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STATE OF SOUTH DAKOTA
Sigurd Anderson, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

NO. 76

PRELIMINARY REPORT

ON

THE REVA GAP ANTICLINE

by

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University of South Dakota
Vermillion, South Dakota
November, 1954

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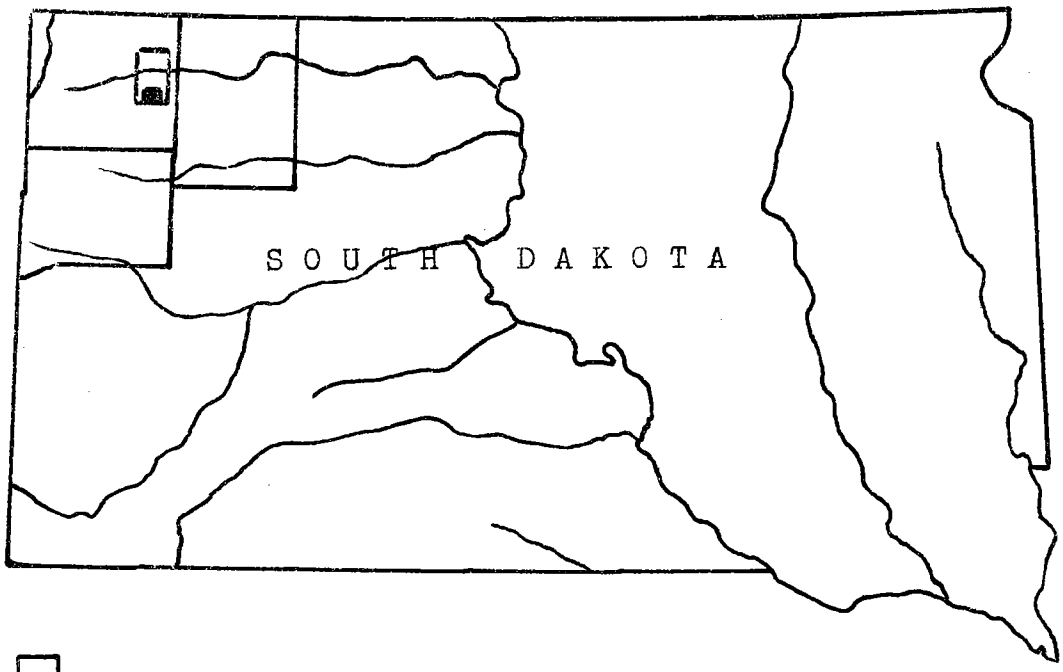
INDEX MAP



REVA QUADRANGLE

Reva Gap Anticline

PRELIMINARY REPORT ON

THE REVA GAP ANTICLINE

By

Bruno C. Petsch

Introduction

Location of the Area

The area described in this report is in east central Harding County, in the Reva Quadrangle[1], which is a standard fifteen minute quadrangle used in the South Dakota State Geological Survey lignite coal mapping program. The area includes 24 square miles of the north two-thirds of T.18 N., R. 8 E., in the locality of the north Slim Buttes Mesa. See Figure 1, State Map.

Purpose of the Report

This report is an outcome of a lignite coal mapping program which is carried on by the South Dakota State Geological Survey. During the mapping of the Reva Quadrangle, the Reva Gap anticline became evident.

Investigations of the Slim Buttes have been carried on intermittently since 1874, by Winchell and Ludlow; 1893 by J. E. Todd; 1909, Darton; 1911, Winchester et al.; 1921, Wilson; 1927, Russell; 1936, Rothrock; 1952, Baker. All investigations were reconnaissance, except those of Russell who made a detailed study of the faults in the area.

Methods of Work

The Reva Quadrangle was mapped on air photos. In the area involved in this report dips and strikes were taken wherever they were available and spotted on the air photos.

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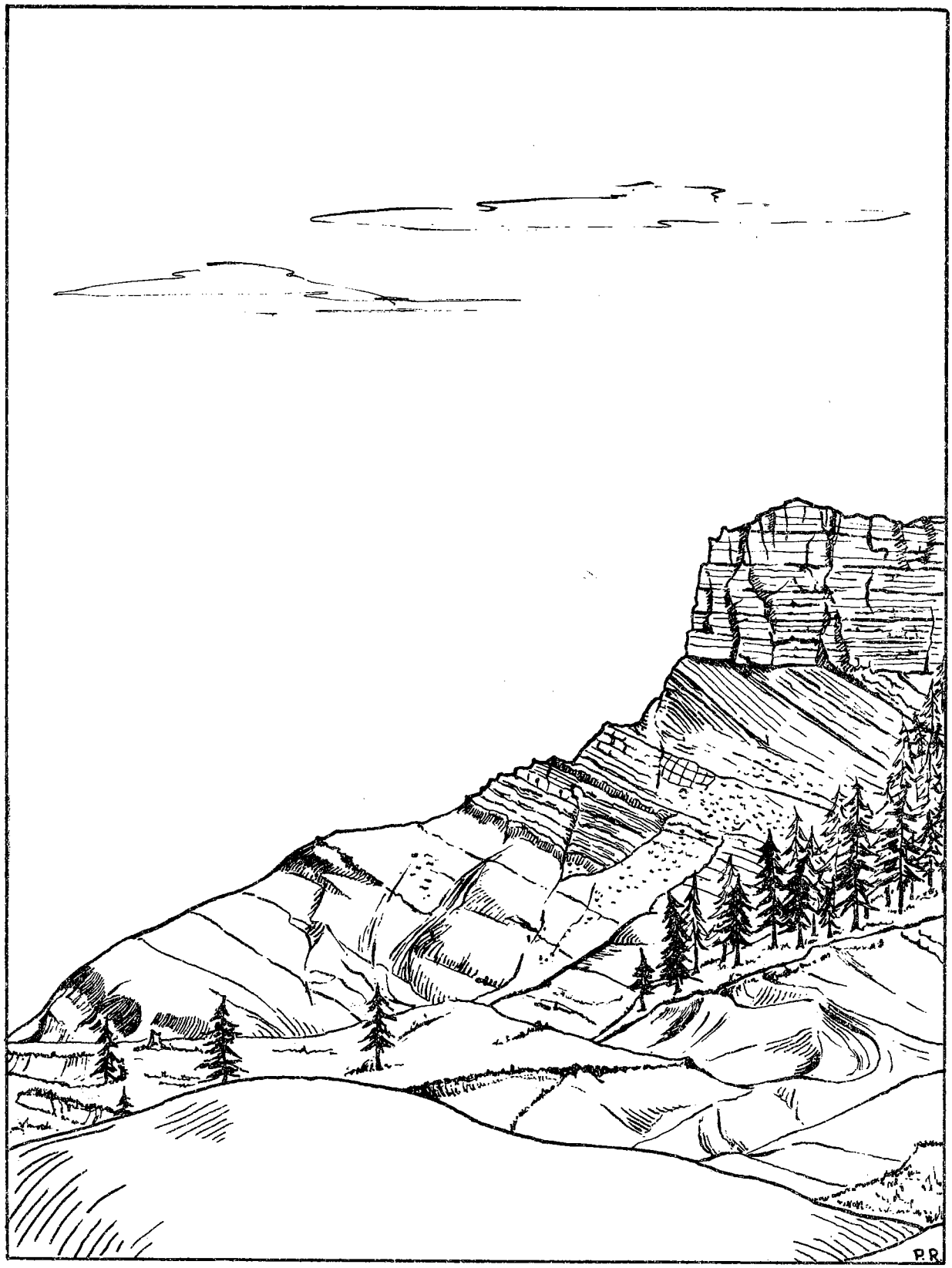
1. To be published by the South Dakota State Geological Survey.

Time did not allow for traversing with plane table and alidade in order to make a contour map of the structure.

Acknowledgments

The ranchers in the area were very kind to the writer in that they allowed his jeeps to travel anywhere on their holdings. The field assistance of William Foley was greatly appreciated.

Field conferences with members of the South Dakota State Geological Survey staff, Dr. E. P. Rothrock, State Geologist, Dr. R. E. Stevenson, R. E. Curtiss, and E. J. Bolin all concurred in the fact that an anticline is present in the vicinity of Reva Gap.



Structural dip in White River formation in Reva Gap, looking south. N.W.cor. Sec.17, T.18N., R.8E.

Figure 2

SURFACE FORMATIONS

STRATIGRAPHY

Introduction

The Area is underlain by sedimentary rock strata. The geologic time interval is interesting because it includes the last of the Mesozoic and the first of the Cenozoic eras.

TIME-ROCK CORRELATION TABLE OF FORMATIONS AT REVA GAP

Cenozoic	Miocene	Barstovian Hemingfordian Arikareean		Ogallala Arikaree?
	Oligocene	White River	Brule	Protoceras[1] Whitney Oreodon[1] Orella
			Chadron	Titanotherium[1]
	Eocene			
	Paleocene	Ludlow		
Mesozoic	Cretaceous	Hell Creek		Upper

1. Bio-Stratigraphic designation.

MIOCENE

ARIKAREE FORMATION OR OGALALLA FORMATION

The exact stratigraphic age of the uppermost beds in the area has been in doubt. They were called Loup Fork (Cope 1880) by Todd, and Arikaree (Darton 1899) by Darton and Ogallala (Darton 1889) by Wood.[1] H. E. Wood II described a late Miocene beaver found in Carter County, Montana in the same formation. The writer agrees with Wood, who states, "Therefore, the late Miocene sandstone of Harding and Carter counties can be thought of as the only known northern remnant of the thin Ogallala veneer, which is still spread so widely over the Great Plains farther south. One would assume that much or all of the intervening area was covered with this Ogallala veneer in the late Tertiary, but that it has since been stripped off. The considerable time interval between the Oligocene White River series and the upper Miocene, at Slim Buttes, South Dakota, leaves time for local diastrophism and peneplanation (Wood, 1942)[2] as an alternative to the hypothesis of large scale slumping, which seems generally accepted currently."

The Ogallala formation (Arikaree) lies perfectly horizontal on the peneplaned surface of White River beds and Ludlow locally. The lower part of the formation is a coarse sandstone with local conglomerate, followed by well bedded white to greenish sandstone. The remainder is hard green stratified to massive sandstone with many green, blocky quartzite beds, and thin bedded fine white sandstone with volcanic ash as the upper part. The forest cover is confined to the Ogallala formation. It is the rim rock and forms the mesa of the Slim Buttes. Steep cliffs at least 100 feet high are the rule, where the formation is present.

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1. Wood, H. E., II, American Museum Novitiates, Am. Mus. of Nat. Hist. 1945.
2. Wood, H. E., II, Problems of our Continental Tertiary, Trans., N. Y. Acad. Sci., Ser. 2, Vol. 4, pp. 135-144 (141-142).

OLIGOCENE

BRULE - CHADRON

The formations are commonly known as the White River Group. It should be mentioned here that the character of the White River in the Slim Buttes is almost identical with those in the Bad Lands National Monument where the deposit was first studied. The Titanothere beds are the lowest member, a pale tan and gray hard silty clay overlain by a coarse dazzling white sandstone is at the base, the upper part consists of pale brown mottled with pale green bentonitic clay, the outcrop weathers to a "popcorn" surface, sometimes a layer of white vuggy limestone is present. The outcrop always has the appearance of an old rounded haystack, sometimes called "elephant backs".

The Oreodon beds are the middle White River. They are hard fine pale green sandstones and alternate with hard pale brownish gray bentonitic clays. Weathering causes a tread and riser effect. The outcrops are generally always steep.

The Protoceras beds are the upper White River. The material is massive pink hard silty clay, stands generally in vertical outcrop. The White River beds outcrop around the edge of the Slim Buttes Mesa.

Landslides of White River material are common surrounding the Slim Buttes, and these areas are quite inaccessible.

PALEOCENE

LUDLOW

This formation is separated from the overlying White River by a complete color change, from the white of the above to the dull yellow to buff of the Ludlow. Furthermore, the Ludlow formation is separated from both the overlying and underlying formations by the numerous lignite coal beds, peat clays, carbonaceous shales and red to pink pseudoscoria. Besides the characteristic layers mentioned, they alternate with tan and buff hard ledgemaking sandstones, soft sandstones and darker clays and shales. Locally it contains radio active elements both in the lignite and sandstone. In a measured section several miles north of the area under consideration, the formation is 369 feet thick. At the base is the Shadehill lignite coal facies,

which is either lignite, carbonaceous shale or peat. The coal facies can be 3 feet thick.

CRETACEOUS

HELL CREEK

The oldest formation in the area is the Hell Creek "Somber beds". It consists of dark clays and shales generally brown to dark gray, the material is bedded, and bentonitic. Weathering leaves a "popcorn" surface. It outcrops in the creek valley in the south part of Section 12, T. 18N. R. 8 E. The top is marked by the Shadehill lignite coal facies which is the base of the above Ludlow formation. In broad outcrops the topography is generally "bad lands". Dark brown ironstone concretion layers are common, on flat surfaces, pieces of concretion are sprinkled about abundantly.

In the creek along State Highway No. 8 east of the Robin's Ranch house in Section 9, T. 18 N., R. 8 E., some gray shale is exposed, that has the "popcorn" surface which could be the Hell Creek.

STRUCTURE

The regional dip into the Dakota (Williston) Basin, in the Slim Buttes area is directly northeast, at 20 feet per mile on the Greenhorn formation datum[1] and 46 feet per mile on the Pre-Cambrian surface[2]. The regional dip is halted at Reva Gap in the upper half of T. 18 N., R. 8 E., by reverse or critical dips of 10 to 29 degrees which are quite obvious in the Ludlow formation, and from 6 to 22 degrees in the White River group. Figure 2. The dip of both formations is in a southwesterly direction, exactly opposite the regional dip. Figure 3.

The approximate axis of an anticline would strike northwest-southeast from the NW corner of Section 4 toward

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1. Petsch, Bruno C., Structure Map of S. Dak., Greenhorn Datum, S. Dak. State Geol. Survey, 1953.
2. Petsch, Bruno C., Pre-Cambrian Surface Map of S. Dak., S. Dak. State Geol. Survey, 1953.

GEOLOGIC MAP OF REVA GAP IN SLIM BUTTES

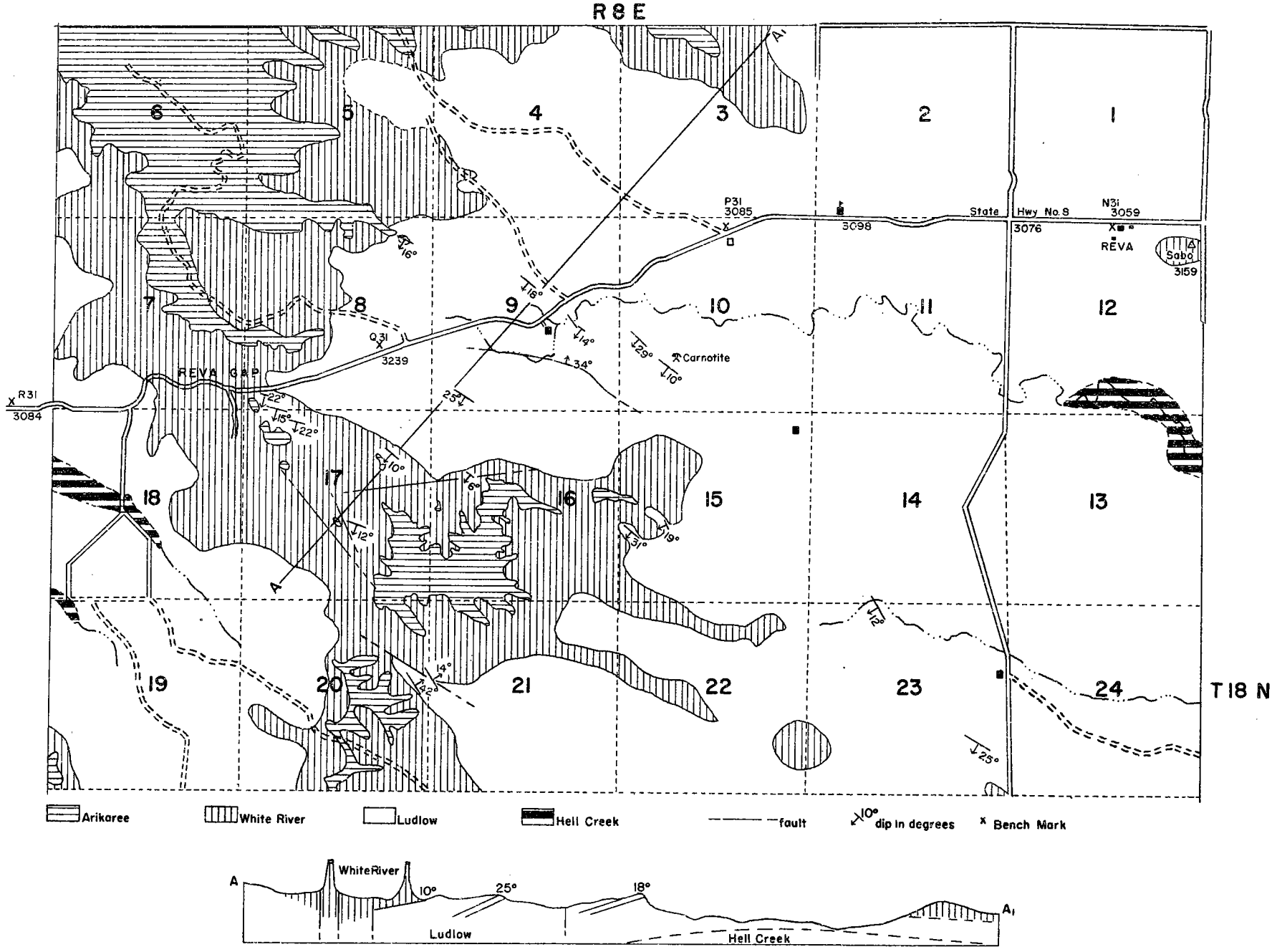

Figure 3

the southeast corner of Section 12 where the Hell Creek, a lower formation, is exposed in the creek due to the uparching of the beds. The length of the axis is questionable. In the northwest it goes under the Slim Buttes north mesa. In all probability, it may be connected to the generally accepted Slim Buttes anticline, whose axis strikes somewhat along the township line between Ranges 7 and 8 E., Township 20 N. Figure 4.

The outcrop of the Ludlow is quite broad, in view of the fact that the formation is in excess of 300 feet thick, and with the steep dips that are present, it would seem that the Hell Creek formation, just below the Ludlow, would be exposed in the creeks on the axis of the structure. The Hell Creek isn't exposed; the assumption is that it is shallow with a thin veneer covering in the gently rolling topography. Faulting in the Ludlow with resultant repetition of beds would account for its broad outcrop. Dips and strikes can be taken with ease on ledgemaking sandstones exposed in the Ludlow.

A fault in the Ludlow can be seen from the highway in the creek cut just east of the ranch house in the SW$\frac{1}{4}$ of Section 9. A short distance directly south, a Ludlow sandstone ledge has a 34 degree dip to the north, which is the result of a fault. This fault trace seems to be shown on the air photo.

Several faults can be traced throughout the "bad land" area of White River outcroppings in Sections 16 and 17. Some of them have a displacement vertically of several hundred feet, because in Section 17 the Titanothere beds (lower White River) are in contact with the pink Protoceras beds (upper White River) side by side. Castle Butte made up of Protoceras beds with horizontal Ogallala capping it, is even in altitude with the tilting Titanothere-Oreodon beds shown in Figure 2 which are also capped by the horizontal Ogallala.

South of the Reva Gap anticline in the same township is a well developed syncline, its axis striking northwest-southeast, across Sections 21 and 22. Figure 4. The northern end is hidden under White River deposits. Apparently it was a surface trough in which was deposited the White River beds. The older Ludlow formation is at higher altitudes on both sides in Section 17, but in Sections 16 and 20 the White River is above the Ludlow in altitude. The syncline is outlined on the sides by steep dips.

Considerable controversy exists in the literature concerning the extreme dips or the folding in general. W. L. Russell[1] devoted quite some time in the area under discussion, stressing the faults and folds. "The Lance formation may be observed in many places immediately below the tilted White River strata, dipping at the same high angle and in the same direction. In fact, the Lance may be seen beneath the highly tilted exposures just south of Reva Gap, dipping at the same high angle and in the same direction as the White River". Todd[2] - "About a mile and a half southeast of Bonnewell's and east of "E6" gap, (Reva Gap), the strata below No. 16 are very much disturbed, dipping from 12 to 25 degrees to the south and southwest with numerous sharp folds most abrupt on the north, sometimes departing into faults." Todd[2] - "The Disturbance Closing the White River. We have already alluded to the disturbance of the Laramie (Ludlow) and White River beds about "E6" Gap (Reva Gap). It is readily seen that the upper strata are clearly horizontal and of a different character from the lower inclined strata." Todd[3] - "An area of disturbance was found in the north half of Slim Buttes in northeast Harding County covering perhaps 20 to 25 square miles. This consists of sharp folds, including the Laramie and White River beds, with throws of perhaps 100 feet and dips of 25 degrees." Todd used the term Laramie (King and Hayden 1876). Later the term Lance (Hatcher 1903) was used as Upper Cretaceous or Tertiary. Now Ludlow (Winchester-Hares 1916) Lower Paleocene is the base of the Tertiary.

Todd and Russell both realized that folding has occurred but did not mention that the reverse dip would form an anticline somewhere to the east in the immediate vicinity.

The following investigators discounted the possibility that a fold exists. Winchester[4], "It is the purpose of this paper to show that the inclination of the beds described above, as well as those exposed at several other localities in the Slim Buttes, is not a true dip due to a dynamic disturbance but is cross-bedding due to the peculiar manner of the accumulation of the White River formation."

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1. Russell, W. L., Ph.D. Thesis 1927, unpublished.
2. Todd, James E., Geology of South Dakota, The First and Second Biennial Reports, Bulletin 2, 1893-6, pp. 53 & 62.
3. Todd, James E., Recent Geologic Work in South Dakota, Am. Geologist XVI 1895, pp. 202.
4. Winchester, Dean E., Cross-bedding in the White River Formation of Northwest S. D., Jour. of Geol. Vol. 21, 1913, pp. 550.

STRUCTURES IN SLIM BUTTES VICINITY

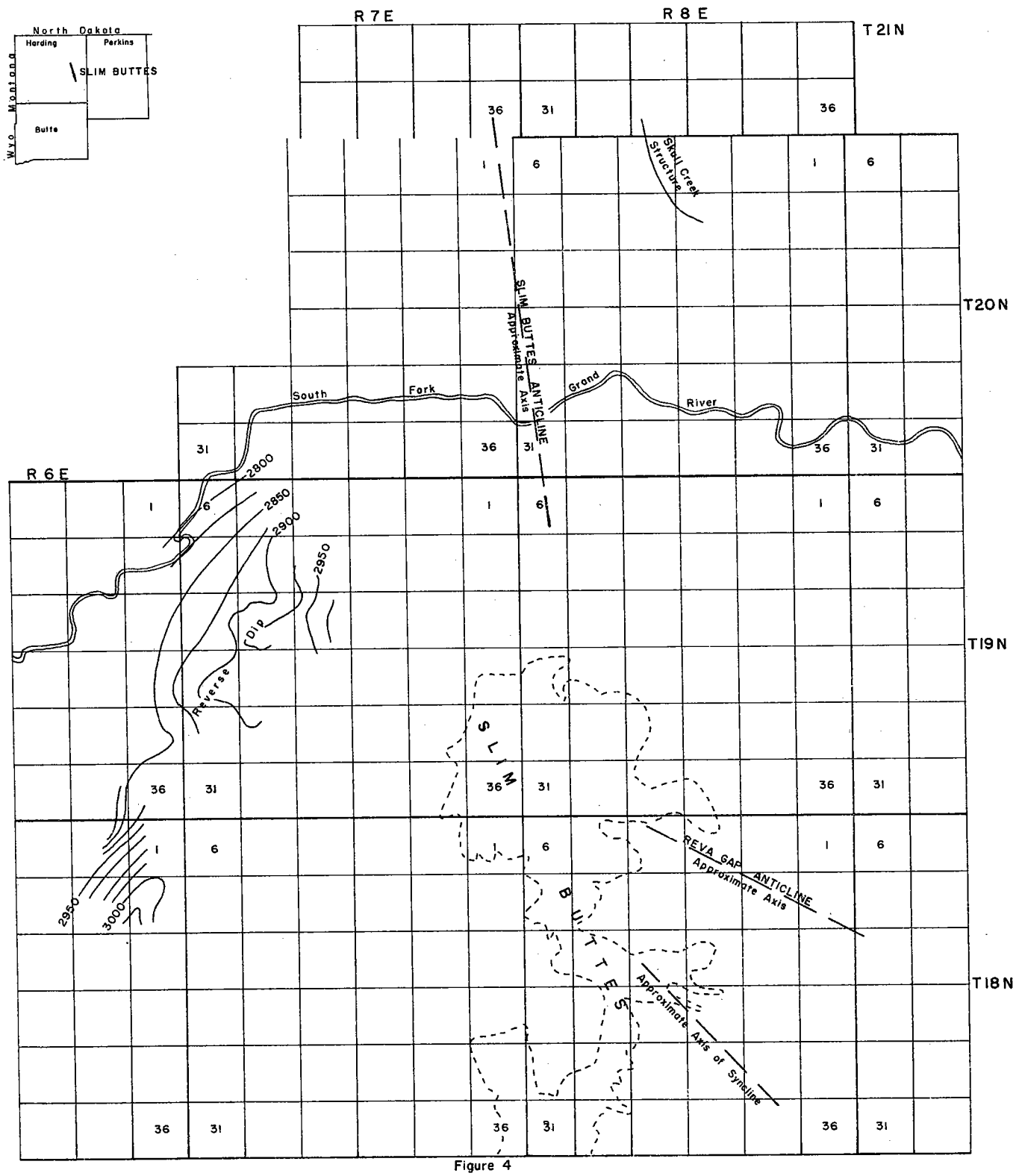

Figure 4

Toepelman[1], "The observations of Winchester and others as reported in Bulletin 627 of the U.S.G.S. are in full accord with those of the present work. Absolutely no evidence for the existence of "structures" favorable for the accumulation was discovered. The steeply dipping beds are entirely superficial and are due to slumping extending over several periods of time."

The writer does not agree with either Winchester or Toepelman in regard to cross-bedding or slumping.

Up arching occurred after the deposition of the White River, and apparently was elevated quite high, because the peneplanation in places cut down to the Ludlow. In the northeast corner of Section 8, T. 18 N., R. 8 E., the tilted Ludlow beds are overlain by the horizontal Ogallala (Arikaree?) beds, with complete absence of White River.

The faulting in the White River and Ludlow also took place during the period of folding. Following these disturbances the entire region was peneplaned, then came the deposition of the Ogallala (Arikaree?) formation. No folding has occurred since, because the Ogallala lies perfectly horizontal.

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1. Toepelman, W. C., Possibilities of Oil in Eastern Harding County, S. Dak. Geol. and Natural History Survey, Cir. 12, 1923.

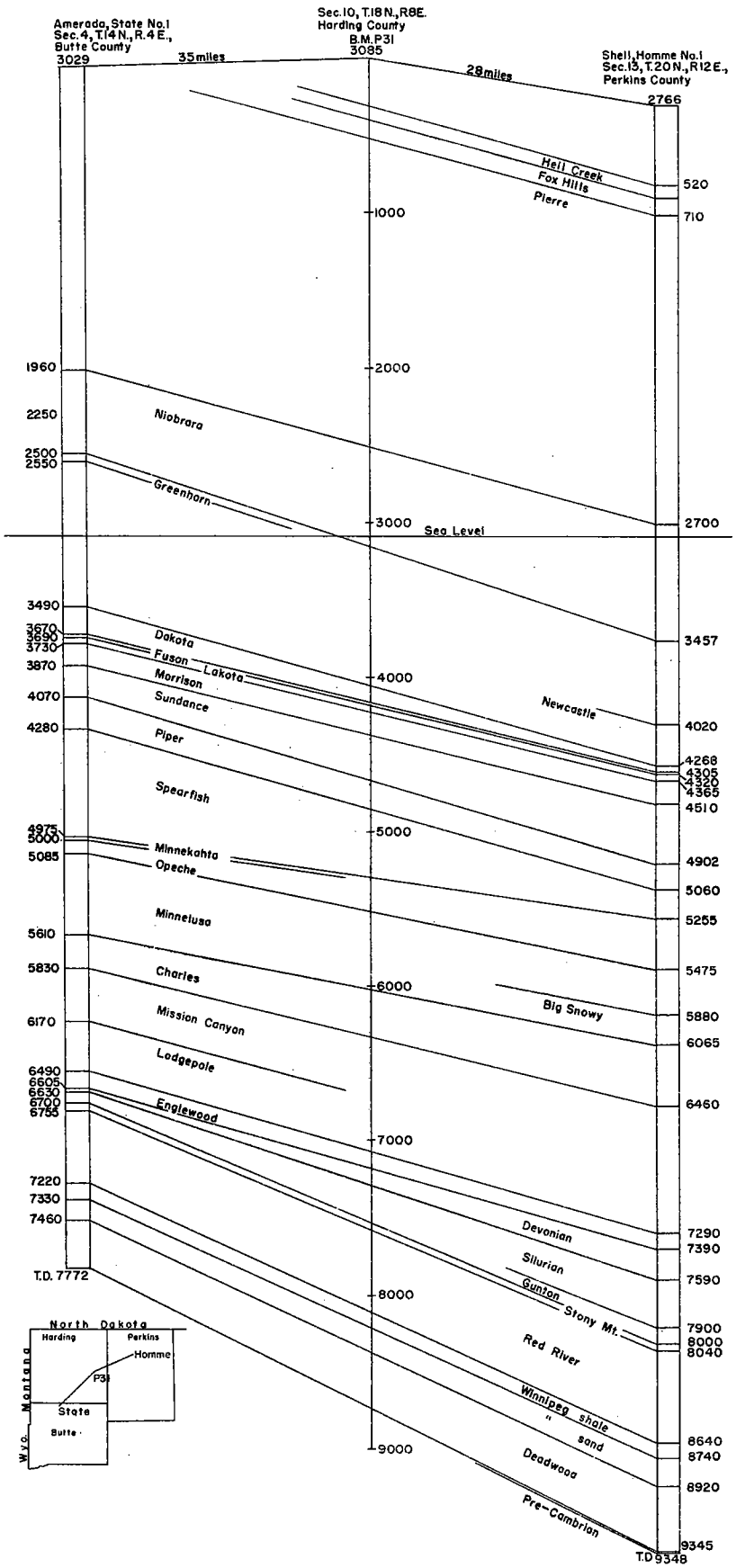
SUBSURFACE FORMATIONS

The nearest borings are over 25 miles northeast of Reva Gap. Two "wildcat" borings were chosen, Amerada-State No. 1, Sec. 4, T. 14 N., R. 4 E., Butte County; and Shell-Homme No. 1, Sec. 13, T. 20 N., R. 12 E., Perkins County. They are aligned southwest northeast across Reva Gap and at right angles to the Dakota (Williston) Basin. Figure 5.

The Paleozoic section thickens northeastward about 1300 feet between the two borings. The Pre-Cambrian surface was struck at 9345 feet in the Homme test. The following table is an estimate of depths where formations will be encountered in a test boring on the Reva Gap Anticline.

	Butte Co. Amerada-State No. 1 Sec.4,T.14N R.4E.	Harding Co. Reva Gap T. 18 N. R.8E.	Perkins Co. Shell Homme No. 1 Sec.13,T.20N R.12E.
Surface	3029	3085	2766
Niobrara	1960	2500	2700
Greenhorn	2500	3150	3457
Dakota	3490	4050	4268
Fuson	3670	4160	4305
Lakota	3690	4180	4320
Morrison	3730	4230	4365
Sundance	3870	4370	4510
Piper	4070	4670	4902
Spearfish	4280	4860	5060
Minnekahta	4975	5300	5255
Minnelusa	5085	5390	5475
Charles	5610	6000	6065*
Mission Canyon	5830	6330	6460
Englewood	6490	7080	7290
Devonian	6605	7190	7390
Silurian	6630	7300	7590
Stony	6700	7540	8000
Red River	6755	7600	8040
Winnipeg Shale	7220	8100	8640
Winnipeg Sandstone	7330	8210	8740
Deadwood	7460	8370	8920
Pre-Cambrian		8700	9345

* 5850 - Big Snowy



SUBSURFACE PROFILE ACROSS SLIM BUTTES

Figure 5

The Cretaceous overlap remains a constant thickness between the two borings. The Sundance thickens to the northeast from 200 feet to 392 feet. The Spearfish red beds thin northeastward from 695 feet to 195 feet. The Silurian-Devonian thickens into the basin from 95 feet to 510 feet.

The above results are taken from the study of cuttings by members of the State Geological Survey Staff. The Amerada-State No. 1 log was made by E. J. Bolin, and the Shell-Homme No. 1 log by C. L. Baker, a former member of the Survey staff. Figure 4.

POSSIBLE OIL AND GAS HORIZONS

Formations which produce oil on the Cedar Creek anticline in Montana and the Nesson anticline in North Dakota are present in the Reva Gap anticline. The entire cretaceous overlap section and the Paleozoic section of the Dakota (Williston) basin are replete with porous and permiable horizons which can contain oil and gas in an anticline.

At present oil is being produced from the Red River formation from two wells--Shell State A, Sec. 9, T. 21 N., R. 4 E., and State 32-16, Sec. 16, T. 21 N., R. 4 E. These wells are about 30 miles to the northwest in Harding County. It is estimated that 500 feet of Red River is present under Reva Gap.

Oil is produced from the Madison formation in several oil fields in North Dakota all being in the Williston basin. The Madison formation is estimated to be about 700 feet thick under Reva Gap.

Very good oil shows were present in the Winnipeg sandstone (St. Peter) in the State Royalty No. 1 test boring, Sec. 35, T. 18 N., R. 1 E., in Harding County. The formation is about 160 feet thick at Reva Gap. Therefore an anticline such as appears to be at Reva Gap should yield oil in commercial quantities.