# Triassic Stratigraphy of Southeastern Idaho and Adjacent Areas

*By* BERNHARD KUMMEL

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

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*Studies in southeastern Idaho, western Wyoming, and southwestern Montana, revealing one of the thickest and most complete marine sequences of Lower Triassic faunal zones in the world*


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# A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

## TRIASSIC STRATIGRAPHY OF SOUTHEASTERN IDAHO AND ADJACENT AREAS

By BERNHARD KUMMEL

ABSTRACT

Thick marine strata of Early Triassic age occur in eastern Idaho and adjacent areas. The area covered in this report lies along the eastern margin of an ancient miogeosycline. Basinward (west) the strata are thickest and consist of fossiliferous marine rocks with no red beds. Toward the craton (east) the strata thin and intertongue with red sandstones and shales. The Dinwoody and Thaynes formations attain their thickest marine development in the region of the Fort Hall Indian Reservation. To the east, north, and south of Fort Hall, the Dinwoody formation intertongues with the red Woodside and Chugwater formations; the Thaynes formation tongues out eastward into the Ankareh and Chugwater formations. The zone of intertonguing for the Dinwoody formation follows a line from southwestern Montana along the Idaho-Wyoming boundary and turns sharply westward in northern Utah. East of this line red beds are predominant; west of the line the red beds are absent or of minor thickness. A similar facies line for the Thaynes formation passes southward from the Idaho-Wyoming boundary through the Wasatch Mountains and does not turn westward in northern Utah as for the Dinwoody formation. New ammonite faunas of Gyronitan and Flemingitan age are recorded from the Dinwoody formation. The *Prohungarites* zone, the youngest Scythian ammonite zone, is recognized in the upper part of the Thaynes formation. The post-Thaynes Triassic rocks of this area are of continental origin and are correlated with the Shinarump conglomerate and Chinle formation of the Colorado Plateau. The marine miogeosynclinal belt was destroyed at the end of Early Triassic time. The eastern Nevada geanticline (Nolan 1943) probably extended northward into Idaho in the middle and late Triassic.

### INTRODUCTION

Throughout the world, data on stratigraphy and paleontology of the upper Permian and Lower Triassic are surprisingly incomplete when compared to higher beds of the Mesozoic. Considering that one of the important era boundaries separates these two series, important physical and paleobiological data should be sought in upper Permian and Lower Triassic rocks.

Although the presence of thick marine deposits of Early Triassic age in southeastern Idaho has long been known, it is only recently that field and laboratory studies have demonstrated that this area contains one of the thickest Lower Triassic marine sections in the world and one of the most complete sequences of Lower Triassic faunal zones. Lower Triassic deposits around the world are generally thin and incomplete in respect to the number of faunal zones present. Data on the Idaho section will add much to our knowledge of North American Triassic stratigraphy and paleontology; but, as is probably more important, they are proving to be a key in the interpretation and correlation of worldwide Lower Triassic faunal zones.

The Early Triassic seaways that covered much of western North America were more widespread than those of Middle or Late Triassic time. The distribution of facies and thickness of Lower Triassic strata in western North America follows a pattern similar that of the late Paleozoic. Permian and Triassic strata of Nevada, California, Oregon, and Washington are characterized by the presence of volcanic rocks. These areas include the eugeosyncline of Kay (1951). Strata of the same age in eastern Nevada, Arizona, Utah, eastern Idaho, western Wyoming, and southwestern Montana contain no volcanic rocks and belong to the miogeosyncline of Kay (1951). The line marking the approximate boundary of the miogeosyncline and the more stable platform area of the continent has been named the Wasatch line by Kay (1951), and it passes in an approximate north-south direction through the area of southeastern Idaho and the adjacent regions discussed in this report. At the Wasatch line the Triassic strata begin to thin, and the marine rocks with red beds intertongue eastward onto the platform area or the craton of Kay (1951).

Nolan (1943) described a late Paleozoic and early Mesozoic geanticline in eastern Nevada. This geanticline began to form in the Permian period and extended northward until by Late Triassic time it reached entirely across Nevada. It was at least a partial barrier between the miogeosyncline and the eugeosyncline dur-

ing Early Triassic time. Nolan (1943) refers to the geosynclines on either side of the geanticline as the western and eastern troughs. He noted the presence of volcanic rocks in the strata of the western trough and the absence of volcanic rocks in the strata of the eastern trough. Across north- and west-central Utah and northern Nevada and in the Lower Triassic formations of southwestern Nevada and in the Inyo Mountains of east-central California, ammonites are found, like those in Lower Triassic formations in Idaho areas, indicating that the geanticline did not form a complete barrier to the sea across the northern half of Nevada in Early Triassic time.

The miogeosynclinal seaway of Paleozoic and Early Triassic time disappeared at the end of Early Triassic time. Later Triassic rocks in this area—Shinarump conglomerate and Chinle formation and their equivalents—are of continental origin. The eastern Nevada geanticline probably extended across Nevada and northward at this time. Middle and Upper Triassic marine rocks are confined to western Nevada, California, Oregon, and Washington. There appears to have been uplift in the region south of the Colorado Plateau in Late Triassic time, which accounts for the widespread development of the Shinarump conglomerate (McKee, 1951). The Gartra grit member of the Ankareh formation in the western Uinta Mountains and the Shinarump conglomerate in the eastern Uinta Mountains are possibly derived from the Uncompahgre positive area in west-central Colorado (Thomas and Krueger, p. 1273, 1946). The Higham grit of eastern Idaho (= Shinarump conglomerate) was derived from positive areas to the west (Mansfield, p. 190, 1927). In western Wyoming, Love (p. 100, 1948) suggests that there was recurrent uplift in Late Triassic time in an area trending northwest along the western margin of the Wind River Basin.

In summary, the eastern Idaho Triassic area occupies a position along the eastern margin of an ancient miogeosyncline. The eastern Nevada geanticline (Nolan, 1943) did not extend across Nevada, for the Early Triassic seaways did have open connections with the eugeosynclinal belt. By Middle Triassic time the seaway retreated from the miogeosynclinal belt and the eastern Nevada geanticline extended farther north. Upper Triassic rocks in eastern Nevada, northern Arizona, Utah, western Colorado, and eastern Idaho consist of a lower conglomerate (for example Shinarump conglomerate) overlain by a red shale and sandstone formation (for example Chinle formation) of continental origin. The conglomerate suggests uplift of areas south of the Colorado Plateau, in the Uncompahgre Mountains of Colorado and in central or western Idaho. Whereas the source of the Lower Triassic sediments for the Idaho area, and the miogeosyncline in general, was to the east, the Upper Triassic rocks had sources that were peripheral to the area of deposition, with some westerly derived materials.

A list and correlation of the Triassic formations in southeastern Idaho and adjacent regions is given in figure 18. The thickest and most complete marine development of Lower Triassic rocks in the miogeosyn-

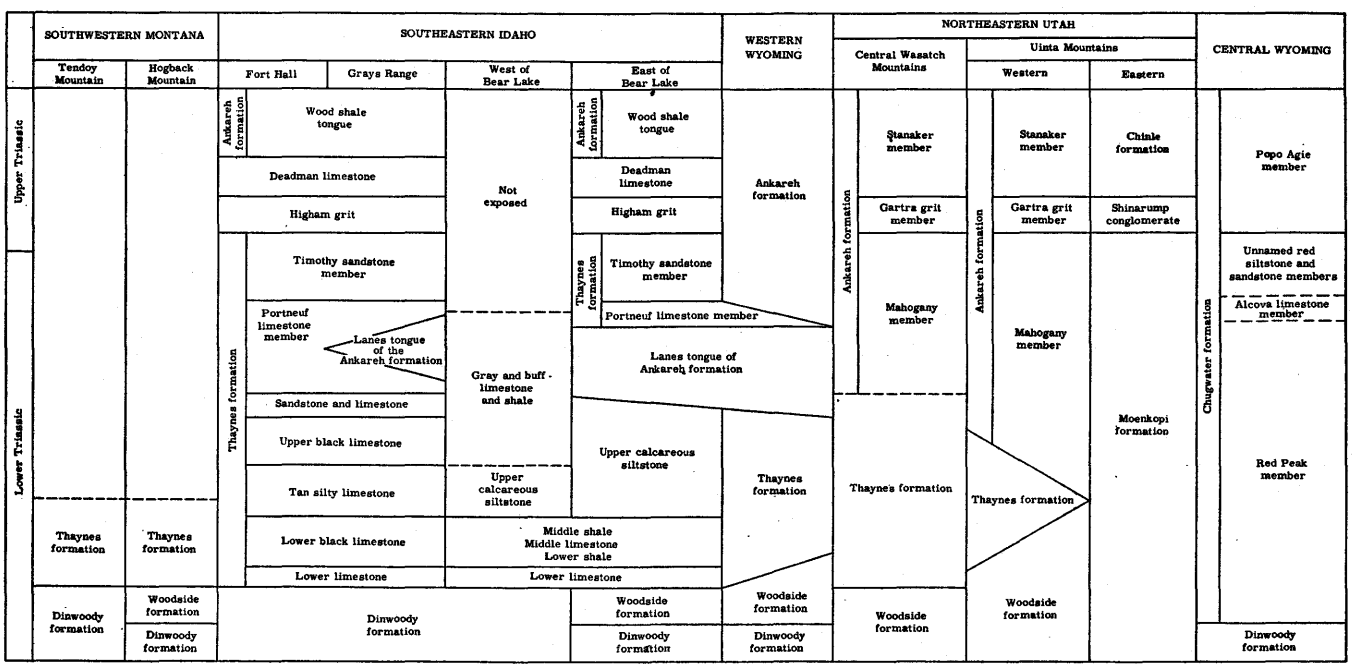


FIGURE 18.—Correlation chart of the Triassic formations in Montana, Idaho, Wyoming, and Utah.

cline is in the Fort Hall Indian Reservation, Idaho. To the east, north, and south, the Dinwoody and Thaynes formations thin and intertongue with red beds of the Chugwater, Woodside, and Ankareh formations (pl. 34). The contact of the Dinwoody formation with the underlying Phosphoria formation appears to be conformable in southeastern Idaho. However, in western and central Wyoming and in the southern Wasatch Mountains, Utah, unconformable relationships exist. The following discussion of the various formations and the text figures present a detailed picture of the facies relationships of the Triassic rocks in the Middle Rocky Mountains. A complete paleontological study of the Triassic faunas from the Middle Rocky Mountains is now in progress. Because this study will require a few more years, the present summary is merely a progress report of the main stratigraphic and faunal data.

Five field seasons were spent studying the Triassic formations of Montana, Idaho, Wyoming, and Utah. Work during the 1949 and 1950 field seasons was done under the auspices of the U. S. Geological Survey. The writer wishes to express appreciation to Mr. V. E. McKelvey for his constant aid and encouragement in the 1949 and 1950 seasons. Messrs. J. B. Reeside, Jr., W. W. Rubey, and A. E. Granger contributed to the work through stimulating discussions and advice on Triassic formational nomenclature. Messrs. W. R. Lowell, W. B. Meyers, and G. C. Kennedy kindly gave locality information on Triassic exposures in southwestern Montana. The writer was ably assisted in the 1949 field season by Mr. A. M. Gutstadt and in the 1950 season by Mr. N. F. Sohl. The Research Committee of the Graduate School at the University of Illinois aided in defraying field expenses for the 1950 field season and in the preparation of the manuscript. Messrs. H. R. Wanless, A. E. Granger, and H. D. Thomas allowed the use of their unpublished Triassic sections, for which the writer is grateful.

## DINWOODY FORMATION

The Dinwoody formation was named and defined by Blackwelder (1918, p. 425–426) from outcrops in Dinwoody Canyon on the northeastern slope of the Wind River Mountains, near Dubois, Wyo. The limits of the formation were defined by the Phosphoria formation below and the bright red shales and siltstones of the Chugwater formation above. Because the color boundary between the Dinwoody, as originally defined, and the red Chugwater was not a useful or natural boundary, Newell and Kummel (1942, p. 941) redefined the Dinwoody at the type locality to include only the dominantly silty strata between the Phosphoria and the top of the resistant siltstone about halfway to the top of the original Dinwoody. Thus, at the type locality the Dinwoody as redefined is 90 feet thick and overlain by gray shales; elsewhere it is generally overlain by red shales and siltstones. The Dinwoody formation crops out throughout western Wyoming, southeastern Idaho, and southwestern Montana. It thickens greatly to the west with the addition of beds both below and above those found at the type locality.

In southeastern Idaho the Dinwoody formation is 700 to 2,400 feet thick and includes beds both older and younger than are found at the type locality in the Wind River Mountains, Wyo. In southwestern Montana, along the boundary area of Idaho and Wyoming, and in northern Utah, the Dinwoody intertongues with the red Woodside formation. The Dinwoody formation in southeastern Idaho, and southwestern Montana, and Western Wyoming is bounded below by the Phosphoria formation of Permian age and above by the Woodside or Thaynes formations. The limestone with *Meekoceras* is the basal member of the Thaynes formation. At the type locality of the Woodside formation in the Park City Mining District, Utah, it consists of red sandstone and shale. The formation is underlain by the Phosphoria formation, and the *Meekoceras* limestone of the Thaynes formation is above. The Dinwoody formation in southeastern Idaho and the Woodside formation at its type locality near Park City, Utah, have the same stratigraphic boundaries at their top and bottom. The top boundary of the Dinwoody and Woodside formations in these two areas is marked by a well-defined ammonite zone and can be considered as the same horizon.

The relationship of the Dinwoody and Woodside formations to the Phosphoria formation is not completely understood. The Phosphoria formation is generally considered to be early Guadalupian in age (Newell, 1948), although the distinctive guide fossils, on which the age determination has been based, generally were not collected from the uppermost part of the Phosphoria formation. A complete summary of the various opinions on the age of the Phosphoria formation has been given by McKelvey (1946). At most exposures there is lack of physical evidence of a hiatus between the Phosphoria and Dinwoody or Woodside formations in the Middle Rocky, Mountains. The Woodside formation is separated from the Permian by an angular unconformity in the southern Wasatch Mountains, Utah, and bevels across nearly 2,000 feet of Permian strata in a horizontal distance of about 10 miles (Baker and Williams, 1940). Newell and Kummel (1942) demonstrated an unconformity between the Phosphoria and Dinwoody formations in southwestern and central Wyoming. They gave as evidence: (1) The marked

leaching of cherty beds at the top of the Phosphoria formation, (2) marked northeastward overlap of the lower Dinwoody strata by upper Dinwoody on the surface of the Phosphoria from southwestern to central Wyoming, and (3) the discovery by Alfred Fischer that upper beds of the Phosphoria are locally truncated by basal beds of the Dinwoody formation. In the same general area, Love (1939, 1948) also noted local evidence of unconformity at the boundary between the Phosphoria and Dinwoody formations and reported that the discordance is apparent only in regional studies.

In southeastern Idaho in the uppermost Phosphoria the shale is black and in some places phosphatic. The upper shale member of the Phosphoria and the lower shale member of the Dinwoody are seldom well exposed; but where they do crop out, the contact, which does not suggest a hiatus, appears to be gradational. If the top of the Phosphoria is of the same age in southeastern Idaho as in northern Utah, the Woodside and Dinwoody formations are probably the time equivalents of each other and intertongue at their margins. Because there are few fossils in the Woodside formation, it will be necessary to rest heavily on the age of the upper part of the Phosphoria formation to determine its exact time span.

The Dinwoody formation in southwestern Montana is similar to that in Idaho and intertongues with the Woodside formation to the east and north. Moritz (1951), quoting Sloss, suggests that the basal beds of the Dinwoody in southwestern Montana may be upper Permian. Moritz further adds:

> It is therefore suggested that these beds may represent the time interval that appears to be missing; thus, there may have been a period of continuous sedimentation from upper Permian to lower Triassic time, accounting for the lack of a recognizable unconformity.

In the same area of southwestern Montana the writer has found lower Scythian amonites and *Claraia* within 5 feet of the Phosphoria formation. Throughout the Middle Rocky Mountains, fossils are not abundant in the lower part of the Dinwoody formation, but it is not uncommon to find poorly preserved specimens of ceratites, *Anodontophora* and *Claraia*, which are typical Early Triassic fossils.

In summary, the regional picture of the Dinwoody formation is as follows. Along an arcuate belt from southwestern Montana, the Idaho-Wyoming boundary, and swinging westward in northern Utah, an intertonguing sequence of nonred Dinwoody and red Woodside formations lies between the Permian Phosphoria formation and the Thaynes formation. West of this arcuate belt the percentage of red Woodside rocks decreases rapidly, and east and south of it the red Woodside thickens rapidly and only a small part of the nonred Dinwoody formation is present in central Wyoming and none at all in the Wasatch and Uinta Mountains, Utah. (See pl. 35.) The contact with the Phosphoria formation in southwestern Montana and southeastern Idaho is conformable. No physical evidence of a hiatus has been recognized. In southwestern and central Wyoming and the southern Wasatch Mountains, Utah, there is evidence of an unconformity between the Dinwoody and Phosphoria formations.

### WESTERN WYOMING

In the Owl Creek and Wind River Mountains the Dinwoody formation ranges in thickness from 40 to 120 feet. The formation is about 120 feet thick at Green River Lakes; 235 feet at Gros Ventre Canyon; 320 feet at Bear Gulch, Hoback Canyon, Hoback Mountains; 370 feet at Phillips Pass, Teton Range; 430 feet near the junction of Martin Creek and Snake River, Wyoming Range; 440 feet along North Piney Creek, Wyoming Range; 735 feet at MacDougals Pass, Salt River Range; 660 feet in Swift Creek Canyon, Salt River Range; 575 feet at Turner Canyon, Sublette Ridge; 540 feet at Cokeville, Sublette Ridge (Newell and Kummel, 1942), and 180 feet along Muddy Creek, Lincoln County, Wyo. (H. D. Thomas, personal communication).

Newell and Kummel (1942) recognized three major lithologic units in the Dinwoody formation that could be traced over a wide area, and referred to them as the basal siltstone, the *Lingula* zone, and the *Claraia* zone. The basal siltstone unit is really a silty limestone and will be called here the basal, silty limestone unit. This unit consists of buff to tan, silty limestone or calcareous siltstone and is present only along the most western part of Wyoming in the Teton Range, the Wyoming Range, the Salt River Range, and at Sublette Ridge. The unit is 50 to 175 feet thick, being thickest in the southern exposures. In the areas east of the Wyoming Range the basal, silty limestone unit is absent and apparently is overlapped by the *Lingula* beds, which extend farther toward the east.

Overlying the basal silty limestone of the Dinwoody formation is the *Lingula* zone, a heterogeneous unit of silty limestone, gray crystalline limestone, and olive-buff to gray shales. The unit is distinguished by the abundance of well-preserved specimens of *Lingula;* the Lingulas occur both above and below this zone but not as abundantly. The *Lingula* zone reaches a maximum observed thickness in the vicinity of Afton, Wyo., where it ranges in thickness from about 250 to 350 feet. Toward the north and east, it thins progressively; and in the Hoback, Gros Ventre, Owl Creek, and Wind River

Mountains, it rests directly on the Phosphoria formation. Throughout its eastern area of outcrop, the *Lingula* zone is commonly only 25 to 50 feet thick.

The *Claraia* zone, the uppermost unit of the Dinwoody formation, is the most extensive of the three units. It is characterized by tan calcareous siltstone, silty limestone, gray crystalline limestone, and a few beds of shale. The calcareous siltstone and gray crystalline limestone appear to grade into each other along the strike. This unit of the Dinwoody commonly contains abundant molds of species of *Claraia* and *Anodontophora*. In the Salt River and Wyoming Ranges the *Claraia* zone is 200 to 300 feet thick; in the Wind River Mountains this unit is as much as 100 feet thick. In the southeastern part of the Wind River Mountains, as at Hidden Anticline, 12 miles southeast of Lander, Wyo., the beds of the *Claraia* zone lie directly on the Phosphoria formation, and the lower units of the Dinwoody are missing, apparently because of nondeposition (Newell and Kummel, 1942). The eastward overlap of the Dinwoody is illustrated in figure 19 and plate 35.

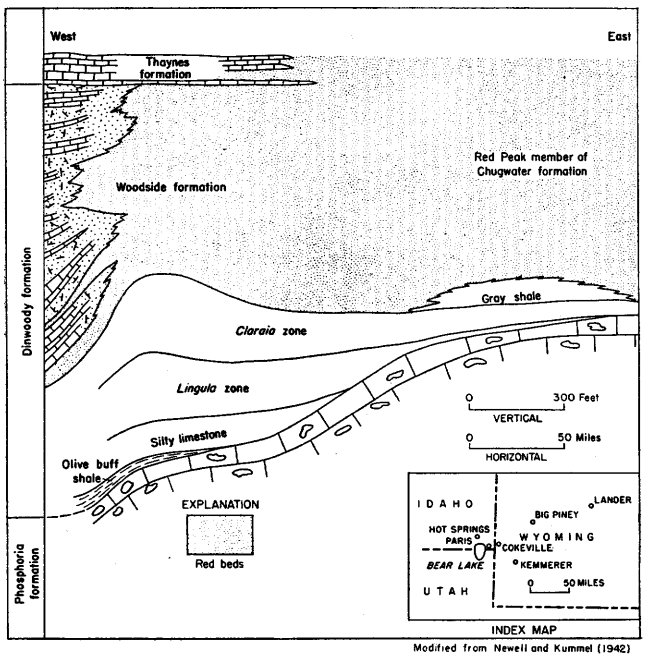


FIGURE 19.—Diagram showing northeastward overlap of Triassic formations on Permian formations in Idaho and Wyoming. Modified from Newell and Kummel (1942).

## SOUTHEASTERN IDAHO

The Dinwoody formation is much thicker in southeastern Idaho than in Wyoming. It is 775 feet thick at Hot Springs on the east side of Bear Lake, 1,240 feet or more in Paris Canyon in the Bear River Range, west of Bear Lake, Bear Lake Valley; 719 feet in Montpelier Canyon; 2,244 feet in Dry Ridge, near Stewart Canyon; 2,443 feet at Bear Creek Reservoir Mountain, near Henry; 2,000 feet in the Portneuf Quadrangle (Mansfield, 1929); and 1,000 feet in the Fort Hall Indian Reservation (Mansfield, 1927).

The lithologic units of the Dinwoody formation that are recognized in western Wyoming by Newell and Kummel cannot be readily traced into Idaho. The *Lingula* zone and the *Claraia* zones can be recognized in Montpelier Canyon and at Hot Springs. The lowermost part of the formation is mainly a shale sequence. The basal, silty limestone unit of the Dinwoody, so persistent throughout extreme western Wyoming, is not present. Along the eastern margin of Bear Lake Valley, the lower half of the Dinwoody consists of gray shale, silty in part, interbedded with thick beds of tan to olive-drab calcareous siltstone and gray, finely crystalline limestone. The upper half of the formation generally consists of massive beds of olive-buff to blue-gray calcareous siltstone and gray limestone that grade into each other along the strike. The lower shaly portion of the Dinwoody in this region is correlative with the basal, silty limestone and part of the *Lingula* zone of western Wyoming. At both Montpelier Canyon and at Hot Springs, the Dinwoody is overlain by the red Woodside formation.

West of Bear Lake in the Bear River Range the Dinwoody formation is overlain by the Thaynes formation. Only two small tongues of red shale are present, one 50 feet thick and approximately 300 feet above the Phosphoria formation and the other 20 feet thick and about 125 feet above the lower red shale. These two red zones represent tongues of the red Woodside formation. The remainder of the Dinwoody in this area consists of an alternation of buff to gray calcareous siltstone and gray, finely crystalline limestone. Fossils are present throughout the sequence, though they are generally poorly preserved.

North of the Bear Lake Valley in the Aspen Range and in Dry Ridge, the Dinwoody formation is more than 2,000 feet thick. It is underlain by the Phosphoria formation and overlain by the Thaynes formation. Less than 20 feet of maroon and chocolate shales in thin interbedded units are present 1,300 feet above the base in the Dry Ridge section (pl. 36). At Wood Canyon, Aspen Range, there is a 40-foot bed of chocolate and maroon shale and siltstone in the Dinwoody, 250 feet below its contact with the Thaynes. The sections at Dry Ridge and Wood Canyon display a twofold division of the Dinwoody with a predominantly shale sequence in the lower half and a calcareous siltstone and gray limestone sequence in the upper half.

The thickest section (2,443 feet) of the Dinwoody formation known is at Bear Creek, Reservoir Mountain,

near Henry, Idaho, where no red beds are present (Newell and Kummel, 1942). The lithologic sequence is similar to that at Wood Canyon and Dry Ridge, except for the presence of more shales in the upper part of the formation. In the Fort Hall Indian Reservation, the Dinwoody is composed of approximately 1,000 feet of shale, thin beds of limestone, and calcareous siltstone (Mansfield, 1927). No red beds are present. It is significant to note that this most western exposure is less than half the thickness of the formation at Henry, Idaho, or Dry Ridge.

### SOUTHWESTERN MONTANA

The lithologic character of the Dinwoody formation in southwestern Montana is similar to that in southeastern Idaho (pl. 37). Most sections are incomplete, however; for the Dinwoody at many localities is overlain uncomformably by the Lower Cretaceous Kootenai formation. The Dinwoody measures 639 feet in thickness at Trapper Creek (Newell and Kummel, 1942); 703 feet at Greenstone Gulch northwest of Dillon, Mont.; 945 feet at Dalys Spur; 893 feet at Small Horn Canyon; 1,000 feet at Little Water Canyon; 483 feet at Blacktail Creek; 62 feet at Cinnabar Mountain (Newell and Kummel, 1942); and 268 feet at Indian Creek, Madison County, (Gardner and others, 1946).

Sections of the Dinwoody formation measured thus far have a general twofold division—a lower shale unit and an upper unit of interbedded calcareous siltstone, silty limestone, and gray crystalline limestone with some interbedded gray to buff shale. Moritz (1951) recognized the twofold division of the Dinwoody formation in southwestern Montana and called them the "Shale member" and the "Limestone member" of the Dinwoody formation. The lower shale unit is 200 to 300 feet thick in the more western exposures. Along the west fork of Blacktail Creek, the lower shale contains a great amount of interbedded, gray crystalline limestone. At Little Water Canyon, Small Horn Canyon, Dalys Spur, Greenstone Gulch, and Trapper Creek, the lower shale unit contains thin-bedded calcareous siltstone and a few beds of gray limestone. In the upper unit of the Dinwoody formation at Dalys Spur, Small Horn Canyon, and Little Water Canyon, there are some thin intercalated beds of red shale and siltstone. These are interpreted as the featheredge of tongues of the Woodside formation. The thick shale at the top of the Dinwoody at Dalys Spur and at Small Horn Canyon is dark green and noncalcareous, quite unlike other shale beds of the formation.

The section of Triassic (?) undifferentiated rocks measured by T. A. Hendricks and H. D. Hadley (see Gardner and others, 1946) along Indian Creek, Madison County, Mont., appears to belong to the Dinwoody formation, judging from the published description. The section here is 268 feet thick and is composed of interbedded, calcareous siltstone and fine- to medium-grained sandstone with some interbedded, sandy limestone and shale. The upper part of the section is gypsiferous. At Devils Slide, Cinnabar Mountains, just north of Gardiner, Montana, where Newell and Kummel (1942) measured, the Dinwoody formation is 62 feet thick. Here the Dinwoody consists mainly of olive-green, silty shale with thin beds of gypsum; the upper 10 feet is olive-green sandstone, siltstone, and a thin bed of limestone. The formation is overlain by red shale and sandstone of the Red Peak member of the Chugwater formation.

The Dinwoody formation at Trapper Creek and Dalys Spur is overlain disconformably by the Kootenai formation. At Greenstone Gulch it is overlain by the Woodside. At Hogback Mountain, Odell Canyon, and Fossil Creek, the Dinwoody is overlain by the Woodside formation. In Little Water Canyon the Dinwoody is overlain by the Thaynes formation.

## WOODSIDE FORMATION

Boutwell (1907) named the Woodside from Woodside Gulch in the Park City mining district, northeastern Utah. In the type area the formation consists of approximately 1,000 feet of maroon and red, shaly siltstone and is barren of fossils. It overlies the Phosphoria formation and underlies the Thaynes formation. The Woodside formation extends over a wide area in northern Utah, western Wyoming, and southwestern Montana; it tongues out westward in southeastern Idaho and southwestern Montana into the Dinwoody formation. The regional relations of the Woodside formation with the Dinwoody formation has been discussed above in the chapter on the Dinwoody formation.

### SOUTHEASTERN IDAHO

The Woodside formation in southeastern Idaho is well developed along the east side of Bear Lake Valley, and at Hot Springs the Woodside is 800 feet thick, of which about half is red shales and siltstone. (See pl. 36.) The red beds are rather evenly distributed throughout the 800 feet of the formation. At Montpelier Canyon the Woodside is about 390 feet thick, of which approximately half is red beds; the nonred rocks are concentrated more toward the middle of this section. The Dinwoody formation is probably the time equivalent of the lower part of the Woodside in its type area (Newell and Kummel, 1942). The red beds above the Din-

woody in southeastern Idaho can be regarded as northwestward tongues of the Woodside.

West of Bear Lake in Paris Canyon in the Bear River Range, there is only a 70-foot thickness of red beds, in two separate units, which represent the featheredges of the tonguing Woodside formation. This same condition is present in Dry Ridge and at Wood Canyon, where only a few thin red zones are present in the Dinwoody formation. At Bear Creek, Reservoir Mountain, near Henry, no red beds are present in the Dinwoody. There are, likewise, no red beds in the Dinwoody in the Portneuf Quadrangle or at Fort Hall.

### WESTERN WYOMING

In the Teton Mountains, Salt Ridge Range, Wyoming Range, and Sublette Ridge, all in western Wyoming; the Woodside formation is made up almost entirely of red shales and siltstone. Thin nonred beds are found at only a few localities in Sublette Ridge and the Salt River Range. In Sublette Ridge the Woodside is about 490 feet thick at Cokeville and 565 feet at Turner Canyon. In the Salt River Range the Woodside is about 710 feet thick at Swift Creek Canyon and 670 feet at MacDougals Pass. In the Wyoming Range the Woodside is 695 feet thick at North Piney Creek and 680 feet at Martin Creek. Gardner (1944, p. 8) records 1,130 feet of Woodside on a ridge between Palisade and Trail Creeks, near the notheast corner of the Irwin Quadrangle. In the Snake River Range along Red Creek the Woodside is about 470 feet thick (H. R. Wanless, personal communication). In Bear Gulch, Hoback Canyon, Hoback Mountains, the Woodside is 645 feet thick; and in Gros Ventre Canyon, north west of Gros Ventre slide, the Woodside is 555 feet thick.

In central Wyoming the Dinwoody is overlain by red shales and siltstones belonging to the Red Peak member of the Chugwater formation. This member has the same lithologic character as the Woodside, but it is equivalent to only the upper half of the type Woodside.

### SOUTHWESTERN MONTANA

Formations of Triassic age in southwestern Montana are generally overlain disconformably by formations of the Jurassic Ellis group or by the Cretaceous Kootenai formation. Northwest of Dillon, at Greenstone Gulch, 165 feet of red Woodside is present. The Dinwoody formation at Dalys Spur, Small Horn Canyon, and Little Water Canyon contain several thin, intercalated red shale and siltstone beds that represent the featheredges of tongues of the Woodside formation. At Hogback Mountain, Snowcrest Range, the Woodside is 610 feet thick and is overlain by the Thaynes formation. Along Fossil Creek, Gravelly Range, the Woodside measures 400 feet. In the Centennial Range along Odell Creek, the Woodside is approximately 800 feet thick (G. C. Kennedy, personal communication).

### NORTHERN UTAH

Throughout the Wasatch and Uinta Mountains of northern Utah, the Woodside formation is composed almost entirely of red beds; only a few thin nonred beds are present. The Woodside is 385 feet thick in the Fort Douglas area (A. E. Granger, personal communication). In the Park City mining district, Boutwell (1907) records 700 feet of Woodside, and at Big Cottonwood Canyon he measured 1,180 feet. Baker (1947) measured 315 feet of Woodside at Deer Creek west of Charleston and 150 feet at Spanish Fork near Thistle.

In the Uinta Mountains the Woodside ranges from 500 to 800 feet in thickness (Thomas and Krueger, 1946). Eastward along the Uinta Mountains the red color gives way in places to tan, or olive-drab beds. In the eastern part of these mountains the red beds of the Woodside grade downward into red beds contemporary with those of the Park City (Thomas and Krueger, 1946) and are commonly included in the Moenkopi formation.

### THAYNES FORMATION

The Thaynes formation was described by Boutwell (1907) from outcrops in Thaynes Canyon, Park City mining district, Utah. In the type region, the Thaynes formation consists of 1,190 feet of limestone, calcareous sandstone, sandstone, shale, and, in the middle, a red shale member. At the type locality, the Thaynes is underlain by the Woodside formation and overlain by the Ankareh formation. The Thaynes formation is found over a wide area in northern Utah, eastern Idaho, western Wyoming, and southwestern Montana. Along its southern, eastern, and northern margins it intertongues with the red Ankareh formation or the Chugwater formation. The thickest development of the Thaynes is in the Fort Hall Indian Reservation. No red beds are present in this section. The Thaynes in southeastern Idaho is diffierentiated into several lithologic units, which can be traced over a wide area. In southwestern Montana, in most of western Wyoming, and in northern Utah, the lithology of the Thaynes formation is more homogeneous.

The base of the Thaynes formation throughout eastern Idaho is a prominent limestone bed containing an abundant ammonite fauna characterized by *Meekoceras*. This same fauna is found in the Wasatch Mountains, Utah, and in southwestern Montana. In western

Wyoming the limestone with *Meekoceras* is present in the Salt River Range and Sublette Ridge. In the Wyoming Range and Teton Range, the lower limestone with *Meekoceras* is not present and that horizon is occupied by red beds of the Woodside formation. The eastward thinning of the Thaynes formation in western Wyoming takes place by lateral change into the lithology of the underlying Woodside formation and the overlying Ankareh formation. The Thaynes formation completely disappears east of the Wyoming Range. In the Fort Douglas area of northern Utah, the Thaynes formation consists of a thick, normal marine succession. Eastward along the Uinta Mountains, the Thaynes formation thins and passes rapidly into the red Ankareh and the Woodside formations. Thus, the regional relationship of the Thaynes formation is very similar to that of the Dinwoody formation except that the boundary area between the red facies and the marine facies goes south from eastern Idaho through the Wasatch Mountains, Utah, rather than westward in northern Utah as for the Dinwoody formation.

The Thaynes is the most fossiliferous formation of Triassic age in the Middle Rocky Mountains. Several distinct ammonite zones are recognized, which are present only in the thicker geosynclinal sections. In the areas where the Thaynes thins and red beds intertongue, the ammonites are generally not present. Smith (1932) recognized three ammonite zones in the Thaynes formation; these are in ascending order the *Meekoceras*, *Tirolites*, and *Columbites* zones. Mathews (1929) described from the Fort Douglas area of Utah, a fauna which is present just above the *Meekoceras* zone that is referred to the *Anasibirites* zone. This zone is also present in southeastern Idaho. A new and highly important zone, the *Prohungarites* zone, is present above the *Columbites* zone in the upper part of the Thaynes formation in the Bear River Range.

### SOUTHEASTERN IDAHO

Mansfield (1927) defined the limits of the Thaynes formation in southeastern Idaho as including all the strata between the base of the limestone, which contains *Meekoceras*, and the Timothy sandstone. Most stratigraphers have followed this procedure. Because the Timothy is lithologically related to the Thaynes formation and appears to be gradational to the Thaynes, it is here considered as the uppermost member of the Thaynes formation. The Timothy sandstone member typically consist of approximately 250 feet of yellowish to grayish sandstone. It attains a maximum thickness of 800 feet in the Fort Hall Indian Reservation and thins rapidly eastward toward Wyoming. The Timothy sandstone member is comformable on the Portneuf limestone member of the Thaynes formation. The Portneuf member contains numerous beds of calcareous sandstone and sandy limestone, and in Grays Range it appears to grade into the Timothy sandstone member. However, Mansfield (1927, p. 91) has reported limestone pebbles, possibly derived from the Thaynes, in the Timothy in Home Canyon near Montpelier, Idaho. The Timothy sandstone member is unconformably overlain by the Higham grit.

The Thaynes is well developed in the area between the Fort Hall Indian Reservation and Bear Lake. Within this area of outcrop, several distinct lithologic members are traceable, and there are considerable changes of facies from the southeast to the north and northwest. The thickest section of the Thaynes was measured in the Fort Hall Indian Reservation. The same sequence of facies present at Fort Hall can be traced eastward to Grays Range, south of Grays Lake. In the area along the eastern side of Bear Lake Valley toward Sublette Ridge in western Wyoming, a quite different sequence of facies is encountered. A third and unique facies development is found in the Bear River Range west of Bear Lake. The Thaynes formation and the interrelation of facies as developed in southeastern Idaho will be discussed in terms of exposures in these three areas.

### FORT HALL INDIAN RESERVATION TO GRAYS RANGE

Mansfield (1916) raised the Thaynes formation to the rank of a group and subdivided it into three formations, which in ascending order are the Ross Fork limestone (called the Ross limestone in Mansfield's paper of 1916), the Fort Hall formation, and the Portneuf limestone. In the area between Fort Hall and Grays Range, these three divisions of the Thaynes are distinctive. Eastward toward the Salt River Range and southward toward the Bear Lake Valley, the Ross Fork and Fort Hall formations lose their identity, although the broad relationships of the various facies of Mansfield's Ross Fork and Fort Hall formations with units of the Thaynes recognized around Bear Lake have been established. The Portneuf limestone is a much more distinctive unit, however, and parts of it can be traced from Fort Hall, Idaho, to Cumberland, Wyo. It is thought best to retain the name Portneuf limestone for a member of the Thaynes formation but not to use in the present paper the names Ross Fork and Fort Hall, as those two units have a very limited distribution. The Timothy sandstone is here considered to be the uppermost member of the Thaynes formation.

The Thaynes formation is about 5,525 feet thick at Fort Hall and 3,550 feet along Sheep Creek, Grays Range. Seven major lithologic units are present in

both of these sections (pl. 38). In the Sheep Creek section there is a prominent tongue (Lanes tongue) of the red Ankareh formation in the upper part of the Thaynes that pinches out westward toward Fort Hall, where there are no red beds in the Thaynes formation. The lithologic units from bottom to top are as follows: (a) Lower limestone, (b) lower black limestone, (c) tan silty limestone, (d) upper black limestone, (e) sandstone and limestone, (f) the Portneuf limestone member, and (g) the Timothy sandstone member. The lower limestone, lower black limestone, tan silty limestone, and the upper black limestone units of the Thaynes formation of Fort Hall and Grays Range comprise the Ross Fork formation of Mansfield and the sandstone and limestone unit (e) is the Fort Hall formation of Mansfield.

*Lower limestone.*—The lower limestone unit of the Thaynes formation is present throughout southeastern Idaho, southwestern Montana, extreme southwestern Wyoming, and in the Wasatch Mountains, Utah. It is a gray crystalline limestone with a large ammonite fauna of the *Meekoceras* zone. The lower limestone is 187 feet thick at Fort Hall and 100 feet at Sheep Creek. At Sheep Creek this limestone unit contains several silty beds and some shale in its lower part.

*Lower black limestone.*—Overlying the lower *Meekoceras*-bearing limestone is a thick unit of limestone, calcareous siltstone, and shale, generally dark gray to black. The strata are thin and contain some zones of nodular and lenticular black limestone. At Fort Hall this unit is 680 feet thick and poorly exposed; at Sheep Creek, however, where the unit is 600 feet thick, the exposures are good. Poorly preserved ammonites were found near the base of the unit at both localities and at scattered horizons throughout the unit. At Sheep Creek a fragment of a *Columbites* sp. was found 250 feet from the top of the unit.

*Tan silty limestone.*—This lithologic unit consists of gray and gray-brown, silty limestone and calcareous siltstone that weathers tan and generally slabby. Fossils are very poorly preserved and are not abundant. Along Sheep Creek, where the unit is 655 feet thick, very fine exposures occur; at Fort Hall the unit is 785 feet thick and poorly exposed. The lithology of this unit is very characteristic of formations of Triassic age in the Middle Rocky Mountains.

*Upper black limestone.*—In the Fort Hall area the tan silty limestone beds are overlain by 865 feet of a homogeneous unit composed of silty, black to blue-black limestone, alternating with irregular-bedded, silty, gray-black limestone. Along Sheep Creek this unit consists of 295 feet of gray-brown to black calcareous siltstone, shale, and limestone. No fossils were observed in these beds at Fort Hall, but a few poorly preserved ammonites and pelecypods were found at Sheep Creek. Preliminary examination of these very fragmentary specimens indicate affinities with the ammonite fauna of the upper part of the Thaynes formation in the Bear River Range area west of Bear Lake.

*Sandstone and limestone.*—This unit includes all the beds placed in the Fort Hall formation by Mansfield. It is about 480 feet thick at Fort Hall and 475 feet along Sheep Creek. The sandstone and limestone unit consists of gray limestone, cherty in part, tan to gray-brown calcareous sandstone, and siltstone. The upper contact with the Portneuf limestone member is gradational and somewhat difficult to define in the field. The unit is more brownish than the Portneuf member and is not generally massively bedded like the overlying Portneuf member.

*Portneuf limestone member.*—The most conspicuous unit of the Thaynes formation in the area between Fort Hall and Grays Range is the Portneuf limestone member. At Fort Hall it is 1,730 feet thick and composed dominantly of massive, gray, finely crystalline limestone containing abundant chert nodules. The limestone is silty and sandy in part, and the member includes some beds of calcareous siltstone and sandstone. Along Sheep Creek the Portneuf limestone member of the Thaynes is 1,170 feet thick and consists of massive, gray, cherty limestone; it is sandy in part and contains some thin interbedded units of calcareous sandstone. The limestone generally contains myriads of poorly silicified fossils. At this locality the Portneuf contains a 440-foot redbed tongue of the Ankareh formation, here named the Lanes tongue. This tongue of the Ankareh is named after Lanes Creek, of which Sheep Creek is a tributary. The best exposures of this tongue are found at the south end of Grays Range, a mile west of the junction of Lanes Creek and Sheep Creek. No redbeds are present in the Portneuf limestone member at Fort Hall.

*Timothy sandstone member.*—The Timothy sandstone member of the Thaynes formation is named from Timothy Creek in the Freedom quadrangle and was originally given formational rank by Mansfield (1920); it typically consists of approximately 250 feet of yellowish to grayish sandstone and is generally not well exposed. In the Fort Hall Indian Reservation the Timothy is about 800 feet thick. The contact with the underlying Portneuf limestone member is conformable. There are several sandstone beds similar to those of the Timothy in the upper part of the Portneuf limestone member in the Grays Range. No fossils have been found in the Timothy sandstone member.

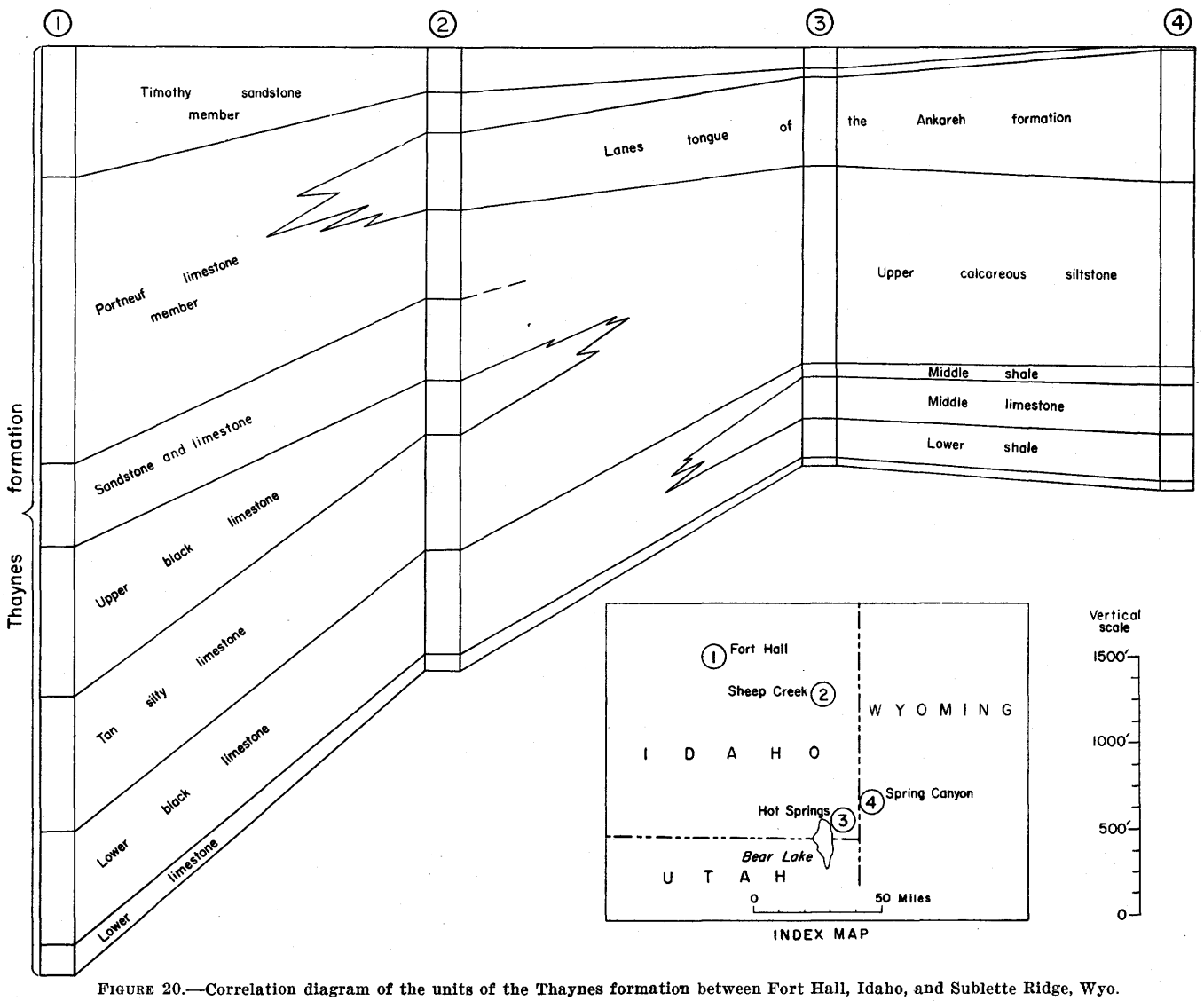


FIGURE 20.—Correlation diagram of the units of the Thaynes formation between Fort Hall, Idaho, and Sublette Ridge, Wyo.

### EASTERN BEAR LAKE TO SUBLETTE RIDGE

Between eastern Bear Lake and Sublette Ridge, eight lithologic units are recognized within the boundaries of the Thaynes formation (Kummel, 1943, 1950). These units, from bottom to top, are the lower limestone, the lower shale, the middle limestone, the middle shale, the upper calcareous siltstone of the Thaynes, the Lanes tongue of the Ankareh formation, the upper part of the Portneuf limestone member of the Thaynes, and the Timothy sandstone member of the Thaynes formation (pl. 39). Complete sections of the Thaynes were measured at Hot Springs, at the northeast corner of Bear Lake, where it is 2,440 feet thick; at Spring Canyon, in Sublette Ridge, where it is 2,560 feet, and at Cokeville, Sublette Ridge, where it is 1,575 feet. The relationships of the lithologic units recognized in the Thaynes in the areas between Fort Hall and Grays Range and between Bear Lake and Sublette Ridge are illustrated in figure 20.

*Lower Limestone.*—The basal unit of the Thaynes formation is a grayish-blue to gray, massive limestone, which weathers gray and contains abundant cephalopods of the *Meekoceras* fauna. Throughout southeastern Idaho the limestone is a prominent stratigraphic marker ranging from 50 to 100 feet in thickness. In the Bear Lake Valley region and in Sublette Ridge, the *Meekoceras*-bearing limestone contains very little clastic material. To the northeast of the Bear Lake Valley region, as at Swift Canyon and at MacDougals Pass, Wyo., the lower limestone includes buff shale and siltstone beds. The quantity of fine clastics intercalated within the limestone increases to the northeast and east of Bear Lake.

At every locality studied, the *Meekoceras* fauna is confined to a 5 to 15 foot zone within the whole lower limestone unit. The remainder of the unit contains no cephalopods, but it does contain pelecypods and lingu-

las. The bed with the cephalopods generally is in the upper third of the lower limestone (Kummel, 1943).

*Lower shale.*—The lower shale unit of the Thaynes formation is seldom well exposed. It is generally represented by a covered interval between the underlying massive beds of the lower limestone and the overlying middle limestone. In Spring Canyon, Sublette Ridge, 287 feet of well-exposed dark-gray, silty limestone is assigned to this unit. At Cokeville the unit is 107 feet thick and at Hot Springs 229 feet. Fossils are relatively scarce, but flattened impressions of cephalopods are occasionally found.

*Middle limestone.*—In the Hot Springs, Montpelier Canyon, and Sublette Ridge areas, the first massive scarp above the lower limestone consists of 90 to 400 feet of massive, gray, finely crystalline limestone containing a few interstratified silty beds. The middle limestone is 90 feet thick at Cokeville, Wyo.; 290 feet at Spring Canyon, Sublette Ridge; 230 feet at Hot Springs and 385 feet in the Montpelier Canyon, where the limestone is very silty. This unit contains brachiopods and pelecypods, but in this area no ammonoids have been found.

*Middle shale.*—Throughout the Bear Lake Valley and Sublette Ridge areas, a black shale and shaly limestone unit, containing fossiliferous black limestone concretions, overlies the middle limestone. Cephalopods are the most abundant fossils present; the ammonites belong to the *Columbites* zone of Smith (1932). The middle shale ranges from 80 to 130 feet in thickness in Paris Canyon, Bear River Range; Montpelier Canyon; and at Hot Springs, Idaho. In Sublette Ridge this unit measures about 105 feet in Spring Canyon and only 50 feet at Cokeville. The fauna of the middle shale consists of cephalopods, pelecypods, and fragmentary bones. The concretions contain abundant well-preserved specimens; in fact, many concretions are coquinoid. The enclosing shale also contains the flattened impressions of cephalopods and pelecypods.

*Upper calcareous siltstone.*—This homogeneous unit of silty limestone overlying the middle shale is one of the thickest and most conspicuous units of the Thaynes formation in this area of southeastern Idaho. The unit as a whole is buff and thin to massively bedded and forms long talus slopes of blocky, silty, buff limestone and calcareous siltstone. Fossils are not common. The unit is about 1,000 feet thick in the area between Hot Springs and Sublette Ridge.

In Sublette Ridge approximately 60 to 200 feet of nodular, black, silty limestone immediately overlies the middle shale. Lithologically, these beds appear to be more closely allied to the underlying black shales than to the overlying gray, silty limestones. The nodular limestone facies has not been found in the Bear Lake Valley area, and for the time being it is placed in the upper calcareous siltstone unit.

*Lanes tongue of the Ankareh formation.*—The red shales and siltstones of the Lanes tongue of the Ankareh formation are 508 feet thick at Hot Springs, 745 feet at Spring Canyon, Sublette Ridge, and 200 feet at Cokeville Canyon. In the Spring Canyon section there are several thin, white sandstone beds and a conspicuous 31-foot bed of white, calcareous sandstone, 145 feet above the upper calcareous siltstone unit. West of Bear Lake the upper part of the Thaynes formation, which will be discussed separately, contains no red beds.

*Portneuf limestone member.*—At Hot Springs this member of the Thaynes formation consists of 67 feet of massive, gray to blue, crystalline limestone that is cavernous in the lower part and contains brachiopods and pelecypods. The upper 5 feet is massive dark-gray siltstone that weathers to a greenish buff and contains some chert bands. In Spring Canyon, Sublette Ridge, it is 12.5 feet of unfossiliferous olive-gray, massive limestone and olive-buff calcareous siltstone. The same thickness and lithology is found in Cokeville Canyon, Sublette Ridge.

*Timothy sandstone member.*—In Home Canyon about 6 miles east of Montpelier, the Timothy contains conglomeratic layers with limestone pebbles possibly derived from the Thaynes (Mansfield, 1927, p. 91). At Hot Springs along Indian Creek, the Timothy is composed of 125 feet of red siltstone, shale, and sandstone. Here it has more of the appearance of the typical lower part of the Ankareh formation of northern Utah. In Spring Canyon and at Cokeville, in Sublette Ridge, the Timothy is missing, and Higham grit lies on the upper part of Portneuf limestone, Thaynes formation.

### BEAR RIVER RANGE

The top of the 3,500 feet of Thaynes west of Bear Lake in Paris Canyon area of the Bear River Range (pl. 29) is unexposed. The lower limestone with *Meekoceras*, middle shale with *Columbites*, and upper calcareous siltstone in Hot Springs-Sublette Ridge are recognizable here. Above the upper calcareous siltstone, however, there is 1,500 feet of non-red limestone and shale unlike the beds above the middle shale in the Hot Springs-Sublette Ridge area. The top of this sequence is buried under deposits of Cenozoic age, but the beds are at least partially equivalent to the Lanes tongue of the Ankareh formation east of Bear Lake and to the upper black limestone, sandstone and limestone, and the Portneuf limestone member of the Thaynes formation in the area between Fort Hall and Grays Range. These upper beds of the Thaynes

formation in the Paris Canyon area were discovered and differentiated by V. E. McKelvey of the U. S. Geological Survey in the course of geologic mapping in 1943.

The lower limestone of the Thaynes is 116 feet thick and lithologically identical with the exposures of this unit east of Bear Lake. The lower shale and middle limestone units of the Hot Springs area are not readily distinguishable. On the west bluff of Bear River, 2.25 miles west of Georgetown, Idaho, the lower part of the lower shale is well exposed and consists of black shale containing black limestone concretions and lenses, which are very fossiliferous. The ammonites present are similar to those from Fort Douglas, Utah, described by Mathews (1929) and belong to the *Anasibirites* zone of the Scythian series (Spath, 1934). Between the lower limestone and the middle shale with *Columbites* in the Paris Canyon area is 1,000 feet of gray to black limestone, nodular in part. The lower 300 feet of this sequence is not exposed and is probably shaly. The overlying 320 feet is dark-gray to gray-buff, fissile, thin-bedded limestone containing impressions of cephalopods. The overlying beds are gray to black limestone, nodular in part, containing cephalopods belonging to the *Tirolites* fauna of Smith (1932). The upper 35 feet of this unit is gray, finely crystalline limestone containing myriads of *Pugnoides triassicus*. None of this sequence, except possibly the upper 35 feet, is lithologically similar to the middle limestone unit that is so well developed east of Bear Lake. The middle limestone unit appears to tongue out westward, as it does northward toward Sheep Creek, into the lower black limestone of that section. The middle shale is 130 feet thick and identical with the exposures east of Bear Lake. The upper calcareous siltstone is similar to that unit as exposed at Hot Springs.

Overlying the upper calcareous siltstone unit is 1,500 feet of beds that are completely unlike any other beds in the upper part of the Thaynes formation known elsewhere in southeastern Idaho. Only part of this unit is well enough exposed to permit detailed study and measurement. The sequence does not seem to be complicated by faults or folds, and the thicknesses seem correct. The lowest 400 feet consists of gray, shaly limestone, in the lower part grading to olive-gray and gray-brown shales containing several thin limestone beds in the upper part. These lower beds contain abundant cephalopods and pelecypods. This lower unit is overlain by 450 feet of gray, argillaceous limestone, part of which is nodular and fossiliferous. The uppermost part, 650 feet, consists of gray, massive, finely crystalline limestone, which is silty in part. Approximately 160 feet above the base of this upper unit is a 25-foot bed of white, mottled sandstone, medium to massively bedded. The upper 350 feet of this unit is poorly exposed, and only isolated pieces of limestone were found. The only fossils found throughout the exposed portion were pelecypods.

The ammonoids present in the lower half of this 1,500-foot sequence are particularly diagnostic because of the presence of *Prohungarites*, a ceratite previously only known from Timor and possibly the Himalayas. Spath (1934) named his highest division of the Scythian after this genus. The writer has previously referred this ceratite to *Arctoceras* (Kummel, 1950).

### WESTERN WYOMING

The Thaynes formation exposed in Sublette Ridge is identical in character and lithologic units with that recognized around Bear Lake Valley, Idaho. Southeast of Sublette Ridge, along Muddy Creek, just west of Cumberland, the Thaynes consists of 1,165 feet of limestone, mostly silty and sandy, interbedded with fine-grained sandstone (H. D. Thomas, personal communication). This section is overlain by about 285 feet of red shale and sandstone, which is the Lanes tongue of the Ankareh formation. Overlying the Lanes tongue is a 3-foot bed of dense, finely crystalline, gray limestone, which is thought to be a tongue of the upper part of the Portneuf limestone member of the Thaynes formation (pl. 39). The lithology of the Thaynes section at Muddy Creek is more homogeneous in character than the Thaynes in southeastern Idaho and in Sublette Ridge.

North of Sublette Ridge in Swift Creek Canyon, Salt River Range, the Thaynes formation is about 1,385 feet thick (pl. 38). The lower two-thirds of the section consists of alternating beds of gray, massive limestone and calcareous siltstone. The gray limestone beds form massive vertical walls in the canyon, and the calcareous siltstone beds form the depressions between these walls. The upper third of the formation is calcareous siltstone with which a few thin gray, finely crystalline limestones are interbedded. The Thaynes formation is overlain by 775 feet of red beds of the Ankareh formation. The *Meekoceras* fauna occurs in the basal limestone unit 135 feet above the Woodside formation. The upper part of the Portneuf limestone member of the Thaynes formation at Sheep Creek, Grays Range, Idaho, tongues out eastward toward the Salt River Range. The Thaynes formation at Swift Creek is equivalent to the beds extending from the lower part of the Portneuf limestone member to the lower limestone with *Meekoceras* at Sheep Creek. The numerous lithologic units recognized in the Thaynes in Idaho cannot be distinguished in this part of western Wyoming. In the Wyoming Range near the head-

waters of Middle Piney Creek the Thaynes formation is approximately 1,000 feet thick and lithologically similar to the section at Swift Creek. The *Meekoceras* fauna is not present at the base of the formation. In fact, no cephalopods were found in the Thaynes formation in this area. No unfaulted section was found where detailed measurements of the formation could be made.

H. R. Wanless (personal communication) measured 1,157 feet of the Thaynes formation in the Snake River Range at Wolf Creek and at Red Pass. The section is similar to that at Swift Creek and at Middle Piney Creek. The formation consists entirely of an alternating sequence of limestone, calcareous siltstone, and sandstone. No cephalopods have been found in the Thaynes formation in this locality. The Thaynes formation is 645 feet thick at the drainage divide between the headwaters of Buck Creek and Adams Creek, about a mile northwest of Ramshorn Peak, Hoback Range. The lower 118 feet consists of sandy and silty, gray limestone with a 3-foot red shale in the middle. This is overlain by 243 feet of red shale and siltstone which is a westward tongue of the Chugwater formation. The upper 283 feet consists of gray sandstone, limestone, and siltstone. The Thaynes formation here is overlain by approximately 700 feet of red shale and siltstone of the Ankareh formation (H. R. Wanless, personal communication).

Near the northeast corner of the Irwin Quadrangle, the Thaynes formation is 1,000 feet thick (Gardner, 1944). The formation consists of a gray limestone and calcareous sandstone, 80 feet thick at the base, overlain by 295 feet of red shale and sandstone and a few gray sandy limestone beds, and finally 625 feet of sandy, gray limestone and calcareous sandstone. In the Gros Ventre Canyon the interval of 400 feet between the Woodside formation and the Nugget sandstone is mostly red shale and siltstone (Newell and Kummel, 1942). There are, however, at the base and near the middle of this red sequence, thin beds of gray limestone and shale that appear to be tongues of the Thaynes formation extending eastward into the Chugwater formation.

### SOUTHWESTERN MONTANA

Pre-Jurassic erosion in southwestern Montana has removed much of the formations of Triassic age so that most sections are incomplete and unconformably overlain by the Jurassic Ellis group or the Cretaceous Kootenai formation. Few thick sections of the Thaynes formation and no Ankareh formation appear to be present in this area. Rather well-exposed but incomplete sections of the Thaynes formation were measured at Little Water Canyon, west of Dell, and in Hogback Mountain near the Notch Ranger Station. Thin incomplete sections are also present in Odell Canyon, Centennial Range, and along Fossil Creek in the Gravelly Range. The most striking character of the Thaynes in southwestern Montana is the predominance of calcareous sandstone (pl. 37).

In Little Water Canyon 680 feet of the Thaynes formation is overlain unconformably by sandstones of the Ellis group. The lower 109 feet of this section consists of gray, finely crystalline limestone interbedded with silty and sandy limestone. Approximately 90 feet above the base of the Thaynes are ammonites belonging to the *Meekoceras* fauna. This lower limestone of the Thaynes formation is overlain by 218 feet of grayish-white to tan calcareous, fine-grained sandstone. The upper 355 feet consists of an alternating sequence of gray, finely crystalline limestone, with numerous chert nodules in parts, and calcareous sandstone and siltstone. Ammonites are present only in the lower part of this section. Pelecypods, brachiopods, and columnals of *Pentacrinus* are sparse throughout the section. Moritz (1951) recognized the threefold lithologic divisions of the Thaynes formation in this part of southwestern Montana and named them the "Lower limestone member," the "Sandstone member," and the "Upper limestone member." Fossil evidence is not yet available to correlate these units of the Thaynes with those recognized in southeastern Idaho.

At Hogback Mountain in the Snowcrest Range, 610 feet of Thaynes formation is unconformably overlain by the Kootenai formation. Here the Thaynes formation is almost entirely fine to medium grained, gray to buff, calcareous sandstone; but it contains several thin beds of gray limestone, sandy limestone, and shale. Two red sandstone beds and several that are mottled red are present in the section. Pelecypods are the only common fossils in this 610-foot section. Along Odell Creek, Centennial Range, 145 feet of silty limestone with numerous chert nodules in the upper part is assigned to the Thaynes.

### CENTRAL WASATCH AND UINTA MOUNTAINS

The Thaynes formation is well developed in the Fort Douglas Military Reservation in Salt Lake City, Utah. Eastward along the Uinta Mountains and southward toward Provo, Utah, the Thaynes intertongues with the Ankareh formation and ultimately disappears completely. At Fort Douglas the Thaynes is about 1,930 feet thick and consists of gray limestone, shale, and calcareous sandstone (A. E. Granger, personal communication). In the Park City mining district, the type locality of the Thaynes, it consists of 1,190 feet of limestone, calcareous sandstone, sandstone, shale and a mid-

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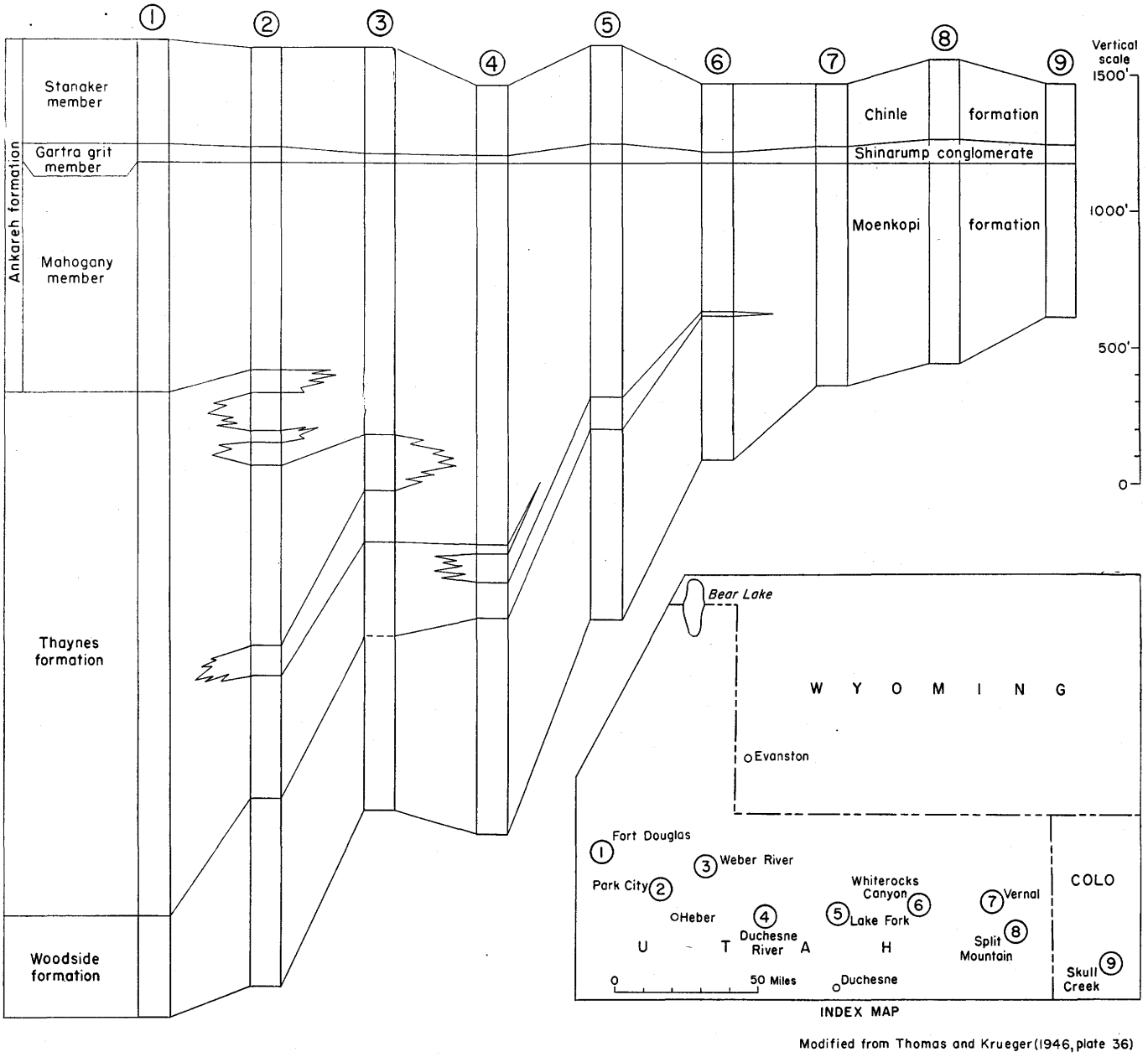


FIGURE 21.—Correlation of formations of Triassic age along the south flank of Uinta Mountains, Utah and Colo. Modified from Thomas and Krueger, 1946, fig. 5.

dle red shale unit (Boutwell, 1907). The lower 375 feet of the Ankareh formation of Boutwell contains intercalated beds of gray sandstone and grayish-blue limestone. These nonred strata are eastward-extending tongues of the Thaynes in the Ankareh formation (fig. 21 and pl. 40).

Along the Weber River, in the western Uinta Mountains, the Thaynes formation is approximately 750 feet thick and has a 190-foot red shale and sandstone unit just above the middle. Above and below this red unit, the Thaynes consists of gray limestone, sandy limestone, and calcareous siltstone. The red unit is correlated with the middle red unit of the section at Park City and represents a westward-extending tongue of the Ankareh formation. Along the Duchesne River, north of Hanna, Utah, the Thaynes is 270 feet thick and appears to be correlative with the lower nonred unit of the Thaynes at Weber River. The section at Duchesne River likewise contains a 110-foot red shale and calcareous sandstone unit near the top. Along the east side of Lake Fork, in Duchesne County, Utah, the Thaynes is represented by 118 feet of calcareous siltstone and sandstone. In Whiterocks Canyon the Thaynes consists of 12 feet of white sandy limestone

(Thomas and Krueger, 1946). The Thaynes disappears completely between Whiterocks Canyon and Vernal, Utah (Thomas and Krueger, 1946). Throughout the Uinta Mountains the Thaynes contains numerous poorly preserved pelecypods; cephalopods are extremely rare.

At the mouth of Diamond Fork, southeast of Provo, Utah, the Thaynes formation is composed of 1,350 feet of gray limestone, which is generally sandy and cherty in part; sandstone; and shale. Numerous red beds are intercalated. The whole section represents an intertonguing facies of the Thaynes and Ankareh formations.

## POST-THAYNES TRIASSIC

A variable sequence of beds that are generally red lies between the top of the Thaynes formation and the base of the Nugget sandstone throughout western Wyoming, southeastern Idaho, and northern Utah. Boutwell (1907) called these beds, in the Park City district, the Ankareh formation. Although they are still so defined in western Wyoming, they have since been subdivided and named differently in other areas. There has been a great deal of confusion in nomenclature and correlation of these formations.

In the original definition of the Ankareh, Boutwell (107, p. 453) stated that only part of this formation occurs in the Park City district and that the uppermost part was marked by a prominent, massive, white sandstone member. Boutwell (1912) later restricted the Ankareh and included the upper 500 feet of white sandstone with some intercalated reddish shale in Veatch's Nugget formation as redefined by Gale and Richards (1910). A similar procedure was followed by Mathews (1931) and Boutwell (1933) for the central Wasatch Mountains. These authors thus considered the Ankareh to include the red strata from the top of the Thaynes to a prominent "basal conglomerate," (Gartra grit of Thomas and Krueger, 1946) which is associated with red shales they thought to be part of the Nugget.

Thomas and Krueger (1946) reviewed in detail the literature on these post-Thaynes Triassic rocks for the central Wasatch and Uinta Mountains. They proposed a threefold division of this interval into the Ankareh formation, Gartra grit, and Stanaker formation. Williams (1945) proposed using the Idaho terminolgy, Ankareh formation, Higham grit, and Wood shale for the formations in the central Wasatch Mountains and western Uinta Mountains, and the Colorado Plateau terminology, Red Wash formation, Shinarump conglomerate, and Chinle formation, for those in the eastern Uinta Mountains.

Baker (1947) included in the Ankareh all the red strata between the Thaynes and the Nugget formations in the region around Provo, Utah. A. E. Granger (personal communication) followed the same procedure in mapping the area just east of Salt Lake City.

For southeastern Idaho and adjacent parts of Utah and Wyoming, Gale and Richards (1910) used the name Ankareh for red shales lying between the Thaynes and the restricted Nugget formation of Veatch. Schultz (1914) used the name Ankareh for red shale and sandstone lying between the Thaynes and the Nugget formations in Lincoln County, Wyo. This usage is still followed in western Wyoming (W. W. Rubey, personal communication).

In southeastern Idaho the thickest sequence of post-Thaynes Triassic rocks is found in the Fort Hall Indian Reservation. Mansfield (1927) recognized the following formations: Timothy sandstone, Higham grit, Deadman limestone, and Wood shale. These units thin and tongue out eastward toward Wyoming.

As now used the name Ankareh formation is applied to different parts of the post-Thaynes sequence in the Middle Rocky Mountains. In western Wyoming it is applied to all the strata between the Thaynes formation and the Nugget sandstone. In Utah it is applied only to the beds from the Thaynes to the Gartra grit. In Idaho the name Ankareh was abandoned by Mansfield. However, the Gartra grit is probably equivalent to the Higham grit, and the Higham grit is present in western Wyoming in the Ankareh formation. To simplify and clarify the nomenclature of these post-Thaynes Triassic rocks, the Ankareh formation as originally defined by Boutwell to include all the strata between the Thaynes and Nugget formations is here applied in northern Utah and western Wyoming, and all the various formations that have been proposed for parts of this sequence reduced to member rank. In the eastern Uinta Mountains, the Colorado Plateau nomenclature is used following Kinney and Rominger (1947). In southeastern Idaho, the Timothy sandstone is now considered to be the uppermost member of the Thaynes formation. The Higham grit and Deadman limestone are ranked as independent formations, and the Wood shale is considered a westward extending tongue of the red Ankareh formation as used in Wyoming. This plan should lead to more consistency and understanding of this stratigraphic interval. Each of the main areas of outcrop and the units present will be discussed briefly.

### CENTRAL WASATCH MOUNTAINS AND UINTA MOUNTAINS

The red bed sequence between the Thaynes and the Nugget formations in the central Wasatch and Uinta Mountains is divisible into three distinct units. There

is (1) a lower red shale and sandstone, (2) a middle coarse white to pink, conglomeratic sandstone, and (3) an upper red shale and sandstone. Thomas and Krueger (1946) proposed restricting the name Ankareh to the lower red shale and sandstone; they called the conglomeratic sandstone and the overlying red beds the Stanaker formation and named the conglomeratic sandstone the Gartra grit member of the Stanaker formation. Williams (1945) proposed using Ankareh formation, Higham grit, and Wood shale in the central Wasatch and western Uinta Mountains. It does not seem advisable, however, to use the Idaho terminology for this series of beds.

Extending the name Ankareh to include the beds between the Thaynes and the Nugget formations as originally defined by Boutwell necessitates reducing the new names proposed by Thomas and Krueger to member rank. Thus, there would be the Stanaker member and Gartra grit member of the Ankareh formation. The unit referred to the Ankareh, as restricted by Thomas and Krueger (1946) and Williams (1945), will have to receive a new name since the name Ankareh cannot be used both for the formation and for one of its members. The Mahogany member of the Ankareh formation is proposed for the red shale and sandstone beds between the top of the Thaynes and the base of the Gartra grit in the central Wasatch and Uinta Mountains. The member is named after the Mahogany Hills, north of Weber River, T. 1 S., R. 6 E., Summit County, Utah, where the Thaynes and Ankareh formations are well developed. The Mahogany member of the Ankareh formation also intertongues with the Thaynes formation.

In the Fort Douglas Military Reservation, Salt Lake City, the Mahogany member is 850 feet thick, the Gartra grit member 60 feet, and the Stanaker member 390 feet (A. E. Granger, personal communication). Between Park City and the Duchesne River, the Mahogany member of the Ankareh formation thickens greatly as the Thaynes formation tongues out eastward (fig. 21). Between the Duchesne River and Whiterocks Canyon of the Uinta Mountains, the Mahogany member thins and is only 555 feet at Whiterocks Canyon. Beyond the point where the tongue of the Thaynes wedges out, the red beds of the Woodside formation and the Mahogany member of the Ankareh cannot be separated. Thomas and Krueger (1946) believe this sequence is entirely Woodside.

However, in the eastern Uinta Mountains where the Thaynes formation is absent, the Triassic nomenclature of the Colorado Plateau, namely the Moenkopi, Shinarump, and Chinle formations, is applicable (Kinney and Rominger, 1947). There is no apparent advantage in using the name Red Wash formation (=Moenkopi) proposed by Williams (1945). The Moenkopi formation is equivalent to the interval of the Woodside, Thaynes, and Mahogany member of the Ankareh formation in the western Uinta Mountains and Wasatch Mountains. The Shinarump conglomerate correlates with the Gartra grit member of the Ankareh formation, and the Chinle formation with the Stanaker member of the Ankareh formation in the western Uinta and Wasatch Mountains.

The Gartra grit member is a poorly sorted, coarse-grained, feldspathic quartz grit. It ranges in thickness from 26 to 93 feet and lies unconformably on the Mahogany member of the Ankareh formation (Thomas and Krueger, 1946). The Stanaker member consists of varicolored shale and sandstone between the Gartra grit member and the Nugget sandstone. The thickness of the Stanaker in northern Utah ranges from 120 to 400 feet (Thomas and Krueger, 1946).

In the vicinity of Provo, Utah, Baker (1947) measured 1,485 feet of the Ankareh in Scott Draw west of Charleston, Utah, and 1,530 feet along Diamond Fork near Thistle, Utah. The Ankareh formation at both localities is divisible into a lower red shale and sandstone unit and an upper unit of variegated, red shale with interbedded red and purplish-red, fine-grained to conglomeratic sandstone. At Scott Draw, Baker records a 35-foot conglomeratic bed at the base of the upper member. This is probably equivalent to the Gartra grit member of the Ankareh formation. The Gartra grit member does not appear to be distinguishable at Diamond Fork.

### SOUTHEASTERN IDAHO

Mansfield (1927) recognized the following sequence of beds between the Thaynes and Nugget formations:

Wood shale
Deadman limestone
Higham grit
Timothy sandstone.

These units are each distinct lithologically and are equivalent to the Ankareh formation of the Wasatch and Uinta Mountains and of western Wyoming. In this report the Timothy sandstone is considered to be the uppermost member of the Thaynes formation. The Timothy sandstone member is lithologically related to and in part gradational with the Portneuf limestone member of the Thaynes formation. The Higham grit unconformably overlies the Timothy sandstone member. The Higham grit and Deadman limestone are recognized as independent formations, but the Wood shale is considered a westward extending tongue of the An-

kareh formation comparable with the Lanes tongue of the Ankareh formation.

The Higham grit consists of coarse conglomeratic, white, pink, and purple quartz sandstone. This formation was named by Mansfield (1916) from Higham Peak in the northeastern part of the Fort Hall Indian Reservation, where it is about 500 feet thick. In the Freedom quadrangle it measures about 200 feet. The Higham is 135 feet thick at Hot Springs, 55 feet at Spring Canyon, and 105 feet at Cokeville, Sublette Ridge, Wyo. The Higham lies unconformably on the Timothy sandstone member or, where this member is not present, on the Thaynes formation. The Higham probably correlates with the Gartra grit and Shinarump conglomerate of northern Utah.

The Deadman limestone has its type locality in the Fort Hall Indian Reservation, where it is 150 feet thick. It consists of white, pinkish, or green, dense, massive, nodular limestone. In its type area it lies directly on the Higham grit; southward around Montpelier the Deadman limestone appears to lie in the midst of red shales (Mansfield, 1927, p. 95). The Deadman limestone was not recognized at Spring Canyon, Sublette Ridge, or at Hot Springs. At Cokeville a 10-foot limestone bed resting on the Higham grit may belong to the Deadman limestone.

Red shales and siltstones that are generally poorly exposed lie between the Deadman limestone and the Jurassic Nugget sandstone. Mansfield (1916) named these beds the Wood shale in the Fort Hall Indian Reservation, where they range from 200 to 250 feet in thickness. This unit is considered to be a westward extending tongue of the Ankareh formation and is here called the Wood shale tongue of the Ankareh formation. The Wood shale tongue is approximately 250 feet thick in Spring Canyon, 40 feet at Cokeville, and 400 feet at Hot Springs.

### WESTERN WYOMING

Throughout western Wyoming the red bed sequence between the Thaynes formation and Nugget sandstone is called the Ankareh formation. The Higham grit is discontinuous and does not constitute a mappable unit (W. W. Rubey, personal communication); where present it is considered a member of the Ankareh. The Ankareh formation at Muddy Creek, in Lincoln County, is about 650 feet thick (H. D. Thomas, personal communication). The formation contains a 3-foot bed of gray limestone in the middle of the section that is correlated with the upper part of the Portneuf limestone member of the Thaynes formation of southeastern Idaho. If this correlation is correct, the underlying red beds are part of the Lanes tongue of the Ankareh formation.

At Swift Creek in the Salt River Range, the Ankareh formation is 775 feet thick. It contains a massive 10-foot bed of light-tan sandstone 215 feet above the Thaynes formation that may be correlative with part or all of the Timothy sandstone member of the Thaynes formation of Idaho. At the headwaters of Middle Piney Creek in the Wyoming Range, the Ankareh is composed of 850 feet of red sandstone and some red shale beds.

In the Snake River Range, H. R. Wanless (personal communication) measured 359 feet of beds between the Thaynes formation and the Nugget sandstone. The lower 258 feet is red shale and sandstone, and the upper 111 feet is red and purple shale and siltstone with which numerous thin beds of gray, red, and purple limestone are intercalated. This 111-foot member Wanless tentatively correlates with the Deadman limestone, but it is possible that the intercalated beds of limestone may represent the featheredge of the Thaynes formation tonguing eastward into the Ankareh. At any event the whole sequence should be considered the Ankareh formation. In the Hoback Mountains there is approximately 700 feet of red shale and sandstone with a 4-foot bed of limestone near the middle that is referable to the Ankareh formation (Wanless, personal communication). The underlying Thaynes formation contains a prominent red tongue of the Ankareh formation. Near the northeast corner of the Irwin Quadrangle, the Ankareh is 550 feet thick (Gardner, 1944).

### CHUGWATER FORMATION OF CENTRAL WYOMING

Throughout the Wind River Mountains, post-Dinwoody Triassic rocks are all red sandstones and siltstones except for one thin limestone member; they are all placed in the Chugwater formation. There are three members of the Chugwater that are distinctive enough to be useful in regional work (Love, 1948). These are the Red Peak, Alcova limestone, and Popo Agie members. The Red Peak consists of 800 to 1,000 feet of red siltstone, shale, and silty sandstone overlying the Dinwoody formation and underlying the Alcova limestone member. Newell and Kummel (1942) demonstrated that at least the lower part of the Red Peak grades into the Woodside formation of the southeastern Idaho. In the area west of Paris, Idaho, and around Henry, Idaho, the rocks of equivalent age are entirely gray and buff limestone, shale, and siltstone of marine origin. The red beds of the Red Peak intertongue with these nonred marine deposits.

The Alcova limestone member consists of approximately 15 feet of gray to slightly pinkish, hard, finely crystalline, thin-bedded limestone. The limestone is present throughout the Wind River Basin and is the

only limestone in the Chugwater formation in this area (Love, 1948). The Alcova member is probably equivalent to some part of the Thaynes formation of southeastern Idaho. Love (1948, p. 99) states, "* * * the Alcova limestone is somewhat younger than at least the major part of the lower Triassic Thaynes formation."

The youngest member of the Chugwater formation is the Popo Agie. It consists of " * * * 100 to 200 feet of ocher-colored, oolitic, siliceous, dolomitic claystone; limestone pellet conglomerate; purple and red shale; and red silty sandstone" (Love, 1948, p. 99). In the northwestern part of the Wind River Basin the Alcova limestone member is missing, but there is a sequence of gray, oil-saturated sandstone called by Love (1939) the Crow Mountain member of the Chugwater formation which is equivalent to sandstone that both underlies and overlies the Alcova member in other parts of the Wind River Basin (Love, 1948). In the Wind River Basin there is generally a series of red siltstones and sandstones between the Alcova and the Popo Agie members. This post-Alcova-pre-Popo Agie unit is similar in lithology to the Red Peak member but has not received a separate name. Around Green River Lakes the post-Alcova consists of 240 feet of maroon sandstone overlain by 85 feet of typical Popo Agie rocks (Richmond, 1945).

Fossils are very scarce in the Chugwater formation, and exact dating and correlation with the marine sequence in Idaho is uncertain. The only fossil recorded from the Red Peak member is a poorly preserved "*Monotis*" sp. identified by J. B. Reeside. The Alcova limestone member has yielded a few marine invertebrates and a marine nothosaur, but none of these fossils are diagnostic. The Alcova member is probably correlative with some portion of the upper part of the Thaynes formation. The Popo Agie member has yielded some phytosaurian remains, poorly preserved plants, and a few pelecypods. The age of the Popo Agie member has been considered to be Upper Triassic by some investigators and Middle Triassic by others (Love, 1948). The Popo Agie member may be correlative with all or part of the post-Thaynes Triassic beds of Idaho and the Stanaker and Gartra grit members of the Ankareh formation in the central Wasatch and Uinta Mountains of Utah.

## AGE AND CORRELATION OF TRIASSIC FORMATIONS

Lower Triassic faunas throughout the world are not varied and consist mainly of pelecypods and ammonites. Whole phyla, such as the echinoderms, foraminifera, bryozoa, coelenterates, and sponges are practically unknown; brachiopods and gastropods are sparsely represented. The known faunas are cosmopolitan and surprisingly homogeneous. Much less is known of Lower Triassic faunas than those of the Middle and Upper Triassic. This is also true for the upper Permian faunas. One of the principal reasons for this is the lack of well-developed late Permian and Early Triassic marine deposits. The late Permian ammonoid, *Cyclolobus*, is found only in the Salt Range, Pakistan; in the Himalayas, India; Madagascar; Timor; and in East Greenland. Other young Permian deposits, such as the Bellerophonkalk of the Alps and the beds at Djulfa in Armenia, contain rather sparse and poorly understood faunas. Earliest Scythian rocks, characterized by the presence of the ammonite *Otoceras*, are only known in the Himalayas and in East Greenland. In the Ussuri Bay region near Vladivostock, early Scythian deposits occur, but *Otoceras* is not present. Younger Scythian rocks are of more widespread occurrence.

Zoning of the Lower Triassic has been done mostly on the basis of ammonites as in the remainder of the Mesozoic. However, there are some pelecypods, especially *Claraia*, which are important. The establishment of a chronology of Lower Triassic ammonite zones has been attempted by numerous Triassic students. J. P. Smith was the leading American student, and he very ably summarized his views in his last monograph (1932). In Europe there were numerous individuals who tackled this problem, in which names of Waagen, Mojsisovics, Diener, Arthaber, Frech, and Noetling are important. Smith (1932) was the last of the above group of authors to summarize his views on Lower Triassic faunal zones. Smith established five faunal zones, into which he placed all the important Lower Triassic faunas known to him. His faunal chronology, starting with the oldest, is as follows: *Otoceras*, *Genodiscus*, *Meekoceras*, *Tirolites*, *Columbites*.

The latest review of Triassic ammonoids and faunal chronology is by Spath (1934, 1951). He proposed six faunal divisions, each of which contains one or more ammonite zones. Spath's subdivisions are as follows:

| | | | |
|---|---|---|---|
| Upper Eo-Triassic | Prohungaritan | Lower Eo-Triassic | Flemingitan |
| | Columbitan | | Gyronitan |
| | Owenitan | | Otoceratan |

The Gyronitan is equivalent to the *Genodiscus* zone of Smith (1932), the Flemingitan and Owenitan to the *Meekoceras* zone of Smith, and the Columbitan includes the *Tirolites* and *Columbites* zones of Smith. Spath demonstrated in a convincing manner that Smith had failed to appreciate the incompleteness and limited time span of his own faunas; likewise, that many of Smith's zones (for example *Columbites*) included heterochron-

ous faunas. At the same time Spath pleads caution and stresses the incompleteness of our knowledge of Lower Triassic faunas. The Prohungaritan division was established tentatively due to lack of sufficient data and faunas. It is a worthy testament to Spath's genius that new faunas in the upper Thaynes substantiate clearly his original theory on this upper Scythian faunal division.

The Lower Triassic strata in Idaho comprise one of the thickest marine sections known in the world. Likewise, the succession of amonite zones is more complete than in most of the classic Scythian localities in Eurasia. The great thickness of marine deposits and the numerous faunas present make the Lower Triassic of Idaho one of the very important sections in the world.

Monographic treatment of the Lower Triassic faunas from the Middle Rocky Mountains is now in progress. The following discussion of faunal zones is confined mainly to the ammonite zones, partly because they are the most significant for interregional correlation and because data on the pelecypods and brachiopods are not yet assembled. These data, however, will not alter the correlations established by the ammonites. The Dinwoody and Thaynes formations contain ammonite faunas belonging to all six of the faunal divisions established by Spath. The Dinwoody formation contains ammonite zones of the Otoceratan, Gyronitan, and Flemingitan divisions. The Thaynes formation contains ammonite zones of the Owenitan, Columbitan and Prohungaritan divisions. The Otoceratan and Gyronitan age of part of the Dinwoody formation was established by Newell and Kummel (1942). New ammonite faunas of Gyronitan and Flemingitan age from the Dinwoody formation are listed below. Smith (1932) monographed the ammonite faunas from the *Meekoceras*, *Tirolites*, and *Columbites* zones of the Thaynes formation. Mathews (1929) has described the *Anasibirites* fauna (upper Owenitan) from Fort Douglas, Utah; this fauna is now also known from Idaho. An ammonite fauna of Prohungaritan age is present in the upper Thaynes in the Paris Canyon area of Idaho.

No large faunas of ammonites have as yet been found in the Dinwoody formation; however, three small faunas of a dozen or less individual specimens and representing three distinct zones have been found. The lower shale unit of the Dinwoody formation in Montana and the silty limestone and "*Lingula*" unit of the Dinwoody in southeastern Idaho and western Wyoming have yielded a few, generally poorly preserved, ammonites. From these beds the following species are recognized:

*Ophiceras* cf. *greenlandicum* Spath
*O.* (*Lytophiceras*) cf. *O. commune* Spath
*O.* (*Glyptophiceras*) *nielseni* Spath
*O.* (*Discophiceras*) *subkyokticum* Spath
*O.* (*Metophiceras*) *subdemissum* Spath

The species listed above are present in the *Ophiceras* beds (of Otoceratan age) of East Greenland. As most students of early Triassic ceratites are aware, specific identification is extremely difficult, especially so when only a few poorly preserved specimens are available. Whereas the above identifications of lower Dinwoody ammonites can only be considered tentative on a specific level, the generic assignments appear to be correct. Newell and Kummel (1942) list the following species from the "*Lingula*" unit of the Dinwoody formation:

*Discophiceras subkyokticum* Spath
*Metophiceras subdemissum* Spath
*Mentzelia* sp.?
*Spiriferina mansfieldi* Girty
*Pleurophorus? bergeri* Girty
*Lingula borealis* Bittner
*Myalina putiatinensis* Kiparisova
*M. spathi* Newell and Kummel
*Claraia stachei* Bittner

Faunas of Otoceratan age are very limited in distribution, and large ammonite faunas of this age are known only from the Himalayas, East Greenland, and the Ussuri district of eastern Siberia. Spath (1935) has demonstrated the close faunal affinities between these three areas. To these three areas we must now add the lower Dinwoody fauna as pointed out by Newell and Kummel (1942). The lower Dinwoody fauna indicates an upper Otoceratan age, though the ceratite *Otoceras*, which characterizes the lowest Scythian ammonite zone in the Himalayas and East Greenland, has not been found in the Middle Rocky Mountains.

There are other areas in North America where faunas of Otoceratan age have been reported, but the evidence is not conclusive. Muller and Ferguson (1939) record *Claraia clarai*, *C. stachei*, and *C. aurita* from the lower part of the Candelaria formation in southwestern Nevada, where they tentatively place this fauna in the *Otoceras* zone. These species of *Claraia* are good index fossils of the Sythian, but they do range above the *Otoceras* zone. Three similar species of *Claraia* (*C. stachei*, *C. clarai occidentalis*, and *C. mulleri*) have been recorded from the "*Claraia*" unit of the Dinwoody formation in southeastern Idaho and western Wyoming at a horizon younger than the *Otoceras* zone (Newell and Kummel, 1942). However, overlying the *Claraia* zone in southwestern Nevada, a *Proptychites* fauna occurs which is Gyronitan in age (Muller and Ferguson, 1939). In the Candelaria formation the beds with *Claraia* could be either Otoceratan or Gyronitan in age.

Warren (1945) records *Claraia stachei* from a bed at or near the base of the Sulphur Mountain member of

the Spray River formation in Alberta. A black magnesium limestone bed containing many flattened ammonites is in sections closely associated with the section containing *Claraia stachei*. Whereas the state of preservation of these ammonites prohibits specific identification, Warren believes they include the following genera: *Ophiceras*, *Proptychites*, and *Otoceras*. This is a very important discovery, and it is unfortunate that more positive identifications cannot be made. *Otoceras* and *Ophiceras* are Otoceratan in age, and all previous records of *Proptychites* place it in the Gyronitan, definitely younger than either *Otoceras* or *Ophiceras*. This fauna is probably lower scythian, but its exact age will remain open to question until better material is found.

In the valley of the Liard River, British Columbia, Kindle (1944) discovered *Claraia* cf. *C. stachei* in the Grayling formation. As McLearn (1945) has pointed out, *Claraia stachei* ranges through the Otoceratan and Gyronitan ages in East Greenland. However, the presence of *Claraia stachei* in British Columbia, Alberta, Idaho, and Nevada afford at least tentative means of correlation. It likewise suggests that the Lower Triassic geosynclines extended from Nevada and Idaho northward to the Arctic Ocean. An open seaway in this position would permit migration of faunas between East Greenland and Idaho and the Ussuri district of eastern Siberia.

The limestone-siltstone beds immediately overlying the lower shale unit of the Dinwoody formation in southwestern Montana have yielded two new ammonite faunas. In Frying Pan Gulch, Beaverhead County, southwestern Montana, a small ammonite fauna was found in a gray, crystalline limestone approximately 60 feet above the lower shale unit of the Dinwoody formation. This fauna contained several specimens referred to *Prionolobus* n. sp. cf. *P. atavus* (Waagen) and one specimen referred to *Koninckites* cf. *K. truncatus* Spath. In the same section approximately 70 feet above the bed with *Prionolobus*, the following ammonites occur: *Kymatites* n. sp. cf. *K. radiosum* (Waagen), *Koninckites* n. sp. cf. *K. timorense* (Wanner), and *Xenodiscoides* cf. *X. involutus* (Frech). At Dalys Spur, 13 miles south of Dillon, Montana, approximately 100 feet above the lower shale unit of the Dinwoody formation, one small ammonite, *Gyronites* cf. *G. frequens* Waagen, has been found.

*Prionolobus atavus* and *Koninckites truncatus* occur in the Lower Ceratite limestone of the Salt Range, as does *Gyronites frequens*. These forms are Gyronitan in age. *Kymatites radiosum* occurs in the lower part of the Ceratite sandstone of the Salt Range and *Xenodiscoides involutus* occurs in the underlying Ceratite marls of the Salt Range of Pakistan. Both of these species are Flemingitan in age. The *Koninckites* associated with the above species compares most closely with *K. timorense* in general shape and involution, but there are discrepancies in their sutures. The genus *Koninckites* range through the Gyronitan and Flemingitan. On the basis of specimens available, the upper half of the Dinwoody formation contains faunas of Gyronitan and Flemingitan ages. The material is too scanty and poorly preserved to allow definite identification as to particular zones at the present time. The Gyronitan age of at least part of the Dinwoody formation was recognized by Newell and Kummel (1942). They recorded no ammonites but did list, among others, the following species: *Myalina spathi* Newell and Kummel, *Claraia stachei* Bittner, and *Anadotophora fassaensis* Wissmann. The upper Dinwoody pelecypod faunas are very similar to those of the Ussuri district described by Kiparisova (1938), the East Greenland faunas described by Spath (1930, 1935), and to the faunas of the Seis member of the Werfen formation in the Alps.

In southwestern Nevada, Muller and Ferguson (1939) recognize a *Proptychites* fauna overlying their *Claraia* fauna in the lower Candelaria formation. Their *Proptychites* fauna contains:

*Hedenstroemia* (*Clypites*) cf. *H.* (*C.*) *evolvens* Waagen
*Meekoceras* cf. *M. lilangense* Krafft
*Meekoceras* cf. *M. tenuistriatum* Krafft
*Proptychites* cf. *P. ammonoides* Waagen
*Proptychites* cf. *P. trilobatus* Waagen
*Grypoceras* cf. *G. brahmanicum* (Griesbach)
*Grypolepis?* sp.

According to Spath (1934) *Meekoceras lilangense* Krafft belongs in *Prionolobus*, and *Meekoceras tenuistriatum* is a transitional form between *Kingites* and *Proptychites*. *Meekoceras lilangense*, *Meekoceras tenuistriatum*, and *Grypoceras brahmanicum* have been previously known only from the so-called "*Meekoceras*" beds of the Himalayas. *Proptychites ammonoides*, *Proptychites trilobatus*, and *Hedenstroemia* (*Clypites*) *evolvens* are known only from the Ceratite marls of the Salt Range. Muller and Ferguson assigned their *Proptychites* fauna to the Gyronitan division of Spath. It is correlative with the horizon of *Prinolobus* n. sp. cf *P. atavus*, *Koninckites* cf. *K. truncatus*, and *Gyronites* cf. *G. frequens* of the Dinwoody formation in southwestern Montana. No other faunal zones above the *Proptychites* fauna have been found in the Candelaria formation in southwestern Nevada.

The Thaynes formation contains five ammonite faunas which from bottom to top belong to the *Meekoceras, Anasibirites*, *Tirolites*, *Columbites*, and *Prohungarites* zones. All except the latter of these zones

were recognized by J. P. Smith (1932). The most widespread and fossiliferous ammonite zone in the Middle Rocky Mountains is the *Meekoceras* fauna of the lower limestone unit of the Thaynes formation. The *Meekoceras* fauna has been reported from several localities in Nevada and in California; also from the Moenkopi formation in southern Utah. The last monograph by J. P. Smith (1932) was largely a description and discussion of the *Meekoceras* fauna. In the past twenty years there have been important additions and revisions in the taxonomy of Lower Triassic ammonites. The following faunal list of species in the *Meekoceras* fauna of Idaho is primarily that of J. P. Smith; but the list has been revised and each species placed in its proper taxonomic position. The generic names enclosed in quotation marks are those used by Smith that do not appear to be correct but are still uncertain.

*"Lecanites" knechti* Hyatt and Smith
*"Xenodiscus" cordilleranus* Smith
*gilberti* Smith
*intermontanus* Smith
*tarpeyi* Smith
*toulai* Smith
*waageni* (Hyatt and Smith)
*whiteanus* (Waagen)
*Dieneroceras dieneri* (Hyatt and Smith)
*Wyomingites aplanatus* (White)
*arnoldi* (Hyatt and Smith)
*Flemingites aspenensis* Smith
*bannockensis* Smith
*russelli* Hyatt and Smith
*russelli* Hyatt and Smith var. *gracilis* Smith
*Euflemingites cirratus* (White)
*Meekoceras arthaberi* Smith
*cristatum* Smith
*gracilitatus* White
*sylvanum* Smith
*bridgesi* (Smith)
*Submeekoceras mushbachanum* (White)
*mushbachanum* (White) var. *corrugatum* (Smith)
*evansi* (Smith)
*patelliforme* (Smith)
*bonnevillense* (Smith)
*Svalbardiceras? haydeni* (Smith)
*pealei* (Smith)
*Pseudaspidites muthianum* (Kraft)
*Anahedenstroemia hyatti* (Smith)
*kossmati* (Hyatt and Smith)
*Clypites tenuis* Hyatt and Smith
*"Dalmatites" richardsi* Smith
*Aspenites acutus* Hyatt and Smith
*obtusus* Smith
*Pseudosageceras* sp. (=*Aspenites laevis* Smith)
*multilobatum* Noetling
*Lanceolites compactus* Hyatt and Smith
*Metussuria occidentalis* (Smith)
*waageni* (Hyatt and Smith)
*Cordillerites angulatus* Hyatt and Smith
*Paranannites aspenensis* Hyatt and Smith
*columbianus* Smith
*compressus* Smith
*pertenuis* Smith
*Juvenites dieneri* (Hyatt and Smith)
*kraffti* Smith
*sanctorum* Smith
*septentrionalis* Smith
*thermarum* (Smith)
*"Prenkites" depressus* Smith

The *Meekoceras* fauna has a very wide distribution. It is well developed in Timor and the Himalayas. Warren (1945) records *Flemingites?* and *Claraia griesbachi* Bittner 600 feet above the base of the Sulphur Mountain member of the Spray River formation in Alberta. Kindle correlates this horizon with the *Meekoceras* beds in Idaho. Petković and Mihajlović (1935) identified *Meekoceras gracilitatis* White, *Meekoceras* (*Koninckites*) *vetustus* Waagen, *Hedenstroemia hyatti* Smith, and *Pseudosageceras multilobatum* Noetling from the Werfen beds in Yugoslavia. They place these forms in the *Meekoceras* zone and correlate them with the *Meekoceras* zone of Idaho.

The lower shale unit of the Thaynes formation, which overlies the lower limestone with *Meekoceras*, contains ammonites characteristic of the *Anasibirites* zone. This fauna from Fort Douglas, Utah, was first described by Mathews (1929). Smith (1932) considered the *Anasibirites* zone to be merely a subzone of his *Meekoceras* zone; however, recent work by Spath (1934) and McLearn (1945) on faunas of this zone strengthen its position as an independent zone.

The *Anasibirites* fauna from Fort Douglas, Utah, described by Mathews is rather poor in diversity of genera but appears to contain numerous species. Both Smith (1932) and Spath (1934) combined many of Mathews' species; likewise, the original generic assignments of many of the species have been changed. Mathews' faunal list is given below; no attempt is made in this list to correct or modify the original species, but the generic names are brought up to date. The status of many of Mathew's species will be discussed in a later paleontological paper on this fauna.

*Pseudosageceras intermontanum* Hyatt and Smith
*Cordillerites compressus* Mathews
*Xenoceltites matheri* (Mathews)
*hannai* (Mathews)
*douglasensis* (Mathews)
*Meekoceras davisi* Mathews
*hertleini* Mathews
*Anasibirites kingianus* (Waagen)
*salisburyi* Mathews
*madisoni* Mathews
*johannseni* Mathews
*whitei* Mathews
*blackwelderi* Mathews
*fisheri* Mathews
*emmonsi* Mathews
*welleri* Mathews

*powelli* Mathews
*whitfieldi* Mathews
*crickmayi* Mathews
*veranus* Mathews
*ketchumi* Mathews
*perrini* Mathews
*weaveri* Mathews
*wardi* Mathews
*pseudoibex* Mathews
*mcclintocki* Mathews
*bifurcatus* Mathews
*alternatus* Mathews
*romeri* Mathews
*dieneri* Mathews
*clarki* Mathews
*bretzi* Mathews
*vanbuskirki* Mathews
*rollini* Mathews
*edsoni* Mathews
*bassleri* Mathews
*guyi* Mathews
*gibsoni* Mathews
*hyatti* Mathews
*mojsisovicsi* Mathews
*Hemiprionites typus* (Waagen)
*americanus* (Mathews)
*walcotti* (Mathews)
*utahensis* (Mathews)
*shumardi* (Mathews)
*slocomi* (Mathews)
*ornatus* (Mathews)
*butleri* (Mathews)
*varians* (Mathews)
*resseri* (Mathews)
*"Kashmirites" subarmatus* Diener
*Wasatchites wasatchensis* (Mathews)
*thornei* (Mathews)
*gilberti* (Mathews)
*seerleyi* (Mathews)
*perrini* Mathews
*meeki* Mathews
*magnus* Mathews
*quadratus* Mathews
*Gurleyites smithi* Mathews
*chamberlini* Mathews
*milleri* Mathews
*boutwelli* Mathews

There are impressions of ammonites in all outcrops of the lower shale unit of the Thaynes formation in Idaho. Only one locality in Idaho is known with a well-preserved fauna in these beds. West of Georgetown, Idaho, the lower part of the lower shale unit has yielded a large, well-preserved fauna, which is almost the same as that at Fort Douglas, Utah. This unit contains numerous species of *Hemiprionites*, *Gurleyites*, *Anasibirites*, *Wasatchites*, and *Anawasatchites*. Species of *Hemiprionites* are far more abundant and diversified in the Georgetown fauna than at Fort Douglas, where *Anasibirites* is the principal element of the fauna.

The *Anasibirites* fauna has not been recognized as yet in the Candelaria formation of southwestern Utah. Hyatt and Smith (1905) record *Anasibirites noetlingi* from the *Meekoceras* zone of the Inyo Range, Inyo County, Calif.; however, it is unfortunate that neither of these authors published stratigraphic sections recording the exact occurrence of their forms. McLearn (1945) described a small fauna that belongs to the *Anasibirites* zone from the Toad formation on the Liard River, British Columbia. This fauna contains species of "*Prionites*," *Wasatchites*, *Anawasatchites*, and *Xenoceltites*. Even though the genus *Anasibirites* is absent, the other genera afford close correlation with the Idaho and Utah faunas of the *Anasibirites* zone.

Outside of North America the *Anasibirites* fauna has been recorded from the Upper Ceratite limestone of the Salt Range, and in Timor, and Spitzbergen. The "*Meekoceras*" fauna from Shikoku, Japan, described by Yehara (1928) probably belongs to the *Anasibirites* zone. Spath (1934) does not consider the various *Anasibirites* beds of different localities to be contemporaneous and states "that a number of additional horizons may eventually be recognized in the Owenitan and Columbitan ages." He further adds that the beds with *Wasatchites* and *Gurleyites* in Spitzbergen are probably a little younger than the *Anasibirites* beds of Utah.

In Paris Canyon, west of Bear Lake, in a gray limestone bed below the middle shale with *Columbites* and approximately 800 feet above the lower limestone with *Meekoceras* occurs a small fauna of amonites and pelecypods that belong to the *Tirolites* zone. Smith (1932) considered the fauna to have distinct Mediterranean affinities, and he records the following species from this bed:

*Dalmatites attenuatus* Smith
*Tirolites harti* Smith
*knighti* Smith
*pealei* Smith
*Nautilus* sp. indet.
*Orthoceras* sp. indet.
*Pseudomonotis idahoensis* White
*pealei* White
*Pugnoides triassicus* Girty
*Pentacrinue (Isocrinus) smithi* Clark and Twitchell

Mathews (1931) records *Tirolites pacificus* from a light-gray fossiliferous limestone 280 feet above the uppermost fossiliferous bed containing the *Anasibirites* fauna in the Fort Douglas area, Utah. The single locality in Idaho and another in Utah are the only two localities known for this fauna in North America.

The middle shale unit of the Thaynes formation which overlies the limestones with *Tirolites* in the Bear Lake Valley region, contains a unique ammonite fauna referred to the *Columbites* zone. This is the only area in the world where this zone has been recorded although Mathews (1931) does record *Columbites*

*parisianus* from the Thaynes formation in the Fort Douglas area. No other Scythian ammonite faunas strictly contemporaneous with the *Columbites* fauna of Idaho are known. The *Columbites* fauna of the Bear Lake Valley area has been described by Smith (1932), and he recognized the following species; the generic names enclosed in quotation marks are those used by Smith that do not appear to be correct but are still uncertain.

*"Ophiceras" jacksoni* Hyatt and Smith
*"Ophiceras" spencei* Hyatt and Smith
*"Meekoceras" curticostatum* Smith
*"Meekoceras" micromphalus* Smith
*"Meekoceras" pilatum* Hyatt and Smith
*"Meekoceras" sanctorum* Smith
*Hellenites idahoense* (Smith)
*Tirolites* cf. *T. illyricus* Mojsisovics
*Pseudosageceras multilobatum* Noetling
*"Celtites" apostolicus* Smith
*"Celtites" planovolvis* Smith
*"Celtites" ursensis* Smith
*Columbites consanguineus* Smith
*ligatus* Smith
*minimus* Smith
*ornatus* Smith
*parisianus* Hyatt and Smith

Smith recognized the *Columbites* fauna only in Paris Canyon, but the writer has found fossiliferous exposures of the middle shale unit in several places in southeastern Idaho. The collections now being studied contain many more genera and species than recorded by Smith.

The upper 1,500 feet of the Thaynes formation in the Paris Canyon area, west of Bear Lake, contain Lower Triassic ammonoids younger than any previously reported from North America. The ammonoids are most abundant in the upper part of the lower half of this 1,500-foot sequence, and no ammonoids have been found in the upper half of this sequence.

This ammonoid fauna is at present being studied and the following forms are recognized in the collections:

*Prohungarites* n. sp. cf. *P. similis* Spath
*Prohungarites* n. sp. cf. *P. crasseplicatus* (Welter)
*Svalbardiceras* sp.
*Metahedenstroemia* n. sp.
*Keyserlingites* n. sp. cf. K. *subrobustus* (Mojsisovics)
*Isculitoides* n. sp.
*Epiceltites* n. sp. cf. *E. genti* Arthaber
*Czekanowskites?* sp.
*Stacheites* sp.
*Olenikites?* sp.

*Prohungarites*, *Keyserlingites*, and *Isculitoides* are the most common genera present. *Czekanowskites* and *Olenikites* are based on only a few poorly preserved specimens in which no sutures are preserved; however, the general appearance of the conch strongly suggests these generic assignments. *Prohungarites similis* and *P. crasseplicatus* are known only from the upper Scythian beds of Timor. *Svalbardiceras*, *Keyserlingites subrobutus*, *Czekanowskites*, and *Olenikites* are known only from upper Scythian beds of the Olenek river region of northern Siberia and in Spitzbergen. *Metahedenstroemia*, *Isculitoides*, and *Epiceltites* are known from upper Scythian beds in Albania and the Island of Chios, off the coast of Turkey.

When Spath (1934) proposed the Prohungaritan age as the upper division of the Scythian, he emphasized the incompleteness of our knowledge of the uppermost beds of the Scythian. He recognized the close affinities of the *Subcolumbites* fauna of Albania with the *Albanites* fauna of Timor. However, there was little to correlate them with the "*Hungarites*" *middlemissi* beds of Kashmir or the faunas of the Olenek region in Siberia or Spitzbergen. Likewise Spath was prompted to propose a new age for the uppermost Scythian based upon the "* * * obvious differences between the lowest Anisian and the highest Scythian faunas so far known * * *."

Renz and Renz (1948) have recently published an important monograph on an upper Scythian ammonite fauna from the Greek Island of Chios that bears on this problem. The fauna of Chios substantiates the close relationship between the *Subcolumbites* fauna of Albania with the *Albanites* fauna of Timor. Neither of these faunas have much in common with Arctic or Himalayan faunas mentioned above. The *Prohungarites* fauna of Idaho is an important link in correlating these Tethyian faunas with the Boreal faunas of Siberia and Spitzbergen. The Idaho *Prohungarites* fauna occurs about 1,000 feet above the *Columbites* zone. The association of these Boreal and Tethyian elements in this zone strongly verifies Spath's arguments for the establishment of a Prohungaritan age. Spath (1934) included the Spitzbergen, Olenek, Kashmir, Albanian, and Timor faunas in his Prohungaritan age but was uncertain as to their correct zoning. This Idaho fauna clearly demonstrates the age relationships of these Tethyian and Boreal faunas, but more detailed paleontologic work is needed to establish the proper zonal relationships.

A fauna of Prohungaritan age from the south Ussuri coastal region of Siberia near Vladivostock has been reported by Kiparisova (1945). No description of the fauna has appeared as yet but Kiparisova's faunal list (1945, p. 439) includes the following ammonite genera: *Subcolumbites*, *Prosphingites*, *Megaphyllites*, *Paranannites*, and *Pseudosageceras*. Interpretation of this fauna must wait until more information is available.

In Spring Canyon, Sublette Ridge, a piece of limestone float was found 150 feet below the top of the upper calcareous siltstone unit, containing a well-preserved ammonite assigned to *Stacheites*. The specimen is similar to species of *Stacheites* described by Renz and Renz (1948) from the Island of Chios. This suggests that the upper part of the upper calcareous siltstone unit in Sublette Ridge is equivalent to at least part of the ammonitiferous beds of the upper part of the Thaynes formation west of Bear Lake.

Hazzard (1937) records *Stephanites* sp. and *Subcolumbites* sp., among other fossils, from Lower Triassic rocks in the Providence Range, San Bernardino County, Calif. *Subcolumbites* is present in the upper Scythian faunas of Albania and the Island of Chios. If the identifications are correct these strata are correlative with the upper part of the Thaynes formation of southeastern Idaho.

The writer has no new data on the age of the post-Thaynes Triassic formations of the Middle Rocky Mountains. These formations, which have yielded no diagnostic fossils, have been considered to be either Middle or Late Triassic in age by various authors. The Higham grit, Deadman limestone, and the Wood shale tongue of the Ankareh formation in southeastern Idaho, the Popo Agie member of the Chugwater formation in western Wyoming, and the Gartra grit and Stanaker members of the Ankareh formation in the central Wasatch and western Uinta Mountains have been correlated with the Shinarump and Chinle formations of the Colorado Plateau and considered Late Triassic in age (see Williams, 1945; and Thomas and Krueger, 1946). Stokes (1950) suggests that the Shinarump conglomerate is a pediment deposit of Middle Triassic age.

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