



## *Summary of coal resources of the Black Mesa coal field, Arizona*

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## SUMMARY OF COAL RESOURCES OF THE BLACK MESA COAL FIELD, ARIZONA\*

by R. B. O'SULLIVAN

## INTRODUCTION

Coal-bearing rocks of Cretaceous age crop out in an area of about 3,500 square miles near the center of the Navajo Indian Reservation in Apache, Navajo, and Coconino counties in northeastern Arizona. Black Mesa, a large elevated prominence, nearly coincides with this area of Cretaceous rocks. Coal deposits of Black Mesa have been mined locally for more than six hundred years. However, there is no detailed information available on the coal resources of this vast area. This report briefly outlines the general geologic features of the Black Mesa coal field.

## GENERAL STRATIGRAPHY

The sequence of Cretaceous rocks exposed on Black Mesa includes, in ascending order, the Dakota sandstone, the Mancos shale, and the Mesaverde group. The Mesaverde consists of the Toreva formation at the base, the Wepo formation, and the Yale Point sandstone at the top. The distribution and stratigraphic relations of the formations are shown in Figure 1.

The Dakota sandstone ranges in thickness from about 50 to 120 feet (Repenning and Page, 1956, p. 261). It consists of interbedded tan, fine- to medium-grained sandstone, siltstone, and dark-gray and brown shale and coal. Generally the Dakota sandstone consists of upper and lower ledge-forming sandstone beds separated by coal-bearing shale. Locally one or more of these units may be absent.

The Mancos shale is composed of light- to yellowish-gray shale and very fine grained sandstone. The formation thins from 669 feet at Yale Point to 424 feet in the southwestern part of Black Mesa (Repenning and Page, 1956, p. 266). The Mancos shale rests conformably on the underlying Dakota sandstone and intertongues with the overlying Toreva formation.

The Toreva formation is about 300 feet thick over most of the Black Mesa (Repenning and Page, 1956, p. 274). In the southern part of the area the formation consists of an upper and lower sandstone member and a middle carbonaceous member. The lower sandstone member consists of light-brown, fine- to medium-grained, cliff-forming sandstone. The middle carbonaceous member is composed of interbedded dark-gray and brown shale, coal, and yellowish-gray, fine- to coarse-grained sandstone. The upper sandstone member consists of light-gray, fine- to coarse-grained, generally conglomeratic sandstone beds, with thin intercalated greenish-gray shale beds.

The middle member of the Toreva formation pinches out northward roughly along a line between Lohali Point and Cow Springs, and the upper and lower members merge to form a single sandstone. Farther to the north this sandstone is split by the middle marine shale of the Toreva formation. This middle slope-forming "shale" unit actually consists of light-gray siltstone and very fine grained sandstone. The middle shale is exposed along the cliffs of the northern part of Black Mesa and most of it is higher stratigraphically than the Toreva formation of the southern part of Black Mesa. An upper cliff-forming sandstone overlies the middle shale and comprises the uppermost part of the Toreva formation. It consists of tan, medium-

to very coarse grained sandstone and conglomeratic sandstone. Like the middle shale, the cliff-forming sandstone is confined to the northern part of Black Mesa.

The Wepo formation conformably overlies the Toreva formation and ranges in thickness from 318 to 743 feet (Repenning and Page, 1956, p. 278). It is composed of interbedded light-gray, fine- to coarse-grained sandstone, olive-gray and brown siltstone and shale, and coal.

The Yale Point sandstone conformably overlies the Wepo formation and is the youngest formation of the Mesaverde group preserved on Black Mesa. The formation has a maximum thickness of 300 feet (Repenning and Page, 1956, p. 280) and consists of tan, medium- to coarse grained sandstone.

## COAL DEPOSITS

## Previous Investigations

Campbell and Gregory (1911, p. 229-238) conducted a brief reconnaissance of the southern part of Black Mesa in May of 1909. Gregory (1917, p. 142-144) included Black Mesa as a part of his study of the Navajo country. During the years 1952-1954, a party under the direction of George Kiersch, of the University of Arizona, mapped and sampled the more important coal mines on the Navajo Indian Reservation. The results of this study were summarized in a subsequent report (Kiersch, 1956, p. 50-63). Other reports (Rubel, 1916; Andrews, and others, 1947) have reviewed the available information on the Black Mesa coal field, or have dealt with the prehistoric use of coal in this area (Brew and Hack, 1939). A recent report (Repenning and Page, 1956) outlines the Cretaceous geology and incidentally mentions the presence of coal at some localities on Black Mesa.

## Coal-bearing rocks

Coal occurs in the Dakota sandstone, Toreva formation, and Wepo formation. In the Dakota sandstone the coal is contained in the middle shale member. Although coal in the Dakota is present at most places, the larger and more extensive deposits are in the southwestern part of Black Mesa. According to Kiersch (1956, p. 50) the coal beds are 2 to 4 feet in thickness with two notable exceptions. At the Tuba City mine the coal is 7 feet thick, and at a locality 4 miles south of Steamboat the coal is 9 feet thick. The following section (Campbell and Gregory, 1911, p. 234) illustrates the nature of the coal seam at the Tuba City mine:

	Feet	Inches
Coal	1'	4
Shale		2
Coal (mined)		8
Bone		1
Coal (mined)	1	2
Bone		½
Coal (mined)	3	6½
	7	0

Other important mines which have produced coal from the Dakota are the Montezuma and Chinle Number 1 (fig. 1).

Coal deposits in the Toreva formation occur in the middle carbonaceous member. The best deposits are in the southeastern part of Black Mesa. Two important mines produce from this member, the Keams Canyon mine and the Chinle Number 2 mine (fig. 1). The coal bed at the Chinle

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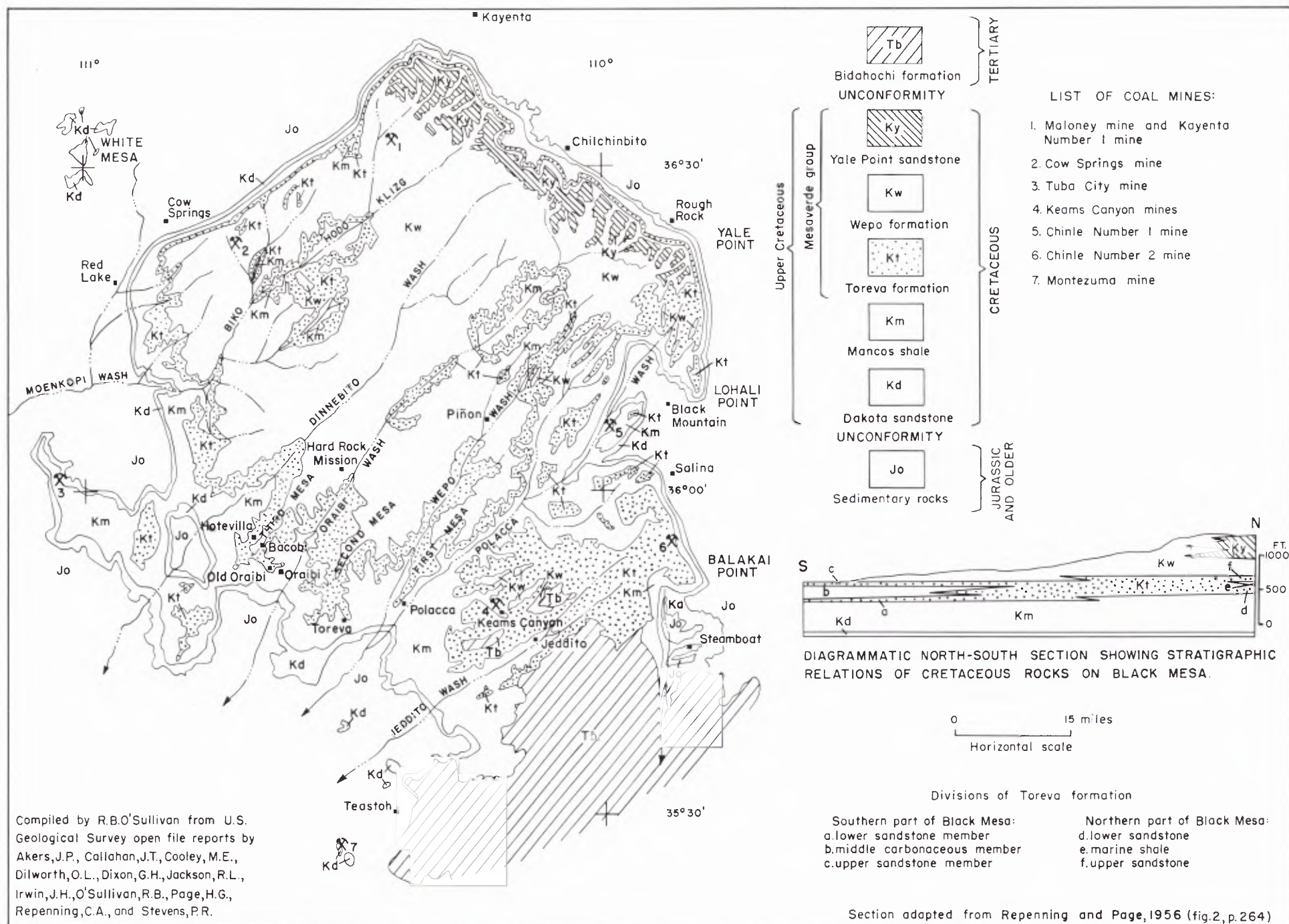


FIG. 1. MAP SHOWING DISTRIBUTION OF CRETACEOUS ROCKS AND RELATED UNITS ON BLACK MESA, ARIZONA



mine is 6 to 7 feet thick (Kiersch, 1956, p. 63). The following section at the Keams Canyon Number 4 mine illustrates the nature of the coal in this area (Kiersch, 1956, p. 55):

	Feet	Inches
Coal	1	9
Shale		4
Coal		6
Shale		4½
Coal	2	6
	5	5½

Coal deposits in the Wepo formation are generally restricted to the northern part of Black Mesa and the best deposits occur in the upper half of the formation. Coal beds are common in the vicinity of major sandstone beds (Repenning and Page, 1956, p. 278). At the Cow Springs mine the coal bed is a uniform 4 feet 7 inches thick without observed shale partings (Kiersch, 1956, p. 59). At the Maloney mine the coal is more than 10 feet thick.

#### Production and consumption

There were no official records of coal production in Arizona before 1926. For the years 1926-34, 1942, and 1944-46 the recorded total production was 88,730 tons valued at about \$358,000 (Wilson and Roseveare, 1949, p. 16). The greatest production in any single year was approximately 11,000 tons (Andrews and others, 1947, p. 16). Most, if not all, of this coal probably came from the Black Mesa field.

The coal produced from the Black Mesa field is utilized for both domestic and power-house requirements. Before the introduction of natural gas to northern Arizona in 1951, some coal was produced to supply the needs of Holbrook, Winslow, and Flagstaff. In addition to the commercial mines, there are a great many small open mines on Black Mesa which are worked by the Navajo and Hopi Indians for their own use.

There was considerable use of coal by the Hopi Indians in prehistoric time. Coal ash has been found in kivas, primitive stone stoves, and pottery firing pits dating back at least to the year 1300 A.D. (Brew and Hack, 1936, p. 8). This indicates that the Hopi Indians were burning coal before it came into general use in Europe. Brew and Hack (1936, p. 14) estimate that over 100,000 tons of coal were produced in Jeddito Valley in the years 1300 to 1600. This figure is greater than the total recorded production for Arizona in the years 1926-1946.

#### Quality of the coal

Coal deposits in the Dakota sandstone are subbituminous C with a high ash content. Coals in the Toreva formation are subbituminous B coal, and the coal in the Wepo formation is high volatile C bituminous. Analyses of coal from Black Mesa shown in Table 1 are averaged from those analyses reported by Kiersch (1956, p. 52-53) and by Campbell and Gregory (1911, p. 237).

Table 1. Averaged Analyses of Coal from Black Mesa

Formation	Number Samples Averaged	Moisture	Volatile Matter	Fixed Carbon	Ash	As Rec'd. Btu
Dakota	8	10.1	38.4	34.6	15.2	8,160
Toreva	6	6.3	34.7	37.7	21.3	9,630
Wepo	4	7.6	40.3	45.2	5.1	11,950

#### Reserves

The coal reserves of Black Mesa cannot be calculated with any degree of accuracy with the available information. Campbell and Gregory (1911, p. 238) estimated a total tonnage for the coal field of 14,082,000,000 short tons, but noted that the figure was only a vague approximation. Of this total, they estimated that 8 billion tons could be recovered under ordinary mining conditions. Kiersch (1956, p. 51) subsequently lowered the figure to 2 billion tons of mineable coal.

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