10.2	10.3
Volatile matter	30.3 (0.17)	30.4	31.2	31.1
Fixed carbon	31.6 (0.27)	31.3	30.8	31.0
Ash	38.1 (0.29)	38.3	38.0	38.0
Carbon	46.92 (0.42)	46.09	48.04	48.00
Hydrogen	3.28 (0.054)	3.44	3.27	3.37
Nitrogen	0.68 (0.045)	1.09	0.80	0.98
Oxygen	6.95 (0.40)	6.82	5.24	5.30
Sulfatic sulfur	0.10 (0)	0.26	0.01	0.0
Pyritic sulfur	2.17 (0.059)	2.36	2.77	2.51
Organic sulfur	1.80 (0.036)	1.61	1.78	1.76
Total sulfur	4.07 (0.071)	4.23	4.55	4.27
Chlorine	0.04 (0.007)	0.03	0.10	0.08
Calorific Value (Btu/lb)	8527 (26)	8407	8462	8469
Free Swelling Index	2.5	2.5	1.5	1.0

[1] Herrin (No. 6) coal (run-of-mine) from a southwestern Illinois underground mine collected December 15, 1983

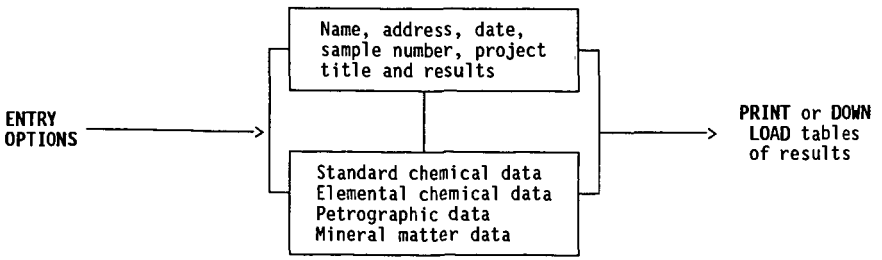
[2] All values are percent except the calorific values and the FSIs

[3] Analyses on riffled fractions from four of the eight barrels

INFORMATION SYSTEM

A computerized information system (data base) is available on a mainframe computer (Control Data, Cyber-175) at the University of Illinois in Urbana. This system operates in parallel with a larger existing data base on the same computer covering the Chemistry of Illinois coals [8]. Both systems can be accessed by an investigator at a remote facility through a modem during a single computer session.

Two types of data files were installed for the IBCSP. The first contains the name, address, project title, and results or objectives of the researchers using the samples; the second contains the chemical and other characteristic properties of the samples:



Names of researchers using these samples and the analytical data can be retrieved. Users of the data base may read about the past and current research on the samples directly at their monitor. Users may also select and obtain hard copy for any type of analytical data or other types of data on a single sample or all six of them. Menu options facilitate downloading retrieved files to the user's own microcomputer. Those who have only a terminal and modem can print retrieved data at the ISGS for mailing to the user. Access to the data base can be obtained by contacting R. Harvey (217-244-0836). A small fee is required to cover the direct computer charges. Persons without terminals can obtain information by contacting either the Coal Section or the Minerals Engineering Section of the Illinois State Geological Survey (217/333-4747) or the Center for Research on Sulfur in Coal (217/333-9241), both located in Champaign, Illinois.

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