

**A PERSPECTIVE ON THE STATUS OF COAL RESEARCH
FROM SHIPMENTS OF SAMPLES**

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INTRODUCTION

Research on all aspects of coal research, at least for more small scale work, involves the use of samples at the beginning of experimental work. Most research workers for smaller scale work do not collect their own coal samples, but rather order them from a group of sample suppliers. The number of suppliers meeting the major needs in the US, as well as for the world, is not very large. An examination of the shipments of samples from each of these suppliers will give an interesting insight into the general trends in volume of work in the field.

The suppliers involved in this study include the Argonne Premium Coal Sample Program, the Illinois Basin Coal Sample Program, the SBN and the several groups of samples from the Pennsylvania State University Coal Sample Bank. Each of these supplies a different number of samples in varying quantities. The quantities and variety of samples is important to the individual worker in selecting a supplier. The type of work to be done frequently affects the quantities and choice of sample, which in turn affects the choice of supplier. Some suppliers tend to ship samples to smaller scale users who tend to do more fundamental work, while other suppliers tend to ship to larger scale users who tend to do both fundamental and the beginnings of applied work. The number of samples shipped from each supplier over a period of years would indicate something of the relative amounts of work done over that period. This paper provides some insight into this measure of work. Individually the trends would speak only for the experience of one sample supplier. If all suppliers have similar experience, then sample shipments may be a useful measure of coal research in the areas that they serve.

The Argonne Premium Coal Sample Program (APCSP).

This program (1) provides samples of 8 coals from the US in two sample container sizes. Either 5 grams of -100 mesh or 10 grams of -20 mesh are available in individual borosilicate glass ampules. Orders may request as many of the ampules as needed for a research program. There is currently a charge of \$1.60 per gram of sample regardless of the sample amount. This program began in late 1982. Samples are processed in a large nitrogen-filled glove box in one ton lots. The samples have been sent to about 350 users in most of the major nations in which coal research is done. Records are kept of the individual shipments, and have been tabulated in terms of the total shipments of ampules on a monthly basis since shipments began. A plot of the cumulative totals of ampule shipments, and also the numbers of -100 and -20 mesh samples shipped is shown in Figure 1. It can be seen that the number of ampules shipped increases in a generally linear fashion at a rate of about 3000 per year. In mid 1987 a number of samples were shipped and appear to have been used in programs until mid 1988 when a more uniform series of orders began. The slope of the plot is consistent to about mid 1991. The slope then decreases through mid 1992, and may be decreasing again. An examination of the relative numbers indicates a greater interest in the finer -100 mesh and smaller sized samples used for the small scale experiments.

An examination of the most popular samples as shown in Figure 2 indicates that the Illinois #6 (IL) is most requested, indicating an interest in the samples with high sulfur content. The second most requested sample, Wyodak (WY), is reactive, large reserves are available at relatively low cost, and is of interest for syn-

thetic fuel production. The other samples in decreasing order of requests are: Beulah-Zap lignite (ND), Pittsburgh (PITT), Upper Freeport (UF) and Pocahontas #3 (POC). Not shown, and less requested are the Blind Canyon and Lewiston-Stockton.

The Illinois Basin Coal Sample Program (IBCSMP)

The goal of this program is to provide reproducible samples of various Illinois Basin coals. The program was initiated in 1983 and currently provides samples of 12 different lots of coal. Most of the lots are mine-washed coals. Samples are available in two sizes, a nominal 1-pound sample (8 mesh by zero particle size) and a nominal 20 pound sample (3/8" by zero) that are 1/256th and 1/16th riffled splits of a barrel of coal, respectively. Samples are provided free of charge to most researchers on request. The ICCI reserves the right to limit the quantities. Distribution of samples from nearly depleted lots is restricted to previous users. Two distinguishing characteristics of the IBCSP are the large sizes of the samples relative to other programs and the focus on Illinois Basin coals.

The time the coal is exposed to air while processing is as short as practical, but the samples (IBC-105 excepted) show minor amounts of sulfatic sulfur and traces of elemental sulfur that are products of air oxidation. Lots are stored under a nitrogen atmosphere to enable users to obtain samples for several years without significant exposure to air.

Analytical historical data and user data are also available. These data include results of semiannual tests of Btu, FSI, forms of sulfur, and chlorine contents, proximate and ultimate analyses and the names, addresses, project titles and research objectives of users of each lot are available. Two hundred investigators made a total of 688 requests and received 2100 samples totaling 25,500 pounds in the ten years of operation through August 1993. Most investigators have requested more than one coal and many have received several shipments. All told, 96 of the investigators were from Illinois, 97 from other states, and 7 from outside the United States; 105 of them were from academic laboratories, 49 from industrial laboratories and 46 from government laboratories. The origins of the 688 requests were: Illinois, 393; other states, 277; outside the United States, 18. The distribution of requests was 327 academic, 250 governmental, and 111 industrial.

The pattern of the distribution for the ten years of operation shows the activity peaked in 1988-90 (Figure 3). Reasons include a peak of activity on laboratory-scale, coal cleaning projects funded by the Illinois Coal Cleaning Institute, Carterville, Illinois. Scale-up of successful projects required quantities larger than those offered by the IBCSP. The program assisted a number of researchers in making arrangements for multi-ton quantities of coal directly from the mines. The pattern of distribution for eight of the 12 lots by year is shown in Figure 4. Not shown are IBC-105, a lot prepared by Argonne National Laboratory from an a block of Illinois #6 coal adjacent to that used in the Premium Coal Sample Program; IBC-107, an $^{34}\text{S}/^{32}\text{S}$ isotopically characterized Herrin (Illinois #6) recommended for researchers who wish to follow the fate of forms of sulfur in chemical reactions of coal by monitoring the ratio of sulfur isotopes in the products; IBC-108, a state-of-the-art, physically-cleaned, micron-sized blend of Herrin (#6) and Springfield (#5) coal (80% and 20% respectively) that now has a very low pyrite and ash; IBC-111, a Danville (Indiana VII) coal.

An ideal projected ten year life for each lot was not reached with IBC-103, IBC-104 and IBC-106. It was not possible to obtain the desired lot of Illinois No. 5 seam in 1983. The compromise was IBC-103, an 80:20 mixture of Illinois #5 and Illinois #6. Its inventory was purposely drawn down in 1986 by use of IBC-103 for mild gasification tests at the time requests for a typical-sulfur coal were shifted to a single-seam lot, IBC-106. Requests for a coal with forms of sulfur typical of Illinois and Indiana coals (about 50:50 pyritic and organic forms) continued high and it was necessary to plan for IBC-106 replacement before 10 years. That replacement is IBC-112. The projected interest in a run-of-mine coal was also underestimated in 1983. The 1500 pounds of IBC-104 lasted only 7 years.

The Pennsylvania State University Coal Sample Bank

Since its inception in 1967, 1457 samples have been collected for this sample bank; 1176 remain available for distribution (2). Thirty more samples will be collected over the next four years as part of the DOE (U. S. Department of Energy) Coal Sample Bank, a subset of the larger Penn State Coal Sample Bank. Samples from all coal provinces of the U. S. are available, representing a wide variety of ranks, organic and inorganic compositions, petrographic constituents and behavior in liquefaction, carbonization and combustion processes.

Typically, whole-seam channel samples of 200 to 300 kg are collected from fresh exposures in active mines. Samples are crushed to -6 mm, homogenized, and subsampled. A portion is crushed to -20 mesh and further subdivided. The typical subsample supplied to researchers is 300 g of coal at -20 mesh, available for \$20.00; larger quantities of -6 mm or -25 mm (for older samples) coal are also available. Samples collected since 1989 in the DECS (Department of Energy Coal Sample) series have been packaged under argon in heat-sealed foil/polyethylene multilaminate bags which preserve initial sample properties (3). Earlier samples in the PSOC series were sealed under argon in steel cans. Analyses are performed on each sample and the resulting data comprise the Penn State Coal Data Base. Computer printouts of analytical data are available for every sample.

The most recent program of sample collection and distribution began in 1988. Since then, over 700 requests for samples and/or data printouts (usually for several samples per request) have been received from more than 250 agencies. Universities accounted for 63% of the requests, government agencies 12 %, and industry 25%. Ninety-five percent of the requests were from the U. S.

Figure 5 shows that in 5 1/2 years, 3270 kg of samples were distributed, 510 kg at -20 or -60 mesh in 300 g bags or cans and the remainder in larger quantities at larger particle sizes. Sharp jumps in the cumulative amount distributed represent occasional shipments of entire 100 kg drums of coal; the increase in May, 1992, represents distribution of 4 drums totaling 400 kg.

The trends in amounts of samples distributed over time are similar to those of the Argonne program. The highest rate of distribution occurred in the first year, followed by four years with a somewhat lower rate which nevertheless represents large quantities of coal samples distributed on a consistent basis. Although a further decrease in rate of distribution occurred late in 1992, periodic variations of 6 to 12 months duration make long term predictions from short term trends inadvisable, and very recent data indicate an increase.

The most requested samples have been those of the Pittsburgh seam (DECS-12, PSOC-1451, -1519, -1528, -1529, 1531), the Illinois #6 seam (DECS-2, PSOC-1493), and the Wyodak (Smith-Roland) seam (DECS-8, PSOC-1520). Recently, U. S. Department of Energy research projects investigating the use of dispersed catalysts for liquefaction have been conducted on the Blind Canyon coal (DECS-6, -16, -17, PSOC-1503). This activity has significantly increased the demand for these samples. Figure 6 illustrates the trends in distribution of these samples. These four seams alone account for over 20% of the samples distributed since 1988, although samples of over 300 other seams with a wide variety of properties are available.

The SBN

The European Center for Coal Specimens, SBN, has collected a large number of coal samples from important mines of the world. These have been prepared in a variety of sizes. A number of these samples have been prepared with special consideration for protection from the atmosphere. A coal catalog is available which indicates source and type of sample as well as analytical information.

It has been observed that the number of requests for general samples from the main collection has been decreasing, but there is a growing interest in production of a certified series of samples dedicated to multi-laboratory research projects as are being sponsored by the European Community's and European Coal and Steel Community's research programs. There is also an interest in samples of coal fly and bottom ashes and of building materials based on secondary resources.

CONCLUSIONS

There are both similarities and differences. There are periodic periods of extensive sample orders that tend to alter some long term trends. The APCSP has seen a period of consistent shipments from late 1988 to late 1991. Since that time there has been a decline to a lower but persistent level of shipments. The most popular coals for the APCSP are the Illinois #6 and Wyodak, reflecting concerns about sulfur in coal, and converting coal into synthetic liquids. The small size of these samples may be an indicator of the level of activity in the most fundamental studies.

The pattern of the Penn State Coal Sample Bank total shipments is similar to that for the APCSP. The most popular coal is from the Pittsburgh seam reflecting interests in liquefaction of this Eastern U. S. high volatile A bituminous coal. The Illinois #6 is second most popular, followed by Wyodak and Blind Canyon seams. The intermediate size of the available samples reflects interests in both basic and somewhat larger scale work.

The IBCSP shipped the largest quantities of coal in 1987 and has shipped declining total amounts since then. The number of researchers requesting samples has declined more slowly than the quantities shipped, reflecting smaller quantities per shipment. The emphasis on coal cleaning at the time of maximum quantities reflects a change in type of work away from coal cleaning. The samples are larger than the APCSP and reflect interests in both basic and applied work.

Overall the distribution curves for the samples reflect a number of rather strong and continuing programs in coal research despite recent difficulties in funding. For all of the programs most of the requests come from academic institutions. Clearly much work is done there, primarily with government funding. Industry and government organizations make similar but fewer requests, reflecting the smaller number of organizations involved in this work. Relatively few requests come from overseas, presumably because their sponsors are outside of the U.S. These workers need to use their domestic sample sources, but want to be able to compare with well-known external samples.

In general these data indicate that researchers realize the advantages of acquiring samples from centralized sample banks. These advantages include a lower cost than would be incurred from individual sampling and preparation; availability of analyzed samples; preservation of samples and the possibility of comparing results with others who have worked on the same samples.

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Figure 4.

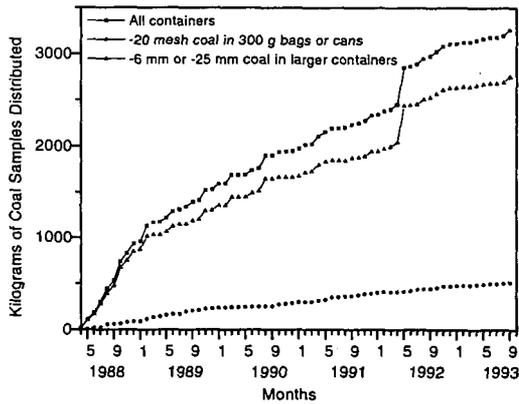
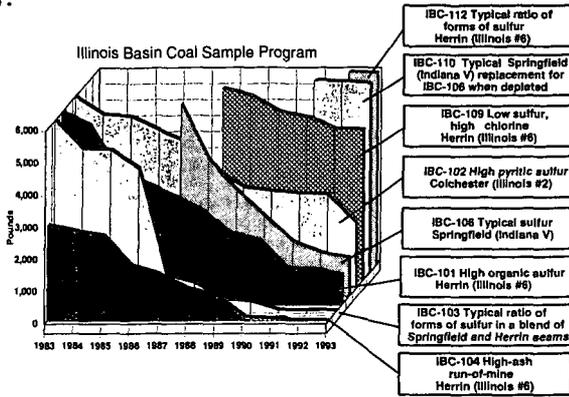


Figure 5. Cumulative weights of samples distributed from the Penn State Coal Sample Bank, -20 mesh (cans and small bags) and -6 mm or -25 mm (buckets, drums and large bags)

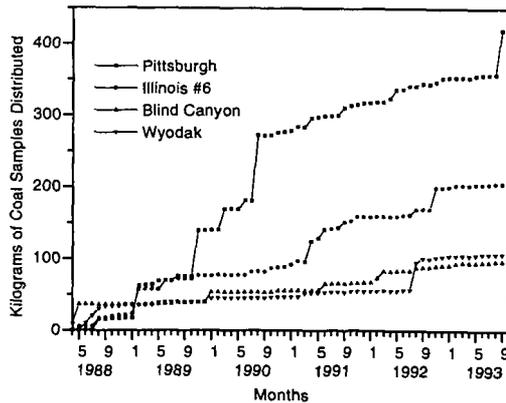


Figure 6. Cumulative weights of most frequently requested samples (Pittsburgh, Illinois #6, Blind Canyon and Wyodak seams) distributed from the Penn State Coal Sample Bank

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