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COMO BLUFF ANTICLINE, ALBANY AND CARBON COUNTIES, WYOMING

BY

ROBERT O. DUNBAR

Contribution from the Geological Survey of Wyoming
University of Wyoming, Laramie

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COMO BLUFF ANTICLINE, ALBANY AND CARBON COUNTIES, WYOMING[1]

ROBERT O. DUNBAR[2]
Laramie, Wyoming

ABSTRACT

Como Bluff anticline is a westward-plunging, asymmetric fold extending across the east-central part of the Laramie Basin. The northeast axial trend of the anticline is nearly normal to the axial trends of the Laramie Basin and the Laramie Range. The northwest and steeper flank of the anticline is faulted by the North Como thrust. The thrust plane dips southeast. The fold probably originated from northwest-southeast compressive stresses. A geologic map of the western quarter of the anticline, interpretative structure sections, and detailed stratigraphic sections are given. The area has been made geologically famous by successful excavations for dinosaurs and other Jurassic reptiles.

INTRODUCTION

Location.—The Como Bluff anticline is located in Albany and Carbon counties, Wyoming (Fig. 1). It extends from the western slope of the northward-trending Laramie Range westward into the Laramie Basin. This anticline terminates 5 miles east of the town of Medicine Bow, Carbon County, Wyoming. Approximately 30 square miles were mapped in Ts. 22 and 23 N., Rs. 77 and 78 W. The western quarter of the anticline was included in this survey.

Purpose of report.—This work was undertaken with the aid of the department of geology of the University of Wyoming, and the Geological Survey of Wyoming to obtain: (1) an accurate geologic map of the region, (2) a detailed stratigraphic section, (3) a report of the geologic structure of Como Bluff anticline, (4) a generalized account of the economic values of the region, and (5) additional general geologic knowledge of Wyoming.

Previous geologic investigations.—This locality has been made geologically famous by the findings of fossilized reptiles during the 1880's and 1890's. Their occurrence in the low-dipping Jurassic Morrison formation on the south flank of the anticline has promoted great excavations by vertebrate paleontologists. Many famous scientists have worked in the area, including O. C. Marsh, Henry Fairfield Osborn, Richard S. Lull, Frederic B. Loomis, Barnum Brown, and W. H. Reed. However, the studies of these men were chiefly limited to vertebrate paleontology. Because of the excellent exposures, many stratigraphic sections have been measured across Como Bluff anticline. Dobbin, Hoots, Dane, and Hancock (6: 137–38), Darton and Siebenthal (4: 26, 28), and Darton (3: 441–44, 445) give reference to sections measured at Como Ridge. W. C. Knight (10: 384) speaks of the Como stage and gives Jurassic faunal lists. Giddings (7: 14, 37) comments on the Como fault and the various exposures. Darton, Blackwelder, Eliot, and Siebenthal (5: 8) mention the vertebrate fauna at Como Bluff. This

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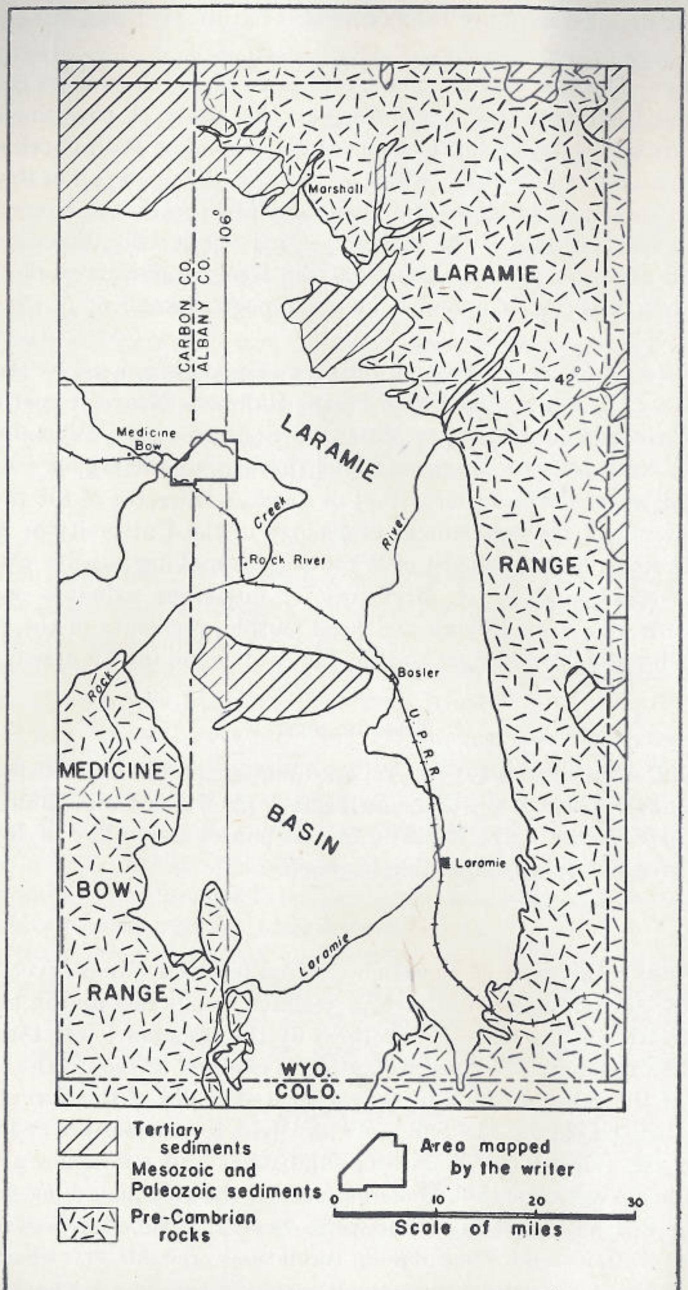

Marshall
106°
CARBON CO.
ALBANY CO.
LARAMIE
42°
Medicine Bow
LARAMIE
Creek
River
Rock River
RANGE
Rock
Bosler
U.P.R.R.
MEDICINE
BASIN
Laramie
BOW
Laramie
RANGE
WYO.
COLO.
Tertiary sediments
Mesozoic and Paleozoic sediments
Pre-Cambrian rocks
Area mapped by the writer
0 10 20 30
Scale of miles

FIG. 1

paper and the detailed map are the first of this nature ever presented about the area.

Field work.—The area was mapped on the scale of 1 inch equals 1,000 feet, by using stadia rod with telescopic alidade and plane table. A base line along the high Dakota ridge on the south flank was established. The Wall Creek sandstone was used as a mapping boundary except on the east and open end of the anticline where Rock Creek was chosen as the boundary. Field work was carried on for 6 weeks during the last half of the summer of 1941 under the direction of S. H. Knight. Field expenses were furnished by the Geological Survey of Wyoming. The entire area mapped is included in the topographic sheet of Como Ridge, Wyoming.

Accessibility.—The west margin of the area mapped is crossed by the Lincoln Highway (U.S. 30), and by the Union Pacific Railroad. Near the east margin of the area, the graded county road to Marshall, Albany County, Wyoming, crosses the anticline. Numerous trails are scattered throughout the region.

Acknowledgments.—The writer wishes to thank, as director of the thesis, S. H. Knight, chairman of the department of geology of the University of Wyoming, and H. D. Thomas, State geologist of Wyoming, for making possible the preparation of this report, and R. H. Beckwith for numerous valuable suggestions. Thanks are also due Tom Boylan and Fred Cuthill, residents of the region, for their hospitality and coöperation, and George A. Ashland for his assistance in the field.

TOPOGRAPHY

Como Bluff anticline is a broad westward-plunging fold. The resistant beds of the south flank give rise to a prominent hogback known as Como Bluff. The corresponding beds of the north flank lie in and border the valley of Rock Creek and do not give rise to a comparable hogback.

SOUTH FLANK

Como Bluff has an average elevation of 7,100 feet and stands several hundred feet above the surrounding country. The hogback trends east and in most places parallels the strike of the beds. It is capped by the resistant lower Dakota sandstone. The less resistant Morrison formation is exposed in the northward-facing, steep slope of the ridge. Erosion of the variegated shales of this formation gives rise to miniature badlands. The Sundance and Jelm formations are exposed in the lower part of this ridge. The Chugwater sandstones and red shales are exposed in the core of the anticline. South of the crest of the ridge is a long gentle slope controlled by beds of comparatively low dip. Several thin-bedded resistant sandstones of the Dakota and Thermopolis formations, the Mowry siliceous shale, and the Wall Creek sandstone form small eastward-trending hogbacks. The less resistant intervening black shales are eroded into shallow valleys.

NORTH FLANK

The beds on this flank of the anticline are nearly vertical and in places are overturned. Here, the resistant beds form minor hogbacks. The strike of the beds is northeast. The less resistant shales are inconspicuous as land forms. The elevation of the Wall Creek outcrop is approximately 6,700 feet and the thicker Dakota sandstone ridge stands about 100 feet higher in elevation.

The nose of the westward-plunging anticline stands at a lower elevation and is crossed by the highway and the railroad.

In summary, the Dakota of the south flank forms a prominent hogback. Also on the south flank, subordinate hogbacks paralleling the main ridge are formed by the Mowry siliceous shale and the Wall Creek sandstone. On the north flank, the Dakota forms a northeastward-trending, well defined minor hogback lying at a lower elevation than Como Ridge. The Frontier black shales, the Morrison variegated shales on the flanks, and the Chugwater red shales in the core of the anticline are non-resistant and do not have pronounced relief.

DRAINAGE

The entire area north of Como Ridge is drained by Rock Creek. Here, Rock Creek flows in a westerly direction and empties into the Medicine Bow river 2 miles northwest of this area.

The area south of Como Ridge is cut by westward-draining intermittent streams which empty into the Medicine Bow River.

A small lake, known as Aurora Lake, occupies a depression in the Chugwater shales. The axis of the anticline passes near the south shore of the lake. The steeply dipping Jelm sandstone crops out along the north shore of the lake. The straight north shore of the lake follows the strike of this bed. On the east, also in the Chugwater shales, are smaller lakes and swamps fed by the overflow of the Medicine Bow water wells and near-by Union Pacific Railroad springs. This water also collects in depressions near the axis of the anticline.

Along the eastern margin of the mapped area, Rock Creek cuts diagonally across the anticline. In this region, the heavy flow of water after rains is carried to the creek by deep gullies cut along strike-valleys. Near the Swan Company ranch and the State Fish Hatchery several springs drain into Rock Creek.

STRATIGRAPHY

GENERAL STATEMENT

The Laramie Basin within which the area described is located, is underlain by thousands of feet of Paleozoic and Mesozoic rocks. The stratigraphic succession is well known.

The oldest exposures in the area mapped are beds of the lower Chugwater formation. However, because of the rise of the anticlinal axis on the east, beds older than Chugwater are exposed along the anticline. Giddings (7: 14), discusses these pre-Chugwater formations as well as the crystalline core of the anticline where they are exposed some miles east.

TABLE I

GENERALIZED STRATIGRAPHIC SECTION OF COMO BLUFF AREA, WYOMING

Age	*Unit Mapped*	*Thickness (Ft.)*	*General Description*
Upper Cretaceous	Carlile shale		Soft black shale and gray calcareous shale
	Wall Creek sandstone	27	Brown to white platy salt and pepper sandstone containing: *Inoceramus fragilis*, *Scaphites warreni*, *Prionocyclus wyomingensis*, *Ostrea sp.* and shark teeth
	Frontier shale	700	Black fissile to platy shale with septarian concretions
	Mowry shale	130	Black to brown platy siliceous fossiliferous shale which weathers to silver-gray color. Thin bentonite seams are present
	Thermopolis shale	80	Dark gray to black shale with thin beds of brown sandstone. A few scattered ironstones
Lower Cretaceous	Dakota group	220	Alternating brown blocky quartzitic sandstones and black shale. Pink, black, and green shale. White fine-grained to coarse-grained conglomeratic sandstone. Brown to gray massive sandstone weathering to mottled maroon-orange color
Upper Jurassic	Morrison formation	300	Largely variegated shale. Gray sandstone. Gray-brown fresh-water limestone. Lenses of limestone pebble conglomerate. Vertebrate remains
	Sundance formation	204	Yellow fine-grained platy sandstone. Olive-drab shale containing *Belemnites densus*. Gray thin-bedded sandstone. Gray sandy shale. Buff massive sandstone
Triassic	Jelm formation	94	Tan sandstone. Red sandy shale. Lenses of green and maroon conglomerate
	Chugwater formation	868	Predominantly orange-red sandy shale. Gray sandstone. Alternating red and green sandy shales. Gypsiferous red shale. Gray jagged and marly limestone
Permian	Embar group		Orange-red shale and gray limestones

The beds exposed in that part of Como Bluff anticline under consideration are shown in the generalized stratigraphic section, Table I, and in the detailed sections listed on the following pages. Thickness was measured normal to the strike of the beds with a Brunton compass and a steel tape with corrections for slope angles.

PRE-CAMBRIAN ROCKS

The pre-Cambrian rocks exposed in the Laramie Range (Fig. 1), as noted by Giddings (7: 9), are gray schists and gneisses made up of quartz, mica, and feldspar. In the pre-Cambrian exposures in the east end of Como Bluff anticline, much varied intrusive material is found. Island-like exposures of pure white quartz, pegmatites, basic dikes, and scattered diabasic masses are abundant in the exposures.

PRE-CHUGWATER ROCKS

The first sedimentary unit lying on the pre-Cambrian granitic complex consists of approximately 50 feet of redbeds composed of conglomerates, sandstones, and shales. Darton (3: 413) correlated these beds with the Pennsylvanian Amsden formation. However, in this paper, because the distinction between the Amsden and the Tensleep is not clear in this area, all of the Pennsylvanian beds are called Tensleep. The basal conglomerate was found to contain molds and imprints of Mississippian fossils. Darton believed that long periods of exposure before the deposition of the Amsden probably removed all of the Mississippian Madison limestone from this area. Overlying the Amsden beds is found about 325 feet of Pennsylvanian Tensleep (also called Casper) formation. These beds consist of cross-bedded sandstones and interbedded sandstones and limestones. Overlying the Tensleep formation are the Permian Satanka red shales and thin limestones, about 200 feet in total thickness. The 15-foot thick Permian Forelle limestone separates these beds from the lower Chugwater. The only part of the Chugwater not exposed in the mapped area consists of approximately 50 feet of red sandy shale which rests directly on the Forelle.

PERMIAN-TRIASSIC ROCKS

Chugwater formation.—The total thickness of the Chugwater formation is approximately 868 feet, of which the upper 815 feet is exposed in the area mapped. The lowest lithological unit exposed is a limestone which occurs 54 feet above the base of the Chugwater as defined by Thomas (17: 1680) in his Freezeout Hills section. In the measurement of the section in this area, the Jelm-Chugwater contact was taken at the base of a buff cross-bedded sandstone. Throughout the Laramie Basin area, the Chugwater formation rests on the crinkly Forelle limestone. The Chugwater formation consists mainly of red sandy shale and red sandstone with subordinate amounts of gray sandstone, gypsum and thin beds of limestone. Thomas (17: 1660) states that the Chugwater is a lithologic unit embracing rocks of both Permian and Triassic age, and a unit with a different age for its basal beds in different localities. Darton and Siebenthal (4: 22–23) measured 1,133 feet of Chugwater which included the Jelm.

Thomas points out (17: 1687) that along the north flank of the Como Bluff anticline the Little Medicine tongue of the Dinwoody formation (17: 1670) and a part of the lower Freezeout tongue of Chugwater (17: 1670) are exposed. In order to map the desired structure within the lower part of the Chugwater formation, four exposed thin beds of porous limestone were used. The Little Medicine tongue is the upper and outermost limestone used in mapping the structure. The

STRATIGRAPHIC SECTION OF PART OF CHUGWATER FORMATION EXPOSED IN SECS. 26, 27, AND 35, T. 23 N., R. 77 W.

	Feet
Jelm formation	
Chugwater formation	
Red sandy shale	9
Gray platy sandstone	3
Gray-green sandy shale	6
Gray fine-grained massive resistant sandstone	12
Red shaly sandstone	25
Greenish gray shaly sandstone	3
Red shaly sandstone with 6-inch beds of greenish gray sandstone	72
Green finely crystalline platy sandy limestone; weathers brown	1
Red sandy shale, green sandy shale, and red shaly sandstone	57
Greenish gray shaly massive sandstone	30
Red sandy shale with several 1-foot thick sandstones near top	295
Red sandy shale	127
Little Medicine tongue of Dinwoody	
Buff fine-grained shaly salt-and-pepper sandstone at top and becoming more shaly in middle. Limestone at bottom; all red-stained	11 (No. 1 ls.)*
Yellow to buff salt-and-pepper sandstone and oölite	1
Dove-colored shale	2
Base of section	
Freezeout tongue of Chugwater	

*See footnote in following table.

STRATIGRAPHIC SECTION OF FREEZEOUT TONGUE OF CHUGWATER, MEASURED NEAR DIFFICULTY POST OFFICE, FREEZEOUT HILLS, CARBON COUNTY, WYOMING, BY THOMAS (17: 1680)

	Feet
Little Medicine tongue of Dinwoody	
Freezeout tongue of Chugwater	
Covered portion, probably mostly red shale; in Flat Top uplift this part consists of red shales and thin breccias. Exact thickness not measureable	20
Porous, impure, massive gray limestone	2 (No. 2 ls.)*
Variegated, red and olive, gypsiferous shale	16.5
Gypsum	3
Breccia; angular masses of gray limestone in red shale matrix	6 (No. 3 ls.)
Breccia; angular fragments of red shale and crinkled limestone in gray limestone matrix	4
Red shale	2
Breccia; angular fragments of crinkled limestone and red shale in gray limestone matrix grading downward into crinkly limestone	2 (No. 4 ls.)
Gray shale	1
Breccia; red shale fragments in limestone matrix	0.2
Breccia; red, sandy shale fragments in matrix of same character	2
Fine-grained, finely laminated, slightly crinkled white limestone	1.5
Red sandy shale with numerous circular gray spots	50**
Total thickness of Chugwater	868
Forelle formation	

* Numbers are writer's and refer to limestones within the lower portion of the Chugwater.
** This portion of Thomas' section is not exposed in the mapped area.

three lower limestones are contained in the Freezeout tongue. Thomas, in describing the Freezeout tongue, measured a section approximately 20 miles northwest of this area. This section is given as representative of that part of the Chugwater which is not exposed or too poorly exposed to be measured in detail.

TRIASSIC ROCKS

Jelm formation.—This formation, consisting of buff massive cross-bedded sandstone, conglomeratic lenses, and red sandy shale, was originally described by Knight (8: 168). The formation takes its name from Jelm Mountain near the Wyoming-Colorado state boundary. The total thickness measured in the mapped area was 94 feet. The upper contact was chosen at the top of the conglomerates. The basal contact was taken at the bottom of the tan cross-bedded sandstone just above the uppermost characteristic Chugwater red shale.

Stratigraphic Section of Jelm Formation, Measured in Sec. 26, T. 23 N., R. 77 W.

	Feet
Sundance formation	
Jelm formation	
Lenses of variable green conglomerate with white mica, green shale, and red sandstone particles; round stones not more than ⅛ inch in diameter	1
Lenses of dirty maroon conglomerate with limestone pellets; ridge-former	1
Red to pink sandy shale; non-resistant	52
Tan to buff coarse-grained massive cross-bedded resistant sandstone with calcite-cemented veinlets	40
Total	94
Chugwater formation	

UPPER JURASSIC ROCKS

Sundance formation.—The Sundance formation is well exposed in this area and is 204 feet in thickness. The top member of the formation is lemon-yellow sand. A middle unit of olive-drab shale contains abundant guards of the cephalopod, *Belemnites densus*. The base was drawn at the contact of the white sandstone and the typical Jelm conglomeratic lenses. The lower unit of sandstone approximately 90 feet thick is believed to be the stratigraphic equivalent of the Nugget sandstone. This sandstone in the Freezeout Hills section has been tentatively correlated by Neely (14: 724) with the Nugget sandstone.

Stratigraphic Section of Sundance Formation, Measured in Sec. 26, T. 23 N., R. 77 W.

	Feet
Morrison formation	
Sundance formation	
Lemon-yellow fine-grained platy semi-friable sandstone	6
Dark green-gray drab shale with *Belemnites densus* beginning to appear 15 feet below yellow sandstone	40
Gray platy soft sandstone	1
Olive-drab shale	5
Gray platy sandstone	1
Olive-drab shale	17
Gray platy soft sandstone	7
Green, gray, and red shale	26
Gray thin-bedded cross-laminated sandstone	3
Gray sandy shale	7
Buff to yellow massive soft sandstone; very fine-grained at top grading to medium-grained and coarse-grained near bottom	80
White medium-grained massive sandstone	11
Total	204
Jelm formation	

Morrison formation.—The thickness of the Morrison measured across the dinosaur-graveyard excavation pits is 308 feet. This world-famous formation consists chiefly of variegated shales, thin sandstones, lenses of limestone conglom erate, and fresh-water limestones at the base. Exposures of this formation have yielded many fossil reptile remains. For this reason the name Como Bluff is usually associated with the name, "Dinosaur Graveyard."

STRATIGRAPHIC SECTION OF MORRISON, MEASURED IN SEC. 17, T. 22 N., R. 77 W.

	Feet
Dakota group	
Morrison formation	
Black, green, red, purple, brown, and maroon variegated shale; weathers to gray clay-balls of pea size	209
Gray fine-grained soft but platy friable sandstone with very thin conglomerate at bottom	17
Green and red shale	5
Brown, gray, red, purple, and green mottled limestone	2
Red, gray, and green shale	28
Gray fine-grained soft sandstone	5
Variegated shales	5
White fine-grained massive semi-friable sandstone	5
Variegated shales	9
White fine-grained platy sandstone	4
Variegated shales	9
Gray-brown finely crystalline massive limestone with conspicuous calcite crystals and calcite-recemented fractures	4
Green and gray shale; lenses of limestone pebble conglomerate with round stones up to ¾ inch in diameter	6
Total	308
Sundance formation	

CRETACEOUS ROCKS

Dakota group.—The rock succession lying between the Morrison formation and the Thermopolis shale has been described by Lee (12: 18) as the Dakota group. On the geologic map (Fig. 2) they are shown as a unit. They are 220 feet thick at Como Bluff. These rocks consist of several alternating black shales and brown blocky quartzitic sandstones forming minor hogbacks, pink to purple, black, and green shales, and a white sandstone with a basal conglomerate. The resistant lower conglomeratic sandstone caps Como Ridge on the south flank of the Como Bluff anticline.

Thermopolis shale.—The Thermopolis shale consists of dark gray to black non-resistant shales with several thin beds of gray platy sandstone containing marks resembling worm trails. A few scattered ironstone concretions are also present. The total thickness is 80 feet.

Mowry shale.—At Como Bluff the thickness of the Mowry shale is 131 feet. This compares favorably with that of Dobbin and associates (6: 139). It is a black to brown platy siliceous shale which weathers to a characteristic silver-gray color and contains fossil fish scales. Bentonite seams are interbedded with the shale. The resistant character of these shales gives rise to prominent ridges commonly covered with scattered pine trees. The fact that this formation gives rise to ridges, taken together with the characteristic silver-gray color, makes it one of the most easily recognizable horizon markers exposed in this area.

Frontier formation.—In the region mapped, the Frontier formation consists of 700 feet of dark gray to black shales becoming more sandy toward the top. Septarian concretions occur near the base.

Wall Creek sandstone.—A sandy shaly succession at the top of the Frontier formation is called the Wall Creek. In the northern part of the Laramie Basin, the Wall Creek is divisible into several sandy zones. Dobbin and associates (6: 139), point out that this sandstone may not be the exact stratigraphic equivalent of the oil-producing sands of the same name in the central part of Wyoming. The bed as found in the mapped area consists of brown fossiliferous sandstone 27 feet in thickness. It is a ridge-forming unit and is easily discernible.

Carlile shale.—The Carlile shale consists of soft black shale and gray calcareous shale containing large ironstone concretions. The thickness given by Beckwith (1: 1520) for the Laramie Basin is 250 feet. Thomas (18: 1196) showed that the fauna of the so-called Carlile of the Laramie Basin is Niobrara in age. He suggested that the name Sage Breaks shale member of the Niobrara proposed by Rubey (15: 4) be used for the shale immediately above the Wall Creek sandstone in the Laramie Basin. These beds were mapped as the Carlile shale.

Stratigraphic Sections of Thermopolis, Mowry, Frontier, and Wall Creek Formations, Measured in Secs. 18 and 19, T. 22 N., R. 77 W.

	Feet
Carlile shale	
Wall Creek sandstone	
Brown above and white below medium- to coarse-grained cross-bedded and platy fossiliferous salt-and-pepper sandstone containing: *Scaphites warreni, Inoceramus fragilis, Prionocyclus wyomingensis, Ostrea* sp., and numerous shark teeth associated with rounded black chert pebbles	27
Frontier formation	
Black fissile to platy sandy shale	60
Dark gray and black fissile to platy shale with septarian concretions about 100 feet from bottom. Shale becomes lighter in color and more sandy near top	643
Total	703
Mowry shale	
Black to brown platy siliceous fossiliferous shale which weathers to silver-gray color and contains fossil fish scales; thin bentonite seams	131
Thermopolis shale	
Dark gray to black platy non-resistant shale with 6-inch bed in middle of gray platy well cemented resistant sandstone containing marks resembling worm trails. A few scattered ironstone concretions	80

Stratigraphic Section of Dakota Formation, Measured in Sec. 18, T. 22 N., R. 77 W.

	Feet
Thermopolis shale	
Dakota group	
Brown fine-grained blocky well cemented resistant quartzitic sandstone forming dip-slope and minor hogback	3
Black shale with gray-green weathered sandy limestone 6 inches thick containing marks resembling worm borings	18

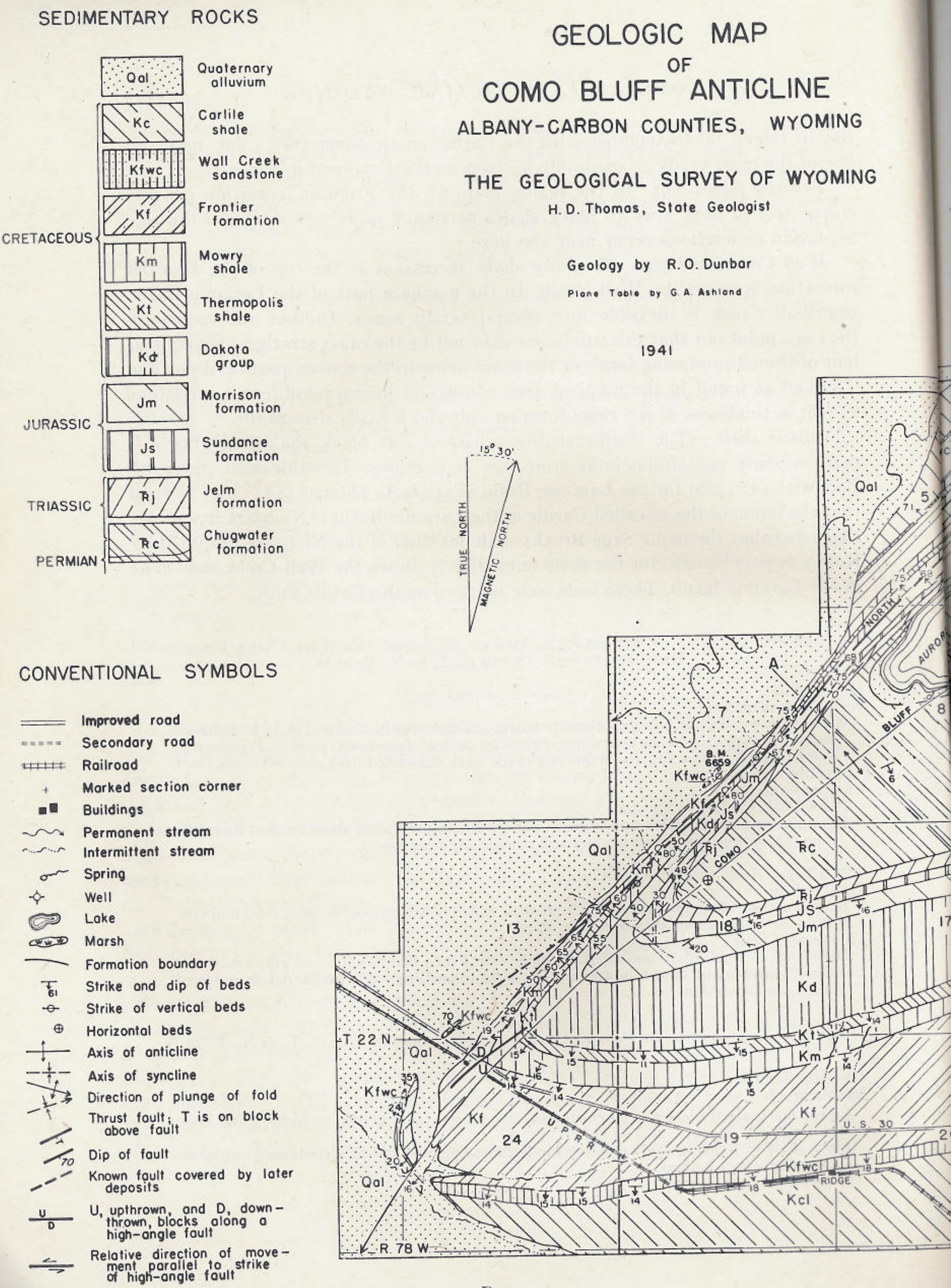
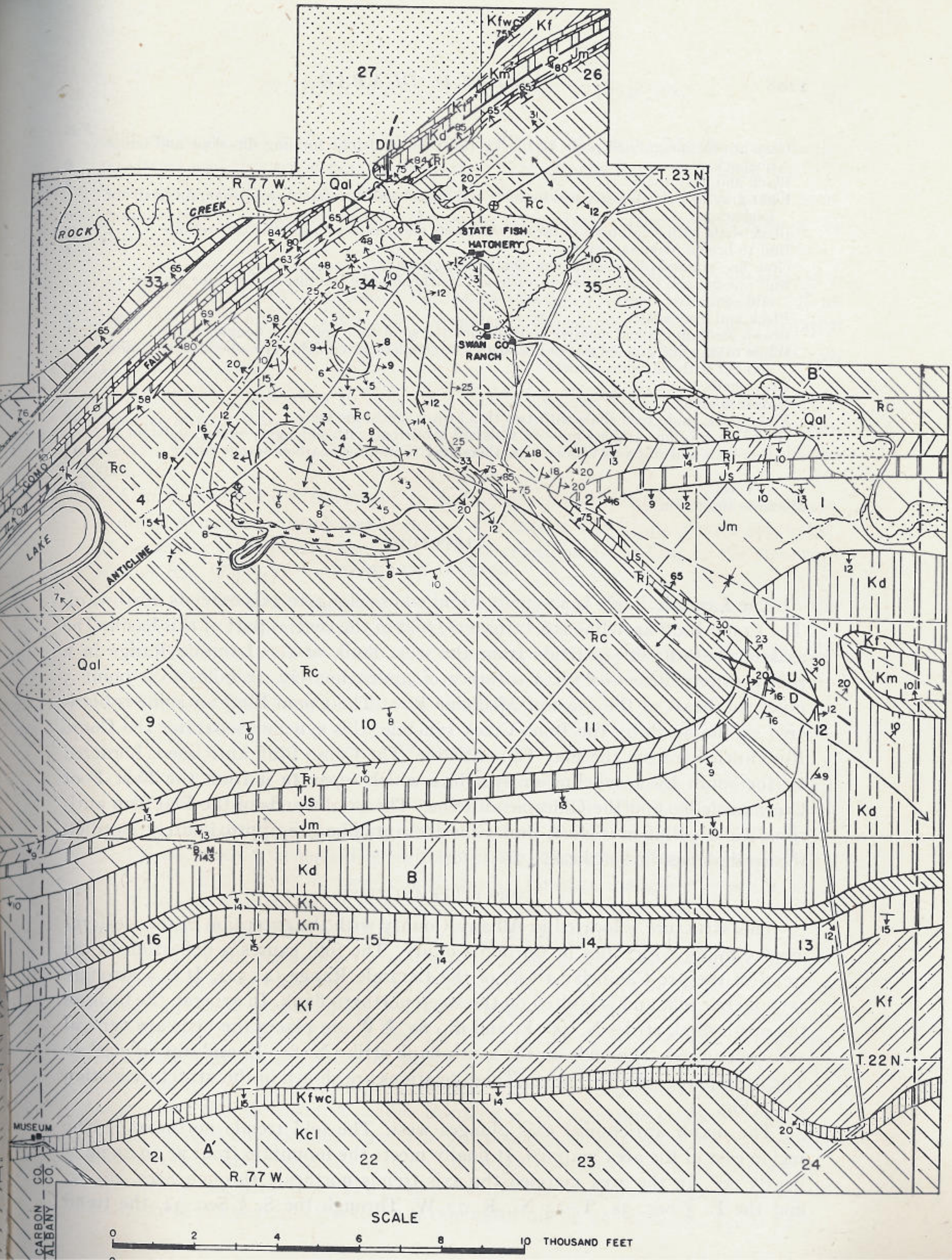

GEOLOGIC MAP
OF
COMO BLUFF ANTICLINE
ALBANY-CARBON COUNTIES, WYOMING
THE GEOLOGICAL SURVEY OF WYOMING
H. D. Thomas, State Geologist
Geology by R. O. Dunbar
Plane Table by G. A. Ashland
1941
SEDIMENTARY ROCKS
Qal Quaternary alluvium
Kc Carlile shale
Kfwc Wall Creek sandstone
Kf Frontier formation
Km Mowry shale
Kt Thermopolis shale
Kd Dakota group
Jm Morrison formation
Js Sundance formation
Rj Jelm formation
Rc Chugwater formation
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CONVENTIONAL SYMBOLS
Improved road
Secondary road
Railroad
Marked section corner
Buildings
Permanent stream
Intermittent stream
Spring
Well
Lake
Marsh
Formation boundary
Strike and dip of beds
Strike of vertical beds
Horizontal beds
Axis of anticline
Axis of syncline
Direction of plunge of fold
Thrust fault; T is on block above fault
Dip of fault
Known fault covered by later deposits
U, upthrown, and D, downthrown, blocks along a high-angle fault
Relative direction of movement parallel to strike of high-angle fault
15° 30'
TRUE NORTH
MAGNETIC NORTH
NORTH
BLUFF
COMO
B. M. 6659
U. P. R. R.
U. S. 30
RIDGE
T. 22 N.
R. 78 W.

FIG. 2


R. 77 W.
T. 23 N.
T. 22 N.
ROCK CREEK
COMO FAULT
LAKE
ANTICLINE
STATE FISH HATCHERY
SWAN CO. RANCH
MUSEUM
B.M. 7143
CARBON CO.
ALBANY CO.
Qal
TRc
TRj
Js
Jm
Kd
Kt
Km
Kf
Kfwc
Kcl
D
U
A'
B
B'
27
26
33
34
35
4
3
2
1
9
10
11
12
16
15
14
13
21
22
23
24
SCALE
0
2
4
6
8
10 THOUSAND FEET

	Feet
Gray-brown fine-grained platy to blocky resistant sandstone forming dip-slope and minor hogback	6
Black and gray shale	4
Light gray to white fine-grained massive and cross-bedded resistant sandstone; forms minor hogback	6
Black shale with small beds of brown sandstone and bands of ironstone concretions	45
Buff to brown platy sandstone	4
Gray fine-grained platy sandstone weathering brown	2
Buff fine-grained platy sandstone with odd conchoidal-like fracture and surface marked by odd concentric rings	15
Black and gray shale	4
Brown medium-grained massive resistant jointed sandstone and some conglomerate	18
White to gray fine-grained massive sandstone to conglomerate; highly cross-bedded, resistant, and cut with siliceous veinlets	49
Gray shale	8
Brown sandstone	3
Pink, black, and green shale with two thin brown sandstone beds	20
Brown to gray fine-grained massive resistant sandstone with some gray platy sandstone in thin beds and siliceous veinlets; weathers gray to mottled maroon-orange color	14
Total	219

Morrison formation

STRUCTURE

GENERAL RELATIONS

The Laramie Basin is a synclinorium whose elongate axis extends northward. The Como Bluff anticline is a transverse fold in the central part of this basin. The axis of the anticline extends from the west flank of the Laramie Range in a southwesterly direction for a distance of approximately 25 miles to a point 5 miles southeast of the town of Medicine Bow. The Como Bluff anticline is bordered on the north by the Bone Creek syncline; this syncline separates the Como Bluff anticline from the Flat Top anticline. The Como Bluff anticline is bordered on the south by a syncline or synclines which separate it from the East Foot Creek anticline and the Gillespie anticline. The axial trends of the Flat Top anticline, Como Bluff anticline, and Gillespie anticline are approximately parallel; the axial planes dip southeast.

COMO BLUFF ANTICLINE

This structure is located in Albany County with the exception of the westernmost 5 miles, which lies in Carbon County. The fold causes a deflection in the trend of the pre-Cambrian rocks of the Laramie Range (4: 52). It is a strongly asymmetric fold and is faulted on the steep northern flank. In general, the beds on the north flank strike N. 45° E. and dip 80° NW.; in places the beds are vertical and overturned. The beds on the south flank strike N. 80° E. and dip 10°–20° S. The axial plane dips 70°–75° S. These relations are shown in the structure section *AA′* (Fig. 3).

The major anticlinical axis plunges west. The fold trends northeast in the region east of the area mapped. It finally meets the mountain front at an angle of nearly 90°. In the area mapped the axis trends northeast through Secs. 26, 35, and the E. ½ Sec. 34, T. 23 N., R. 77 W. Through the S. ½ Sec. 34, the trend changes to N. 25° E. In the NW. ¼ Sec. 3, T. 22 N., R. 77 W., the trend is also northeast and this trend persists southwest through the nose of the anticline. The fold dies out in Sec. 24, T. 22 N., R. 78 W. The curvature of the Wall Creek sandstone in the W. ½ Sec. 24, clearly shows the structural relations of the nose of the anticline.

The Chugwater formation is exposed in the core of the anticline. On the south flank these beds near the top of the formation dip 6°–8° S. On the north flank these beds dip 65° N. Four thin Chugwater limestones reveal a heart-shaped dome along the axis of the anticline in Secs. 3 and 4, T. 22 N., and in Sec. 34, T. 23 N., R. 77 W.

Along the south flank in Sec. 12, T. 22 N., R. 77 W., the strike of the beds changes abruptly from N. 80° E. to N. 45° W. In Sec. 2, the strike changes from N. 45° W. to N. 80° E. The abrupt change of strike gives rise to an S-shaped structure.

A minor anticline is developed in Sec. 3, the axis of which trends southeast. A minor syncline is developed in Sec. 2, the axis of which also trends southeast. These minor folds plunge southeast. These relations are shown in the structure section *BB′* (Fig. 4).

The prominent Como Ridge on the south flank of the anticline is due to the resistant Dakota sandstones rising on a gentle dip of 10°–14°.

The S-shaped structure and the dome-shaped rise of the beds probably are the results of differences of strength or structural relationships within the pre-Cambrian basement complex at the time of folding.

NORTH COMO FAULT

The North Como fault is the name employed to designate the thrust fault along the steep north flank of the Como Bluff anticline. The fault extends southwesterly from the pre-Cambrian of the Laramie Range in T. 24 N., R. 73 W. (7: Pl. xi), with a remarkably uniform strike, through the area mapped into Sec. 13, T. 22 N., R. 78 W., where it disappears beneath the alluvium of the Rock Creek valley. The thrust plane dips 70° S. This observation was taken along a gully 20 feet deep in the NE. ¼ Sec. 7, T. 22 N., R. 77 W.

The following discussion traces the fault from its west end, northeast toward the Laramie Range. In the east part of Sec. 13, T. 22 N., R. 78 W., the fault traverses the lower part of the Frontier. Farther west the fault is covered with alluvium. In the SW. ¼, NW. ¼ Sec. 18, T. 22 N., R. 77 W., the fault cuts across the Mowry and the Thermopolis. In the S. ½ Sec. 7, the Mowry wedges out and the Dakota is thrust upon Frontier. In the E. ¼ Sec. 7, the fault is parallel with the strike of the Morrison. A sudden thinning of the Morrison clays was observed at this point. A conspicuous transverse gully has developed along the trace of the fault where it cuts across the Dakota. Through the rest of the area mapped the fault lies in the Morrison. The geologic map (Fig. 2) shows a minor change of the strike of the beds and the strike of the fault from N. 45° E. in Sec. 33, T. 23 N.,

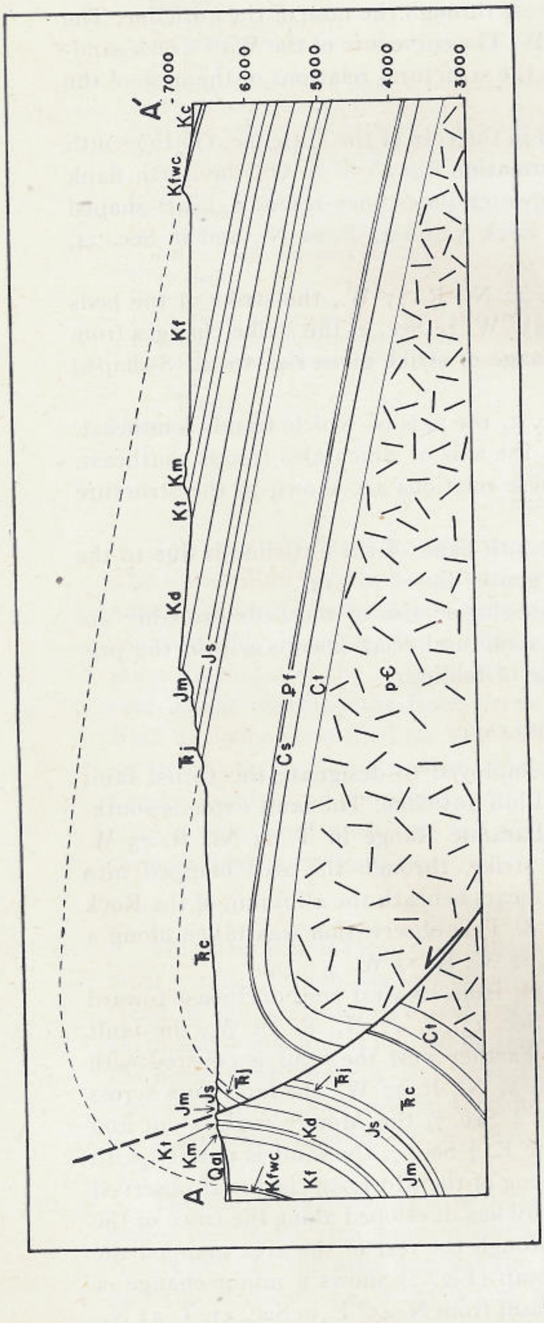

A
A′
7000
6000
5000
4000
3000
Kc
Kfwc
Kf
Km
Kd
Jm
Js
TRj
TRc
Cs
Pf
Ct
p€
Qal

FIG. 3

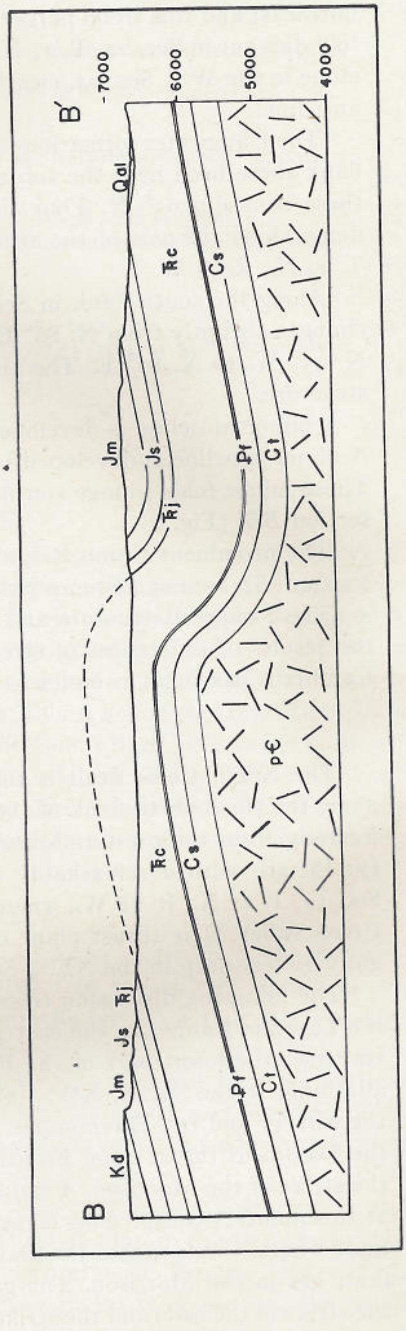

B
B′
7000
6000
5000
4000
Qal
TRc
Cs
Jm
Js
TRj
Pf
Ct
p€
Kd

FIG. 4

R. 77 W., to N. 55° E. in Sec. 34. The North Como fault east of the mapped area has been described by Giddings (7).

The general thinning of the Morrison as it is traced northeastward along the strike, and the minor distortions in the Dakota rocks adjacent to the Morrison, are evidence of the presence of the fault. It is to be expected that the fault would follow a zone of weakness, such as the poorly consolidated Morrison clays.

The south block is the apparently upthrown block. It is believed that the greatest amount of displacement occurs in the pre-Cambrian and decreases upward through the sediments. From measurements taken along the projected fault plane shown in the structure section *AA′* (Fig. 3), the displacement along the fault plane of the pre-Cambrian-sedimentary contact is 500 feet. Measurements of that part of the structure section drawn above the ground indicate a displacement of the Wall Creek-Frontier contact of approximately 100 feet. In the drawing of these structure sections, the beds were drawn as concentric. No attempt was made to employ variation in the crestal and flank thicknesses.

MINOR FAULTS

In the S. $\frac{1}{2}$ Sec. 27, T. 23 N., R. 77 W., a fault extends northward from the North Como fault. This nearly vertical fault strikes due north and makes a 45°-angle with the northeast strike of the major thrust. North beyond the Dakota hogback the fault is obscured by alluvium. The fault is visible where it offsets the tan and black beds of the Dakota in the south face of the hogback. This fault is probably a vertical tear fault. The major component of the net-slip is strike-slip. There is little evidence of dip-slip movement. The horizontal displacement is about 50 feet.

In the N. $\frac{1}{2}$ Sec. 24, T. 22 N., R. 78 W., on the nose of the westward-plunging anticline, the resistant Mowry shale is highly distorted by a fault striking N. 50° E. There is about 200 feet of offset of the Mowry beds. The fault dies out at the east in the Thermopolis shale and at the west in the Frontier shale. This tension fault resulted from the sharp flexure of the beds at this point during the folding of the anticline.

A nearly vertical fault striking N. 50° W. occurs in the NW. $\frac{1}{4}$ Sec. 12, T. 22 N., R. 77 W. Here, the Sundance and the Jelm beds are offset about 100 feet. The fault dies out northwest in the Chugwater shales and southeast in the wide outcrop of the Dakota. This tension fault was the result of the sharp flexure of the beds at the time the S-shaped structure was formed.

ORIGIN OF COMO BLUFF ANTICLINE AND THRUST

The axial trend of the Laramie Range anticline is deflected in a broad arc extending from north to west. This westward deflection begins at a point nearly due east of the region under discussion, which therefore lies on the inner or concave side of the arc. This area was a zone of compression due to the crowding of the materials within the arc. Here compressional forces would operate in directions paralleling chords of the arc, or in this area, in a north-northwest direction Within the area of the arc the direction of least resistance or direction of maximum relief to the compressive stresses is upward.

The Como Bluff anticline trends northeast or normal to the direction of compression. A thrust in the pre-Cambrian dipping southeast is to be expected from an interpretation derived from the application of the strain-ellipsoid theory. Beckwith (2: 1475), discusses a similar thrust that probably was initiated in the pre-Cambrian and was propagated upward into the sediments. The sediments are gradually warped into a steep monocline in front of the edge of the growing fracture. As the fracture penetrated the monocline it was deflected upward by the stratification in the vertical beds, such as are found on the north flank of Como Bluff anticline. As analyzed by Beckwith, this produces a thrust which steepens as it cuts upward through the sediments toward the surface. It is believed that the thrust has a nearly uniform dip in the pre-Cambrian. This interpretation explains the high dip of the plane of the thrust at the present ground surface. Surfaceward propagation of such a pre-Cambrian thrust fault by continued horizontal compression would give rise to an anticlinal fold and thrust fault, such as the Como Bluff anticline and the North Como fault.

STRUCTURAL SUMMARY

The northeast-trending transverse folds extending across the east-central part of the Laramie Basin are asymmetric, with the steeper flanks of the anticlines on the north. These folds are in some places faulted by a southeastward-dipping thrust. Such folds were the results of a general northwest-southeast compression with the predominant direction of maximum relief upward. These movements are believed to have occurred intermittently through late Upper Cretaceous and Paleocene time.

ECONOMIC VALUES OF REGION

SALINE DEPOSITS

In Albany County there are numerous deposits of sodium sulphates and magnesium sulphates in the bottoms of small lake depressions. About 15 miles north of the town of Rock River, Wyoming, and 4 miles east of the area mapped, these deposits occupy the lower parts of undrained excavations in the Chugwater formation. These deposits range from 1 acre upward to 90 acres.

W. C. Knight (11: 259) stated that those deposits are commonly covered with water after heavy rains. Upon the evaporation of the water layers of solid salts remain which range from thin crusts to beds several feet in thickness. Knight ascertained that the salts were derived from decomposing Chugwater sandstones and were transported by water to the natural depressions. Ordinarily, there is a regular gradation from the sodium salts in the upper basins to the magnesium salts in lower basins. As explained by Knight, this is a natural method of differentiation. The magnesium salts having a greater solubility than the sodium salts are carried by high waters to the lower basins. Upon evaporation, the sodium salts are deposited in the upper basins and the magnesium salts in the lower basins.

In 1933, a detailed report on this subject was prepared for the Geological Survey of Wyoming by S. H. Knight (9). Among his samples collected for analysis were those from the largest lake, named Brooklyn or Pazeka Lake. The average figures obtained on the salt composition of this deposit were: 86 per cent epsomite and 5 per cent mirabilite. Because of this occurrence of nearly pure epsomite a large building has been erected on the edge of this lake to obtain and to purify Epsom salts for commercial use.

UNDERGROUND WATER

The succession and structure of the rocks in the Laramie Basin are favorable for the occurrence of large supplies of underground water. Most of the water-bearing sandstones are interbedded with relatively impervious shales, a condition favorable for underground storage.

Springs in the mapped area furnish an abundant supply of cold water of good quality. Because of this available source of water, a fish hatchery has been established in the narrow Rock Creek valley. This hatchery was founded by Tom Boylan, local pioneer, and is now owned and being developed by the State of Wyoming. Numerous springs were mapped adjacent to the hatchery in the NE. $\frac{1}{4}$ Sec. 34, T. 23 N., R. 77 W.

The domestic water supply for the town of Medicine Bow (Fig. 1), is furnished by two artesian wells in the NE. $\frac{1}{4}$ Sec. 4, T. 22 N., R. 77 W. The water is piped 9 miles and lifted into the town's elevated tank by the force of gravity. The two wells resulted from oil exploration wells drilled in 1920.

Immediately south and in the same section as the Medicine Bow wells are the Union Pacific springs. The roadbed of the railroad was formerly located near these springs. A large abandoned masonry reservoir lies down the slope from this supply. The entire flow draining from the reservoir and the overflow from the Medicine Bow wells drains into the lakes and swamps.

The domestic supply for the Swan Company ranch is furnished by springs mapped near the west section line of the SW. $\frac{1}{2}$ Sec. 35, T. 23 N., R. 77 W.

Several springs occur adjacent to the south shore of Aurora Lake which is located in the core of the anticline. Water from these springs drains into the lake.

In all of the foregoing locations, the water comes from the Chugwater red shales which are exposed on the surface and found in the core of the anticline. It is believed that the Tensleep sandstone is the chief source bed. About 15 miles east and at a higher elevation than this area the Tensleep formation has a wide outcrop and large catchment area where it is exposed in the core of the anticline. The thick sandstones of this formation are carried westward by their low dip toward the center of the Laramie Basin where they are covered by shales so that the contained water is under considerable hydrostatic head. It is probable that water wells drilled into the Tensleep sandstone in the vicinity of the mapped area would yield water. Some of these wells would probably flow. Springs with a smaller water supply may have the upper Chugwater sandstones as their source beds.

Small springs found in the SW. $\frac{1}{4}$ Sec. 17, T. 22 N., R. 77 W., flow from the Mowry shale where it is exposed along the south flank of the anticline. These springs are of little importance as the water is either evaporated or absorbed after flowing a short distance along intermittent stream gullies. The source bed is the upper Dakota sandstone.

GYPSUM DEPOSITS

Extensive deposits of gypsum are found in the N. $\frac{1}{2}$ Sec. 35 and in the S. $\frac{1}{2}$ Sec. 26, T. 23 N., R. 77 W. These deposits are found in the Chugwater shales and in places change the general appearance from the characteristic red to a white color. The dip of the beds ranges from 20° N. to 10° S. The axis of the Como Bluff anticline passes through these sections; consequently, the beds are nearly horizontal in much of the area. No estimate of the available tonnage was attempted.

OIL POSSIBILITIES

In Sec. 34, T. 23 N., and Secs. 3 and 4, T. 22 N., R. 77 W., is a small anticlinal structure. In order to map this structure, four limestones of the lower Chugwater formation were used. The first limestone resembles the Little Medicine tongue of the Dinwoody formation described by Thomas (16). This bed can be followed through the afore-listed sections. It appears on the map (Fig 2) as a heart-shaped structure. Three other recognizable limestone units of the Freezeout tongue are also present. The red shale of the Freezeout tongue, exposed inside of the innermost limestone mapped, is the oldest exposed bed in this area.

The potential oil-bearing beds are the Satanka shales (Embar group), or more probably, the Tensleep sandstones. In near-by proved structures both of these formations were found void of oil. These beds elsewhere in Wyoming produce a black crude of low gravity.

In 1920, this structure was tested by the drilling of two wells in the NE. $\frac{1}{4}$ Sec. 4. Figure 2 shows that these locations are not on the center of the structure but on the west flank. Two artesian water wells flow from the Tensleep and now furnish the domestic supply for the town of Medicine Bow.

The low effective closure of about 60 feet and the large flow of fresh water from the Tensleep sands suggest that a well drilled on the crest of the dome would not encounter oil. As far as known to the writer the logs of the two test wells are unavailable.

BENTONITE

In this region bentonite deposits are found in the Mowry shale. The beds range in thickness from 5 feet to a few inches. It is not extensively excavated in this locality but some of the clay is prepared in the powdered form and sold as a beauty-aid. Local deposits in the past have been used as a drilling-mud in near-by oil fields. Details concerning the bentonite deposits in Wyoming are published in the Wyoming Geological Survey *Bulletin 28*.

BRIEF HISTORY OF EXPLORATION OF DINOSAUR REMAINS

The Jurassic Morrison beds at Como Bluff have yielded an important fauna of Mesozoic reptiles. Many of these Wyoming specimens are displayed in distant museums. During the Mesosoic, turtles, lizards, crocodiles, and primitive mammals existed along with dinosaurs and their remains are found in the same beds.

W. H. Reed is given credit for the discovery of these Wyoming dinosaur deposits in 1877, just south of the now abandoned railroad station of Como. The list of famous paleontologists who have spent much time and field work at Como Bluff includes: O. C. Marsh, Henry Fairfield Osborn, Richard S. Lull, Frederic B. Loomis, Barnum Brown, and Reed.

A highly fossiliferous bed is found about 80 feet below the Dakota near the middle of the Morrison. It is a clay bed beneath a 4-foot band of sandstone. Simpson (16: 1), states that every order of non-marine vertebrate known to have been in existence during Upper Jurassic time, and smaller forms of other classes, are represented in the collection from one quarry at Como Bluff.

A small museum has been founded at Como Bluff, Wyoming, by Tom Boylan. The museum building, on U. S. Highway 30, is built entirely of fragments of fossilized dinosaur bones. Boylan has lived in this region for nearly 50 years and, as a youth, helped in the excavation work.

A complete and detailed discussion of the Wyoming dinosaurs has been written by Moodie (13).

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