



Class 378.788B Author B962a

University of Colorado  
Library

REFERENCE BOOK

*Gift of Author*

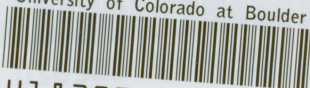
Accession No. 70610

FORM 288, 4-13-2M



EARTH SCIENCES LIBRARY

University of Colorado at Boulder



U18302 2202945

PERMIAN OR "PERMO-CARBONIFEROUS"  
OF THE EASTERN FOOTHILLS  
OF THE ROCKY MOUNTAINS IN COLORADO

by

ROY MORRILL BUTTERS

THESIS FOR  
DEGREE OF MASTER OF ARTS

UNIVERSITY OF COLORADO

1912

COLORADO GEOLOGICAL SURVEY  
BOULDER  
R. D. GEORGE, State Geologist

BULLETIN 5—Part 2

PERMIAN OR  
“PERMO-CARBONIFEROUS”

OF THE

EASTERN FOOTHILLS

OF THE

ROCKY MOUNTAINS *IN* COLORADO

BY

R. M. BUTTERS

70610  
 378.788B  
 B982a

# CONTENTS

	Page
Introduction .....	65
Acknowledgments .....	65
Geography .....	66
Formation names .....	66
Stratigraphic relations .....	68
Local Sections .....	71
Fountain and Ingleside at North Table Mountain.....	71
Lykins and Sundance at Heygood Canyon.....	73
Lykins at Box Elder Canyon and South Table Mountain.....	74
Owl Canyon .....	74
Ingleside at Owl Canyon .....	75
Bellvue, North of Cache la Poudre River.....	76
Bellvue, South of Cache la Poudre River.....	76
Stout .....	77
Masonville .....	78
Arkins .....	78
Cottonwood Creek .....	78
Carter Lake .....	79
Town of Lyons.....	79
Lefthand Creek .....	80
Bear Canyon (near Boulder).....	80
Ralston Creek .....	80
Morrison .....	81
Turkey Creek .....	81
Deer Creek .....	81
Indian Creek .....	81
Perry Park .....	81
Colorado Springs between Fountain Creek and Bear Creek.....	82
Between the Arkansas River and the New Mexico line.....	82
Red Canyon North of Badito.....	82
Six Miles Northwest of Badito.....	83
Age and Correlation of the Lykins.....	83
Age .....	83
Correlations .....	85
Bibliography .....	92

## INTRODUCTION

Lykins is the name given by Fenneman, in his bulletin on the geology of the Boulder district, to the upper portion of the "Red Beds" in the Front Range of eastern Colorado. The age of this formation has never been settled. It has been assigned to various ages from the Upper Carboniferous to the Triassic, but is commonly spoken of as Triassic. This is due primarily to the almost total lack of fossil evidence. Up to the summer of 1910 there had been no well-authenticated report of fossils from this formation along the entire range.

In the summer of 1910 the Colorado Geological Survey sent out the writer and Mr. David L. Curtis to examine the formation with special reference to the determination of its age. The last direction from the state geologist was: "Bring back fossils from the Lykins formation." During the summer and fall we followed, with considerable care, the foothills from the Wyoming line down to the New Mexico line, keeping as close to the outcrop of the Lykins as possible. In this work it was found necessary to study, to a greater or less extent, the underlying Lyons, Fountain and other Upper Carboniferous formations, and the overlying Morrison or Jurassic formations. That is, we had to keep in touch with practically all the sedimentary formations from the pre-Cambrian to the Cretaceous. The topographic sheets of the United States Geological Survey were used for the geographical work.

## ACKNOWLEDGMENTS

In this work the writer is greatly indebted to Mr. David L. Curtis for his able assistance in the field-work. Professor Junius Henderson furnished us his notes on field-work in the northern part of the state. These were very useful and saved us much time. He also gave valuable assistance in the determination of the fossils. The Lykins fossils were turned over to Dr. G. H. Girty for final determination. Professor R. D. George made the work possible and assisted very much with advice, information and in proof-reading. Notes from his lectures on the geology

of Colorado were used in the correlation. In this correlation the writer has looked up all the literature he could find on the subject, and the bibliography will be found at the end of this paper.

### GEOGRAPHY

The general trend of the outcrop studied is very nearly north and south. A strip of country from ten to twenty miles wide, extending from the 105th meridian westward, would include practically all of the outcrops of the upturned sedimentary formations from the pre-Cambrian to the Montana. From Pikes Peak south they are found somewhat farther west. In general, the Carboniferous outcrops form the eastern flank of the foothills; however, in places, several ridges of low hills of more recent sediments parallel the outcrops of the older formations.

### FORMATION NAMES

The Lykins formation is a part of that which the Hayden and later geologists have called the "Red Beds" of the Rocky Mountain region. Emmons, in the Denver Basin Monograph, divides the "Red Beds" into Lower and Upper Wyoming. Cross, in the Pikes Peak Folio, has called them the Fountain formation. Fenneman<sup>1</sup> divides the Lower Wyoming of Emmons into the Fountain and Lyons. The Upper Wyoming he calls the Lykins. Fenneman's names will be used in this paper, as far as possible. Fenneman correlates his Fountain with the lower part of the Fountain of Cross in the Pikes Peak area. The Fountain of Fenneman is lithologically and stratigraphically identical with the typical Fountain at Fountain Creek; the red shales and the "crinkled sandstone" are lithologically the same as the Lykins at Boulder; and there can be very little doubt that they are the same formations, even though the continuity cannot be established so completely as can that of the Fountain. The strata corresponding to the Lyons were recognized at this point also, but the formation is not nearly so distinctive as it is at Boulder. In the Walsenburg Folio (22) Hills gives the name Badito formation to the "Red Beds." Hills discusses the "Red Beds" of the Sangre de Cristo Mountains west of Trinidad as the

<sup>1</sup> Geology of the Boulder District: U. S. Geol. Survey, Bull. 265.

Sangre de Cristo formation. A portion of the "Red Beds" in the southern part of the state has been named the Arkansas sandstone.

Darton has given the name Sundance to a buff-to-yellow sandstone series which occurs between the red shale series and the Morrison formation in the Sherman quadrangle and elsewhere in Wyoming. He records from the Sundance *Belemnites densus*, *Gryphaea calceola* and *Pentacrinus asteriscus*, "of late Jurassic age." In the summer of 1912 I followed this formation from Darton's Horse Creek locality, in Wyoming, southward into Colorado. The formation is not exposed continuously, but there is very little doubt that it extends into Colorado as far south as the Cache la Poudre River. South of this river there are one or two places where it may be exposed, but there are no fossils, and a safe correlation cannot be made on lithological grounds; so, south of the river no Sundance is mapped. Darton<sup>1</sup> says that the "Sundance formation extends only a few miles into Colorado from the northward, finally thinning out." Hayden<sup>2</sup> reports the finding of *Ostrea* and *Pentacrinus asteriscus* on Box Elder Creek, in "thin layers of fine-grained, grayish, calcareous sandstone," near the base of a series of strata consisting of "ashen-brown nodular or indurated clay, with deep, dull-purple bands, with some layers of brown and yellow fine-grained sandstone, undoubtedly the usual Jurassic beds with all the lithological characters as seen near Lake Como, on the Union Pacific Railroad—150 to 200 feet." Marvine and Darton both quote Hayden's report without any further information. No one since appears to have been able to locate that fossil horizon.

Fenneman's Lyons (16) is the Creamy sandstone of Emmons (15). The Lyons is in part equivalent to Darton's Tensleep sandstone (9), but the formation I have called "Ingleside" is more nearly the equivalent of the Tensleep. Darton's Chugwater (9) is equivalent to the Lykins. The Sundance has been traced from Wyoming southward practically to the Cache la Poudre. In this paper the names Fountain, Ingleside, Lyons, Lykins and Sundance will be used for the equivalent subdivisions of the "Red Beds," wherever they have been found in the area studied. In southern Colorado it is not easy to subdivide the "Red Beds" on lithological or structural grounds, and sufficient paleontological evidence is

<sup>1</sup> U. S. Geol. Survey, Prof. Paper No. 32, p.96.

<sup>2</sup> Third Annual Report, 1869, p. 119.

not at hand; so that subdivision has not been attempted in this paper.

I have hesitated to burden the literature of the "Red Beds" with a new name; but, in order to make myself clearly understood, and to avoid confusion by the use of the term Lyons in too broad a sense, it has been thought advisable by Dr. Girty, Professor Henderson and others. I have, therefore, given the name Ingleside to a sandstone-limestone series extending geographically from beyond the state line to the north, to a point a little north of Lyons. It is typically developed at the Ingleside quarries and also at Owl Canyon. (See section at Owl Canyon.) These places are a few miles north of La Porte on the Fort Collins-Livermore stage-road. This formation lies apparently conformably upon the Fountain, and consists of an alternating series of limestones and fine-grained sandstones, varying from 100 to 125 feet in thickness—possibly a little more at the state line. These sandstones and limestones vary in color from gray to almost white, through pink to almost red. This formation is quite different from the Lyons as described by Fenneman, especially in the fact that it contains the limestone bands, some of them very pure. It is also in a different and lower horizon than the Lyons. It is possible that the Ingleside should be regarded as merely a lithological unit in the Fountain, showing a change in conditions of sedimentation, transitional to Lykins conditions.

### STRATIGRAPHIC RELATIONS

The Fountain formation, as a rule, lies unconformably upon the pre-Cambrian rocks, but in a few places it lies upon pre-Pennsylvanian rocks. These range in age from Cambrian to Mississippian. In no place was it possible to detect angular unconformity, from the base of the Fountain to the top of the Lyons or Ingleside. The fact that the Ingleside plays out just north of Lyons, and that from this point southward there is a marked and decided change from the coarser Fountain sediments to the finer Lyons, would suggest a possible unconformity, although the angular difference is so slight, if present at all, as to defy detection thus far. But this decided change from Lyons southward, coupled with the fact that northward from Lyons there is no such abrupt change, and that the contact is hard to place, as though sedimentation had been continuous, has for a long time given rise to the belief that southward from Lyons we

have a slight unconformity, as though the sea withdrew from this portion of the area for a short time. The Fountain material is such that erosion would not be shown unless it were quite marked. However, if there is an unconformity here, it is probably small and of merely local importance.

In most places the contact between the Fountain and the Lyons, and in many between the Lyons and Lykins, is clean-cut and distinct; but in other places it is quite indistinct, and its position is more or less arbitrarily chosen. Field observations have shown that the subdivisions of the "Red Beds," as made in some places, are not the exact equivalent of these divisions as made in others.

At the Wyoming line the Fountain is immediately overlain by the Ingleside formation—a series of about 100 feet of hard, fine-grained sandstones and limestones of a light-pink color. These strata maintain their thickness and lithological character to a point a short distance north of the Cache la Poudre River. From this point south the limestone becomes less and less important, and the sandstone proportionately more important; but the series as a whole gradually decreases in thickness, and finally disappears a short distance north of Lyons. Immediately overlying this series, at the state line, is a thick shale and shaly sandstone series of dark brick-red color. As the basal portion of this series is traced southward, it becomes more and more arenaceous, and lighter in color, and numerous thin bands of sandstone appear. Of these sandstone bands the most prominent is one that appears at the south end of North Table Mountain, north of Owl Canyon, where it consists of from 15 to 20 feet of light-colored, rather hard, crossbedded sandstone, separated from the Ingleside formation by from 60 to 80 feet of red shale and shaly sandstone. At Owl Canyon it decreases to from 6 to 10 feet. From this point southward this band increases in thickness and approaches somewhat closer to the Ingleside formation. Just north of Lyons the crossbedded sandstone is about 50 feet thick, and as the quarries are practically all in the upper part of the ridge, this crossbedded band furnishes the bulk of the rock quarried. From Owl Canyon southward other sandstone bands appear in the shales between the Ingleside formation and the crossbedded sandstone just described. Toward the south these bands increase in importance, and just north of Lyons they occupy practically the entire space between the crossbedded

sandstone above and the hard rock in contact with the Fountain—that is, what is left of the Ingleside formation. To the south of Lyons these sandstones and the crossbedded sandstone are lithologically alike, and together constitute the Lyons, as that formation is known south of Boulder, and no strata corresponding to the Ingleside are to be found. At the Wyoming line all the strata between the Ingleside formation and the Sundance are lithologically and stratigraphically a unit, and must therefore be included in the Lykins. Since the sandstone bands which unite to form the entire body of the Lyons, at the town of Lyons, first appear within these Lykins strata, entirely above the Ingleside formation, and since the Ingleside wedges out at a short distance north of Lyons, it is evident that the Lyons formation is but a hard sandstone series developed in the basal part of the Lykins. It would therefore seem desirable to regard the Lyons as a lithological, rather than a stratigraphical, unit. Otherwise the Lyons must be regarded as merging laterally into the Lykins north of the town of Lyons.

Overlying the Lykins formation between the Wyoming line and the Cache la Poudre River is a series of massive sandstones from 100 to 150 feet thick, the lower two-thirds of which is pink, grading to yellow, and the upper one-third yellow to creamy white. There is an abrupt and very pronounced lithological break between the soft, brick-red Lykins shales and shaly sandstones, and this overlying massive, harder, pink sandstone, but no discovered unconformity, either angular or erosional. This abrupt change in sedimentation conditions is wide-spread. No unconformity has been noted between the pink, massive sandstone and the yellow sandstone, though there are a lithological change, a difference in color and a difference in cross-bedding, indicating a change in sedimentation conditions. We have no fossils from the pink sandstone and no identifiable specimens from the yellow. The yellow portion—upper one-third—is undoubtedly equivalent to Darton's Sundance; and the pink lower two-thirds may be also, or may be transitional between Lykins and Sundance. I have confined the Sundance in Colorado to the yellow upper third, which forms a series of from 25 to 40 feet of yellow and white sandstone at the northern Colorado line. This gets thinner and thinner southward toward the Cache la Poudre, beyond which it is not found. Hence no Sundance is mapped south of that river. If the pink sandstone is regarded

as Sundance, it would have to be carried to about the Big Thompson River, west of Loveland.<sup>1</sup>

Overlying the Sundance where present, and the Lykins where the Sundance is absent, is a series of strata containing a fresh-water fauna, principally *Unios* and fresh-water algæ, and these are considered of Jurassic age, the equivalent of the Morrison at Morrison. There is an unconformity between the Lykins and the Morrison, but it is slight and very difficult to detect, due to the character of the beds and the slight difference in dip between the strata of the two formations. In fact, in northern Larimer County the exact contact of Lykins, Sundance and Morrison is hard to place. The basal Morrison varies from sandstone in some places to shale, and possibly limestone, in others. There is a marked change in color from the red or brown of the Lykins to the yellowish white or ash-gray of the Morrison. In places in northern Larimer County the Lykins gradually gets lighter in color, and there is almost a transition from the red Lykins to the gray Morrison.

Within the "Red Beds" there are conditions which suggest interrupted deposition, such as the change in character and color of the sediments, and the presence of beds of gypsum; but there is no angular unconformity, unless it is the small one noted at the top of the Fountain formation, from about the town of Lyons southward. North of Lyons there was probably continuous deposition, or nearly so, to the end of the Lykins period.

### LOCAL SECTIONS

*Fountain and Ingleside at North Table Mountain, Larimer County, Colorado.*—At the Wyoming line there is, at the base of the Fountain, a shale horizon containing chert boulders in which occur fossils of Mississippian age, identical with those of the

<sup>1</sup>EDITOR'S NOTE.—Professor Henderson furnishes the following note upon this subject:

"The slight thickness of the strata between Butters' Lykins fossils, which are considered late Carboniferous or Permian, and the Morrison, which is late Jurassic or possibly Cretaceous, points emphatically to the probability of a non-deposition or erosion period or periods during Permian, Triassic and early Jurassic time. The most likely place for such a break appears to be just at the top of the soft, brick-red Lykins material. My impression in the field was that the massive, pink sandstone above this break is much more nearly related to the yellow sandstone above, which Mr. Butters correlates with the Sundance, than to the underlying brick-red strata. Probably the upper limit of the Lykins should be placed at the top of the brick-red series, and the pink sandstone either placed in the Sundance, or, which is quite as likely, considered a distinct formation. As both these massive sandstones, the pink and the yellow, thin out and finally disappear in coming southward from Wyoming, and the upper Lykins, as developed farther south, seems to belong with the strata in which a late Paleozoic fauna has been found, it is extremely likely that at least from the Big Thompson southward there is a marked, though not easily discovered, unconformity, representing Triassic and early Jurassic time."

Millsap of Perry Park. These chert boulders seem not to have been formed in place, as they are somewhat rounded themselves, and are associated with smaller quartz pebbles, also somewhat rounded, and feldspar but little altered. Also, the chert boulders contain no foreign material, as they undoubtedly would if formed where they are now found. If not formed in place, the question immediately arises, Where were they formed? A study of the Millsap at Perry Park shows a soft, shaly formation, with a hard band or bands of chert. On slight exposure to the elements, the soft shale would be easily eroded, without leaving any evidence of its presence; but the chert boulders would remain practically unaltered. Had there been such a formation at the Wyoming line before the Fountain was laid down, and it had been exposed to erosion, as would not be impossible when we remember that the basal Fountain is a very shallow water deposit, the chert boulders would have been left as boulders along the shore. The location of the chert boulders is such as to suggest that they were deposited in the low places of the slightly undulating sea-floor, probably by the action of the tides, waves and shore currents. The red iron cement may have been derived from the granites direct, or from the shale of the older formations, or both.

These chert boulders in the base of the Fountain seem to be more prominent near the Wyoming line, but in many places the actual contact with the granite is not exposed. Possibly, if the granite contact could be found in other places, remnants of such a formation might be found. Farther north, in Wyoming, would probably be the better place to look for such remnants, as all the formations seem to be better developed northward than southward; but, unfortunately, for the first few miles north of the Colorado-Wyoming line the contact with the granite is not exposed any better than in Colorado.

This band is exposed in only a few places, and in these very poorly. It is probably less than 20 feet in thickness. Above this horizon the Fountain consists of a series of alternating bands of conglomerate, arkose, limestone, sandstone and shale, all more or less calcareous. There are several bands containing fossils of early Pennsylvanian age. Near the top of the ridge the arkose and conglomerate become less and less important, and limestones and sandstone cap the ridge. These limestones have been called "Lyons," and they are probably equivalent to the Tensleep of Darton (9). They are equivalent to the upper part of the Casper formation of Darton. I have called them the

Ingleside formation. —The contact between the Ingleside and the Fountain is hard to place, but it appears to be at the top of the last prominent band of arkose conglomerate, though there are bands of sandstone in the Fountain similar to those in the Ingleside. The fossils of the Ingleside are Pennsylvanian, and of practically the same species as those of the Fountain. The basal Ingleside is a light-colored sandstone, somewhat harder than the rest. Above the Ingleside occur the characteristic Lykins red shales and shaly sandstones. The dips in this region are from  $10^{\circ}$  to  $30^{\circ}$ , except where increased by local folding. At this point there is, if anywhere in the state, continuous deposition from the Fountain to the end of the Lykins period.

*Section of Lykins and Sundance at Heygood Canyon (Sand Creek).*—At the contact with the Lykins the Ingleside is a creamy sandstone, with but little calcium carbonate. The dip is  $9^{\circ}$  southeast.

<i>Sundance:</i>	Feet
Sandstone—yellow, thick-bedded, soft, to basal Morrison	25
 <i>Lykins:</i>	
Sandstone—light pink, possibly, Sundance.....	100
Sandstone—thin-bedded; would make fair flagstones...	15
Shale—soft, flaky and clayey sandstones, with one white, quite thin, limy band.....	240
Covered portion—partly thin, flaky, red shales.....	20
Shales and shaly sandstones—red, with a few bands of limestone 10 to 12 inches thick.....	90
Shales—mottled, red, with bands of white limestone from 2 to 6 feet.....	50
Shales—soft, red, sandy; almost a sandstone in places, with several white, limy bands up to one foot in thickness .....	40
Sandstone—light pink; intercalated with grayish, sandy limestone, 2 to 8 feet thick, with a band of impure red limestone, which grades into a shaly sandstone near the top; this weathers away, leaving the limestone capping the ridge; fossiliferous.....	16
Sandstone—red, massive, thick-bedded, quite soft; intercalated with bands of dark-red clay shale, 3 inches to 2 feet thick.....	135

*Lykins—Continued*

Feet

Sandstone—basal Lykins; a soft, pink, rather friable sandstone, intercalated with a dark-red shale and several bands of light-colored, strongly calcareous sandstone .....	85
Total .....	
	791

This is the most complete exposure of the Lykins to be found in Colorado, so far as I know. The fossils are few and scattering. *Bellerophon crassus* and *Myalina subquadrata* have been identified from the fossiliferous horizon about 200 feet from the base.

*Lykins at Box Elder Canyon and South Table Mountain.*—

The lower part of the Lykins here is about the same as it was in Heygood Canyon. The fossiliferous band is thinner, more sandy, contains more crystallized calcite, and the fossils are in poorer condition than they were in Heygood Canyon. The white, limy series which was found above the fossil horizon at Heygood Canyon is either missing or represented by a few thin, light-colored bands of sandstone and a thin bed of gypsum of limited area. There is another bed of gypsum at the same horizon outcropping, in the road north of Table Mountain, not over a mile distant from the mouth of Box Elder Canyon.

The fold on the north slope of Table Mountain exposes the fossiliferous band found in Heygood Canyon. Above this horizon there is a bed of gypsum, which outcrops in the wagon-road, and above the gypsum there is a limy series very similar to the limy series above the fossiliferous horizon at Heygood Canyon. This is probably the horizon of the "crinkled sandstone" at Boulder. The gypsum is in several bands, from 2 to 12 feet thick, separated by thin, red shales, the upper bands being about 12 feet thick. Above the gypsum there is a shaly limestone series, some bands of which are quite calcareous. About 25 feet above the top of the gypsum bed, in the limestone shales, fossils were found, a list of which is inserted on a later page. The upper portion of the Lykins is practically all covered, but the band of yellow Sundance sandstone is exposed in one area at an elevation of between 400 feet and 500 feet above the fossil horizon.

*Owl Canyon.*—

At this point it is very difficult to separate the Ingleside from the Fountain. A coarse sandstone, which grades into a fine, red sandstone, seems to mark the base of the Ingleside. Conformably below this, at the top of the Fountain, is

a brick-red sandstone, grading into a shale toward the top. Next below this is a band of arkose. Perhaps the top of the Fountain should have been placed at the top of this arkose, but the intervening sandstone is soft, while the band now regarded as the base of the Ingleside is very hard, almost a quartzite. No matter where the line is put, there will be lithologically similar bands both above and below it, as there is no abrupt change, but rather a gradual transition from the one formation to the other.

*Section of Ingleside Formation at Owl Canyon.—*

	Feet
Limestone—pinkish, white, to base of Lykins shale.....	15
Sandstone—soft, poorly cemented .....	12
Sandstone—pink, thin-bedded, somewhat limy.....	12—14
Limestone—mottled, pink and gray.....	4
Sandstone—limy, pink .....	10—12
Sandstone—soft, massive .....	12—14
Sandstone—gray, limy .....	2
Sandstone—soft, massive, red.....	12—14
Limestone—lighter-colored, sandy, thin-bedded.....	4
Sandstone—basal Ingleside formation; hard, thick-bedded, limy near the top .....	25—30

This upper band of limestone burns to a white lime, and is quarried at Ingleside by the Great Western Sugar Company for use in its factories in northern Colorado. Fossils of Pennsylvanian age were found about 4 feet from the base of this upper band. The dip varies from  $10^{\circ}$  to  $12^{\circ}$ , and is nearly due east.

On following southward, the upper four-foot band of limestone thickens rapidly to about 12 feet, and thins down again as rapidly to about 4 feet. This lens-like form is characteristic of the limestones. The sandstone bands retain about the same thickness. At Ingleside there are three bands of limestone, each from 10 to 14 feet thick. The lowest one is quite sandy, but the uppermost is said to be 99½ per cent pure calcium carbonate. Farther south the two lower bands have a tendency to become sandy, and sandstone layers become interbedded with them to such extent that the pure limestone is reduced to a thickness of about two feet. Just south of Ingleside the lower band wedges out entirely, but the other two, although getting much thinner, may be traced continuously to within a quarter of a mile of the Cache la Poudre River. At this point the ridge is low and makes an abrupt turn

to the west. From Ingleside southward the Lykins outcrops in a low ridge of very much crossbedded sandstone, which will be referred to in the following pages as the "Crossbedded sandstone." It looks very much like the Lyons of Boulder, and it is separated from the Ingleside by shales that are identical in character with those of the Lykins. On this ground, both the sandstone and the shales below have been included in the Lykins formation. Just north of the Poudre River the ridge turns west for about a quarter of a mile, and then turns again as abruptly and resumes its old course, a little east of south. In this bend the Ingleside shows practically no limestone, and the ridge it forms is no more prominent than that of the Crossbedded sandstone. Above the Crossbedded sandstone the Lykins is not well exposed, and only the red shales are visible; probably the upper red sandstone is absent at this point.

*Bellvue, North of the Cache la Poudre River.*—The Fountain formation is a series of alternating arkose, arkose conglomerates, and dark-red, clayey sandstones. The basal Ingleside is a hard, thick-bedded, creamy sandstone, with thinner beds near the top. It contains one band of sandy limestone, 6 feet to 8 feet thick. The uppermost member of the formation is a heavy-bedded sandstone. Between the Ingleside ridge and the Crossbedded sandstone ridge a valley has been cut in the Lykins red shale. The Crossbedded sandstone is 15 to 20 feet thick. Above this in one place, and separated from it by a few feet of shales, is a small bed of gypsum. Above this gypsum there are 3 to 4 feet of limestone. This sequence of beds suggests the section north of Table Mountain, but the strata at this point are non-fossiliferous. A few cherty concretions occur in one layer nearer the base.

*Bellvue, South of the Cache la Poudre River.*—The Ingleside is about the same as it was north of the river, but is perhaps somewhat darker in color and contains two narrow bands of white, sandy limestone. Above the Ingleside are the red shales and the Crossbedded sandstone of the Lykins. The latter forms a ridge fully as prominent as that of the Ingleside. Above the Crossbedded sandstone the red shales contain one limestone band. At this place most of the quarries are in the Ingleside, but there is one in the Crossbedded sandstone of the Lykins. Most of the rock is not well cemented and is too soft for a good building stone. It is also quite likely to be irregular in hardness.

South of Bellvue the Crossbedded sandstone approaches nearer and nearer to the Ingleside, the shales between become

more and more sandy, and in places true sandstone occurs in narrow bands, which resemble both the Ingleside below and the Crossbedded above. About ten miles south of Bellvue one of these sandstone bands becomes so prominent as to form a small ridge between the Ingleside and the Crossbedded sandstone. The upper portion of the Lykins is red shales and sandstone, and the uppermost band grades from red through pink to yellow and white. The upper yellow to white sandstone at this point may represent Sundance, but the correlation is uncertain, and the exposure so limited in thickness and extent that it is considered Lykins. Through this area there is usually no limestone, but due west of Fort Collins the Ingleside contains two lens-like bands of limestone. The Crossbedded sandstone at this point looks more like the Boulder Lyons than does the Ingleside. South of this point all the quarries are in the Crossbedded sandstone, as the Ingleside is in thin, irregular bands.

*Stout.*—The Fountain is a series of arkose, conglomerates, dark-red shales, and sandstones. The Ingleside is somewhat thinner and contains no limestone bands. The Crossbedded Lykins is closer to the Ingleside. North of Stout there is a series of calcareous strata in the Lykins, separated from the Crossbedded sandstone by from 30 to 40 feet of shales. These bands, which make a slight ridge, are in about the same horizon as the Crinkled sandstone of Boulder, and consist of about 50 to 60 feet of thin limestones, shales and sandstones. And in the basal member, which is an impure limestone, fossils are found. This series appears to be a local development, as it extends but a short distance north and south. Some of the bands of limestone in this series reach a thickness of 3 feet, but no fossils were found above the basal member. All the Ingleside stone is clayey, and chert occurs in one band.

The Crossbedded sandstone is about 50 feet thick, and all except the upper 10 or 12 feet is rather heavy-bedded, and cross-bedding is prominent throughout. Below the Crossbedded sandstone there are about 100 feet of alternating sandstones and shales, with sandstones predominating. At the base there is a very persistent band of red shale, which makes it possible to separate the Lykins from the Ingleside. In the Ingleside the two calcareous bands are still present, but they would be more suitably described as calcareous sandstones. Dr. G. H. Girty identified *Myalina wyomingensis* and *Myalina perattenuata* from the fossiliferous horizon in the fossil beds in the Lykins from Stout.

South of Stout the calcareous shales are present above the Crossbedded sandstone, but contain no fossils. A small bed of gypsum was noticed in one place. The limestone has been burned for lime, but must have made a poor lime on account of the high content of clayey material. This limy series is undoubtedly the Crinkled sandstone horizon of the Boulder quadrangle. The Ingleside and the Crossbedded sandstone of the Lykins may be traced continuously as distinct formations as far south as the Big Fold west of Loveland. In this Big Fold the Lykins contains good gypsum in a bed 25 to 30 feet thick.

*Masonville.*—At Masonville the Fountain is very similar to the Boulder Fountain, and consists of a series of arkose, conglomerates, micaceous sandstones, and shales. The Ingleside is less than 100 feet thick and consists of rather hard, thin, crossbedded, pink-to-red sandstone. It becomes more and more like the Lykins below the Crossbedded sandstone, which is here about 80 feet thick. The basal Lykins is the dark, brick-red shale which has been so persistent. At this point it is from 3 to 10 feet in thickness, and considerably harder than it was at Owl Canyon. This is probably due to the metamorphism caused by the folding. The Crossbedded sandstone is about 50 feet thick, forms a more prominent ridge than the Ingleside, and contains all the quarries. Above the Crossbedded sandstone the Lykins shales are not well exposed.

*Arkins.*—The quarries at Arkins are in a ridge of the Crossbedded Lykins, while that portion of the formation below the quarry ridge forms a slope into a shallow gulch. Just a little north of the Big Thompson River there are three low ridges. From west to east the first one is the Ingleside ridge, the third one is the Crossbedded sandstone ridge, while the one between is in the Lykins below the Crossbedded sandstone. Just north of the Estes Park stage-road occurs the first Crinkled sandstone which shows the characteristic crinkling. It is very calcareous, and contains a band of good limestone, from 2 to 8 feet thick. There are 30 feet of red shales separating it from the Crossbedded sandstone, which is cream-colored and from 30 to 40 feet thick. The Ingleside is about 60 feet thick and harder, better cemented and thicker than it has been, more nearly resembling the Boulder Lyons.

*Cottonwood Creek.*—The Fountain is about the same as at Masonville, and near the top there is a band of limestone. The Ingleside is about 60 feet thick, and is a thin, crossbedded, light-

pink sandstone. The material is so different from that of the Fountain that the point of contact is easy to determine. Above the Ingleside there are from 25 to 30 feet of alternating shales and sandstones, of the lower portion of the Lykins. The shales are mottled red and white, and there is a thin band of mottled shale just below the Crossbedded sandstone. The Crossbedded is from 30 to 40 feet thick. Above it the Lykins is covered.

*Carter Lake.*—A cross-section shows two ridges, one capped with the Crossbedded sandstone, the other by sandstone of the lower portion of the Lykins. The top of the Fountain is a heavy-bedded arkose, which is followed by about 12 feet of thin-bedded, pink, very much crossbedded sandstone. This is all that is left of the Ingleside, as above it there is the band of red shale which has been found so persistently at the base of the Lykins. Above this band is a series of sandstones, with a few thin shale bands near the base, some of the sandstone containing a little feldspar and mica. The Crossbedded sandstone is very hard and varies from creamy white to a yellowish brown on the weathered surface. This is undoubtedly the horizon that is quarried at Lyons. In no place are there quarries in a horizon as low as the Ingleside. Above the Crossbedded Lykins from 30 to 40 feet is the Crinkled sandstone, which is quite limy, one bed of from 2 to 3 feet being a good limestone. One noticeable thing about this section is the thinning-out of the Ingleside from 60 feet at Cottonwood Creek down to 12 feet here; but it was noticed in following down that the Ingleside rapidly gets thinner, while the lower Lykins holds its thickness and becomes relatively more important.

*Town of Lyons.*—The Fountain is thicker than at points farther north, with increased hardness, due probably to the movement and pressure of folding. Some bands of sandstone in the Fountain look very much like bands in the Ingleside. The top of the Fountain is a variegated red and white, fine-grained arkose, below which there is a band of limestone 1 to 1½ feet thick. This contains cavities filled with calcite crystals, which may possibly result from replacement of fossils. The lower portion of the Ingleside is a hard, thin-bedded, creamy sandstone. Following this is thin-bedded sandstone, which is being quarried for flagstone. It is practically impossible to separate the Ingleside, if present, from the Crossbedded sandstone and the lower portion of the Lykins below the Crossbedded, because of the change, due to pressure and movement of folding. Probably, if Ingleside is present here at all, it is represented by the

lower 6 to 8 feet, and the remainder is in the same horizon as the lower portion of the Lykins. The quarries here at Lyons are undoubtedly in the horizon of the Crossbedded Lykins, with perhaps one or two in that portion of the Lykins below the Crossbedded sandstone. From this point southward this whole series will be called the Lyons; that is, the Ingleside, if present, and the Crossbedded sandstone, taken together; thus following Fenner's nomenclature.

*Lefthand Creek.*—At this point there is a band of hard, red sandstone from 6 to 8 feet thick at the base of the Lyons, followed upward by from 8 to 12 feet of sandstone, which contains so much feldspar that it approaches a fine-grained arkose in character. Above this there are 60 to 70 feet of massive, creamy sandstone, having a pink tinge in places. Above this and below the Crinkled sandstone there is an intrusion of mica dacite into the shales. Possibly the two lower members which were put into the Lyons should have been placed in the Fountain, but at Lyons there are similar bands having the same rough, irregular manner of weathering and the same crossbedding, and there they belong to the base of the Lyons.

*Bear Canyon (Near Boulder).*—The Fountain is a thick and hard, high, jagged ridge, including the "Flatirons." In contact with the arkose of the Fountain are more than 100 feet of rather heavy-bedded, creamy sandstone. This represents all the sediments from the top of the Crossbedded Lykins to the top of the Fountain, and since it is impossible to make any subdivisions, it will all be regarded as Lyons. There are about 30 feet of soft, red shales above the Lyons, and then follow 12 to 15 feet of Crinkled sandstone. Above this the Lykins formation is covered with wash.

*Ralston Creek.*—The Fountain formation is very thick north of Ralston Creek, Ralston Peak being practically all Fountain, while south of the creek it is quite thin. The Fountain is considerably altered here and much resembles granite, and, were it not for large, rounded pebbles, particularly pebbles of white quartz, it might easily be mistaken for granite. The Lyons is quite thick, pink in color, and is capped with a band of thin, Crossbedded sandstone. It is hard to determine the contact between Fountain and Lyons, but probably it should be placed at the top of the last band of arkose. The Lykins is exposed in only a few small patches, and is recognized by the Crinkled sandstone horizon.

*Morrison.*—The Fountain, known locally as the “Old Red Rocks,” is at least 500 feet thick, and is characterized by a jagged ridge, in which occur several triangular blocks of strata, known as “Flatirons.” The Lyons is represented by about 200 feet of light, yellowish-gray, rather soft sandstone, of which the upper 20 to 30 feet show considerable crossbedding. Above this are 30 to 40 feet of soft, red Lykins shales; then 8 to 10 feet of rather limy, Crinkled sandstone, in places showing 2 feet of good limestone. No fossils were found, but there is much calcite in small cavities, which may be the remains of fossils. Above the Crinkled sandstone there are 150 to 200 feet of soft, red shales. The contact with the Morrison is not exposed.

*Turkey Creek.*—Turkey Creek is a few miles south of Morrison. The formations are about the same, but the Fountain and Lyons are thinner and do not make such a prominent ridge. The Lykins shales are a little thinner below the Crinkled sandstone, which occurs in two bands, separated by from 12 to 15 feet of red shale. The lower band is about 3 feet thick, and the upper 8 to 10 feet. There are less than 100 feet of Lykins shales to the base of the Morrison. Near the top of the Lykins there is locally a bed of yellow sandstone, not unlike that in northern Larimer County. The Morrison is fairly well exposed, and consists of a shale series, interrupted by hard bands of limestone and sandstone. A thin bed of gypsum occurs toward the top of these shales.

*Deer Creek.*—Conditions are similar to those at Turkey Creek. The Fountain is thicker but softer, and the Lyons is the ridge-maker. The Crinkled sandstone of the Lykins is in two bands, separated by 12 to 14 feet of shales. The lower half of the upper band is a fairly good limestone, but the upper half is a calcareous shale.

*Indian Creek.*—The Fountain is quite thick, and is exposed in several saw-toothed ridges. The Lyons is about 75 feet thick, and about 30 feet of shales intervene between it and the Crinkled sandstone, which is in two bands—the lower 3 to 5 feet thick, and the upper 8 to 10 feet. No fossils were found, but small cavities filled with calcite suggest that possibly fossils were once present. All higher formations up to the Dakota are covered by alluvium.

*Perry Park.*—The Fountain is thick, and consists of alternating hard and soft bands, which result in the formation of saw-tooth ridges and intervening valleys. The Lyons is also quite thick, and varies in color from red to white, but is usually cream-colored. The exact contact of the Lyons with the Foun-

tain is hard to determine. Above the Lyons are from 20 to 30 feet of soft, red shales, followed by the Crinkled sandstone in two bands, of which the lower is calcareous. About one-quarter of a mile south of the lake in Perry Park fossils were found in a band about 6 inches thick near the base of the Crinkled sandstone. In the upper portion of the Lykins there is a bed of gypsum, 40 to 50 feet thick, which is overlain by limestone resembling the Morrison. The following fossils, identified by Dr. G. H. Girty, were found in this fossiliferous horizon:

*Myalina wyomingensis.*

*Myalina perattenuata.*

*Alula squamulifera.*

*Alula gilberti* (?)

*Pleurophorus* sp.

*Colorado Springs between Fountain Creek and Bear Creek.*—

The basal sedimentaries are covered. The lowest member exposed is the red conglomerate, followed by a brick-red sandstone in alternating hard and soft bands. Above this is a pink, cross-bedded sandstone, undoubtedly Lyons, but it is difficult to set it off definitely from the Fountain. This is followed by 30 to 50 feet of soft, red Lykins shales, containing the Crinkled sandstone near the top. The Crinkled sandstone here is from 8 to 10 feet thick. The lower half is a good limestone, but the upper half is clayey. The Morrison is not well exposed.

*Between the Arkansas River and the New Mexico Line.*—

There is no exposure which can be assigned to the Lykins, unless it is the upper part of Hills' Badito formation in Red Canyon, just north of Badito. These sediments are lithologically similar to the Lykins shales, but there is no Crinkled sandstone horizon. They are finer-grained than the lower part of the Badito formation, but much brighter red in color than the rest of the Badito, or any other formation along the entire Front Range. No fossils were found in the formation.

The slopes of the Sangre de Cristo Mountains on the western side of Huerfano Park were not studied. In many places south of the Arkansas River the Dakota sediments lap over onto the granite. The larger portion of the country is rather heavily timbered and deeply covered with wash, and is hard to work.

*Red Canyon North of Badito.*—The base of the Badito formation is not exposed, but there are 300 to 400 feet of arkose and conglomerates which are identical in appearance with the Fountain. As the area is so isolated from the known Fountain areas,

positive correlation was not attempted. There are no sediments corresponding in lithological character to the Lyons, and if that formation is represented, it is by sediments of a different character. Above the upper band of arkose there are about 75 feet of bright-red shales and clayey sandstones, resting apparently conformably upon the arkose. Following this are 15 to 20 feet of a lighter-colored sandstone, similar to one in the northern part of Larimer County in the Lykins formation. Following this are 40 to 50 feet of red sandstone, some bands of which are quite hard. The red shales become mottled near the top. Above this there are bands of purple, shaly sandstone, alternating with layers of calcite from 1 to 6 inches thick. At the top there are 12 to 15 feet of soft, yellowish sandstone. The dip is about 36° east. If this series represents the Lykins, it is much thicker than is usual in central Colorado, and is comparable to the Ingleside and Lykins of Northern Larimer County. It very much resembles the Ingleside of Larimer County.

*Six Miles Northwest of Badito.*—This exposure is on the western side of the ridge, 2 or 3 miles due west of Red Canyon. The conditions are similar to those in Red Canyon. The Lykins (?) is all red shales and sandstone, with no light-colored bands. It is much harder to separate it from the rest of the Badito formation than it was in Red Canyon. The base of the Badito is exposed, and the lower part consists of 400 to 500 feet of sediments. The lowest member is a very coarse conglomerate, containing gneissoid and granitic boulders up to 2 feet in diameter and not well cemented together. It lies with angular unconformity upon the pre-Cambrian rocks. Above the conglomerates are arkose and other bands of conglomerate, not nearly so coarse and much better cemented than the basal band. Following this are the red shales and sandstones of the Lykins (?). The pre-Cambrian rocks show their sedimentary origin much better than usual.

#### AGE AND CORRELATION OF THE LYKINS

*Age.*—The "Red Beds" in northern Larimer County are very thick, and probably present quite the most complete record to be found on the eastern slope in Colorado. The Mississippian period is represented by a thin band of chert in a dark-red shale formation in Perry Park. Overlying the Mississippian or older formations is the Fountain series, considered equivalent to the Hermosa formation, containing a Pennsylvania fauna. Overlying

the Fountain in the northern part of the state is a series of limestones and sandstones (the Ingleside), which Professor Henderson in his report correlates provisionally with the Lyons of Fenneman; but the present work has shown that the series at Box Elder Creek represents at best only the horizon of the lower part of Fenneman's Lyons, and is possibly entirely below it. This series contains Pennsylvania fossils at several horizons. One such horizon is at the very top. Professor Henderson is now inclined to the view that the Ingleside is below the Lyons. Overlying this is the Lykins formation, and at one horizon about 200 feet from the base, at Heygood and Box Elder Canyons, *Bellerophon crassus* and *Myalina subquadrata* were found. The same species are found in the Fountain and Ingleside below. On this evidence, together with the fact that there is no angular unconformity, and no marked difference of lithological character, this basal portion of the Lykins is assigned to the Pennsylvanian period. On the northern slope of Table Mountain, Larimer County, 40 to 50 feet higher than the lower fossiliferous stratum, and separated from it by a gypsiferous series, another fossiliferous stratum occurs. This is probably more than 300 feet from the top of the Lykins formation, and seems to be in the same stratigraphic position as the fossiliferous beds near Stout, and also those in the Crinkled sandstone near Perry Park. At Stout, and also at Table Mountain, the "crinkly" structure is not present. From this horizon Dr. G. H. Girty identified the following fossils:

From Table Mountain:

*Myalina wyomingensis*  
*Myalina perattenuata*  
*Alula squamulifera*  
*Murchisonia buttersi*

From Stout:

*Myalina wyomingensis*  
*Myalina perattenuata*

From Perry Park:

*Myalina wyomingensis*  
*Myalina perattenuata*  
*Alula squamulifera*  
*Alula gilberti* (?)  
*Pleurophorus* sp.

This fauna has been recently discussed, *Alula squamulifera* and *Murchisonia buttersi* described as new, and *Allerisma* (*Pleu-*

*rophorella?*) *gilberti* removed to the new genus *Alula*, by Dr. Girty (18a).

It will be seen that the faunas are essentially the same, and while some of the species are new, the number of known forms is such that Dr. G. H. Girty believes a tentative correlation with the Rico formation of the San Juan region is justifiable. The Hermosa is Pennsylvanian, while the Rico is considered, tentatively, Permian. This leaves 100 to 400 feet of shales to represent the Permian or the remainder of the Permian, the Triassic, and all the Jurassic up to the Morrison. These sediments are usually a soft, red shale or shaly sandstone, and the conditions of deposition were apparently unfavorable for the preservation of fossil evidence.

There seems to be no angular unconformity between Lykins and Sundance, or between Sundance and Morrison, or between Lykins and Morrison where the Sundance is absent. The character of the Lykins is such that erosional unconformity would be very difficult to detect, but the Sundance should show erosion, if it occurred. Of course, it is quite possible that the Sundance is rather local and never occurred where it is not now found.

There seem to be more sediments above the Crinkled sandstone in the northern part of the state than there are in the central and southern parts. In fact, the best section of the Lykins in the state is found in northern Larimer County, and it is possible that over the line in Wyoming an even more complete section might be found. Triassic vertebrate remains are reported by Williston about 200 feet from the top of the "Red Beds" from the Popo Agie River, which is east of Lander (31). If these "Red Beds" can be correlated with those of Colorado, and the identification is correct, possibly the Triassic may be represented in northern Larimer County. The conditions seem to show that, from the Wyoming line south, there was either less and less deposition, or more and more subsequent erosion. It seems probable that, if it is possible to work out the age of the upper part of the Lykins, it must be done in Wyoming.

*Correlations.*—The correlation of the Fountain, Ingleside, Lyons and Lykins along the foothills from the Wyoming line to Colorado Springs is a question of recognizing the same formation under different names. This has been discussed under the paragraphs headed "Formation Names." Thus the Fountain of Fenneman in the Boulder quadrangle is equivalent to the lower part of the Fountain of Cross in the Pikes Peak area. The

Fountain, Ingleside and Lyons together are equivalent to the Lower Wyoming of the Denver Basin area. The Lykins is equivalent to the Chugwater of Darton and the Upper Wyoming of Emmons. The upper portion of the Fountain and the Ingleside together are equivalent to Darton's Casper formation. The Lyons is equivalent to the Creamy sandstone of the Denver Basin area, but Darton's Tensleep is not the equivalent of the Lyons and the Creamy sandstone. It is a lower horizon, and can be correlated only with the lower portion of the Lyons, and also the Ingleside. An explanation of this requires a description of conditions in northern Colorado. This has been made under "Formation Names." Darton's Tensleep in Colorado is probably in part equivalent to the sandstone-limestone series; that is, the Ingleside formation.

Owing to the absence of fossil evidence in the Badito formation, and from the fact that it is separated so widely from any recognized Fountain exposures, it has not been definitely correlated with the Fountain. Lithologically they are very similar, and the Badito overlies pre-Cambrian rocks unconformably, bearing about the same relation to overlying formations as does the Fountain. On these grounds they are at least approximately in the same horizon.

The Cutler formation is defined as that portion of the "Red Beds" lying above the Rico, where that is present, or otherwise as succeeding the Hermosa, and below the Dolores. The Cutler is assigned to the Permian purely on stratigraphic grounds, and is separated from the Rico by a purely arbitrary line. There seems to be as good ground for assigning the Lykins, above the Crinkled sandstone, or at least the lower portion of it, to the Permian, and thus correlating it with the Cutler.

Above the Cutler formation in the San Juan region is a series of sandstones, sandy shales and conglomerates which vary in thickness from 800 to 400 feet, and from that down to 30 feet at the San Miguel River, disappearing entirely north of this river. These shales and sandstones are a bright vermilion in color, and are known as the Dolores formation. They are assigned to the Triassic age because of scanty, but wide-spread, vertebrate, invertebrate and plant remains. The extreme upper portion of the Lykins in Larimer County may be equivalent to the Dolores, and thus be Triassic. If so, it is impossible to draw a line between the Permian and Triassic in eastern Colorado.

Dr. Girty, in Professional Paper No. 16, in his correlation says that "the evidence seems to show that the lower Pennsylvanian deposits of the San Juan, Crested Butte and Leadville areas are essentially synchronous."

There seems to be sufficient evidence for the belief that the Fountain also was laid down at this time.

The following is a partial list of fossils identified from the "Red Beds" of the Front Range:

From the Fountain:

Manitou region:

*Orbiculoidea manhattanensis*

*Marginifera ingrata*

Livermore quadrangle:

*Chaetetes milliporaceous*

*Derbya* n. sp.

*Meekella striaticostata*

*Productus nebraskensis*

*Spirifer rockymontanus*

*Squamularia perplexa*

*Ambocoelia* sp.

*Composita subtilita*

*Myalina swallowi*

*Myalina subquadrata*

*Bellerophon crassus*

*Nautilus* sp.

*Phillipsia* aff. *major*

From the Ingleside (Lyons of Professor Henderson):

Livermore quadrangle:

*Myalina subquadrata*

*Myalina aviculoides*

*Bellerophon crassus*

*Meekella striaticostata*

*Productus cora*

*Loxonema* sp.

From the Lykins:

Lower horizon:

*Myalina subquadrata*

*Bellerophon crassus*

Upper horizon, identified by Dr. G. H. Girty:

*Myalina wyomingensis*

*Myalina perattenuata*

*Alula squamulifera*

*Alula gilberti* (?)

*Pleurophorus* sp.

*Murchisonia*

Of the Lykins fossils all except *Alula squamulifera* and *Murchisonia buttersi*, which are new species, and *Alula gilberti* (?) are found in the Rico formation of the San Juan region. Girty reports about thirty-seven species from the Rico. Of these, *Bellerophon crassus* and *Myalina subquadrata*, and others, also occur in the Hermosa. It will be noticed by the list of the Lykins fossils that these two occur at a different and lower horizon in the Lykins than the remainder. This rather strengthens the correlation of the Lykins with the Rico. *Bellerophon crassus* and *Myalina subquadrata* are found in the Hermosa and other Pennsylvanian horizons lower than the Rico. *Pleurophorus subcostatus* and *Pleurophorus occidentalis* occur in several localities, but it is by no means certain that the *Pleurophorous* of the Lykins belongs to either one of these species. A doubtful identification of *Myalina wyomingensis* has been made from Leadville. With these possible exceptions, none of the Lykins fossils have been reported by Girty from any formations in Colorado other than the Rico. In summarizing, it will be seen that there is fairly good evidence for correlating the Lykins with the Rico, and no evidence for correlating it with any other horizon. The Lykins fossils were collected from localities a long distance apart—from the extreme northern part of Larimer County in the north, to Perry Park in El Paso County in central Colorado—so that the Lykins appears to be more widely distributed than the Rico.

On comparing the Fountain fauna with that of the Ingleside formation in the northern part of the state, it will be seen that, with one or two exceptions, all the fossils reported in the Ingleside are reported from the Fountain, so that they will be considered together, thus treating this series as if it were merely the upper portion of the Fountain, which in reality it is, as it is exceedingly difficult to draw a line between them in many places, on either lithological or structural grounds. *Myalina subquadrata* and *Bellerophon crassus*—species common to both this series and the Fountain—are also found in the lower part of the Lykins formation in northern Larimer County.

On examination of the fossils in the various localities, it will be noticed that those in common are the ones that are most frequently met with in the Fountain, and those which differ are those which are not so frequently met with, or are in such poor condition that genera only could be determined. When it is remembered that many of the localities were on opposite sides of the then existing land area, and hence were more or less isolated

from one another, the correlation becomes more noteworthy. There seems to be enough evidence to correlate the Fountain, Ingleside and Lyons with the Hermosa. If this correlation is accepted, the correlation of the Fountain with the Maroon of Crested Butte and the Weber of Leadville follows from Dr. Girty's correlation (15).

Section No. I is just north of Table Mountain, in northern Larimer County. This section shows the Fountain comparatively thin, being only about 500 feet, but probably complete, as a good deal of the formation is finer-grained sandstone, sandy limestone, and shale in contact with the coarser arkose and conglomerates which represent a greater part of the formation in those places farther south where it is thicker. In this section the Fountain shows conglomerates containing chert and other boulders at the base, and arkose higher up. Nearly all the strata, even the conglomerates and arkose, carry lime in varying quantities. The Ingleside consists of about 125 feet of fine-grained limestone. There appears to have been continuous, or nearly continuous, deposition from the basal Fountain to the top of the Ingleside, and it is difficult to separate the two formations. The Lykins is 791 feet thick, and shows the most complete section of this formation to be found in Colorado. It is composed of fine, brick-red shales and shaly sandstones, with a few bands of sandy or shaly limestones, some of which contain fossils. The lower fossiliferous band is about 200 feet from the base. The upper is from 75 to 100 feet higher, and is separated from the lower by the characteristic red shales and a thin bed of gypsum. The top of the Lykins is a massive, red sandstone, containing more or less clay in the lower part. It varies in color from brick-red to pink, to the yellow of the Sundance.

Geologists who have worked in this region have regarded the gray strata as the basal part of the Morrison, but a study of the section shows no evidence of an unconformity, and as there is no fossil evidence to aid in placing the contact, one naturally looks for the most important lithological change as the most natural place for the contact of the two formations. This is the change from the massive, white-to-yellow sandstone of the Sundance, to the fine, gray-to-drab, flaky shales. There are, however, thin bands of similar white sandstone at various horizons in the shales. It is possible that farther south one of these bands may thicken and form the basal member of the Morrison as it occurs at Boulder. If it is assumed that the basal part of the Morrison

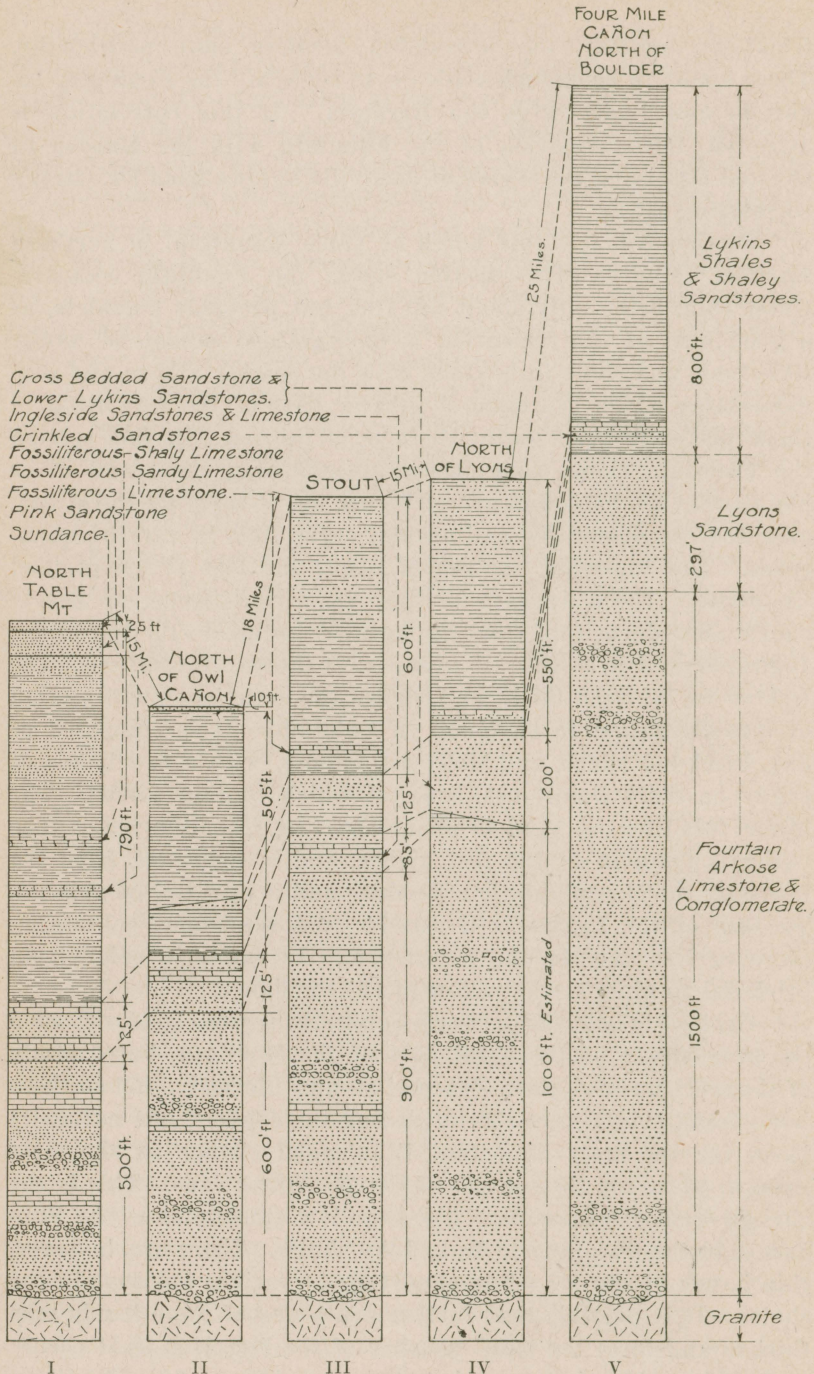


FIGURE 1

Sections Showing Relationship of Lykins, Fountain, and Ingleside Formations, North of Boulder, Colorado.

in northern Larimer County is the massive, white-to-gray sandstone, it is extremely difficult to fix upon the contact between this formation and the Sundance.

Section No. II is north of Owl Canyon and about 15 miles south of Section No. I. In this section the Fountain is a little thicker and contains less lime in the lower part. The Ingleside is of about the same character and maintains a thickness of about 125 feet. The calcareous bands of the Lykins are thinner and more clayey, and no fossils were found in them. The Sundance is thinner, from 10 to 15 feet, and often absent. About 100 feet above the top of the Ingleside an inconspicuous band of light-colored, much Crossbedded sandstone appears in the shale, and thickens southward to about 6 feet, forming a low ridge. From this point south it gradually attains a maximum thickness of about 70 feet. This band can be traced continuously to Lyons, where it forms the top of the Lyons formation. The Lykins below this band becomes more and more sandy toward the south, and at Lyons it has become so much like the Crossbedded sandstone that it is practically impossible to separate the two. The Lykins at this point is about 525 feet thick.

Section No. III is at Stout, about 18 miles south of Section No. II. In this section the Fountain has thickened to about 900 feet, and there is more arkose and conglomerate and less limestone. The Ingleside is thinner and contains less lime, the thinning-out being due apparently to the wedging-out of the limestone members, as the sandstone maintains about its normal thickness. The Lykins also is somewhat thinner. The Crossbedded sandstone is about 50 feet thick. I have discontinued the line separating the Crossbedded sandstone from the lower Lykins sandstone between Sections Nos. III and IV, because at Section No. IV there is no way of distinguishing the contact; all that can be said of Section No. IV is that the upper portion is Crossbedded sandstone. Otherwise they are lithologically alike. From 30 to 40 feet above the Crossbedded sandstone, at Stout, there is a limy series 50 to 60 feet thick, consisting of sandy or clayey limestone bands, with shale between. Fossils were found at the base of the lower limestone band.

Section No. IV is a few miles north of Lyons. The formation is about the same as at Stout. The Ingleside wedges out. At this point it is no longer possible to separate the Crossbedded sandstone from the lower Lykins sandstone. This may be in part due to the sharp folding, which seems to have somewhat modified

the lithological character of the formation. About 30 feet above the Crossbedded sandstone there are calcareous beds, 20 to 30 feet thick, consisting of sandy limestone and shale. The sandy limestone members show that peculiar wavy lamination which characterizes Fenneman's Crinkled sandstone of the Boulder area.

Section No. V is at Four Mile Canyon, about  $3\frac{1}{2}$  miles north of Boulder. The thickness of the Fountain, 1,500 feet, is greater than at any point in the northern part of the state. The thickness which the Lyons has attained at this point, 297 feet, is exceeded only at the town of Lyons, where the compression accompanying folding may have thickened the beds. At the point where this section is taken the formation is of coarse texture and more sandy. The measurements in this section are taken from Bulletin No. 265, United States Geological Survey.

#### BIBLIOGRAPHY

1. Cross, Whitman, and Hole, A. D.: Engineer Mountain Folio. U. S. Geol. Survey, Atlas No. 171.
2. Cross, Whitman; Spencer, A. C., and Purington, C. W.: La Plata Folio. U. S. Geol. Survey, Atlas No. 60.
3. Cross, Whitman; Howe, Ernest; Irving, J. D., and Emmons, W. H.: Needle Mountains Folio. U. S. Geol. Survey, Atlas No. 131.
4. Cross, Whitman: Pikes Peak Folio. U. S. Geol. Survey, Atlas No. 57.
5. Cross, Whitman; Howe, Ernest, and Irving, J. D.: Ouray Folio. U. S. Geol. Survey, Atlas No. 153.
6. Cross, Whitman, and Howe, Ernest: Red Beds of Southwestern Colorado and Their Correlation. Bull. Geol. Soc. Am., Vol. 16, pp. 447-449.
7. Cross, Whitman, and Ransome, F. L.: Rico Folio. U. S. Geol. Survey, Atlas No. 130.
8. Cross, Whitman; Howe, Ernest, and Ransome, F. L.: Silverton Folio. U. S. Geol. Survey, Atlas No. 120.
9. Darton, N. H.: Comparison of the Stratigraphy of the Black Hills with That of the Front Range of the Rocky Mountains. Bull. Geol. Soc. Am., Vol. 12, p. 478.
10. Darton, N. H.: Preliminary Report on the Geology and Underground Waters of the Great Central Plains. U. S. Geol. Survey, Prof. Paper No. 32, pp. 80, 82, 96.

11. Darton, N. H.: Jurassic Formations of the Black Hills of South Dakota. Bull. Geol. Soc. Am., Vol. 10, pp. 383-396.
12. Darton, N. H.: Laramie-Sherman Folio, Wyoming. U. S. Geol. Survey, Atlas No. 173.
13. Eldridge, Geo. H.: Crested Butte Folio. U. S. Geol. Survey, Atlas No. 9.
14. Emmons, S. F.: Geology and Mining Industry of Leadville. U. S. Geol. Survey, Mon. No. 12, pp. 63-70.
15. Emmons, S. F.: Eldridge, G. H., and Cross, Whitman: Geology of the Denver Basin. U. S. Geol. Survey, Mon. No. 27, pp. 63-70.
16. Fenneman, N. M.: Geology of the Boulder District. U. S. Geol. Survey, Bull. No. 265, pp. 22-26.
17. Finlay, Geo. I.: The Gleneyrie Formation and Its Bearing on the Fountain Formation of Manitou, Colorado. Jour. Geol., Vol. 15, pp. 586-590.
18. Girty, Geo. H.: The Carboniferous Formations and Faunas of Colorado. U. S. Geol. Survey, Prof. Paper No. 16.
- 18a. Girty, Geo. H.: On Some Invertebrate Fossils from the Lykins Formation of Eastern Colorado. Annals N. Y. Acad. Sci., Vol. 22, pp. 1-8, 1912.
19. Gilbert, G. K.: Pueblo Folio. U. S. Geol. Survey, Atlas No. 36.
20. Hayden, F. V.: Third Annual Report of the United States Geological Survey of the Territories, Embracing Colorado and New Mexico.
21. Henderson, Junius: Foothills Formations of Northern Colorado. 1st Rept., Colorado Geol. Survey, 1909, pp. 155-170.
22. Hills, R. C.: Walsenburg Folio. U. S. Geol. Survey, Atlas No. 68.
23. Knight, W. C.: Red Beds of the Laramie Plains. Jour. Geol., Vol. 10, pp. 413-422.
24. Knight, W. C.: Jurassic Rocks of Southeastern Wyoming. Bull. Geol. Soc. Am., Vol. 11, pp. 377-388.
25. Lee, W. T.: Note on the Carboniferous of Sangre de Cristo Range, Colorado. Jour. Geol., Vol. 10, pp. 393-396.
26. Lee, W. T., and Girty, G. H.: Manzano Group of the Rio Grande Valley, New Mexico. U. S. Geol. Survey, Bull. No. 289, pp. 42-43.
27. Lee, W. T.: The Red Beds of the Rio Grande Region, Central New Mexico. Jour. Geol., Vol. 15, pp. 52-58.

28. Marvine, Arch. R.: Report of Arch. R. Marvine, Assistant Geologist Directing the Middle Park Division; Ch. II. 7th Ann. Rept., U. S. Geol. Surv. Terr. for 1873, pp. 93-137 (1874).
29. Patton, H. B., and Smith, C. E.: Geology of the Grayback Mining District, Costilla County, Colorado. Colo. Geol. Survey, Bull. No. 2, pp. 21-25.
30. Spencer, A. C., and Cross, Whitman: Geology of the Rico Mountains. 21st Ann. Rept., U. S. Geol. Survey, Pt. 2, pp. 47-73.
31. Spurr, J. E., and Emmons, S. F.: Geology of the Aspen District. U. S. Geol. Survey, Mon. No. 31, pp. 22-41.
32. Williston, S. W.: Triassic Vertebrates in the Wyoming Red Beds. Jour. Geol., Vol. 12, pp. 688-697.

# INDEX

## A

	Page
Alkali, estimation of in dacite from Muddy Pass.....	54
red rock from Buffalo Peak.....	54
Alkali, table .....	55
Allerisma (Pleurophorella) (?) Gilbert.....	84
Alluvium .....	15, 23, 40
Alula gilberti (?) .....	82, 84, 87, 88
squamulifera .....	82, 84, 87, 88
Ambocoelia sp. ....	87
Anchura nebrascensis .....	33
Ancyloceras sp. ....	33
Andesite porphyry .....	20, 45, 50, 51
Anomia cf. subquadrata .....	31
Arapahoe Creek .....	14
Arapahoe Peak, see Spicer Peak.	
Arkansas River and New Mexico line, section between.....	82
Arkansas sandstone, age and equivalents.....	67
Arkins, section at .....	78
Avicula linguiformis .....	33

## B

Baculites compressus .....	32, 33
cf. gracilis .....	31
cf. patina .....	33
ovatus .....	32, 33
sp. ....	34
Badito, Red Canyon, section at.....	82
six miles northwest of, section at.....	83
Badito formation, age and equivalents of.....	66, 82, 83, 86
Baker Mountain .....	14
Basalt .....	19, 45, 48, 49, 54
Base Line .....	11
Bear Canyon, (near Boulder) section at.....	80
Bear Mountain .....	14
Belemnites densus .....	23, 67
Bellerophon crassus .....	74, 84, 87, 88
Bellvue, Cache la Poudre River, sections at.....	76
Benton formation .....	15, 22, 30
Bethel, Ellsworth .....	38
Bibliography .....	42, 92
Box Elder Canyon, sections of Lykins at.....	74
Creek, fossils from .....	67, 84
Breccia .....	19, 20, 39, 51, 52, 53
Building stone .....	57

## C

Carter Lake, section at .....	79
Casper formation, age and equivalents of.....	72, 86
Cenozoic .....	34
Chaetetes (?) dimissus .....	33
Chaetetes milliporaceous .....	87
Chugwater formation, age and equivalents of.....	67, 86

	Page
Clay .....	57
Climate .....	17
Coal .....	36, 57
measures .....	23, 37, 46
Coalmont .....	9
Cockerell, T. D. A., cited.....	39
Colorado formation .....	22, 30, 34
Colorado Springs, section near.....	82
Composita subtilita .....	87
Concretions .....	22, 33, 36
Contact intrusives and sediments.....	46
Continental divide .....	9, 13, 14
Corbula rel. undifera .....	37
Correlations of formations .....	85
Cottonwood Creek, section on.....	78
Crawford, R. D., acknowledgments to.....	11
Creamy sandstone, age and equivalents of.....	67, 86
Crenella elegantula .....	33
Crinkled sandstone, age and equivalents of.....	74
Cross, Whitman, cited .....	35, 38, 66
Cross and Howe, cited.....	46
Curtis, David L., acknowledgments to.....	65
Cutler formation, age and equivalents of.....	86
D	
Dacite porphyry .....	21, 45, 49, 50, 54
Dakota formation .....	22, 28
fire clay in .....	57
Darton, N. H., cited and quoted.....	67
Debris .....	12, 40
Deer Creek, section on.....	81
Denver Beds, referred to .....	35
Derbya, n. sp. ....	87
Diamond Mountain .....	14
Dinosaur bones .....	28
Dolores, age and equivalents of.....	86
E	
Economic geology .....	56
Emmons, S. F., cited.....	66
Eruptive rocks .....	44
Extrusions .....	44
F	
Faults .....	40
Fenneman, N. M., cited.....	65, 66, 67
Ficus proteides .....	30
Fish scales .....	37
Folds .....	16, 24, 40
Fossils from	
Benton formation .....	31
Box Elder Creek .....	67
Coal Measures .....	37, 38
Fountain formation .....	87
Hermosa formation .....	88
Ingleside formation .....	87
Laramie (?) formation .....	37
Lykins formation .....	87
Niobrara formation .....	31, 32
Pierre formation .....	32, 33
Popo Agie River, Wyoming.....	85
Post-Laramie of Middle Park.....	38
"Red Beds" .....	87
Rico formation .....	88

	Page
Fossils of—	
Jurassic age .....	71
Mississippian age .....	71
Pennsylvanian .....	72, 84
Fountain formation, age and equivalents of.....	66, 68, 85, 89
fossils from .....	87
section of, at North Table Mountain.....	71
Four Mile Canyon, north of Boulder, section at.....	90
Fox Hills formation .....	34
Freshwater beds of Middle Park.....	35
Fuel .....	36, 57

## G

George, R. D., acknowledgments to.....	11, 65
Gilsonite .....	57
Girty, G. H., acknowledgments to.....	65
quoted .....	87
reference to .....	68, 84, 85
Glaciation .....	39
Glacial topography .....	14
Gneiss .....	18, 24, 56
Gold .....	56
Goniobasis (?) sp. ....	37
Gradations of igneous rocks.....	51
Granite .....	18, 24, 43
Grizzly placer .....	56
Gryphaea calceola .....	67
Gypsum .....	74, 78, 82

## H

Halymenites major .....	36
Hayden, F. V., cited .....	67
Haystack Mountain .....	14
Henderson, Junius, acknowledgments to .....	67
quoted .....	71
reference to .....	68
Hermosa formation, age and equivalents of.....	83, 89
fossils from .....	88
Heteroceras cochleatum .....	33
Heygood Canyon (Sand Creek), fossils from.....	84
section of Lykins and Sundance at.....	73
Hills, R. C., cited .....	66
Hinds, N. E., work of .....	10
Historical geology, Rabbit Ears Range .....	41
Horse Creek, Wyoming, formations of, reference to.....	67
Howe and Cross, cited.....	46
Hydrocarbons .....	57

## I

Igneous activity .....	43, 44
Igneous rocks .....	19, 43, 51
analysis of .....	53
modified types of .....	51
Indian Creek, section on .....	81
Industries .....	17
Ingleside, limestone quarries at .....	75
Ingleside formation .....	67, 68, 69, 71, 74, 84, 85
fossils from .....	87
Inlier of Morrison .....	40
Inoceramus deformis .....	31
fragilis .....	31
sagensis .....	33
sp. ....	31

	Page
Intrusions .....	44
Ironclad Mountain .....	14
Irrigation .....	16
<b>J</b>	
Jointing .....	19
Juglans rugosa .....	37, 38
thermalis .....	37, 38
Jurassic .....	26
fossils from .....	71
<b>K</b>	
Kaolinization .....	44
Kremmling .....	9, 31
<b>L</b>	
"Lake Beds" .....	32
Lakes .....	16
Laramie (?) .....	34, 35, 37
Lava flows .....	20
Leadville, fossils from .....	88
Leaves from coal measures.....	35
Lefthand Creek, section on.....	80
Lignitic formation .....	34
Limestone, quarries at Ingleside .....	75
Livermore quadrangle, fossils from.....	87
Lower Muddy Butte .....	31
Lower Wyoming formation, age and equivalents of.....	66, 86
Loxonema, sp. ....	87
Lucina occidentalis .....	33
Lykins formation .....	66, 67, 73, 74, 85
lower horizon, fossils from .....	87
upper horizon, fossils from.....	87
Lyons, formations near, described .....	69, 79, 90
Lyons formation .....	66, 67, 70, 72, 85
<b>M</b>	
Manitou, fossils from .....	87
Mapping methods .....	11
Marginifera ingrata .....	87
Marls, Eocene .....	38
Maroon, correlation .....	89
Martin, P. J., acknowledgments to.....	11
Martine, A. R., cited.....	30, 32, 33, 34
Masonville, section at .....	78
Meekella striaticostata .....	87
Medicine Bow Range .....	9, 13
Mesozoic .....	26
Middle Park, topography of.....	9, 16
Millsap formation, character of.....	72
Mineralization along contacts .....	56
Mineral production .....	56
Miocene .....	39
Mississippian, Perry Park .....	83
Modified types of igneous rocks.....	51
Monadnocks .....	14
Montana formation .....	22, 30
Moraines .....	23, 39
Morrison, section at .....	81
Morrison formation .....	21, 26, 27, 40, 71
Mount Bross, fossils from.....	38

	Page
Murchisonia .....	87
<i>buttersi</i> .....	84, 88
Murphy, Frank, acknowledgment to.....	11
Myalina aviculoides .....	87
<i>perattenuata</i> .....	77, 82, 84, 87
<i>subquadrata</i> .....	74, 84, 87, 88
<i>swallowi</i> .....	87
<i>wyomingensis</i> .....	77, 82, 84, 87

## N

Nautilus sp. ....	87
Niobrara formation .....	22, 31
North Park .....	9
coal lands, classification of.....	11
section across Plate I.....	25
structure .....	23
topography .....	13
North Platte River .....	14
North Table Mountain, formations of.....	69, 71, 90
Nucula obsoletistriata .....	33

## O

Orbiculoidea manhattanensis .....	87
Ostrea .....	67
Ostrea congesta .....	31, 32
<i>cf. patina</i> .....	33
Owl Canyon, formations of described.....	69, 74, 90
Ozokerite .....	57

## P

Paleozoic .....	25
Parahippus .....	39
Park Range .....	9
Pentacrinus asteriscus .....	67
Perry Park, Millsap formation of described.....	72
section at .....	81
Phillipsia aff. major .....	87
Pierre formation .....	22, 30, 32, 35
Placenticeras sp. ....	34
Placer mining .....	12, 56
Plantanus nobilis .....	37
Pleurophorus occidentalis .....	88
<i>sp.</i> .....	82, 84, 87
<i>subcostatus</i> .....	88
Popo Agie River, Wyoming fossils from.....	85
Post-Archean .....	44
Post-Laramie fossils from Middle Park.....	38
Prionocyclus wyomingensis .....	31
Productus cora .....	87
<i>nebraskensis</i> .....	87
Proterozoic .....	24
Pseudomonotis curta .....	26
Ptychoceras crassum .....	33
Pyroxenite .....	43, 44

## Q

Quartz Latite .....	21, 45, 46, 47, 54
Quaternary .....	22, 39

## R

Rabbit Ears Mountain .....	9, 11, 14
Range .....	9, 13
Railroads .....	9
Ralston Creek, section at.....	80
"Red Beds" .....	21, 25, 66, 67, 83
fossils from .....	87
Red Canyon, north of Badito, section at.....	82
Rhyolite, alkali in .....	55
Riach coal mine .....	33, 57
Rico formation, age and equivalents of.....	85
fossils from .....	88
Roches Moutonnees .....	14

## S

Sand Creek (Heygood Canyon) .....	73
Sangre de Cristo formation, age and equivalents of.....	67
Scaphites nodosus quadrangularis .....	33
warreni .....	31
Schist .....	18, 46
Scoria .....	20
Serpula markmani .....	33
Sedimentary rocks .....	21
Slump topography .....	15
Smith, A. C., work of .....	10
Soil .....	17, 57
South Table Mountain, section of Lykins at.....	74
Spicer .....	9
Peak .....	11
Spirifer rockymountainus .....	87
Squamularia perplexa .....	87
Steamboat Springs .....	9
Stout, section at .....	77, 90
Stratigraphy .....	24
Streams .....	16
Structure .....	40
Sundance formation, age and equivalents of.....	67, 70, 73
Syncyclonema rigida .....	33

## T

Tellina scitula .....	33
Tensleep formation, age and equivalents of.....	67, 72, 86
Terraces .....	15
Tertiary igneous rocks .....	19
sediments .....	23, 34
Thetis circularis .....	33
Timber .....	12
Topography .....	6
Triangulation .....	11
Triassic .....	26, 85, 86
Turkey Creek, section on .....	81

## U

Unios .....	71
United States Geological Survey, acknowledgments to.....	10, 24
cited .....	25
Upper Wyoming, age and equivalents of.....	66, 86

Page

## V

Vegetation .....	12, 16
Vivipara paludinaeformis .....	38
Volcanic ash .....	19
breccia .....	19, 39
Vulcanism, topography controlled by.....	14

## W

Water supply .....	16
Weathering of breccia.....	20
Weber formation correlations.....	89
Whiteley Peak .....	9, 11, 14

# Date Due

MAY 28 1958

~~MAY 18 81~~

~~EARTH SCIENCE LIBRARY~~

*One week's use*

~~ES DEC 7 '73~~

~~ES MAY 18 '81~~

MAY 14 1981

7

EARTH SCIENCE  
LIBRARY

378.788 B 70610  
B982a

