PREPARED IN COOPERATION WITH THE U.S. DEPARTMENT OF ENERGY

Table 1.--ASTM Classification of Coals[a]

[from ASTM, 1977]

Class	Group	Fixed Carbon limits percent (Dry, Mineral-Matter-Free Basis) Equal or Greater Than	Less Than	Volatile Matter limits percent (Dry, Mineral-Matter-Free Basis) Greater Than	Equal or Less Than	Calorific Value limits, Btu per pound (Moist[b], Mineral-Matter-Free Basis) Equal or Greater Than	Less Than	Agglomerating Character
I. Anthracite	1. Meta-anthracite	98	...	...	2	...	...	nonagglomerating
	2. Anthracite	92	98	2	8	...	...	
	3. Semianthracite[c]	86	92	8	14	...	...	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	...	...	commonly agglomerating[d]
	2. Medium volatile bituminous coal	69	78	22	31	...	...	
	3. High volatile A bituminous coal	...	69	31	...	14 000[e]	...	
	4. High volatile B bituminous coal	...	...	...	...	13 000	14 000	agglomerating
	5. High volatile C bituminous coal	...	...	...	...	11 500	13 000	
						10 500	11 500	
III. Subbituminous	1. Subbituminous A coal	...	...	...	...	10 500	11 500	nonagglomerating
	2. Subbituminous B coal	...	...	...	...	9 500	10 500	
	3. Subbituminous C coal	...	...	...	...	8 300	9 500	
IV. Lignitic	1. Lignite A	...	...	...	...	6 300	8 300	
	2. Lignite B	...	...	...	...	...	6 300	

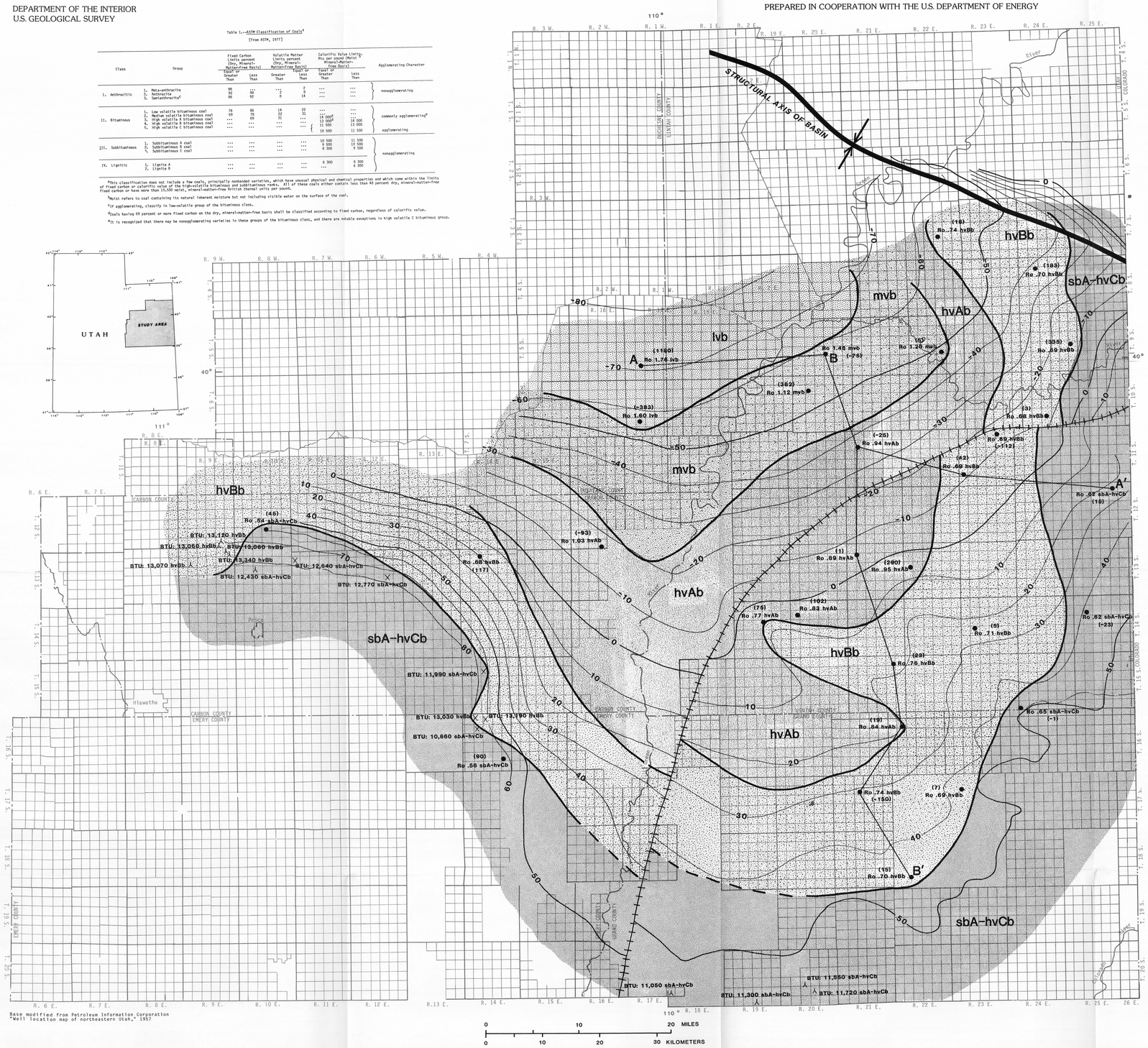
[a]This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free British thermal units per pound.

[b]Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

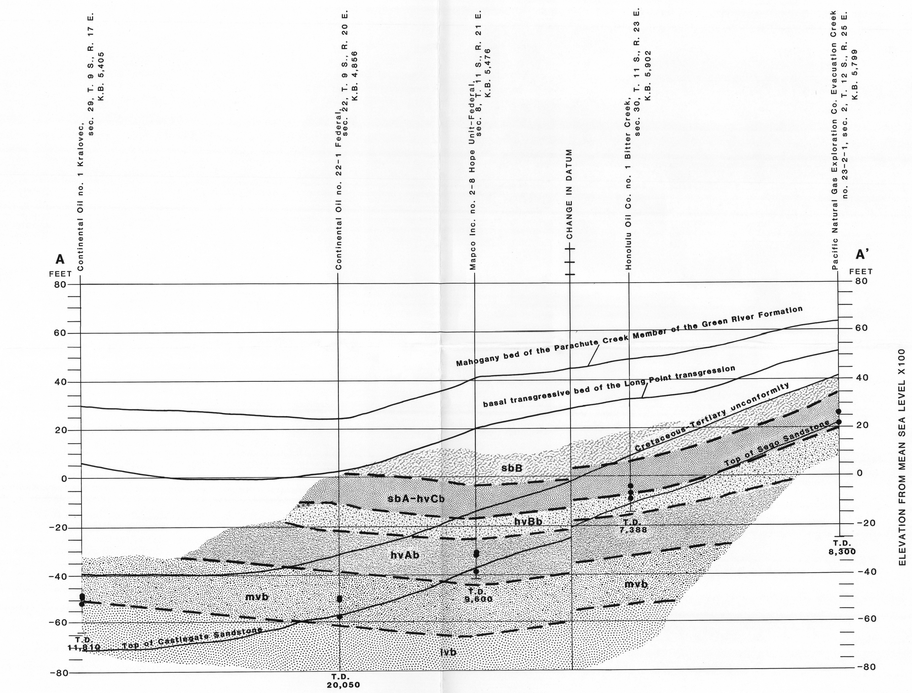
[c]If agglomerating, classify in low-volatile group of the bituminous class.

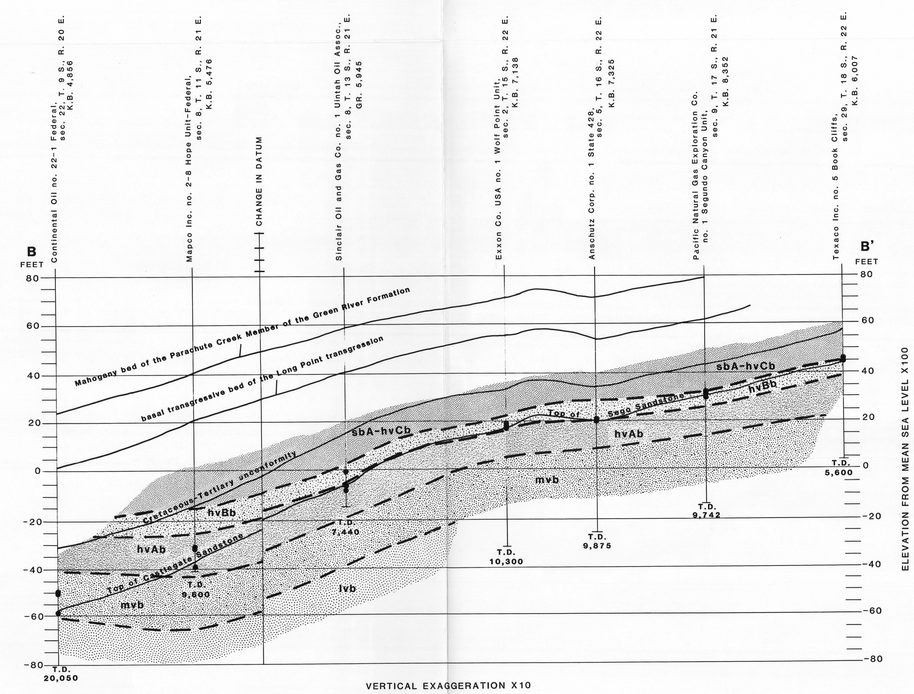
[d]Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[e]It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.



Base modified from Petroleum Information Corporation "Well location map of northeastern Utah," 1957





EXPLANATION FOR MAP

COAL RANKS--Coal ranks provide an indication of thermal maturity (see text and table 1)

- sbA-hvCb — Subbituminous A coal and high volatile C bituminous coal combined--coal not tested for agglomerating characteristics
- hvBb — High volatile B bituminous coal
- hvAb — High volatile A bituminous coal
- mvb — Medium volatile bituminous coal
- lvb — Low volatile bituminous coal

CONTACT BETWEEN DIFFERENT COAL RANKS--Dashed where uncertain

40 50 — STRUCTURE CONTOUR--Drawn on top of Castlegate or Sego Sandstones, X100 ft. Contour interval 1,000 ft

CHANGE IN DATUM--Coal ranks west of hachured line determined from coal beds associated with the Castlegate Sandstone. Coal ranks east of hachured line determined from coal beds associated with the Sego Sandstone

(50) Ro .71 hvBb — DRILL HOLE--Showing vitrinite reflectance (Ro) (mean random, oil immersion) and associated rank of coal sample using ASTM classification. Number in parentheses indicates closest coal bed (in feet) above or below the Castlegate or Sego Sandstones

BTU: 12,000 sbA-hvCb — MINE--Showing British thermal units (Btu) content and ASTM rank classification of coal sample

BTU: 12,000 sbA-hvCb — PROSPECT--Showing British thermal units (Btu) content and ASTM rank classification of coal sample

INTRODUCTION

The ability of rock to generate oil and gas is directly related to the type and quantity of kerogen and to its thermal maturity; therefore, thermal maturity is a commonly used tool for oil and gas exploration. The purpose of this study was to provide a thermal-maturity map for the lower part of the Upper Cretaceous Mesaverde Group in the eastern part of the Uinta Basin. Prior to this study, thermal-maturity data were not available for the Uinta Basin. This study uses coal rank to show the thermal maturity of the associated rocks. The map was prepared in cooperation with the U.S. Department of Energy under its western gas sands project.

The map was constructed from a variety of sources. Authors used coal-rank data from underground coal mines, wells used in oil and gas exploration, outcrop samples, and analyses listed in British thermal units (Btu) and converted them to coal rank using the ASTM (1977) classification for coal (table 1). Cuttings from several wells were analyzed for vitrinite reflectance (Ro) and the vitrinite reflectance values were converted to coal rank using the ASTM classification for coal on the basis of vitrinite reflectance in oil (fig. 1). For this study, coal-chip cuttings from wells were obtained from the American Stratigraphic Company.

East of the hachured line on the map, coal ranks were determined from coal beds directly above or below the Sego Sandstone of the Mesaverde Group. Most of these coal beds were within 100 vertical ft of the top of the Sego. West of the hachured line on the map, the Sego has merged, or nearly merged with the underlying Castlegate Sandstone of the Mesaverde Group, and, in this area, coal ranks were determined from coal beds within the Castlegate. These coal beds occur above and below the top of the Castlegate, but, in general, they are mostly within 100 vertical ft of the top of the Castlegate. As with the Sego coal beds, the distances in feet above and below the top of the Castlegate are shown on the map. A few of the coal beds in the northernmost part of the map area are several hundred feet above or below the Castlegate.

Structure contours are also shown on the map so that one can see how coal-rank variations are related to structure. In the eastern part of the map, structure contours are plotted on the top of the Sego Sandstone. In the western part of the map, structure contours are shown on the top of the Castlegate Sandstone. The structure contours on the top of the Castlegate are from Johnson (in press).

The cross sections show, in general, how coal rank varies vertically within the Mesaverde Group. Most of the coal-rank data used to construct the cross sections were obtained from coal beds in the Sego and Castlegate Sandstones, but some of the data were obtained from other parts of the Mesaverde; hence, the contacts between coal ranks are approximate. In general, there are few coal beds in the upper part of the Mesaverde and data from this part of the section are difficult to obtain. The basal transgressive bed of the Long Point transgression (Johnson, 1984) and the Mahogany bed of the Parachute Creek Member of the Green River Formation are shown on the cross sections for reference only.

GENERAL STRATIGRAPHY AND NOMENCLATURE

The name Castlegate was applied by Forrester (1918) and Clark (1928) to a prominent cliff-forming sandstone sequence of late Cretaceous age that locally forms a topographic feature called the Castle Gate in Price Canyon about 10 mi northwest of the town of Price, Utah. The Castlegate Sandstone was formally named a member of the Price River Formation by Spieker and Reeside (1925). The Castlegate was traced to the Book Cliffs and Wasatch Plateau (fig. 1). West of the Green River, the Castlegate is predominantly nonmarine in origin and similar to other cliff-forming sandstone beds of the Blackhawk Formation (Fisher and others 1960; Fouch and others, 1983). East of the Green River and extending to near the Utah-Colorado state line, the Castlegate is predominantly of marginal marine origin and forms a prominent dip slope. Throughout most of the area east of the Green River, the Castlegate is overlain by the Buck Tongue of the Mancos Shale, and no coal beds are associated with it.

The marginal marine Sego Sandstone was named for the town of Sego, Utah, by Erdmann (1934) and Fisher (1936). Fisher mapped the Sego along the Book Cliffs from the Utah-Colorado state line westward to north of Deseret, Utah, where the Buck Tongue, which separates the Sego from the underlying Castlegate, wedges out and the Sego and Castlegate merge into one unit. Erdmann mapped the Sego along the Book Cliffs of Colorado, where it is separated into an upper and lower unit by the Anchor Mine Tongue of the Mancos Shale. The Anchor Mine Tongue wedges out a few miles west of the Utah-Colorado state line. Several coal zones, including the Palisade, Chesterfield, and Carbonera, occur 100-200 ft above the Sego.

DISCUSSION

In general, organic matter can be divided into sapropelic (fatty) and humic (coaly) matter. Marine source rocks tend to be sapropelic and generate mostly oil, whereas continental source rocks tend to be humic and generate mostly gas. Because of the dominantly nonmarine environments of deposition of the coal-bearing parts of the Mesaverde Group, the coal beds likely contain humic organic matter; therefore, gas should be the dominant hydrocarbon generated.

The onset of major gas generation in nonmarine rocks occurs at about a Ro of 0.80 (Law, 1984), which corresponds to High volatile B bituminous and High volatile A bituminous ranks. Gas will continue to be generated at a Ro of 4.0 or even higher, which is much higher than the Ro values found in this study. Using these parameters, the map shows that most of the study area contains rocks that are thermally mature enough for gas generation; however, this does not mean that gas will be ubiquitous. Other conditions, such as migration problems, structural requirements, and reservoir quality must be understood before exploring for petroleum.

As can be seen on the map and the cross sections, coal ranks generally follow structure but usually have a gentler dip. This suggests that structural deformation could have occurred at the same time or later than thermal maturation.

REFERENCES CITED

American Society for Testing and Materials, 1977, Standard specifications for classification of coals by rank, in Annual book of ASTM Standards, Part 26: Philadelphia, American Society for Testing and Materials, p. 211-215.

Clark, F. R., 1928, Economic geology of the Castlegate, Wellington, and Sunnyside quadrangles, Carbon County, Utah: U.S. Geological Survey Bulletin 793, 165 p.

Erdmann, C. E., 1934, The Book Cliffs coal field in Garfield and Mesa Counties, Colorado: U.S. Geological Survey Bulletin 851, 150 p.

Fisher, D. J., 1936, The Book Cliffs Coal Field in Emery and Grand Counties, Utah: U.S. Geological Survey Bulletin 852, 104 p.

Fisher, D. J., Erdmann, C. E., and Reeside, J. B., 1960, Cretaceous and Tertiary formations of the Book Cliffs, Carbon, Emery, and Grand Counties, Utah, and Garfield and Mesa Counties, Colorado: U.S. Geological Survey Professional Paper 332, 80 p.

Forrester, J. D., 1918, Notes on Geological Survey bulletin no. 371: Transactions of the Utah Academy of Sciences, v. 1, p. 24-31.

Fouch, T. D., Lawton, T. F., Nichols, D. J., Cashion, W. B., and Cobban, W. A., 1983, Patterns and timing of synorogenic sedimentation in Upper Cretaceous rocks of central and northeast Utah, in Reynolds, R. W., and Dolly, E. D., eds., Rocky Mountain Paleogeography Symposium 2, Mesozoic Paleogeography of the West-Central United States: Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, p. 305-336.

Johnson, R. C., 1984, New names for units in the lower part of the Green River Formation, Piceance Creek Basin, Colorado: U.S. Geological Survey Bulletin 1529-I, 20 p.

Johnson, R. C., in press, Structure contour map of the top of the Castlegate Sandstone, eastern part of the Uinta Basin and western part of the Piceance Creek Basin, Utah and Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1826, scale 1:253,440.

Law, B. E., 1984, Relationships of source-rock, thermal maturity, and overpressuring to gas generation and occurrence in low-permeability Upper Cretaceous and lower Tertiary Rocks, Greater Green River Basin, Wyoming, Colorado, and Utah, in Woodward, Jane, Meissner, F. F., and Clayton, J. L., eds., Hydrocarbon source rocks of the Rocky Mountain region: Rocky Mountain Association of Geologists, p. 469-490.

Spieker, E. M., and Reeside, J. B., Jr., 1925, Cretaceous and Tertiary formations of the Wasatch Plateau, Utah: Geological Society of America Bulletin v. 36, p. 435-454.

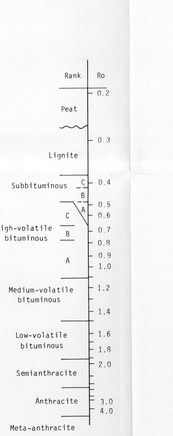
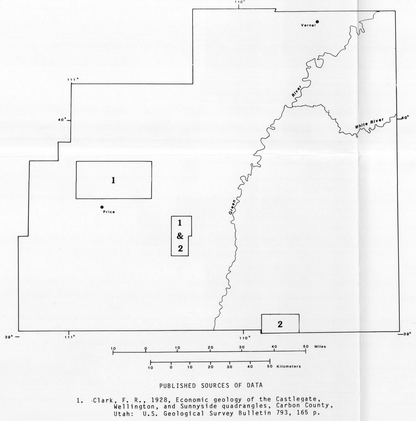


Figure 1.--ASTM classification of coal on the basis of vitrinite reflectance in oil (Ro).



EXPLANATION FOR CROSS SECTIONS

COAL RANKS--Coal ranks provide an indication of thermal maturity (see text and table 1)

- sbB — Subbituminous B coal
- sbA-hvCb — Subbituminous A coal and high volatile C bituminous coal combined--coal not tested for agglomerating characteristics
- hvBb — High volatile B bituminous coal
- hvAb — High volatile A bituminous coal
- mvb — Medium volatile bituminous coal
- lvb — Low volatile bituminous coal

GEOLOGIC CONTACT

COAL RANK BOUNDARY--Approximately located

CHANGE IN DATUM--Coal ranks west of hachured line determined from coals beds associated with the Castlegate Sandstone. Coal ranks east of hachured line determined from coal beds associated with the Sego Sandstone

T.D. 9,600 — DRILL HOLE--Dots indicate data points; T.D. indicates total depth in feet

K.B. 4856, GR. 5945 — KELLY BUSHING OR GROUND ELEVATION (in feet)

PUBLISHED SOURCES OF DATA

1. Clark, F. R., 1928, Economic geology of the Castlegate, Wellington, and Sunnyside quadrangles, Carbon County, Utah: U.S. Geological Survey Bulletin 793, 165 p.

2. Fisher, D. J., 1936, The Book Cliffs coal field in Emery and Grand Counties, Utah: U.S. Geological Survey Bulletin 852, 104 p.

THERMAL MATURITY MAP OF THE LOWER PART OF THE UPPER CRETACEOUS MESAVERDE GROUP, UINTA BASIN, UTAH

By
Vito F. Nuccio and Ronald C. Johnson

1986

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