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EFFECTS OF OUTDOOR STORAGE ON ILLINOIS STEAM COALS

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ABSTRACT

The effect of outdoor storage on the properties of steam coal was studied, using a high-volatile C bituminous coal from St. Clair County, Illinois. One portion of the coal was stored in summer, another portion in winter. Procedures used and results obtained are described.

Ash, volatile matter, and total sulfur were not significantly affected by storage begun in either summer or winter, under the conditions used. Free swelling index values dropped after about 48 weeks of storage. Calorific values dropped 2.1 percent in 52 weeks for the summer-stored coal and 1.4 percent in 20 weeks for the winter-stored coal. Definite slacking of the winter-stored coal took place in 88 weeks of storage.

INTRODUCTION

Satisfactory storage of coal is a subject of much concern to users of both small and large tonnages. Considerable experimental work has been done, pointed toward a better understanding of the factors involved and toward development of methods by which coals may be stored for varying periods of time and under various conditions without detriment to desirable characteristics of the coal. Various factors, such as rank of coal, size consist, temperature, weather conditions, place of storage, and type of storage, have been found to influence change in these characteristics.

The Illinois State Geological Survey studied the effect of outdoor storage on the coking characteristics of certain Illinois coals (Jackman et al., 1957, 1959). However, not much work has been done on the effect of outdoor storage on Illinois coals used primarily for heating and raising steam. At the suggestion of George W. Land, member of the Coal Advisory Committee to the Illinois State Geological Survey, work was begun in 1958 to secure such information, and this report presents results of that work. No attempt has been made to include a complete survey of the literature.

Acknowledgments

The cooperation of the Peabody Coal Company in furnishing the coal used in this work is gratefully acknowledged. Various members of the Geological Survey staff, particularly those in the Coal Analysis laboratory, contributed to the investigation.

PROCEDURE

Samples

Two samples of approximately two tons each were obtained from the Seminole Mine of the Peabody Coal Company, St. Clair County, one in July 1958 and one in January 1959. Both were No. 6 Coal and were similarly prepared at the mine as follows:

The raw coal as delivered to the tipple was crushed to 8 x 0 inches at the bottom of the conveyer. The 8 x 3-inch fraction was washed in heavy media vessels at 1.45 sp gr. The 3-inch x 0 fraction was washed in wash boxes at 1.50 sp gr and screened to 3 x 1½ inches and 1½ inches x 0. The 3 x 1½-inch fraction from the wash boxes was combined with the 8 x 3-inch clean product and crushed to give a top size of 1½ inches. The 1½-inch x 0 coal so prepared was collected and used in this study.

The day after arrival at the Survey laboratory, the samples were turned with shovels to mix them thoroughly and put into storage.

Storage

One lot of coal was stored in the summer (July 17, 1958) and the other in the winter (January 21, 1959) to determine, among other things, whether the weathering effects on coal stored in the summer might be different from the weathering effects on coal stored in the winter. Both sets of samples of coal were stored in cloth bags, each holding approximately 100 pounds of coal. The bags of coal were placed on a concrete base outdoors near the Survey Applied Research building. They were placed in tight groups with tops open to permit exposure of the coal to the weather. Around the periphery of the groups other bags of coal were placed as protection against side drafts. At prescribed intervals of elapsed time in storage, samples for analysis were taken by removing one bag of sample coal and replacing it with one of the outside bags of coal in order to disturb as little as possible the weathering conditions of the remaining coal. Fifteen bags of coal (approximately 1500 pounds) were stored in summer and seventeen (approximately 1700 pounds) were stored in winter.

Analyses

Analytical determinations were made for moisture, ash, volatile matter, calorific value, total sulfur, and free swelling index. Moisture, ash, total sulfur, and free swelling index values were determined by regular ASTM (1959) procedures. Calorific values were determined in oxygen bomb adiabatic calorimeters and volatile matter values were determined by the ASTM (1959) modified procedure.

Screen analyses were made on the winter-stored coal both before and after storage.

RESULTS

The results obtained for the summer-stored coal are shown in table 1 and for the winter-stored coal in table 2. Figure 1 shows graphically the effect of outdoor storage on the free swelling index for both the summer- and winter-stored coal. Figure 2 shows graphically the effect of outdoor storage on calorific value (Btu) for both the summer- and winter-stored coal. Table 3 presents the screen analyses of the winter-stored coal.

DISCUSSION

Moisture values are of no significance in this work but they permit calculation of other analytical items to the dry basis. Tables 1 and 2 show no significant changes in ash, volatile matter, and total sulfur for the periods of storage used. However, the ash values serve as an indication of satisfactory sampling throughout the course of this work. For the summer-stored series the widest difference in dry ash values was 0.5, or approximately 5 percent of the average of all determined ash values, and for the winter-stored series it was 0.8, or approximately 7 percent of the average. Both are below the frequently accepted limit of 10 percent of real value for sampling accuracy.

Effects of outdoor storage on the free swelling index of the coal studied may be observed in tables 1 and 2 and in figure 1. The free swelling index (FSI) of the coal stored in the summer of 1958 decreased from an initial value of 4.5 to 2.5 in 60 weeks. The FSI of the coal stored in the winter decreased from 5.0 to 2.0 in 79 weeks. Although these observations are apparent in a general way, it may be noted that the FSI data curves form several hills and valleys for the first 44 to 48 weeks of storage. The precision of the FSI method is probably not better than $\pm \frac{1}{2}$ unit so we might conclude by inspection that the average FSI value of the unweathered coal is approximately 4.0. The FSI value of both the summer- and winter-stored coal remained approximately at this starting value during 47 or 48 weeks of storage. The consistent downward trend of FSI values below the average value of 4.0 occurs after about the same length of storage time for both summer- and winter-stored coal.

Data relating calorific value to storage time appear in tables 1 and 2 and in figure 2. Moisture- and ash-free calorific values (Btu) are plotted to the nearest 100 Btu in figure 2. The heating value of the summer-stored coal decreased from the initial 14,200 to 13,900 Btu in 52 weeks, or 2.1 percent. That of the winter-stored coal decreased from an initial 14,300 to 14,100 Btu in 20 weeks, or 1.4 percent, where (ignoring for the present the indicated drop to 13,900 after 32 weeks storage) it remained through the seventy-ninth week of exposure. A further drop of 100 Btu to 14,000 is shown at the end of 88 weeks of storage.

Certain other indications may be observed in figure 2. Although no firm conclusions can be made at this time, these indications may have possible significance. First, for both summer- and winter-stored coal the first significant drop in calorific value appears to have started at the same time of year, that is, in April.

Second, beginning in the twenty-fourth week, the curve for the winter-stored coal shows a drop of 200 Btu (14,100 to 13,900), followed by a return to 14,100 in the fortieth week, where it remained for 39 weeks of storage.

TABLE 1 - ANALYSES FOR SUMMER-STORED COAL

Lab. no.	Storage time Date	Storage time Weeks	Moisture as rec'd	Ash dry	Vol. matter dry	Sulfur dry	Btu as rec'd	Btu dry	Btu M-A free	FSI
C-10551	7-17-58	0	10.3	10.5	41.1	3.89	11400	12712	14203	4.5
C-10565	7-24-58	1	11.6	10.6	41.0	3.95	11277	12764	14277	4.0
C-10573	7-31-58	2	11.2	10.2	41.3	3.85	11364	12796	14249	4.5
C-10606	8-14-58	4	10.6	10.3	41.3	3.87	11373	12722	14183	3.5
C-10621	9-11-58	8	9.4	10.2	40.8	3.74	11570	12767	14217	3.5
C-10667	10-9-58	12	10.5	10.2	41.6	3.77	11336	12668	14107	4.5
C-10719	11-6-58	16	9.5	10.1	40.3	3.76	11620	12837	14279	4.0
C-10777	12-4-58	20	12.4	10.3	40.6	3.79	11203	12788	14256	4.5
C-10831	1-8-59	24	12.3	10.5	39.9	3.87	11131	12692	14181	3.5
C-10867	2-5-59	28	13.4	10.3	40.4	3.74	11028	12732	14194	4.0
C-10971	4-3-59	36	12.5	10.4	40.2	3.70	11135	12727	14204	3.5
C-11043	5-28-59	44	11.7	10.1	40.7	3.66	11209	12688	14113	4.5
C-11145	7-28-59	52	7.1	10.2	40.4	3.61	11583	12466	13882	3.0
C-11199	9-22-59	60	8.8	10.5	40.7	3.74	11342	12436	13895	2.5

TABLE 2 - ANALYSES FOR WINTER-STORED COAL

Lab. no.	Storage time Date	Storage time Weeks	Moisture as rec'd	Ash dry	Vol. matter dry	Sulfur dry	Btu as rec'd	Btu dry	Btu M-A free	FSI
C-10856	1-21-59	0	10.4	10.9	42.1	3.98	11413	12740	14299	5.0
C-10857	1-29-59	1	7.9	11.0	42.2	4.04	11684	12692	14261	4.5
C-10868	2-5-59	2	9.4	11.2	42.9	4.11	11510	12701	14303	3.5
C-10889	2-19-59	4	10.8	11.3	40.9	4.01	11293	12660	14273	4.5
C-10930	3-19-59	8	11.0	11.2	42.4	4.05	11317	12716	14320	4.0
C-10985	4-16-59	12	9.1	11.1	41.1	3.89	11558	12713	14300	5.0
C-11020	5-14-59	16	10.2	10.8	41.6	3.98	11409	12708	14247	3.0
C-11078	6-11-59	20	7.3	10.9	41.6	3.88	11640	12553	14089	4.0
C-11121	7-15-59	24	6.3	11.1	40.6	4.01	11740	12529	14093	4.0
C-11169	8-12-59	28	7.8	11.1	41.3	4.00	11456	12419	13970	4.5
C-11178	9-8-59	32	10.1	11.0	40.7	3.84	11130	12386	13917	3.5
C-11277	11-6-59	40	12.6	10.9	38.4	3.79	10981	12561	14097	3.5
C-11336	1-4-60	48	12.3	11.4	38.5	3.92	10980	12521	14132	4.0
C-11402	3-22-60	60	7.4*	10.7	41.1	3.74	11692	12621	14133	3.5
C-11539	5-31-60	70	11.3	11.0	40.2	3.70	11114	12526	14074	3.0
C-11658	8-5-60	79	9.6	10.9	42.0	3.73	11337	12536	14070	2.0
C-11718	10-7-60	88	8.7	10.6	39.4	3.66	11426	12516	14000	2.0

* Snow on sample as taken. It was necessary to partially dry the sample in the laboratory before pulverizing it and determining moisture shown.

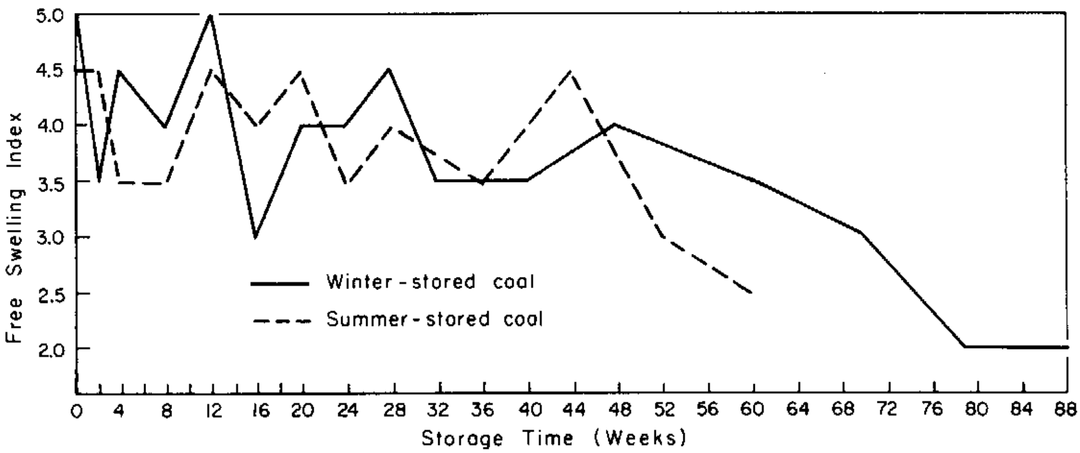

Fig. 1 - Free swelling index vs storage time.

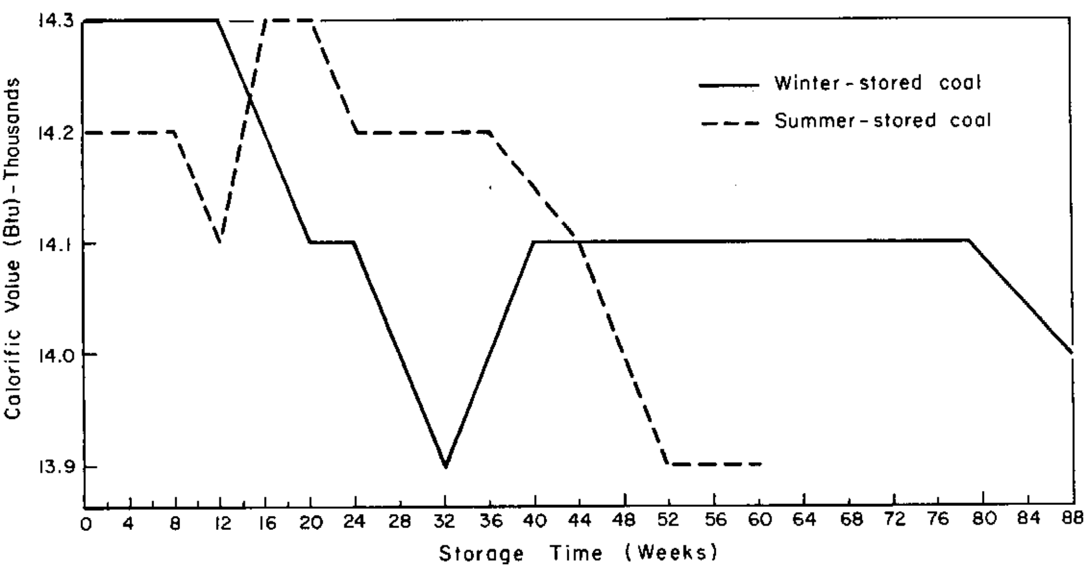

Fig. 2 - Calorific value vs storage time.

TABLE 3 - EFFECT OF STORAGE ON SIZE CONSIST
(Sample stored January 21, 1959)

Size	Before storage (percent)	After 88 weeks storage (percent)
+1 in.	13.5	4.6
-1 in. x 3/4 in.	32.2	12.9
-3/4 in. x 1/2 in.	21.4	19.3
-1/2 in. x 3/8 in.	7.3	13.0
-3/8 in.	25.6	50.2

This may or may not be significant, but it is interesting to note that this is not the first time such behavior has been observed. Several years ago we participated in a three-laboratory check on the effects on calorific value of storing laboratory samples. All three laboratories analyzed the same coal at prescribed times and the data obtained by all three laboratories showed a dip and subsequent return of Btu value.

A third item for speculation is the indicated drop of 100 Btu for the winter-stored coal beyond 79 weeks of storage. Whether this may indicate an actual further effect of storage or whether it is merely experimental error is not known. The early indicated drop of 100 Btu in the curve for the summer-stored coal is not believed to be significant because of the immediately following increase of 200 Btu shown.

One of the known effects of outdoor storage on coal is degradation of particle size, or slacking. Table 3 presents results of screen analyses on the winter-stored coal before and after storage for 88 weeks. Storage brought about a definite increase in percentage of fines at the expense of the larger sizes with the percentage of minus 3/8-inch coal increasing about two-fold. Unfortunately, similar data for the summer-stored coal are not available.

The type of storage used in this study did not duplicate commercial storage, but it did permit control of certain variables such as sampling and non-disturbance of the stored coal. This type of storage probably provided more drastic weathering conditions than would be encountered in a commercial storage pile properly laid down. Therefore, it would seem reasonable to expect that effects of commercial storage on this coal would at least not be greater than those exhibited in this study.

CONCLUSIONS

Neither summer nor winter storage significantly affected ash, volatile matter, and total sulfur of the coal studied.

Free swelling index values for both summer- and winter-stored coal showed little if any reduction up to about 48 weeks of storage. Beyond this period, FSI values dropped, those for the summer-stored coal showing a somewhat more rapid drop.

Calorific value for both summer- and winter-stored coal dropped. The heating value for the summer-stored coal dropped 2.1 percent in 52 weeks, that for the winter-stored coal dropped 1.4 percent in 20 weeks and, in general, remained at this level throughout most of the following 59 additional weeks of storage.

Distinct slacking took place during 88 weeks of outdoor storage of the winter-stored coal.

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