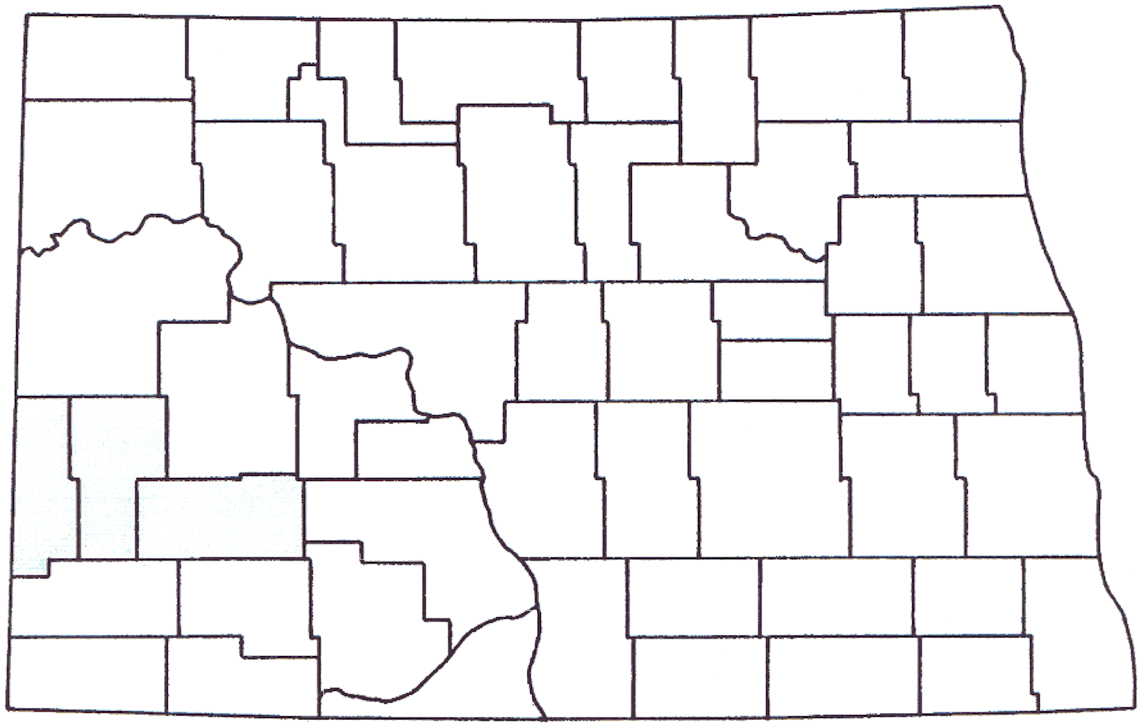
THE MAJOR COALS IN BILLINGS, GOLDEN VALLEY, AND STARK COUNTIES, NORTH DAKOTA

by

Edward C. Murphy, Ned W. Kruger, and Gerard E. Goven



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ACKNOWLEDGMENTS

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ILLUSTRATIONS

Figure

INTRODUCTION

Stratigraphic data on the Fort Union from all of the available oil and gas, coal, and uranium holes in Billings, Golden Valley, and Stark counties were entered into a computer database (Stratifact). Lithologic data from 2233 holes was entered into the system for this three-county area (Figure 1). The majority of logs available were gamma logs run through surface casing in oil wells. Suites of gamma, density, resistivity, and spontaneous potential logs are available from coal and uranium holes. Unfortunately, these holes were seldom more than 400 feet deep. Lignites are often difficult to detect on gamma logs run through casing and are impossible to verify without an accompanying density log.

The badlands topography created by incision of the Little Missouri River has resulted in the exposure of strata ranging from the Slope Formation (Paleocene) to the Arikaree Formation (Miocene) capping isolated buttes in this part of southwestern North Dakota (Figure 2). The Fort Union Group (the coal-bearing strata) ranges in thickness from approximately 400 feet in southern Golden Valley County to over 1,800 feet in northern Billings County. Any given locality in this area may be underlain by 20 or more beds of coal. Most of these coals are less than 3 feet thick, but there are at least three major coal horizons within this tri-county area: Lehigh, HT Butte, and Harmon/Hansen, where the coals typically approach or exceed 10 feet in thickness. As determined from subsurface correlations during previous open-file reports (Murphy, 1998; Murphy and Goven, 1998; and Murphy et al., 1999) widespread swamp systems existed across western North Dakota at the time these thick coals were deposited. As a result, coals of varying thickness are often present at these stratigraphic horizons. The purpose of this report is to identify areas of thick coal for coalbed methane exploration. Names were applied to these coals when they were situated within one of these major stratigraphic horizons. Better well control is needed over much of the area to enable accurate single-bed correlations.

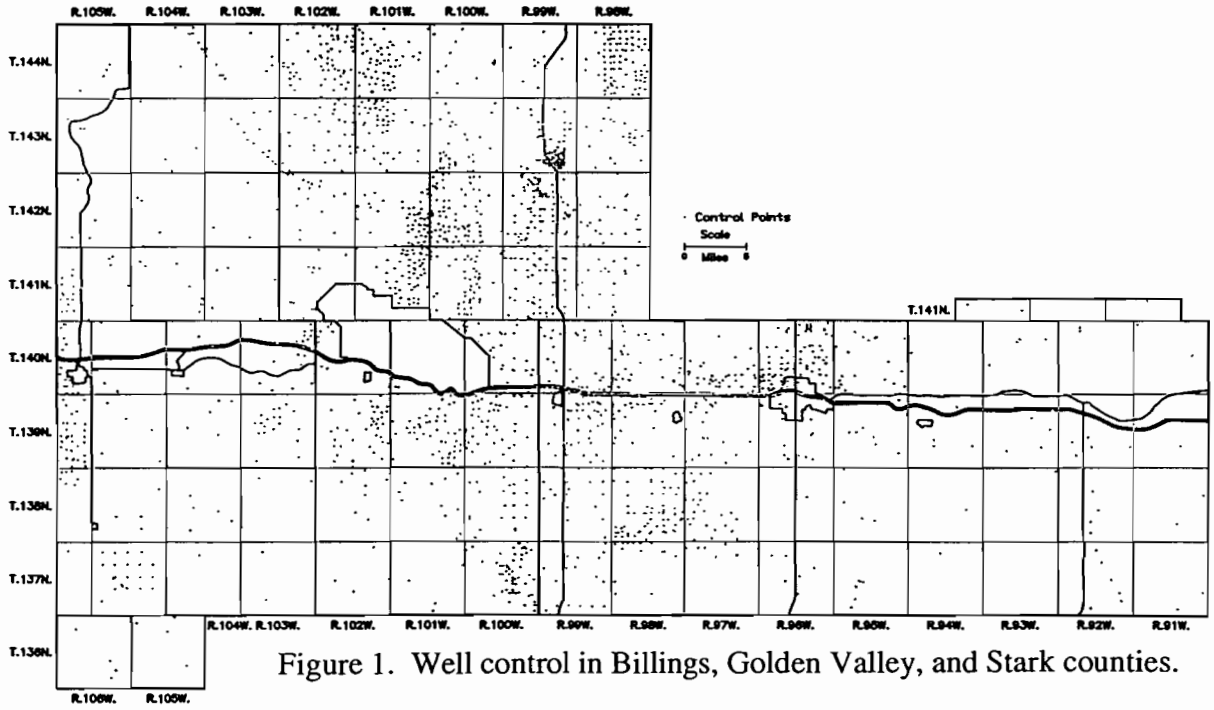

Figure 1. Well control in Billings, Golden Valley, and Stark counties.

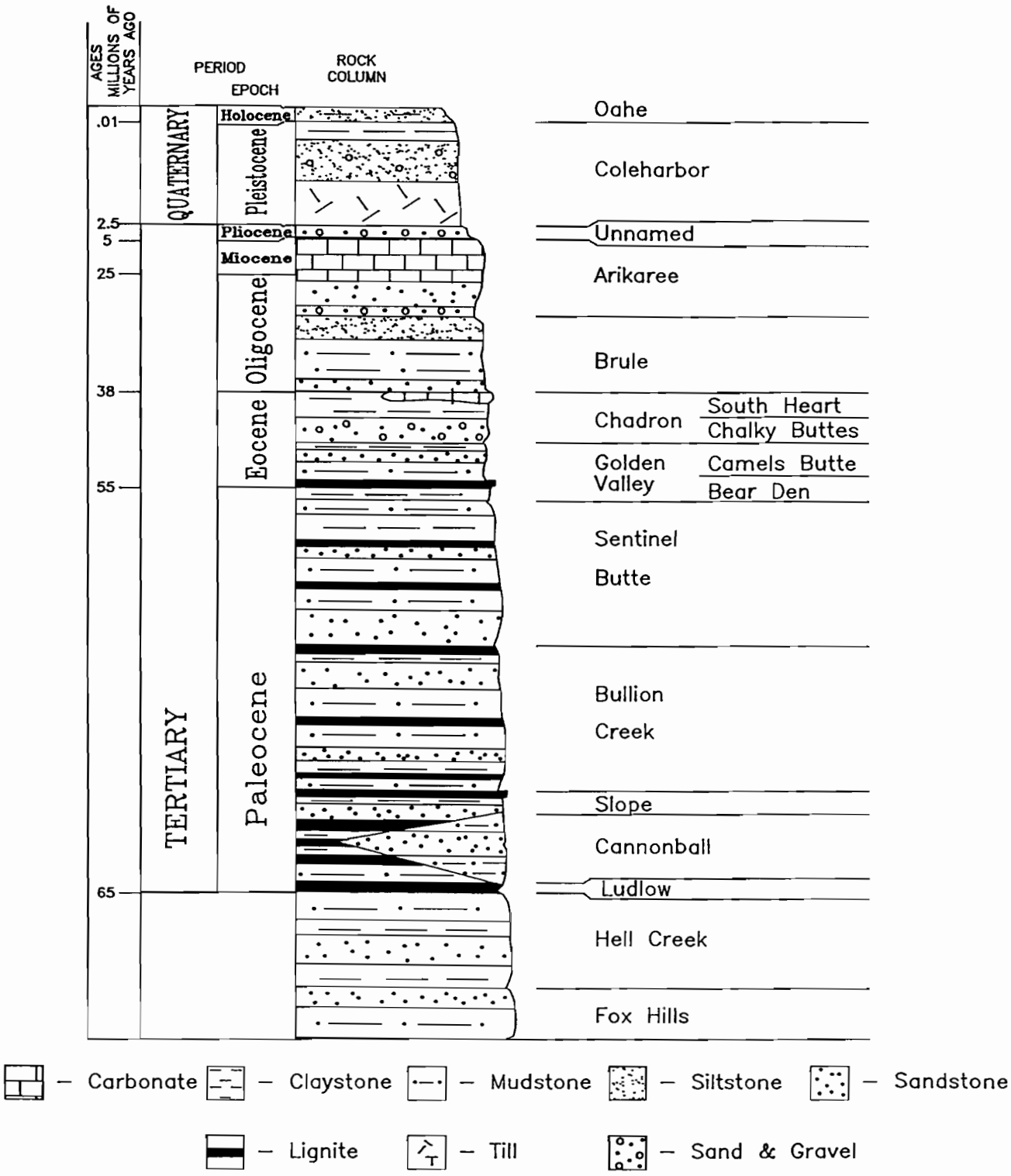

Figure 2. Generalized stratigraphic column of surface strata in western North Dakota.

GOLDEN VALLEY COUNTY

Introduction

Lithologic data from 276 drill holes was entered into the data base for this county. Most of the logs came from coal holes drilled in the vicinity of Beach and uranium holes drilled in the south-central part of the county (Figure 3).

T Cross Lignite

The T Cross lignite occurs at the base of the Slope Formation and appears to be the oldest thick coal in the county. It ranges in thickness from a few feet up to 26 feet in this area (Figure 4). It occurs at elevations ranging from a high of 2600 feet along the southern edge of the county to less than 1400 feet in the northeastern edge of the county, a dip to the north-northeast of 25 feet per mile (Figure 5). The T Cross coal occurs at an average depth of 1100 to 1200 feet in T.144N., 1000 feet in T.143N., 600 to 800 feet in Ts.139-140N., and 300 to 400 feet in T.136N. The top of the Ludlow Formation was best approximated using logs that penetrated the base of the Fox Hills Formation. Coals, especially thick ones, that occurred within this stratigraphic interval were identified as the T Cross. Given the poor deep-well control over most of the county, it is likely that a number of coals that have been tentatively identified as the T Cross may, in fact, not be this bed (Figures 6 - 10).

Harmon and Hansen Lignites

The Harmon and Hansen lignites occur within the lower portion of the Bullion Creek Formation. The Harmon overlies the Hansen and the stratigraphic interval between the coals generally averages 50 feet in this area. This interval often consists of claystone or

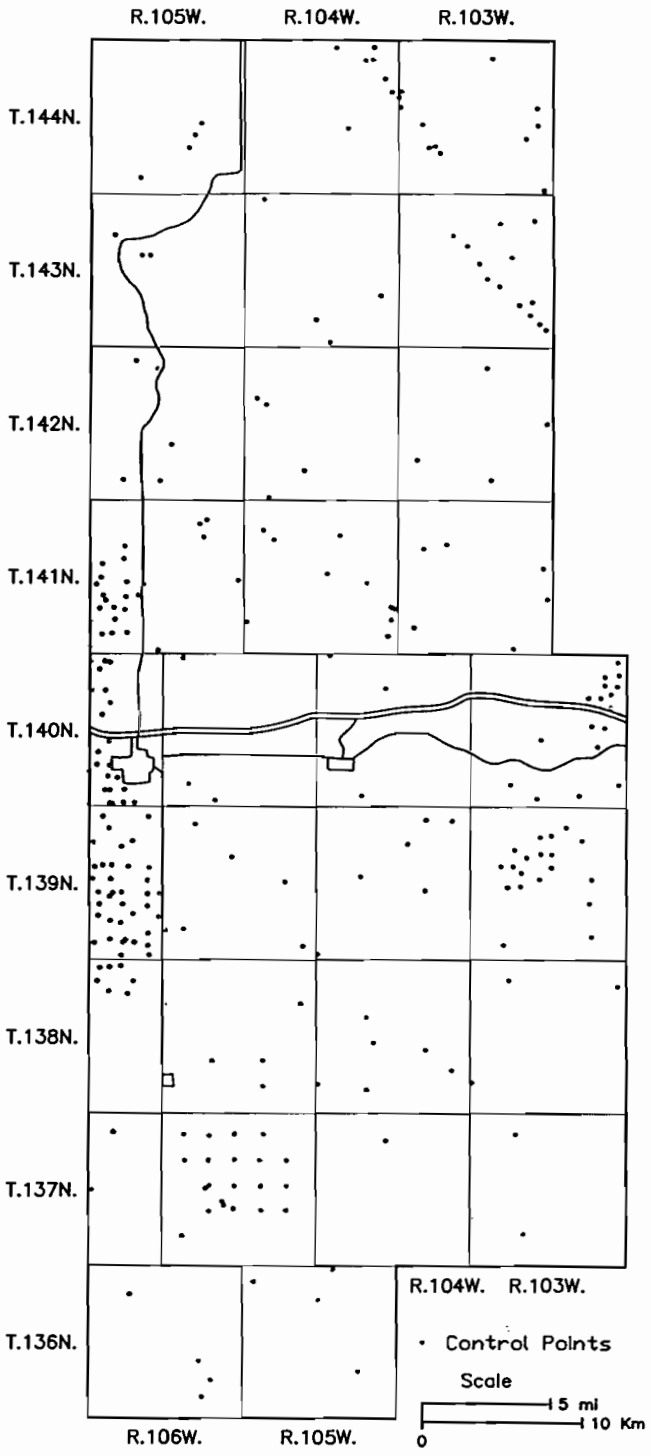

Figure 3. Well control in Golden Valley County.

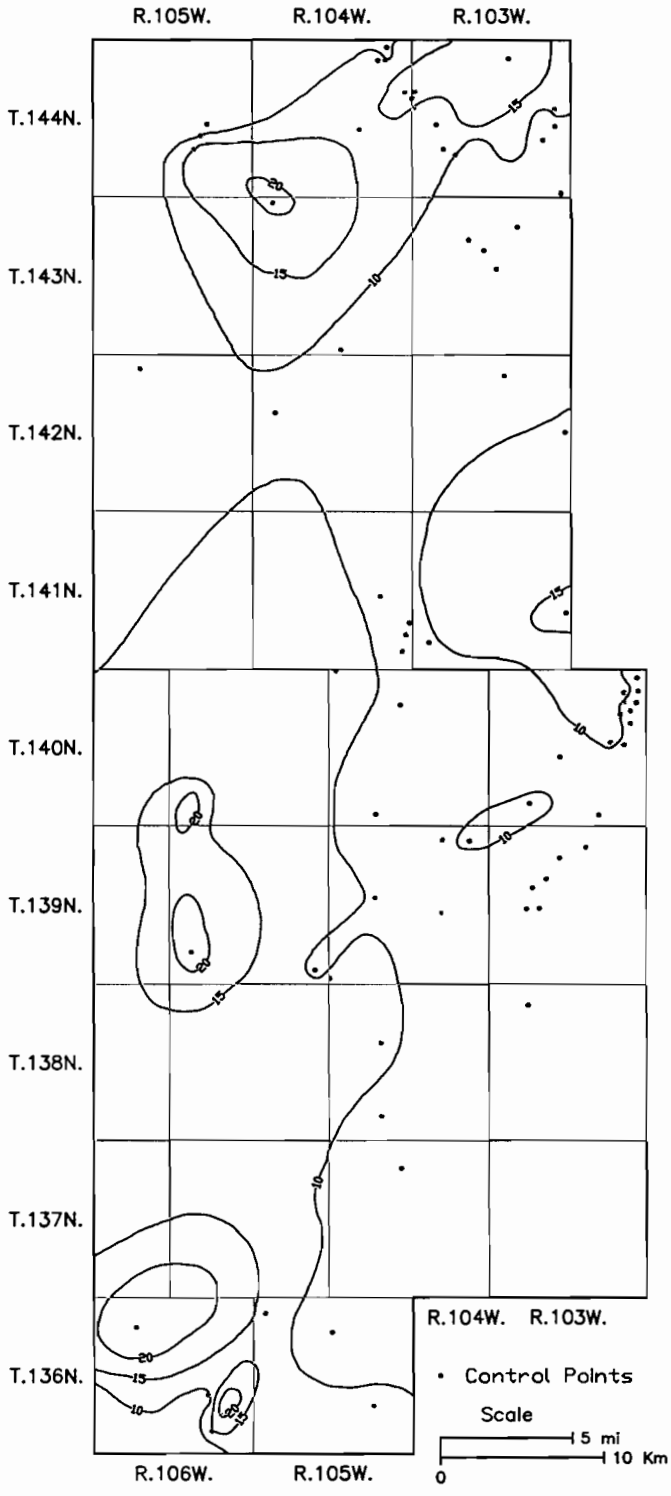

Figure 4. Isopach of the T Cross coal in Golden Valley County.

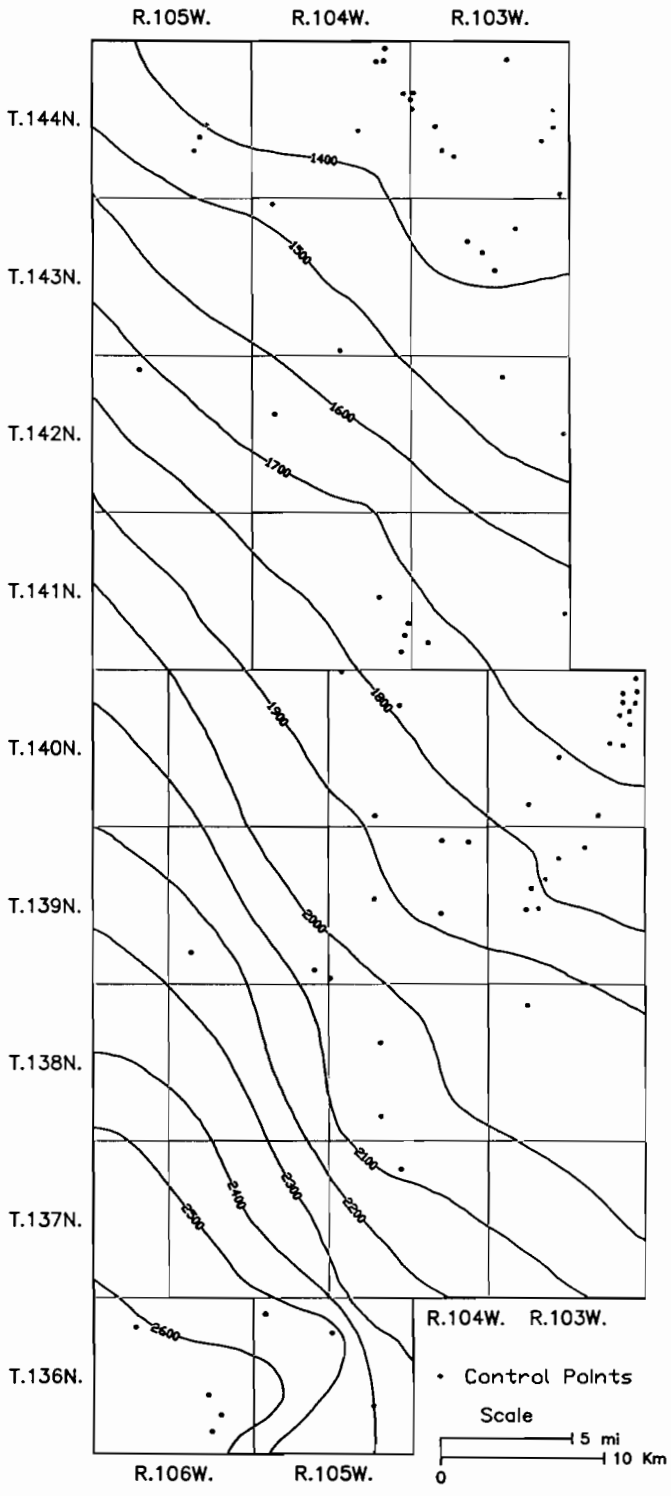

Figure 5. Contour map of the elevation at the top of the T Cross coal in Golden Valley County.

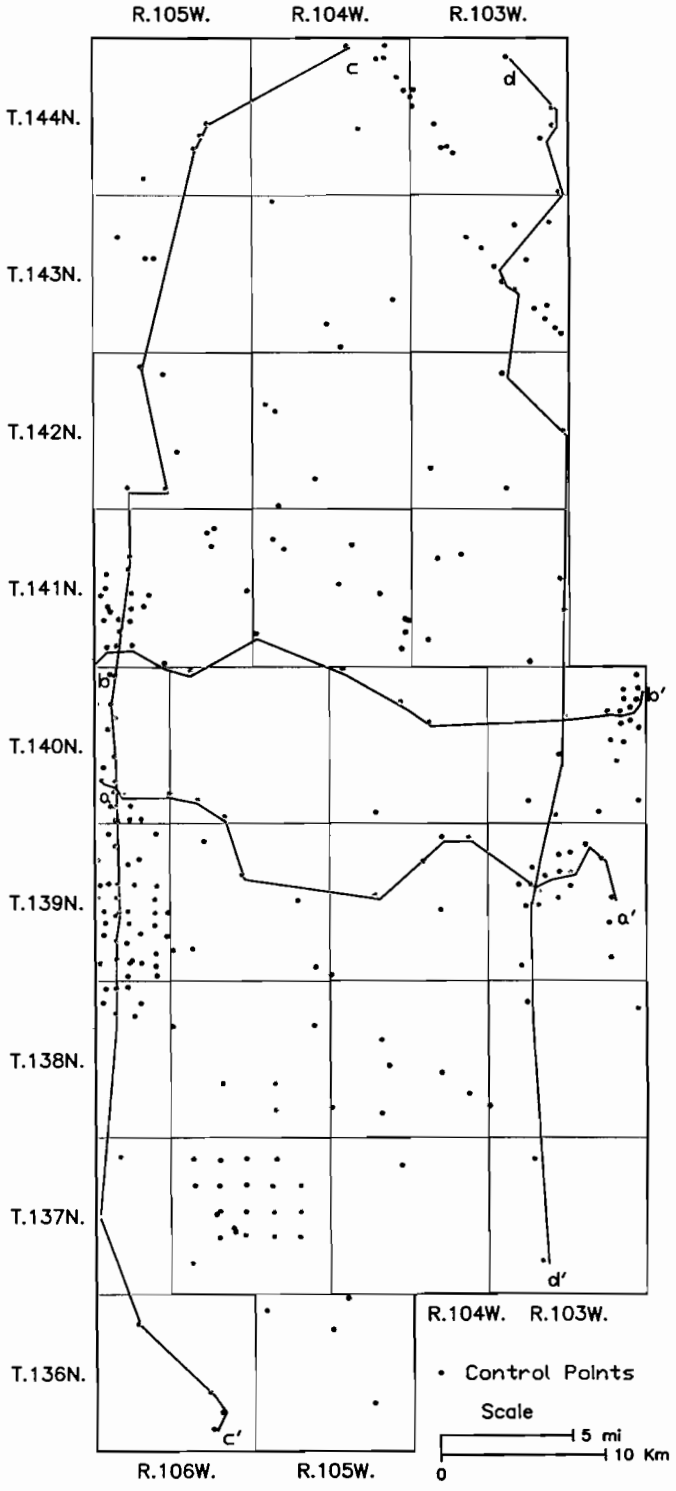

Figure 6. Traces of geologic cross-sections in Golden Valley County.

mudstone. Throughout most of the county, the Harmon bed is less than 10 feet thick. It reaches a maximum thickness of 31 feet in several areas in the vicinity of Beach in west-central Golden Valley County (Figures 11 and 12). The Hansen bed tends to be the thinner of the two beds throughout the west half of the county (Figures 7-10 and 13). But, to the east, the Hansen bed thickens and is often the thicker of the two beds or the only bed present in parts of east-central Golden Valley County. It reaches a maximum thickness of 19 feet in T.139N., R.104W. (Figure 13). The Harmon and Hansen beds range in elevation from 2900 feet along the western edge of the county to less than 2200 feet along the northeastern edge and are absent due to erosion along the southern edge of the county (Figures 7-10, 12, and 14). The Harmon is present at depths ranging from less than 100 feet in the Beach area to more than 600 feet in east-central Golden Valley County.

HT Butte Lignite

The HT Butte coal is situated at the contact between the Sentinel Butte and Bullion Creek Formation. The Sentinel Butte Formation, and therefore the HT Butte coal, has been eroded from all but about ten percent of the county. The HT Butte obtains a maximum thickness of 25 feet at depths of 200 to 400 feet in the vicinity of Square Butte in east-central Golden Valley County (Figures 15 and 16).

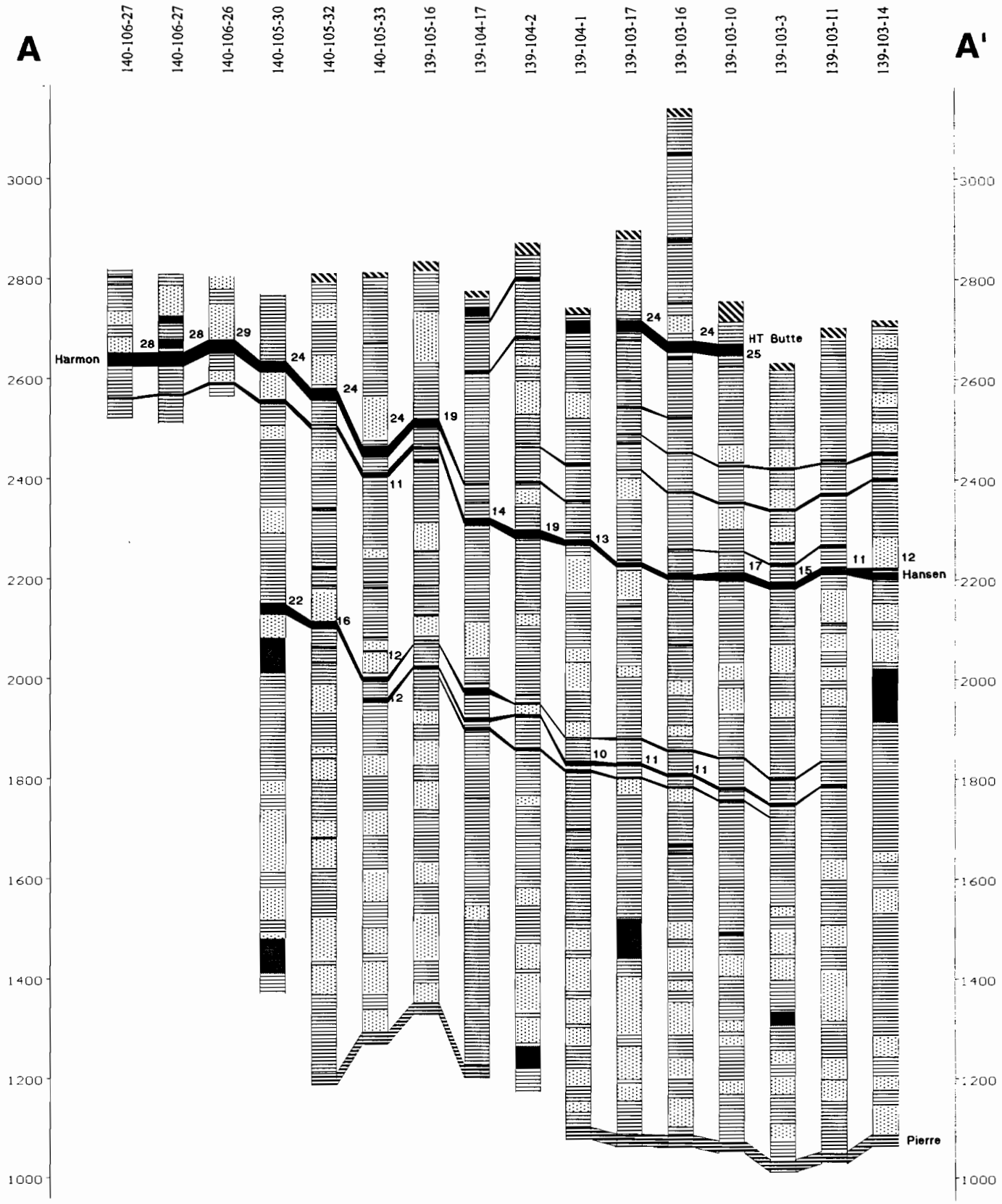

Figure 7. Cross-section A-A' of Upper Cretaceous and Fort Union strata in central Golden Valley County (see appendix A for lithologic pattern descriptions).

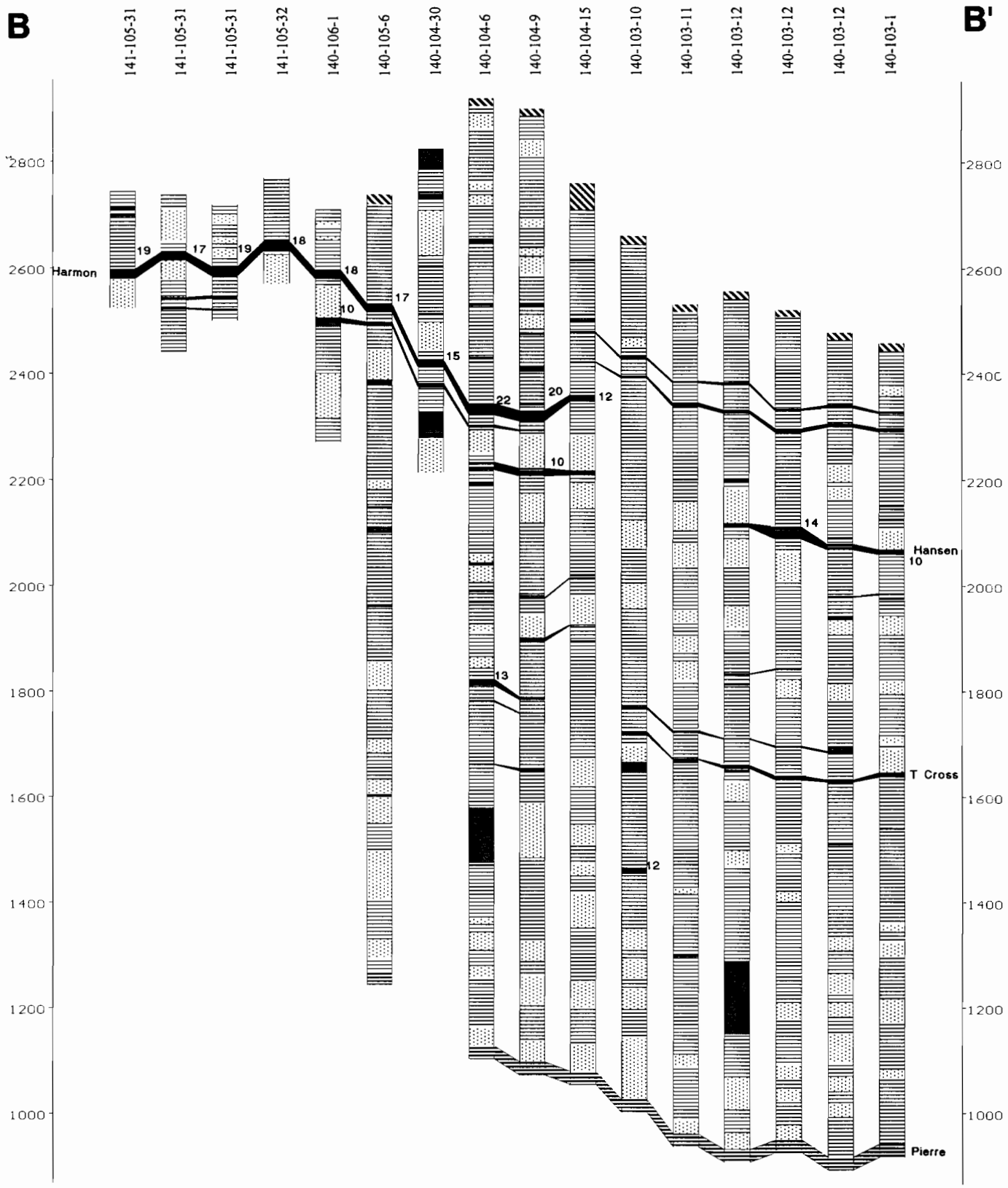

Figure 8. Cross-section B-B' of Upper Cretaceous and Fort Union strata in central Golden Valley County.

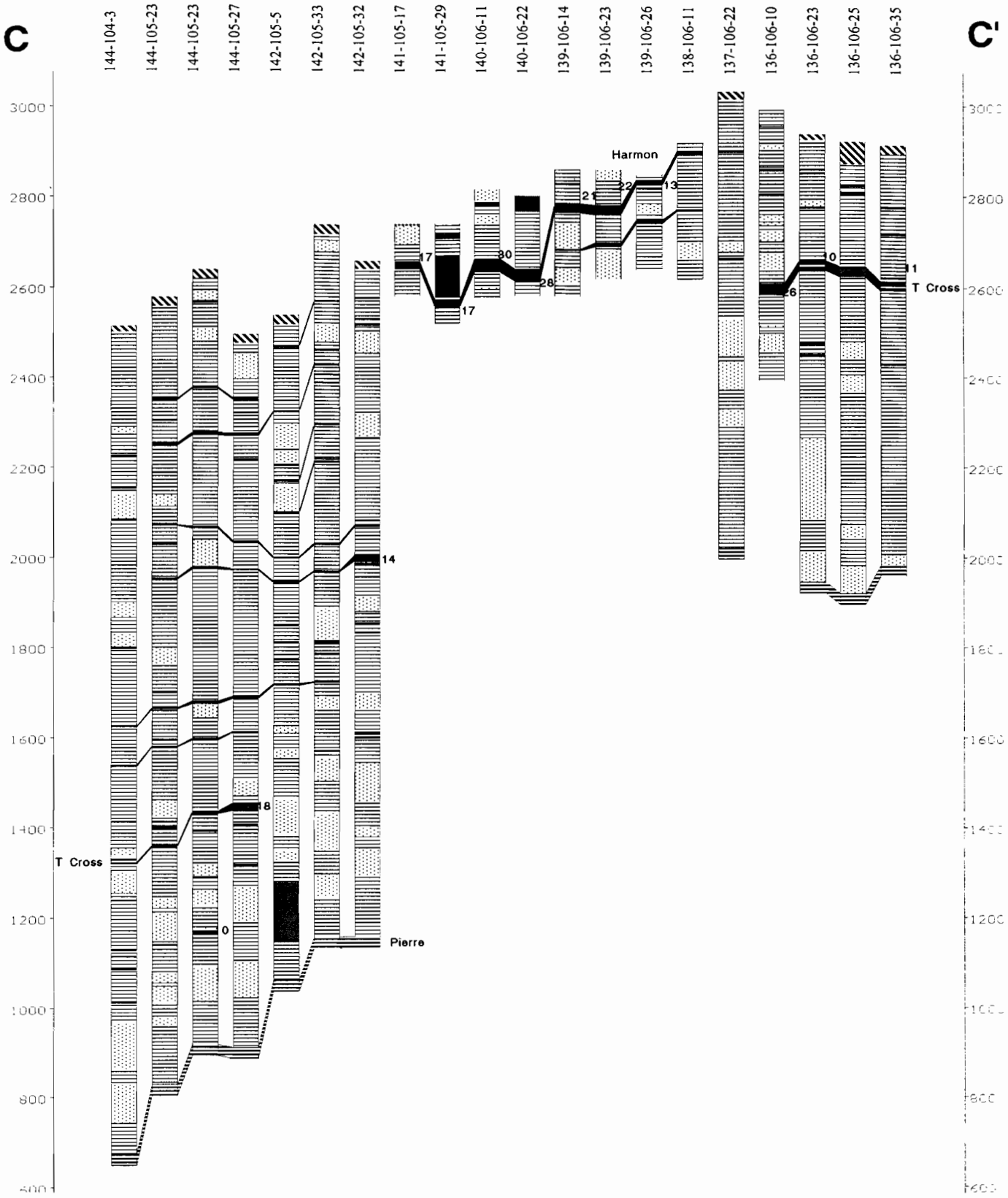

Figure 9. Cross-section C-C' of Upper Cretaceous and Fort Union strata in western Golden Valley County.

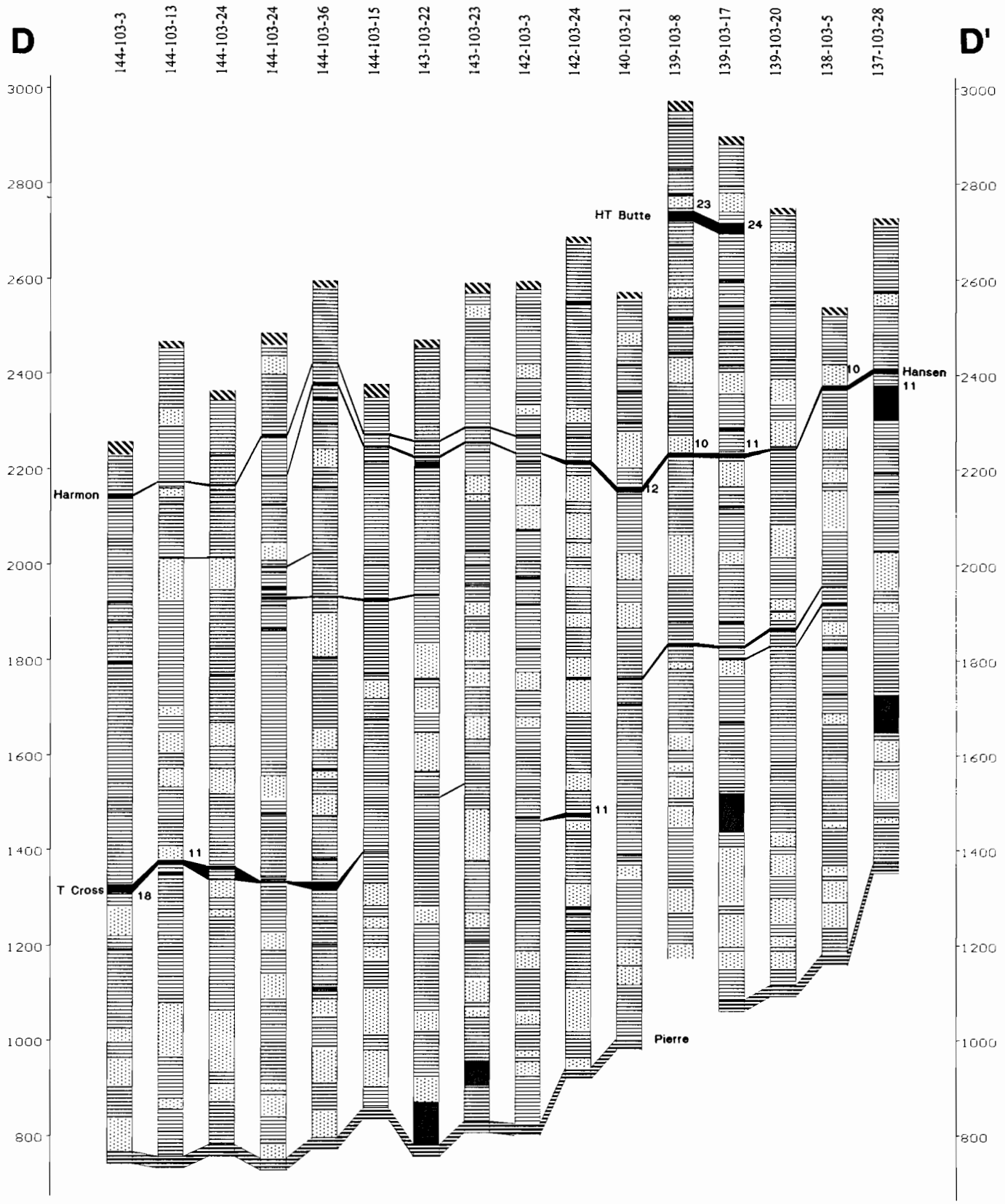

Figure 10. Cross-section D-D' of Upper Cretaceous and Fort Union strata in eastern Golden Valley County.

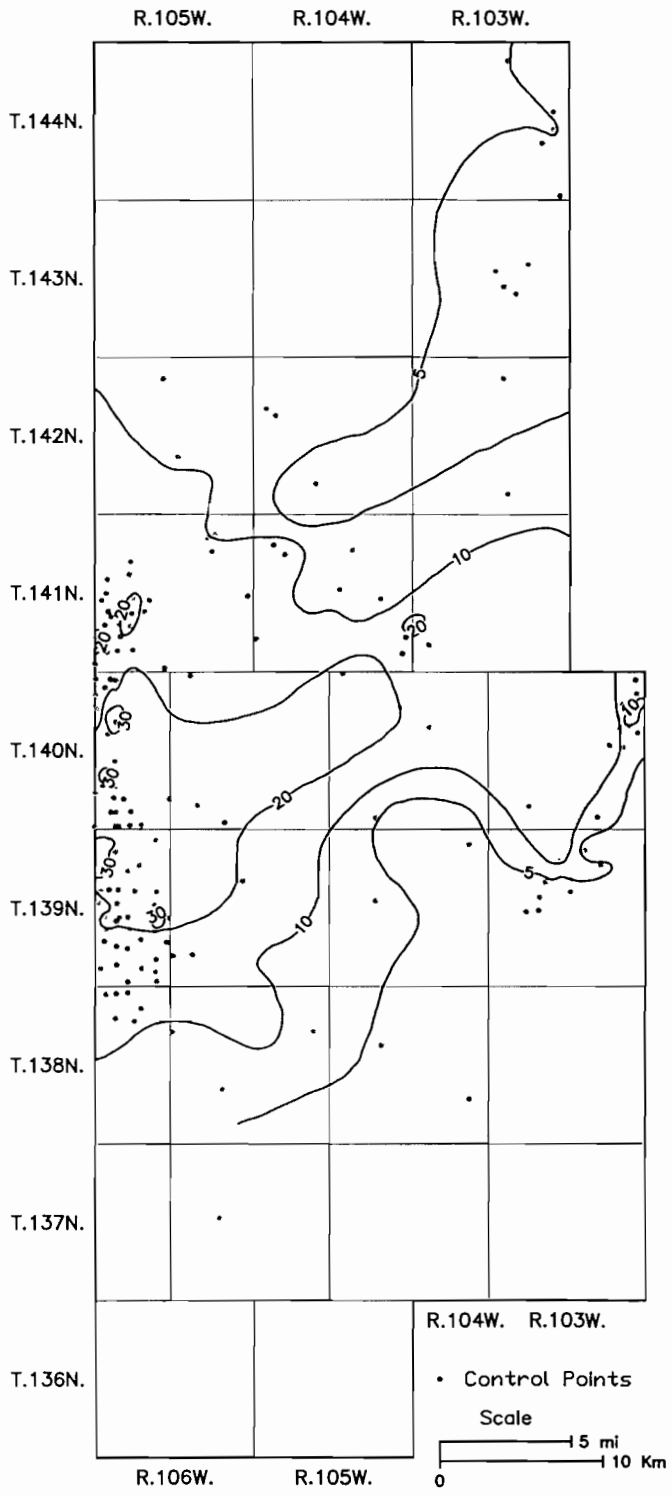

Figure 11. Isopach of the Harmon coal in Golden Valley County.

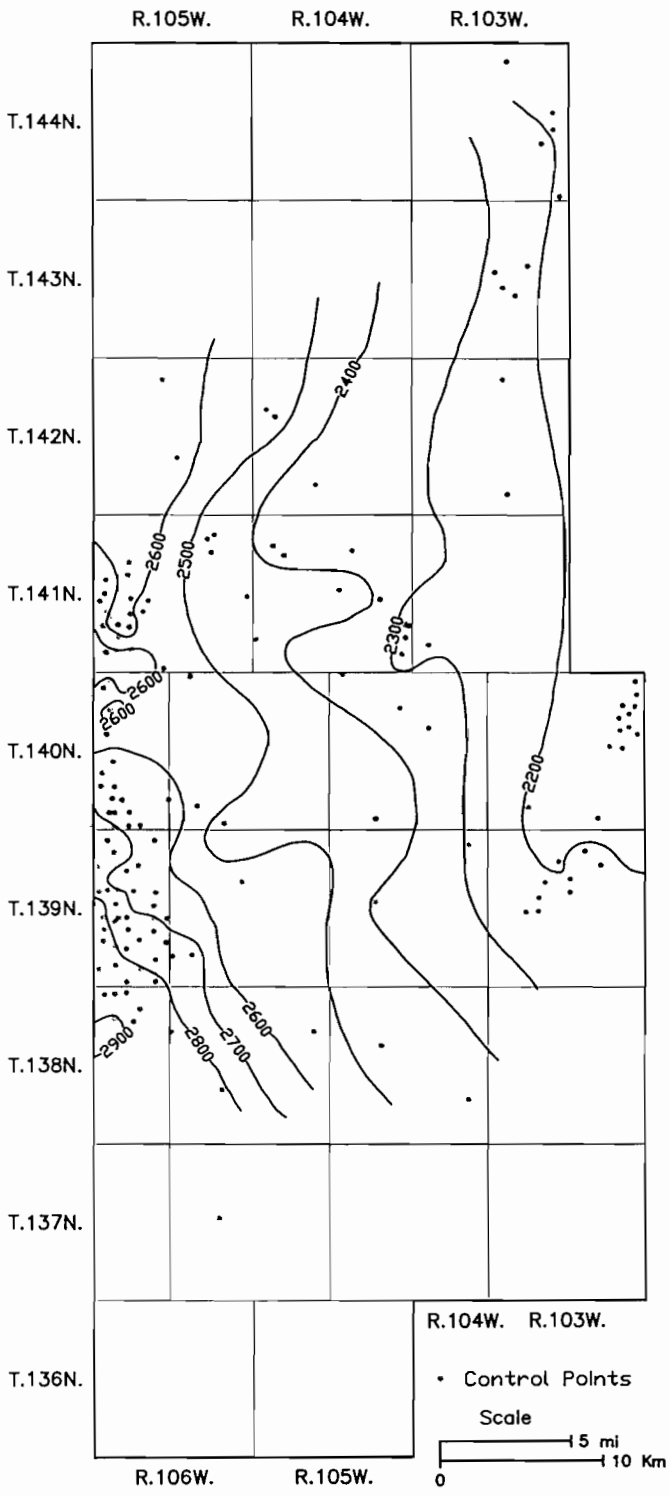

Figure 12. Contour map of the elevation at the top of the Harmon coal in Golden Valley County.

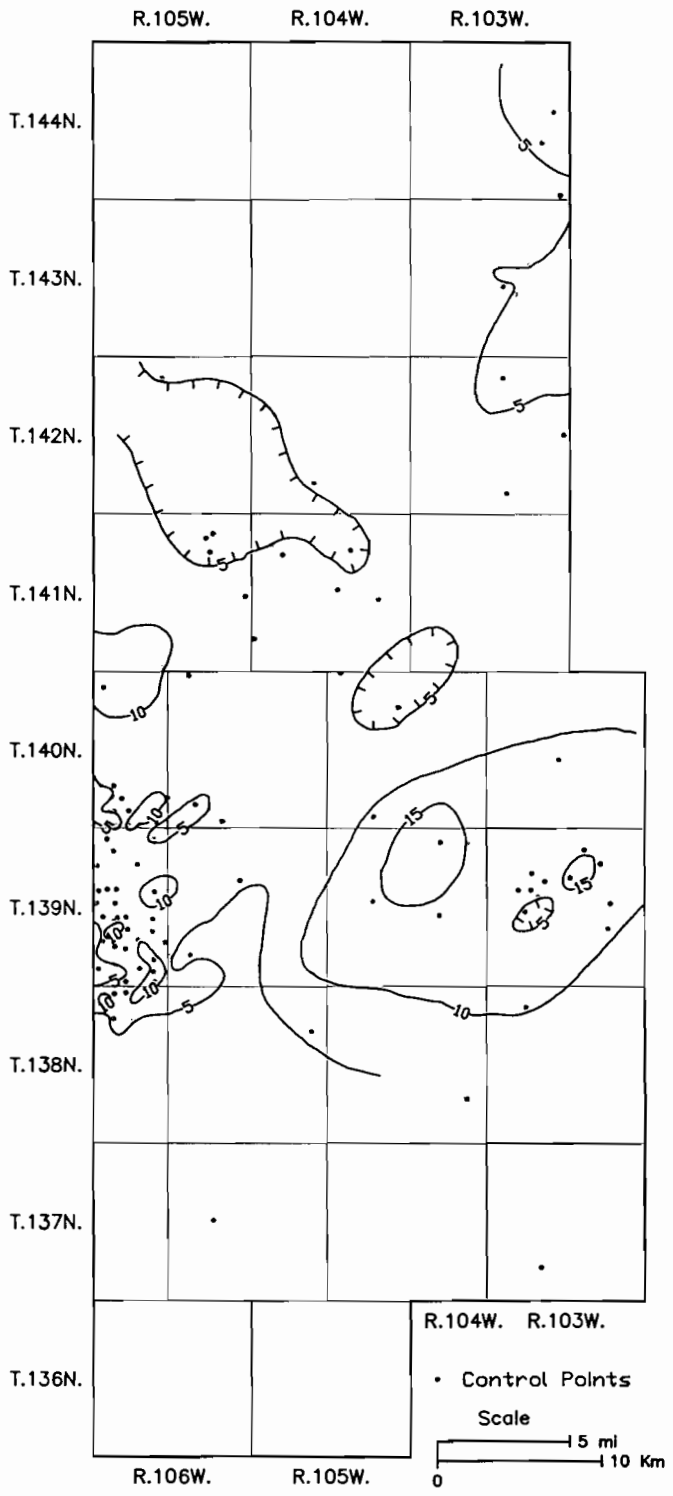

Figure 13. Isopach of the Hansen coal in Golden Valley County.

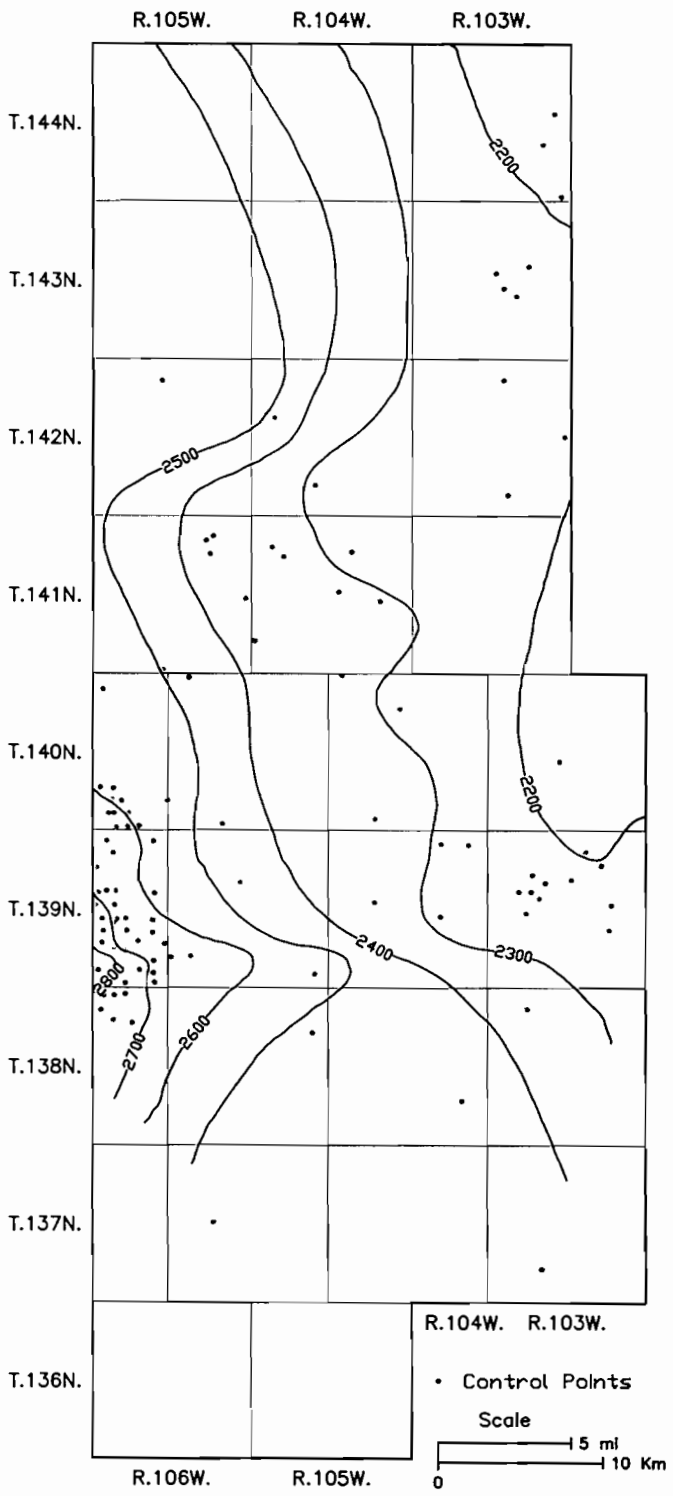

Figure 14. Contour map of the elevation at the top of the Hansen coal in Golden Valley County.

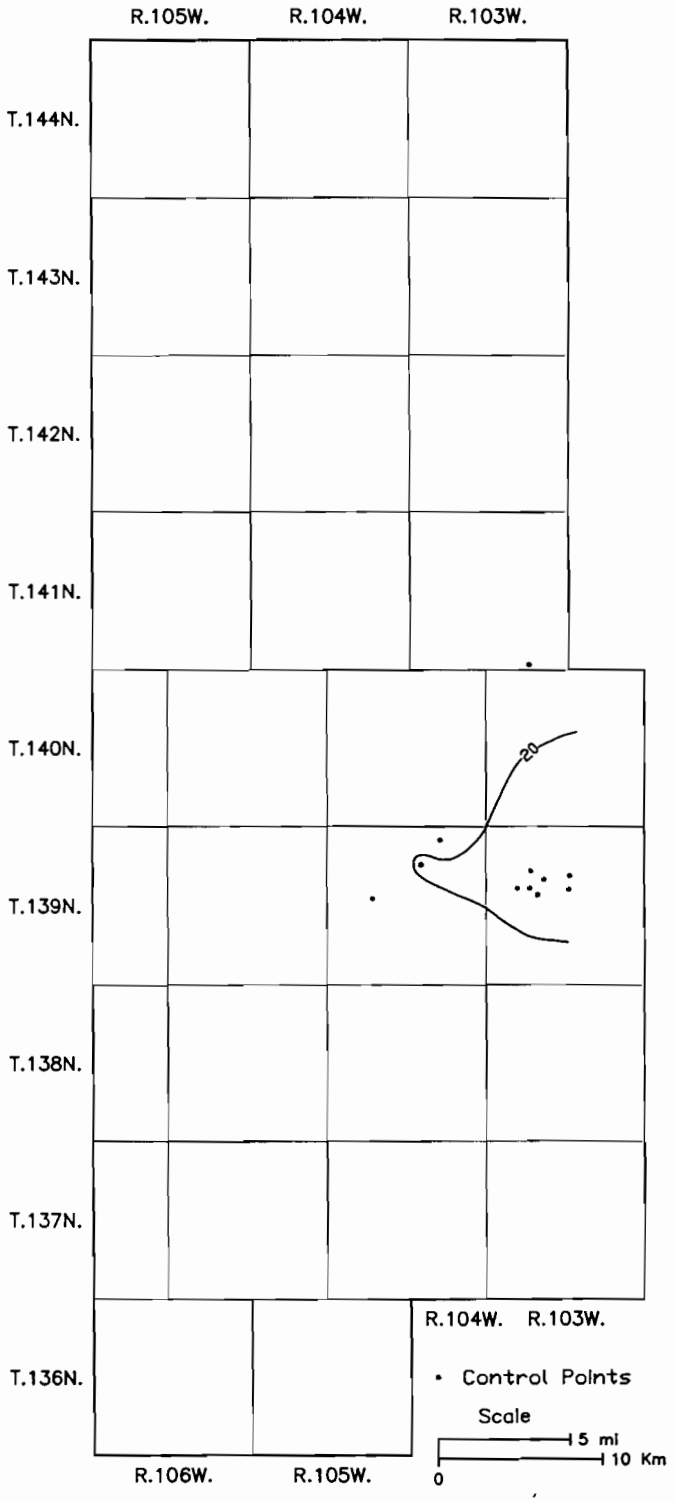

Figure 15. Isopach of the HT coal in Golden Valley County.

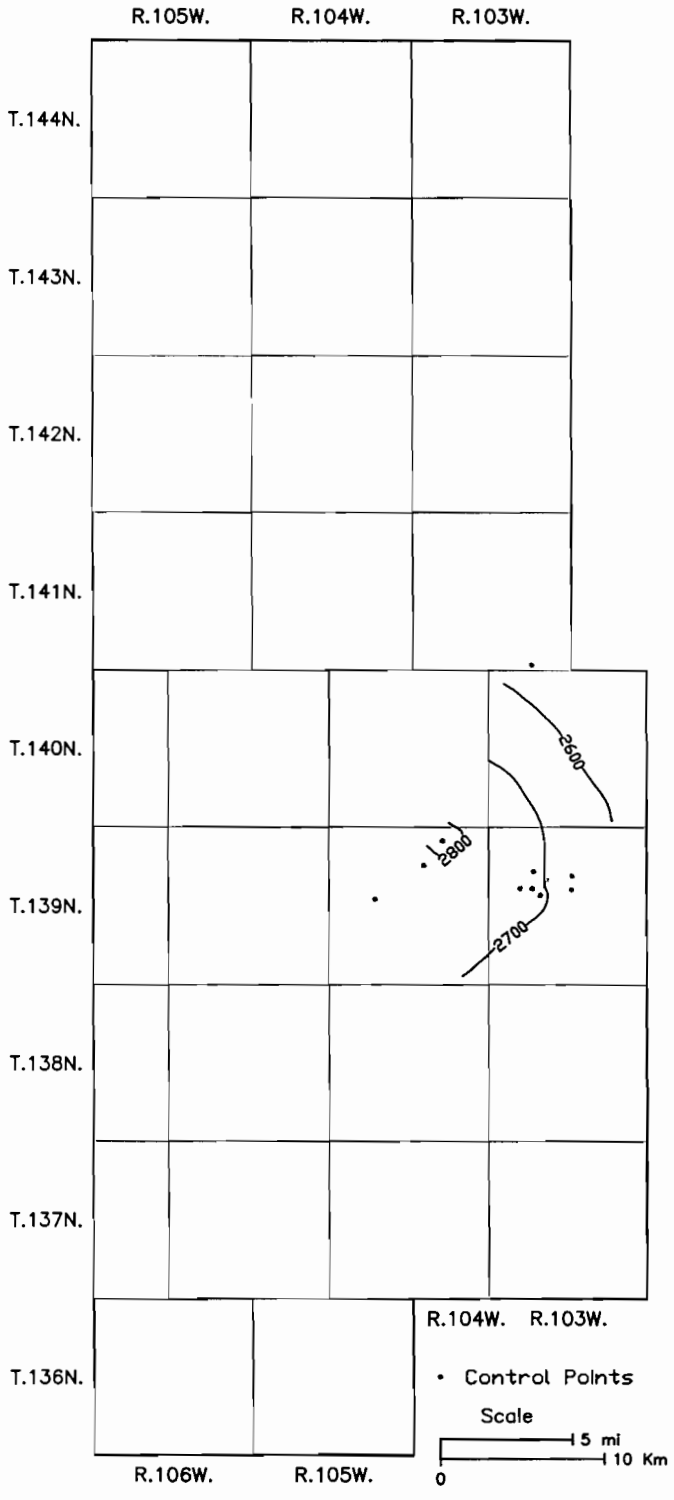

Figure 16. Contour map of the elevation at the top of the HT coal in Golden Valley County.

BILLINGS COUNTY

Introduction

A total of 1330 drill holes were entered into the data base for Billings County. Most of this information (907 data points) came from wide-spread, oil-and-gas gamma logs run through surface casing. Uranium exploration holes drilled in the northeastern portion of the county (near old uranium mine sites), scattered coal exploration holes, and ND State Water Commission monitoring wells provide additional data (Figure 17).

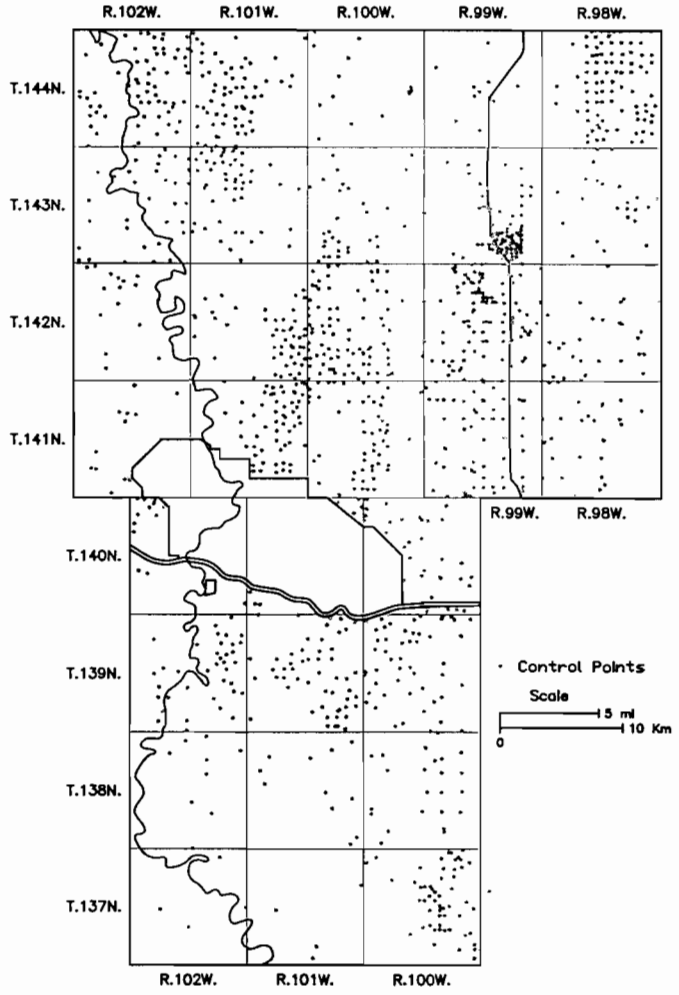

Figure 17. Well control in Billings County.

T Cross Lignite

A 3 to-10-foot thick coal or series of coal beds is present at the approximate stratigraphic position of the top of the Slope Formation which coincides with the position of the T Cross coal, if the Cannonball Formation is absent in this area. This stratigraphic horizon dips to the north from an elevation of over 1700 feet along the southern border of the county to less than 1000 feet in the northeastern corner (Figures 18 and 19). The coal, or coals, occur at depths of 800 to 1,600 feet in Billings County. These thin coals are difficult to accurately correlate (Figures 20-26).

Harmon and Hansen Lignites

Both the Harmon and Hansen are present throughout most of Billings County, except in the south-central part of the county where only one bed is present. The Harmon typically overlies the Hansen by 25 to 75 feet. The Harmon bed averages around 10 feet in thickness over the area, but is more than 20 feet thick in the north half of townships T.141N. Rs.100&101W. and the south half of townships T.142N. Rs.100&101W. in north-central Billings County (Figures 22 and 27). The Hansen bed averages around 10 feet thick in the north half of the county (Figure 29). Both beds dip to the northwest at an average rate of 20 feet per mile (Figures 28 and 30). Based on thickness and depth, the Harmon and Hansen beds appear to be the best candidates for coalbed methane exploration in Billings County (Figures 21-26).

HT Butte Lignite

The HT Butte lignite is absent from the western 1/3 of Billings County due to erosion. It is in excess of 15 feet thick over portions of south-central and north-central Billings County (Figures 22, 23, and 31). The HT Butte coal is generally at depths of less than 300 feet and occurs at elevations ranging from 2200 to over 2500 feet (Figure 32). The bed appears to be thin or absent in northeastern Billings County.

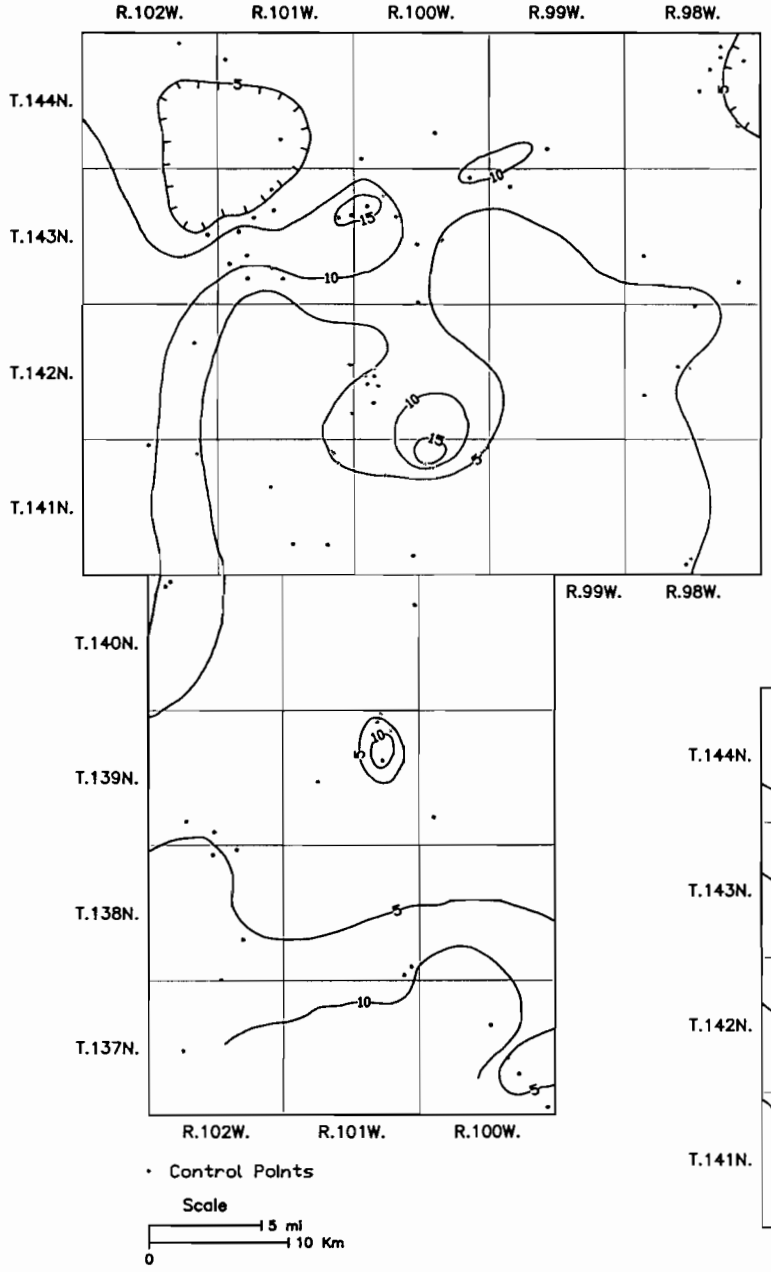

Figure 18. Isopach of the T Cross coal in Billings County.

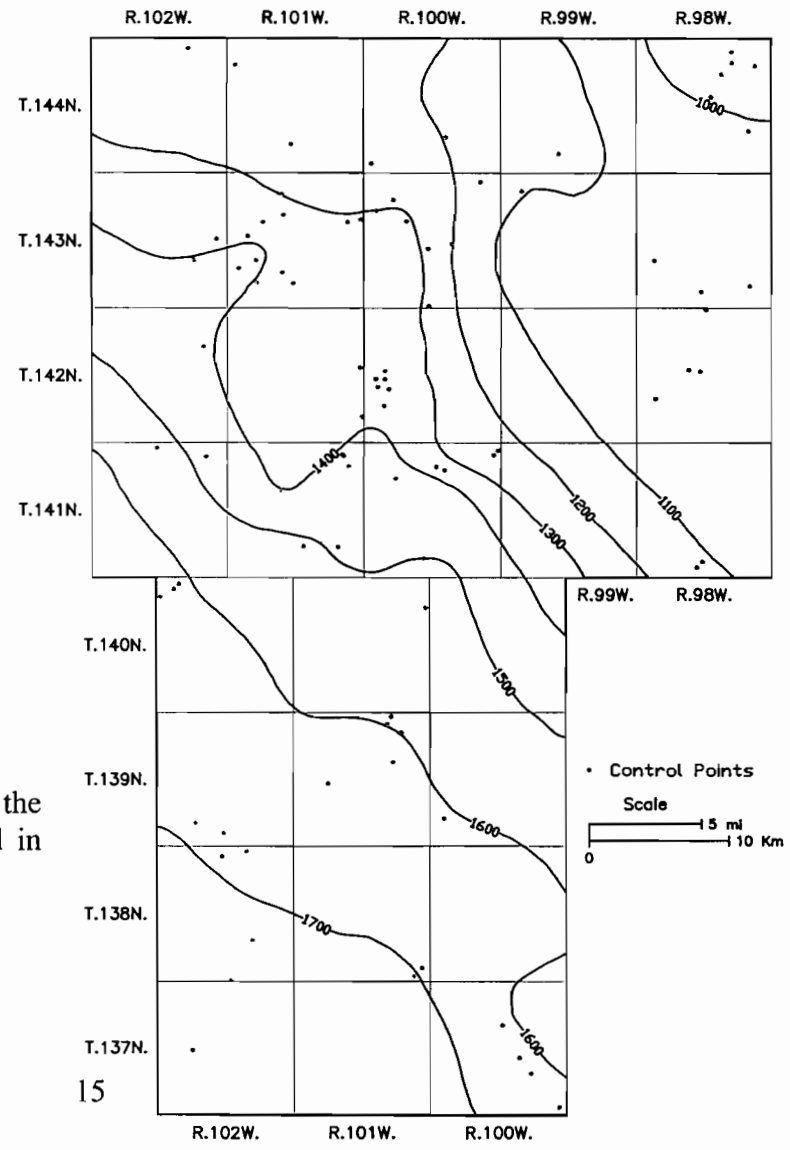

Figure 19. Contour map of the elevation at the top of the T Cross coal in Billings County.

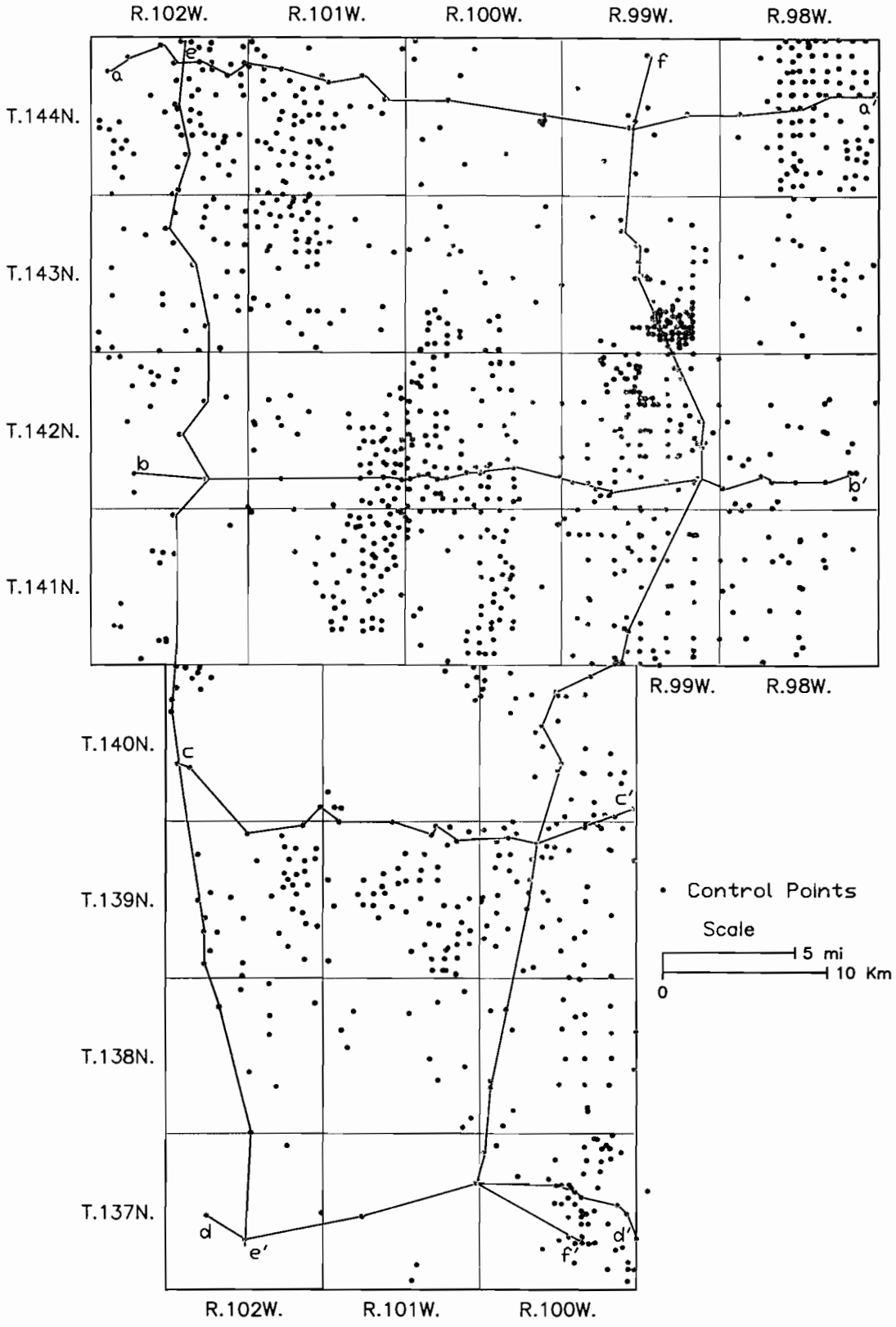

Figure 20. Traces of geologic cross-sections in Billings County.

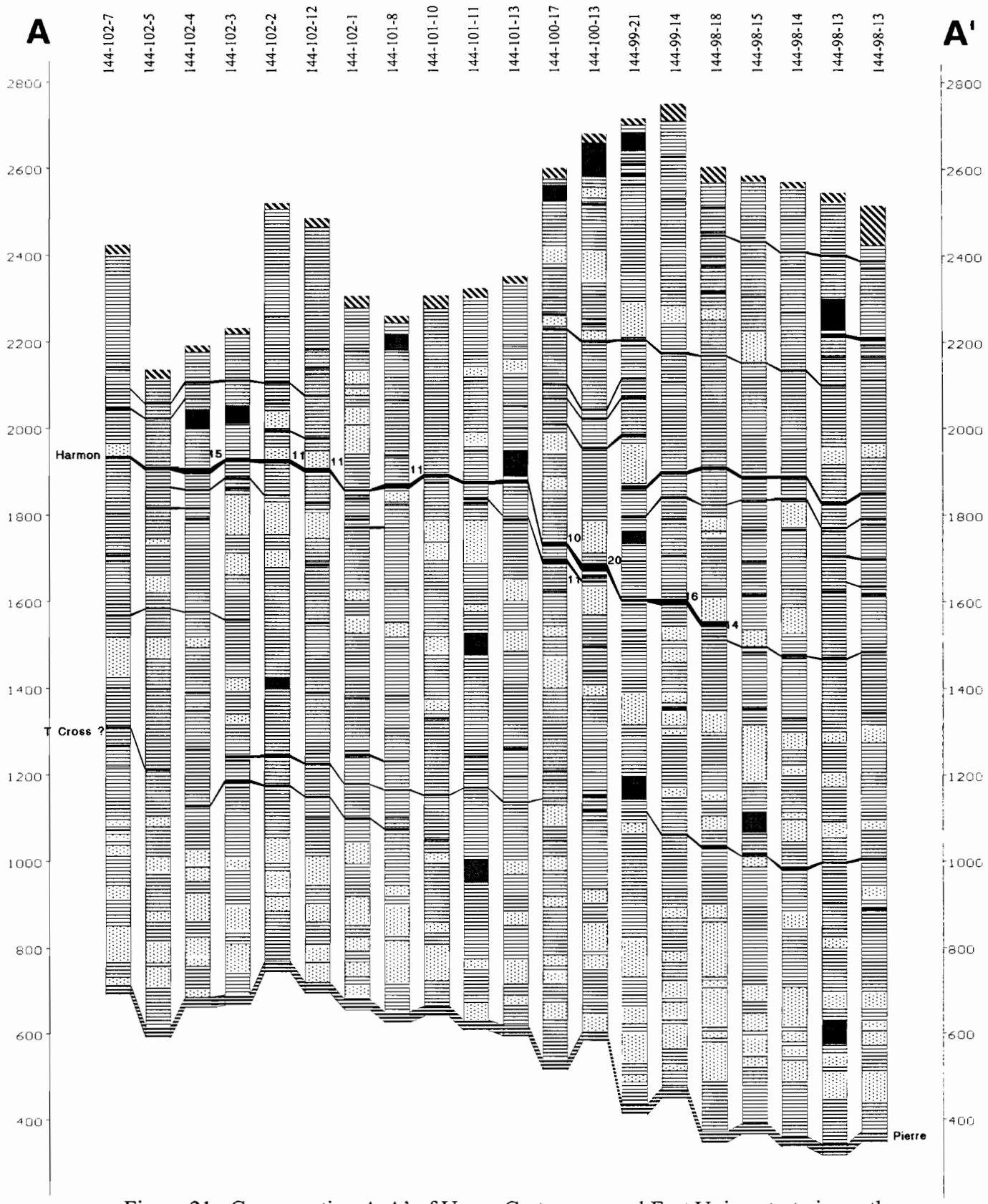

Figure 21. Cross-section A-A' of Upper Cretaceous and Fort Union strata in northern Billings County.

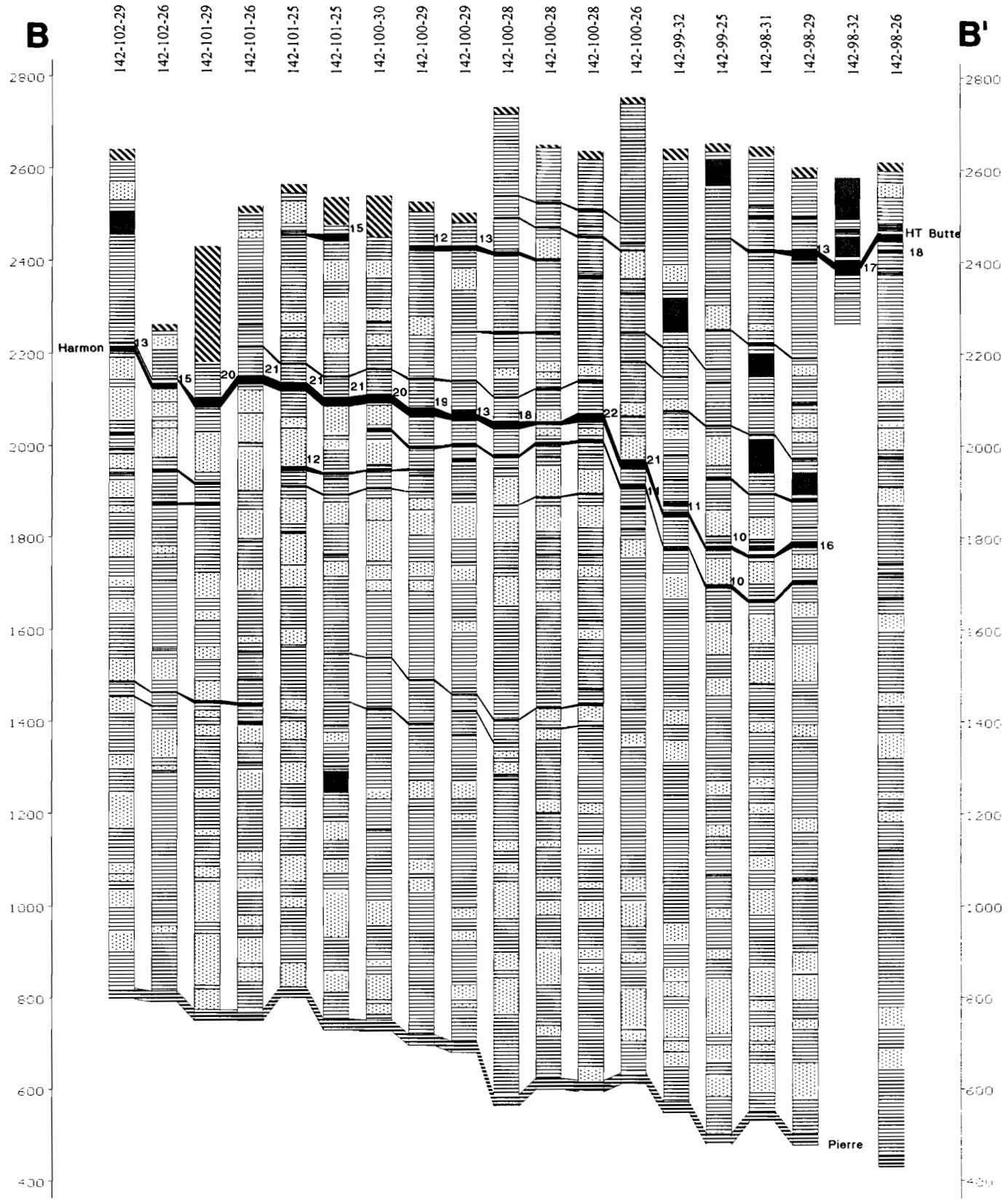

Figure 22. Cross-section B-B' of Upper Cretaceous and Fort Union strata in central Billings County.

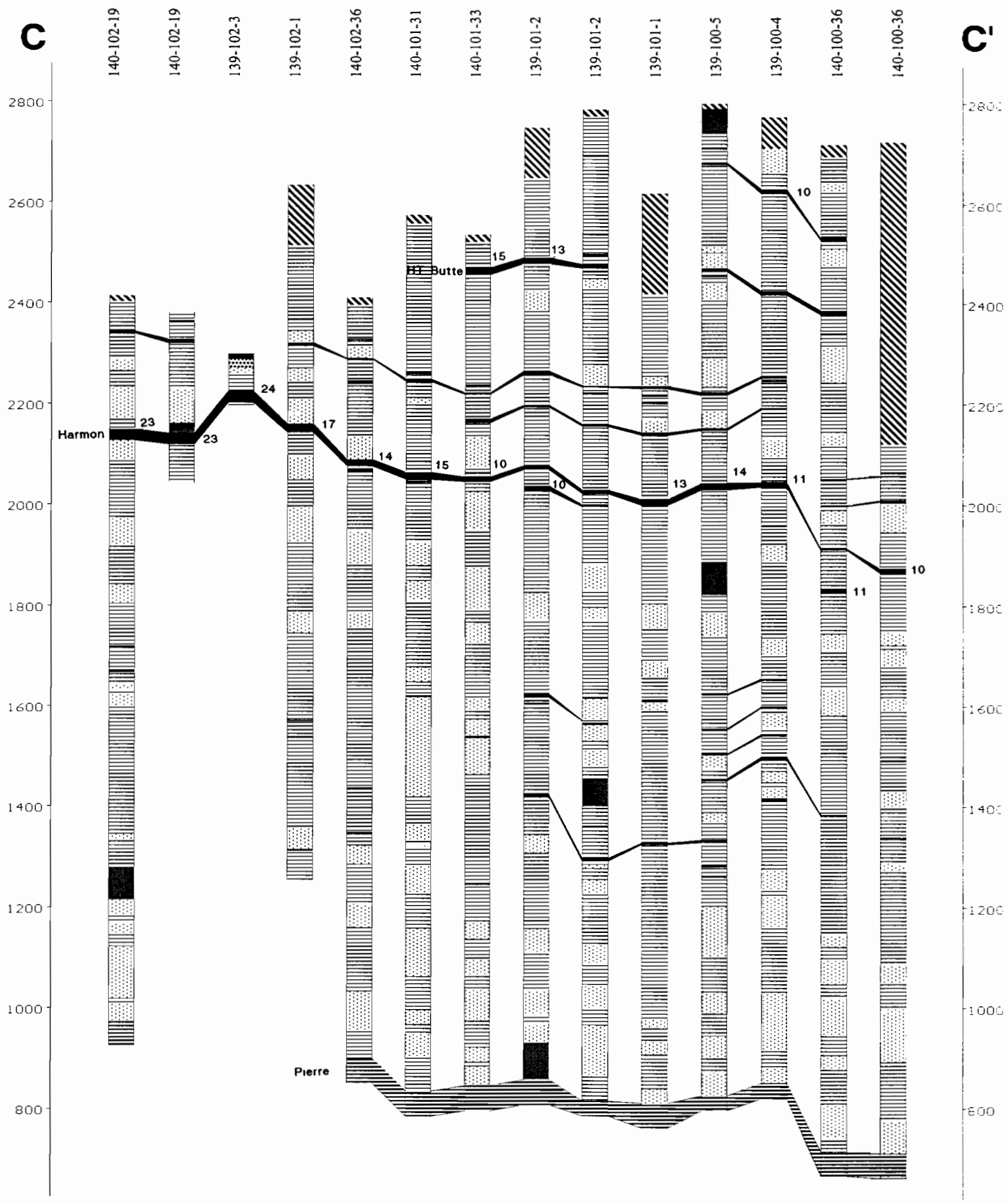

Figure 23. Cross-section C-C' of Upper Cretaceous and Fort Union strata in south-central Billings County.

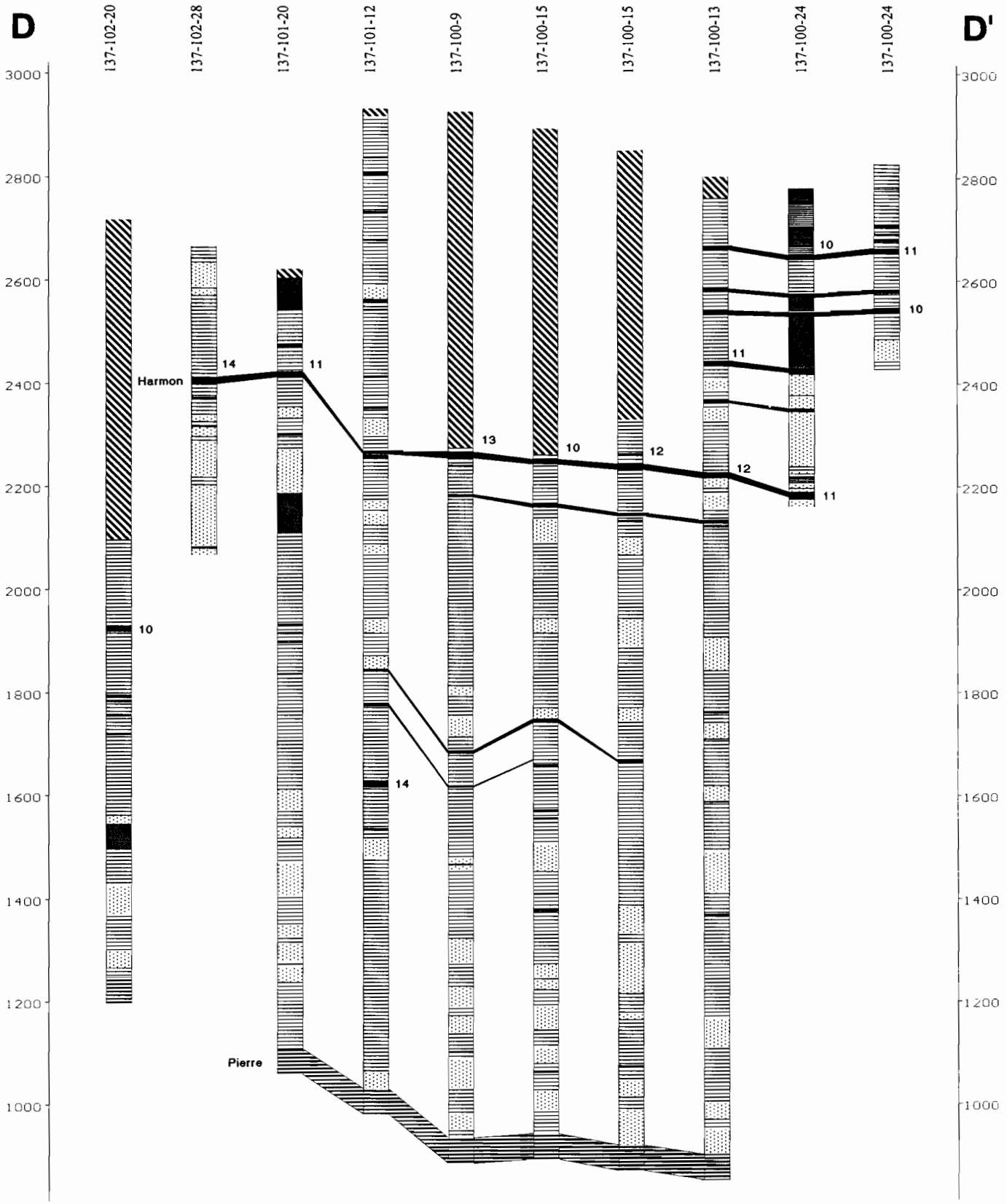

Figure 24. Cross-section D-D' of Upper Cretaceous and Fort Union strata in southern Billings County.

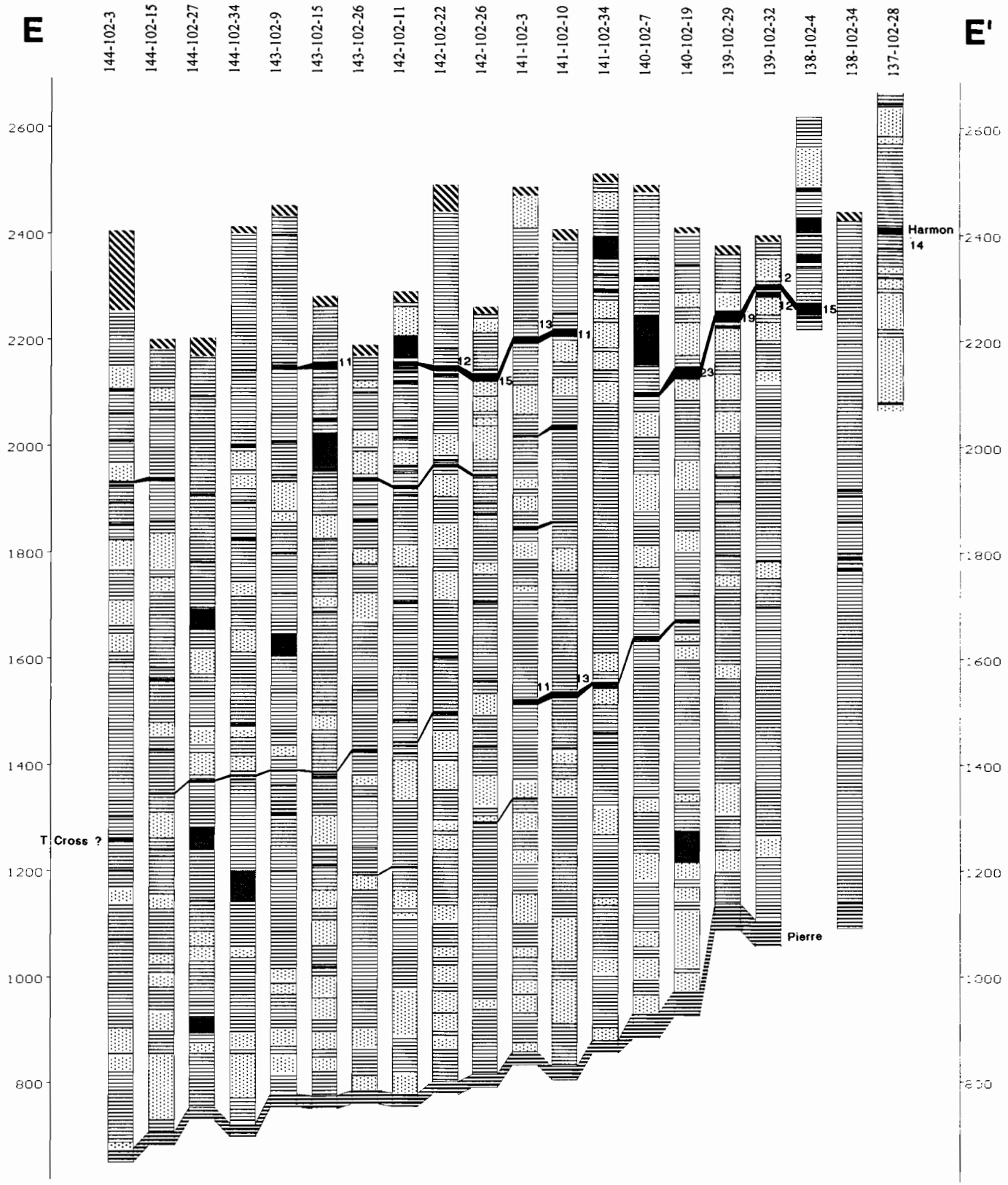

Figure 25. Cross-section E-E' of Upper Cretaceous and Fort Union strata in western Billings County.

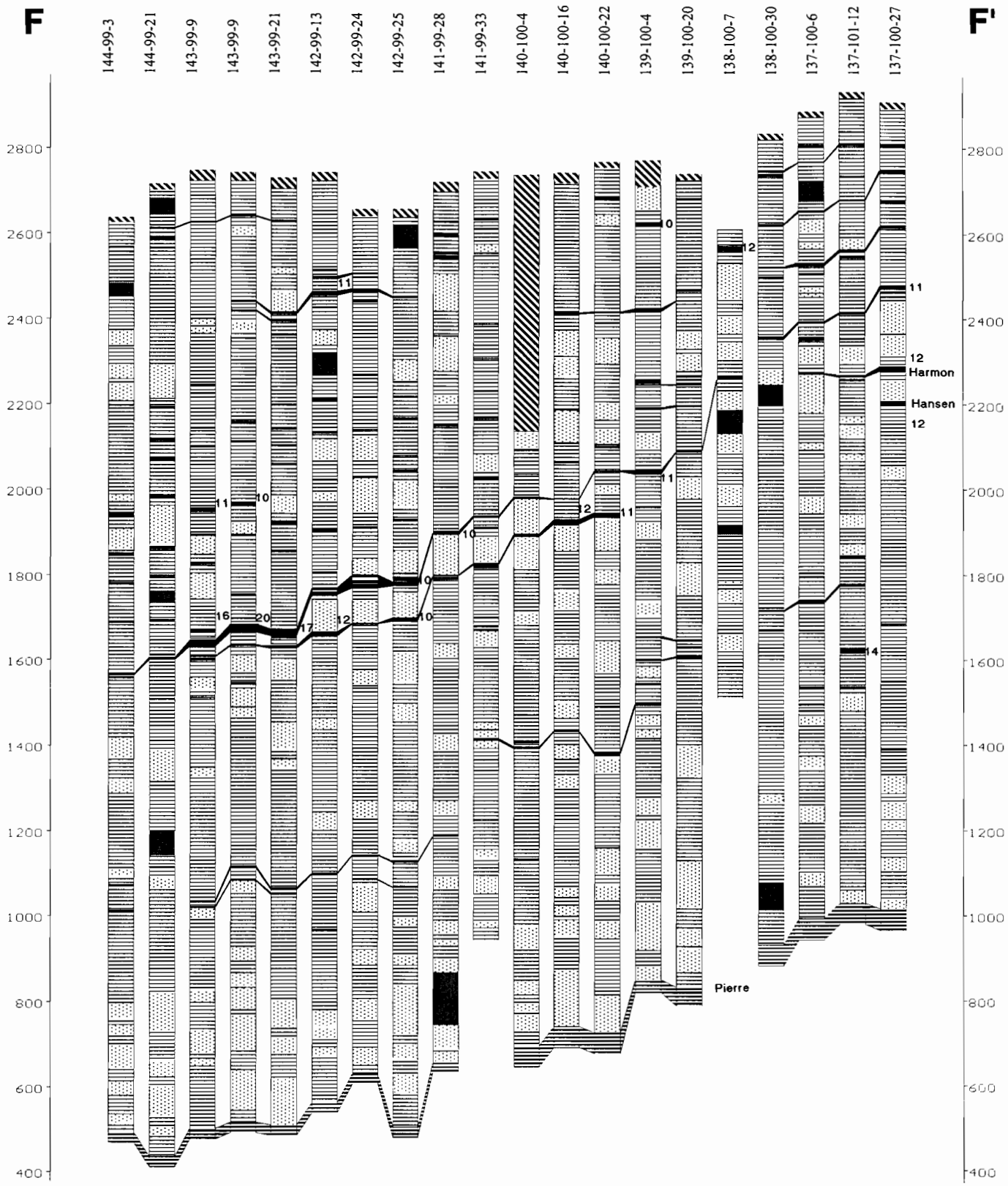

Figure 26. Cross-section F-F' of Upper Cretaceous and Fort Union strata in eastern Billings County.

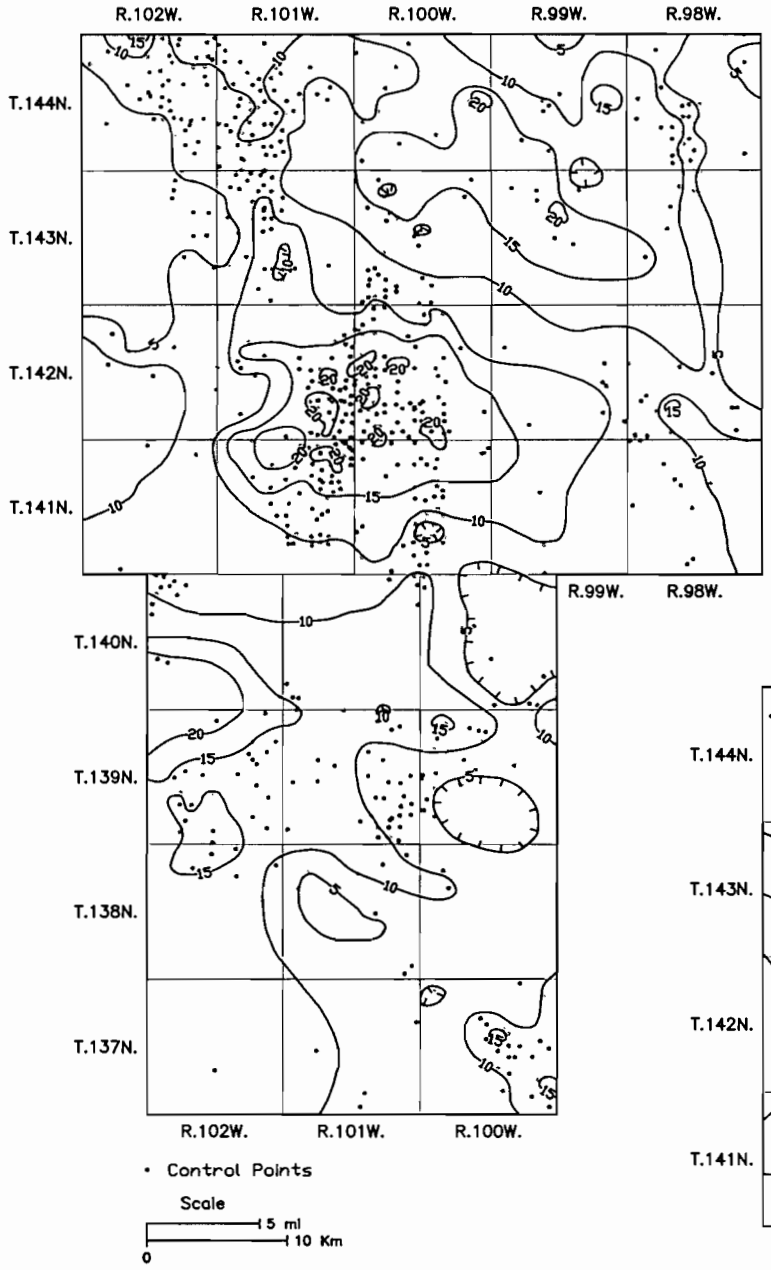

Figure 27. Isopach of the Harmon coal in Billings County.

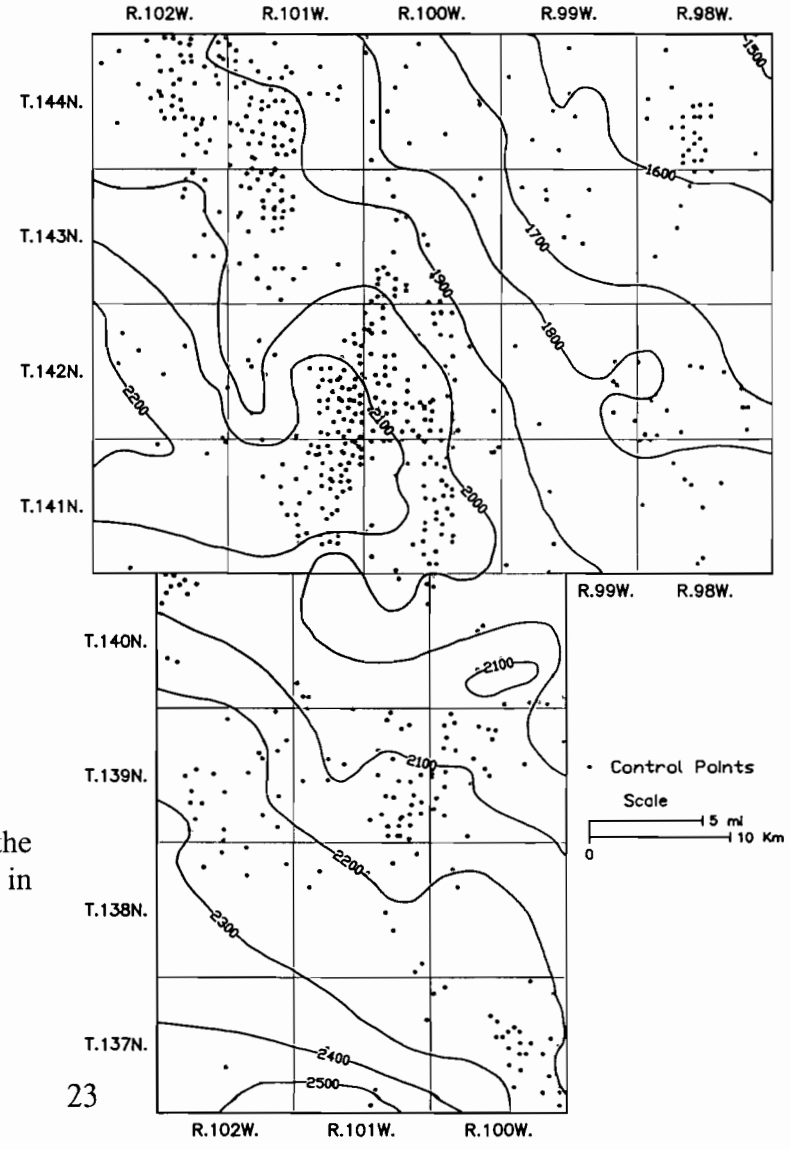

Figure 28. Contour map of the elevation at the top of the Harmon coal in Billings County.

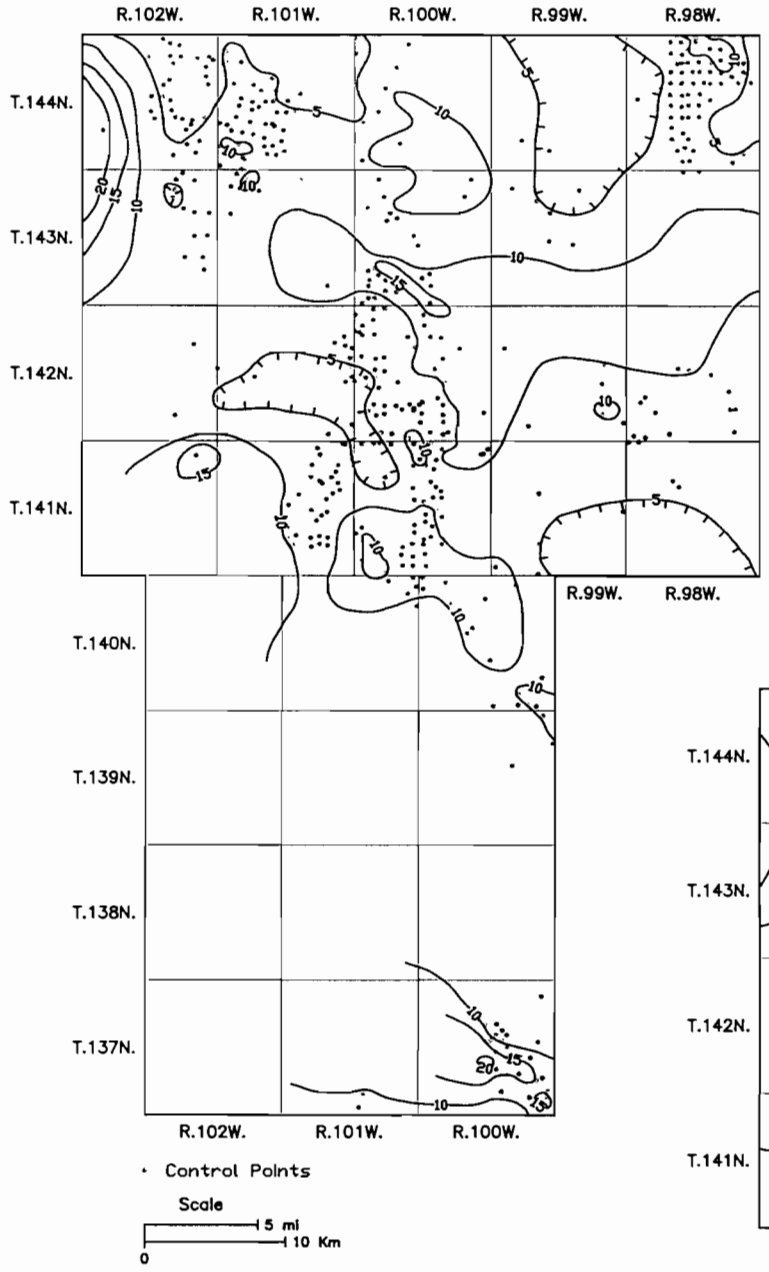

Figure 29. Isopach of the Hansen coal in Billings County.

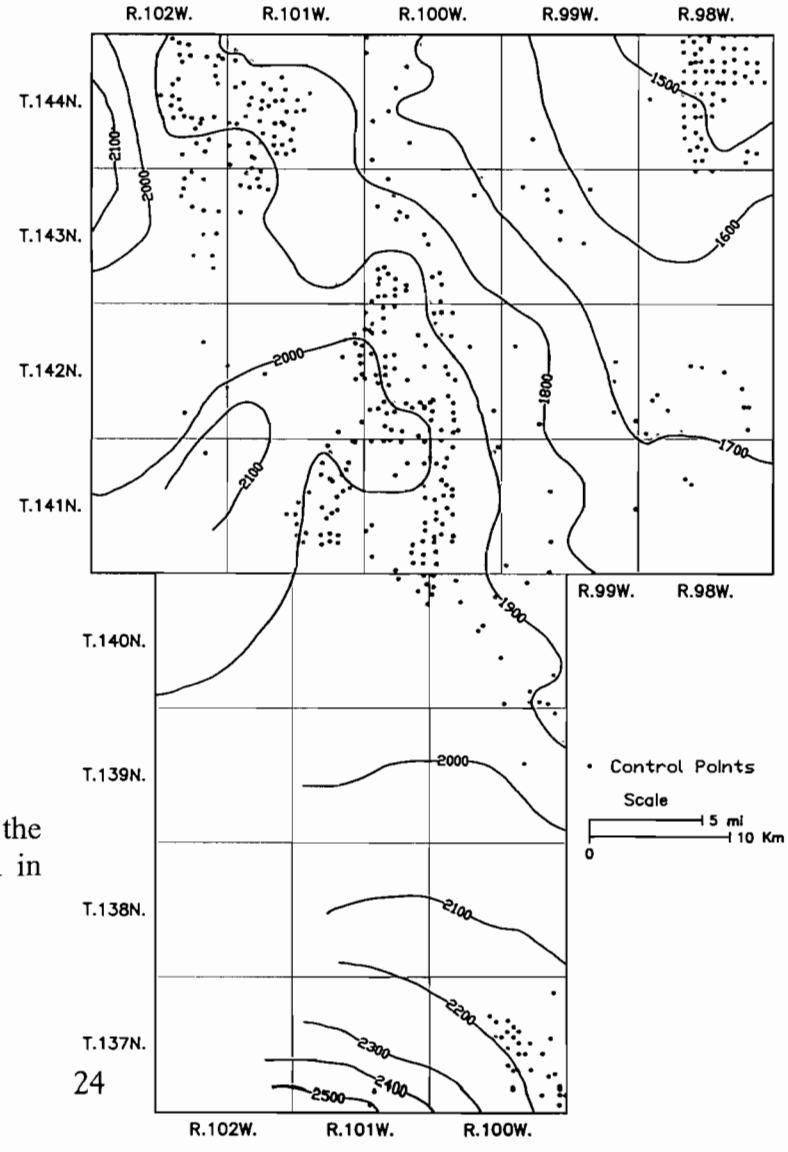

Figure 30. Contour map of the elevation at the top of the Hansen coal in Billings County.

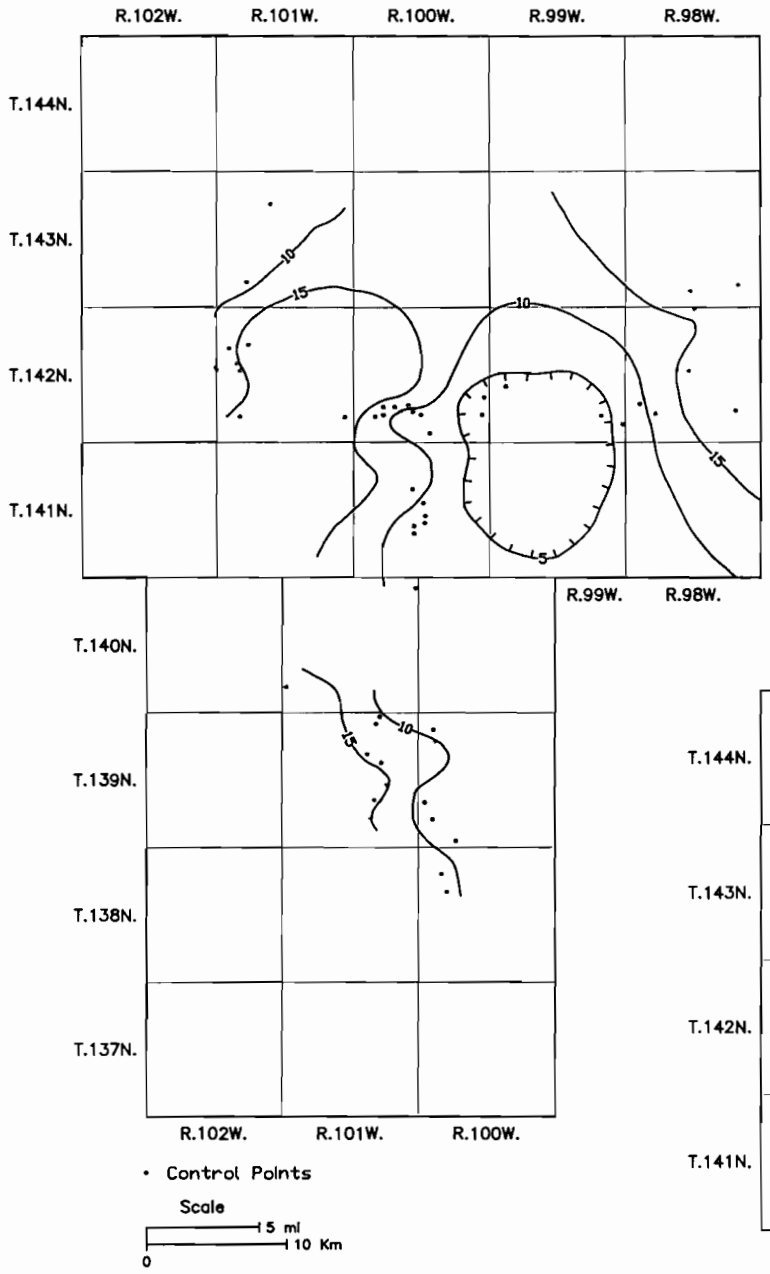

Figure 31. Isopach of the HT Butte coal in Billings County.

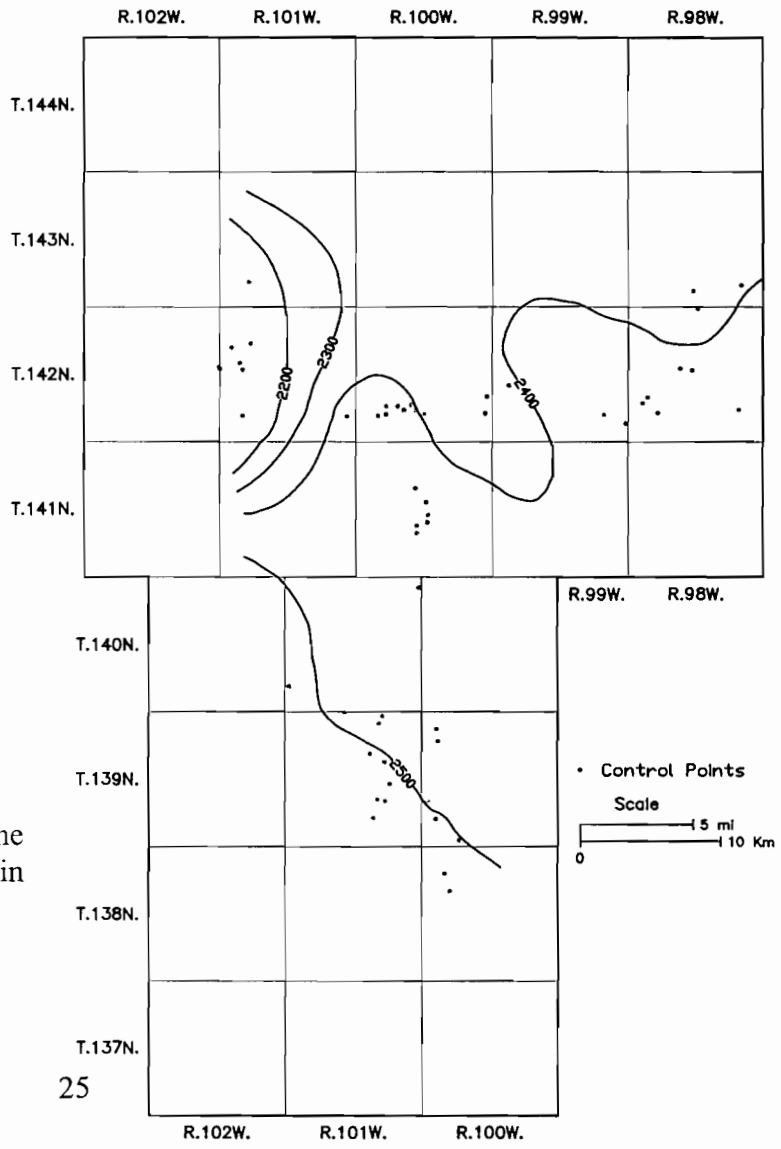

Figure 32. Contour map of the elevation at the top of the HT Butte coal in Billings County.

STARK COUNTY

Introduction

Lithologic data from 627 holes in Stark County was entered into the database. Approximately half of the electric logs entered into the system came from coal and uranium exploration holes (Figure 33). Most of the uranium holes were focused in the area of the Little Badlands because of the presence of White River strata, generally considered to be a likely source of radioactive minerals. Coal test holes and oil wells are scattered across the county but are also concentrated in the northwestern portion of Stark County. Unfortunately, about half of the oil wells in the county were of little or no use, either because they had not run gamma logs through surface casing or had terminated surface casing below the Fort Union Group.

The coal-bearing strata in Stark County has a maximum thickness of 1700 to 1800 feet. Most of Stark County is rolling prairie underlain by the Sentinel Butte Formation (Paleocene). Eocene, Oligocene, and Miocene strata are exposed in the Little Badlands in the west-central portion of the county (Figure 34).

Harmon and Hansen Lignites

The Harmon and Hansen beds average less than 10 feet thick in Stark County. The Harmon exceeds 10 feet in the southwestern corner of the county and in a small area just east of South Heart (Figure 35). The Hansen bed is in excess of 10 feet thick in the southwestern corner and along the south-central edge of the county as well as near the towns of Belfield and South Heart (Figure 37). The beds dip to the north-northeast at approximately 16 feet per mile (Figures 36 and 38). The position of the northeast-trending Little Badlands synclinal axis can be approximated

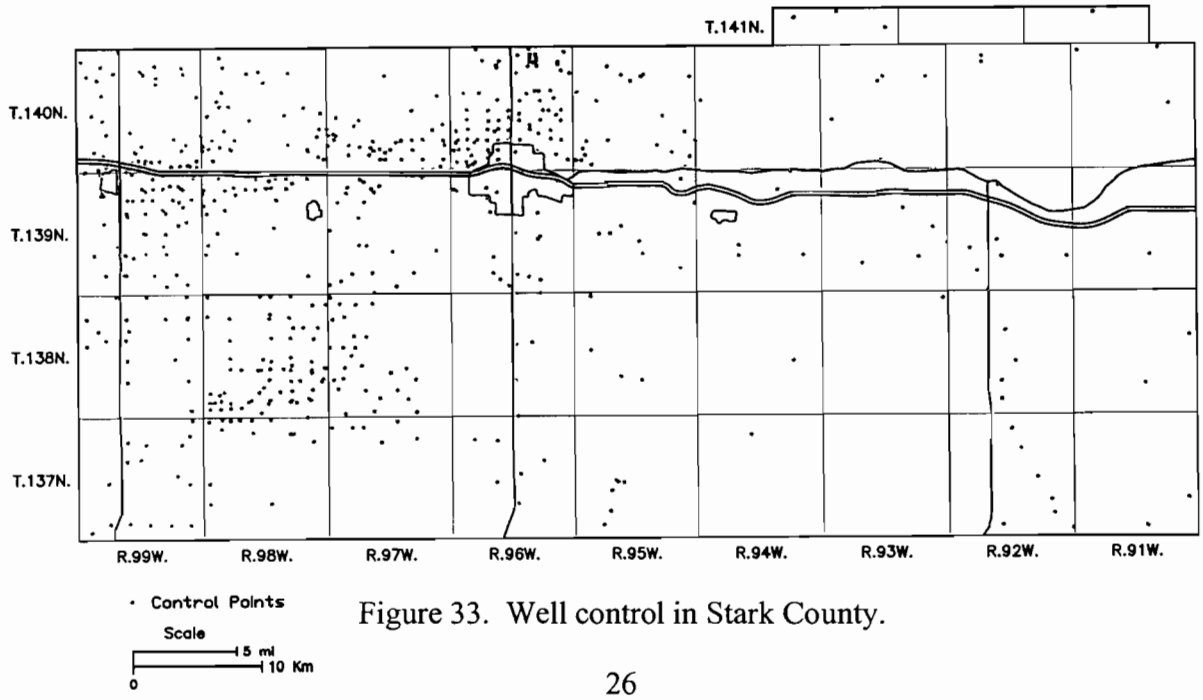

Figure 33. Well control in Stark County.

from these contour maps as well as from various cross-sections across the county (Figures 34 and 39-47). The limbs of the syncline are best displayed by coal beds in Figures 43-45. The Harmon and Hansen beds are at depths of 600 to 900 feet in this county.

Lehigh and Dickinson Lignites

The Lehigh bed is a thick coal located in the middle to upper portion of the Sentinel Butte Formation. The Dickinson bed is a thin coal that overlies the Lehigh by some 30 to 50 feet. The Lehigh is over 25 feet thick north of Dickinson and is in excess of 15 feet thick south of Belfield (Figures 46 and 48). Both the Lehigh and Dickinson seams were mined in the Dickinson area, first in underground mines and later by the open pit method, from the late 1800s through the 1980s. Well control is missing in key areas, but it appears that the Dickinson and Lehigh beds extend throughout northwestern and north-central Stark County and into southern Dunn County (Figures 39, 41, and 43-47). The Lehigh bed dips to the north-northeast at approximately 10 feet per mile (Figure 49). The Lehigh bed is generally less than 100 feet beneath the surface between Belfield and Dickinson but more than 300 feet northeast and south of Dickinson due to the Little Badlands

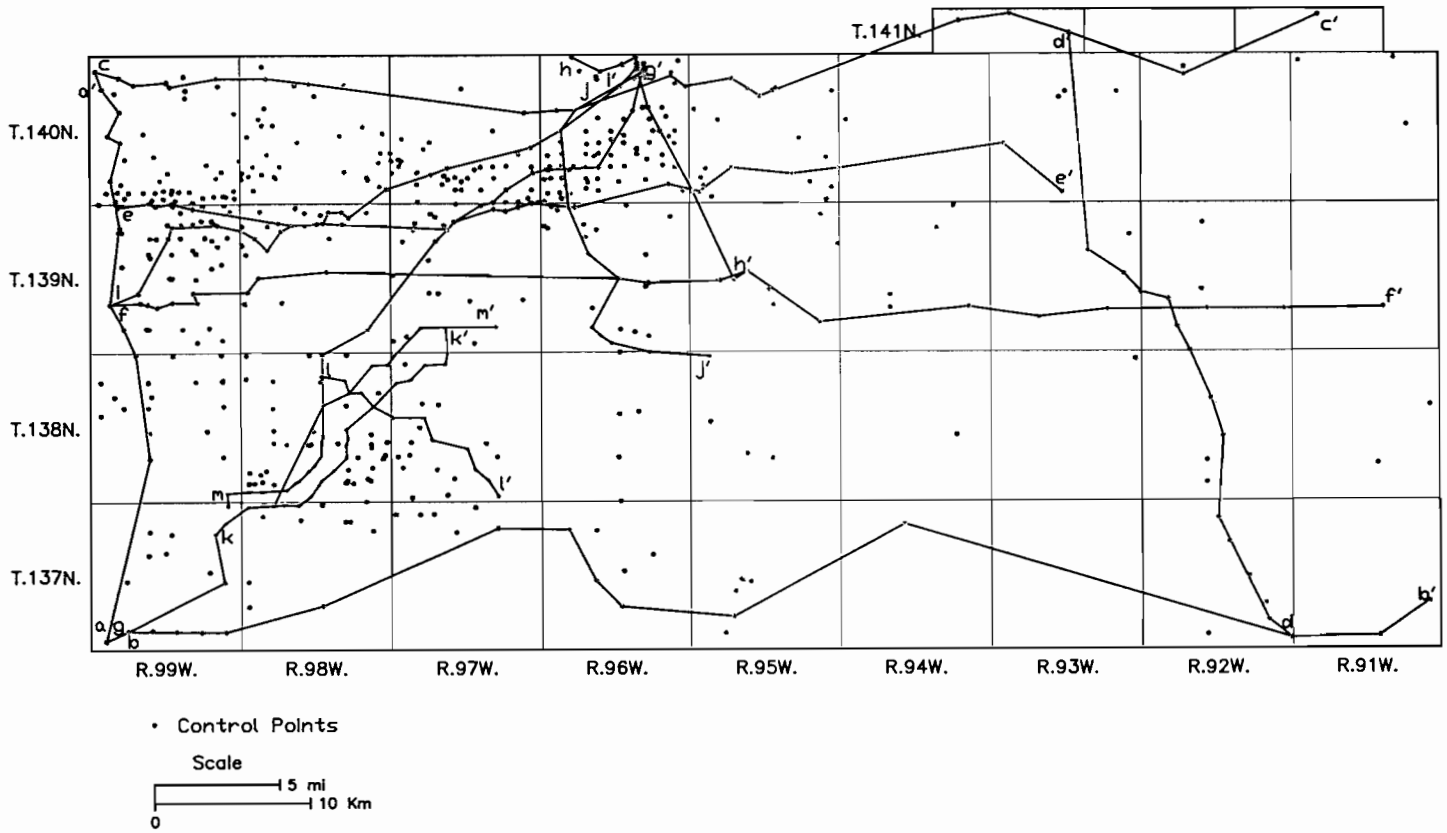

Figure 34. Traces of geologic cross-sections in Stark County.

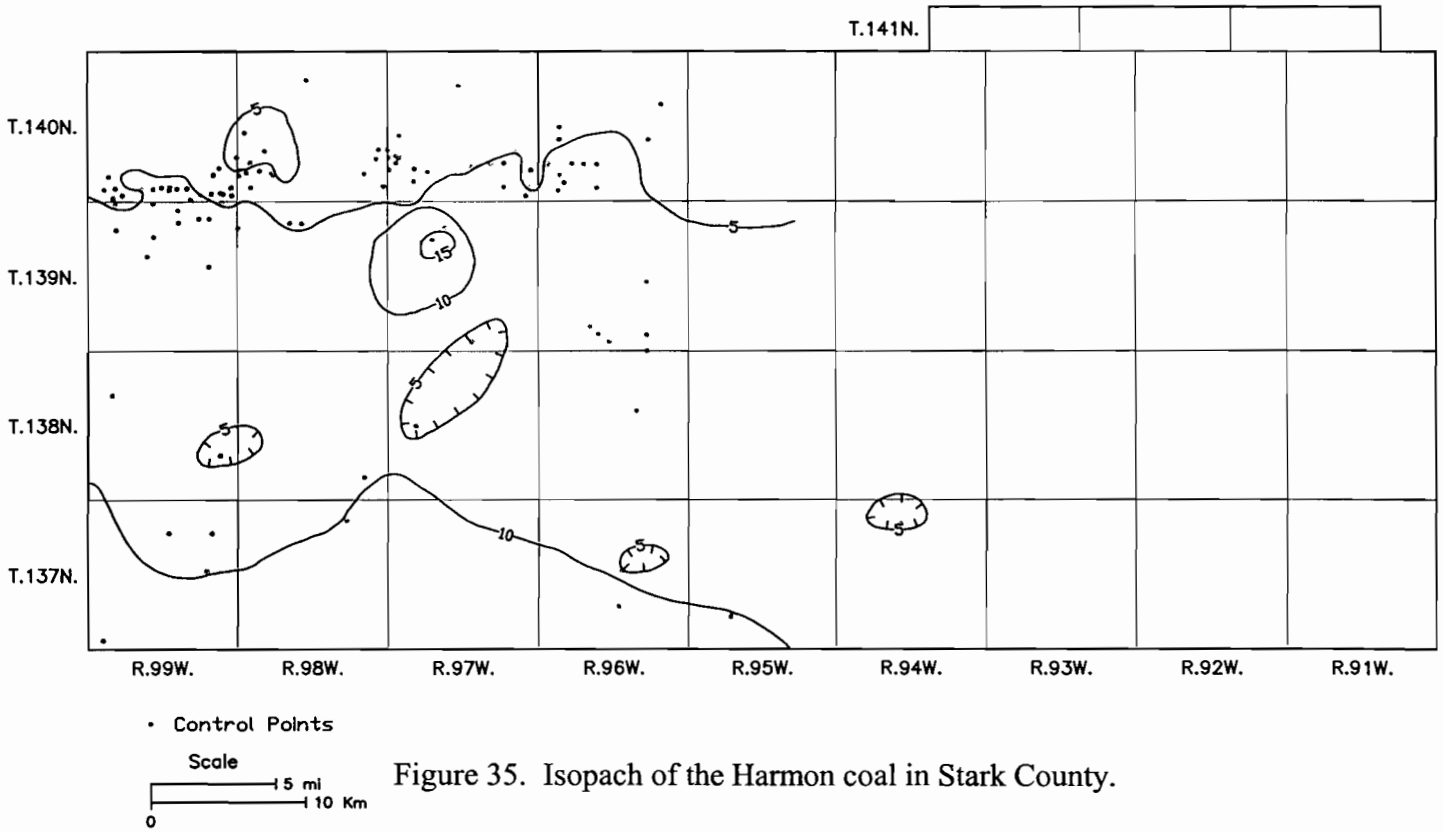

Figure 35. Isopach of the Harmon coal in Stark County.

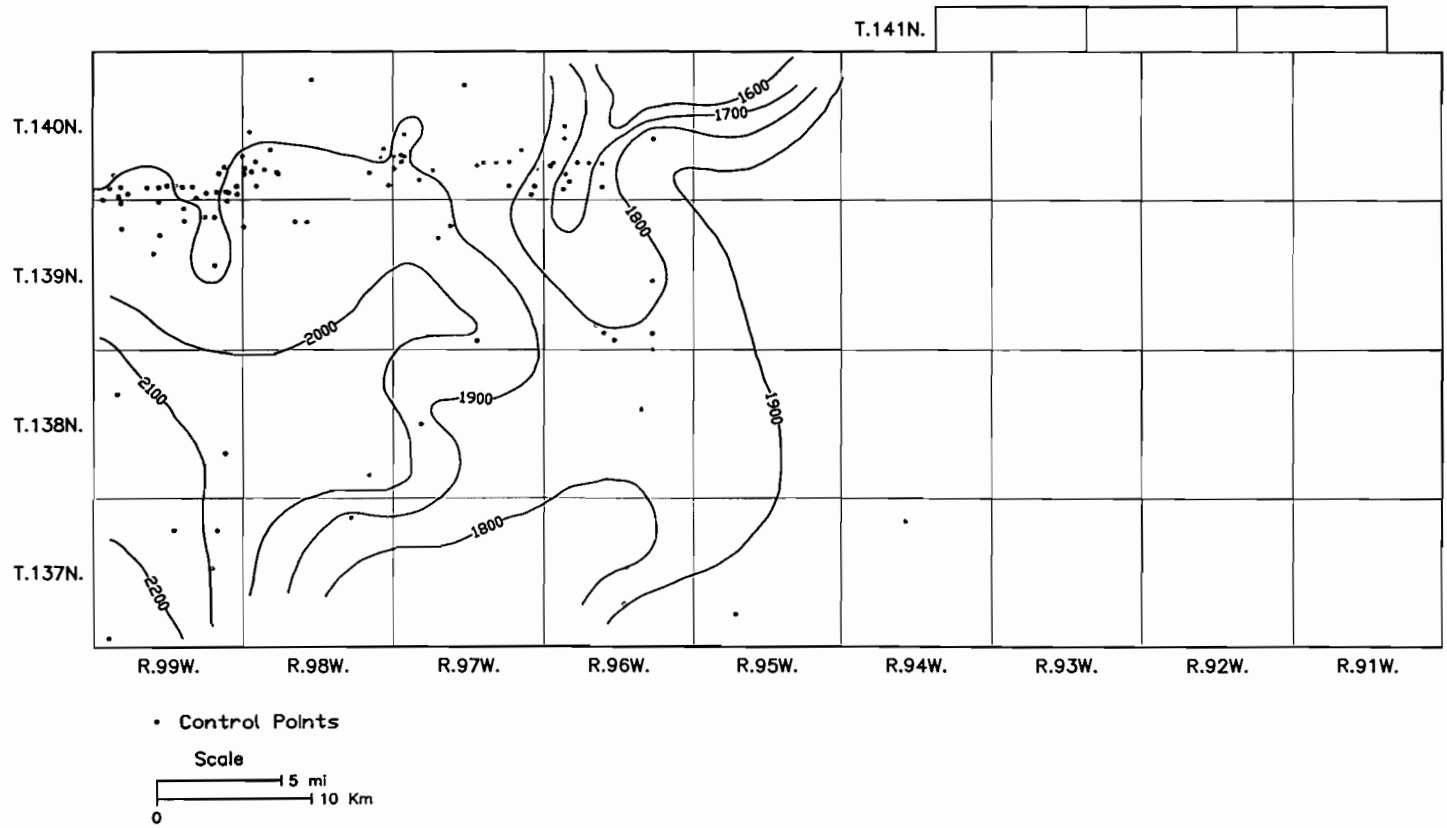

Figure 36. Contour map of the elevation at the top of the Harmon coal in Stark County.

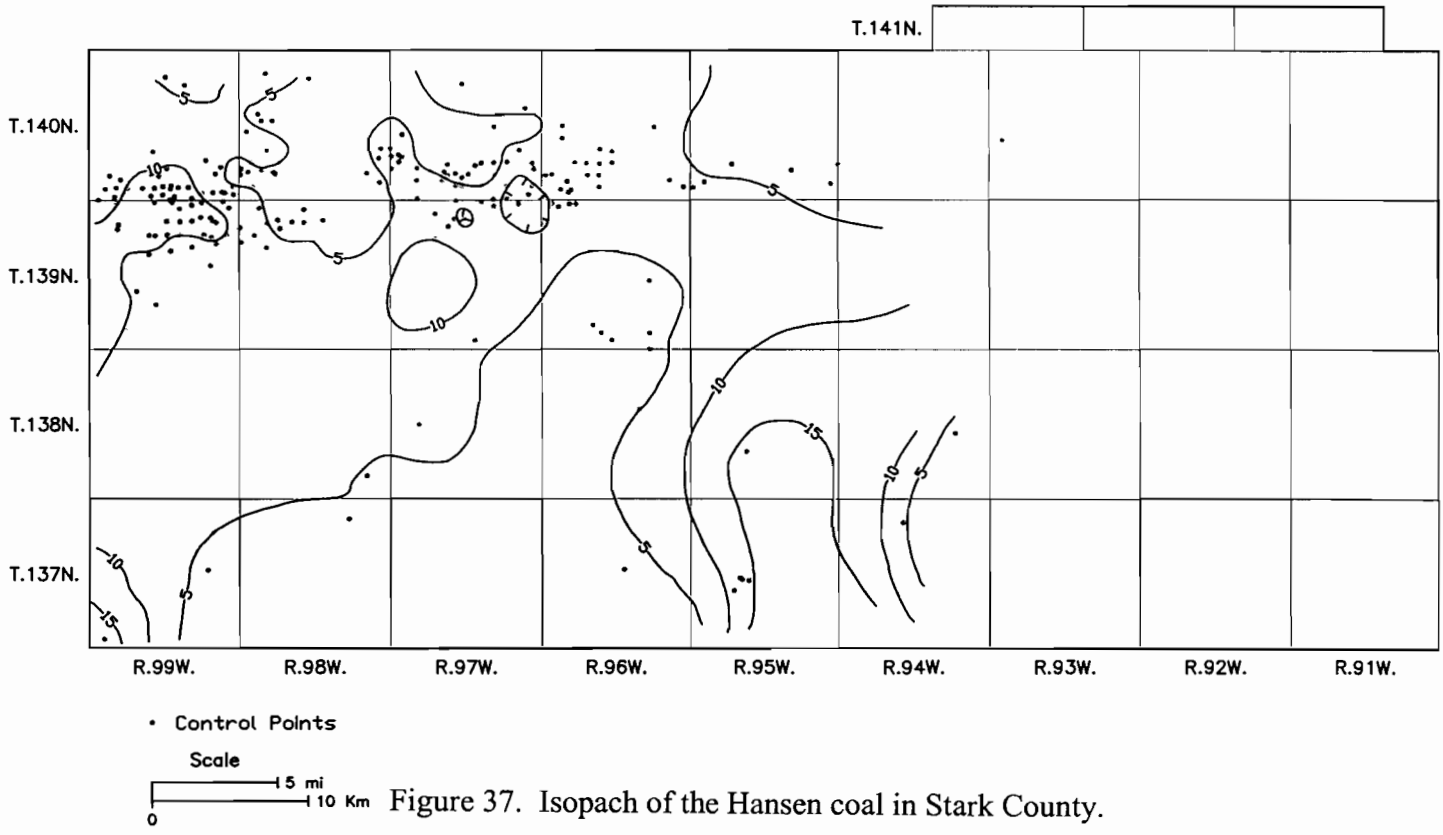

Figure 37. Isopach of the Hansen coal in Stark County.

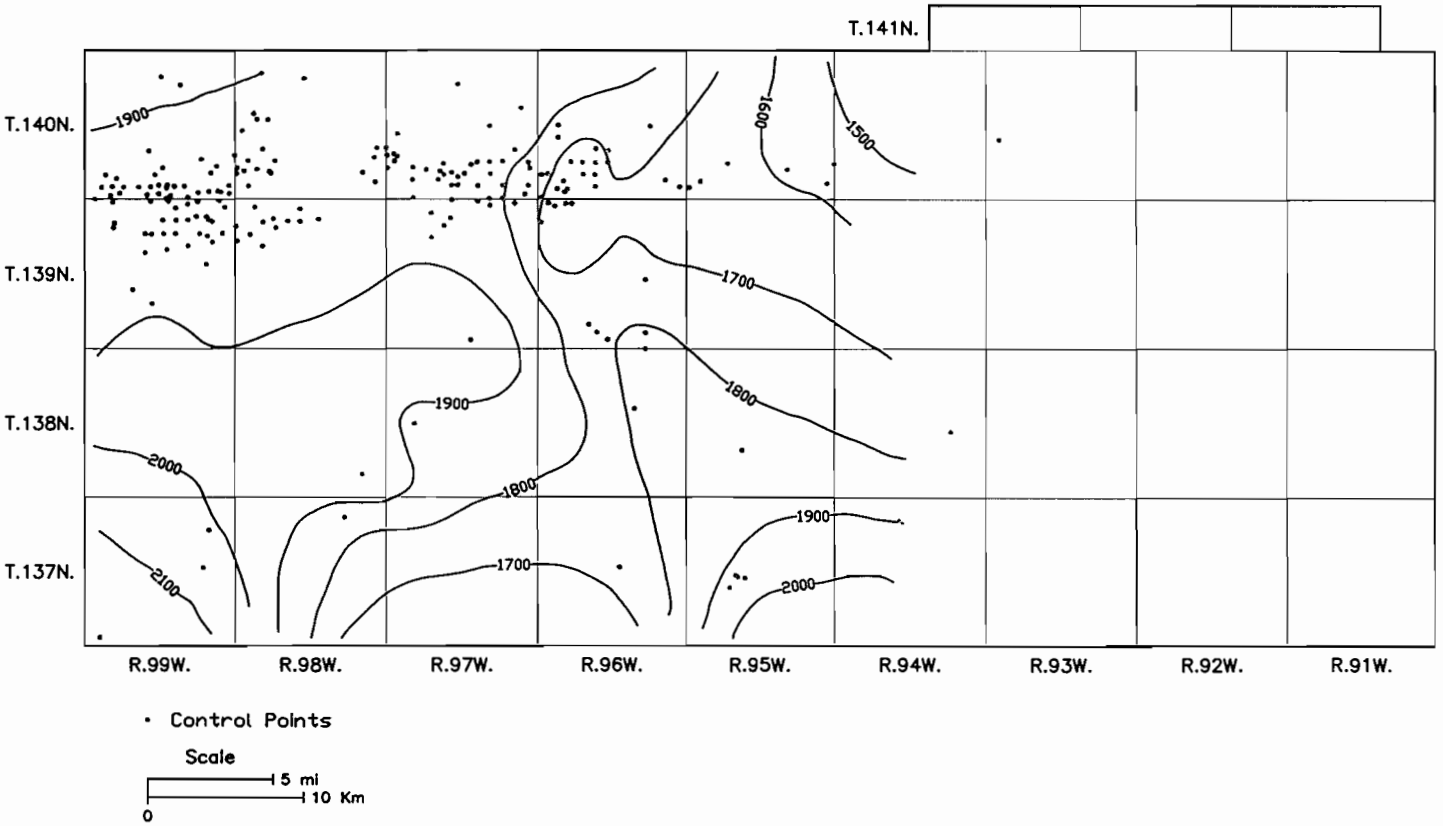

Figure 38. Contour map of the elevation at the top of the Hansen coal in Stark County.

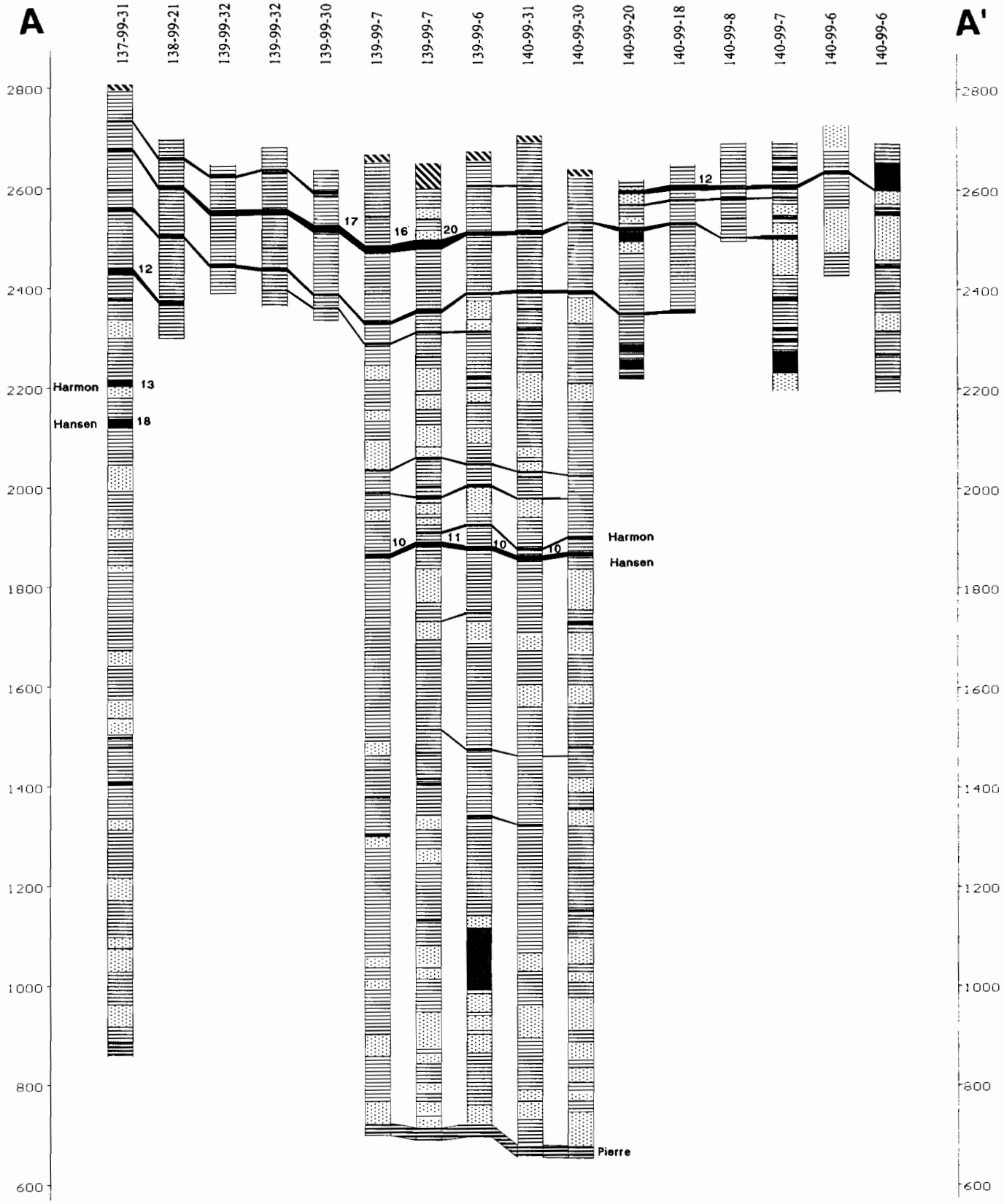

Figure 39. Cross-section A-A' of Upper Cretaceous and Fort Union strata in western Stark County.

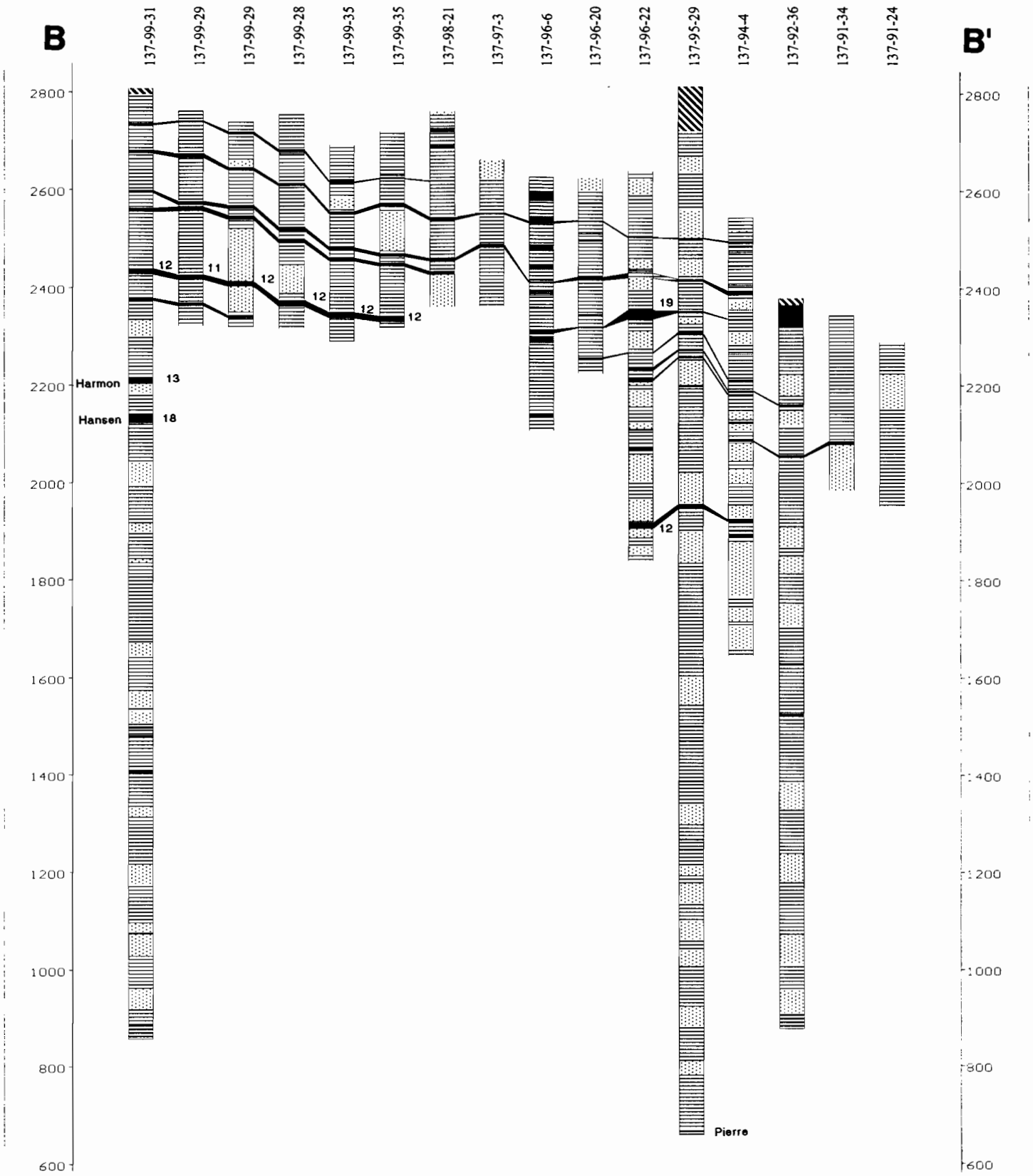

Figure 40. Cross-section B-B' of Upper Cretaceous and Fort Union strata in southern Stark County.

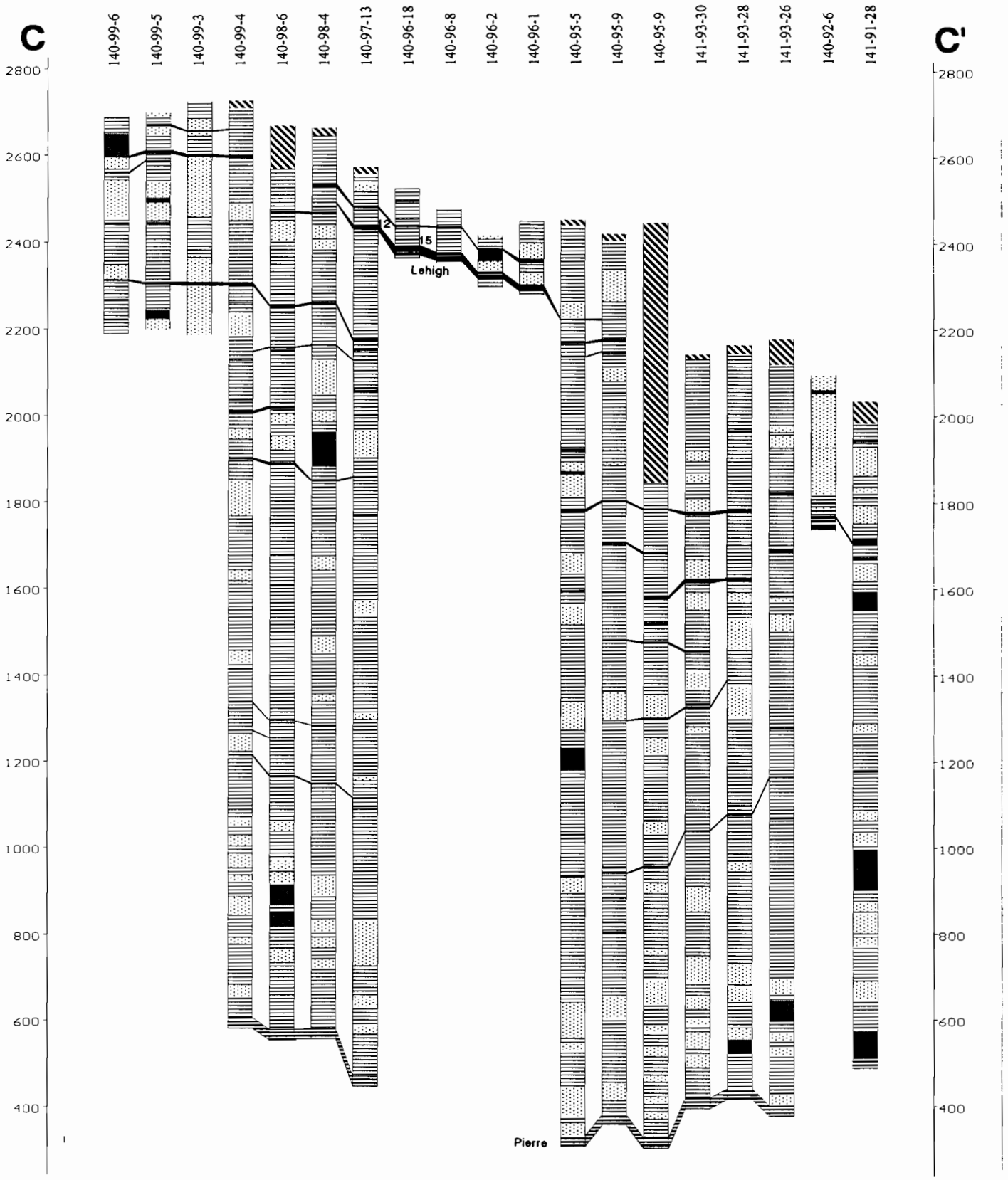

Figure 41. Cross-section C-C' of Upper Cretaceous and Fort Union strata in northern Stark County.

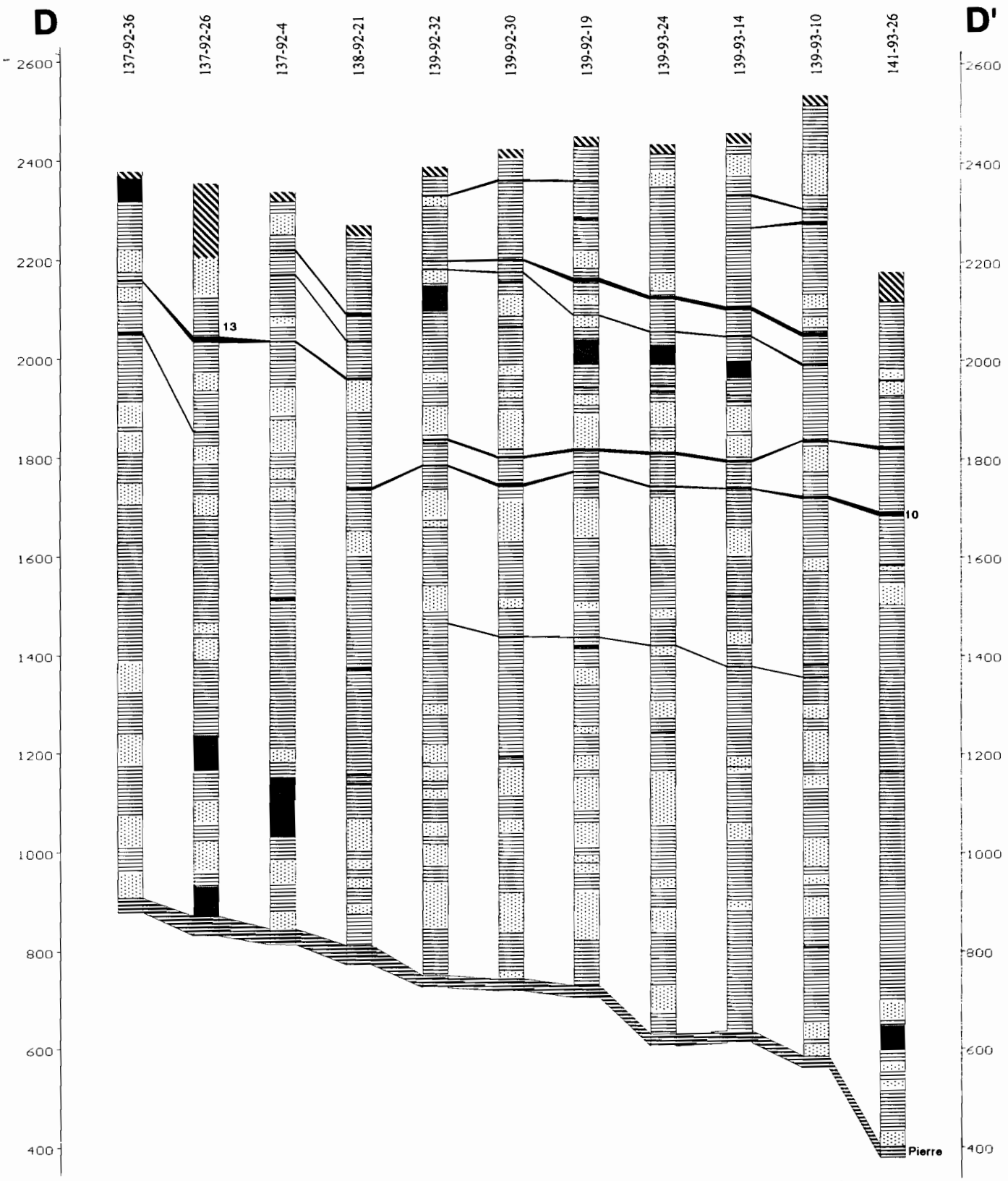

Figure 42. Cross-section D-D' of Upper Cretaceous and Fort Union strata in eastern Stark County.

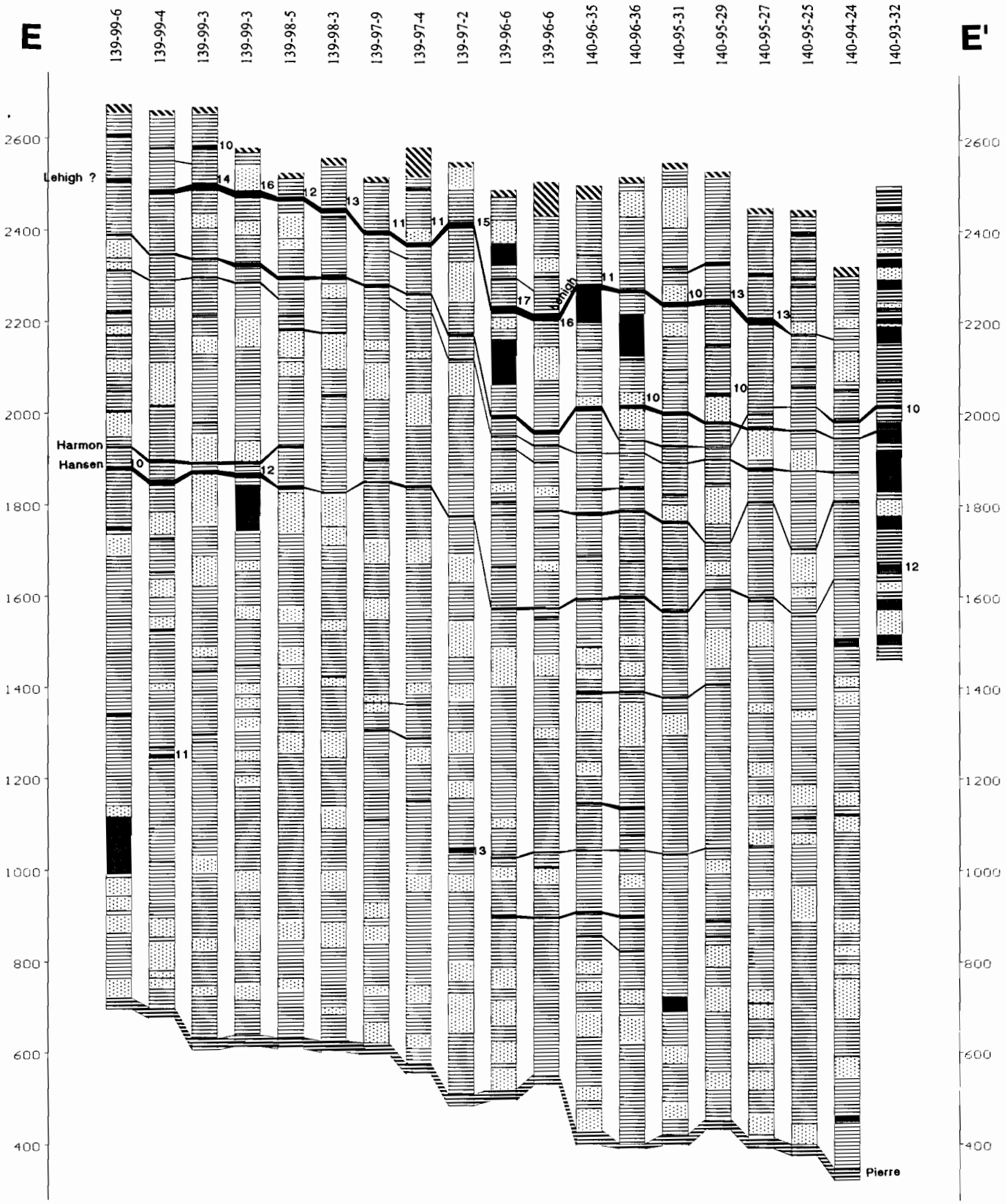

Figure 43. Cross-section E-E' of Upper Cretaceous and Fort Union strata in north-central Stark County.

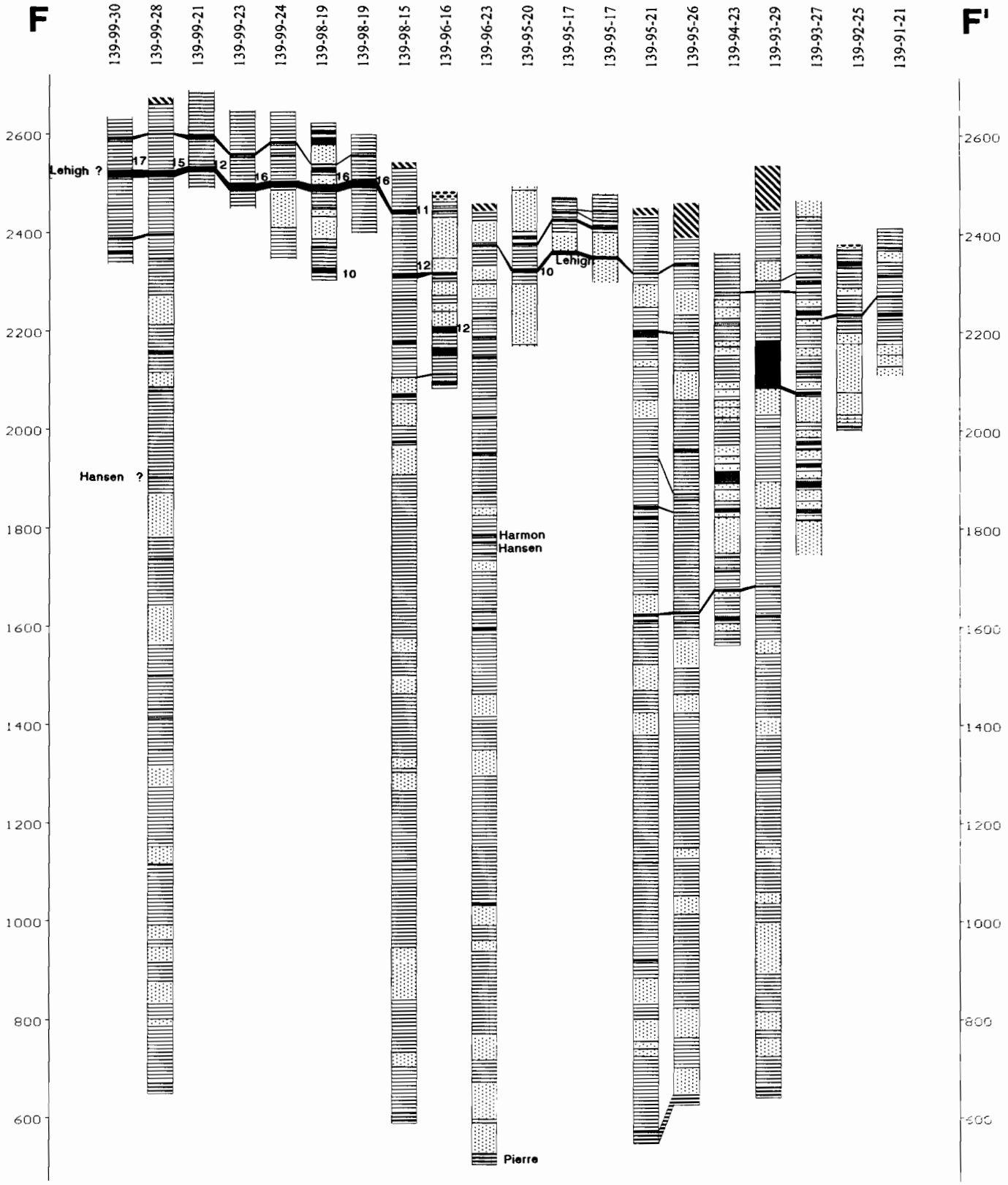

Figure 44. Cross-section F-F' of Upper Cretaceous and Fort Union strata in central Stark County.

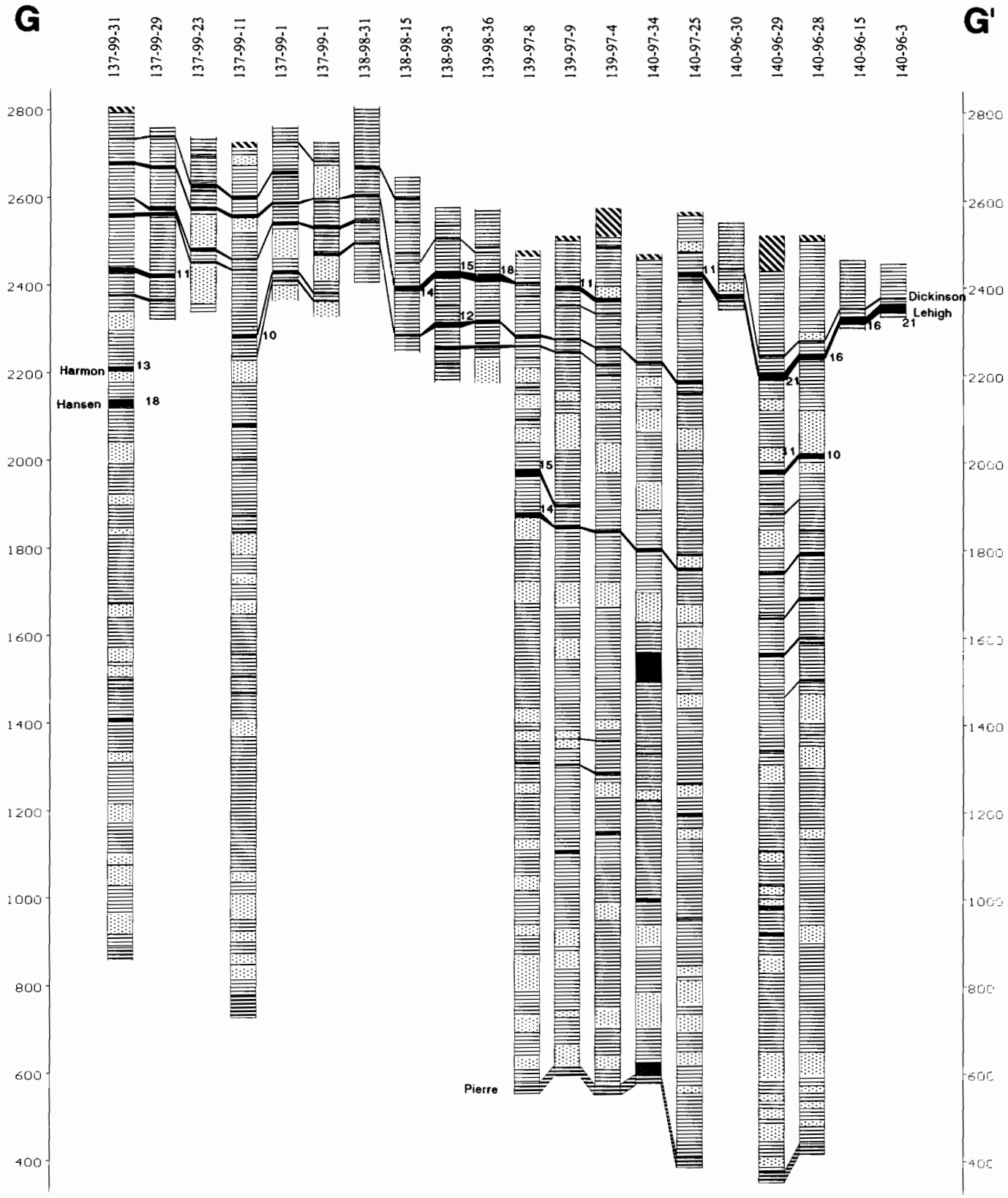

Figure 45. Cross-section G-G' of Upper Cretaceous and Fort Union strata in western Stark County.

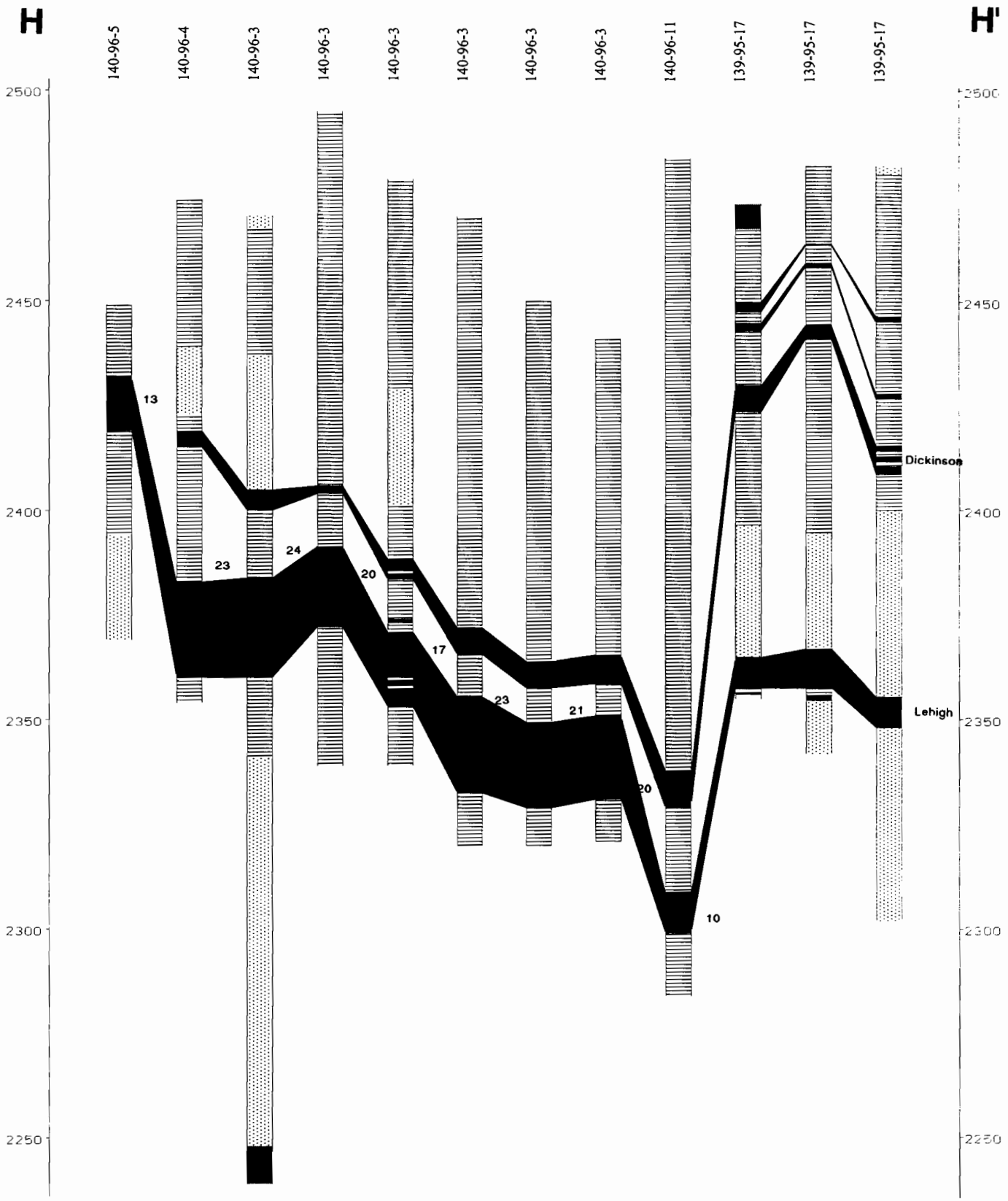

Figure 46. Cross-section H-H' of Sentinel Butte strata in north-central Stark County.

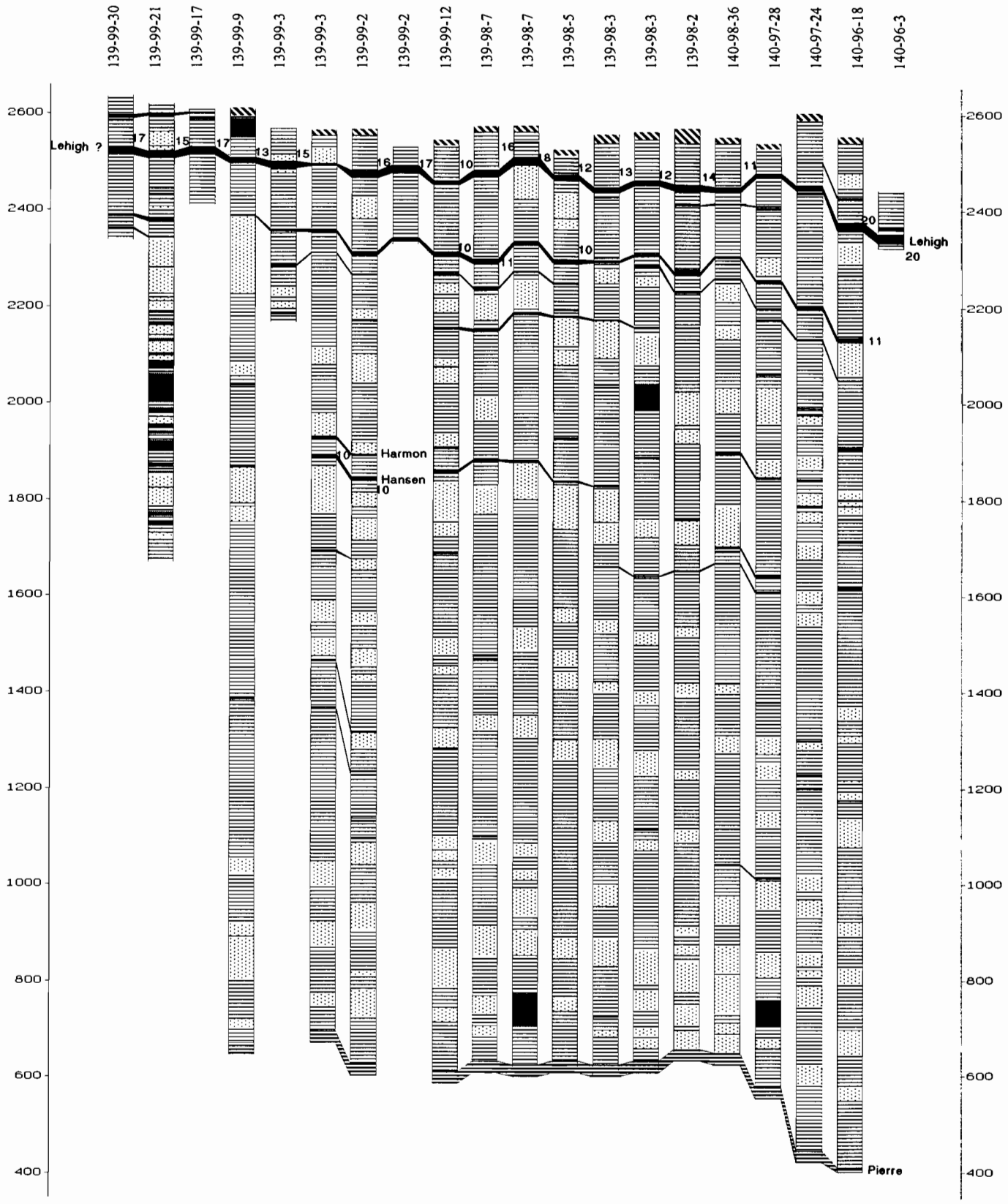

Figure 47. Cross-section I-I' of Upper Cretaceous and Fort Union strata in northwestern Stark County.

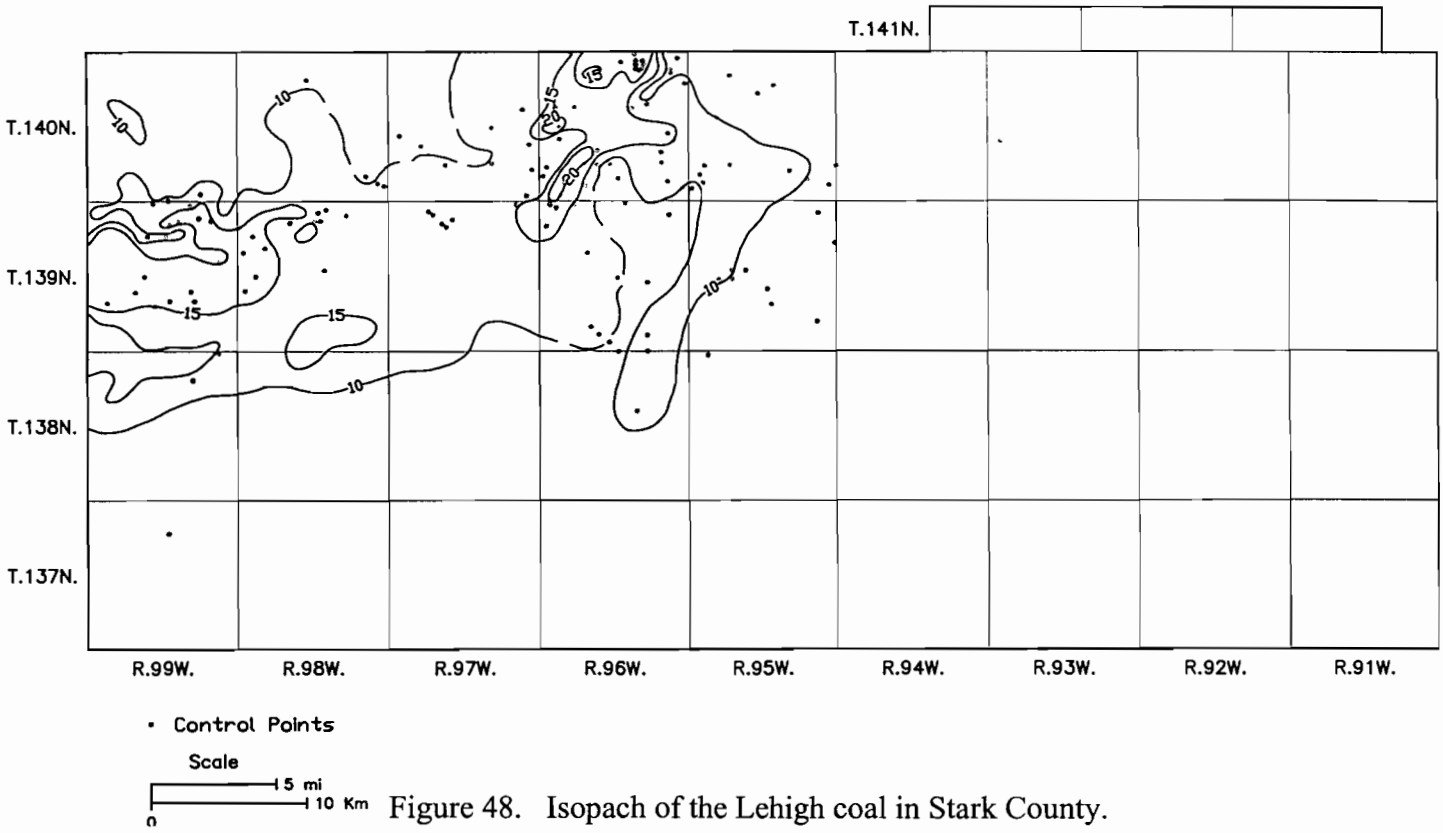

Figure 48. Isopach of the Lehigh coal in Stark County.

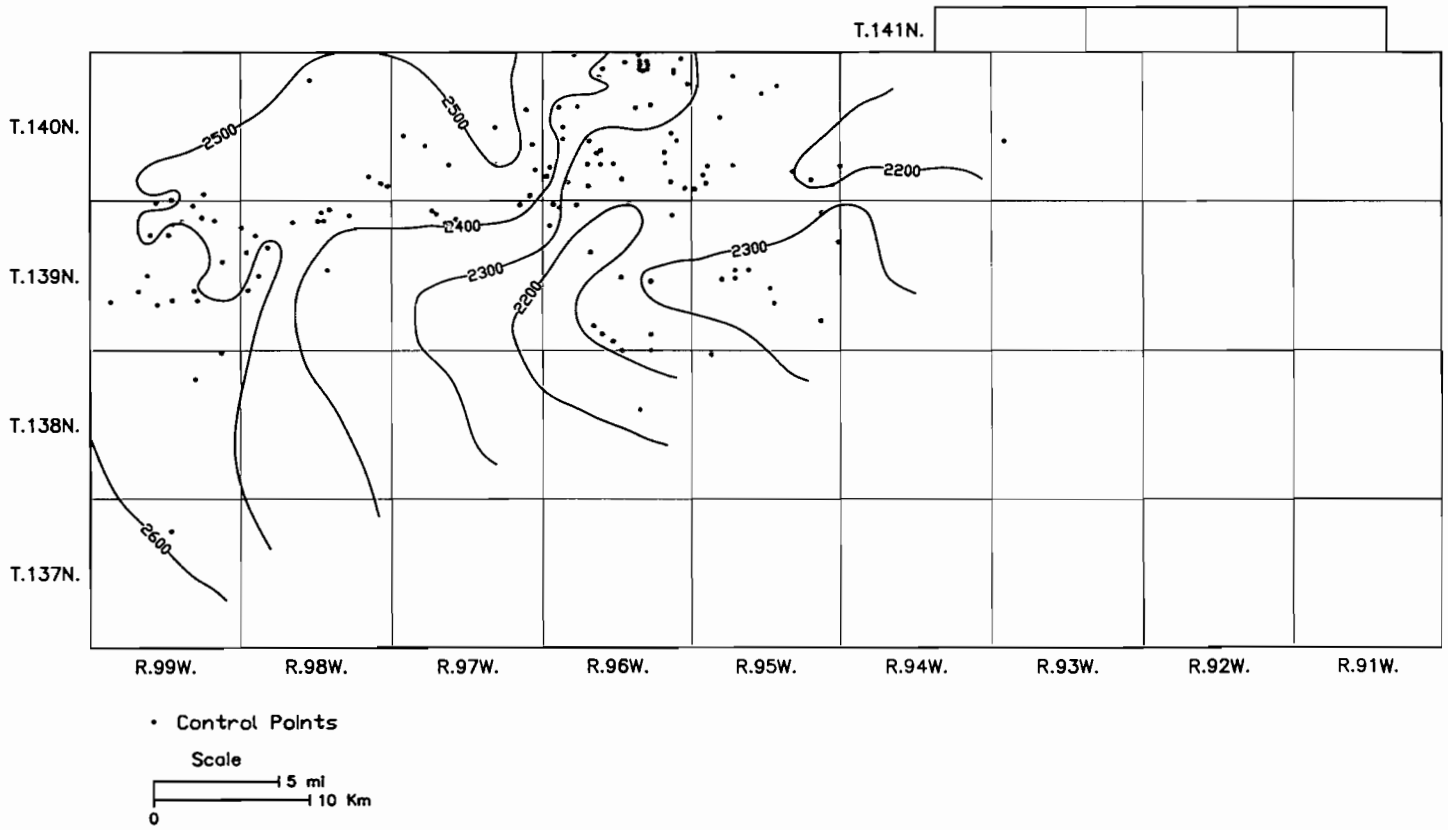

Figure 49. Contour map of the elevation at the top of the Lehigh coal in Stark County.

syncline. Menge (1977) and Hinds (1985) correlated a series of coals in this area, from top to bottom, the Lehigh, Heart River, and Fryburg beds. They may be correct that what has been identified in this report as the Lehigh lignite is, in fact, three separate beds that occur within a 100 foot , or they may have been confused by structural complications imposed by the Little Badlands syncline. Due to the nature and scope of this report, no attempt was made to resolve this issue.

SUMMARY

Ten-foot-thick sub-bituminous coals have been shown to be economically viable producers of coalbed methane in areas such as Drunkards Wash field near Price, Utah. Lignite beds in excess of ten feet-thick can be found throughout this tri-county area (Figure 50). The majority of thick coals encountered in these drill holes were assigned to the Harmon/Hansen coals. The widespread nature of coal(s) at this stratigraphic interval within this tri-county area is in agreement with previous studies both to the north in Dunn and McKenzie counties (Murphy and Goven, 1998) and to the south in Bowman, Slope, Adams, and Hettinger counties (Murphy et al., 1999). The Harmon/Hansen coal zone contains the most extensive, thick coals in southwestern North Dakota.

The Harmon bed is within 100 feet of the surface near Beach and is exposed along the Little Missouri River and its tributaries in southwestern Billings County. Throughout most of the rest of this area it is at depths of 400 to 800 feet with a maximum depth of 1100 feet in northeastern Billings County. Another deep and thick deposit is the T Cross (?) coal in northern Golden Valley County, where it is more than 20 feet thick and occurs at depths of 900 to 1000 feet (Figure 50). In Stark County, the Lehigh bed is often within 150 feet of the surface but it does occur at depths of 200 to 300 feet in T.140N., R.96W. The HT Butte bed is over 20 feet thick near Square Butte in Golden Valley County (T.139N., R.103W.) but outcrops within the area.

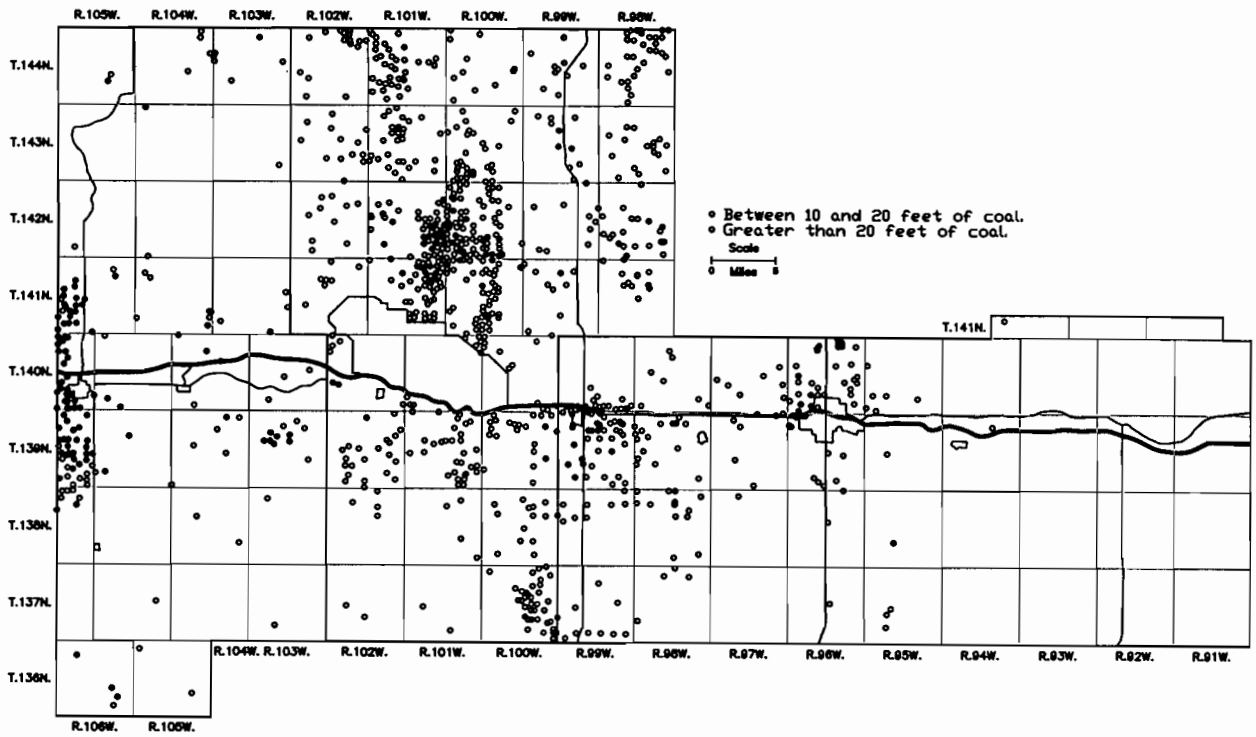

Figure 50. Location of drill holes that encountered thick coals in the three county area.

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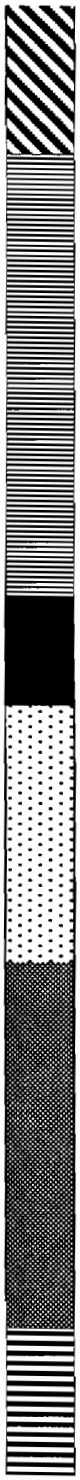
Hinds, J.S., 1985, Stratigraphic cross-section and coal bed correlations of uppermost Cretaceous and Paleocene rocks between Painted Canyon and Davis Buttes, North Dakota: U.S. Geological Survey Field Map MF 85-1766, 2 plates.

Menge, M.L., 1977, Preliminary report on the coal resources of the Dickinson area, Billings, Dunn, and Stark counties: U.S. Geological Survey Open File Report 77-482, 11 p.

Murphy, E.C. and Goven, G.E., 1998, Thick coals in Dunn and southern McKenzie counties, North Dakota: North Dakota Geological Survey Open-File Report no. 98-3, 31 p.

Murphy, E.C., Kruger, N.W., and Goven, G.E., 1999, The major coals in Bowman, Slope, Adams, and Hettinger counties, North Dakota: North Dakota Geological Survey Open-File Report no. 99-1, 56 p.

APPENDIX A
Lithologic Symbols Used on Geologic Cross-Sections



No Record.

Mudstone and/or Claystone.

Lignite.

Sandstone.

Siltstone.

Shale.