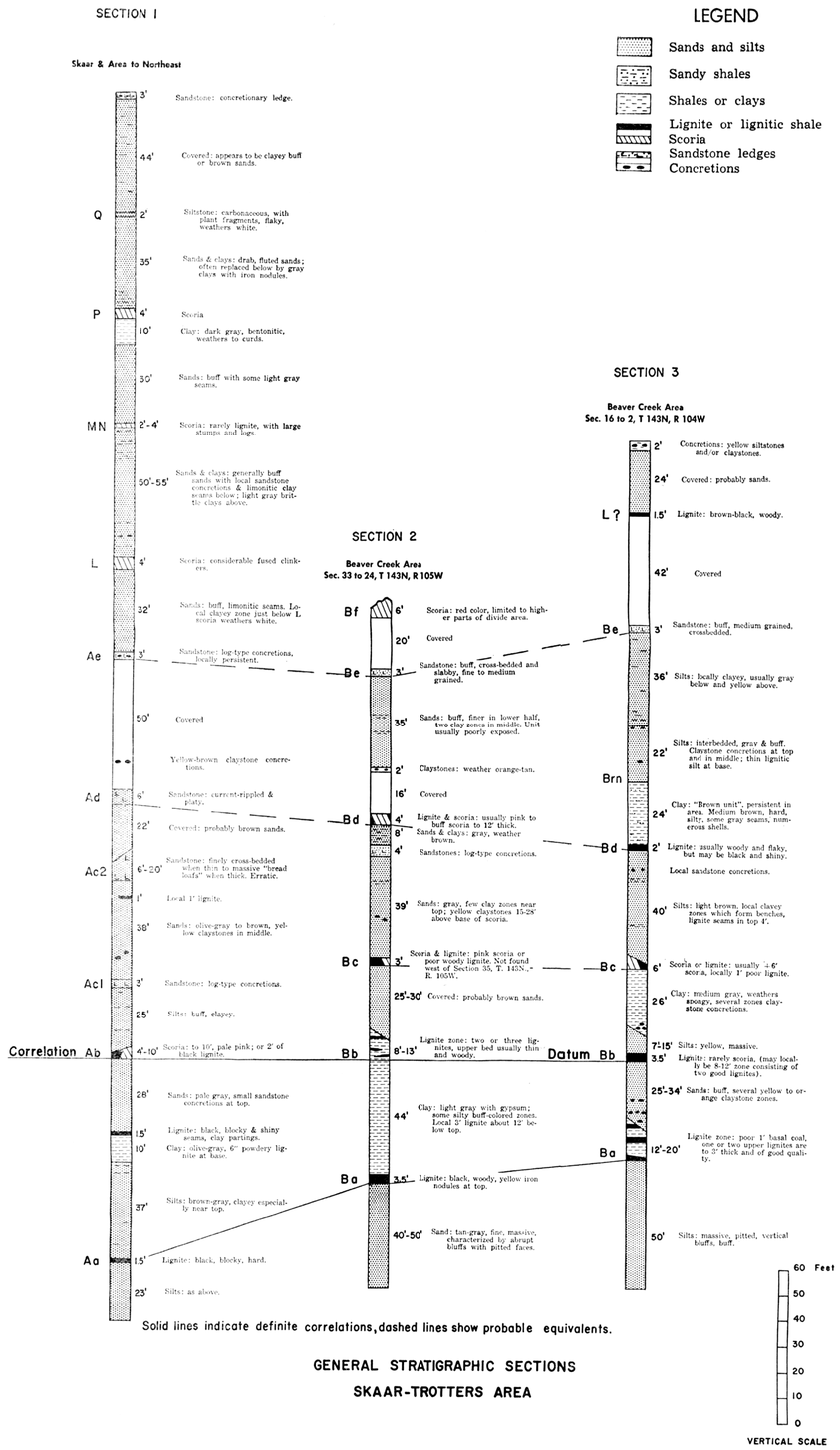

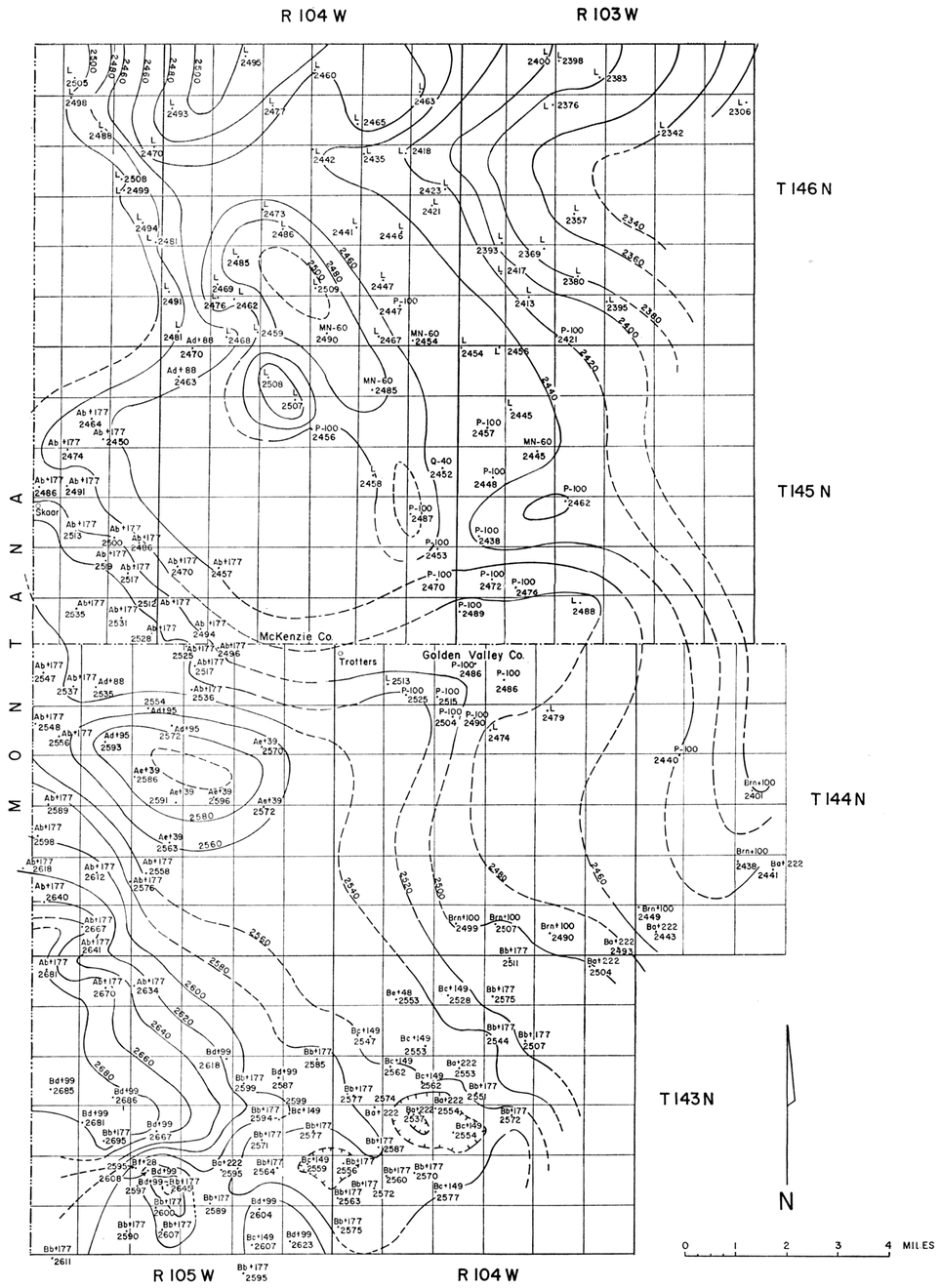

SURFACE STRUCTURE MAP
SKAAR-TROTTERS AREA, McKENZIE AND GOLDEN VALLEY COUNTIES, NORTH DAKOTA

Introduction

The area mapped for this report includes eight townships, four in the southwestern corner of McKenzie County and four in the northwestern part of Golden Valley County. The post office of Trotters is located in the center of the area, approximately 34 miles north of Beach, North Dakota. Skaar is near the central portion of the map on the western boundary. State Route 16 bisects the area in a north-south direction.

Topographically the region is youthful with much of the interstream upland remaining. Beaver Creek, a sizeable tributary of the Little Missouri, flows across the southeastern third of the area in a canyon 200-300 feet deep. The terrain bordering this stream is typical badlands topography with bare slopes and bluffs which provide excellent rock exposures but also present access problems. The northern part of the area is drained by many small tributaries of the Yellowstone River. Here the valleys are often broad and shallow with the result that most of the slopes are grass covered and rock outcrops, except for "scorias," are very few. Between these two drainage systems, and trending to the northeast, is a wide interstream divide which is barren of outcrops, thus making the correlation of rock strata on either side rather difficult. State Route 16 traverses the divide for a number of miles south of Trotters.

Previous Work

In 1924 the Northern Pacific Railroad mapped the lignites within the area of this report. Several oil companies have undertaken geophysical and surface mapping projects, but these sources of information are not generally available.

Eugene Stebinger (1912) mapped the lignites and made a small scale surface structure map of the area south of Sidney, Montana and immediately west of the area described in this report. A. G. Leonard (1925) measured a considerable number of rock sections all along the Little Missouri River and on Beaver Creek. In the North Dakota Geological Survey Report of Investigations No. 11, 1953, the writer describes the general rock section and structures in the adjoining area on the north.

Purpose and Methods of Field Work

The aim of the present paper was to continue the surface structure map published in Report of Investigations No. 11. It was thought desirable to follow out the extensive L scoria which served as contour datum in that report, and to locate the position of this bed in the sections measured by Leonard along the Little Missouri River.

Field work was done between the middle of June and the middle of July, 1953. Elevations and field notes were made directly upon the base maps which were State Highway Department maps drawn on a scale of one inch to the mile. Paulin altimeters reading to 2 feet were used to obtain elevations and very frequent checks were made to establish bench marks along State Route 16 in the center of the area. Additional temporary elevation stations were set up every 6 to 8 miles apart in other sections of the area. These stations were checked and averaged on several successive days prior to their initial use.

Acknowledgements

Fritz Roth and Charles Waldren, students at the University of North Dakota, are commended for their excellent assistance with the field work. Miller Hansen drafted the final structure map and figures for this report and saw the report through the press.

Stratigraphy

All the surface rocks within the area are part of the Tongue River formation of Paleocene age. Taff (1909, p. 129) gave the name Tongue River to the lignite-bearing beds beneath the approximate equivalents of the old Sentinel Butte shale of "Eocene" age. Brown (1948) has since shown that the Sentinel Butte sediments are the upper facies member of the typical Tongue River formation and the entirety is now recognized to be of Paleocene age. The maximum stratigraphic section complied in this area is about 450 feet thick.

The standard Tongue River sediments, those below the Sentinel Butte facies, are exposed over all the area south of a line between Trotters and a point 3 miles north of Skaar. These sediments consist of clays, shales, lignites, and soft sandstones with local concretionary zones and ledges. The usual color of the fresh sands and shales is light gray to olive-gray. Almost all of these beds weather to varying shades of light or yellow-brown and, because they tend to slump and cover the dark lignites, the color is monotonously uniform. Lignites and lignitic shales constitute an important part of the Tongue River formation. The lignitic shales are chocolate-brown, woody, and fissile whereas the true lignites are black, usually dense and non-woody, and frequently display good jointing. Silicified stumps and wood fragments along with impurities of gypsum, pyrite and marcasite are associated with many of the lignites.

There is every possible gradation from one type of rock to another both laterally and vertically. Two measured sections within a short distance of each other may often show very little correspondence between their strata. With very few exceptions sandstone ledges cannot be relied upon to continue any distance or to remain at the same horizon. The lignites may locally be replaced by lignitic shales, or may be split by clay seams some of which are several feet thick.

The lignites are the most persistent of all the beds. For this reason and because the lignites are often marked by red "scorias", most mapping is based upon one or more lignites. "Scorias" are the baked, reddened clays and silts overlying lignites which in times past have burned along the outcrop. Spontaneous combustion was the most probable cause of the burning of these coals.

One of the most widespread and prominent scorias of this region has been designated the L scoria. In McKenzie and northern Golden Valley counties at least, this scoria marks the contact between the light-colored standard Tongue River sediments and the overlying somber Sentinel Butte facies. A more detailed discussion of the characteristics of scorias is presented by Fisher (1953) and Leonard (1925 p. 5).

The Sentinel Butte beds are generally more somber and gray than those below. Some of the clays are bentonitic, and the lignites, particularly the M-N zone, contain larger silicified logs and stumps. In SW/SE, Section 7, T. 144N., R. 103W. several logs between 38 and 52 feet in length were found. The statements concerning the variability of the lithology and the difficulty of correlation of the standard Tongue River section apply equally to the Sentinel Butte facies.

Section 1 is a generalized stratigraphic section of the sediments encountered in the vicinity of and to the northeast of Skaar post office, north of the Yellowstone River-Beaver Creek divide. The changes in the rock sections exposed in the bluffs along Beaver Creek, south of the divide, are represented by Sections 2 and 3. The beds from L upward were followed into this area from west central McKenzie County and are designated by the letters previously given them in that area. (See Fisher, 1953). As will be explained below, the beds in the lower part of the section could not be accurately correlated with their equivalents to the north. Therefore these beds are marked by lower case letters "a" through "f": the capital letters refer only to the areas north (A) and south (B) of the main interstream divide. Elevations on the surface structure map are similarly marked.

An attempt was made to correlate the various strata with the work of other investigators. Leonard's general columnar section and written descriptions (1925, Plate IV, pp. 52, 100-101) indicate that his R bed is the L scoria of the present report, and the M, N, and O beds of his Beaver Creek sections correspond generally with the writer's Ba, Bb, and Bc lignites. Also, the massive and rather unique L scoria of the writer is definitely correlated with the K horizon of Stebinger (1912, pp. 313) in the area south of Sidney, Montana.

The designation "I" given the solitary scoria in the vicinity of the Skaar on Stebinger's map may be questionable. The discrepancy may be briefly explained: South of the Yellowstone River bend the writer determined the K (or L) —J and J-I intervals to be 210 and 70 feet respectively, a total of 280 feet. Similarly, in the Skaar area the L (or K)—Ab and Ab-Aa intervals are 185 and 80 feet, respectively, a total of 265 feet. Thus, because the overall intervals between major lignites in both areas are about equal and because no appreciable lignite occurs between the "Skaar scoria" and the L horizon, it may be that Stebinger's J instead of his I bed is correlative with the Ab or "Skaar scoria".

The Ab horizon almost always occurs as scoria in the vicinity of Skaar whereas the equivalent Bb zone along Beaver Creek consists of two or three lignites each approximately 2 feet thick. Correlation of the horizon was achieved only by working along the state line and into Montana.

It will perhaps be interesting to some readers to speculate a moment as to why this lignite zone has burned and formed a scoria north of the interstream divide while just to the south it is untouched. The reason is probably associated with the glacial (Pleistocene time) history of the region. Lignites are ignited only along their outcrops; where exposed by stream erosion. The Yellowstone River and its longer tributaries existed in pre-glacial time much as they do today, and the Ab lignite has been subjected to ignition and burning for a long time. On the other hand, the glacial ice sheet altered considerably the course of the Little Missouri River causing it to erode and lower its bed. (See Leonard, 1916 or Fisher 1953). Thus, Beaver Creek, a tributary of the Little Missouri River, has been downcutting and exposing the lignites along its course, Bb included, for a relatively shorter length of time. That the last cycle of downward erosion is quite young is shown by the short, steep-sided valleys tributary to the main creek. The lignites here have been exposed for so short a time that relatively few have burned and thus formed scorias.

As the Bb zone is followed down Beaver Creek it becomes a single thick lignite, but the Ba lignite in turn assumes a multiple character. The Ba scoria and Bd lignite are consistent in this area and they often aid in determining the stratigraphic position of the more changeable lignites below. Immediately above Bd along the downstream portion of the creek is a notable silty clay that has a medium-brown to olive-brown color unusual in the local Tongue River sediments. It also contains numerous shell fragments and is persistently about 24 feet thick. This unit is best utilized in the western part of T. 144N., R. 103W. where an overall section from the Ba lignite through the P scoria was measured. The thickness of this section compared within 15 feet to the section (Aa through L and P) in the area northeast of Skaar.

The sandstones Ac, Ad, and Ae are usually isolated, erratic, and difficult to separate with certainty, but in a few localities, they are the only beds exposed and so they had to be used for mapping purposes. The writer believes that the intervals Ae-L and Be-Bf are correlative, but because the Bf scoria is restricted to the higher parts of the stream divide, proof of this relationship is lacking.

Structural Geology

The datum horizon for the surface structure map is the base of the L scoria which is, locally at least, the top of the typical Tongue River sediments. It is, therefore, intended that this map be considered a direct continuation of work done the previous summer in McKenzie County where the L scoria was similarly used. Elevations on all other beds employed in the construction of the map are designated by a letter, and the interval required to raise or lower these points to datum are given.

The Skaar-Trotters area is located on the western side but well down toward the axial portion of the Williston Basin. The regional dip averages between 25 and 40 feet per mile to the northeast, and is probably inherited from the Cedar Creek and Poplar anticlines or upfolds of eastern Montana. These large structures strike northwest-southeast whereas the long Nesson anticline, to the northeast of the report area, trends approximately north-south.

Subsurface evidence suggests that the Cedar Creek and Nesson anticlines were formed by faulting in the Pre-Cambrian basement rocks along their western flanks. The faults most likely were initiated by the stresses of differential subsidence, and they were active from time to time throughout the long history of the basin. Such intermittent movements cause an increase downward in the dip or steepness of the flanks of an anticline. Thus the closure or "depth" of this type of structural oil trap increases with depth. Although on a smaller scale, a parallel origin is accountable for most moderate-sized structures observed in the surface rocks of this region.

With one exception the structures in the map area strike to the northwest or north. The exception is the fold in T. 144N., R. 105W. which trends almost east-west and is continued to the northeast across the map by a gentle anticlinal nose. In the north-central part of the area an elongate anticline consisting of three high areas runs north to northwest and merges into the half-structure at the top of the map. It is, therefore, part of a long anticlinal area that nearly parallels the state line in western McKenzie County. The configuration of both of the above structures is compromised by the fact that the southern margins of each enter upon areas barren of rock exposures. The main interstream divide interferes with the first and a broad grassy valley limits the second. However, the beds upon which the north-central fold is constructed were quite distinct and easy to work.

Several separate anticlines are present in the southwestern corner of the map, and these also seem to strike in a general northwest-southeast direction. An anticlinal nose does lead eastward from these structures to the eastern township line, but there it too turns southeastward between two small synclines.

The folds within this area are small to moderate in size and possess closures of 30 to 50 feet at the surface. As stated above, the probable mode of origin of these folds suggests an increase in the amount of closure in the older strata. Although considerably removed from the nearest oil production, these structures are located almost equidistant from 4 areas in which oil has been found—Croff and Fryberg in North Dakota and Deer Creek and N. W. Sidney in Montana.

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NORTH DAKOTA GEOLOGICAL SURVEY

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Structural Geology of the Skaar-Trotters Area McKenzie and Golden Valley Counties, North Dakota

by

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