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Strippable Coal Reserves in Twelve Southern Iowa Counties

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Estimates of strippable coal reserves were made for 12 counties in south-central Iowa, for the purpose of updating information regarding Iowa's coal reserve base. Strippable coal here is defined as that coal occurring in seams no less than 28 inches (71 cm) thick and beneath no more than 150 feet (46 m) of overburden. Data concerning location, depth, and thickness of coal were obtained from county reports, and coal mine and water well records on file at the Iowa Geological Survey, supplemented by information from the survey's coal drilling program. Extension of information outside known data points was made in accordance with procedures established by the United States Geological Survey. The all-too-frequent lack of good information about the character of Iowa coal, plus the geological complexity of the coal-bearing rock, make coal bed correlation extremely difficult and adversely affect the reliability of the estimates. About two billion tons (1.8 billion metric tons) of strippable coal are contained within the 12 counties investigated. Coal distribution maps prepared in conjunction with this study may be of value to future coal exploration in Iowa.
INDEX DESCRIPTORS: Iowa Coal, Coal Reserves, Coal Exploration.

Strippable reserves of bituminous coal have been estimated for 12 counties in southern Iowa. The research project was administered by the Iowa Geological Survey under a grant from the United States Bureau of Mines. The purposes of the research were (1) to provide information to the federal government as part of a nationwide program to assess the nation's coal reserve base, (2) to update the State of Iowa's coal reserve data, and (3) to produce coal distribution maps as aids to exploration.

The 12 counties chosen for this study — Polk, Jasper, Warren, Marion, Mahaska, Lucas, Monroe, Wapello, Jefferson, Wayne, Appanoose, and Van Buren — were selected because most of the coal mined previously in the state came from them, and because information about coal mining in these counties was more readily available (see figure 1). Coal underlying these counties forms part of a region including the southwest one-third of Iowa, and extending southward into Missouri, Kansas, and Oklahoma. Stratigraphically, nearly all commercial coal in Iowa comes from the Marmaton and Cherokee Groups of the Des Moines Series of Pennsylvanian age.

PREVIOUS RESEARCH

No previous systematic estimate of original reserves of strippable coal in Iowa has been made. The only other systematic study to date was that done by Landis and Van Eck (1965), in which they estimated

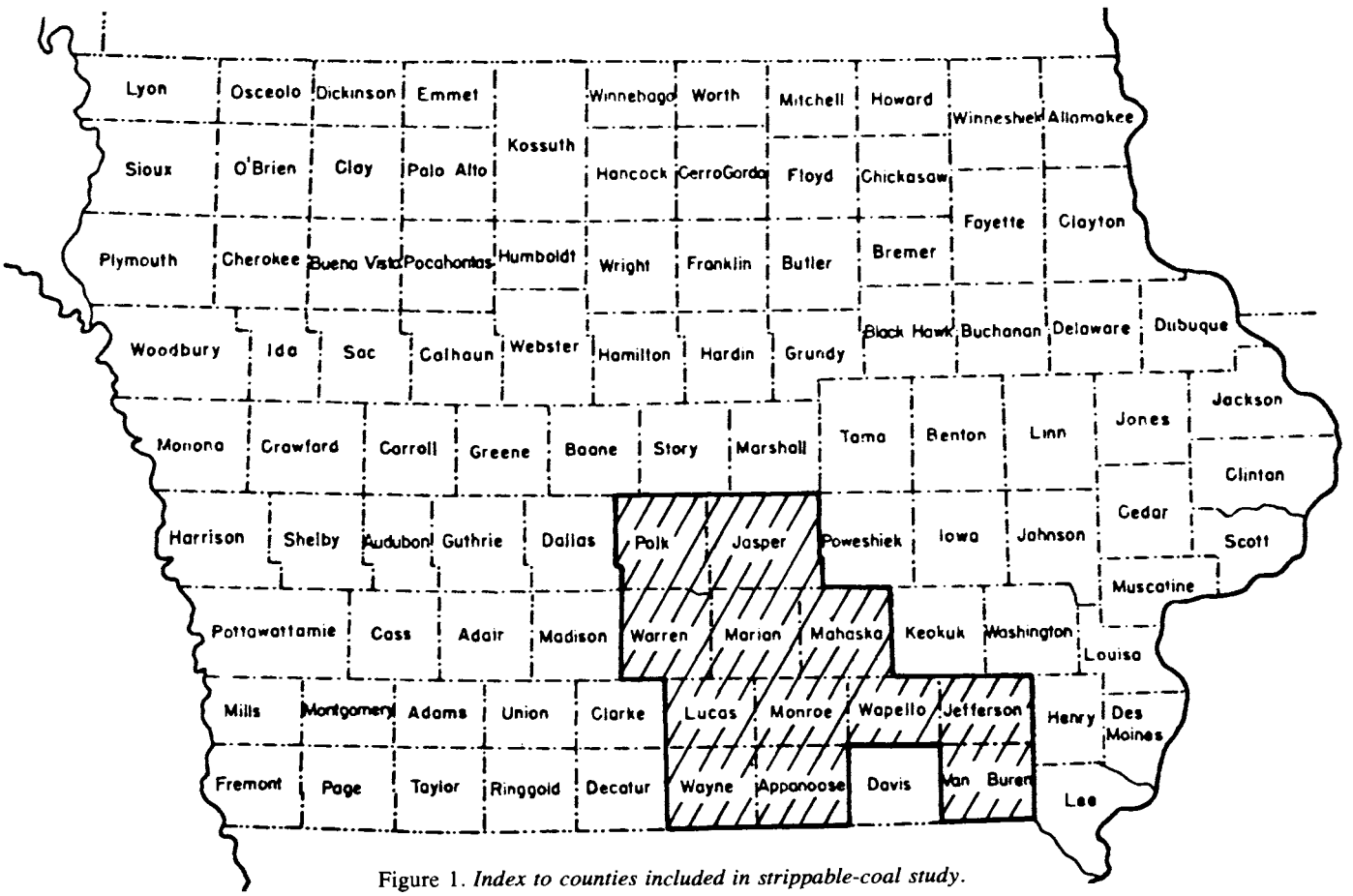

Figure 1. *Index to counties included in strippable-coal study.*

total original reserves in all counties in the state regardless of depth.

SOURCES OF INFORMATION

Data used in defining areas underlain by coal were taken from records of underground mine shafts, coal prospect drill holes, water wells, coal outcrops, and strip mines. Information was gathered chiefly from Annual Reports of the Iowa Geological Survey (see Arey, 1910; Bain, 1895, 1896, 1897; Beyer and Young, 1903; Gordon, 1895; Hinds, 1909; Keyes, 1894; Lees, 1909a, 1909b; Leonard, 1902; Lugn, 1927; Miller, 1901; Norton, 1928, 1935; Tilton, 1896; Udden, 1902; White, 1870; and Williams, 1905), Biennial Reports of the Iowa State Mine Inspector (1880-1970), Iowa Geological Survey Technical Paper #4 (Landis and Van Eck, 1965), geologic logs of water wells, and geologic maps of the 12 counties investigated. Also utilized was information from the Iowa Survey Coal Division's active core drilling program. Additional data were obtained from miscellaneous unpublished information on file at the Survey, which included maps showing locations of abandoned coal mines, and nonconfidential information concerning the activities of specific coal mining companies. Owing to the short period allowed for the research, field checks of the data were not made.

CRITERIA USED IN RESERVE ESTIMATES

Reserve estimates of any kind are not meaningful unless the criteria for estimation are expressly stated. The United States Geological Survey has established standard criteria for estimating coal reserves (Averitt, 1967, 1970). These regard the thickness of the coal, the thickness of the overburden, the weight of the coal, and the reliability of the estimate (see Table 1). Because of the paucity of reliable information about Iowa coal, and because of the complexity of Iowa coal geology, it was necessary to modify the standard criteria. In this study, all coal less than 28 inches (71 cm) thick was not counted (the standard cutoff is 14 inches) (35 cm). Since most Iowa coal lies at relatively shallow depth, i.e. between zero and 1000 feet (300 m), smaller divisions of overburden thickness were employed. The reliability-of-estimate categories "measured" and "indicated" were combined into a single category, "measured-indicated."

Coal Bed Thickness

Information regarding the thickness of coal beds is not abundant. Much of it is taken from reports of the Iowa State Mine Inspector and from Annual Reports of the Iowa Geological Survey, where only an average coal thickness for the mine or mining district is reported. Coal thicknesses reported in drilling water wells in Iowa have often proven unreliable, therefore this source was considered with skepticism. The complex geologic history of Iowa coal and the lack of subsurface data complicate correlation of bed thickness and construction of isopach maps. Reserve estimates are given for intermediate coals (28 to 42 inches) (71-107 cm) and thick coals (greater than 42 inches) (107 cm). For purposes of constructing thickness isopach maps, it was assumed that coal at the outer edges of all defined coal bodies is 28 inches (71 cm) thick, except where erosion of coal has taken place.

Thickness of Overburden

Estimated reserves are reported for three categories of overburden thickness: 0 to 50 feet (0-15 m), 50 to 100 feet (15-30 m), and 100 to 150 feet (30-46 m).

Weight of Coal

The generally-accepted weight of 1800 tons per acre-foot (1.32 metric tons per cubic meter) for Iowa coal was used in calculating the tonnage.

Table 1. *Criteria for Estimating Reserves of Bituminous Coal*

Coal Bed Thickness
14 to 28 inches (thin)
28 to 42 inches (intermediate)
greater than 42 inches (thick)
Thickness of Overburden
0 to 1000 feet
1000 to 2000 feet
2000 to 3000 feet
Weight of Coal
1800 tons per acre-foot
Reliability of Estimate
measured reserves
indicated reserves
inferred reserves

Reliability of Estimates

Measured-indicated reserve calculations were based on groups of closely spaced data points, such as outcrops or mine shafts, for which the average coal thickness was known, and for which the uncertainty in determining the thickness of overburden was 20 feet (6 m) or less. Included in these reserves were all bodies of coal at a distance not greater than one-half mile (0.8 km) outward from such data points. Calculations of inferred reserves were based on isolated data points for which coal thickness and depth were not accurately known, and on groups of data points for which coal thickness or thickness of overburden could not be determined accurately. Areas of inferred coal often are represented as halos surrounding areas of measured-indicated coal, and they extend no more than one-half mile (0.8 km) beyond the outer measured-indicated boundary. Areas of inferred coal defined by isolated data points extend to distances not greater than one mile (1.6 km) from the nearest data point. Inferred reserves were also extended to include areas of abandoned underground coal mines and strip pits adjacent to defined areas, for which necessary information was lacking. Small abandoned mines remote from data points, for which depth and thickness information were not available, were not included in the reserves estimates.

GENERAL PROCEDURES IN RESERVE CALCULATIONS

In order to determine the original reserves for each township, data points from all available sources were first plotted on standard 15 minute or 7½ minute topographic base maps. Each point recorded coal elevation and thickness where known. Using the criteria for reliability of estimates previously discussed, the areas of measured-indicated and inferred coal were outlined on working overlay maps. Thickness of overburden for each data point was determined by the difference between the surface elevation shown on the topographic base map and the elevation of the coal bed. Boundaries between the three thickness-of-overburden categories were contoured and each category was color-coded on the overlay for ease in recognition. Using known coal thickness and assuming minimum thickness at the outer edge of inferred coal (28 inches) (71 cm), average thickness values were assigned to each coal basin. Where known thickness exceeded 42 inches (107 cm), a single 42-inch (107 cm) isopach line was added in order to distinguish the two thickness categories. Defined areas were then measured by means of a polar planimeter. The planimeter measurements were converted to acre-feet and then to tonnage by means of computer. Within each county the calculations were tabulated according to coal bed thickness, thickness of overburden, and reliability of the

Table 2. *Original Reserves of Bituminous Coal in Southern Iowa. Values are in millions of tons*

COUNTIES	Measured-Indicated Reserves						Inferred Reserves						TOTAL ORIGINAL RESERVES
	Coal Bed Thickness						Coal Bed Thickness						
	28-42 inches			more than 42 inches			28-42 inches			more than 42 inches			
	Overburden Thickness (ft)						Overburden Thickness (ft)						
	0-50	50-100	100-150	0-50	50-100	100-150	0-50	50-100	100-150	0-50	50-100	100-150	
Polk	0.92	15.47	11.63	0.62	8.14	25.26	8.91	36.05	46.56	0.00	10.92	21.62	186.10
Jasper	1.57	3.14	1.50	2.57	4.81	4.27	14.35	28.94	23.51	7.79	10.23	7.36	110.04
Warren	6.10	6.88	6.24	0.27	1.87	0.68	25.43	19.39	19.12	4.07	1.34	0.59	101.98
Marion	9.12	9.83	3.92	28.37	23.77	9.99	68.47	83.49	65.44	17.17	32.54	28.72	380.83
Mahaska	5.43	7.40	0.65	25.27	53.23	27.05	48.47	58.04	26.84	30.79	42.68	19.07	344.92
Lucas	1.80	3.76	3.76	1.29	3.48	7.44	3.33	8.86	18.83	0.93	0.90	2.10	56.48
Monroe	1.23	2.85	3.31	4.00	19.99	23.04	7.57	18.77	38.49	1.87	7.22	15.12	143.46
Wapello	5.40	7.49	6.24	1.47	6.08	8.21	53.01	67.23	39.98	10.29	8.88	2.52	216.80
Jefferson	1.62	2.50	0.15	0.29	3.94	0.00	48.33	67.45	15.60	6.49	3.86	0.00	150.23
Wayne	2.12	3.55	4.21	0.00	0.00	0.00	10.41	12.88	16.72	0.00	0.00	0.00	49.89
Appanoose	6.91	9.10	24.27	0.00	0.00	0.00	26.98	67.29	86.80	0.00	0.00	0.00	221.35
Van Buren	4.64	4.23	0.03	0.00	0.00	0.00	23.22	21.17	6.92	1.31	1.31	0.55	63.38
Totals	46.86	76.20	65.91	64.15	125.31	105.94	338.48	499.56	404.81	80.71	119.88	97.65	2025.46

estimate. For Wayne and Appanoose counties it was possible to assign all strippable coal to the Mystic bed within the Marmaton Group, which is noted for its remarkable lateral continuity. For the remaining counties, however, difficulties with coal bed correlation made such specific geologic age assignments impossible.

LIMITATIONS OF METHODS

Estimation of coal reserves in Iowa is a difficult undertaking. Subsurface information is sparse to absent in many areas. Records of early mining were poorly kept, if at all. One can demonstrate the existence of a great many underground mines and strip pits, the accurate locations and/or descriptions of which are unknown. This is particularly true in the Mystic area of Appanoose County, where numerous closely-spaced large mines are known to exist, but for which the character of the coal cannot be determined. In areas such as Polk County, where more than one minable coal bed is known, mine records often describe only the bed being exploited, without the slightest mention of beds above or below. Because of the general lack of stratigraphic control and because of the great lateral variation in coal character, coal bed correlation is at present virtually impossible. The only criteria for correlation which were employed in this study were elevation of the coal bed coupled with knowledge of the general geology of the area. Another limitation is that virtually all coal discoveries in southern Iowa are the result of exposure by erosion by major rivers and their principal tributaries. Very little data exist in interstream divide areas. Although much of this coal probably lies beneath a thick blanket of Pleistocene and Pennsylvanian overburden and is too deep to be strippable under existing economic conditions, there is undoubtedly some coal in these areas which is shallow enough to be minable. It is clear that much more drilling, especially beneath interstream divides, is needed to evaluate the underlying coal reserves.

RESULTS

Despite the limitations previously discussed, available data permit an estimation of reserves, and present a general picture of coal distribution and trends in southern Iowa. Original reserves of coal in the 12 counties investigated were reported by county and township according to the criteria described above. Original reserves are defined as reserves in the ground prior to the beginning of all mining operations. It was our intent at the outset of the research to be conservative in the estimates, i.e. to not "create coal on the drafting board."

Table 2 lists original measured-indicated and inferred reserves of strippable coal for the 12 counties. These are tabulated according to thickness of coal seam and thickness of overburden. A study of the table reveals that for most counties inferred reserves are much larger than measured-indicated reserves. The high inferred/measured-indicated reserve ratio reflects the high degree of uncertainty in much of the data. Most of the coal in Jefferson County was identified from areas where needed topographic information was available only from United States Army Map Service NK-Series maps. It is well known that these maps are inadequate for determining accurate surface elevations. The table also shows that thick, strippable coals are more plentiful in the northern counties, especially Marion, Mahaska, and Monroe counties.

Table 3 compares original strippable reserves of intermediate and thick coals with those determined by Landis and Van Eck (1965). Wayne and Jefferson counties are not compared because of unresolved discrepancies in the data. The table reveals that approximately one-third of all original coal in the 12 counties is strippable. It also shows that coals in Jasper, Marion, Mahaska, and Wapello counties are primarily shallow, while coals in Polk, Lucas, Monroe, and Appanoose counties are primarily deep.

The combined results of Tables 2 and 3 demonstrate that thick, shallow coals are more plentiful in Marion and Mahaska counties. This conclusion is supported by the record of large coal production from,

Table 3. *Comparison of Strippable Reserves of Bituminous Coal With Total Reserves For Southern Iowa Counties (values in millions of tons).*

County[2]	Strippable Reserves	Total Reserves[1]
Polk	186.10	602.57
Jasper	110.14	130.38
Warren	101.98	193.86
Marion	380.83	541.84
Mahaska	344.92	490.20
Lucas	56.48	283.32
Monroe	143.46	809.00
Wapello	216.80	318.05
Appanoose	221.35	527.06
Van Buren	63.38	111.76

[1]values taken from Landis and Van Eck (1965)
[2]comparisons for Jefferson and Wayne counties were not made due to unresolved discrepancies in the data

and recent strip mining activity in, these counties.

A more realistic picture of the potential for coal mining in the future may be obtained by determining the recoverable reserves. Recoverable reserves are defined as that coal remaining at the time of the estimate, after mining and other losses, which can be recovered with existing mining methods. First the amount of coal (M) mined from the area of interest is determined. It is generally considered that for every ton of coal mined a ton is left behind and probably unrecoverable; therefore, twice the amount of coal mined is subtracted from the original reserves (O). This difference is the remaining reserves. To determine the recoverable reserves (C) this number is multiplied by a recoverability factor (F), which ranges from 0.5 to 0.8 (Averitt 1967, 1970). The resulting equation for calculating recoverable reserves is:

$$C = F(O - 2M)$$

Coal production figures for each county were obtained from Landis and Van Eck (1965) and from United States Bureau of Mines Minerals Yearbooks (1964). Since these figures reflect all coal mined, whether by surface or underground methods, comparison of recoverable reserves with original strippable reserves would be valid only for those counties where coal is at shallow depth, i.e., Marion, Mahaska, Jasper, and Wapello counties. Recoverable reserves for these counties are shown in Table 4. It can be seen that at 50% recoverability, nearly half of the original strippable coal underlying the four counties is recoverable today. At 80% recoverability (some strip-mining operations claim 90-95% recoverability), well over half of the original coal can be recovered. It is believed that recoverable reserves for the remaining counties would be of the same order of magnitude.

COAL DISTRIBUTION MAPS

In order to show the distribution of coal reserves of the various categories, coal maps are currently being prepared for each county (Garvin and Van Eck, in preparation). Color patterns are used to denote thickness of overburden and reliability of the estimate. Average coal thickness for each coal basin is also shown. The maps are made consistent with the criteria for reserve estimates previously discussed, hence, they are idealized illustrations which indicate the areas of greatest likelihood of finding coal within the mapped areas. It is expected that these maps will be useful guides to coal exploration in Iowa. They indicate that the most likely targets for prospecting are adjacent to areas of past mining. In the past, limits of coal mines were often determined by property limits, roof rock conditions, and local "cutouts," rather than by the absence of coal. Numerous small mines have successfully "scavenged" commercial coal from the borders of older mines. Working maps used to determine coal distribution define the areas of past mining activity, and should prove useful aids to exploration of adjacent areas. In addition, the maps reveal some linear coal trends, for example in Mahaska County, which should be explored further.

Table 4. *Recoverable Reserves of Strippable Coal in Jasper, Marion, Mahaska, and Wapello Counties (values in millions of tons)*

County	Original Reserves	Reserves at 50% Recoverability	Reserves at 80% Recoverability
Jasper	110.14	44.82	71.75
Marion	380.83	150.75	241.19
Mahaska	344.92	130.46	208.74
Wapello	216.80	93.62	149.79

In conclusion, this study indicates that strippable reserves of Iowa coal, while not large when compared to those of the leading coal-producing states, are nevertheless significant. When developed to their full potential, they should decrease substantially Iowa's demand for imported energy. The study also demonstrates the great need to acquire additional information regarding the location and character of Iowa coal.

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