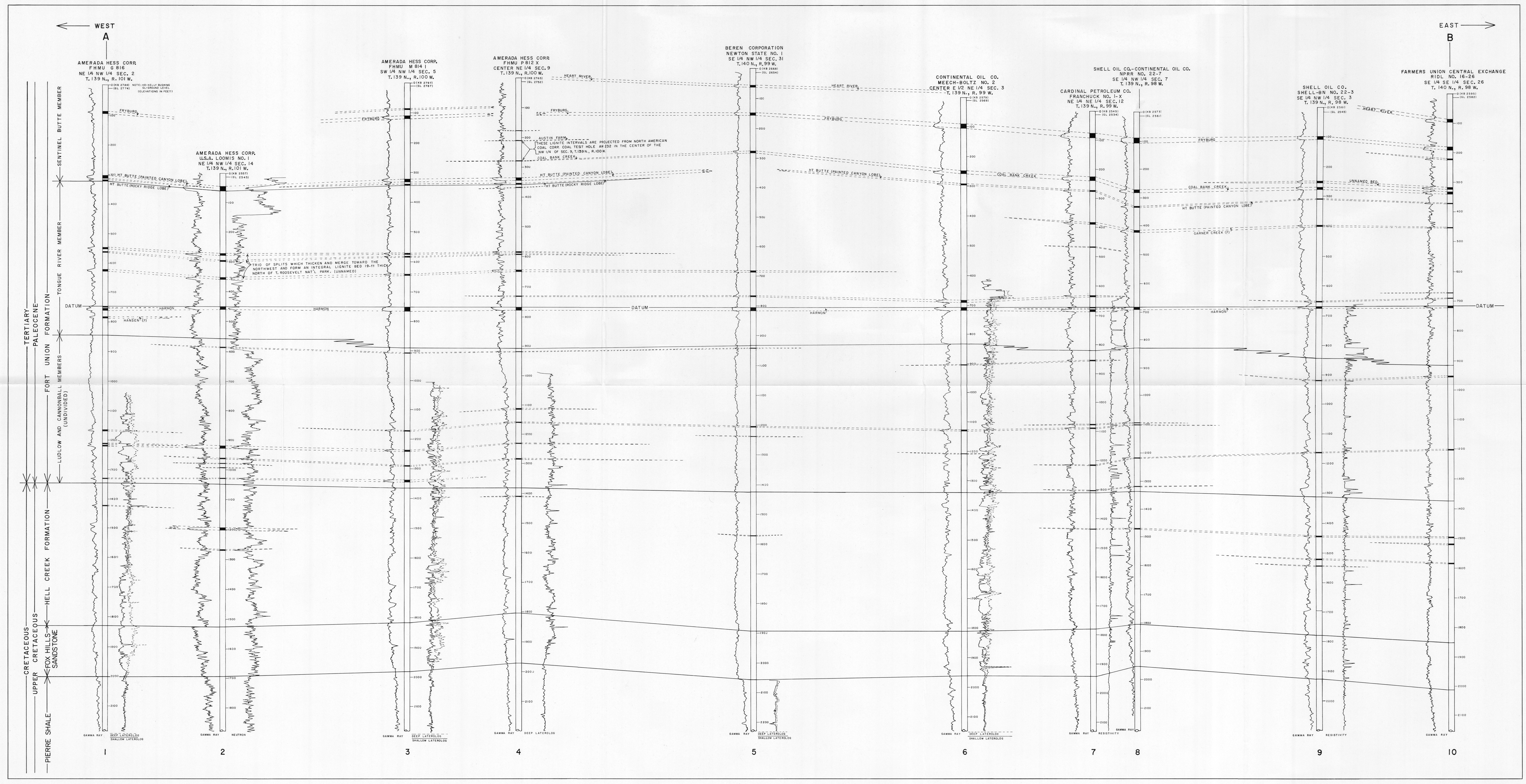

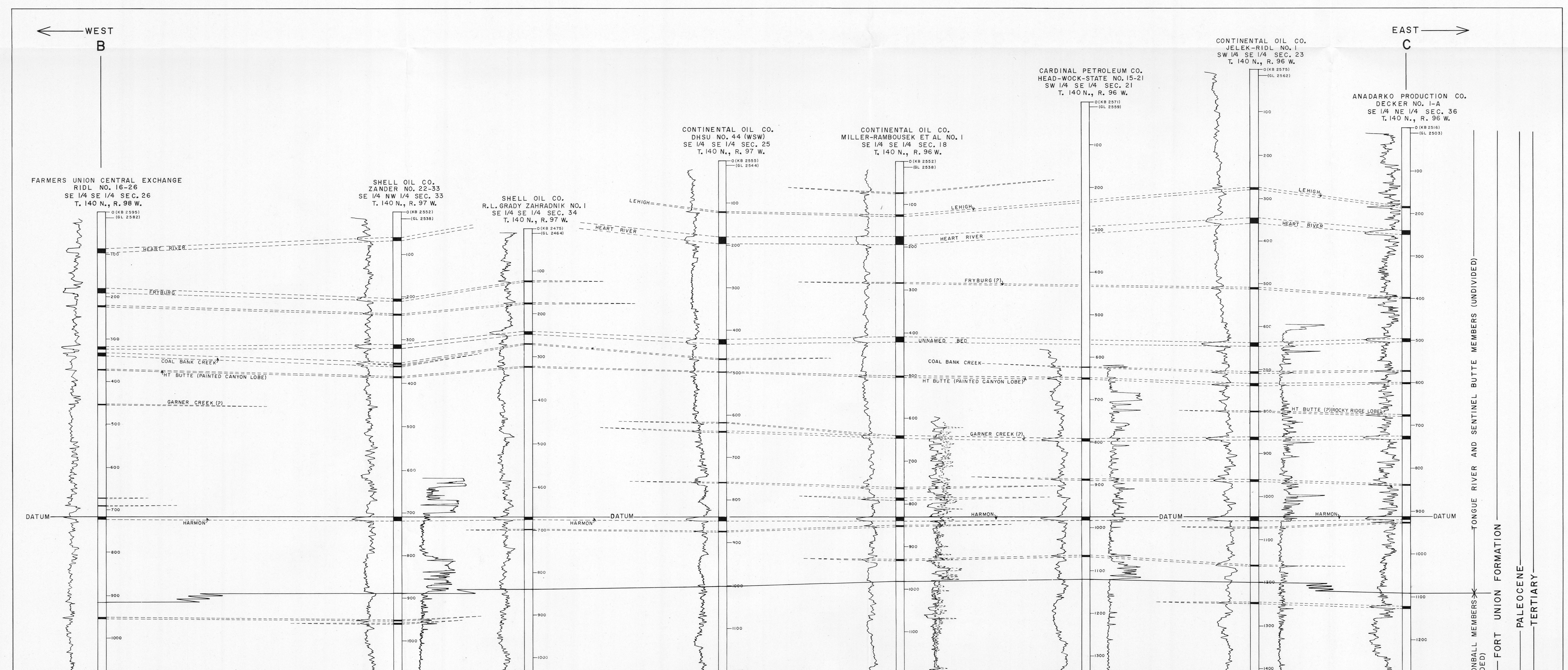

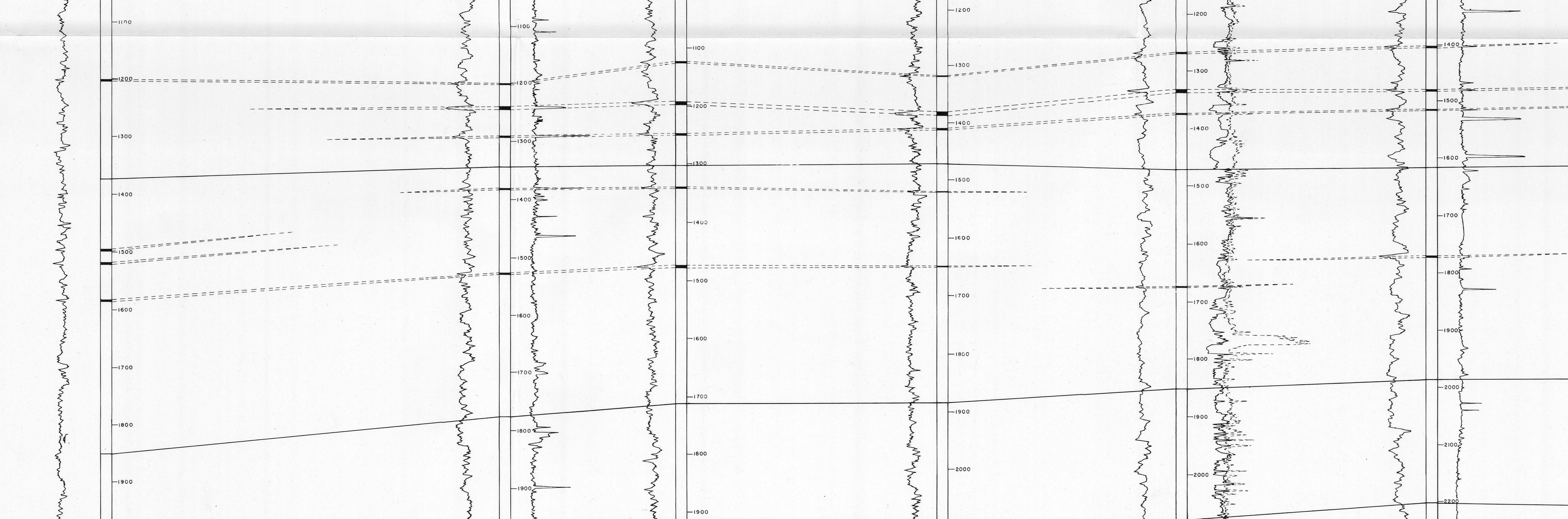

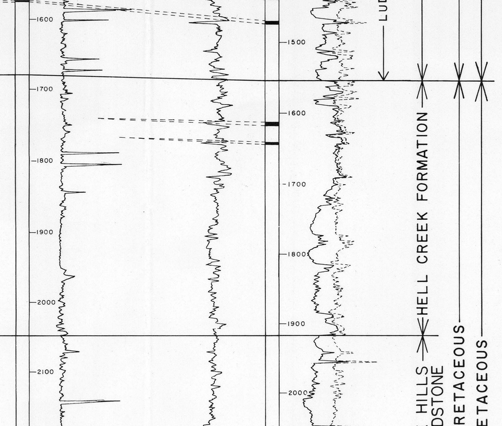

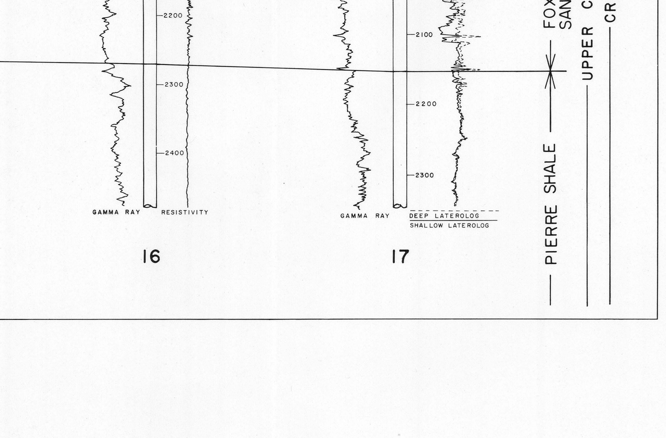

STRATIGRAPHIC CROSS SECTION AND COAL BED CORRELATIONS OF UPPERMOST CRETACEOUS AND PALEOCENE ROCKS BETWEEN PAINTED CANYON AND DAVIS BUTTES, NORTH DAKOTA

By
Jim S. Hinds
1985

INTRODUCTION

Recent detailed coal studies in the area between Havelock and Fryburg, N. Dak. (Hinds, 1983; 1985), have resulted in some revised coal-bed correlations that are, in places, in disagreement with previous work (Banet, 1980; Hares, 1928; Lewis, 1979; Menge, 1977; Owen, 1979; Rehbein, 1977; Royse, 1967). The stratigraphically most important of these have been specifically discussed (Hinds, 1983; 1985), but many others, of more or less local significance, were not specifically mentioned.

This report is an extension of the author's stratigraphic and coal-bed correlations from the vicinity of the Painted Canyon Overlook, at the south edge of Theodore Roosevelt National Memorial Park, eastward to the vicinity of Davis Buttes, near Dickinson, N. Dak.

INTERPRETATION OF OIL-WELL LOGS

The correlations of this report are based on the interpretation of lignite intervals from the gamma-ray logs of oil-well drill holes. Major lignite beds are readily apparent on these logs when the logging speed and sensitivity settings were appropriate. Lignite beds less than about 2.5 ft thick, however, are not discernible with certainty on oil-well gamma-ray logs. The Hell Creek and Fort Union Formations contain many such thin beds that are not shown on the cross section. Where correlated beds thin to less than identifiable thicknesses they are shown as pinching out, although they may in fact sometimes persist for several miles in thicknesses of less than 2 ft or as carbonaceous shales. Examples of these thin beds are the Austin Farm and Coal Bank Creek lignite intervals shown in the stratigraphic column of the Amerada Hess Corp. FHMU P812X well at Fryburg (location 4). Both of these lignite beds are less than 2 ft thick at that location and are not identifiable on the gamma-ray log. Their interval was projected to this drill hole from a North American Coal Corp. coal test hole located one-half mile away where both beds are obvious on the density log, although each is only 1.5 ft thick (Hinds, 1984). The user of this report should bear in mind the limitations on detail of oil-well gamma-ray log interpretations of thin coal beds and realize that many very thin beds are not shown on the cross section.

STRATIGRAPHY

Upper Cretaceous rocks

Pierre Shale

The oldest stratigraphic unit shown on the cross section is the upper part of the Pierre Shale. The Pierre consists principally of dark-gray shale deposited in an offshore marine environment. The contact between the Pierre Shale and the overlying Fox Hills Sandstone is the best regional stratigraphic marker horizon for subsurface well-log correlations in the Upper Cretaceous-Paleocene interval. This horizon provides a reliable reference point for correlations higher in the stratigraphic column.

Fox Hills Sandstone

The Fox Hills Sandstone is an olive-brown to brown regressive marine shoreline sandstone and shale deposit. In most surface studies the contact between the Fox Hills and the overlying Hell Creek Formation has been picked at the base of the first prominent lignite or lignitic shale occurring above the predominantly marine sandstone (Feldman, 1972, p. 32). In the area of this study there are no obvious lignites visible on the oil-well gamma-ray logs in this stratigraphic interval. Therefore, the Fox Hills-Hell Creek contact has been arbitrarily placed at the top of the first well-developed sandstone sequence above the Pierre. This choice of contacts results in about 150-230 ft of section being assigned to the Fox Hills, with the thickest occurrence at the east end of the cross section (location 17).

Hell Creek Formation

The Hell Creek Formation consists of about 360-460 ft of delta, marine-fringe and flood-plain deposits of dull-gray to brown, fine-to medium-grained sandstone, siltstone, shale, and claystone that are commonly lignitic or bentonitic. Thin, lenticular lignite beds, typical of deltaic interdistributary swamp deposition, are common; thick persistant lignite beds are rare in the Hell Creek.

The contact of the Hell Creek Formation with the overlying Paleocene Ludlow Member of the Fort Union Formation is arbitrary on oil-well gamma-ray or resistivity logs. There is no discernible "persistant lignite" at the contact in this part of North Dakota. I have chosen a point of marked difference in separation of the deep and shallow laterolog curves below the more persistent lignites of the Ludlow Member as a working contact in the subsurface for this area. For wells lacking laterolog curves through this interval the contact is projected to equivalent points on the gamma-ray curves. On this basis of interpretation, the cross sections show a gradual eastward thinning of the Hell Creek Formation.

Paleocene rocks

Fort Union Formation

Ludlow and Cannonball Members (undivided).--The Ludlow and Cannonball Members of the Fort Union Formation cannot be definitively separated in the subsurface strictly on interpretation of gamma-ray or resistivity logs; therefore, these members are shown "undivided" on the cross sections. The Ludlow Member consists of deltaic, marine-fringe, and flood-plain deposits of sandstone, siltstone, shale, and coal that underlie and intertongue toward the east with the marine sandstone of the Cannonball Member. The lignites of the Ludlow Member are, in general terms, thicker and more persistent than those in the underlying Hell Creek Formation, but less so than those in the overlying Tongue River and Sentinel Butte Members of the Fort Union Formation.

The contact of the Ludlow and Cannonball interval with the overlying Tongue River Member is at the base of the massive basal sandstone unit of the Tongue River Member. This contact, though variable with the thickness of the basal sandstone, is usually apparent on the well logs.

Tongue River Member.--The Tongue River Member of the Fort Union Formation consists of channel-fill, point bar, crevasse splay, flood-plain, shallow freshwater lake, and swamp deposits of sandstone, siltstone, shale, thin limestones, and coal, differentiated in outcrop by their charcteristic light gray, yellow, and tan colors, which contrast with the darker, somber hues of the overlying Sentinel Butte and underlying Ludlow Members. This member contains, in its lower part, the thickest, most extensive lignite in North Dakota--the Harmon lignite bed. The upper limit of the member is the base of the HT Butte coal bed or of its lower (Rocky Ridge) lobe where it is split. Where the Rocky Ridge lobe of the HT Butte coal bed is missing, the Tongue River and Sentinel Butte Members are shown as undivided. Their lithologic contact cannot be recognized on gamma-ray or resistivity logs; the general zone of contact can be located only by referring to its bracketing coal beds.

Sentinel Butte Member.--The Sentinel Butte Member consists of the HT Butte lignite bed (where present) and overlying channel, overbank, flood-plain, and swamp deposits of sandstone, siltstone, shale, and coal. In surface exposures along the Little Missouri River valley, the Sentinel Butte Member is easily differentiated from the Tongue River Member by its somber brown and dark-gray colors, which contrast strongly with the yellow and light-hued gray and tan beds below the HT Butte lignite. Away from the Little Missouri River, in some other areas, the Sentinel Butte Member contains considerable light-gray and yellow sandstone and shale in its lower part. This is notable near Havelock and Regent, N. Dak., where the Coal Bank Creek lignite bed is overlain and underlain by light-colored sediments.

In the subsurface there is no distinctive color difference in fresh, unweathered drill-hole cuttings from Sentinel Butte and Tongue River strata. As noted above, there is also no distinctive difference in gamma-ray or resistivity log responses between the members. Thus, the author considers the Tongue River and Sentinel Butte sequence to be a depositional continuum indivisible in the subsurface using available drill-hole logs, beyond the depositional limits of the lowest major split of the HT Butte lignite bed. The color change that is so evident on the outcrops along the Little Missouri River valley may represent a change in sediment source that was not everywhere contemporaneous or necessarily stable. Lateral displacement of major stream systems is in itself sufficient to begin or end peat deposition and to effect change in the color or other characteristics of the enclosing sediments, particularly if the overlying and underlying sediments were deposited by different (but contemporaneous) stream systems.

Royse (1970, p. 54, 55) observed that "Lignite beds are more abundant and better developed in Tongue River than in Sentinel Butte strata." It is obvious from cursory examination of the cross section of this report and earlier work by the author (Hinds, 1983; 1985) that Royse's observation was a function of geographic location. In many areas the Sentinel Butte Member contains more numerous and thicker coal beds than are present in the Tongue River Member. Several of the Sentinel Butte lignites are regionally extensive; for instance, the Heart River, Fryburg, and Coal Bank Creek beds.

LIGNITE BEDS

The coal-bed nomenclature of this report is the same as that used in previous reports of Hinds (1983; 1985) except for the addition of the Lehigh lignite bed overlying the Heart River bed at locations 13-17. The Lehigh bed is currently mined at the Lehigh mine of Husky Briquetting, Inc., in T. 139 N., R. 95 W., 6 miles southeast of Dickinson, N. Dak. The Lehigh bed has not been correlated definitely beyond the general vicinity of Dickinson, and its lateral extent is unknown.

The Heart River and Fryburg lignite beds were traced and correlated throughout the Dickinson-Belfield-Fryburg area by Menge (1977). The southern persistence and extent of these two beds were illustrated by Hinds (1983; 1985) and Owen (1979). The Fryburg bed thins to a pinchout eastward in the vicinity of location 12, but a thin bed occupying the same stratigraphic interval at locations 14-17 may be an eastward continuation of the bed. The designation of Fryburg is queried at this end of the cross section to signify a high degree of uncertainty.

The Austin Farm lignite bed is shown on the cross section only at location 4, where its interval has been projected from a nearby coal test hole, which had a detailed density log showing a thickness of 1.5 ft for the bed. The bed is either missing through nondeposition or is too thin to identify on the gamma-ray logs of other wells in the cross section. The Austin Farm bed becomes persistent and thickens southward from this location (Hinds, 1983; 1985).

The Coal Bank Creek lignite bed has been correlated in the subsurface from the vicinity of Havelock and Regent, N. Dak., to the line of cross section of this report (Hinds, 1983; 1985; Owen, 1979). The eastward thickening of this bed along the line of the cross section, coincident with the easterly splitting, thinning, and pinching out of part of the underlying HT Butte bed, has resulted in miscorrelation of the Coal Bank Creek bed as a split of the HT Butte bed in this area in earlier reports (Rehbein, 1977; Menge, 1977). Rehbein (1977), in addition, erroneously placed the Coal Bank Creek bed below the HT Butte lignite stratigraphically. Owen (1979) and Banet (1980), following Rehbein's nomenclature, then misidentified the overlying Austin Farm bed as the HT Butte bed in areas to the south of the present report where the Austin Farm is a persistent thick lignite. Having thus preempted the HT Butte name, they miscorrelated the real HT Butte bed in those areas as the Garner Creek lignite. Then, to account for the thick underlying bed (the real Garner Creek bed), Owen (1979) coined a new name, the "Nomad" bed, which Banet (1980) also used. Numerous local miscorrelations, detectable with more recently available data, also add some confusion to parts of those earlier reports. Compounding the confusion in the Dickinson area is the appearance of still another thick lignite (unnamed in this report) about 20 ft above the Coal Bank Creek bed at location 9 and extending eastward to location 17 at the east end of the cross section, an area across which the Coal Bank Creek bed splits, thins, and is locally absent.

The HT Butte bed of this report is a single thick (16 ft) lignite bed at location 2 that splits toward the east into two major lobes (Hinds, 1985). Along the line of this cross section, both lobes pinch out eastward between locations 4 and 5. The upper (Painted Canyon) lobe of the HT Butte bed is present east of location 5 and persists toward the east as a thin, but identifiable, bed to the east end of the cross section at Davis Buttes. The lower (Rocky Ridge) lobe of the HT Butte bed is not present along the line of section between locations 4 and 16. At locations 15 and 17, at the east end of the cross section, there is a lignite present at this stratigraphic horizon that may be an extension of the Rocky Ridge lobe of the HT Butte bed from the south and southwest, where the Rocky Ridge lobe is a thick (4-14 ft) persistent lignite in the southwestern part of Stark County, N. Dak., and adjacent parts of Billings and Slope Counties (Hinds, 1983; 1985). The correlation is queried on the cross section to indicate some degree of uncertainty.

The Garner Creek lignite bed is a major, persistent bed a few miles south of the line of this cross section (Hinds, 1983; 1985). It thins and pinches out in a north and northwest direction in the area south of Fryburg and Belfield. A probable northern extension of the Garner Creek bed intercepts the line of section between locations 7 and 10, and a bed present in the proper stratigraphic position between locations 13 and 17 is tentatively correlated with the Garner Creek bed.

At locations 1-5 there are three unnamed eastward-thinning lignites between the Harmon and HT Butte beds. Oil-well drill-hole log correlations show that these lignites are the distal extremities of several splits which thicken and merge to the northwest. At the location of the Al-Aquitaine Exploration LTD well no. U.S. 1-11 in sec. 11, T. 141 N., R. 101 W., 3 miles north of the north boundary of the south unit of Theodore Roosevelt National Memorial Park, these splits are represented by a single 19-ft-thick lignite 117 ft above the Harmon bed.

An unnamed lignite of unknown, but probably local, significance is present between the Garner Creek(?) and Harmon beds at locations 15-17, at the east end of the cross section. Other local lignites as much as 4 ft thick occur in places 10-40 ft above the Harmon bed, but these have no known regional significance.

The Harmon lignite bed is a thick persistent coal bed that has been mapped and correlated throughout a large area of southwestern North Dakota. The top of the Harmon bed, as correlated by the author, is the datum used in the construction of the cross section of this report.

The Hansen lignite bed underlies the Harmon lignite in many parts of Bowman, Slope, and southern Stark and Billings Counties, N. Dak. The author's interpretation is that the Hansen bed is not present along the line of this cross section with the possible exception of the bed a few feet below the Harmon at location 1 at the western extremity of the cross section. Even this correlation is queried. Other thin lignites below the Harmon bed near the east end of the cross section are interpreted as local beds with no established or apparent connection to the Hansen bed farther south. This interpretation is at odds with that of earlier reports (Banet, 1980; Rehbein, 1977; Menge, 1977).

The lignite beds shown in the undivided Ludlow and Cannonball Members and the lenticular beds of the Hell Creek Formation have not been correlated with any beds beyond the trace of the cross section and have not been assigned names in this report.

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