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Preliminary report on the geology of Colgrove Butte, Hettinger County, North Dakota

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PRELIMINARY REPORT ON THE GEOLOGY OF COLGROVE BUTTE, HETTINGER COUNTY, NORTH DAKOTA

A Thesis

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Thorsteinn Thorsteinsson

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The drilling was done by Mr. Walter Kittler of Mandan, North Dakota, who also collected the samples from all but three of the holes. His son, William Kittler, assisted the writer in surveying the butte.

The chemical analyses of the samples were performed by Mr. W. S. Fallgatter, chemist for the North Dakota Research Foundation, in his laboratory at the University of North Dakota.

The writer is indebted to Mr. Irving Grossman, formerly of the University of North Dakota, for helpful advice and assistance in the organization of the field work, and to Mr. Wallace Samuelson and Mr. Paul Beck for assistance in the field.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF ILLUSTRATIONS

ABSTRACT

Colgrove Butte is a flat-topped erosional remnant with a cap of rock area of approximately 0.845 square miles, rising about 200 feet above the surrounding Missouri Plateau in northeastern Hettinger County, North Dakota. Its upper portion consists of flat lying fresh water deposits of White River (Oligocene) age, containing beds of hard limestone, marls, argillaceous limestones, calcareous clays, clays and sands. It is everywhere covered by a mantle of top soil 6 inches to 3 feet 6 inches thick. Below this topsoil, extending over approximately two-thirds of the caprock area of the butte, is a bed of hard limestone averaging one foot in thickness, which is succeeded by alternate beds of marl, argillaceous limestone and calcareous clays down to a depth of 20-25 feet from the surface.

By rough calculations the weight of the uppermost limestone bed with a thickness of one foot was found to be 1,300,000 short tons, and its calcium carbonate content 80-90 per cent. Bodies of rock extending three, six, and ten feet down from the bottom of the topsoil,and coverihg two-thirds of the butte area, were found to contain 61.5, 55.0, and 47.3 per cent of calcium carbonate and weigh 3,820,000, 7,640,000, and 12,740,000 short tons respectively. Additional test holes need to be sunk into and through the caprock to determine more accurately the amount and grade of calcareous material available in the uppermost layers.

Manufacture of Portland cement from calcareous material at Colgrove Butte calls for the wet process, provided that sufficient supply of water can be economically developed.

INTRODUCTION

Purpose

The main purpose of this investigation was to determine the quantity and quality of limestone of the White River formation at Colgrove Butte, in northeastern Hettinger County, North Dakota, which might be used for cement manufacture. Secondly, the investigation was undertaken to obtain a detailed knowledge of the stratigraphy of the White River beds in this locality, which is one of the few in North Dakota in which remnants of the formation are known to be present.

Field Work

The butte and the territory for a quarter of a mile around its base was surveyed with a plane table and alidade during the summer of 1948, and a topographic map on a scale of eight inches to one mile, with five and ten feet contour intervals, and an areal map were constructed.[1]

Eleven 4-inch holes were drilled, as shown on the areal map of the butte. A Bucyrus Erie 22W truck-mounted, water-well drilling rig was used and samples were taken with a core barrel whenever the holes were dry and the formation was soft enough. Where the holes were wet a standard bit was used and samples were taken from the dart valve bailer at one to three foot intervals, or when the lithology changed abruptly.

The upper limestone and an underlying bed of sand and gravel are exposed in a few localities on the east and south sides of the butte. Representative samples were collected from the sand and gravel for lithologic studies, mechanical size, and heavy mineral analyses.

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[1] Plates I and II.

The volume of water in small springs emerging from the limestone bed on the sides of the butte was roughly estimated and the elevation of the water level was measured.

Previous Work

The first and only detailed study of this area was made by W. E. Powers[2] in 1945. Powers mapped the butte in some detail by plane table. He described the stratigraphic sequence of the White River formation and estimated the cubic yardage of limestone available.

A number of papers have been published on the geology and physiography of this general area. Alden[3] has described the general characteristics of the Northern Great Plains and the history of the Oligocene epoch in eastern Montana and adjacent areas. The late Dr. A. G. Leonard[4] of the North Dakota Geological Survey, did much work in this area. His work includes a description of the surface features of North Dakota, the history of the White River formation in North Dakota, and a geological map of North Dakota. The United States

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2 Powers, W. E., Cement Rock and limestone deposits of North Dakota: Unpublished manuscript in the files of the North Dakota Geological Survey.

3 Alden, W. C., Physiography and glacial geology of eastern Montana and adjacent areas: U. S. Geol. Survey Prof. Paper 174, pp. 3-12, 1932.

4 Leonard, A. G., Geology of southwest North Dakota: North Dakota Geol. Survey Fifth Biennial Report, pp. 29-114, 1908.
_____, The surface features of North Dakota: Univ. of North Dakota Quarterly Journal, vol. 9, p. 209, 1919.
_____, Geological map of North Dakota: Univ. of North Dakota Quarterly Journal, vol. 4, pp. 2-13, 1913.
_____, The geological history of North Dakota: Univ. of North Dakota Quarterly Journal, vol. 5, pp. 228-235, 1917.
_____, The White River formation of North Dakota: Univ. of North Dakota Quarterly Journal, vol. 12, pp. 218-228, 1922.

Geological Survey[5] has published a number of reports on lignite deposits and ground water of areas immediately adjacent to this area.

History

William Colgrove of Mott, North Dakota, was, as far as is known, the first to discover the calcareous nature of the caprock of Colgrove Butte. He and his family filed a squatter right on the butte in 1885 and built a small kiln for the burning of lime. They quarried the limestone outcrops and sold the lime to the neighboring farmers.

The limestone has also been extensively used locally as building stone; most farms in the neighborhood have one or more buildings constructed of this White River limestone.

Geography

Location

Colgrove Butte occupies the greater part of sections 16 and 17, township 136, range 93, west, in the northern part of Hettinger County, in southwestern North Dakota. It is located about 19 miles south of Richardton, and about 16 miles north of Mott, and 2 miles west of State Highway 2.

Climate and Vegetation

The flat-topped butte formerly served largely as grazing grounds for livestock, but is now almost all under cultivation. The average annual rainfall[6] is about 15 inches.

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[5] Hares, C. J., Geology and lignite resources of the Marmarth Field, southwestern North Dakota: U. S. Geol. Survey Bull. 775, 1928.
Simpson, H. E., Geology and ground water resources of North Dakota; U. S. Geological Survey Water Supply Paper 498, 1929.
Lloyd, R. E., The Cannonball River lignite field, North Dakota: U. S. Geol. Survey Bull. 541-G, 1914.

[6] Simpson, H. E., The ground waters of North Dakota: North Dakota Geol. Survey Bull. 7, p. 7, 1932.

PHYSIOGRAPHY

Topography

The area under investigation lies in the south-central part of the Missouri Plateau, popularly known as the Missouri Slope. Its topography is that of the rolling plateau type, marked by flat-topped buttes and nearly level stretches in between the valleys of the larger streams.

The buttes are capped by rocks more resistant to weathering and erosion than those of the surrounding territory. They rise above the general level of the plateau and are usually located in the vicinity of the divides of old streams, and are roughly accordant in level.

These main features are mainly the result of erosion by running water. No part of the surface relief is due to glaciation, although the area is located only ten to fifteen miles[7] southwest of the established boundary of the earliest Wisconsin stage of glaciation.

The topography shows evidence of at least three different cycles of erosion,[8] each of which resulted in the formation or partial formation of a semi-accordant level. The flat tops of the buttes represent one such level. After the formation of this first peneplain the area was uplifted and a second erosion level, represented by the present upland surface of the Missouri Plateau, was produced by the renewed down-cutting of the streams and the mass wastage of the divides. Below this upland stage the present streams have incised their valleys to considerable depth and thethird cycle is under way.

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7 Leonard, A. G., The surface features of North Dakota: Univ. of North Dakota Quarterly Journal, vol. 9, p. 212, 1919.

8 Leonard, A. G., op. cit., p. 217.

Colgrove Butte has a summit area of .845 square miles, as determined by accurate alidade mapping in the field and measurement by planimeter in the office. The length of the butte from east to west is approximately two miles, and its width from north to south one mile. About one-fourth mile to the southwest, and entirely cut off from Colgrove Butte, lies Bull Butte, approximately three-fourths mile long and one-fourth mile wide, with a summit area of 0.118 square miles.[9]

Colgrove Butte is irregular in outline with steep sides except for a short stretch on the southeast side and around three main creeks which incise the butte. These three fairly large V-shaped valleys have all but divided the butte into three separate parts. One valley opens to the north and practically cuts off the easternmost part. The other two trend northeast and southwest respectively, and are separated from each other only by a divide 2000 feet wide. The sides of the butte show evidence of rock creeps, slumps and earthflows. Large blocks of hard limestone have become separated from the low vertical cliff formed by the uppermost limestone bed and have started down the sides which are made up largely of calcareous clay, clay and sand. Low mounds, formed by earthflows and slumps, interrupt the lower part of the relatively even slope.

A number of small springs that emerge at the base of the hard limestone bed at the head of the creeks, and at various other points around the outline, have undoubtedly influenced this form of mass wastage and have played a significant part in the formation of the three valleys.

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[9] Powers, W. E., op. cit., p. 17.

Drainage

Colgrove Butte is situated on a divide that separates the drainage basins of the Heart and the Cannonball rivers. The drainage of the area is for the most part effected by tributaries of the Heart River to the north, and to some extent by the headwaters of the Thirty Mile Creek which flows into the Cannonball River to the south.

The Heart and the Cannonball rivers rise in a divide that runs north and south parallel to the Little Missouri River. They flow eastward into the Missouri River along wide valleys that are covered by extensive flood plains and are topographically in late maturity. The rivers have relatively narrow drainage basins, and the short tributaries joining them at right angles form a roughly rectangular drainage pattern for each basin.

The tributaries are for the most part intermittent streams in which water flows only during the seasons of heavy rain or melting snow.

Structure

The White River beds of Colgrove Butte have a slight dip to the northwest.[10] No evidence of faults or sharp dips are observed. Local inclinations of beds have been observed in the White River formation at several localities in the Slim Buttes, but these irregularities are attributed to cross-bedding rather than disturbance of the strata.

STRATIGRAPHY

General Considerations

The Colgrove Butte area is one of the few localities in North Dakota

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[10] Winchester, Dean E., Cross bedding in the White River formation of northwestern South Dakota: Journal of Geology, vol. 21, pp. 550-556, 1915.

where beds of White River age have been found. Other locations where beds of proved or probably White River age occur are several small buttes in southeastern Stark County; Antelope Butte, and Young Man's Butte in eastern Stark County; Sentinel and Flattop buttes in central Golden Valley County; the Lefor district in southern Stark County and northern Hettinger County; Shalky Butte and Black Butte in western Stark County; Blue Butte in northeastern McKenzie County; Killdeer Mountains in western Dunn County; and Bullion Butte in the southeast corner of Golden Valley County.

These beds are the youngest Cenozoic beds in North Dakota, and are generally located in low buttes or outliers that have withstood erosion because of their favorable location on old river divides, or because of greater resistance of their rocks to weathering, or both.

The contact between the White River formation and the underlying formation in the Colgrove Butte area was not observed in this study, but it is believed that the White River beds are here unconformably underlain by beds of the Fort Union group of the Paleocene series of the Cenozoic Era.

Fort Union Group

Name and Definition

The term Fort Union was originally proposed by Meek and Hayden[12] for beds overlying the Fox Hills beds of Upper Cretaceous age and underlying the Wind River deposits of Eocene age. More recently the term Fort Union in North Dakota has been used for beds lying between the Hell Creek formation of

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[11] Powers, W. E., op. cit., p. 1.

[12] Meek, E. B., and Hayden, E. V., Phila. Acad. Nat. Sci. Proceedings, vol. 15. p. 433, 1862.

Cretaceous age and the Sentinel Butte shale of Eocene (Wasatch) age. The name is derived from exposures of Old Fort Union near the mouth of the Yellowstone River, near Buford, North Dakota.

Occurrence

The Tongue River member of the Fort Union group is exposed over the greater part of the Marmarth field in Bowman, Slope, Golden Valley, and Billings counties,[14] not more than 30 miles west of Colgrove Butte, and beds of the same age are present almost everywhere in Hettinger and Stark counties, where they crop out along the upper slopes of every stream valley and in the steeper slopes of buttes and mesas.[15]

Fort Union beds also cover most of the Heart River quadrangle, 15 to 20 miles east of the area under investigation, in Morton and Grant counties.[16]

Lithology

The Fort Union group is alternately of fresh water and marine origin. Its basal beds, the Ludlow formation, consist of thin-bedded, fine-grained, shaly sands, which are often interbedded with brown to black lignitic shales, are fresh water deposits. The Cannonball formation, the middle beds, is of marine origin and consist of fine-grained sands and gray thin-bedded clay and shale. The uppermost beds, or Tongue River formation, are of non-marine origin, and consist of clayey or silty shale, lignite beds, and buff, fine-grained sands.

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13 Laird, W. M., Mitchell, R. H., The geology of the southern part of Morton County, North Dakota: North Dakota Geol. Survey Bull. 14, p. 16, 1942.

14 Hares, C. J., Geology and lignite resources of the Marmarth field, southwestern North Dakota: U. S. Geol. Survey Bull. 775, p. 50, 1928.

15 Simpson, H. E., Geology and ground water resources of North Dakota: U. S. Geol. Survey Water-Supply Paper 598, p. 145, 1929.

16 Tisdale, E. E., The geology of the Heart Butte quddrangle: North Dakota Geol. Survey Bull. 13, p. 10, 1941.

Thickness

The thickness of the Fort Union group ranges up to 1000 feet in western North Dakota, but is much less elsewhere. A section in the Cannonball lignite field, about 20 miles southwest of Colgrove Butte, measured 350 feet.[17]

Historical Interpretation

The lithology and fossils of the Fort Union beds indicate fluctuations between continental and marine conditions during deposition. The lignite seams in the Ludlow and Tongue River formations point to swampy continental conditions, while marine fossils and lithology of the middle member, the Cannonball formation, are evidence of deposition in shallow epicontental seas.[18]

White River Formation

Name and Definition

The White River formation is named after the White River in the South Dakota badlands. The term was first applied to beds overlying the Pierre shale of upper Cretaceous age and overlain by the Loup Fork formation of Miocene age. Usage in North Dakota for the term White River formation has been for beds of fred water origin overlying the Wasatch group of Eocene age. In some areas outside of North Dakota the formation is treated as a group, divided into the Brule clay formation above and the Chadron formation below. The first White River fossil was described in 1847 by Dr. Joseph Leidy.[19]

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17 Lloyd, R. E., the Cannonball River lignite field, North Dakota: U. S. Geol. Survey Bull. 541-G, p. 10, 1914.

18 Laird and Mitchell, op. cit., pp. 18-23.

19 Wanless, H. R., Lithology of the White River sediments: American Philosophical Society Proceedings, vol. 61, p. 184, 1922.

Occurrence

Outcrops of White River beds have been located north of Pine Ridge, from Wyoming eastward through Nebraska, and into northwestern South Dakota and southwestern North Dakota.

White River beds are exposed in a number of outcrops along the southern edge of Colgrove Butte, in sections 16 and 17, township 136, range 93, west. The thickest section, as measured by Powers[20] near the center of Section 16, Township 136, range 93 west, is 52 feet from the top down, with an unexposed zone of 21 feet.

Lithology

The White River beds at Colgrove Butte consist, from the base up, of sandy greenish clays, sand and gravel, greenish and yellow calcareous clays, which are interbedded with thin layers of hard light-gray limestone and overlain in many places by a thin lens of hard, pinkish-gray to light-gray limestone.

Limestone

Limestone lenses appear intermittently from the surface of the butte down to about 25 feet. They are not continuous in extent but lense out and reappear at intervals. Generally, there is a more indurated limestone bed at or near the surface. This bed consists of brittle, dense, pinkish-gray limestone containing minute cavities and fractures filled with pure crystalline calcite, presumably of secondary origin. The lower limestone layers are argillaceous, and some are minutely stained with limonite. They are light-gray to greenish-gray in color.

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20 Powers, W. E., Cement rock and limestone deposits of North Dakota: Typed manuscript in the North Dakota Geological Survey files, 1945.

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[20] Powers, W. E., Cement rock and limestone deposits of North Dakota: Typed manuscript in the North Dakota Geological Survey files, 1945.

Clay

The White River clays are predominantly of a greenish color and grade into grayish to nearly white caliche-like limey material on one hand and greenish sandy clays on the other.

Sand and Gravel

A thin sheet of medium-grained, brownish sand appears at 30 to 32 feet from the surface of the butte. It is succeeded downward by a slightly calcareous or non-calcareous greenish-gray clay and a thicker bed of fine to coarse-grained greenish sand and gravel, which appear at 35 to 37 feet from the surface.

The sand consists predominantly of quartz grains which are well-rounded and measure up to 2mm in diameter. It contains a number of pebbles of silicious material, with a few intergrown fragments of orthoclase feldspar. Most are well-rounded and some are highly polished. Observed under the petrographic microscope they showed an intergrown mixture of chalcedony with fibrous structure and low relief in clove oil, and quartz with low birefringence. The long dimension of the largest chert pebble found was 1.5 inches, but most were much smaller.

An opinion as to the source and age of the pebbles will not be ventured in this report, but it seems possible that they have been transported from far off, likely from the Black Hills, or from places farther west, and range in age from Paleozoic to Cenozoic.

Thickness

The total thickness of the White River beds could not be determined exactly in this study, but it is believed to be 60 to 70 feet.[21]

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[21] Powers, W. E., op. cit., p. 20.

Paleontology

Skeletons of vertebrates which are abundant in the White River formation elsewhere appear to be absent at Colgrove Butte, or were overlooked in this investigation. The only evidence found of ancient life were two brachiopods and fragments of silicified wood, found in the sand and gravel member.

Correlation

The apparent absence of index fossils in the White River formation at Colgrove Butte prohibits a definite correlation with beds in the type area. However, the lithology of the beds, especially the sand and gravel, seems to indicate that the beds are stratigraphically related to the lower part of the Chadron formation of the White River badlands of South Dakota.

Historical Interpretation

The absence of marine fossils in the White River formation suggests that the formation was laid down in fresh water under continental conditions. The fresh water theory of deposition has been generally accepted, but the mode of deposition has been a controversial issue. The first theories, such as those of Hayden,[22] in 1867 and Dutton[23] stated that the beds were of lacustrine origin, and were laid down in great fresh water lake (White River).

Johnson[24] rejected the lacustrine theory and described the Cenozoic of the Great Plains as a debris apron or subareal delta deposit made by distributary streams emerging from the front of the Rocky Mountains.

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[22] Hayden, F. V., Geol. Survey Terr. 1st Ann. Report, p. 58, 1867.

[23] Dutton, C. E., Tertiary History of the Grand Canyon district: U. S. Geol. Survey Monograph II, p. 216, 1882.

[24] Johnson, W. D., The high plains and their utilization: U. S. Geol. Survey 21st Ann. Report, vol. 4, pp. 612-656, 1900.

Holes to be drilled		Holes already drilled
9	39	10
14	40	11
17	41	12
23	51	18
25	53	19
27	36	20
28	58	51
32	60	61
34	70	63
36		64
38		69

County Road

OUTLINE MAP
OF
COLGROVE BUTTE

SCALE - 1 IN = 660 FT

MAP OF CAPROCK AREAS OF LEFOR AND COLGROVE BUTTES

SCALE:
0 — 1 MILE

N

R 95 W — R 94 W — T 137 N

12 7 36 31

LEFOR BUTTES

T 136 N — R 94 W — R 95 W

18 6 33 31 36

LEFOR BUTTES

BULL BUTTE

COLGROVE BUTTES

13 18 12 7 15 3

T 136 N

MAP OF KILLDEER MOUNTAINS

MIDDLE HARD LEDGE: ~

UPPER HARD LEDGE: - - -

SCALE:
0 — 1 MILE

N

R 96 W — T 147 N — T 146 N

NORTH MOUNTAIN

35 2

KILLDEER MOUNTAINS

SOUTH MOUNTAIN

OAKDALE

INDIAN KNOB

31 0 35

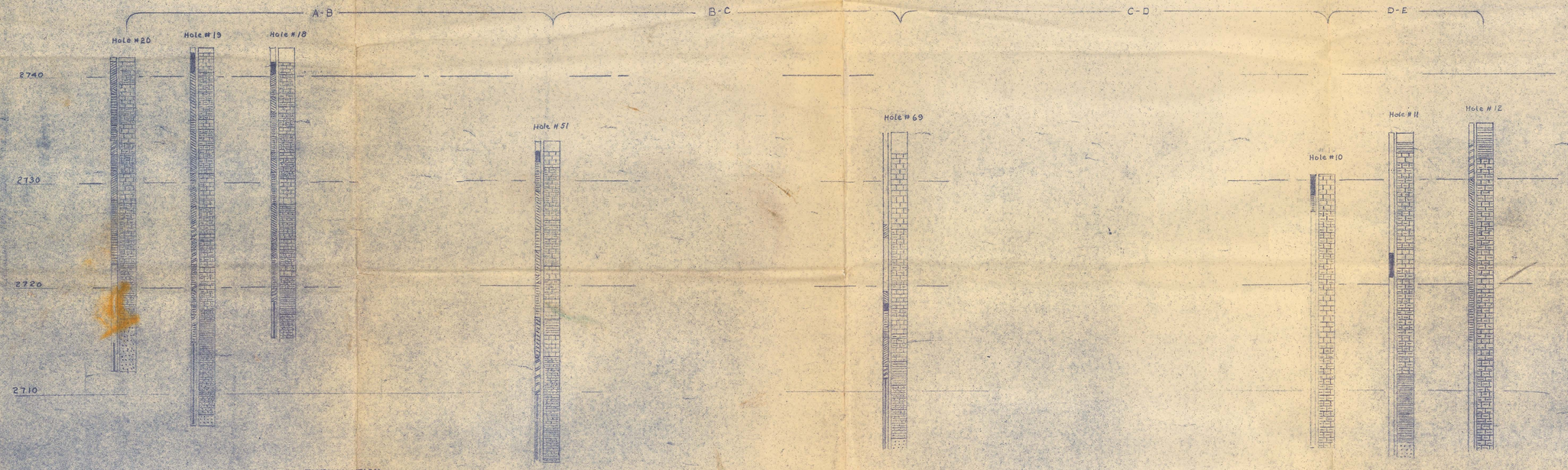
R 96W

R 93 W — R 92 W — T 137 N

36 31 BUTTES 12 7

Plate II Powers

PLATE III A



EXPLANATION

Soil | Limestone | Argillaceous Limestone | Sandy Argillaceous Limestone | Shale | Sandy Shale | Sand

No Sample | 0-10 | 10-20 | 20-40 | 40-60 | 60-80 | 80-90

Per Cent $CaCO_3$

STRATIGRAPHIC CROSS SECTIONS

VERTCAL SCALE

5 0 5 10 FT

HORIZONTAL SCALE

1/8 2 1/16 0 1/4 MI

PLATE IV

holes to be drilled in alphabetical order

Appox. location Sec Cor

ABSENT OR LOW GRADE

Garbutford Samples

MEASURE ALL SECTIONS
HAND LEVEL

AREAL MAP
OF
COLGROVE BUTTE
(SHOWING ESTIMATED EXTENT OF UPPERMOST 1 FOOT)

SCALE 8 INCHES = 1 MILE